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CURRENT STATUS OF CALIFORNIA SUMMER STEELHEAD (*Salmo gairdneri*) STOCKS AND HABITAT, AND RECOMMENDATIONS FOR THEIR MANAGEMENT.

A Report Presented to Region 5,

U.S.D.A. Forest Service

prepared by

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INTRODUCTION

John Snyder concluded his paper, "The Half-pounder of Eel River, A Steelhead Trout":

> It may not be out of place here to call attention to the well known fact that stream fishing for trout, a major sport in California, is rapidly entering a critical stage. The extension of roads easily negotiated by the automobile, the building of high dams, the netting of steelheads in the rivers, water pollution, the use of water for irrigation, and many other things incident to a rapid growth in population, are causing a marked and sudden depletion in the number of fish. It has been said that intelligent conservation must depend largely on our knowledge of the natural history of the species, and nowhere else is this more applicable. Very often our attempts at conservation serve among other things to bring to the surface our lack of definite knowledge of the habits and life history of the very fish that we are striving to protect. It is to be hoped that active support will be given to the Fish and Game Commission in every effort at careful investigation along this line.

Published in 1925, the paragraph above describes too well the problems currently facing summer steelhead trout (Salmo gairdneri) in California as well as would-be managers of this resource. For a number of reasons it is impossible to appraise the current status of summer steelhead in California in any kind of a historical context. There are no records of historical distribution and abundance patterns. The presence of summer steelhead in various rivers may have been noted in the journals of early explorers, miners, or other settlers, but the description by Snyder (1925) of steelhead in the Klamath and Eel Rivers during late summer and early fall[1/], and mention of a steelhead in Elk Creek (Klamath tributary) in June 1934 by Shapovalov (1935) as cited by Shapovalov and Taft (1954) are among the earliest published accounts. Only in the past two decades have surveys been conducted in a few

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1/ Snyder did not use "summer" or other seasonal designations in describing these fish.

streams for the purpose of estimating adult summer steelhead numbers. In the past three years nearly all the known and potential streams having summer steelhead have been surveyed by State and Federal personnel. Without knowing the past distribution and abundance of these fish in California, however, only limited inferences can be made about population trends. The problem of assessing the current status of summer steelhead is further confounded by lack of agreement on what exactly a summer steelhead is, a problem discussed in more detail later in this report.

Summer steelhead are classed as a sensitive species in California by the U.S. Forest Service. This designation reflects the uncertain status of these fishes, and a particular concern about the Middle Fork Eel River population (Dean Carrier, pers. comm.). The sensitive species designation serves to "red flag" proposed actions on Forest Service lands when these actions may affect summer steelhead.

Steelhead trout are anadromous rainbow trout. These migratory fish inhabit streams from central California north to Alaska and west to Siberia (Sheppard 1972). Steelhead trout can be divided into two races, winter and summer. Withler (1972) states "it seems likely that the Columbia River historically has been the North American center of steelhead abundance, especially for summer fish." California is the southern latitude limit for both winter and summer steelhead in North America. Summer steelhead ascend streams during the spring and summer months. Their gonads are poorly developed (gonad weight: body weight is about 1:100, never less than 1:80 (Smith 1969)), and may remain in the stream 8 to 10 months before spawning. Winter steelhead ascend streams during late Fall on into the winter months. At time of stream entry their gonads are more completely developed (ratio of gonad weight to body weight is about 1:10 and never less than 1:30 (Smith 1969)), and spawning occurs within a few months.

This report deals with the current status of summer steelhead in California. Their known distribution and abundance is described, along with information on their life history and aspects of their behavior including seasonal movements, habitat selection, and fright responses. Actual and potential threats to these fishes are discussed. Finally, I make several management recommendations aimed at protecting, and where possible, enhancing the fish stocks and their habitat.

During the course of the study, we compiled a bibliography on summer steelhead that includes over 350 references (Appendix A). The bibliography is cross-indexed by key words and can be accessed at the Humboldt State University Computer Center. It is our intention to keep adding references to this bibliography in the future.

Extensive photo-documentation on summer steelhead and their habitat throughout northern California was collected. This material is stored at Humboldt State University and can be accessed by contacting Dr. Terry Roelofs, Fisheries Department, Humboldt State University.

SUMMER STEELHEAD LIFE HISTORY

Summer steelhead are distinguished from winter steelhead races based on time of adult entry to the streams, state of gonad maturation at time of freshwater entry (Shapovalov and Taft 1954; Withler 1966; and Smith 1969), and time and location of spawning activity (Everest 1973; Anon. 1980). Everest (1973) has published the only extensive study of summer steelhead biology and, of necessity, will be cited frequently in this section. Because of similarities between the Rogue River in southern Oregon where Everest did his work, and the Klamath and Eel Rivers of northern California, many of Everest's findings may apply to summer steelhead in California.

Spawning

Little is known about the time and location of spawning by wild summer steelhead. Remote locations, often in combination with severe winter conditions, limit access needed to make the required observations. Smith (1969) speculated that summer steelhead spawn before winter steelhead, and higher in the drainage basin, a view shared by Anon. (1980). Spawning by summer and winter steelhead in the Rogue River was separated both in location and time (Everest 1973).

est (1973) reported summer steelhead spawning in 72 Rogue River itaries and 21 Applegate River tributaries. He characterized these ims as follows:

> Physical characteristics of streams utilized for spawning were unusual. Nearly all were small, with watershed areas of less than 25 square miles and winter streamflows of less than 50 cubic feet per second. Most streams normally became intermittent in summer, some as early as mid-June... More than 2,000 adults are estimated to utilize this stream (Kane Creek) which has no rearing capacity in summer and fall. The situation is typical; many streams that support large populations of spawning adults in winter are completely dry in summer. Obviously, most fry must migrate from natal streams to large tributaries or the main stem Rogue soon after emergence.

(1973) found that Rogue River summer steelhead ascended spawning following the first fall freshets, December 12, 1969, and November 23, Spawning was first observed in late December, peaked in late January, ended until March. By mid-February stream flows in many of the smaller ries were too low to permit spawning, but spawning continued until ch in larger streams.

Everest (1973) observed no difference in spawning times or locations between adult and half-pounder summer steelhead that had been tagged in the Rogue River estuary in July through September:

> No evidence was gathered during the study to support the contention that early run (river entry in May, June, July) and late run (river entry in August, September, October) summer steelhead are racially distinct populations. Obvious differences in time of entry, migration speed and seasonal positioning were observed and could have been genetically encoded or stimulated by environmental conditions and previous experience as juveniles or adults. However, the differences that exist are not sufficiently strong to segregate the runs while spawning. Members of both groups spawned simultaneously in the same areas indicating they are members of a common race (underlining added).

If these observations are valid for California summer steelhead, then the fish entering the Eel, Mad, and Klamath Rivers from mid-summer through early fall (October) (Figure 1) should be considered to be summer steelhead, and thus could be expected to spawn with fish that have been in the various streams from late spring through the summer. Supporting the idea that fall run steelhead in California in fact may be summer steelhead is the observation that the only streams that have a late summer early fall sport fishery for steelhead, are those with known summer steelhead runs (e.g., Klamath, Mad, and el Rivers). Although the Russian and Smith Rivers are renowned steelhead :reams, they do not have summer steelhead populations, and do not support ll steelhead fisheries. These rivers yield steelhead only after winter orms have started in November and December.

e use of low order, intermittent streams, by spawning summer steelhead may ve several biological advantages. First, the peak flows in these small .butaries may be less severe than those of larger streams, thereby reducing chance the eggs will be scoured out. Second, intraspecific predation, ed by Shapovalov and Taft (1954) to be significant during emergence, may be imized by the presence of fewer steelhead. Other potential predator or petitor populations may be lower in intermittent streams. Finally, by rging prior to winter steelhead fry, summer steelhead may be able to itain a greater size during their time in streams, thus giving them a petitive advantage in defending and maintaining feeding territories. These intriguing possibilities regarding summer steelhead ecology, and merit her study.

at Spawning

ke the Pacific salmons (Oncorhynchus spp.), steelhead do not die after ning, and may spawn a number of times (Table 1). The percentage of summer head repeat spawners varies from year to year and between river systems. ar percentages of repeat spawning have been reported for winter steelhead ovalov and Taft 1954; Withler 1966; and Narver and Withler 1971). Table ws that more females than males survive to repeat spawn. Everest (1973) that females remained on the spawning sites for a much shorter time than males. In some cases females ascended spawning tributaries, constructed a redd, mated, and returned to the mainstem Rogue within a period of several days. Males, however, stayed in the spawning area for weeks, spawning with several females. In some instances males left spawning sites in one stream and ascended nearby streams for further spawning. This difference in time spent spawning likely explains why relatively fewer male steelhead survive to spawn more than once.

Table 1. Percentages of summer steelhead found to be repeat spawners in eight river systems. Number in parenthesis is fish number.

River	No. Fish Examined	% Repeat Spawners	%2X	%3X	%4X	Sex Ratio (Male/Female)	Reference
Middle Fork Eel	54	6(3)	4(2)	2(1)	0	2:1[1/]	Puckett 1975
North Fork Trinity	41[2/]	41(17)	41(17)	0	0	--	Freese 1982
Rogue River	504	12.7(64)	10.5(53)	2(10)	0.2(1)	1:11.3	Everest 1973
apilano R.,B.C.	99	6(6)	6(6)	0	0	all female	Withler 1966
eymour R., B.C.	45	4(2)	4(2)	0	0	all female	Withler 1966
oquihalla R., B.C.	158	6(10)	6(9)	0.1(1)	0	1:4	Withler 1966
abine R., B.C.	121	3(4)	3(4)	0	0	all female	Narver 1969
an R., .C.	90	11(10)	8(7)	2(3)	0	1:5.1	Hemus 1973

Four of 28 fish (14%) with regenerated scales and not included with the 54 fish reported here, were repeat spawners, one male and three females.

From a single pool collected on September 15, 1981.

Early Life History

Everest (1973) found that most of the streams where summer steelhead spawned were unsuitable for rearing because the streams became intermittent or had water temperatures lethal to salmonids. Faudskar (1980) conducted an intensive study on emergence and emigration patterns of Rogue River summer steelhead. Emergence from the gravel began in April and ended in June. Some fish began emigrating from spawning streams immediately upon emergence, and emigration continued into July and August, ending when the streams became intermittent.

Faudskar (1980) found that emigrating juvenile summer steelhead consisted of two distinct size groups. Smaller fry (26-33mm) moved primarily at night, did not school, and drifted passively downstream near the surface. Larger fry (38-87mm) emigrated actively, often in schools, near the surface at night, and along the bottom or at intermediate depths during the day. Fry of the larger size group were not seen until the fourth week of emigration, leading Faudskar (1980) to believe that the larger fry had maintained positions in the stream upon emergence. These fry emigrated after days to weeks following emergence in response to requirements for food and space associated with intraspecific competition.

Stream Residence

Juvenile summer steelhead spend from one to five years in freshwater before smolting and going to the ocean (Table 2). Sixty-five to ninety-five percent of the summer steelhead examined in California spent two years in streams, with 2-27% migrating after one year, and 2-17% after three years (Table 2). Kesner and Barnhart (1972) studying half-pounder scales calculated that Klamath River steelhead smolts spending one year in freshwater were 187-210mm fork length, two year olds were 199-215mm, and three year olds were 247-280mm. There are no reports of summer steelhead in California spending more than three years in freshwater, although Table 2 shows that more northern summer steelhead populations tend to remain in freshwater longer. This is not suprising since smolting occurs when the fish grow to 150-200mm (Conte et al. 1965). Growth is temperature dependent and is therefore slower in the cooler waters of northern latitudes, more seasons of growth being required to reach smolts size. A similar increase in stream residence and latitude is exhibited by Atlantic salmon (Salmo salar) on the east coast of North America (Schaffer and Elson 1975). Summer steelhead smolts from the Rogue River, migrated to sea at the same time (April-May) and size (about 150mm) as winter steelhead smolts (Everest 1973).

Table 2. Years of stream residence (percentages) prior to ocean migration for summer steelhead from nine river systems. Numbers in parentheses are fish numbers.

River System	No. Fish Examined	1/	2/	3/	4/	Reference
Middle Fork Eel	82	4%(3)	79%(65)	17%(14)	0	Puckett 1975
North Fork Trinity R.	41	2%(1)	95%(39)	2%(1)	0	Freese 1982
Klamath R.	391 1/	27%(106)	65%(254)	8%(31)	0	Kesner and Barnhart 1972
Rogue River	432	9%(38)	77%(333)	14%(60)	0.2%(1)	Everest 1973
Capilano R.,B.C.	86	1%(1)	16%(14)	83%(71)	0	Withler 1966
Seymour R., B.C.	25	0	40%(10)	60%(15)	0	Withler 1966
Coquihalla R., B.C.	150	0.6%(1)	18%(27)	75%(113)	6%(9)	Withler 1966
Babine R., B.C.	100	0	2%(2)	82%(82)	15%(15)	Narver 1969
Dean R., B.C.	368	0	15%(55)	83%(304)	2%(9)	Hemus 1973

1/ Half-pounder scales

Ocean Life

In contrast to our knowledge of summer steelhead life in streams, little is known of their ocean existence. They are occasionally caught at sea by both sport and commercial fishermen (Withler 1972). Sheppard (1972) summarizes the known ocean distribution of steelhead stocks based on tag recoveries, showing that many steelhead originating in Washington, Oregon, and California have been recovered off Alaska as far north as 58°N and as far west as 170°E. Summer and winter race steelhead are not distinguished in the summary by Sheppard, however. All of the tag returns from Rogue River summer steelhead have been from ocean and freshwaters located south of the Rogue (Everest 1973), indicating a southern migration route for these fish.

Time spent in the ocean varies from a few months in the case of "half-pounders" (discussed in the next section) to several years (Table 3). Scales examined from California summer steelhead showed one to two years of ocean growth before the first spawning migration, while more northern populations may spend three to four years in the ocean (Table 3).

Table 3. Ocean residence time (percentages) for summer steelhead prior to their first spawning run in nine river systems. A plus (+) indicates less than one full year.

River System	No. Fish Examined	Years /0+	/1+	/2+	/3+	/4+	Reference
Middle Fork Eel R.	80	--	55%(44)	43%(34)	2%(2)	--	Puckett 1975
North Fork Trinity R.	23 1/	? 2/	87%(20)	13%(3)	0	0	Freese 1982
Klamath R.	391	? 3/	78%(305)	21%(84)	1%(2)	0	Kesner and Barnhart 1972
Rogue River	---	7-10% 4/	--	--	--	--	Everest 1973
Capilano R.,B.C.	84	0	0	57%(48)	43%(36)	0	Withler 1966
Seymour R., B.C.	25	0	0	64%(16)	36%(9)	0	Withler 1966
Coquihalla R., B.C.	150	0	12%(18)	83%(124)	5%(8)	0	Withler 1966
Babine R., B.C.	118	0	10%(12)	69%(82)	20%(24)	0	Narver 1969
Dean R., B.C.	368	0	0.8%(3)	74%(271)	17%(64)	2%(7)	Hemus 1973

1/ Collected from one pool on September 15, 1981.
2/ Half-pounders present, but number actually spawning is not known.
3/ Only 3 of 391 half-pounders examined were sexually mature.
4/ Percent of total spawning fish captured that were half-pounders (all male fish).

Half-pounders

Everest (1973) found that 97% of the summer steelhead in the Rogue River spent an average of three months at sea before returning to freshwater during the same year. A similar life history pattern has been documented for some California steelhead in the Mad (Knutson 1975), Eel (Snyder 1925), and Klamath (Kesner and Barnhart 1972) Rivers, although the proportions of these runs that first enter freshwater after three of four months of ocean residence is not known. First described by Snyder (1925) and termed "half-pounders", the name used by Eel and Klamath River anglers, these fish are usually 230-400mm (9-16 inches) in length. They are usually sexually immature, although Everest (1973) found that about eight percent of the Rogue River summer steelhead population on the spawning grounds was comprised of half-pounders, all of which were males.

Half-pounders enter the rivers from late June through early October, with peak runs on the Rogue River in 1969 in late August and again in mid-September, and in 1970 in late July and in mid-August (Everest 1973). In 1976-1982 the Klamath River half-pounder catch in the California Department of Fish and Game seining operations (river kilometer 4.8, Figure 1) peaked in late August and early September (Hubbell 1979, 1980 and Hopelain, pers. comm.). These fish feed actively and some migrate considerable distances (over 200km) (Kesner and Barnhart 1972; Everest 1973). They are much sought after by anglers, and thousands are landed each year.

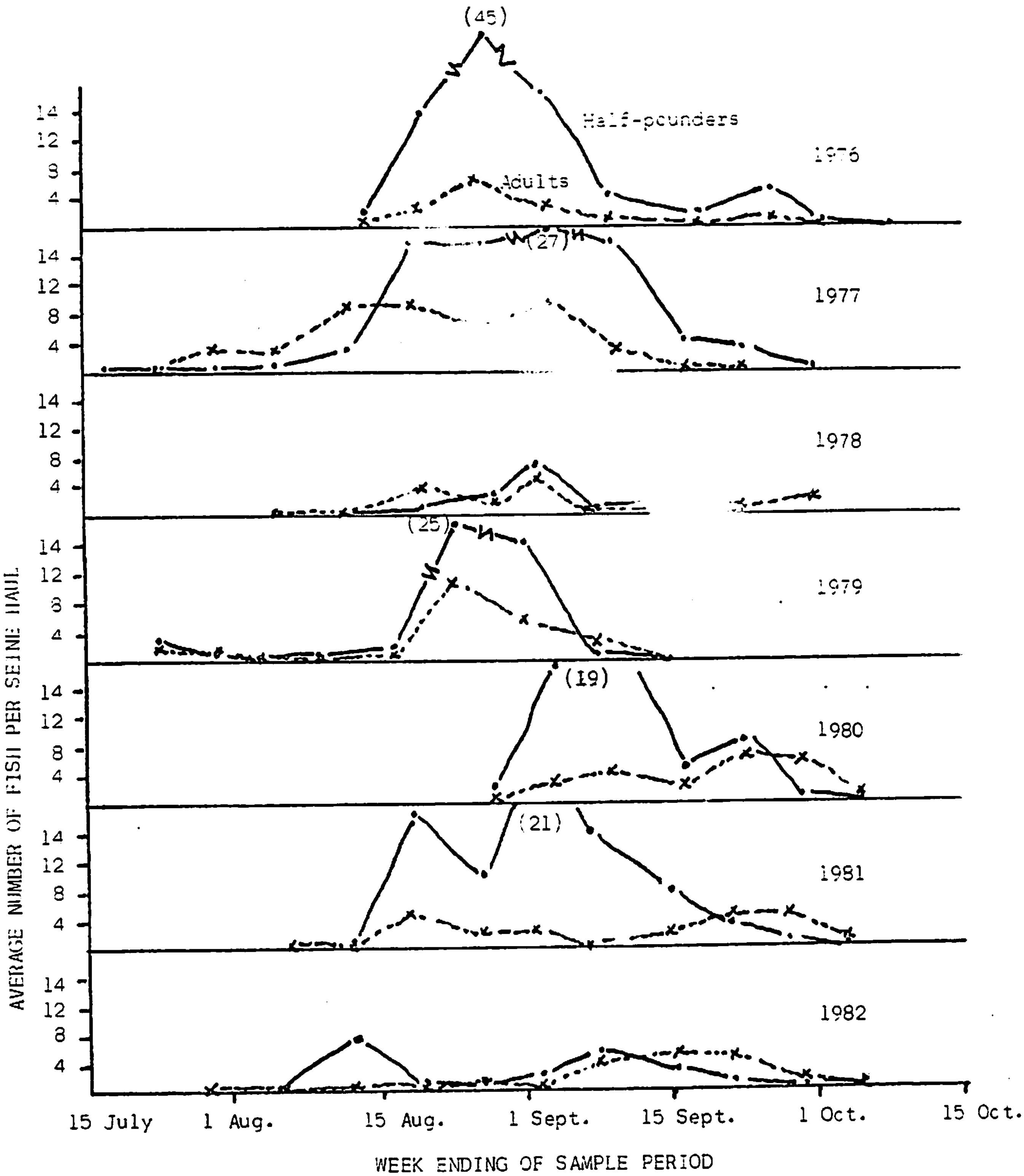

Figure 1. Average number of half-pounder (•—•—) and adult summer steelhead (x---x---) caught per seine haul during weekly sampling periods from 1976-1982 by California Department of Fish and Game personnel at a seining site 4.8km from Klamath River mouth (Hubbell 1979, 1980 and Hopelain, pers. comm.).

Although the half-pounder is an integral part of the Rogue River summer steelhead life history (Everest 1973), less is known about the role of this life history stage in California summer steelhead. Eight adult summer steelhead collected from Clear Creek in August 1980, all exhibited half-pounder checks on their scales, while only 20 of 40 adult fish sampled on September 15, 1981 from a single pool in the North Fork Trinity River had half-pounder checks (Freese 1982). More scale samples from Klamath River summer steelhead have been collected by California Department of Fish and Game personnel, and should be examined for half-pounder checks. Hopelain (pers. comm.) has also found half-pounder checks on winter steelhead scales from the Klamath basin.

It is difficult to understand why these fish return to freshwater for several months when, for the most part, they are not on a spawning migration. Everest (1973) found that half-pounders do grow during the time (up to six months) that they are in freshwater. Another unanswered question is why are half-pounders found only in the southern-most summer steelhead rivers (e.g., Eel, Klamath, and Rogue Rivers)? The Umpqua River, the next major drainage north of the Rogue River, has both winter and summer seelhead, but no half-pounders.

DISTRIBUTION AND ABUNDANCE

Existing populations of summer steelhead in California occur primarily in declared or de facto wilderness areas. Renowned summer steelhead populations in the Rogue and Umpqua Rivers of Oregon are not restricted to wilderness areas. Perhaps because summer steelhead in California are at the southern limit of their range, their habitat requirements are particularly stringent and sensitive to human impacts. Elton Bailey in a October 6, 1966 California Department Fish and Game memo to E.P. Hughes stated:

> In most instances they [summer steelhead] are found in the more remote areas of certain streams such as Wooley Creek, Mad River, Middle Fork Eel River, North Fork Trinity River, Elk Creek, Van Duzen River, etc. Perhaps this remoteness is responsible for their presence just as much as stream conditions.

Streams containing summer steelhead in California are shown in Figure 2. Table 4 lists the numbers of summer steelhead counted in these streams in recent years. Drainage basin data on geomorphology and geology for each stream in Table 4 plus several streams lacking summer steelhead are presented in Appendices B and C. During this study we examined the relationships between 1980 summer steelhead numbers in 25 northern California streams and 45 geomorphic variables (Appendix B) and 35 geologic types (Appendix C). This was done in an attempt to characterize watershed parameters of importance to summer steelhead. Only a few variables showed a positive correlation with

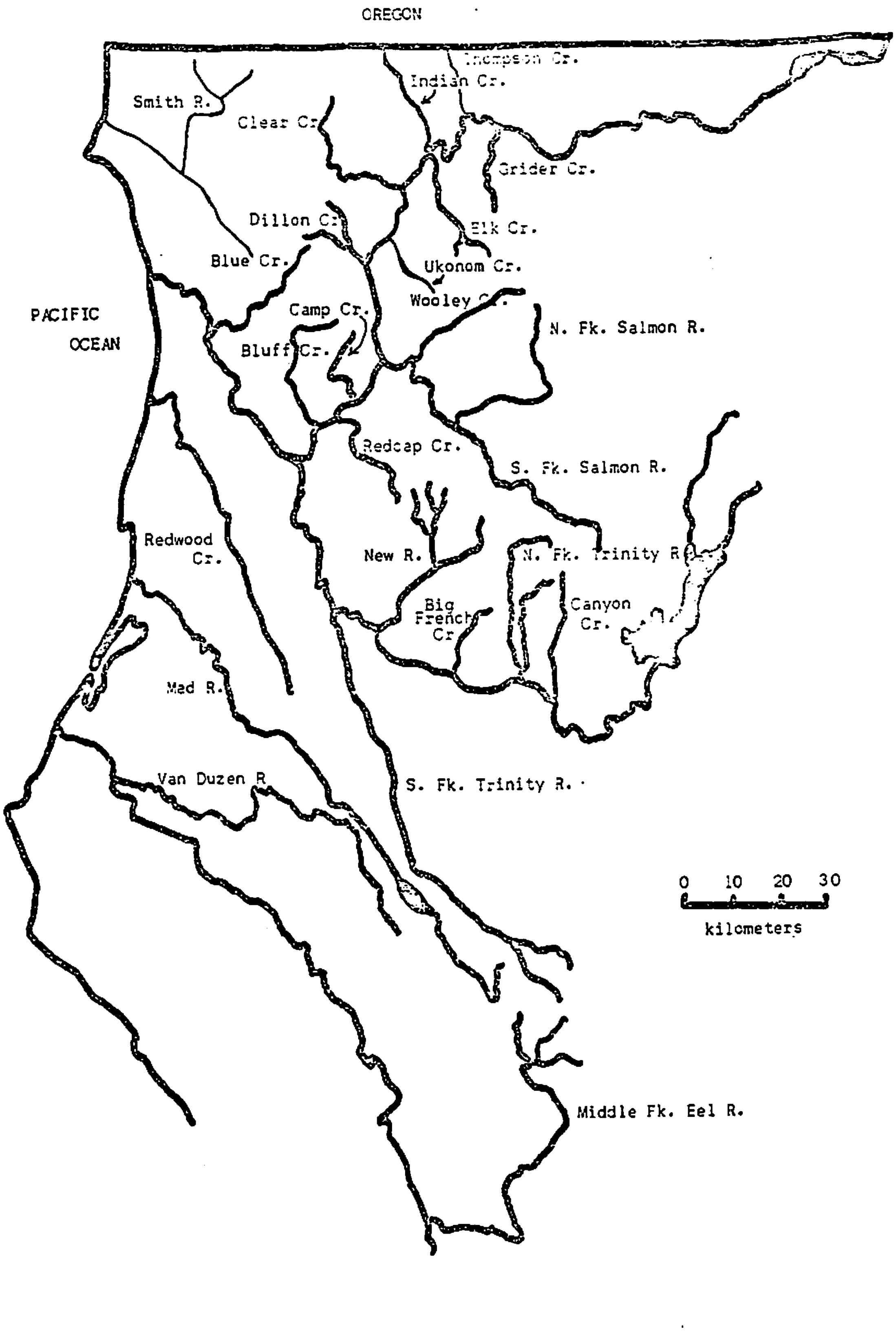

Figure 2. Known summer steelhead streams in Northern California (see Table 4 for population trends).

summer steelhead numbers. These were ruggedness number, stream gradient, and maximum basin relief, only the first of which was significant at the 0.01 level. Ruggedness number is a measure of basin relief and relates directly to slope erosion processes (Krupin 1978). It is defined as the product of maximum basin relief and drainage density. Since ruggedness number, stream gradient, and maximum basin relief all are interrelated, it is difficult to make any inferences about conditions favoring or limiting summer steelhead distribution and abundance.

The watershed analysis did not provide any insights into such questions as why summer steelhead are not found in abundance in the Smith River watershed. The analysis was limited to the 1980 summer steelhead counts, and was applied regardless of the watershed conditions with respect to human impacts. An analysis of this type would be most appropriate when applied to pristine watersheds. Then, perhaps, correlations could be found between summer steelhead numbers and geomorphic and geologic conditions. Human impacts introduce additional variables that influence summer steelhead.

The southern-most summer steelhead population is in the Middle Fork Eel River, although there have been reports of sightings in the Mattole River (Decker, pers. comm.). The northern-most runs in California are in several south-draining tributaries of the Klamath River, including Bluff, Clear, Indian and Dillon Creeks, and a few adult fish seen in the Smith River in 1982. There follows a brief description of each known summer steelhead population in California.

Table 4. Adult summer steelhead counts by year in California streams (locations given in Figure 2) with known populations. Accessibility and land status of adult holding habitat are given.

KLAMATH RIVER SYSTEM	Adult Fish Counts (Year over count plus extent of area surveyed - see legend)					Relative Accessibility of Adult Holding Habitat to Public	Land Status[1/]
Salmon River							
N. Fork Salmon	1980 / 69(b)	1981 / 57(e)	1982 / 31(a)			Road parallels much of its length	Klamath National Forest State and National Wild and Scenic River
S. Fork Salmon	1980 / 166(a)	1981 / 200(e)	1982 / 226(a)			Road parallels stream channel	Klamath National Forest State and National Wild and Scenic River
Salmon R. below Forks[2/]	1980 / 65(a)	---	1982 / 330(a)[3/]			Good - road parallels stream channel	Klamath National Forest State and National Wild and Scenic River
Wooley Creek	1968 / 200(a)	1970 / 20(f)	1972 / 45(f)	1975 / 124(a)	1977 / 510(a)	Poor- trail access only-holding area starts about 10km from trail head.	Klamath National Forest State and National Wild and Scenic River Proposed Portugese addition to Marble Mt. Wilderness Area
	1978 / 105(a)	1979 / 160(a)	1980 / 165(a)	1981 / 250(a)	1982 / 343(a)		
Main Stem Klamath Tributaries							
Blue Creek	1978 / 3(f)	1980 / 4(a)	---	1982 / 0(a)		Limited - private roads	Six Rivers National Forest Siskiyou release area plus Burton Hill study area
Bluff Creek	1979 / 41(d)	1980 / 37(a)	1981 / 25(a)	1982 / 160(e)		Limited	Six Rivers National Forest multiple use
Red Cap Creek	1980 / 10(c)	---	1982 / 47(a)			Very limited, primarily trail access to holding habitat.	Six Rivers National Forest Headwaters in Proposed Orleans Mt. further planning area, and proposed Trinity Alps Wilderness Area
Thompson Creek	Past / Few	1982 / None(a)				Limited-some logging roads	Klamath National Forest multiple use
Ukonom Creek	Past / Few	1982 / 5(a)				Poor	Klamath National Forest multiple use

Table 4. Continued	Adult Fish Counts	Accessibility	Land Status
Camp Creek	1980: 2(b)	Road access only to lower few kilometers	Six Rivers National Forest-multiple use
Dillon Creek	1980: 268(b); 1981: 187(a); 1982: 344(a)	Very limited	Siskiyou Release Area and Klamath National Forest-multiple use
Clear Creek	1970: 208(f); 1972: 116(f); 1975: 224(f); 1978: 1810(a)[4/]; 1979: 77(a); 1980: 241(a); 1981: 270(a); 1982: 610(a)[5/]	Limited-road access to near Ten Mile Creek, trail access upstream	Proposed Siskiyou Wilderness (upper half of basin), Klamath National Forest - multiple use (Lower half of basin)
Elk Creek	1978: 480(a)[4/]; 1980: 90(a); 1981: 47(a); 1982: 249(a)	Fair - road parallels much of holding area	Johnson Release area and Klamath National Forest - multiple use
Grider Creek	1981: 1(a); 1982: 0(b)	Limited	Grider Release area, Klamath National Forest, multiple use
Indian Creek	1978: 421(a)[4/]; 1980: 1(c); 1982: 16(a)	Good - road parallels stream	Klamath and Siskiyou National Forests - private land downstream from South Fork
TRINITY RIVER SYSTEM			
South Fork Trinity	1979: 5(b); 1982: 27(a)	Limited road and trail access	State and National Wild and Scenic River, and South Fork Mt. Release, plus state model steelhead stream
East Branch	1982: 1(b)	Limited road and trail acess	
Hayfork Creek	1979: 0(a); 1982: 0(c)	Limit road and trail acess	Proposed Pattison Wilderness in Burton Hill
Tish Tang Creek	1981: 1(a); 1982: 0(a)	Poor	Hoppa Indian Reservation

Table 4. Continued

	Adult Fish Counts					Accessibility	Land Status
New River, including Eagle, Slide and Virgin Creeks	1979 / 344(a)	1980 / 320(a)	1981 / 236(a)	1982 / 350(e)		Limited - road access to a few areas, trail to others (inhabitants sometimes beligerent)	Shasta-Trinity National Forest State and National Wild and Scenic River, existing and proposed Trinity Alps Wilderness Area.
North Fork Trinity R.	1978 / 200(d)	1979 / 320(a)	1980 / 454(a)	1981 / 225(a)	1982 / 200(e)	Limited except for road access to Hobo Gulch, good trails upstream from Hobo Gulch, poor access below	Shasta-Trinity National Forest State and National Wild and Scenic River, proposed Trinity Wilderness
Canyon Creek	1980 / 6(a)	1981 / 4(a)				Good - road parallels creek	Shasta-Trinity National Forest Proposed Trinity Alps Wilderness, Shasta-Trinity National Forest, multiple use
MAD RIVER SYSTEM							
Mad River	1980 / 42(a)	1981 / 8(d)	1982 / 172(a)			Limted - Scattered private roads	Mostly private land, Six Rivers National Forest, multiple use
EEL RIVER SYSTEM							
Middle Fork Eel R.	1966 / 198(a)	1967 / 241(a)	1968 / 335(a)	1970 / 865(a)	1971 / 997(a)	Limited - road parallels much of the holding habitat, but river is far below road	State and National Wild and Scenic River, Butte-Shinbone Further Planning Area, Mendocino National Forest, multiple use, Bureau of Land Management, and private land.
	1972 / 500 6/	1973 / 1422(a)	1974 / 1522(a)	1975 / 1149(a)	1976 / 792(a)		
	1977 / 654(a)	1978 / 377(a)	1979 / 1298(a)	1980 / 1052(a)	1981 / 1600(a)		
	1982 / 1051(a)						

Table 4. Continued

	Adult Fish Counts			Accessibility	Land Status
Van Duzen River	1979: 31(b) 7/	1980: 25(b)	1982: 8(a)	Very limited, private roads	State and National Wild and Scenic River, private land, Six Rivers National Forest, multiple use
South Fork Van Duzen	1982: 0(b)			Limited	Private land and Six Rivers National Forest multiple use
REDWOOD CREEK SYSTEM					
Redwood Creek	1980: 4(b)	1981: 16(b)	1982: 4(b)	Limited, private road access	Redwood National Park and private land
SMITH RIVER SYSTEM					
Main Stem	1982: 9(c)			Paralleled by roads	Six Rivers National Forest, State Park, State and National Wild and Scenic River
North Fork	1982: 2(b)			Road access at mouth and river-mile 13.	Six Rivers National Forest, State and National Wild and Scenic River
Middle Fork	1982: 2(b)			Paralleled by roads	Six Rivers National Forest, State and National Wild and Scenic River
South Fork	1982: 5(a)			Partially paralleled by road	Six Rivers National Forest, State and National Wild and Scenic River
Jones Creek	1982: 2(c)			Some logging roads	Six Rivers National Forest

1/ After Gerstung (1980) - status of National Wild and Scenic Rivers and U.S.D.A. Forest Service RARE II uncertain, pending court decisions.
2/ Fish likely in transit to upstream areas
3/ About 2/3 of these adults were probably Fall run (Gerstung, pers. comm.)
4/ Count made in late September
5/ Includes 95 fish killed by fire retardant
6/ Partial Survey
7/ 30 fish in one pool

Estimated percent of summer steelhead holding area surveyed
(a) 70-100%
(b) 50-69%
(c) 25-44%
(d) less than 24%
(e) estimate based on expansion of a partial count
(f) unknown

Middle Fork Eel River - This river has the largest run of summer steelhead in California. It is also the largest watershed containing summer steelhead (Appendix B). The population has been monitored more closely than any other in California, and is the only population protected by a management plan (Jones and Ekman 1980). Shapovalov first became aware of this summer steelhead population in 1938 (Shapovalov and Taft 1954).

Table 4 summarizes summer steelhead population fluctuations in this river between 1965 and 1981, ranging from a low of 198 in 1966 to a high of about 1600 in 1981. Large yearly population fluctuations are primarily due to hydrologic conditions (floods and droughts), but also may be affected by legal angling and poaching (Jones and Ekman 1980). These authors summarize the management actions taken by the California Department of Fish and Game and the U.S.D.A. Forest Service to protect these fish. These actions include angling closures, vehicle restrictions, and a river patrol started in 1979 to collect biological and physical data, and to enforce the angling closure.

Van Duzen River - Recent summer steelhead counts in this river have been low (Table 4). Gerstung (pers. comm.) reported seeing over one hundred summer steelhead in the South Fork Van Duzen River in the early 1960's, but evidently changes in channel morphology during the 1964-65 flood resulted in barriers to upstream migration between Bridgeville and the South Fork and a total loss of holding pools. No summer steelhead were seen in the South Fork in 1980 or 1982 when surveyed by Department of Fish and Game personnel (McLeod, pers. comm.).

Beginning in 1981 special angling regulations (described later) went into effect to protect summer steelhead in the Van Duzen River.

Mad River - Surveys in recent years on this river have found few wild summer steelhead (Table 4). Shapovalov and Taft (1954) give the steelhead counts by two week periods over Sweasy Dam for nine seasons between 1941 and 1953. About 14% (6047) of 42,953 of the fish counted in all years combined passed the counting facility between April 1 and April 28. Only 36 (0.1%) were counted between April 29 and May 12, and none was counted in any year between May 13 and October 28. These April and May fish were likely summer steelhead. About eight percent (324 in a total of 3888) of the Waddell Creek total run was counted between April 1 and May 12, and these were not termed summer steelhead by Shapovalov and Taft (1954) because these fish were spawning immediately.

Since 1971 the Mad River Hatchery near Blue Lake has released Washougel River (Washington) strain summer steelhead into the Mad River (Anon. 1980). Knutson (1975) studied summer steelhead in the Mad River, reporting that wild summer steelhead ascended upstream to just above Bug Creek (about river kilometer 50). More recent surveys have found summer steelhead upstream beyond Highway 36 (McLeod, pers. comm.).

Redwood Creek - Four summer steelhead were observed in Redwood Creek in August 1980 (Hofstra, pers. comm). A more thorough survey in August 1981 found 16 (Hofstra, pers. comm). Virtually nothing is known about this recently discovered population regarding time of entry, extent of upstream migration, and so on.

Canyon Creek - Very few summer steelhead have been reported in this stream (Table 4). Upstream migration is thought to be blocked at about river kilometer 20 by a large rock slide (Freese, pers. comm.). No historical counts prior to 1979 have been located.

North Fork Trinity River - This river supports a significant run of summer steelhead, second only to the Middle Fork Eel River in 1980 (Table 4). Freese (1982) has conducted extensive surveys on this river since 1979, including tagging and life history studies in 1981. Historically this drainage has been mined heavily. A dam constructed at Raymond Flat in the 1930's completely blocked fish passage until it was removed by the Department of Fish and Game in the 1950's (LaFaunce 1966). Hearsay has it that up to several hundred summer steelhead used to reach the base of the dam where they were fished heavily by legal and illegal means (Horn, pers. comm.). Unfortunately, there are no estimates of summer steelhead numbers prior to 1979, so it is impossible to determine either the effects of the dam or its removal on summer steelhead stocks.

South Fork Trinity River - This river has been designated a Model Steelhead Stream Demonstration Project in an agreement signed August 1981 by the U.S.D.A. Forest Service, California Department of Fish and Game, and California Trout, Inc. The cooperative project was undertaken in order to restore the steelhead runs of the South Fork, to demonstrate best management practices and technology in fishery and other resource management, and to serve as a model for protecting and enhancing steelhead trout resources throughout California. Recent summer steelhead surveys on the South Fork Trinity River found five fish in 1979 and 27 in August 1982 (Table 4).

New River - Like the North Fork Trinity, this river supports a significant summer steelhead run (Table 4) and has been studied extensively by Freese (1982). It also has been heavily mined in the past, and continues to be dredged for gold throughout much of its length (disscussed in a later section). Perhaps more than any other summer steelhead run in California, this population faces severe human-caused problems stemming from legal and illegal harvest, plus the potential impacts of gold dredging on juvenile and adult fish. Human access by roads and trails is extensive throughout much of the summer steelhead holding water in this stream.

Big French Creek - This stream basin lies between the New and North Fork Trinity Rivers. A snorkel survey conducted by the U.S. Forest Service in 1980 revealed no summer steelhead (Brouha, pers. comm.). Humboldt State University personnel surveyed six kilometers in 1981 and found no summer steelhead (Freese 1982). DeMartini (pers. comm.) reported seeing two summer steelhead in one of the lowermost pools in August 1977.

Salmon River - The North and South Forks of the Salmon Rivers were first surveyed for summer steelhead in 1980 through a cooperative effort by the Department of Fish and Game and the U.S. Forest Service. They made counts of 69 and 166 respectively in the North and South Forks (Table 4). They also report 65 summer steelhead in the mainstem Salmon River below Forks. The destination of these mainstem fish is unknown.

Wooley Creek - This large Salmon River tributary enters about seven kilometers upstream from Somes Bar. It has been recognized as a summer steelhead stream at least as early as the late 1960's when Roger Lanse, a Department of Fish and Game employee made some preliminary surveys. More complete surveys have been made since the 1970's, and Dunn (1981) conducted extensive surveys throughout the summer of 1980. Wooley Creek is among the most pristine streams remaining in California, with only a small portion of the watershed being roaded. Most of the summer steelhead holding area and all of the presumed spawning areas are within the Marble Mountain Wilderness boundary. Only the Middle Fork Eel River summer steelhead population has been monitored more often than the Wooley Creek population (Table 4). Limted trail access and rugged terrain restrict human impacts on this stream, although Ahrenholz (1973) reports that summer steelhead were harvested illegally in the past. A former guide told Ahrenholz that dynamiting used to be common place in Wooley Creek. During the August 1982 survey, U.S.D.A. Forest Service personnel observed people in the vicinity of Wooley Camp along the stream with spears, and surmised that they were attempting to spear summer steelhead (Konnoff, pers. comm.).

Klamath River Tributaries

Blue Creek - Recent surveys of Blue Creek have revealed few summer steelhead (Table 4). During mid-July 1979, large numbers of steelhead held for several weeks in the mainstem Klamath River immediately below Blue Creek and in lower Blue Creek (Hoplain, pers. comm.). High temperatures in the Klamath at this time inhibited upstream migration. A similar condition often exists on the Rogue River where large numbers of fish move in to the lower Illinois River in mid-summer and hold over until temperatures in the Rogue permit fish passage (Everest 1973). Summer steelhead do not spawn in the Illinois River system, yet by providing a thermal refuge, this river is important to summer steelhead. Blue Creek thus may be an important stream for summer steelhead when mainstem Klamath temperatures are high. As such, the existing thermal regime of Blue Creek should be maintained.

Bluff Creek - This stream was affected greatly by the 1964-65 flood when it overtopped a ridge and entered the Klamath River at a new, upstream location (Barnes, pers. comm.). This change led to a rapid down-cutting in the lower stream reaches, and created a barrier to anadromous fish migration, about 1.5 km from the mouth. A fish passage facility was constructed by the Six Rivers National Forest in 1978. Summer steelhead numbers from 25-41 have been recorded since 1979 (Table 4, Barnes pers. comm.).

Camp Creek - A partial survey of Camp Creek in 1980 revealed two summer steelhead. The stream has not been surveyed for summer steelhead before or since 1979.

Redcap Creek - A partial survey of this stream found 10 summer steelhead in 1980 (Brock, pers. comm.). A survey of the entire stream in 1982 found 47 summer steelhead (Barnes, pers. comm.).

Clear Creek - Seven summer steelhead counts have been conducted on this stream since 1970 (Table 4) ranging from a low of 77 in 1979 to a high of 1810 in late Septembber 1978. While several biologists question whether all of these fish in 1978 were summer steelhead, work by Everest (1973) on the Rogue River showed that steelhead entering this river from spring through fall comprised a single spawning stock. It is possible, therefore, that the Clear Creek summer steelhead population, including the fall fish, is comparable in numbers to that of the Middle Fork Eel River. The headwaters of this stream are in the proposed Siskiyou Wilderness Area. Wilderness Falls constitutes the upstream limit to anadromous fish in Clear Creek.

Dillon Creek - A waterfall about 3.5 kilometers up Dillon Creek was thought for years to be impassable to anadromous fish. A snorkel survey above the falls in August 1980 found 268 summer steelhead (Rogers, pers. comm.). a more complete survey in 1981 found 187 (Rogers, pers. comm.). A Department of Fish and Game memorandum of November 10, 1966, by E.P. Hughes contains an estimate of summer steelhead taken by anglers in Dillon Creek. Obviously angler use on this stream is extremely restricted, and it is among the most difficult summer steelhead streams to survey (Rogers, pers. comm.). Extensive logging is proposed in this drainage and an application for a small hydro-electric project has been filed (Gerstung, pers. comm.).

Elk Creek - Shapovalov and Taft (1954) cite an earlier publication by Shapovalov (1935) reporting that steelhead were observed ascending Elk Creek on June 3, 1934. Summer steelhead counts of 47 to 480 have been recorded in this stream since 1979. Happy Camp gets its domestic water supply from this stream whose headwaters are in the Marble Mountain Wilderness area. There is road access to much of the summer steelhead holding habitat on this stream.

Indian Creek - Sixteen summer steelhead were counted in this stream during 1982, while a late September survey in 1978 revealed 421 (Table 4). As in the September 1978 surveys on Clear and Elk Creeks, the large number of fish may include fish that entered Klamath River in late summer, and therefore would not be considered summer steelhead by some biologists. More extensive summer steelhead surveys are needed on this stream from August through October. An application for a small hydro generating facility has been filed on the East Fork Indian Creek (Abbott 1982). A large open pit mine (Noranda) has been proposed in this drainage (Gerstung, pers. comm.). Little is known about the importance of this stream to summer steelhead.

Smith River - In 1982 over 80 miles of the Smith River drainage were surveyed for summer steelhead and coastal cutthroat trout (*Salmo clarki clarki*). A total of 19 adult summer steelhead was counted (Table 4) (Gerstung, pers. comm.). It is not known why this large drainage, famous for winter steelhead and fall chinook salmon (*Oncorhynchus tshawytscha*), does not support larger populations of summer steelhead. It may be that winter steelhead have access to most of the drainage, thereby eliminating any advantage that could be gained by a summer run of fish.

ADULT SUMMER STEELHEAD BEHAVIOR

In this section I summarize what is known about the behavior of adult summer steelhead in streams. Most of these observations have been made during the annual summer surveys to count adult fish. To my knowledge, only one person has spent extended periods of time (several days) watching the behavior of adult summer steelhead in pools (Lorenz, pers. comm.).

Fright Responses

Summer steelhead holding in deep pools (>3m) show little response to divers who remain at the surface. Fish in shallower pools, or fish in deep pools when approached closely by divers, seek cover under ledges, boulders, shaded areas, and in turbulent, bubble-filled cascades at the head of the pool. Sometimes when there are too many fish in a confined space to permit an accurate count, divers can herd the fish toward the downstream end of the pool. It is then possible to count the fish as they swim singly or in small groups past the divers. Only rarely are fish observed exiting downstream from a pool. They often move upstream and hide in turbulent areas, however, as previously noted.

Fish seeking cover in boulders or under other objects often are incompletely concealed, much of their body remaining visible. These fish can be touched easily, and are extremely vulnerable to spear-armed poachers. Even fully exposed fish can be approached close enough to touch, if the person moves slowly. Many underwater photographs were taken of fish at distances of about 1 meter.

When summer steelhead are disturbed for a prolonged period of time by divers, they may leave the holding area. On August 4, 1981, two SCUBA divers spent about two hours photographing 33 summer steelhead in a Wooley Creek pool. Two days later when the pool was resurveyed, only two fish remained (Dunn, pers. comm.). Vaunghn Hutchins, a stream surveyor on the Middle Fork Eel River, reported seeing 17 fish in a pool one afternoon while the surveying party was taking a swim; no fish remained in the pool the following morning.

In an effort to learn more about the effects of divers on holding adult summer steelhead, M. Lorenz, California Department of Fish and Game seasonal aide, on three occasions spent three days observing fish behavior on the Middle Fork Eel River in the summer of 1982. On the first day he would observe the fish all day without entering the pool. The second day he watched the fish all day and made one dive through the pool at mid-day. On the third day he dove the pool repeatedly, watching the fish during and after each dive. Lorenz (pers. comm.) feels that fish disturbed by divers are more likely to leave a pool early in the migration season than later in the summer and early fall. All eight steelhead in a Middle Fork Eel River pool observed 21-23 July 1982 exited within 20 hours following the initial dive. The twenty-two fish in a pool observed from August 3-6 1982 remained throughout the three day observation period, as did seventy-seven fish in a pool observed from September 13-16.

During July through September 1982, I and others made as many as 3-5 dives per week to count the summer steelhead in a single pool on Canton Creek, a Steamboat Creek tributary in the North Umpqua River drainage in Oregon. The counts varied from 17-27, with there being no indication that the diving activity displaced the fish. Two fish recognizable by distinct marks were always present.

In an extreme case of harrassment to summer steelhead in a pool, no fish left. A crew of six people seined, measured, took scale samples, and tagged 42 fish in one pool on the North Fork Trinity late in the afternoon of September 15, 1981 (Freese 1982). The next morning most of the fish remained, and an additional 28 fish were tagged. Three weeks later 21 tagged fish were still in the pool.

Based on these preliminary observations it appears that the presence of divers can cause migrating adult summer steelhead to leave a pool early in the migratory season. Later in the summer and early fall, fish are more likely to remain in a pool in spite of divers.

Daily Movements

It seemed that most of the upstream movement of summer steelhead in the streams surveyed occurred during the day (Dunn 1981). Fish were seen moving through riffles and runs by stream surveyors walking these stream reaches. Puckett (1975) observed several fish in the Middle Fork Eel River moving upstream on a moon-lit night, but speculated that the nighttime movement may have been in response to cooler water temperatures at night. Everest (1973) found that few summer steelhead in the Rogue River moved upstream at night.

Dunn (1981) noted that summer steelhead holding in pools are most active just before sunrise and after sunset. During most of the day, the fish remain motionless for hours unless disturbed, sometimes moving slightly to remain in the shade (Freese 1982).

Seasonal Movements

Seasonal movement patterns of adult summer steelhead in Wooley Creek have been documented by Dunn (1981) from June through September 1980. Entry into the Creek peaked between July 5 and July 14, 1980, but fish continued to move into the Creek throughout the summer. Fish counts in his 33 study pools appeared to stabilize in mid-September. He found pool volume was the most important factor influencing the number of steelhead per pool. Pool volume, pool surface area, ledges, percentage substrate gravel, and upstream gradient all significantly affected steelhead numbers in pools (Dunn 1981).

Freese (1982) followed the seasonal movements of summer steelhead in 27 New River pools throughout the summer and early fall 1980. Steelhead began entering the river in early June, and entry peaked in mid-July. He found that shade and cover were significant determinants of summer steelhead numbers in New River pools. There did not appear to be a relationship between steelhead numbers per pool and pool dimensions, upstream gradient, downstream gradient, or distance to the first downstream pool. Freese felt that the lack of correlation between steelhead numbers and pool dimensions in the New River may have been influenced by gold dredging activity in that stream. Although no statistical analyses of summer steelhead numbers and pool variables were performed for the North Fork Trinity, Freese (1982) felt that fish in this stream selected the larger, deeper pools for holding. It is important to note that there were no indications in the Humboldt State University studies that summer holding habitat was limiting to adult summer steelhead in either Wooley Creek (Dunn 1981) or New and North Fork Trinity Rivers (Freese 1982). Freese also discusses the effects of barrier modification in the North Fork Trinity on the seasonal movements of the fish.

In 1980 it appeared that Trinity River tributary fish ascended the streams earlier in the season than those in Klamath and Salmon River tributaries. Fish in the New River were at the junction of Virgin and Slide Creeks in late June (Freese 1982). Wooley Creek held only seven fish in the 33 pools examined in early July (Dunn 1981); Clear Creek contained very few fish in early July 1980 (personal observation).

Neither Dunn (1981) in Wooley Creek, nor Freese (1982) in New River saw any evidence of new summer steelhead entering these streams in late September 1980. As discussed elsewhere, there was evidence for significant numbers of fish in Clear, Elk, and Indian Creeks in late September 1978. It is not known, however, when these fish entered, although counts made on Clear Creek in August of years prior to and since 1978 have never exceeded 270 (Table 4). Further studies are needed to determine late fall movement patterns by summer steelhead in California. A counting weir installed on the lower North Fork Trinity River from August 30 until November 18, 1982 passed only three adult steelhead (Hopelain, pers. comm.).

ACTUAL AND POTENTIAL THREATS TO SUMMER STEELHEAD

Many of the threats discussed here apply as well to winter steelhead and other anadromous and resident salmonid species. Adult summer steelhead, because they are in small streams during the summer and fall, are particularly vulnerable to legal and illegal harvest.

Timber Harvest and Roads

Sediments enter streams primarily by mass wasting processes such as soil creep, slump earth flows, debris avalanches and debris torrents (Swanston and Swanson 1976). Much of the summer steelhead habitat in California is located in geological units that are extremely unstable (Figure 2). The high seasonal precipitation, in combination with unstable geology, leads to massive amounts of materials entering stream channels. Increased inputs of sediments and bedload material can lead to channel morphology changes such as pool filling, and channel braiding, or increases in the fine sediment levels in stream substrates that are detrimental to summer steelhead. Stream channel aggradation eliminated a significant summer steelhead run from the South Fork Van Duzen River (Gerstung, pers. comm.).

Many of these mass wasting events are unrelated to human actions, but others are triggered or aggravated by human actions, particularly road building. Road construction across some slopes can initiate slope failures, or accelerate the frequency and magnitude from several to hundreds of times (Yee and Roelofs 1980). Gibbons and Salo (1973), after reviewing extensive literature on the subject of timber harvest impacts on stream environments, concluded that forest roads are the primary initiator of erosion stemming from human actions. Based on the total areas involved in roads and harvested areas, both roads and logging appear to contribute eroded materials about equally (Yee and Roelofs 1980).

Little can be done to limit natural mass wasting, or to stop or slow these processes once they are in motion. It is possible, however, to reduce human impacts on these processes by careful sighting and maintenance of roads (Yee and Roelofs 1980).

When forest roads cross summer steelhead streams, upstream passage by adult and juvenile fish must be considered (Yee and Roelofs 1980; Reeves and Roelofs, in press). These authors summarize bridge and culvert designs and modification that facilitate fish passage.

In addition to the potential negative impacts on stream habitats from timber harvest and road construction the latter can provide increased access to summer steelhead holding, spawning, and rearing areas, an aspect of roads noted in the quote from Snyder (1925) given on page 1 of this report. As described previously, and for reasons that are not entirely clear, summer steelhead in California exist almost exclusively in remote areas within undisturbed watersheds. Any increase in access or significant disturbances within these watersheds could lead to reduced numbers of summer steelhead, both through changes in stream habitat conditions and direct human actions on the fish (legal and illegal harvest). Later in this report I make recommendations regarding timber harvest in watershed containing summer steelhead.

Gold Mining Activity

Some of the summer steelhead populations in northern California are located in areas that were extensively gold mined in the mid-1800's through the early 1900's. Gold mining activity has increased dramatically in the past few years in response to higher gold prices, and the availability of portable gold dredges (Table 5). During the 1980 field season, I became concerned about the number of gold dredges operating in streams containing summer steelhead. Gold dredges were counted during a two day aerial survey in August 1980 (Table 6). Although there were many dredges in the 30 kilometers below Junction City on the Trinity River, this is not summer steelhead holding habitat (Freese 1982). Based on these preliminary surveys, it appears that the most serious potential threat to summer steelhead from gold dredging is on the New River, and to a lesser extent on the North Fork Trinity River.

Table 5. Numbers of gold dredging permits issued in California.

	1979	1980
Throughout California	5,000	11,000
Region 1, Calif. Dept. Fish and Game	910	2,398
Within Big Bar Ranger District on Shasta-Trinity National Forest	15	105

Table 6. Aerial survey count of gold dredges operating in northern California rivers in August 1980, and summer 1981.

River	Date of Survey	No. of Gold Dredges	Remarks
Scott River	17 Aug. 1980	8	All within 20km of Klamath River
North Fork Salmon River	17 Aug. 1980	12	Upper-most dredge below the East Fork
South Fork Salmon River	17 Aug. 1980	16	Upper-most dredge at Rush Creek
Main Salmon River below Forks	17 Aug. 1980	4	All near Butler Cr.
New River	26 Sept. 1980	47	24 in the area between Denny and the East Fork
Mainstem Trinity R.	18 Aug. 1980	76	All between Burnt Ranch and Junction City.
	July 1981 1/	65	
	Aug. 1981 1/	63	
	Sept.1981 1/	60	

1/ Aerial surveys made by Region 1, California Department of Fish and Game.

Little is known about the impacts of gold dredging on juvenile or adult summer steelhead. The May 1 to October 1 dredging season is scheduled to minimize direct impacts on eggs and alevins in the gravel. Potential adverse impacts on the juvenile fish include: 1) direct damage to gills from suspended sediments; 2) reduced growth rates due to restricted vision in turbid waters; 3) lowered growth rate caused by reduced in-stream production of food organisms due to fine sediment deposition and, to lesser extent, reduced light penetration; and 4) a reduction in carrying capacity due to channel morphology changes. Potential benefits to juvenile steelhead include: 1) insects and other food organisms on the bottom dislodged by dredging may be available to fish downstream; 2) channel morphology changes resulting from dredging may increase the carrying capacity of the stream reach.

Potential adverse impacts from gold dredging on adult summer steelhead include: 1) physical damage to gills from high suspended sediment levels; 2) interruption of upstream migration to summer holding areas[1/]; and 3) filling of holding pools with sediments. Potential positive impacts for adult steelhead include the deepening of holding pools.

The foregoing is speculation. As stated before, however, the dredging effort on the New River is great enough to warrant further studies on the impacts this activity has on juvenile and adult steelhead. An adverse impact on adult summer steelhead that is <u>not</u> speculation is poaching, as discussed later.

1/ The largest concentration of adult summer steelhead counted in the 1980 surveys of the New River occurred immediately below four 4-inch dredges in lower Virgin Creek (Freese 1982). Sixty seven fish held in a long, shallow (1.5m) pool. A large, undercut ledge on the east side of the pool provided some cover that may have compensated for the lack of depth. It is not known whether the mining activity upstream (that included blocking portions of the flow with small dams) interrupted further migration by this large group of fish.

Small Hydroelectric Power Production

The development of small hydroelectric projects in summer steelhead streams poses a potential threat to these fishes. Everest (1973) states:

> "The sequence of spawning, incubation, emergence, and migration is so restricted in time that any deviation in natural flow patterns in these intermittent streams could seriously impair their ability to produce summer steelhead."

Small hydroelectric projects can alter both the flow patterns and the thermal regimes of streams, thereby interferring with summer steelhead reproduction and growth. Lowered summer flows could prevent or restrict adult steelhead from reaching summer holding areas.

Roads built during the construction of hydroelectric projects could cause problems by increasing the mass wasting of sediments, and by providing increased access to summer holding areas. Living space for juvenile steelhead would be reduced in stream sections where water was being diverted. Finally, juvenile fish may be entrained, unless the water intakes are screened adequately. Small hydroelectric projects have been proposed for Dillon, Ukonom, Camp, Blue, Indian, Big French, Tish Tang a Tang, and Canyon Creeks (Gerstung, pers. comm.).

Angler Harvest by Legal Methods

Concern about the low numbers of summer steelhead prompted the California Department of Fish and Game to close most of the Middle Fork Eel River upper drainage to fishing during the summer of 1966 (Jones and Ekman 1980). Further protection was provided in 1978 when the entire Middle Fork was closed to angling from March to July 15. A trial catch and release fishery on the lower Middle Fork went into effect in spring 1982, but unusually high spring flows restricted the effort and catch (Jones, pers. comm.).

The only other adult summer steelhead population receiving protection through special regulation is in the Van Duzen River. Here a regulation change in 1980 on portions of the river between the Highway 36 bridge near Bridgeville and junction with the South Fork Van Duzen required: 1) the use of artificial lures or flies with single, barbless hooks; and 2) the release of all trout larger than 12 inches. These regulations were adopted after biologists expressed concern both about the low numbers of fish counted in 1979 and illegal fishing activity (McLeod, pers. comm.).

At present there is no evidence that other adult summer steelhead populations are overharvested by legal methods. The question of allowing fishing in the summer holding areas was raised by Hughes in 1966. If more angling pressure results from increased access or public awareness about the location of summer holding areas in the future, fishing restrictions may be necessary. This could include permitting angling for adult steelhead only while they are in route to summer holding areas (e.g., mainstem Klamath, Salmon, Trinity, and Eel Rivers), and not in the tributaries. Management plans for each summer steelhead population should address the problem of overharvest.

Juvenile steelhead, held by many anglers (many who should have or did know otherwise) to be resident "trout", have been fished heavily in the past when 10 fish per day and more generous limits were in effect in California. As discussed elsewhere, this has been recognized as a potential problem for sometime (Taft 1933) and has led to substantial reductions of juvenile steelhead, particularly the larger individuals (Pollard 1969). Dunn (1981) reported large catches of juvenile steelhead by anglers in Wooley Creek. I am not aware of any evidence, however, that has showed a correlation between juvenile steelhead harvest and a reduction in adult steelhead returns. Nevertheless, the 1982 California angling regulations for northcoast rivers limit the daily catch of steelhead of all sizes to three fish, a philosophical change regardless of its biological impact, a change welcomed by many people who stress the value of angling for sea-run fish.

Harvest by Illegal Means

Snagging, spearing, netting, trapping, and dynamiting summer steelhead has been, and unfortunately continues to be a problem in California and elsewhere. These fish, often holding throughout the summer in pools where they are highly visible, are extremely vulnerable to illegal harvest. The behavior of the fish, discussed previously, makes them easy to approach, particularly after they have taken refuge under rocks or other cover. Partially hidden fish can be grabbed by hand, snared, or speared. There is no question that some individuals along the New River in particular, and the North Fork Trinity to a lesser extent, kill many summmer steelhead (Freese 1982). Several miners talk about netting and spearing summer steelhead[1]. We often observed spears in mining camps along the river, and watched a New River miner attempting to spear a summer steelhead. Six filleted summer steelhead carcasses were found in Virgin Creek, an upper New River tributary, during a September 1981 survey (Freese, pers. comm.). Although this illegal fish harvest occurs in both the New River, and North Fork Trinity River (probably in the Salmon River as well), the biological significance to summer steelhead populations is not known.

The biological significance of this illegal kill is not known. Wardens contacted in Willow Creek and Weaverville did not confirm rumors about people being arrested at Hobo Gulch and on the lower New River with large numbers of summer steelhead taken with spear guns. Given the remoteness of the areas involved, and the vast areas that each warden must patrol, it seems unlikely that this illegal harvest can be controlled. Perhaps the new Cal-Tip program will lead to some reductions. Information programs to inform people about the sensitive status of summer steelhead might help, but could also increase public awareness of the fish, thereby creating more legal and illegal harvest. It appears to me to be a problem that we must live with, and hope that the steelhead can follow suit.

In-river Net Fishery

Several summer steelhead seen in Klamath and Trinity River tributaries during the 1980 and 1981 population surveys were net-scarred. Hubbell (1980) reported that about 3.5% of the steelhead examined at the Department of Fish

[1] Some miners interviewed claimed that the 1872 Mining Act gave them the right to live off the land, including year around deer hunting and fishing by any method.

and Game counting weir on the Trinity River near Willow Creek had net marks. The U.S. Fish and Wildlife Service estimated that the Indian net fishery on the Klamath and Trinity Rivers between mid-July and the end of October 1981, had an incidental catch of 716 steelhead (Harper, pers. comm.). Since the net mesh size is chosen to catch fall chinook salmon, the nets are likely selective for larger steelhead. The significance of this steelhead catch is not known. The catch could increase if smaller mesh sizes are ever used.

Predators

Summer steelhead predators include garter snakes, Pacific giant salamanders, kingfishers, dippers, mergansers, great blue herons, various marine mammals, river otters, and, of course humans. Shapovalov and Taft (1954) point out the intraspecific predation can be substantial in steelhead populations. Only the mammalian predators kill adult steelhead, and the human harvest is the only loss open to regulation. Steelhead have co-evolved with these other members of the biological community, and I do not believe that these various non-human predators exert a primary control on summer steelhead numbers. Even if these predators do take biologically significant numbers of summer steelhead, the predators are not likely to be controlled by human actions anyway. Human predation, legal and illegal, is discussed in another section.

Potential Competitors

Competition faced by juvenile steelhead, both winter and summer races, appears to be primarily intraspecific in the stream areas surveyed. In the stream areas used by adult summer steelhead, juvenile steelhead were usually the only fish present. The potential for and significance of intraspecific competition between summer and winter steelhead is not known. A limitation in investigating this potential interaction stems from our present inability to distinguish between the two races based on either external or internal characteristics of the fish.

Competition with other non-gamefish species may occur when juvenile steelhead are rearing in mainstem portions of the Eel, Mad, Klamath, and Trinity River, but the extent and significance of these interactions are not known. Fite (1973) found little indication of competition between juvenile steelhead (likely winter race fish) and roach (Hesperoleucus symmetricus) in the South Fork Eel River.

Livestock Grazing

Livestock grazing is noted as a problem in the Middle Fork Eel River and is addressed by specific recommendations in the summer steelhead management plan for this river (Jones and Ekman 1980). There is some damage to the riparian zone along the New River downstream from Denny (personal observations in August 1980), and there may be some problems on private lands in the Van Duzen and Mad River systems. While the negative impacts on salmonid habitat resulting from livestock grazing are well recognized and documented (Leopold 1974; Platts 1981), with the exceptions noted above, I do not feel that overgrazing poses a serious threat to summer steelhead in California.

MANAGEMENT RECOMMENDATIONS

Protecting and preserving summer steelhead in California depends on management of both the fish and their habitat. The California Department of Fish and Game is responsible for managing the resource, while the U.S.D.A. Forest Service (hereafter, Forest Service), as the agency managing nearly all of the summer steelhead habitat, must assume the primary responsibility for maintaining the habitat.

In making these recommendations, I am evermindful of the following:

> We pretend to a great deal of understanding when we propose to manage natural-cultural systems. We are assuming that we correctly perceive societal interests and goals and that they are good; that we know the causal-deterministic core of relations, that we can manipulate the major determinants, that contingencies will not make ineffective our efforts, and that society will support these efforts, and accept the results (Warren 1979).

Resource Management

The California Fish and Game Commission adopted the following policy on steelhead rainbow trout on August 15, 1975:

1. The steelhead rainbow trout in California is recognized as a valuable resource with strict environmental requirements and a limited range.

Steelhead waters include all streams or stream sections accessible to steelhead in the North and Central Coast Regulation Districts and in the Sacramento River drainage above the Delta, and such other waters as the Commission may designate.

2. The greatest fishery value of this resource is its potential to provide recreational angling for sea-run fish. Management shall be directed toward providing such angling and maintaining a vigorous, healthy resource. Angling for juvenile steelhead will be restricted only to the extent necessary to insure optimum spawning stock and angling opportunity for sea-run fish.

3. Resident fish will not be planted or developed in steelhead waters. Resident fish will not be planted or developed in drainages of steelhead waters, where, in the opinion of the Department, such planting or development will interfere with steelhead populations. Programs on threatened or rare and endangered species, within the species natural range, are excepted.

4. California's steelhead resources are largely dependent upon the quality and quantity of habitat. Because of damage and threats to this

restricted habitat, emphasis shall be placed on management programs to inventory and protect and, wherever possible, restore or improve the habitat of natural steelhead stocks.

5. The Department shall seek prevention or alleviation of those aspects of projects, developments or activities which would or do exert adverse impact on steelhead habitat or steelhead populations. All available steps will be taken to prevent loss of habitat, and the Department shall oppose any development or project which will result in irreplaceable losses of fish.

6. The Department shall develop and implement plans and programs to improve the protection of steelhead habitat including, but not limited to, assessment of habitat status and adverse impacts, land use planning, acquisition of interests in streams threatened with adverse developments, and research on effects of habitat changes caused by activities such as over-grazing, gravel extraction, logging, road construction, urbanization and water development.

7. The Department shall develop and implement programs to measure and, where appropriate, increase steelhead population size and angler use and success, consistent with the objectives of providing quality angling and maintaining a healthy resource.

8. Artificial propagation of steelhead, except for mitigation, shall be for the purpose of improving angling for sea-run fish, and should include strains or varieties of steelhead which have the greatest potential to contribute to recreational angling. Artificial production or rearing and

stocking programs shall be managed so as to produce minimal interference with natural salmonid stocks, and such programs shall be periodically reviewed to assess their effects on these stocks.

9. Juvenile steelhead rescue shall be limited to instances where habitat conditions are temporarily inadequate to maintain fish life and when suitable rearing areas are available with the capacity to rear rescued fish to smolts without impairment of other steelhead populations. Rescue should be undertaken only in special circumstances involving large numbers of steelhead of special significance.

Item 10 deletes some stream sections from the steelhead waters described in paragraph 1 of the policy, and item 11 allows for the addition of streams or sections thereof.

The Anadromous Fisheries Branch of the California Department of Fish and Game outlined the following intentions regarding spring-run (summer) steelhead in a report of March 31, 1980 to the State Fish and Game Commission:

> It is the intention of the Department to maintain identifiable native spring-run steelhead populations, to preserve the genetic integrity of the populations, and where feasible, to restore certain of these populations to levels capable of supporting significant summer fisheries.

It is also the intention of the Department to provide and maintain summer steelhead fisheries, using artificial rearing programs, in certain California waters which contain no wild, native spring-run steelhead populations.

The Department intends to continue efforts to identify wild native stocks and to monitor their abundance.

To help protect the genetic integrity of wild, native spring-run stocks, the Department will avoid the future planting of spring-run exotics in the Klamath River system, the Eel River system, and other waters found to support distinct wild native populations.

The future planting of artificially-reared spring-run fish in areas supporting native populations will be limited to the endemic strains, and will be done only when other management measures are judged to be impractical or ineffective.

If adhered to, these policies and intentions will function to preserve and protect summer steelhead. With the exceptions of the New and North Fork Trinity Rivers, where illegal harvest is of concern (Freese 1982), there are no indications that adult summer steelhead are being overharvested. Even in these two streams, the actual level and impact of poaching are not known. Limited access to summer holding areas, in combination with relatively few people knowing of the existence or location of the fish, serve to restrict the harvest of summer steelhead. Only the Van Duzen and Middle Fork Eel River populations are protected by special regulations and fishing closures (discussed previously).

Future restrictions on angling may be needed in summer holding areas, if fishing pressure warrants it. Once located, the fish are quite vulnerable to legal angling methods, and highly vulnerable to poaching. I believe that angling should be encouraged on migrating fish ..... before they reach the summer holding areas. The special regulation catch and release fishery on the Middle Fork Eel River, spring 1982, gave anglers an opportunity to fish for summer steelhead while protecting the fish from overharvest. Similar seasons could be applied to mainstem portions of the Trinity, Salmon, and Klamath Rivers in the future. Hughes (1966), in a Region 1 California Department of Fish and Game memorandum, suggested that the Department consider closing all summer fishing on one continuous reach of a river that holds 75% of the known summer steelhead of that river. He suggested that the Middle Fork Eel, Van Duzen, and New Rivers, and Wooley Creek were in need of immediate attention.

Angling on juvenile steelhead, often thought of as resident "trout" has been of concern for years. Taft (1933) maintained that overharvest of juveniles in California had been more detrimental to run sizes than water development or timber harvest. Pollard (1969) found that normal sport angling could remove over half the age II+ steelhead in Crooked Fork River, a Clearwater River tributary in Idaho. He found that angling was selective for larger steelhead juveniles.

The 1982 California angling regulations limit the salmon and trout possession limit on most northcoast streams accessible to anadromous fish to three fish (not more than two salmon). This is certainly in keeping with the Department policy to provide angling opportunities for sea-run steelhead.

There are two emergency actions regarding summer steelhead that the Department of Fish and Game should be prepared to take when the conditions warrant. The first action is emergency closures of fishing when overharvest is occurring, and the second action involves barrier removal. The special regulations adopted in 1982 for the spring catch and release fishery on the Middle Fork Eel included the stipulation the Department could close the fishery at any time. This would be a good policy with respect to all angling for summer steelhead throughout the State. As mentioned previously, in July 1979 large numbers of steelhead held for weeks in lower Blue Creek and downstream in the Klamath River. Anglers were able to catch many steelhead while the fish remained confined in a restricted area. The Department of Fish and Game should be given the authority to stop angling harvest any time the resource appears to be threatened, regardless of whether the harvest is on juveniles, half-pounders, or adults.

Both the Department of Fish and Game and the Forest Service should cooperate in evaluating barrier removal when conditions develop that deny adult fish access to known summer holding areas. This is particularly true when the fish become concentrated in areas where access permits excessive harvest. As Freese (1982) points out, however, barrier removal should only be carried out when there is no concern about permitting upstream access of potential competitors, and when the summer steelhead are afforded better protection above, than at and below the barrier. When low flow barriers develop in inaccessible areas, no action may be the preferred policy.

Habitat Management

Forest Service planning for habitat protection aimed at preserving and enhancing summer steelhead populations in California should be done at three levels. Planning begins at the Regional level where management goals are specified. These goals are next incorporated at the level of a Forest Plan, and finally in a specific management plan for each existing population of summer steelhead. At this time, only the Middle Fork Eel River has a specific managment plan.

Streams with the highest priorities for summer steelhead management plans are:

1. New River - Summer steelhead populations in the New River are thought to be more threatened by human actions (dredging and poaching) than any other California population.

2. Clear and Dillon Creeks - Both streams have significant summer steelhead populations and the future status of their respective watersheds is uncertain (Table 4).

3. Wooley Creek - Most of the essential habitat (as defined later in this report) is located in the Marble Mountain Wilderness Area. Because of the pristine nature of the watershed, and because of the nearly continuous

population estimates for the past decade, Wooley Creek can serve as an index stream for the Klamath River system summer steelhead.

4. Indian Creek - This stream may be important to Fall-run (synonymous with "summer"?) steelhead, as evidenced by the 1978 census (Table 4). Proposed small hydroelectric development on the East Fork may pose a threat to steelhead. Forest Service lands in the watershed are designated for multiple use, and special treatment will be required to protect steelhead.

Every effort should be made to see that no existing summer steelhead populations are extripated. It is important to maintain as much genetic material as possible, particularly so that future reintroduction or enhancement programs can use fish adapted to the conditions of a particular biogeoclimatic region.

Management Goals

I believe that the following three management goals should be adopted by Region 5 of the Forest Service and the California Department of Fish and Game:

Goal 1: THE PRIMARY GOAL OF MANAGEMENT FOR SUMMER STEELHEAD IS TO PROTECT AND PRESERVE THIS RACE OF FISH IN CALIFORNIA.

Rationale: Summer steelhead should be protected and preserved for their intrinsic, aesthetic, scientific, and economic values.

Goal 2: INCREASE SUMMER STEELHEAD NUMBERS TO THE POINT WHERE THEY CAN BE DECLASSIFIED AS A SENSITIVE SPECIES.

Rationale: The range of options open to humans regarding the use of summer steelhead and watersheds containing these fish are or should be restricted by the sensitive species designation for summer steelhead.

Goal 3: PROMOTE ANGLING OPPORTUNITIES FOR SUMMER STEELHEAD WHEN THERE ARE NO CONFLICTS WITH GOALS 1 AND 2.

Rationale: Summer steelhead, by virtue of their size, their renowned fighting abilities, and ther presence in streams during seasons of the year when fishing conditions are excellent (low, clear water, mild temperatures) are highly prized by anglers.

Meeting Goal 1 (The primary goal of management for summer steelhead is to protect and preserve this race of fish in California.)

1. Maintain the essential habitat - I will define essential habitat as all stream reaches used by adult summer steelhead for extended time periods (holding times of weeks to months) and all portions of the drainage adjacent to and upstream from these reaches that are accessible to adult fish. The maintenance of this essential habitat can be achieved only through land management practices. Warren (1979), noting that public support for stream habitat protection often stems from an interest in fish states, "Far better it would be that society could come to know that any product of a system, most especially natural systems that we cannot rebuild (underlining added), are (sic) best protected and provided for by maintaining the system entire."

Summer steelhead in California in nearly every case are associated with watersheds having no or minimal human impacts, primarily on public lands classified or potentially classifiable as wilderness. Warren (1979) points out that stream physical habitat may require geological time to repair, while biological communities require successional time.

"In the long run, it can be argued, our attention might better be focused on the maintenance of physical habitat for, so long as the potential capacity for biological colonization is maintained in the biogeoclimatic zone, maintenance of the stream community is assured (Warren 1979)."

If the physical habitat is maintained, summer steelhead can be maintained; without the physical habitat, all other management efforts for summer steelhead are pointless.

Streamside protection zones should be established (see Jones and Ekman 1980) and maintained. Low order streams must be adequately protected in order for summer steelhead to thrive. These streams may be used for spawning, and are important for this reason. Perhaps more important is the intimate relationship between streams and land in small watersheds. Annual flow patterns, temperature regimes, and sediment erosion patterns are all closely linked to the conditions of small watersheds.

Road construction and other logging activites should be done in such a way to assure minimum impacts on summer steelhead essential habitat. Logging practices that involve minimum roading (e.g., helicopter and high lead operations) would be preferred. When roads are built, they should not penetrate the stream inner gorage (Farrington and Savina 1977), an area within the streamside protection zone.

As noted previously, many problems faced by summer steelhead can be compounded by increased human access. Therefore, if roads do cross or approach essential habitat areas, crossings should be pulled following logging, and roads put to bed to discourage human access to the stream.

2. Protect summer steelhead stocks from overharvest - Steelhead are harvested primarily in streams. They are taken legally and illegally by anglers and others, and are caught incidentally in the Indian net fishery. Sufficient fish must remain after all harvest to use the available essential habitat, or overfishing can be said to be occurring. Therefore, escapement goals should be set for each stream, and harvest monitored so that the fishery can be closed if there are indications of overfishing. This will be a most difficult, but not impossible task. It is made easier if one adopts the tactic of being too restrictive, rather than too liberal in setting harvest goals. Overfishing will have to be defined for each population based on the desired spawning escapements.

3. Continue the annual population surveys - The annual population surveys[1/] should continue until there is at least a 10 year record for each of the major summer steelhead streams (annual counts of 100 or more fish). Only the Middle Fork Eel River currently meets this criterion, and I recommend continuing the annual survey on this river for several reasons: first, it contains nearly half the known summer steelhead remaining in the state; second, it is the only stream with a management plan (Jones and Ekman 1980)

1/ Guidelines for snorkel surveys are given in Appendix D.

specific for summer steelhead, the annual count being an important indicator of the efficacy of the plan; and last, the Department of Fish and Game has initiated a unique catch-and-release fishery on this population, and careful monitoring of the fish population will assist in evaluating this program. Wooley and Clear Creeks could serve as index streams for the Klamath system streams, while the North Fork Trinity River would be an appropriate index stream for the Trinity system.

The annual counts provide insights into annual variations in run strength, and are a key index to overall habitat suitability and population status. Most of the summer steelhead counts given in Table 4 were made in July and August. Only rarely have counts been made in September, and never later in the fall. Trinity River tributaries can be surveyed from mid-August on, since Freese (1982) found that most of the fish reach the holding areas by this time. Dunn (1981) found that the fish in Wooley Creek reached the holding water in late August, and recommended that the annual survey on this stream should be made in September. It would appear that Klamath River tributaries might better be surveyed in late September or October to include late entering fish (the late September count on Clear Creek in 1978 was about four times larger than counts made earlier in the season in other years (Table 4)). Much of the holding water in the Middle Fork Eel River is separated by intermittent reaches by early August, so the August count seems appropriate. The question remains, however, as to the destination of steelhead entering the Eel in late summer and early fall, and whether these fish should be considered summer steelhead. Tagging studies on these late-entering steelhead could show their migration patterns. Radio-tagging techniques could be used to good advantage (Bailey, pers. comm.).

Meeting Goal 2 (Increase summer steelhead numbers to the point where they can declassified as a sensitive species.)

Summer steelhead could be declassified as sensitive species if and when the total known wild population reaches a number of 6000 or more, and classified as threatened if and when their numbers drop below 2000. The total count in 1980 was about 3000 fish (Table 4). The 6000 and 2000 fish limits recommended are arbitrary, but I feel that they provide a measure of safety in both directions. The populations are able to come back after severe natural disasters, as evidenced by the Middle Fork Eel River population following the 1964-65 flood (Table 4). At present, with seven streams having average annual populations in excess of 100 fish (Table 4) the aggregate California race has some resilience against extinction by a single storm or other catastrophic event, or by disease, or overfishing.

There may be more summer steelhead than currently are recognized if the so called "fall run" fish of the Klamath and Eel Rivers are, in fact, breeding with spring or summer run fish. This has been shown to be the case in the Rogue River (Everest 1973), and should be investigated in California, as recommended later.

The numbers of wild summer steelhead potentially could be increased by several methods: 1) by opening up more habitat through barrier removal (e.g., access to the South Fork Van Duzen River, Clear Creek above Wilderness Falls); 2) by planting eggs or fry from suitable native stocks from nearby streams in to streams lacking summmer steelhead (e.g., South Fork Van Duzen River, Big

French Creek); 3) by increasing in-stream cover for juvenile steelhead through boulder additions[1/] or other means (Reeves and Roelofs 1982); and 4), by planting or fostering riparian vegetation to provide shade and improving stream temperature conditions.

Meeting Goal 3 (Promote angling opportunities for summer steelhead when there are no conflicts with Goals 1 and 2.)

The same water conditions that help make summer steelhead so desirable as a sport fish, also make them vulnerable to overharvest by legal and illegal means. Future angling regulations on wild populations may have to be very restrictive if anglers are to continue to have an opportunity to enjoy these fish. The experimental catch and release fishery on the Middle Fork Eel River may serve as a prototype for future management of wild summer steelhead in California. Harvest monitoring necessarily will be part of managing summer steelhead.

Intensive culturing of summer steelhead at Irongate (Klamath River) and Lewiston (Trinity River) hatcheries could help meet (or create) the demand for angling opportunites on summer steelhead. There is no question that if such

1/ Brock (in preparation) saw a three-fold increase in the age I steelhead in stream reaches with boulder additions when compared to control reaches. It is not known however, how this will influence the number of returning adults.

programs were successful, there would be great economic benefits. At least two problems could arise, however: first, an intensified sport fishery could overharvest the wild fish[1/]; and second, straying hatchery fish could interbreed with wild fish (not everyone would agree that this is a problem). Recommendations by Everest (1973) and Resienbichler and McIntyre (1977) should be considered for incorporation into any hatchery programs with summer steelhead. In keeping with the Department of Fish and Game policy of maintaining the genetic integrity of spring-run (summer) steelhead stocks, any fish used in the hatchery programs described above would have to be native stocks from the drainage in question.

Management Options

There are several management options. One or some combination of the following could be selected:

1. No action. If this option is selected, those populations in existing wilderness areas would be maintained, providing overharvest was prevented. Other populations could decline if watershed conditions were degraded by human activities.

2. Further habitat protection. Portions of watersheds containing summer steelhead and currently unroaded or having limited access, could be designated as controlled access areas. Stream specific management plans could be developed to permit timber harvest and other activities at levels and by methods consistent with maintaining summer steelhead habitat.

1/ One way to minimize the harvest of wild fish would be to mark all hatchery fish and then have separate regulations for hatchery and wild fish.

3. Habitat restoration and enhancement. Some summer steelhead streams may have potential for habitat restoration and enhancement through improvement of fish access (e.g., falls modification, steep-pass facilities, etc.), cover additions, and riparian zone management (Reeves and Roelofs 1982).

4. Introduce summer steelhead into other stream systems. Summer steelhead eggs or juveniles from an appropriate native stock could be placed in suitable streams to establish new fish populations, assuming that the donor population had sufficient numbers to allow removal of eggs or fry. Downstream migrant traps could be used to capture "surplus fry", the small size category of outmigrants described by Faudskar (1980). Streams that might be considered for planting would include Big French Creek and the South Fork VanDuzen River.

5. Intensive culture of summer steelhead at Irongate and Lewiston hatcheries. Successful culturing of summer steelhead at Lewiston (Trinity River) and Irongate (Klamath River) hatcheries could help meet (and create) an angling demand for summer steelhead. Both of these hatcheries are located a considerable distance from the ocean, both are paralleled by Highways 96 (Klamath) and 299 (Trinity) for much of their length, thereby giving anglers a lot of access to migrating fish. The problem of overharvest of wild fish, and straying of hatchery fish would have to be considered.

RESEARCH NEEDS

The following is a priority listing of further research needs:

1. The relationship, if any, between so called "fall-run" fish (those entering the Klamath and Eel Rivers between mid-July and early October) and summer steelhead. This can be accomplished by conducting stream surveys on selected streams at monthly intervals from August through November.

2. Determining the time and location of summer steelhead spawning in selected streams. Given the logistical problems of winter research in remote areas, this may be best accomplished by radio-tagging a number of summer steelhead (similar to the tagging experiment described by Freese (1982) in the North Fork Trinity River). Weekly aerial surveys could then be flown to monitor the fish locations. This study would help determine the limits of the essential habitat, as defined in this report.

3. Continued efforts on the parts of the Fish and Wildlife Service and the Department of Fish and Game to estimate the Indian and sport harvest of Klamath River steelhead. A similar monitoring of angler harvest on the Eel River would also be of use.

4. Studies on the effects of gold dredging on growth and survival of juvenile steelhead, and movement patterns of adult fish. The New River would be an appropriate study location.

5. Estimate of survival rates between half-pounder and adult stages in the Klamath River. In the Rogue River Everest (1973) found that 50% of the half-pounders returned to spawn the following year. The 1982 daily limit of three steelhead in several California rivers will likely reduce the catch of half-pounders, and this may be reflected in increased catches of adult fish in subsequent seasons.

6. Studies on the role of the half-pounder in the life history patterns of summer steelhead in the Klamath and Eel Rivers.

7. Continued efforts to identify juvenile summer steelhead so that their life history can be studied, including survival rates to adulthood.

8. Continued research on increasisng juvenile rearing habitat in streams, coupled with studies listed in priority seven to determine survival rates to adult size.

9. Correlation between yearly runs of summer and winter steelhead within the same river system. It would seem that good rearing conditions within a stream one year would promote growth and survival of both summer and winter race juveniles, and that this would be reflected in the number surviving to first spawning.

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REFERENCES

Abbott, M. 1982. Small hydro permit problems. Eco News 12(7):3.

Anon. 1980. Memorandum from the Anadromous Fisheries Branch, California Dept. of Fish and Game, to the California State Fish and Game Commission, dated 31 March 1980.

Ahrenholz, Dean. W. 1973. Wooley Creek summer salmonid status report for years 1971 and 1972. California Dept. Fish and Game Region 1 Memorandum, dated 5 Oct. 1973. 6 p.

Bailey, E. D. 1966. Memorandum to Chester Woodhull on the subject of Wooley Creek, dated 7 July 1966. Region 1, California Dept. of Fish and Game.

Brock, William (in preparation). Enhancement of rearing habitat for juvenile steelhead trout (Salmo gairdneri) by boulder placement in a tributary to the Klamath River. MS Thesis. Humboldt State University, Arcata, Calif.

Conte, F. P., G. Gnose, H. H. Wagner, and J. Fessler. 1965. Mechanism of saltwater adaptation in juvenile salmon and steelhead trout. Pages 182-183 In: Proc. 45th Ann. Conf. West. Assoc. State Game Fish Comm., Anchorage, Alaska.

Dunn, P. L. 1981. Migration behavior and holding habitat of adult summer steelhead in Wooley Creek, California. MS Thesis, Humboldt State University, Arcata, CA 83 p.

Everest, F. H. 1973. Ecology and management of summer steelhead in the Rogue River. Oreg. St. Game Comm., Fish. Res. Rept. No. 7, Proj. AFS-31. 48 p.

Gibbons, Dave R., and Ernest O. Salo. 1973. An annotated bibliography of the effects of logging on fish of the Western United States and Canada. USDA For. Serv. Gen. Tech. Rep. PNW-10, 145 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Farrington, Richard L., and Mary E. Savina. 1977. Off-site effects of roads and clearcut units on slope stability and stream channels. Fox Planning Unit. Six Rivers National For., Eureka, Calif.

Faudskar, J. C. 1972. Determining mechanisms stimulating downstream movement of summer steelhead fry. MS Thesis, Oregon State University, Corvallis, OR. 55 p.

Fite, K. 1973. Feeding overlap between roach and juvenile steelhead in the Eel River. MS Thesis, Humboldt State College, Arcata, CA 38 p.

Freese, J. L. 1982. Selected aspects of the ecology of adult summer steelhead in Trinity River, California. MS Thesis. Humboldt State University, Arcata, CA.

Hemus, D. 1974. Dean River summer steelhead observations on life history, population, and the fishery in 1973. Unpub. File Rept. Brit. Col. Fish and Wildl. Branch, Nanaimo. 48 p.

Hughes, E. P. 1966. Memorandum to Chief of Marine Resources on the subject of summer steelhead regulations, dated 10 Nov. 1966. California Dept. of Fish and Game.

Hubbell, P. 1979. Trinity River Basin Fish and Wildlife Task Force Priority Work Item No. 5. Evaluation Report--FY 1978 Activities.

Hubbell, P. 1980. Progress Report on Fishery Investigations--Trinity River. Trinity River Basin Fish and Wildlife Task Force Priority Work Item No. 5. 141 p.

La Faunce, D. A. 1967. A king salmon spawning survey of the South Fork Trinity River. 1964. California Dept. Fish and Game, Marine Res. Admin. Rep. 67-10. 13 p.

Leopold, A. S. 1974. Ecosystem deterioration under multiple use. Proceedings, Wild Trout Management Symposium, p. 96-98. U.S. Dep. Inter. Fish and Wildl. Serv. and Trout Unlimited, Denver, Colo.

Kesner, W. D., and R. A. Barnhart. 1972. Characteristics of the fall-run steelhead trout of the Klamath River system with emphasis on the half-pounder. Calif. Fish and Game 58:204-220.

Krupin, P. J. 1978. Quantitative basin morphology and channel stability with reference to nonpoint sources of pollution in Evans Creek, Oregon. MS Thesis, Oregon State University, Corvallis, OR. 164 p.

Knutson, A. C., Jr. 1975. Biology of summer steelhead (Salmo gairdneri) of the Klamath River system with emphasis on the half-pounder. MS Thesis, Humboldt State College, Arcata, CA 65 p.

Narver, D. W. 1969. Age and size of steelhead trout in the Babine River, British columbia. J. Fish. Res. Bd. Can. 26:2754-2760.

Narver, D. W. and F. C. Withler. 1971. Age and size of steelhead trout (Salmo gairdneri) in anglers catches from Vancouver Island, British Columbia, Streams. Fisheries Research Board of Canada. Circular 91. 25 p

Platts, W. S. 1981. Effects of livestock grazing. In: Influence of Forest and Rangeland Management on Anadromous Fish Habitat in Western North America. USDA Forest Service General Technical Report PNW-124.

Puckett, L. K. 1975. The status of spring-run steelhead (Salmo gairdneri) of the Eel River system. California Dept. of Water Resources and California Dept. of Fish and Game Memorandum Rept. 22 p.

Reeves, G. H. and T. D. Roelofs. 1982. Rehabilitating and enhancing stream habitats: field applications. In: Influence of Forest and Rangeland Management on Anadromous Fish Habitat in Western North America. USDA Forest Service General Technical Report PNW - 140

Reisenbichler, R. R., and J. D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, (*Salmo gairdneri*). J. Fish. Res. Bd. Can. 34:123-128.

Shapovalov, L., and A. C. Taft. 1954. Life histories of the steelhead and silver salmon with special reference to Waddell Creek, California. Calif. Dept. Fish and Game, Fish Bull. 98. 375 p.

Sheppard, D. 1972. The present status of the steelhead trout stocks along the Pacific Coast. MS Thesis, Univ. of Washington, Seattle, WA.

Snyder, John O. 1925. The half-pounder of Eel River, a steelhead trout. Calif. Fish and Game 11 (2):49-55.

Swanston, Douglas N., and Frederick J. Swanson. 1976. Timber harvesting, mass erosion, and steepland forest geomorphology in the Pacific Northwest. *In* Geomorphology and engineering, p. 199-221. Donald R. Coates, ed. Darden, Hutchison, and Ross, Inc., Stroudsburg, PA.

Taft, A. C. 1933. California steelhead trout problems. Calif. Fish and Game 19:192-198.

Schaffer, W. M. and P. F. Elson. 1975. The adaptive significance of variations in life history among local populations of Atlantic salmon in North America. Ecology 56:577-590.

Smith, S. B. 1969. Reproductive isolation in summer and winter races of steelhead trout. Pages 21-38. In: T. Northcote (Ed.) Symposium on Salmon and Trout in Streams. Univ. of Brit. Col., Vancouver.

Withler, F. C. 1972. Research needs for intensive management of British Columbia steelhead. Fish. Res. Bd. Can., Pac. Biol. Sta., Nanaimo.

Withler, I. L. 1966. Variability in life history characteristics of steelhead trout along the Pacific Coast of North America. J. Fish. Res. Bd. Can. 23:365-393.

Yee, C. S. and T. D. Roelofs. 1980. Planning forest roads to protect salmonid habitat. In: Influence of Forest and Rangeland Management on Anadromous Fish Habitat in Western North America. USDA Forest Service General Technical Report PNW-109.

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Freese, Lincoln. Fisheries biologist. Formerly a Humboldt State University graduate student. Arcata, CA

Gerstung, Eric. Fisheries biologist. Inland Fisheries Branch, California Department of Fish and Game, Rancho Cordnona, CA

Harper, Brooks. Fisheries biologist. U.S. Fish and Wildlife Service, Arcata, CA

Hofstra, Terry. Biologist. Redwood National Park. Arcata, CA

Hoplain, James. Fisheries biologist. Anadromous Fisheries Branch, California Department of Fish and Game. Arcata, CA

Horn, Virgil. Miner. Raymond Flat. North Fork Trinity River (Helena, CA)

Jones, Wendy. Fisheries biologist. California Department of Fish and Game, Ukiah, CA

Konnoff, Deborah. Hydrologist. Klamath National Forest. Somes Bar, CA

Lorenz, Mitchell. Seasonal Aide, California Department of Fish and Game. Ukiah, CA

McLeod, David. Fisheries biologist. California Department of Fish and Game. Eureka, CA

Rogers, David. Fisheries biologist. California Department of Fish and Game. Yreka, CA

Appendix A. Bibliography on Steelhead Trout and Other Salmonids. The bibliography is cross-indexed by key words (shown beneath each reference) and is on file at the Humboldt State University Computer Center.

Adams, B. L., W. S. Zaugg, and L. R. McLain. 1973. Temperature effect on parr-smolt transformation in steelhead as measured by gill sodium-potassium stimulated ATP. Comp. Biochem. Physiol. 44A:1333-1339.
Summer Steelhead, Parr-Smolt, WA

Adams, B. L., W. S. Zaugg, and L. R. McLain. 1975. Inhibition of salt water survival and NA-K-ATPase elevation in steelhead trout by moderate water temperatures. Trans. Am. Fish. Soc. 104:766-799.
Summer Steelhead, Parr-Smolt, WA

Allee, B. J. 1975. Spatial requirements and behavioral interactions of juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout. From Diss. Abstr. Int. B Sci. Eng. 35(10). 177 p.
Coho Salmon, Steelhead, Ecology, Juvenile

Amend, D. F. 1980. Increase in ocean survival of freely migrating steelheads vaccinated against Vibrio anguillarum. Trans. Am. Fish. Soc. 109:287-289.
Winter Steelhead, Diseases, Diseases, Mad, CA

Andrews, R. E. 1958. Factors influencing the seaward migration of smolt steelhead trout, Salmo gairdneri, in the Alsea River, Oregon. MS Thesis, Oregon St. University, Corvallis, OR. 90 p.
Winter Steelhead, Juvenile, Migration, Racial, OR

Anonymous. 1960. A study to investigate the effects of fatigue and current velocities on adult salmon and steelhead trout. College of Fish., Univ. of Wash., Prog. Dept. Fish., Engr. Res. Prog. 1960, pp. 112-121.
Salmon, Steelhead, Migration, Physiology, WA

Anonymous. 1971. An environmental tragedy. Rept. by Citizen Advisory Committee on Salmon and Steelhead Trout. Sacramento, CA. 40 p.
Salmon, Steelhead, Management, Trinity, CA

Argue, A. W., L. M. Patterson, and R. W. Armstrong. 1979. Trapping & coded-wire tagging of wild coho, chinook, and steelhead juveniles from the Cowichan-Koksitah River system. Can. Fish. and Mar. Serv. Tech. Rept. No. 850. 117 p.
Chinook Salmon, Coho Salmon, Steelhead, Culture, Juvenile, BC

Arnold, J. R. 1971. A study of the silver salmon and steelhead rainbow trout in Redwood Creek, Marin County, California. Unpub. Rept. to U.S. Dept. of the Int., Nat. Park Serv., Contract 14-10-9-990-33. 31 p.
Coho Salmon, Winter Steelhead, Juvenile, Life History, Migration, CA

Ashley, P. 1974. The summer feeding ecology of the Humboldt sucker, Catostomus humboldtianus, & juvenile steelhead in the upper Eel River. MS Thesis, Humboldt St. College, Arcata, CA. 95 p.
Winter Steelhead, Ecology, Juvenile, Eel, CA

Bali, J. M. 1957. Scale analyses of steelhead trout, Salmo gairdnerii gairdnerii Richardson, from various coastal watersheds of Oregon. MS Thesis, Oregon St. University, Corvallis, OR. 169 p.
Winter Steelhead, Culture, Life History, Racial, OR

Banks, J. W. 1969. A review of the upstream migration of adult salmonids. J. Fish Biol. 1:85-136.
Chinook, Chum, Sockeye, Pink Salmon, Winter Steelhead, Brown, Rainbow Trout, Dams, Migration, Pollution, PAC

Banowetz, G. M., J. L. Fryer, P. J. Iwai, and M. E. Martignoni. 1976. Effects of the douglas-fir tussock moth Nucleopolyhedrosis virus (Baculovirus) on three species of salmonid fish. USDA, For. Serv. Res. Pap. PNW-214. 6 p.
Chinook Salmon, Coho Salmon, Steelhead, Diseases, OR

Bates, D. W., E. W. Murphey, and E. F. Prentice. 1970. Design and operation of a cantilevered traveling fish screen (model V). U.S. Fish and Wildl. Serv., Special Scientific Rept.--Fisheries No. 608:6-15.
Coho Salmon, Steelhead, Culture, Juvenile, OR

Beach, D. W. 1972. A brief life history of winter run (1970-1971) steelhead from the South Fork of the Eel River. Unpub. Rept. Calif. Coop. Fish. Res. Unit, Humboldt St. College, Arcata, CA.
Winter Steelhead, Life History, Eel, CA

Bell, R. 1959. Time, size, and estimated numbers of seaward migration of chinook salmon & steelhead in the middle Snake River. Idaho Dept. Fish and Game, Processed Report. 33 p.
Chinook Salmon, Steelhead, Juvenile, Migration. ID

Bjornn, T. C. 1966. Steelhead trout production studies--Lemhi, Big Springs Creek. Ann. Comp. Rept., Proj. 49-R-4, Idaho Fish and Game Rept. Multilith Rept. 183 p.
Steelhead, Ecology, Juvenile, ID

Bjornn, T. C. 1966. The production of juvenile rainbow-steelhead trout (Salmo gairdneri) in the Lemhi River, Idaho. Ph.D. Thesis, Utah State Univ., Logan, UT. 185 p.
Chinook Salmon, Steelhead, Ecology, Eggs-Embryos, Juvenile, Migration, ID

Bjornn, T. C. 1969. Salmon and steelhead investigations, Job No. 5.--Embryo survival and emergence studies. Job Completion Rept. F-49-R-7. Idaho Fish and Game Dept. 11 p.
Chinook Salmon, Steelhead, Eggs-Embryos, ID

Bjornn, T. C. 1971. Trout & salmon movements in two Idaho streams correlated to temperature, food, streamflows, cover, & population density. Trans. Am. Fish. Soc. 100:423-438.
Chinook Salmon, Steelhead, Rainbow Trout, Ecology, Juvenile, Migration, ID

Bjornn, T. C. 1977. Mixed stocks of wild and hatchery steelhead trout: A management problem in Idaho. Pages 31-42 In: Proc. Genetic Implications of Steelhead Manag. Symp. Ca. Coop. Fish. Res. Unit, HSU, Spec. Rept. 77-1.
Steelhead, Ecology, Management, Migration, Racial, ID

Bjornn, T. C. 1978. Survival, production, and yield of trout and chinook salmon in the Lemhi River, Idaho. Col. of For., Wildl., and Range Sci., Univ. of Idaho, Moscow, Bull. No. 27. 57 p.
Chinook Salmon, Steelhead, Dolly Varden, Culture, Ecology, Juvenile, Migration, ID

Bjornn, T. C., M. A. Brusven, M. P. Molnau, J. H. Milligan, R. A. Klamt, E. Chacho, and C. Schaye. 1977. Transport of granitic sediment in streams and its effects on insects and fish. Col. of For., Wildl., and Range Sci., Univ. of Idaho, Moscow, Bull. No. 17. 43 p.
Chinook Salmon, Steelhead, Cutthroat Trout, Ecology, Juvenile, Pollution, ID

Bjornn, T. C., M. A. Brusven, M. P. Molnau, F. Watts, and R. L. Wallace. 1974. Sediment in streams and its effects on aquatic life. Water Resources Res. Inst., Univ. of Idaho, Moscow, Res. Tech. Comp. Rep. OWRR Proj. No. 8-025-IDA. 47 p.
Chinook Salmon, Steelhead, Cutthroat Trout, Ecology, Juvenile, Pollution, ID

Bjornn, T. C., P. Hiebert, and R. R. Ringe. 1979. Seaward migration of Dworshak Hatchery steelhead trout in 1977 as related to rearing history. For., Wildl., and Range Exp. Stat. Tech. Rept. No. 10, Univ. of Idaho, Moscow, ID. 58 p.
Steelhead, Culture, Dams, Diseases, Juvenile, Management, Migration. Parr-Smolt, ID

Bjornn, T. C., and N. Horner. 1980. Artificial propagation of Pacific salmon and steelhead in relation to the Endangered Species Act. Spec. Rept. to Nat. Mar. Fish. Serv., Seattle, WA. 13 p.
Salmon, Steelhead, Culture, Management, PAC

Bjornn, T. C., and N. Horner. 1980. Biological criteria for classification of salmon & steelhead as threatened or endangered by the Endangered Species Act. Spec. Rept. to Nat. Mar. Fish. Serv., Seattle, WA. 24 p.
Salmon, Steelhead, Management, PAC

Bjornn, T. C., R. R. Ringe, and P. Hiebert. 1978. Seaward migration of Dworshak Hatchery steelhead trout in 1976. For., Wildl., and Range Exp. Sta. Tech. Rept. No. 6, Univ. of Idaho, Moscow. 45 p.
Steelhead, Culture, Dams, Diseases, Management, Migration, Parr-Smolt, ID

Bouck, G. R., G. A. Chapman, P. W. Schneider, Jr., and D. G. Stevens. 1976. Observations on gas bubble disease among wild adult Columbia River fishes. Trans. Am. Fish. Soc. 105:114-115.
Sockeye Salmon, Steelhead, Dams, OR

Bouck, G. R., A. V. Nebeker, and D. G. Stevens. 1976. Mortality, saltwater adaptation and reproduction of fish during gas supersaturation. EPA, Ecol. Res. Ser. EPA-600/3-76-050. 55 p.
Chinook Salmon, Coho Salmon, Sockeye Salmon, Summer Steelhead, Winter Steelhead, Dams, Juvenile, OR

Bowler, V. L. 1972. A comparison of salmonid production between allopatric and sympatric populations in an Idaho stream. MS Thesis, Univ. of Idaho, Moscow, ID. 39 p.
Winter Steelhead, Ecology, Juvenile, ID

Boydstun, J. B. 1977. California's steelhead program. Pages 26-30 In: Proc. Genetic Implications of Steelhead Manag. Symp. Ca. Coop. Fish. Res. Unit, HSU, Spec. Rept. 77-1.
Winter Steelhead, Culture, Management, Racial, Klamath, Mad, Trinity, CA

Boydstun, J. B., and J. S. Hopelain. 1977. Cage rearing of steelhead rainbow trout in a fresh-water impoundment. Prog. Fish Cult. 39:70-75.
Winter Steelhead, Culture, CA

Braatan, B. A., and H. O. Hodgins. 1976. Protection of steelhead trout against vibriosis with a living low-virulence strain of Vibria anguillarum. J. Fish. Res. Bd. Can. 33:845-847.
Steelhead, Diseases, WA

Briggs, J. C. 1953. The behavior and reproduction of salmonid fishes in a coastal stream. Calif. Dept. Fish and Game, Fish Bull. No. 94. 62 p.
Chinook Salmon, Coho Salmon, Winter Steelhead, Culture, Ecology, Life History, Migration, CA

Bruns, J. A. 1973. Behavior of steelhead in an artificial stream. MS Thesis, Humboldt St. College, Arcata, CA. 42 p.
Coho Salmon, Winter Steelhead, Ecology, Racial, Mad, CA

Buchanan, D. V. 1975. Willamette River steelhead. Federal Aid Prog. Rept., Fisheries, No. 88275008, Closing Rept., July 1, 1974 - June 30, 1975.
Summer Steelhead, Angling, Culture, Diseases, Juvenile, Migration, OR

Buchanan, D. V. 1975. Willamette River steelhead. Federal Aid Prog. Rept., Fisheries, No. 88E2508, July 1 - Dec. 31, 1975.
Steelhead, OR

Buchanan, D. V. 1977. Willamette River steelhead. Federal Aid Prog. Rept., Fisheries, July 1, 1976 - Sept. 30, 1977.
Steelhead, OR

Buchanan, D. V., R. M. Hooten, and J. R. Moring. 1981. Northern squawfish predation on juvenile salmonids in sections of the Willamette River Basin. Can. J. Fish. Aquat. Sci. 38:360-364.
Chinook Salmon, Coho Salmon, Steelhead, Cutthroat Trout, Rainbow Trout, Ecology, Juvenile, OR

Bulkey, R. V. 1967. Fecundity of steelhead trout, Salmo gairdneri, from Alsea River, Oregon. J. Fish. Res. Bd. Can. 24:917-926.
Winter Steelhead, Ecology, Eggs-Embryos, OR

Burns, D. C. 1974. Feeding by mature steelhead (Salmo gairdneri) in the spawning stream. Calif. Fish and Game 60:205-207.
Winter Steelhead, Ecology, CA

Burns, J. W. 1971. The carrying capacity for juvenile salmonids in some Northern California streams. Calif. Fish and Game 57:44-57.
Coho Salmon, Winter Steelhead, Ecology, Juvenile, CA

Bustard, D. R., and D. W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). J. Fish. Res. Bd. Can. 32:667-680.
Coho Salmon, Winter Steelhead, Ecology, Juvenile, BC

Butler, J. A., and R. E. Milleman. 1971. Effect of the "salmon poisoning" trematode on the swimming ability of juvenile salmonid fishes. J. Parasit. 57:860-865.
Coho Salmon, Summer Steelhead, Diseases, Juvenile

California Dept. Fish and Game, Anad. Fish. Branch. 1977. A study of Trinity River steelhead emigration. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 77-5. 38 p.
Steelhead, Juvenile, Migration, Trinity, CA

Cartwright, J. W. 1960. Steelhead propogation in British Columbia, 1954-1959. Fish and Game Branch, Rep. Rec. and Conserv., Victoria, Brit. Col. 13 p.
Steelhead, Culture, BC

Chaney, E., and L. E. Perry. 1976. Columbia Basin salmon and steelhead analysis. Pac. N.W. Reg. Comm. Rept. 74 p.
Salmon, Steelhead, WA

Chang, W. 1975. Estimation of weight of steelhead trout (Salmo gairdneri) by analysis of body curves. MS Thesis, Humboldt St. College, Arcata, CA. 89 p.
Steelhead, Physiology, CA

Chapman, D. W. 1957. Studies on age, growth and migration of steelhead rainbow trout in the Alsea River, Oregon. MS Thesis, Oregon St. University, Corvallis, OR. 96 p.
Winter Steelhead, Culture, Juvenile, Life History, Management, Racial, OR

Chapman, D. W. 1957. Use of latex injections to mark juvenile steelhead. Prog. Fish Cult. 19:95-96.
Steelhead, Culture, Juvenile, OR

Chapman, D. W. 1958. Studies on the life history of Alsea River steelhead. J. Wildl. Mgt. 22:123-134.
Winter Steelhead, Juvenile, Life History, OR

Chapman, D. W., and T. C. Bjornn. 1969. Distribution of salmonids in streams, with special reference to food and feeding. Pages 153-176 In: T. Northcote (Ed.) Symp. on Salmon and Trout in Streams. Inst. of Fish., Univ. of B.C., Vancouver.
Chinook Salmon, Steelhead, Ecology, Juvenile, ID

Chapman, W. M. 1941. Observations on the migration of salmonoid fishes in the upper Columbia River. Copeia 1941:240-242.
Chinook Salmon, Sockeye Salmon, Steelhead, Migration, WA

Chapman, W. M., and E. Quistorff. 1938. The food of certain fishes of North-Central Columbia drainage, in particular, young chinook salmon and steelhead trout. Wash. Dept. Fish., Biol. Rept. No. 37A. 14 p.
Chinook Salmon, Steelhead, Ecology, Juvenile, WA

Chilcote, M. W., B. A. Crawford, and S. A. Leider. 1980. A genetic comparison of sympatric populations of summer and winter steelheads. Trans. Am. Fish. Soc. 109:203-206.
Summer Steelhead, Winter Steelhead, Racial, WA

Chrisp, E. Y., and T. C. Bjornn. 1974. Parr-smolt transformation in summer-run steelhead trout and chinook salmon. Job Performance Report. Proj. F-49-R-12. Idaho Fish & Game Dept. 13 p.
Chinook Salmon, Summer Steelhead, Juvenile, Migration, Parr-Smolt, ID

Clancy, D. W. 1960. Effects of tagging on the swimming ability of steelhead and hatchery rainbow trout. MS Thesis, Univ. of Washington, Seattle, WA.
Steelhead, Rainbow Trout, Culture, Juvenile, Life History, WA

Clancy, D. W. 1963. The effect of tagging with Peterson disc tags on the swimming ability of fingerling steelhead trout. J. Fish. Res. Bd. Can. 20:969-981.
Steelhead, Culture, Juvenile, WA

Coble, D. W. 1961. Influence of water exchange and dissolved oxygen in redds on survival of steelhead trout embryos. Trans. Am. Fish. Soc. 90:469-474.
Steelhead, Eggs-Embryos, OR

Collins, G. B. 1976. Effects of dams on Pacific salmon and steelhead trout. Mar. Fish. Rev. 38(11):39-46.
Chinook Salmon, Steelhead, Culture, Dams, WA

Collins, G. B., J. R. Gauley, and C. H. Elling. 1962. Ability of salmonids to ascend high fishways. Trans. Am. Fish. Soc. 91:1-7.
Chinook Salmon, Sockeye Salmon, Steelhead, Migration, WA

Combs, T. 1971. The steelhead trout, life history, early angling, contemporary steelheading. Northwest Salmon Trout Steelheader Co., Portland, Oregon. 187 p.
Summer Steelhead, Winter Steelhead, Angling, Ecology, Eggs-Embryos, Life History, Migration, Parr-Smolt, PAC

Conte, F. P., G. Gnose, H. H. Wagner, and J. Fessler. 1965. Mechanism of saltwater adaptation in juvenile salmon and steelhead trout. Pages 182-183 In: Proc. 45th Ann. Conf. West. Assoc. State Game Fish Comm., Anchorage, Alaska.
Salmon, Steelhead, Parr-Smolt, Physiology

Conte, F. P., and H. H. Wagner. 1965. Development of osmotic and ionic regulation in juvenile steelhead trout, Salmo gairdneri. Comp. Biochem. Physiol. 14:603-620.
Steelhead, Juvenile, Parr-Smolt

Cooper, J. C., and A. T. Scholz. 1976. Homing of artificially imprinted steelhead (rainbow trout), Salmo gairdneri. J. Fish. Res. Bd. Can. 33:826-829.
Steelhead, Rainbow Trout, Culture

Coutant, C. C. 1969. Behavior of sonic-tagged chinook salmon and steelhead trout migrating past Hanford thermal discharges. Pages 21-26 In: Biological effects of thermal discharges: Ann. Prog. Rept. for 1968.
Chinook Salmon, Steelhead, Migration, Pollution

Coutant, C. C., and R. G. Genoway. 1968. An exploratory study of interaction of increased temperature and nitrogen supersaturation or mortality of adult salmonids. Battelle Memorial Institute, PAC. Northwest Lab., Richland, Wash., Sept. 1965. 19 p.
Salmon, Steelhead, Dams, Pollution, WA

Cramer, S. P., and J. T. Martin. 1979. Juvenile Progress Report Rogue Basin Fisheries Evaluation Program. Oregon Dept. Fish and Wildlife, Research Section. 80 p.
Chinook Salmon, Summer Steelhead, Winter Steelhead, Angling, Dams, Ecology, Juvenile, Migration, Racial, OR

Cramer, S. P., and B. P. McPhearson. 1980. Juvenile Report Rogue Basin Fisheries Evaluation Program. Oregon Dept. Fish and Wildlife, Research Sections. 126 p.
Chinook, Coho Salmon, Summer Steelhead, Winter Steelhead, Cutthroat Trout, Juvenile, Life History, Migration, Parr-Smolt

Crawford, B. A. 1977. A study of the contribution of hatchery-reared summer steelhead to wild steelhead recruitment using genetic markers. Pages 16-19 In: Proc. Genetic Implications of Steelhead Manag. Symp. Ca. Coop. Fish. Res. Unit, HSU, Spec. Rept. 77-1.
Summer Steelhead, Management, Racial, WA

Crawford, B. A., S. A. Leider, and J. M. Tipping. 1977. Technique for rapidly taking samples of skeletal muscle from live adult steelhead trout. Prog. Fish Cult. 39:125.
Summer Steelhead, Culture, WA

Cross, D. 1975. Early life history of steelhead trout (Salmo gairdneri) in a small coastal stream. MS Thesis, Humboldt St. College, Arcata, CA. 44 p.
Winter Steelhead, Ecology, Juvenile, Life History, CA

Davis, J. C., I. G. Shand, and B. J. Mason. 1976. Biological and oceanographic studies at a kraft pulp and paper mill outfall at Crofton, B.C. Fish. Mar. Serv. Res. Dev. Tech. Rept. No. 652. 76 p.
Steelhead Pollution, BC

Dawley, E. M., and W. J. Ebel. 1975. Effects of various concentrations of dissolved atmospheric gas on juvenile chinook salmon and steelhead trout. U.S. Fish and Wildl. Serv., Fish. Bull. 73:787-796.
Chinook Salmon, Steelhead, Dams, WA

Dawley, E. M., M. Schiewe, and B. Monk. 1974. Effects of long-term exposure to supersaturation of dissolved atmospheric gases on juvenile chinook salmon & steelhead. Pages 1-10 In: D. Fickeisen & M. Schneider (Eds.) Gas Bubble Disease: Proc. of a Workshop, Richland, WA, Oct. 8-9, 1974.
Chinook Salmon, Steelhead, Dams, Juvenile, WA

Dell, M. E. 1974. Tag returns and movements of rainbow trout and rainbow-steelhead trout released in the Lake Washington system. Trans. Am. Fish. Soc. 103:250-254.
Steelhead, Rainbow Trout, Culture, Ecology, WA

Dunn, P. L. 1981. Migration behavior and holding habitat of adult summer steelhead in Wooley Creek, California. MS Thesis, Humboldt St. College, Arcata, CA. 83 p.
Summer Steelhead, Ecology, Management, Migration, Klamath, Wooley, CA

Eales, J. G. 1964. The influence of temperature on thyroid histology and radioiodine metabolism of yearling steelhead trout, Salmo gairdneri. Can. J. Zool. 42:829-841.
Steelhead, Juvenile, Physiology, Pollution

Eales, J. G. 1965. Factors influencing seasonal changes in thyroid activity in juvenile steelhead trout, Salmo gairdneri. Can. J. Zool. 43:719-729.
Steelhead, Juvenile, Physiology

Ebel, W. J. 1969. Supersaturation of nitrogen in the Columbia River and its effect on salmon and steelhead trout. U.S. Fish and Wildl. Serv., Fish. Bull. 68:1-10.
Chinook Salmon, Sockeye Salmon, Steelhead, Dams, Juvenile, WA

Ebel, W. J. 1971. Dissolved nitrogen concentrations in the Columbia and Snake Rivers in 1970 & their effect on chinook salmon & steelhead. U.S. Fish and Wildl. Serv., Special Scientific Rept.--Fisheries No. 646. 7 p.
Chinook Salmon, Steelhead, Dams, Juvenile, WA

Ebel, W. J. 1973. Relations between fish behavior, bioassay information, and dissolved gas conc. on survival of juv. salmon & steelhead. Pages 516-527 In: West. Proc. 53rd Ann. Conf. West. Assoc. State Game Fish Comm., July 10-13, 1973.
Chinook Salmon, Steelhead, Dams, Juvenile, WA

Ebel, W. J. 1974. Marking fishes and invertebrates. III. Coded wire tag useful in automatic recovery of chinook salmon and steelhead trout. Mar. Fish. Rev. 36(7):10-13.
Chinook Salmon, Steelhead, Culture, Juvenile, WA

Ebel, W. J. 1978. Effect of downstream transportation of Idaho smolts on adult salmonid returns. Ph.D. Thesis, Univ. of Idaho, Moscow, ID.
Chinook Salmon, Steelhead, Juvenile, Management, Migration, WA

Ebel, W. J., E. M. Dawley, and B. M. Monk. 1971. Thermal tolerance of juvenile Pacific salmon and steelhead trout in relation to supersaturation of nitrogen gas. U.S. Fish and Wildl. Serv., Fish. Bull. 69:833-843.
Chinook Salmon, Coho Salmon, Steelhead, Dams, Juvenile, Management, WA

Ebel, W. J., D. L. Park, and R. C. Johnsen. 1973. Effects of transportation on survival and homing of Snake River chinook salmon and steelhead trout. U.S. Fish and Wildl. Serv., Fish. Bull. 71:549-563.
Chinook Salmon, Steelhead, Juvenile, Migration, WA

Ebel, W. J., and H. L. Raymond. 1976. Effect of atmospheric gas supersaturation on salmon and steelhead trout of the Snake and Columbia Rivers. Mar. Fish. Rev. 38(7):1-14.
Chinook Salmon, Coho Salmon, Sockeye Salmon, Steelhead, Dams, Juvenile, Migration, WA

Ebel, W. J., H. L. Raymond, G. E. Monan, W. Farr, and G. K. Tononaka. 1974. Effect of atmospheric gas as supersaturation caused by dams on salmon and steelhead of the Snake and Columbia Rivers. Nat. Mar. Fish. Serv., Seattle, WA. 111 p.
Chinook Salmon, Steelhead, Dams, Juvenile, WA

Edmundson, E. H. 1967. Diurnal and diel movements of juvenile steelhead trout and chinook salmon in two Idaho streams. MS Thesis, Univ. of Idaho, Moscow, ID. 35 p.
Chinook Salmon, Steelhead, Ecology, Juvenile, ID

Edmundson, E. H., F. H. Everhart, and D. W. Chapman. 1968. Permanence of station in juvenile chinook salmon and steelhead trout. J. Fish. Res. Bd. Can. 25:1453-1464.
Chinook Salmon, Winter Steelhead, Ecology, Juvenile, ID

Ekdahl, D. 1979. The role of the inner dental epithelium during odontogenesis in salmo gairdneri (Salmonidae:osteichthyes). MS Thesis, Humboldt St. College, Arcata, CA. 97 p.
Steelhead, Juvenile, Physiology, CA

Everest, F. H. 1969. Habitat selection and spatial interaction of juvenile chinook salmon and steelhead trout in two Idaho streams. Ph.D. Thesis, Univ. of Idaho, Moscow, ID. 77 p.
Chinook Salmon, Winter Steelhead, Ecology, Juvenile, ID

Everest, F. H. 1973. Ecology and management of summer steelhead in the Rogue River. Oreg. St. Game Comm., Fish. Res. Rept. No. 7, Proj. AFS-31. 48 p.
Summer Steelhead, Angling, Ecology, Eggs-Embryos, Juvenile, Life History, Management, Migration, Parr-Smolt, Racial, OR

Everest, F. H., and D. W. Chapman. 1972. Habitat selection and spatial interaction by juvenile chinook salmon and steelhead trout in two Idaho streams. J. Fish. Res. Bd. Can. 29:91-100.
Chinook Salmon, Winter STeelhead, Ecology, Juvenile, ID

Everest, F. H., and E. H. Edmundson. 1967. Cold branding for field use in marking juvenile salmonids. Prog. Fish Cult. 29:175-176.
Chinook Salmon, Steelhead, Culture, Juvenile, ID

Fagerlund, U. H. M., and J. R. McBride. 1977. Effects of 17 alpha-methyltestosterone on growth, gonad devel., external features, and muscle comp. of steelhead. Fish. Mar. Serv. Tech. Rept. No. 716. 35 p.
Coho Salmon, Pink Salmon, Steelhad, Physiology, Pollution

Falter, C. M., and R. R. Ringe. 1974. Pollution effects on adult steelhead migration in the Snake River. EPA, Ecol. Res. Ser. EPA-660/3-73-017. 101 p.
Summer Steelhead, Dams, Migration, ID

Faudskar, J. C. 1972. Determining mechanisms stimulating downstream movement of summer steelhead fry. MS Thesis, Oregon St. University, Corvallis, OR. 55 p.
Summer Steelhead, Ecology, Juvenile, Migration, OR

Fessler, J. L. 1973. An ecological and fish cultural study of summer steelhead in the Deschutes River, Oregon. Oreg. St. Wildl. Comm., Federal Aid Project F-88-R-2. 42 p.
Summer Steelhead, Ecology, OR

Fessler, J. L. 1974. Determination of factors limiting efficiency of hatchery prod. & pop. char. & life history of Deschutes R. sum. st. Oregon. St. Wildl. Comm., Federal Aid Project F-88-R-6. 27 p.
Summer Steelhead, Culture, Life History, OR

Fessler, J. L., and H. H. Wagner. 1969. Some morphological and biochemical changes in steelhead trout during the parr-smolt transformation. J. Fish. Res. Bd. Can. 26:2823-2841.
Winter Steelhead, Parr-Smolt, OR

Fields, P. E. 1960. Guiding downstream migrant salmon and steelhead trout. A Research Summary. School of Fish., Univ. of Wash., Prog. Rept. Fish. Engr. Res. Prog., N. Oc. Div., U.S. Army Corps of Engr. Pp. 162-179.
Salmon, Steelhead, Culture, Juvenile, Migration, WA

Finlayson, B. J., and H. J. Rectenwald. 1978. Toxicity of copper and zinc from the Penn Mine area on King Salmon and steelhead trout in the Mokelumne River Basin, CA. Calif. Dept. Fish and Game, Env. Serv. Br. Admin. Rept. No. 78-1. 42 p.
Chinook Salmon, Winter Steelhead, Pollution, CA

Fite, K. 1973. Feeding overlap between roach and juvenile steelhead in the Eel River. MS Thesis, Humboldt St. College, Arcata, CA. 38 p.
Winter Steelhead, Ecology, Eel, CA

Forsgren, H. 1979. Age, growth, origin and repeat spawning of winter steelhead (Salmo gairdneri) in Mad River, California. MS Thesis, Humboldt St. College, Arcata, CA. 56 p.
Winter Steelhead, Life History, Racial, Mad, CA

Fraser, F. J. 1968. The effect of population densities on survival, growth, and behavior of coho salmon and steelhead trout fry. MS Thesis, Univ. of British Columbia. 67 p.
Coho Salmon, Steelhead, Ecology, Juvenile, BC

Fraser, F. J. 1969. Population density effects on survival and growth of juvenile coho salmon and steelhead trout in experimental streams. Pages 253-268 In: T. Northcote (Ed.) Symp. on Salmon and Trout in Streams. Inst. of Fish., Univ. of B.C., Vancouver.
Coho Salmon, Steelhead, Ecology, Juvenile, BC

French, R. R., R. G. Bakkala, and D. F. Sutherland. 1975. Ocean distribution of stocks of Pacific salmon. and steelhead trout as shown by Canada, Japan, and the United States. U.S. Fish and Wildl. Serv.. Special Scientific Rept.--Fisheries No. 689. 89 p.
Chinook Salmon, Chum Salmon, Coho Salmon, Pink Salmon, Sockeye Salmon, Steelhead, Migration, PAC

Fryer, J. L., K. S. Pilcher, J. E. Sanders, J. S. Rohovec, J. L. Zinn, W. J. Groberg, and R. H. McCoy. 1976. Temperature, infectious diseases, and the immune response in salmonid fish. EPA, Ecol. Res. Ser. EPA-600/3-76-21. 72 p.
Chinook Salmon, Coho Salmon, Steelhead, Diseases, Juvenile, Pollution, OR

Fulton, L. A. 1970. Spawning areas and abundance of steelhead trout and coho, sockeye, and chum salmon in the Columbia River Basin. U.S. Fish and Wildl. Serv., Special Scientific Rept.—Fisheries No. 618. 37 p.
Chum Salmon, Coho Salmon, Pink Salmon, Steelhead, Migration, PAC

Gall, G. A. 1977. Steelhead management - Do we understand the potential of hatcheries. Pages 4-5 In: Proc. Genetic Implications of Steelhead Manag. Symp. Ca. Coop. Fish. Res. Unit, HSU, Spec. Rept. 77-1.
Steelhead, Management, Racial, CA

Garrison, R. L. 1969. Lint Slough: Salmon and steelhead rearing impoundment. Unpub. Rept., Oreg. St. Game Comm. Pp. 1-3.
Salmon, Steelhead, Culture, OR

Gauley, J. R., and C. S. Thompson. 1963. Further studies on fishway slope and its effect on rate of passage of salmonids. U.S. Fish and Wildl. Serv., Fish. Bull. 63:45-62.
Chinook Salmon, Sockeye Salmon, Steelhead, Culture, Dams, Migration, WA

Gibson, R. J. 1980. Behavioral interactions between coho & Atlantic salmon, brook & steelhead trout at the juvenile fluvatile stage. Contract proposal No. 627 to the woods hole oceanogrphic institution.
Atlantic Salmon, Coho Salmon, Steelhead, Brook Trout, Ecology, Juvenile

Goodnight, W. H., and T. C. Bjornn. 1971. Fish production in two Idaho streams. Trans. Am. Fish. Soc. 100:769-780.
Chinook Salmon, Steelhead, Ecology, Juvenile, ID

Grabowski, S. J. 1973. Effects of fluctuating & constant temperatures on some hematological char., tissue glycogen levels, & growth of steelhead. PhD Thesis, Univ. of Idaho, Moscow, ID. 77 p.
Steelhead, Physiology, Pollution, ID

Graham, P. J. 1977. Juvenile steelhead trout densities in the Lochsa and Selway River drainages. MS Thesis, Univ. of Idaho, Moscow, ID. 91 p.
Steelhead, Ecology, Juvenile, Management, ID

Graves, D. S., and J. W. Burns. 1971. Comparison of yields of downstream migrant salmonids before & after logging road construction on the S. Fk. Caspar Creek. Calif. Fish and Game, Inl. Fish. Br. Admin. Rept. No. 70-3. 12 p.
Coho Salmon, Winter Steelhead, Juvenile, Migration, Pollution, CA

Graybill, J. R., and H. F. Horton. 1969. Limited fertilization of steelhead trout eggs with cryo-preserved sperm. J. Fish. Res. Bd. Can. 26:1400-1404.
Steelhead, Culture, Eggs-Embryos, OR

Groberg, W. J., Jr., R. H. McCoy, K. S. Pilcher, and J. L. Fryer. 1978. Relation of water temperatures to infections of coho and chinook salmon, and steelhead with Aeromonas salmonica. J. Fish. Res. Bd. Can. 35:1-7.
Chinook Salmon, Coho Salmon, Steelhead, Diseases, Juvenile, OR

Gudjonsson, T. V. 1946. Age and body length at the time of seaward migration of immature steelhead trout in Winter Creek. MS Thesis, Univ. of Washington, Seattle, WA. 52 p.
Steelhead, Juvenile, Life History, Migration, WA

Hahn, P. 1976. Effects of fluctuating and constant temperatures on autecology of steelhead trout. Comp. Rept. Idaho Coop. Fish. Res. Unit, Univ. of Idaho, Moscow, ID. 68 p.
Steelhead, Ecology, Pollution, ID

Hahn, P. 1977. Effects of fluctuating and constant temperatures on behavior of steelhead trout (Salmo gairdneri). Ph.D. Thesis, Univ. of Idaho, Moscow, ID. 129 p.
Steelhead, Ecology, Juvenile, Pollution, ID

Hallock, R. J., D. H. Fry, Jr., and D. A. LaFaunce. 1957. The use of wire fyke traps to estimate the runs of adult salmon and steelhead in the Sacramento River. Calif. Fish and Game 43:271-298.
Chinook Salmon, Coho Salmon, Winter Steelhead, Culture, CA

Hallock, R. J., W. F. Van Woert, and L. Shapovalov. 1961. An evaluation of stocking hatchery-reared steelhead rainbow trout (Salmo gairdneri) in the Sacramento River system. Calif. Dept. Fish and Game, Fish Bull. 114:1-74.
Winter Steelhead, Angling, Juvenile, Life History, Management, Migration, CA

Hanson, D. L. 1977. Habitat selection and spatial interaction in allopatric and sympatric populations of cutthroat and steelhead trout. Ph.D. thesis, Univ. of Idaho, Moscow, ID. 66 p.
Winter Steelhead, Cutthroat Trout, Ecology, Juvenile, ID

Harper, W. 1980. Age, growth, and migration of coho salmon and steelhead trout in Jacoby Creek, California. MS Thesis, Humboldt St. College, Arcata, CA. 104 p.
Coho Salmon, Winter Steelhead, Juvenile, Life History, Migration, CA

Hartman, G. F. 1965. The role of behavior in the ecology and interaction of underyearling coho salmon and steelhead trout. J. Fish. Res. Bd. Can. 22:1035-1081.
Coho Salmon, Winter Steelhead, Ecology, Juvenile, BC

Hartman, G. F. 1966. Some effects of temperature on the behavior of underyearling coho and steelhead. Fish and Wildl. Br., Dept. Recreation and Cons., Mgmt. Rept. No. 51. 15 p.
Coho Salmon, Steelhead, Ecology, Juvenile, Pollution

Hartman, G. F., and C. A. Gill. 1968. Distributions of juvenile steelhead and cutthroat trout within streams in southwestern British Columbia. J. Fish. Res. Bd. Can. 25:33-48.
Winter Steelhead, Cutthroat Trout, Ecology, Juvenile, BC

Hayes, L. W., I. J. Tinsley, and R. R. Lowry. 1973. Utilization of fatty acids by the developing steelhead sac-fry, Salmo gairdneri. Comp. Biochem. Physiol. 45(3B):695-707.
Winter Steelhead, Eggs-Embryos, Physiology, OR

Healey, T. P., Jr. 1973. Studies of steelhead and salmon emigration in the Trinity River. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 73-1. 37 p.
Salmon, Steelhead, Juvenile, Migration, Trinity, CA

Heckeroth, D. N. 1965. A three-year comparison of winter steelhead angling on the Columbia River, NcNary Area, 1961-1964. In: Ann. Rept. Oreg. St. Game Comm., 1965.
Winter Steelhead, Angling, OR

Heckeroth, D. N. 1965. Summer steelhead angling success for the Columbia River for five years, 1960-1964. In: Ann. Rept. Oreg. St. Game Comm., 1965.
Summer Steelhead, Angling, OR

Hemus, D. 1974. Dean River summer steelhead observations on life history, population, and the fishery in 1973. Unpub. File Rept. Brit. Col. Fish and Wildl. Branch, Nanaimo. 48 p.
Summer Steelhead, Angling, Ecology, Juvenile, Life History, Migration, Management, BC

Holt, R.A., J. E. Sanders, J. L. Zinn, J. L. Fryer, and K. S. Pilcher. 1975. Relation of water temperature to flexibacter columnaris infection in steelhead trout, coho and chinook salmon. J. Fish. Res. Bd. Can. 32:1553-1559.
Chinook Salmon, Coho Salmon, Diseases, OR

Horner, N. J. 1978. Survival, densities, and behavior of salmonid fry in streams in relation to fish predation. MS Thesis, Univ. of Idaho, Moscow, ID.
Chinook Salmon, Steelhead, Ecology, Juvenile, ID

Hoss, S. A., K. W. Ball, and T. L. Welsh. 1975. Salmon and steelhead investigations. Job 1-A. Proj. F-49-R-14. Idaho Fish and Game Dept., Boise, ID. 38 p.
Salmon, Steelhead, ID

Houston, A. H. 1959. Osmoregulatory adaptation on steelhead trout (Salmo gairdneri) to sea water. Can. J. Zool. 37:729-748.
Steelhead, Parr-Smolt, BC

Houston, A. H. 1961. Influence of size upon the adaptation of steelhead (Salmo gairdneri) and chum salmon (Oncorhynchus keta) to sea water. J. Fish. Res. Bd. Can. 18:401-415.
Chum Salmon, Steelhead, Parr-Smolt, BC

Hubbell, P. M. 1973. Program to identify and correct salmon and steelhead problems in the Trinity River Basin. Calif. Dept. Fish and Game, Anad. Fish. Br., Unpub. Rept. to Trinity River Basin Fish & Wildl. Task Force. 70 p.
Chinook Salmon, Steelhead, Dams, Management, Pollution, Trinity, CA

Huzyk, L., and H. Tsuyuki. 1974. Distribution of LDH-B" gene in resident and anadromous rainbow trout (Salmo gairdneri) from streams in British Columbia. J. Fish. Res. Bd. Can. 31:106-108.
Steelhead, Rainbow Trout, Physiology, Racial, BC

Iwama, G. K., and A. F. Tautz. 1981. A simple growth model for salmonids in hatcheries. Can. J. Fish. Aquat. Sci. 38:649-656.
Chinook, Coho, Pink, Sockeye Salmon, Steelhead, Brook, Brown Trout, Culture, BC

Johnson, B. W., E. M. Miller, and C. H. Ellis. 1952. A report on steelhead egg and fry survival experiments on the N. Fk. of Stillaguamish R. with relation to an earthslide. Unpub. Rept., Washington State Fish. Dept., Olympia, WA.
Steelhead, Eggs-Embryos, Pollution, WA

Johnson, D. E., and P. E. Fields. 1959. The effectiveness of an electric hot-wire branding technique for marking steelhead fingerling trout. College of Fish., Univ. of Wash., Tech. Rept. No. 47. 4 p.
Steelhead, Culture, Juvenile, WA

Jones, D. E. 1972. A study of steelhead-cutthroat trout in southeast Alaska. Alaska Dept. Fish and Game, Sport Fish Studies, Ann. Rept. of Prog. 1971-1972, Study G-11. 13:91-108.
Steelhead, Cutthroat Trout, Life History, AL

Jones, D. E. 1973. Steelhead and sea-run cutthroat life history in southeast Alaska. Alaska Dept. Fish and Game, Div. of Sport Fish., Anad. Fish Studies, Ann. Rept. of Prog. 1972-1973, Study AFS-42-1. 18 p.
Steelhead, Cutthroat Trout, Life History, AL

Jones, D. E. 1974. The study of cutthroat-steelhead in Alaska. Alaska Dept. Fish and Game, Div. of Sport Fish., Anad. Fish Studies, Ann. Rept. of Prog. 1973-1974, Study AFS-42-2. 31 p.

Jones, D. E. 1975. Steelhead and sea-run cutthroat trout life history in Southeast Alaska. Alaska Dept. Fish and Game, Div. of Sport Fish., Anad. Fish Studies. Ann. Rept. of Prog. 1974-1975, Study AFS-42-3. 42 p.
Steelhead, Cutthroat Trout, Life History, AL

Jones, D. E. 1976. Steelhead and sea-run cutthroat trout life history study in southeast Alaska. Alaska Dept. Fish and Game, Div. Sport Fish., Anad. Fish Studies, Ann. Rept. of Prog. 1975-1976, Study AFS-42-4. 55 p.
Steelhead, Cutthroat Trout, Life History, AL

Jones, D. E. 1977. A study of steelhead-cutthroat in Alaska. Alaska Dept. Fish and Game, Anad. Fish Studies, Ann. Rept. of Prog. & Comp. Rept. 1971-1977, Study AFS-42-5. 105 p.
Steelhead, Cutthroat Trout, Life History, AL

Jones, W. E. 1980. Summer steelhead in the Middle Fork Eel River and their relationship to environmental changes, 1966 through 1978. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 80-2. 25 p.
Summer Steelhead, Angling, Ecology, Life History, Management, Eel, CA

Jones, W. E., and E. Ekman. 1980. Summer steelhead management plan - Middle Fork of the Eel River. Unpub. Rept. to Calif. Fish and Game, and USFS. 48 p.
Summer Steelhead, Ecology, Life History, Management, Survey, Eel, CA

Joseph, H. L. 1977. A steelheader's view. Pages 6-9 In: Proc. Genetic Implications of Steelhead Manag. Symp. Ca. Coop. Fish. Res. Unit, HSU, Spec. Rept. 77-1.
Steelhead, Management, Racial, CA

Kabel, C. W., and E. R. German. 1967. Caspar Creek study completion report. Calif. Fish and Game, Mar. Res. Br. Admin. Rept. No. 67-4. 27 p.
Winter Steelhead, CA

Keating, J. F. 1970. Annual survey of the salmon and steelhead sport fishery harvest in Idaho, 1969. Idaho Fish and Game Dept., Statewide Fishing Harvest Survey, F-18-R-16. Job 1:11.
Chinook Salmon, Steelhead, Angling, ID

Kerstetter, T. H., and M. Keeler. 1976. Smolting in steelhead trout: A comparative study of populations in two hatcheries and the Trinity River. Seagrant Proj. No. 9, Marine Lab., Humboldt St. College, Arcata, CA. 26 p.
Summer Steelhead, Winter Steelhead, Juvenile, Parr-Smolt, Racial, Trinity, CA

Kesner, W. D. 1969. Characteristics of the fall-run steelhead trout of the Klamath River system with emphasis on the half-pounder. MS Thesis, Humboldt St. College, Arcata, CA. 79 p.
Summer Steelhead, Ecology, Life History, Migration, Klamath, CA

Kesner, W. D. 1969. Summer steelhead management plan. Unpub. Rept. to Klamath Nat. Forest, California. 24 p.
Summer Steelhead, Ecology, Management, Survey, Klamath, Wooley, CA

Kesner, W. D., and R. A. Barnhart. 1972. Characteristics of the fall-run steelhead trout of the Klamath River system with emphasis on the half-pounder. Calif. Fish and Game 58:204-220.
Summer Steelhead, Ecology, Life History, Migration, Klamath, CA

King, D. N. 1966. Deschutes River summer steelhead. Oreg. St. Game Comm., Cent. Reg. Admin. Rept. 66-3. 41 p.
Summer Steelhead, OR

Klamt, R. R. 1976. The effects of coarse granitic sediment on the distribution and abundance of salmonids in the central Idaho batholith. MS Thesis, Univ. of Idaho, Moscow, ID. 85 p.
Chinook Salmon, Steelhead, Juvenile, Pollution, ID

Knittel, G. A., G. A. Chapman, and R. R. Garton. 1980. Effects of hydrostatic pressure on steelhead survival in air-supersaturated water. Trans. Am. Fish. Soc. 109:755-759.
Steelhead, Dams, Juvenile, OR

Knutson, A. C., Jr. 1975. Biology of summer steelhead (Salmo gairdneri gairdnerii) of the Klamath River system with emphasis on the half-pounder. MS Thesis, Humboldt St. College, Arcata, CA. 65 p.
Summer Steelhead, Ecology, Life History, Management. Migration. Mad, CA

Korn, L. 1961. A winter steelhead tagging program on the Columbia River. Fish Comm. Oregon, Contr. No. 26. 35 p.
Winter Steelhead, OR

Koski, K. V. The use of otoliths for age determination and stock differentiation in steelhead trout, Salmo gairdneri Richardson. Unpub. Rept., Oreg. St. Univ., Dept. Fish and Wildlife. 10 p.
Summer Steelhead, Winter Steelhead, Culture, Racial, OR

Kralik, N. J., and J. E. Sowerwine. 1971. The role of two northern California intermittent streams in the life history of anadromous salmonids. MS Thesis, Humboldt St. College, Arcata, CA. 68 p.
Chinook Salmon, Coho Salmon, Winter Steelhead, Juvenile, Life History, Migration, Mad, CA

Kubicek, P. F., and D. G. Price. 1976. An elevation of water temperature and its effect on juvenile steelhead in geothermally active areas of big sulphur Ck. Pac. Gas and Elec. Co. Rept. No. 7784. 4-75. 37 p.
Winter Steelhead, Juvenile, Pollution, CA

Laarman, P. W. 1969. Effects of a limited food supply on growth rates of coho salmon and steelhead trout. Trans. Am. Fish. Soc. 98:393-397.
Coho Salmon, Winter Steelhead, Ecology, Juvenile

Lanse, R. I. 1970. An estimate of angler pressure and sport harvest from the Klamath R., Inc. Data describing anadromous fish migrations.' Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. 70-3. 18 p.
Chinook Salmon, Steelhead, Angling, Juvenile, Klamath, CA

Lanse, R. I. 1972. The 1970 sport fish harvest - Shasta River, including the proportion of the steelhead population harvested by anglers. Calif. Dept. Fish and Game, Anad. Fish.Br. Admin. Rept. No. 72-1. 21 p.
Steelhead, Angling, Juvenile, Klamath, CA

Larkin, P. A. 1950. Report on the preliminary survey of the steelhead of the lower Fraser River. Pages 58-69 In: Ann. Rept. Brit. Col. Game Comm. for 1948.
Steelhead, Survey, BC

Larson, R. W., and J. H. Ward. 1954. Management of steelhead trout in the State of Washington. Trans. Am. Fish. Soc. 84:261-274.
Winter Steelhead, Angling, Culture, Juvenile, Life History, Management, WA

Lebrasseur, R. J. 1966. Stomach contents of salmon and steelhead trout in the northeastern Pacific Ocean. J. Fish. Res. Bd. Can. 23:85-100.
Chum Salmon, Coho Salmon, Pink Salmon, Sockeye Salmon, Steelhead, Ecology, PAC

Lichtenheld, R. W. 1966. Effect of light, temperature and gamma radiation on the locomotor activity of juvenile steelhead trout (Salmo gairdneri). Ph.D. Thesis, Univ. of Washington, Seattle, WA. 237 p.
Steelhead, Juvenile, Physiology, Pollution, WA

Liscom, K. L. 1971. Orifice placement in gatewells of turbine intakes for bypassing juvenile fish around dams. Trans. Am. Fish. Soc. 100:319-324.
Chinook Salmon, Coho Salmon, Steelhead, Culture, Dams, Juvenile, WA

Liscom, K. L., and C. D. Volz. 1975. Impedance bridge fish counter. Prog. Fish. Cult. 37:39-42.
Salmon, Steelhead, Culture, Dams, Juvenile, WA

Lloyd, J. 1973. Effects of temperature and time on viability of stored gametes of steelhead and cutthroat trout. MS Thesis, Humboldt St. College, Arcata, CA. 29 p.
Steelhead, Cutthroat Trout, Culture, Eggs-Embryos, Mad, CA

Loftus, K. H. 1976. Science for Canada's fisheries rehabilitation needs. J. Fish. Res. Bd. Can. 33:1822-1857.
Chinook Salmon, Chum Salmon, Coho Salmon, Pink Salmon, Sockeye Salmon, Steelhead, Culture, Management, Pollution, PAC

Long, C. W., F. J. Ossiander, T. E. Ruehle, and G. M. Matthews. 1975. Survival of coho salmon fingerlings passing through turbines & steelhead fingerlings passing through spillways. Final Prog. Rept. to U.S. Army Corps of Eng., Nat. Mar. Fish. Serv., Seattle, WA
Coho Salmon, Steelhead, Dams, Juvenile, WA

Long, J. B., and L. E. Griffin. 1937. Spawning and migratory habits of Columbia River steelhead trout as determined by scale studies. Copeia 1937:62.
Steelhead, Life History, WA

MacPhee, C., and F. C. Cheng. 1975. Lethal effects of 2008 chemicals upon steelhead, sockeye salmon and threespine stickleback. Alaska fish and Game Dept. 10 p.
Sockeye Salmon, Steelhead, Pollution, AL

MacPhee, C., and R. Ruelle. 1969. Lethal effects of 1888 chemicals upon four species of fish from Western North America. For., Wildl., and Range Exp. Sta. Bull. No. 3, Moscow, ID. 112 p.
Steelhead, Pollution, ID

Maher, F. P., and P. A. Larkin. 1954. Life history of the steelhead trout of the Chilliwack River, British Columbia. Trans. Am. Fish. Soc. 84: 27-38.
Winter Steelhead, Juvenile, Life History, Management, Migration, BC

Mains, J. E., and J. M. Smith. 1956. Determination of the normal stream distribution, size, time & current preferences of downstream migrating salmon & steelhead. Wash. Dept. Fish., Prog. Rept., Corps of Engineers Fish. Engineering Res. Program:14-25.
Salmon, Steelhead, Juvenile, Migration, WA

Manzer, J. I. 1968. Food of Pacific salmon and steelhead trout in the northeast Pacific Ocean. J. Fish. Res. Bd. Can. 25:1085-1089.
Coho Salmon, Pink Salmon, Sockeye Salmon, Steelhead, Ecology, PAC

Matthews, G. M., G. A. Swan, and J. R. Smith. 1977. Improved bypass and collection system for protection of juvenile salmon and steelhead trout at Lower Granite Dam. Mar. Fish. Rev. 39(7):10-14.
Salmon, Steelhead, Culture, Dams, Juvenile, WA

McBride, J., G. Strasdine, and U. H. M. Fagerland. 1975. Acute toxicity of kanamycin to steelhead trout (Salmo gairdneri). J. Fish. Res. Bd. Can. 32:554-558.
Steelhead, Juvenile, Pollution, BC

McCuddin, M. E. 1977. Survival of salmon and trout embryos and fry in gravel-sand mixtures. MS Thesis, Univ. of Idaho, Moscow, ID.
Salmon, Steelhead, Eggs-Embryos, Juvenile, ID

McIntyre, J. D. 1973. Toxicity of methyl mercury for steelhead trout sperm. Bull. of Environ. Contam. and Toxicol. 9:98-99.
Steelhead, Eggs-Embryos, Pollution, OR

McIntyre, J. D., and J. M. Blanc. 1973. A genetic analysis of hatching time in steelhead trout (Salmo gairdneri). J. Fish. Res. Bd. Can. 30:137-139.
Steelhead, Eggs-Embryos, OR

McKern, J. L. 1971. Steelhead trout otoliths for age, race, and stock analysis. MS Thesis, Oregon St. University, Corvallis, OR. 55 p.
Summer Steelhead, Winter Steelhead, Culture, Racial, OR

McKern, J. L., and H. F. Horton. 1970. A punch to facilitate the removal of salmonid otoliths. Calif. Fish and Game 56:65-68.
Salmon, Steelhead, Culture, CA

McKern, J. L., H. F. Horton, and K. V. Koski. 1974. Devel. of steelhead otoliths & usages for age analysis & for separating summer from winter races & wild from hatchery stock. J. Fish. Res. Bd. Can. 31:1420-1426.
Summer Steelhead, Winter Steelhead, Juvenile, Racial, BC, OR, WA

McMaster, K. N., R. G. White, R. R. Ringe, and T. C. Bjornn. 1977. Effects of reduced nighttime flows on upstream migration of adult chinook salmon & steelhead trout in the Lower Snake River. MS Thesis, Univ. of Idaho, Moscow, Id.
Chinook Salmon, Steelhead, Ecology, Migration, Pollution, WA

Meacham, C. P. 1973. Water impoundment and diversion structures and their effect on salmon and steelhead in California. MS Thesis, Humboldt St. College, Arcata, Ca. 67 p.
Salmon, Steelhead, Dams, Management, Migration, Eel, Klamath, Mad, Trinity, CA

Meade, T. L., and S. J. Perrone. 1980. Selective haematological parameters in steelhead trout, Salmo gairdneri Richardson. J. Fish. Biol. 17:9-12.
Steelhead, Physiology

Meigs, R. C., and C. F. Pautzke. 1941. Additional notes on the life history of the Puget Sound steelhead (Salmo gairdnerii). State of Wash. Dept. of Game, Biol. Bull. No. 5. 13 p.
Winter Steelhead, Angling, Life History, Management, WA

Mighell, J. L. 1969. Rapid cold-branding of salmon and trout with liquid nitrogen. J. Fish. Res. Bd. Can. 26:2765-2769.
Chinook Salmon, Coho Salmon, Sockeye Salmon, Steelhead, Culture, WA

Milhe, D. J. 1948. The growth, morphology, and relationship of the species of Pacific salmon and the steelhead trout. Ph.D. Thesis, McGill University, Montreal, Canada. 101 p.
Salmon, Steelhead, Physiology, Racial

Millenbach, C. 1965. Natural rearing pond production of steelhead trout. Pages 166-177 In: Proc. 45th Ann. Conf. West. Ass. State Game Fish Comm., Anchorage, Alaska.
Steelhead, Culture

Milner, G. B. 1977. Biochemical genetic variation: Its use in mixed fishery analysis. Pages 10-15 In: Proc. Genetic Implications of Steelhead Manag. Symp. Ca. Coop. Fish. Res. Unit, HSU, Spec. Rept. 77-1.
Steelhead, Physiology, Racial, WA

Monan, G. E., and K. L. Liscom. 1975. Radio-tracking studies to determine the effect of spillway deflectors on adult chinook salmon and steelhead trout. Nat. Mar. Fish. Serv., Northwest Fish. Center, Seattle, Wash.
Chinook Salmon, Steelhead, Culture, Dams, WA

Mosher, K. H. 1969. Identification of Pacific salmon and steelhead trout by scale characteristics. U.S. Fish and Wildl. Serv., Bur. of Comm. Fish., Circular 317.
Salmon, Steelhead, Culture, Racial

Murphy, L. W., and H. E. Metsleer. 1962. Inventory of Idaho streams containing anadromous fish Inc. Recommended for improving production of salmon and steelhead. Unpub. Rept. to Idaho Dept. Fish and Game. 196 p.
Salmon, Steelhead, Management, Survey, ID

Narver, D. W. 1969. Age and size of steelhead trout in the Babine River, British Columbia. J. Fish. Res. Bd. Can. 26:2754-2760.
Summer Steelhead, Life History, BC

Narver, D. W. 1974. Age and size of Nahmint River summer steelhead in anglers' catcjes. 1973. Fish. and Marine Service, Pac. Biol. Sta., Nanaimo, Brit. Col. Circ. 97. 15 p.
Summer Steelhead, Angling, Life History, BC

Narver, D. W., and F. C. Withler. 1971. Age and size of steelhead trout (Salmo gairdneri) in anglers' catches from Vancouver Island, British Columbia, streams. Fish. and Marine Serv., Pac. Biol. Sta., Nanaimo, Brit. Col. Circ. 91. 26 p.
Winter Steelhead, Angling, Juvenile, Life History, Migration, BC

Neave, F. 1940. The steelhead in the Cowichan River. Prog. Rept. of Fish. Res. Bd. Can. Pac. Coast St. 46:20-21.
Steelhead, BC

Neave, F. 1944. Racial characteristics and migratory habits in salmo gairdneri. J. Fish. Res. Bd. Can. 6:245-251.
Winter Steelhead, Rainbow Trout, Life History, Racial, BC

Nebeker, A. V., J. D. Andros, J. K. McCrady, and D. G. Stevens. 1978. Survival of steelhead trout (Salmo gairdneri) eggs, embryos, and fry in air-supersaturated water. J. Fish. Res. Bd. Can. 35:261-264.
Steelhead, Dams, Eggs-Embryos, OR

Nebeker, A. V., and J. R. Brett. 1976. Effects of air-supersaturated water on survival of Pacific salmon and steelhead smolts. Trans. Am. Fish. Soc. 105:338-342.
Coho Salmon, Sockeye Salmon, Steelhead, Dams, Juvenile, OR

Needham, P. R., and A. C. Taft. 1934. Observations on the spawning of steelhead trout. Trans. Am. Fish. Soc. 64:332-338.
Winter Steelhead, Ecology, CA

Newcomb, T. W. 1974. Changes in blood chemistry of juvenile steelhead trout following sublethal exposure to nitrogen supersaturation. J. Fish. Res. Bd. Can. 31:1953-1957.
Steelhead, Dams, Juvenile, Physiology, WA

Norris, D. O. 1969. Depression of growth following radiothyroidectomy of larval chinook salmon and steelhead trout. Trans. Am. Fish. Soc. 98:104-106.
Chinook Salmon, Steelhead, Juvenile, Physiology, WA

Norris, D. O., and A. Gorbham. 1965. Radiothyroidectomy of larval steelhead trout. Proc. Soc. Exp. Biol. Med. 119:1205-1207.
Steelhead, Juvenile, Physiology, WA

Orcutt, O. D., B. R. Pulliam, and A. Arp. 1968. Characteristics of steelhead trout redds in Idaho streams. Trans. Am. Fish. Soc. 97:42-45.
Winter Steelhead, Ecology, ID

Ott, A. G., and H. F. Horton. 1971. Fertilization of steelhead trout (Salmo gairdneri) eggs with cryo-preserved sperm. J. Fish. Res. Bd. Can. 28:1915-1918.
Steelhead, Culture, Eggs-Embryos, OR

Park, D. L., and W. J. Ebel. 1974. Marking fishes and invertebrates III. Brand size & configuration in relation to long-term retention on steelhead & chinook. Mar. Fish. Rev. 36(7):7-9.
Chinook Salmon, Steelhead, Culture

Park, D. L., and W. E. Farr. 1972. Collection of juvenile salmon and steelhead passing through orifices in gatewells of turbine intakes at Ice Harbor Dam. Trans. Am. Fish. Soc. 101:381-384.
Chinook Salmon, Coho Salmon, Sockeye Salmon, Steelhead, Culture, Dams, Juvenile, WA

Parker, L. A., and P. A. Larkin. 1959. A concept of growth in fishes. J. Fish. Res. Bd. Can. 16:721-745.
Chinook Salmon, Steelhead, Life History, BC

Patten, B. B. 1975. Comparative vulnerability of fry of Pacific salmon and steelhead trout to predation by torrent sculpin in stream aquaria. U.S. Fish and Wildl. Serv., Fish. Bull. 73:931-934.
Chinook Salmon, Chum Salmon, Coho Salmon, Pink Salmon, Sockeye Salmon, Steelhead, Ecology, Juvenile, WA

Paulik, J. G., and A. C. Delacy. 1957. Swimming abilities of upstream migrant silver salmon, sockeye salmon and steelhead at several water velocities. Univ. of Wash. School of Fish. Tech. Rept. No. 44. 38 p.
Coho Salmon, Sockeye Salmon, Steelhead, Migration, WA

Pautzke, C. F. 1938. Studies on the effect of coal washings on steelhead and cutthroat. Trans. Am. Fish. Soc. 67:232-233.
Steelhead, Cutthroat Trout, Juvenile, Pollution, WA

Pautzke, C. F., and R. C. Meigs. 1940. Studies on the life history of the Puget Sound steelhead (Salmo gairdnerii). Trans. Am. Fish. Soc. 70:209-220.
Winter Steelhead, Angling, Culture, Juvenile, Life History, Management, Migration, WA

Peters, G. B., H. J. Dawson, B. F. Hrutfiord, and R. R. Whitney. 1976. Aqueous leachate from western red cedar: effects on some aquatic organisms. J. Fish. Res. Bd. Can. 33:2703-2709.
Coho Salmon, Steelhead, Eggs-Embryos, Juvenile, Pollution, WA

Peterson, N. R. 1977. Biological characteristics of wild and hatchery steelhead trout, Salmo gairdneri, in two Oregon rivers. Page 42 In: Proc. Genetic Implications of Steelhead Manag. Symp. Ca. Coop. Fish. Res. Unit, HSU, Spec. Rept. 77-1.
Summer Steelhead, Winter Steelhead, Management, Racial, OR

Pettit, S. W. 1977. Comparative reproductive success of caught-and-released & unplayed hatchery female steelhead from the Clearwater River. Trans. Am. Fish. Soc. 106:431-435.
Summer Steelhead, Angling, Eggs-Embryos, ID

Phillips, R. W., and H. J. Campbell. 1962. The embryonic survival of coho salmon and steelhead trout as influenced by some environmental conditions in gravel beds. Pac. Mar. Fish. Comm. Annual Rept. 14:60-73.
Coho Salmon, Steelhead, Eggs-Embryos

Phillips, R. W., R. L. Lantz, E. W. Claire, and J. R. Moring. 1975. Some effects of gravel mixtures on emergence of coho salmon and steelhead trout fry. Trans. Am. Fish. Soc. 104:461-466.
Coho Salmon, Steelhead, Eggs-Embryos, OR

Phinney, D. E., and G. Deschamps. 1970. The use of mesh restrictions to minimize the steelhead catch in the Grays Harbor gillnet fishery for salmon. Wash. Dept. Fish. Res. Pap. 3(2):19-28.
Salmon, Steelhead, Management, WA

Pinsent, M. E. 1971. Population size and some other characteristics of steelhead in the Babine River, B.C. Unpub. Rept. to Brit. Col. Fish and Wildlife, File:42-02.
Steelhead, BC

Platts, W. S. 1972. The effects of heavy metals on anadromous runs of salmon and steelhead in the Panther Creek Drainage, Idaho. Pages 582-597 In: West. Proc. 52nd Ann. Conf. West. Assn. State Game Fish Comm., July 10-13, 1973.
Chinook Salmon, Steelhead, Pollution, ID

Platts, W. S. 1975. Timetrends in Riverbed sediment composition in salmon and steelhead spawning areas: South Fork Salmon River. Pages 229-239 In: Trans. 40th North Amer. Wildl. and Natur. Resources Conf.
Chinook Salmon, Steelhead, Ecology, Pollution, ID

Platts, W. S. 1979. Including the fishery system in land planning. USDA For. Serv. General Tech. Rept. INT-60.
Chinook Salmon, Ecology, ID

Platts, W. S., and F. E. Partridge. 1978. Rearing of chinook salmon in tributaries of the South Fork Salmon River, Idaho. USDA For. Serv. Research Paper INT-205.
Chinook Salmon, Ecology, ID

Pollard, H. 1969. Effects of planted trout and angling on juvenile steelhead trout. MS Thesis, Univ. of Idaho, Moscow, Id. 52 p.
Winter Steelhead, Rainbow Trout, Angling, Ecology, Juvenile, Management, ID

Pollard, H., and T. C. Bjornn. 1973. The effects of angling and hatchery trout on the abundance of juvenile steelhead trout. Trans. Am. Fish. Soc. 102:745-752.
Winter Steelhead, Rainbow Trout, Angling, Ecology, Juvenile, Management, ID

Prakash, A. 1961. Distribution and differentiation of alkaline phosphatase in the gastro-intestinal tract of steelhead trout. J. Exp. Zool. 146:237-251.
Steelhead, Eggs-Embryos, Juvenile, Physiology, BC

Puckett, L. K. 1975. The status of spring-run steelhead (Salmo gairdneri) of the Eel River system. Dept. of water resources and Dept. of Fish and Game Memorandum Rept. 22 p.
Summer Steelhead, Angling, Culture, Ecology, Life History, Management, Migration, Survey, Eel, CA

Puckett, L. K., R. Blake, and J. Horton. 1968. Summer run steelhead, are they here to stay? Outdoor California 29(1):3-4.
Summer Steelhead, Management, CA

Pugh, J. R., G. E. Monan, and J. R. Smith. 1971. Effect of water velocity on the fish guiding efficiency of an electrical guiding system. U.S. Fish and Wildl. Serv., Fish. Bull. 68:307-324.
Chinook Salmon, Coho Salmon, Steelhead, Culture, Dams, Juvenile, WA

Quinn, W. W., and J. T. Allen. 1969. Downstream migrant fish trapping operations, Nicasio Creek, Marin County, Calif. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 69-3. 14 p.
Coho Salmon, Winter Steelhead, Culture, Juvenile, Migration, CA

Raymond, H. L. 1970. A summary of the 1969 and 1970 outmigrations of juvenile chinook salmon and steelhead trout from the Snake River. Bur. of Comm. Fish. Biol. Lab., Seattle, Wa.
Chinook Salmon, Steelhead, Juvenile, Migration, WA

Raymond, H. L. 1975. Snake River runs of salmon and steelhead trout: Trends in abundance of adults and downstream survival of juveniles. NOAA, Nat. Mar. Fish. Serv., Seattle, Wa. 11 p.
Salmon, Steelhead, Juvenile, Management, Migration, WA

Raymond, H. L. 1979. Effects of dams and impoundments on migrations of juvenile chinook salmon & steelhead from the Snake River, 1966 to 1975. Trans. Am. Fish. Soc. 108:505-529.
Chinook Salmon, Steelhead, Dams, Ecology, Juvenile, Migration, WA

Redding, J. M., and C. B. Shreck. 1979. Possible adaptive significance of certain enzyme polymorphisms in steelhead trout (Salmo gairdneri). J. Fish. Res. Bd. Can. 36:544-551.
Winter Steelhead, Juvenile, Physiology, Racial, OR

Reeves, G. 1979. Population dynamics of juvenile steelhead trout in relation to density and habitat characteristics. MS Thesis, Humboldt St. College, Arcata, CA. 67 p.
Winter Steelhead, Ecology, Juvenile, Migration, Mad, CA

Reingold, M. 1964. Movement of juvenile steelhead between tributary and mainstem streams. Proj. No. 1-000-07-Segment 2. Idaho Fish and Game Dept.
Steelhead, Ecology, Juvenile, Migration, ID

Reingold, M. 1965. Steelhead spawning study. Idaho Wildl. Rev. Jan.-Feb., 1965.
Winter Steelhead, Ecology, ID

Reingold, M. 1968. Water temperature affects the ripening of adult fall chinook salmon and steelhead. Prog. Fish Cult. 30:41-42.
Chinook Salmon, Summer Steelhead, Culture, Eggs-Embryos, ID

Reingold, M. 1975. Effects of displacing, hooking, and releasing on migrating adult steelhead trout. Trans. Am. Fish. Soc. 104:458-460.
Steelhead, Angling, Migration, ID

Reisenbichler, R. R. 1977. Effects of artificial propagation of anadromous salmonids on wild populations. Pages 2-3 In: Proc. Genetic Implications of Steelhead Manag. Symp. Ca. Coop. Fish. Res. Unit, HSU, Spec. Rept. 77-1.
Steelhead, Management, Racial, OR

Reisenbichler, R. R., and J. D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, Salmo gairdneri. J. Fish. Res. Bd. Can. 34:123-128.
Summer Steelhead, Eggs-Embryos, Juvenile, Management, Racial, OR

Ricker, W. E. 1959. Evidence for environmental and genetic influence on certain characters which distinguish stocks of salmon and steelhead. Fish. Res. Bd. Can., Nanaimo, Brit. Col., Manuscript Series. 129 p.
Chinook, Chum, Coho, Sockeye Salmon, Steelhead, Angling, Juvenile, Life History, Management, Migration, Racial, PAC

Rivers, C. M. 1955. Steelhead of the Rogue River system with special reference to management programs and related studies from 1941 to 1954. Unpub. Rept., Oreg. St. Univ., Corvallis, Or. 81 p.
Steelhead, Management, OR

Rivers, C. M. 1964. Rogue River report--steelhead. Unpub. Rept. to Oreg. St. Comm. 24 p.
Steelhead, OR

Rothfus, L. O., W. D. Ward, and E. Jewell. 1956. Grays River steelhead trout population study, Dec. 1955 - April 1956. Part II: Columbia R. Steelhead Enumeration. Unpub. Rept. to Wash. Dept. of Fish. 11 p.
Steelhead, WA

Rybock, J. T., H. F. Horton, and J. L. Fessler. 1975. Use of otoliths to separate juvenile steelhead trout from juvenile rainbow trout. U.S. Fish and Wildl. Serv., Fish. Bull. 73:654-659.
Summer Steelhead, Rainbow Trout, Eggs-Embryos, Juvenile, Racial, OR

Sanders, J. E., K. S. Pilcher, and J. L. Fryer. 1978. Relation of water temperature to bacterial kidney disease in coho salmon, sockeye salmon, and steelhead trout. J. Fish. Res. Bd. Can. 35:8-11.
Coho Salmon, Sockeye Salmon, Steelhead, Diseases, Juvenile, OR

Sazaki, M., W. Heubach, and J. E. Skinner. 1973. Some preliminary results on the swimming ability & impingement tolerance of young-of-the-year steelhead and king salmon. Final Rept. for Anad. Fish. Act Proj. Calif. AFS-13, Development of fish screen design criteria. 31 p.
Chinook Salmon, Winter Steelhead, Culture, Juvenile, CA

Scholz, A. T., R. M. Horrall, J. C. Cooper, A. D. Hasler, and D. M. Madison. 1975. Artificial imprinting of salmon and trout in Lake Michigan. Wis. Dep. Nat. Res., Fish Management Rept. No. 80. 45 p.
Salmon, Steelhead, Trout, Culture, Migration

Sekulich, P. T., and T. C. Bjornn. 1977. The carrying capacity of streams for rearing salmonids as affected by components of the habitat. Compl. Rept. for Suppl. 99, USDA, US Forest Service. 79 p.
Salmon, Steelhead, Ecology, Juvenile, ID

Shapovalov, L. 1937. Experiments in hatching steelhead eggs in gravel. Calif. Fish and Game 23:208-214.
Winter Steelhead, Eggs-Embryos, CA

Shapovalov, L. 1946. The management of a relatively small coastal steelhead stream system, with special reference to Big Creek, California. Calif. Dept. Fish and Game, Inl. Fish. Br. Admin. Rept. No. 46-2. 14 p.
Winter Steelhead, Management, CA

Shapovalov, L. 1953. An evaluation of steelhead and salmon management in California. Calif. Dept. Fish and Game, Inl. Fish. Br. Admin. Rept. No. 53-4. 54 p.
Salmon, Winter Steelhead, Angling, Culture, Ecology, Juvenile, Management, CA, PAC

Shapovalov, L. 1954. An analysis of the effect of an extended angling season on California steelhead runs. Calif. Dept. Fish and Game, Inl. Fish Br. Admin. Rept. No. 54-2. 11 p.
Winter Steelhead, Angling, Life History, Management, Migration, Eel, CA

Shapovalov, L. 1967. Biology and management of steelhead trout in California. Calif. Dept. Fish and Game, Inl. Fish. Br. Admin. Rept. No. 67-7. 6 p.

Shapovalov, L., and A. C. Taft. 1954. Life histories of the steelhead and silver salmon with special reference to Waddell Creek. California. Calif. Dept. Fish and Game, Fish Bull. 98. 375 p.
Coho Salmon, Winter Steelhead, Angling, Diseases, Ecology, Eggs-Embryos, Juvenile, Management, Migration, Eel, CA

Sheppard, D. 1972. The present status of the steelhead trout stocks along the Pacific Coast. MS Thesis, Univ. of Washington, Seattle, Wa.
Winter Steelhead, Angling, Culture, Juvenile, Life History, Management, Migration, PAC

Sholes, W. 1979. Narrative report of the Middle Fork Eel River summer steelhead survey. File Rept. to USFS, Mendocino Nat. Forest, California.
Summer Steelhead, Ecology, Management, Eel, CA

Shumway, D. L., C. E. Warrne, and P. Duodoroff. 1964. Influence of oxygen concentration and water movement on the growth of steelhead trout and coho salmon embryos. Trans. Am. Fish. Soc. 93:342-356.
Coho Salmon, Steelhead, Eggs-Embryos, OR

Sigler, J. W., and T. C. Bjornn. 1979. Effects of chronic turbidity on feeding, growth, and social behavior of steelhead trout and coho salmon. Rept. to USDA For. Serv. Pac. NW For. and Range Exp. Sta. 28 p.
Coho Salmon, Steelhead, Pollution, ID

Silver, S. J., C. E. Warrne, and P. Doudoroff. 1963. Dissolved oxygen requirements of developing steelhead trout and chinook salmon embryos at differing water velocities. Trans. Am. Fish. Sox. 92:327-343.
Chinook Salmon, Steelhead, Eggs-Embryos, OR

Simpson, J. L., and T. C. Bjornn. 1965. Methods used to estimate salmon and steelhead harvests in Idaho. Pages 217-226 In: Proc. 45th Ann. Conf. West. Assoc. State Game Fish Comm., Anchorage, Alaska.
Salmon, Steelhead, Angling, Culture, ID

Sims, C. W., W. W. Bentley, and R. C. Johnsen. 1977. Effects of power peaking operations on juvenile salmon and steelhead trout migrations--progress 1976. Nat. Mar. Fish. Serv., Northwest Fish. Center, Seattle. Rept. to U.S. Army Corps of Eng. 19 p.
Salmon, Steelhead, Dams, Juvenile, Migration, WA

Slatick, E. 1970. Passage of adult salmon and trout through pipes. U.S. Fish and Wildl. Serv., Special Scientific Rept.--Fisheries No. 592. 18 p.
Chinook Salmon, Coho Salmon, Sockeye Salmon, Steelhead, Culture, Dams, Migration, WA

Slatick, E. 1971. Passage of adult salmon and trout through an inclined pipe. Trans. Am. Fish. Soc. 100:448-455.
Chinook Salmon, Coho Salmon, Sockeye Salmon, Summer Steelhead, Culture, Dams, Migration, WA

Slatick, E. 1976. Comparative retention of dart and jaw tags on chinook salmon and steelhead trout during their spawning migration. Mar. Fish. Rev. 38(7):24-26.
Chinook Salmon, Coho Salmon, Sockeye Salmon, Steelhead, Culture, Dams, Migration, WA

Slatick, E., D. L. Park, and W. J. Ebel. 1975. Further studies regarding effects of transportation on survival and homing of Snake River chinook salmon and steelhead. U.S. Fish and Wildl. Serv., Fish. Bull. 73:925-931.
Chinook Salmon, Steelhead, Culture, Dams, Juvenile, Migration, WA

Smith, A. K. 1973. Development and application of spawning velocity and depth criteria for Oregon salmonids. Trans. Am. Fish. Soc. 102:312-316.
Chinook, Chum, Coho Salmon, Summer Steelhead, Winter Steelhead, Brook Trout, Brown Trout, Rainbow Trout, Ecology, OR

Smith, A. K., B. P. McPhearson, S. P. Cramer, and J. T. Martin. 1978. Adult salmonid studies. Rogue evaluation program. Prog. Rep. Oreg. Dept. Fish and Wildl. Res. Sec. 78 p.
Chinook Salmon, Summer Steelhead, Angling, Dams, Ecology, Juvenile, Migration, OR

Smith, A. K., B. P. McPhearson, S. P. Cramer, and J. T. Martin. 1979. Adult salmonid studies. Rogue evaluation program. Prog. Rep. Oreg. Dept. Fish and Wildl. Res. Sec. 117 p.
Chinook Salmon, Summer Steelhead, Angling, Dams, Ecology, Juvenile, Migration, OR

Smith, C. L. 1980. Attitudes about the value of steelhead and salmon angling. Trans. Am. Fish. Soc. 109:272-281.
Salmon, Steelhead, Angling, Management, WA

Smith, J. R. 1974. Distribution of seaward-migrating chinook salmon and steelhead trout in the Snake River above monumental dam. Mar. Fish. Rev. 36(8):42-45.
Chinook Salmon, Steelhead, Dams, Juvenile, Migration, WA

Smith, J. R., and L. J. Weber. 1976. The regulation of day-night changes in hydroxyindole-o-methyltransferase activity in the pineal gland of steelhead trout. Can. J. Zool. 54:1530-1534.
Winter Steelhead, Juvenile, Physiology, OR

Smith, R. T., and E. Quistorff. 1943. Experiments with the spermatozoa of the steelhead, Salmo gairdnerii, and the chinook salmon, Oncorhynchus tshawyscha. Copeia 1:164-167.
Chinook Salmon, Steelhead, Culture, Eggs-Embryos, WA

Smith, S. B. 1960. A note on two stocks of steelhead trout (Salmo gairdnerii) in Capilano River, British Columbia. J. Fish. Res. Bd. Can. 17:739-742.
Summer Steelhead, Winter Steelhead, Racial, BC

Smith, S. B. 1968. Racial characteristics in stocks of anadromous rainbow trout, Salmo gairdneri Richardson. Ph.D. Thesis, Univ. of Alberta, Edmonton, Alberta. 160 p.
Summer Steelhead, Winter Steelhead, Racial

Smith, S. B. 1969. Reproductive isolation in summer and winter races of steelhead trout. Pages 21-38 In: T. Northcote (Ed.) Symposium on Salmon and Trout in Streams. Univ. of Brit. Col., Vancouver.
Summer Steelhead, Winter Steelhead, Racial, BC

Snyder, J. O. 1921. Steelhead caught at sea off the coast near Fort Bragg. Calif. Dept. Fish and Game 7:9-11.
Summer Steelhead, Migration, CA

Snyder, J. O. 1925. The half-pounder of Eel River, a steelhead trout. Calif. Fish and Game 11:49-55.
Summer Steelhead, Ecology, Life History, Migration, Eel, Klamath, CA

Snyder, J. O. 1933. A steelhead migration in Shasta River. Calif. Fish and Game 19:252-254.
Winter Steelhead, Migration, Klamath, CA

Southward, G. M., and J. Douglas. 1972. Evaluation of winter steelhead fishery on a western Washington river. Trans. Am. Fish. Soc. 101:29-34.
Winter Steelhead, Angling, Racial, WA

Stabler, D. F., R. R. Ringe, R. G. White, and T. C. Bjornn. 1976. The effects of altered flow regines, temperatures, and river impoundment on adult steelhead trout and chinook salmon. Prog. Rept. on DACW 68-75-C-0046. Dec. 1975 to Dec. 1976. 14 p.
Chinook Salmon, Steelhead, Dams, Pollution, ID

Staley, J. R. 1976. American River steelhead (Salmo gairdnerii gairdnerii) management, 1956-1974. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Rept. No. 76-2. 41 p.
Summer Steelhead, Winter Steelhead, Angling, Life History, Management, Migration, CA

Stevens, D. G., A. V. Nebeker, and R. J. Baker. 1980. Avoidance responses of salmon and trout to air-supersaturated water. Trans. Am. Fish. Soc. 109:751-754.
Chinook Salmon, Coho Salmon, Sockeye Salmon, Steelhead, Rainbow Trout, Dams, Juvenile, OR

Stroud, R. K., and A. V. Nebeker. 1975. A study of the pathogenesis of gas bubble in steelhead trout. Pages 66-71 In: Proc. gas-Bubble Disease Workshop, Battelle Northwest, Richland, Wa.
Steelhead, Dams, Juvenile, OR

Stuehrenberg, L. C. 1974. The effects of granitic sand on the distribution and abundance of salmonids in Idaho streams. MS Thesis, Univ. of Idaho, Moscow, Id. 47 p.
Chinook Salmon, Steelhead, Ecology, Juvenile, Pollution, ID

Sumner, F. H. 1948. Age and growth of steelhead trout caught by sport and commercial fishermen in Tillamook County, Oregon. Trans. Am. Fish. Soc. 75:77-83.
Winter Steelhead, Angling, Life History, WA

Sumner, F. H. 1952. Migrations of salmonids in Sand Creek, Oregon. Trans. Am. Fish. Soc. 82:139-150.
Chum Salmon, Coho Salmon, Winter Steelhead, Juvenile, Migration, OR

Sutherland, D. F. 1973. Distribution, seasonal abundance and some biological features of steelhead trout in the North Pacific Ocean. U.S. Fish and Wildl. Serv., Fish. Bull. 71:787-826.
Steelhead, Angling, Ecology, Life History, PAC

Taft, A. C. 1933. California steelhead trout problems. Calif. Fish and Game 19:192-198.
Winter Steelhead, Angling, Juvenile, Management, Eel, Klamath, CA

Taft, A. C. 1934. California steelhead experiments. Trans. Amer. Fish. Soc. 64:248-251.
Coho Salmon, Winter Steelhead, Juvenile, Migration, CA

Taft, A. C., and L. Shapovalov. 1938. Homing instinct and straying among steelhead trout (Salmo gairdnerii) and silver salmon (Oncorhynchus kisutch). Calif. Fish and Game 24:118-125.
Coho Salmon, Winter Steelhead, Migration, Klamath, CA

Taylor, G. T., and R. J. Lebrasseur. 1957. Distribution, age and food of steelhead trout, Salmo gairdneri, caught in the northeast Pacific Ocean, 1956. J. Fish. Res. Bd. Can., Pac. Prog. Rept. 109:9-11.
Steelhead, Ecology, PAC

Technical Committee. 1966. Status of major North American stocks of Pacific salmon and steelhead. Pac. Salmon Inter-Agency Council Rept. No. 4. 143 p.
Salmon, Steelhead

Thomas, R. C. 1971. The British Columbia steelhead sport fishery. British Columbia Fish and Wildlife Tech. Circ. No. 6.
Steelhead, Angling, BC

Thomsen, W., C. R. Hazel, and S. J. Meith. 1970. Toxicity of copper and zinc ions to steelhead in Mokelumne River water. Calif. Dept. Fish and Game, Water Proj. Br. Lab Rept. 50 p.
Winter Steelhead, Pollution, CA

Thorgaard, G. H. 1977. Chromosome studies of steelhead. Pages 20-25 In: Proc. Genetic Implications of Steelhead Manag. Symp. Ca. Coop. Fish. Res. Unit, HSU, Spec. Rept. 77-1.
Wummer Steelhead, Winter Steelhead, Physiology, Racial, PAC

Tomlinson, N., S. E. Geiger, and W. W. Kay. 1964. Apparent onset of rigor mortis in steelhead trout in the absence of loss of ATP from the ordinary muscle. J. Fish. Res. Bd. Can. 21:857-859.
Steelhead, Physiology, BC

Tsuyuki, H., and S. N. Williscroft. 1973. The PH activity relations of two LDH homotetramers from trout liver and their physiological significance. J. Fish. Res. Bd. Can. 30:1023-1026.
Steelhead, Physiology, BC

Tsuyuki, H., and S. N. Williscroft. 1977. Swimming stamina differences between genotypically distinct forms of rainbow (Salmo gairdneri) and steelhead trout. J. Fish. Res. Bd. Can. 34:996-1003.
Steelhead, Rainbow Trout, Physiology, Racial, BC

Utter, F. M., and F. W. Allendorf. 1977. Determination of the breeding structure of steelhead populations through gene frequency analysis. Pages 44-54 In: Proc. Genetic Implications of Steelhead Manage. Symp. Ca. Coop. Fish. Res. Unit, HSU, Spec. Rept. 77-1.
Steelhead, Trout, Racial, PAC

Van Kirk, R. R. 1977. Klamath River fishery; an introductory study. Unpub. Rept. to the Ad Hoc Fishing Comm. Representing the Klamath River Indians. 24 p.
Chinook Salmon, Coho Salmon, Steelhead, Management. Pollution, Klamath, Trinity, CA

Van Woert, W. 1957. Time pattern of migration of adult salmon and steelhead into the upper Sacramento River during the 1956-1957 season. Calif. Dept. Fish and Game, Inl. Fish. Br. Admin. Rept. No. 57-19. 5 p.
Chinook Salmon, Coho Salmon, Winter Steelhead, Migration, CA

Vernon, E. H., and R. G. McMynn. 1957. Scale characteristics of yearling coastal cutthroat and steelhead trout. J. Fish. Res. Bd. Can. 14: 203-212.
Winter Steelhead, Cutthroat Trout, Juvenile, Racial, BC

Wagner, H. H. 1967. A summary of investigations of the use of hatchery-reared steelhead in the management of a sport fishery. Oreg. St. Game Comm., Res. Div., Fish. Rept. No. 5. 62 p.
Winter Steelhead, Angling, Culture, Juvenile, Management, OR

Wagner, H. H. 1968. Effect of stocking time on survival of steelhead trout, Salmo gairdneri, in Oregon. Trans. Am. Fish. Soc. 97:374-379.
Winter Steelhead, Juvenile, Management, Migration, Parr-Smolt, OR

Wagner, H. H. 1969. Effect of stocking location of juvenile steelhead trout, Salmo gairdneri, on adult catch. Trans. Am. Fish. Soc. 98:27-34.
Winter Steelhead, Angling, Juvenile, Migration, OR

Wagner, H. H. 1970. The parr-smolt metamorphosis in steelhead trout as effected by photoperiod and temperature. Ph.D. Thesis, Oregon St. University, Corvallis, Or. 177 p.
Steelhead, Parr-Smolt, OR

Wagner, H. H. 1970. Winter steelhead investigations. Pages 8-9 In: Prog. in Game and Sport Fishery Research, 1963-1970. Rept. to Res. Div., Oreg. St. Game Comm.
Winter Steelhead, OR

Wagner, H. H. 1974. Photoperiod and temperature regulation of smolting in steelhead trout (Salmo gairdneri). Can. J. Zool. 52:219-234.
Winter Steelhead, Parr-Smolt, OR

Wagner, H. H. 1974. Seawater adaptation independent of photoperiod in steelhead trout (Salmo gairdneri). Can. J. Zool. 52:805-812.
Winter Steelhead, Parr-Smolt, OR

Wagner, H., and J. Haxton. 1968. Observations on the migration disposition of summer steelhead reared at Oak Springs and Wizard Fall hatcheries. Oreg. St. Came Comm., Res. Div. Prog. Rept. 5 p.
Summer Steelhead, Migration, OR

Wagner, H. H., R. L. Wallace, and H. J. Campbell. 1963. The seaward migration and return of hatchery-reared steelhead, Salmo gairdneri Richardson, in the Alsea River, Oregon. Trans. Am. Fish. Soc. 92:202-210.
Winter Steelhead, Juvenile, Management, Migration, OR

Wales, J. H. 1938. Mortality in young Eel River steelhead. Calif. Dept. Fish and Game, Inl. Fish. Br. Admin. Rept. No. 38-10. 10 p.
Steelhead, Diseases, Juvenile, Eel, CA

Wales, J. H. 1941. Development of steelhead trout eggs. Calif. Fish and Game 27:250-260.
Winter Steelhead, Culture, Eggs-Embryos, CA

Wallis, J. 1968. Recommended time, size and age for relase of hatchery reared salmon and steelhead trout. Oreg. Fish. Comm., Res. Div., Clackamas, Or. 61 p.
Chinook Salmon, Chum Salmon, Coho Salmon, Steelhead, Culture, Juvenile, Migration, OR

Warren, C. E., P. Doudoroff, and D. L. Shumway. 1973. Development of dissolved oxygen criteria for freshwater fish. EPA, Ecol. Res. Ser. EPA-R3-73-019. 122 p.
Steelhead, Pollution

Washington, P. M. 1970. Occurrence on the high seas of a steelhead trout in its ninth year. Calif. Fish and Game 56:312-314.
Steelhead, Life History, PAC

Washington, State of, Department of Fisheries. 1938. Report of the preliminary investigations into the possible methods of preserving the Columbia River salmon and steelhead. State of Washington, Dept. of Fish. Spec. Rept. 121 p.
Salmon, Steelhead, Dams, Management, WA

Weaver, C. R. 1963. Influence of water velocity upon orientation and performance of adult migrating salmonids. U.S. Fish and Wildl. Serv., Fish. Bull. 63:97-121.
Chinook Salmon, Coho Salmon, Steelhead, Migration, WA

Weber, D. D., and M. H. Schiewe. 1976. Morphology and function of the lateral line of juvenile steelhead trout in relation to gas-bubble disease. J. Fish Biol. 9:217-233.
Steelhead, Dams, Juvenile, OR

Weber, W. G., and J. D. Fortune, Jr. 1974. Siletz River summer steelhead study. Anad. Fish Program (PL-89-304), Oreg. St. Game Comm. 121 p.
Summer Steelhead, OR

Wedemeyer, G. 1972. Some physiological consequences of handling stress in the juvenile coho salmon and steelhead trout. J. Fish. Res. Bd. Can. 29:1780-1783.
Coho Salmon, Steelhead, Juvenile, Physiology, WA

Wedemeyer, G. 1973. Some physiological aspects of sublethal heat stress in the juvenile steelhead trout (Salmo gairdneri) and coho salmon. J. Fish. Res. Bd. Can. 30:831-834.
Coho Salmon, Steelhead, Physiology, Pollution, WA

Wedemeyer, G., and W. T. Yasutake. 1974. Stress of formalin treatment in juvenile spring chinook salmon (Oncorhynchus tshawytscha) and steelhead trout. J. Fish. Res. Bd. Can. 31:179-184.
Chinook Salmon, Steelhead, Culture, Physiology, WA

Wedemeyer, G., and W. T. Yasutake. 1978. Prevention and treatment of nitrate toxicity in juvenile steelhead trout (Salmo gairdneri). J. Fish. Res. Bd. Can. 35:822-827.
Steelhead, Juvenile, Physiology, Pollution, WA

Whitt, C. R. The age, growth, and migration of steelhead trout in the Clearwater River, Idaho. MS Thesis, Univ. of Idaho, Moscow, ID. 67 p.
Steelhead, Juvenile, Life History, Migration, ID

Whitt, C. R., and V. S. Pratt. 1955. Age and migration of the Clearwater River steelhead. Idaho Wildl. Rev. 7(6):5-7.
Summer Steelhead, Winter Steelhead, Life History, Migration, ID

Whoriskey, F. G., Jr., R. J. Naiman, and P. H. Heinermann. 1981. Steelhead trout (Salmo gairdneri) on the north shore of the Gulf of St. Lawrence, near Sept-Iles, Quebec. Can. J. Fish. Aq. Sci. 38:245-246.
Steelhead, Ecology, Management

Wingfield, W. H., L. Nims, J. L. Fryer, and K. S. Pilcher. 1970. Species specificity of the sockeye salmon virus (Oregon strain) and its cytopathic effects in salmonid cell lines. Reprint From: A Symposium on Diseases of Fishes and Shellfishes. Spec. Pub. No. 5, Amer. Fish. Soc., Washington, D.C.
Sockeye Salmon, Steelhead, Diseases

Winter, G. W., C. B. Schreck, and J. D. McIntyre. 1980. Meristic comparison of four stocks of steelhead trout (Salmo gairdneri). Copeia 1980:160-162.
Summer Steelhead, Winter Steelhead, Racial, OR

Winter, J. D. 1977. Movements and behavior of largemouth bass (<u>Micropterus salmoides</u>) and steelhead determined by radio telemetry. From Diss. Abstr. Int. B Sci. Eng. 37(12). 200 p.
Steelhead, Culture, Ecology, Migration

Withler, F. C. 1972. Research needs for intensive management of British Columbia steelhead. Fish. Res. Bd. Can., Pac. Biol. Sta., Nanaimo, Brit. Col., Circular No. 92. 41 p.
Summer Steelhead, Winter Steelhead, Angling, Management, PAC

Withler, I. L. 1966. Variability in life history characteristics of steelhead trout along the Pacific coast of North America. J. Fish. Res. Bd. Can. 23:365-393.
Summer Steelhead, Winter Steelhead, Life History, Migration, Racial, BC, PAC

Zaugg, W. S., B. L. Adams, and L. R. McLain. 1972. Steelhead migration: Potential temperature effects as indicated by gill adenosine triphosphatase activities. Science 176:415-416.
Steelhead, Migration, Parr-Smolt, Pollution, WA

Zaugg, W. S., and L. R. McLain. 1972. Changes in gill ATP activity associated with parr-smolt transformation in steelhead, coho, and spring chinook salmon. J. Fish. Res. Bd. Can. 29:167-171.
Chinook Salmon, Coho Salmon, Steelhead, Parr-Smolt, WA

Zaugg, W. S., and H. H. Wagner. 1973. ATPase activity related to parr-smolt transformation & migration in steelhead trout: influence of photoperiod & temp. Comp. Biochem. Physiol. 45(4B):955-965.
Winter Steelhead, Parr-Smolt, OR

Appendix B. List of 45 geomorphic variables (after Krupin 1978) used in this watershed analysis of 25 northern California streams.

Drainage Basin Area

Basin Perimeter

Basin Length

Maximum Basin Width

Drainage Density

Stream Frequency

Stream Channel Storage Ratio

Maximum Basin Relief

Relative Relief

Ruggedness Number

Compactness

Form Factor

Shape Factor

Mainstem Length

Miles of 1st Order Streams

Miles of 2nd Order Streams

Miles of 3rd Order Streams

Miles of 4th Order Streams

Miles of 5th Order Streams

Total Stream Miles

Numbers of 1st Order Streams

Numbers of 3rd Order Streams

Numbers of 4th Order Streams

Numbers of 5th Order Streams

Total Stream Numbers

Mean Length of 1st Order Streams

Mean Length of 2nd Order Streams

Mean Length of 3rd Order Streams

Mean Length of 4th Order Streams

Mean Length of 5th Order Streams

Weighted Bifurcation Ratio

Weighted Stream Length Ratio

$\frac{\text{1st Order Stream Length}}{\text{Total Stream Length}}$

$\frac{\text{Number of 1st Order Streams}}{\text{Total Stream Numbers}}$

Numbers of Intermittent Streams

Percent of 1st Order Streams which are Intermittent

Length of Intermittent Streams

Percent of 1st Order Stream Lengths which are Intermittent

Average Gradient of 1st Order Streams

Average Gradient of 2nd Order Streams

Average Gradient of 3rd Order Streams

Average Gradient of 4th Order Streams

Average Gradient of 5th Order Streams

Weighted Mean Channel Gradient

(Continued)

	Basin areas (Mi^2)	Total number of completely intermittent streams	Percent of 1st order streams which are intermittent	Total length of completely intermittent streams (miles)	Percent of 1st order stream lengths which are intermittent (%)	1st order lengths / Total stream length (%)	Number of 1st order streams / Total stream numbers	Drainage density	Stream frequency	R_1/R_B Ratio	Maximum basin relief (feet)	Relative relief	Ruggedness number	Compactness	Form factor	Shape factor
Klamath Drainage																
Blue Creek	127	3	3	2.5	2	62	78	1.32	.99	.112	5682	.017	.82	1.55	.55	.71
Bluff Creek	75	3	6	2.5	4	61	79	1.24	.89	.125	4648	.018	.71	1.58	.25	.37
Camp Creek	42	0	0	0	0	64	84	1.37	1.02	.062	4578	.028	.63	1.39	.42	.68
Clear Creek	113	3	4	3.1	3	64	82	1.22	.79	.112	6379	.022	.99	1.49	.35	.57
Dillon Creek	74	4	8	4.0	8	60	76	1.18	.93	.161	5267	.024	.84	1.37	.47	.72
Elk Creek	97	6	14	6.0	10	59	77	1.02	.59	.415	6370	.023	1.18	1.49	.34	.41
Grider Creek	41	7	29	5.6	17	69	80	1.18	.72	.122	5686	.033	.91	1.44	.21	.43
Indian Creek	136	14	20	13.6	15	59	75	1.13	.66	.234	6222	.021	1.04	1.33	.50	.82
Redcap Creek	67	1	3	.4	1	67	77	1.13	.72	.221	6657	.033	1.12	1.32	.37	.42
N. Fk. Salmon R.	206	47	31	35.2	22	63	78	1.25	.93	.149	7006	.018	1.06	1.44	.56	.86
S. Fk. Salmon R.	292	75	44	88.9	42	62	76	1.15	.76	.177	7776	.015	1.28	1.63	.40	.68
Wooley Creek	152	6	6	6.0	5	64	76	1.20	.80	.212	7156	.025	1.13	1.23	.42	.82
Thompson Creek	36	4	19	4.3	17	66	84	1.07	.69	.102	5257	.034	.93	1.35	.30	.41
Trinity Drainage																
Big French Creek	39	5	18	7.6	25	66	82	1.18	.86	.079	6209	.042	1.00	1.77	.35	.52
Canyon Creek	65	7	14	8.9	20	58	75	1.19	1.04	.131	7564	.031	1.20	1.96	.18	.31
Hayfork Creek	388	72	30	106.3	37	61	79	1.20	.77	.439	5139	.009	.81	1.59	.34	.55
New River	246	13	9	24.5	15	59	79	1.09	.75	.158	6798	.016	1.18	1.40	.43	.56
N. Fk. Trinity R.	154	15	13	13.1	14	53	81	1.15	.92	.073	7622	.024	1.26	1.37	.35	.45
Middle Fk. Eel R.	722	255	67	364.2	69	63	77	1.16	.68	.115	6801	.008	1.11	1.70	.53	.89
Mad River	461	114	33	137.5	35	63	79	1.37	.95	.119	6070	.006	.84	2.74	.07	.14
Mattole River	299	0	0	0	0	59	80	1.70	.82	.070	4087	.007	.46	1.70	.26	.35
Redwood Creek	280	51	21	42.9	20	59	78	1.32	1.09	.540	5276	.007	.76	2.33	.13	.15
Middle Fk. Smith R.	125	0	0	0	0	61	79	1.38	.94	.113	5964	.018	.82	1.62	.42	.76
Upper S. Fk. Smith R.	215	1	1	1.3	1	60	80	1.32	.83	.091	6054	.016	.87	1.42	.74	.91
Van Duzen River	435	82	32	59.1	19	58	76	1.23	.76	.253	5843	.008	.90	1.85	.20	.45

(Continued)

Appendix B. (Continued)

Gradient	Mean length of streams of a given order (miles) L_1	L_2	L_3	L_4	L_5	Length ratios (Dimensionless) L_1/L_2	L_2/L_3	L_3/L_4	L_4/L_5	Gradient (%) of streams of a given order N_1	N_2	N_3	N_4	N_5	Weighted mean channel gradient
Klamath Drainage															
Blue Creek	1.1	1.2	4.7	14.0		.92	.26	.34		22.4	11.1	4.4	2.2		16.4
Bluff Creek	1.1	1.4	4.0	13.5		.78	.35	.30		23.4	8.8	2.1	2.7		16.2
Camp Creek	1.0	1.7	10.5			.59	.16			20.3	10.7	3.3			15.5
Clear Creek	1.2	2.2	3.6	12.5		.54	.61	.29		23.3	8.6	3.0	1.9		17.0
Dillon Creek	1.0	1.2	4.0	6.4		.83	.30	.62		22.8	10.5	6.0	3.1		16.8
Elk Creek	1.3	2.1	7.8	3.7		.62	.27	2.10		18.7	9.4	3.8	1.4		13.7
Grider Creek	1.4	1.4	8.0			1.00	.18			22.6	9.1	3.6			17.5
Indian Creek	1.3	2.2	2.2	5.0	7.6	.59	1.00	.44	.66	19.5	9.0	6.9	2.2	.9	14.3
Redcap Creek	1.4	0.9	16.0			1.60	.10			20.7	13.1	3.4			16.1
N. Fk. Salmon R.	1.1	1.4	2.6	4.3	18.5	.78	.54	.60	.23	26.6	11.0	6.7	3.0	1.4	19.4
S. Fk. Salmon R.	1.2	1.9	2.0	6.4	17.4	.63	.95	.31	.37	22.4	9.5	5.8	2.8	1.3	16.5
Wooley Creek	1.3	2.0	1.7	2.8	9.6	.65	1.18	.61	.29	25.9	12.3	12.1	4.4	2.0	20.2
Thompson Creek	1.2	2.4	6.0			.50	.40			26.0	9.4	3.5			19.5
Trinity Drainage															
Big French Creek	1.1	1.8	7.2			.61	.25			25.5	10.8	4.1			19.4
Canyon Creek	.9	1.3	2.1	9.7		.69	.62	.22		30.1	11.9	8.3	1.8		20.9
Hayfork Creek	1.2	1.7	5.3	16.4	5.5	.70	.32	.32	2.98	10.9	5.1	2.1	1.3	1.0	8.0
New River	1.1	2.1	3.6	5.2	13.8	.52	.58	.69	.38	25.5	8.6	5.2	2.2	1.2	17.6
N. Fk. Trinity R.	.8	2.0	5.1	18.0		.40	.39	.28		25.2	11.9	3.7	1.9		16.9
Middle Fk. Eel R.	1.4	1.9	4.2	9.0	28.8	.74	.45	.47	.31	17.3	10.0	3.9	1.8	.4	13.3
Mad River	1.1	1.2	3.9	20.2	52.8	.92	.31	.19	.38	18.6	7.4	2.6	.6	.7	13.0
Mattole River	1.2	1.7	6.8	44.2		.70	.25	.15		12.4	3.5	1.5	.2		8.1
Redwood Creek	.9	1.2	6.0	13.4	3.6	.75	.27	.45	3.72	19.8	10.5	2.2	.4	.1	13.9
Middle Fk. Smith R.	1.1	2.0	2.8	14.8		.55	.71	.19		20.3	6.3	3.2	1.3		12.8
Upper S. Fk. Smith R.	1.2	1.7	5.1	19.7		.70	.33	.26		21.6	7.8	4.1	1.6		15.1
Van Duzen River	1.2	1.5	3.0	25.5	12.5	.80	.50	.12	2.04	16.3	6.4	3.3	1.0	.6	11.0

(Continued)

Appendix B. (Continued)

Drainage	Stream order	Total number of streams of a given order N_1	N_2	N_3	N_4	N_5	Total number of streams	Bifurcation ratio N_1/N_2	N_2/N_3	N_3/N_4	N_4/N_5	Weighted bifurcation ratio WR_b	Total length of streams of a given order (miles) L_1	L_2	L_3	L_4	L_5	Total length of streams (miles)	Mainstem length (miles)	Basin Perimeter (miles)	Basin length (miles)	Maximum width (miles)
lamath Drainage																						
Blue Creek	4	98	22	5	1		126	4.4	4.4	5.0		5.37	104.7	26.2	23.7	14.0		168.6	22.0	62.3	15.2	10.8
Bluff Creek	4	53	11	2	1		67	4.8	5.5	2.0		5.70	56.5	15.1	8.0	13.5		93.1	22.5	48.5	17.4	6.5
Camp Creek	3	35	6	1			43	6.0	6.0			6.84	37.2	10.2	10.5			57.9	13.1	32.0	10.0	6.8
Clear Creek	4	73	12	3	1		89	6.1	4.0	3.0		6.63	88.9	26.0	10.8	12.5		138.2	23.0	56.0	18.0	10.2
Dillon Creek	4	52	13	3	1		69	4.0	4.3	3.0		4.94	53.0	16.3	12.0	6.4		87.7	14.1	41.8	12.5	9.0
Elk Creek	4	44	10	2	1		57	4.4	5.0	2.0		5.33	58.5	20.8	15.6	3.7		98.6	19.6	52.0	17.0	7.0
Grider Creek	3	24	5	1			30	4.8	5.0			5.60	33.7	7.0	8.0			48.7	14.2	32.8	14.0	6.0
Indian Creek	5	70	16	4	2	1	93	4.4	4.0	2.0	2.0	5.12	91.7	35.9	8.8	10.0	7.6	154.0	18.0	55.0	16.5	13.5
Redcap Creek	3	37	10	1			48	3.7	10.0			5.91	50.5	9.0	16.0			75.5	18.0	38.3	13.4	5.6
N. Fk. Salmon R.	5	150	29	9	3	1	192	5.2	3.2	3.0	3.0	5.73	163.4	40.2	23.0	12.8	18.5	257.9	32.7	73.1	19.2	16.6
S. Fk. Salmon R.	5	170	37	13	2	1	223	4.6	2.8	6.5	2.0	5.36	209.3	71.9	26.2	12.8	17.4	337.6	34.4	98.9	27.0	18.4
Wooley Creek	5	92	20	6	2	1	121	4.6	3.3	3.0	2.0	5.21	117.3	40.5	10.1	5.6	9.6	183.1	21.1	53.7	19.0	15.6
Thompson Creek	3	21	3	1			25	7.0	3.0			7.20	25.7	7.1	6.0			38.8	10.7	28.8	10.9	4.5
rinity Drainage																						
Big French Creek	3	28	5	1			34	5.6	5.0			6.30	30.5	8.8	7.2			46.5	11.0	28.3	10.6	5.5
Canyon Creek	4	51	13	3	1		68	3.9	4.3	3.0		4.86	45.3	17.0	6.2	9.7		78.2	19.7	46.6	19.0	5.9
Hayfork Creek	5	237	48	11	2	1	299	4.9	4.4	5.5	2.0	5.80	285.1	81.6	58.7	32.9	5.5	463.8	35.4	111.0	34.0	18.8
New River	5	145	29	7	2	1	184	5.0	4.1	3.5	2.0	5.73	159.1	61.6	24.9	10.3	13.8	269.7	30.5	77.9	24.0	13.5
N. Fk. Trinity R.	4	114	22	4	1		141	5.2	5.5	4.0		6.17	92.9	45.1	20.4	18.0		176.4	25.1	60.2	21.0	9.4
iddle Fk. Eel R.	5	378	87	17	5	1	488	4.3	5.1	3.4	5.0	5.80	528.7	166.3	71.5	44.8	28.8	840.1	61.0	160.0	37.2	33.1
ad River	5	346	77	14	2	1	440	4.5	5.5	7.0	2.0	5.73	397.2	88.6	54.9	40.3	52.8	633.8	101.0	209.0	79.2	11.0
attole River	4	197	41	7	1		246	4.8	5.8	7.0		6.00	231.9	70.6	47.6	44.2		394.3	64.4	104.2	33.9	12.0
edwood Creek	5	238	55	9	2	1	305	4.3	6.1	4.5	2.0	5.59	219.1	66.8	54.2	26.8	3.6	370.5	59.4	138.4	46.0	6.8
iddle Fk. Smith R.	4	92	19	5	1		117	4.8	3.8	5.0		5.60	105.4	38.5	13.8	14.8		172.5	23.9	64.2	17.3	13.1
pper S. Fk. Smith R.	4	142	27	9	1		179	5.2	3.0	9.0		6.02	171.0	45.7	46.2	19.7		282.6	28.6	73.7	17.0	15.5
an Duzen River	5	252	63	13	3	1	332	4.0	4.8	4.3	3.0	5.13	310.7	94.6	39.2	76.4	12.5	533.4	77.4	137.0	46.5	21.0

Appendix C. Geologic analysis of 25 northern California streams. The numbers presented are the percentages of the various rock types within each watershed areal surface area. Presence but less than one percent is significant by P.

Drainage	Mesozoic ultrabasic intrusive rocks	Mesozoic granitic rocks	Precretaceous metamorphic	Upper jurassic marine	Mesozoic basic intrusive	Quartenary nonmarine terrace deposits	Presilurian metavolcanic	Precretaceous metavolcanic	Alluvium	Precretaceous metasedimentary	Presilurian metasedimentary	Franciscan formation	Tertiary marine	Plio-pleistocene nonmarine	Jura-triassic metavolcanic	Upper cretaceous marine	Upper pliocene marine
Klamath Drainage																	
Blue Creek	28	5	1	66													
Bluff Creek	43			57													
Camp Creek	14		3	80		3											
Clear Creek	44	35		20													
Dillon Creek	18	44	2	36													
Elk Creek	9	32	55			1											
Grider Creek	29	17	44		8	2											
Indian Creek	36	12	37	7		1											
Redcap Creek	7	45	20	28													
N. Fk. Salmon R.	P	29	11		1			40		19							
S. Fk. Salmon R.	6	14	49		1		24				4						
Wooley Creek		53	10					35		2							
Thompson Creek	2	7	76					9									
Trinity Drainage																	
Big French Creek	13		82					5									
Canyon Creek		29				2	68										
Hayfork Creek	5	22	64			P			2								
New River	5	11	80		P			4									
N. Fk. Trinity R.	4	3	20		6	P	51	15									
Middle Fk. Eel R.	3					P		1	3	6		85		P		1	
Mad River						1			4	11		81	2				
Mattole River	1					2			1			1	1			6	
Redwood Creek						P			3	50		44		3			
Middle Fk. Smith R.	32	6		32	2				1						26		
Upper S. Fk. Smith R.	28	9		60	P										1		
Van Duzen River	2					2			4			67	6	2		16	1

(continued)

Drainage (continued)	Oligocene nonmarine	Pleistocene marine & marine terrace deposits	Paleozoic marine	Tertiary nonmarine	Franciscan volcanic & metavolcanic	Pleistocene nonmarine	Lower cretaceous marine	Undivided cretaceous marine	Tertiary Intrusive	Glacial deposits	Presilurian metamorphic	Middle miocene marine	Eocene marine	Paleocene marine	% Igneous rocks	% Sedimentary metamorphic rocks
Klamath Drainage																
Blue Creek															33	67
Bluff Creek															43	57
Camp Creek															14	86
Clear Creek											1				79	21
Dillon Creek															62	38
Elk Creek											3				41	59
Grider Creek															54	46
Indian Creek											7				48	52
Redcap Creek															52	48
N. Fk. Salmon R.															70	30
S. Fk. Salmon R.										2					45	55
Wooley Creek															88	12
Thompson Creek											6				18	82
Trinity Drainage																
Big French Creek															18	82
Canyon Creek										1					97	3
Hayfork Creek	7						P								27	73
New River			P												20	80
N. Fk. Trinity R.										1					79	21
Middle Fk. Eel R.					P			P				P	P	P	4	96
Mad River		1				P			P						0	100
Mattole River					P			88							1	99
Redwood Creek															0	100
Middle Fk. Smith R.														1	66	34
Upper S. Fk. Smith R.														2	38	62
Van Duzen River					P	P									2	98

Appendix D. Snorkel Survey Recommendations.

The following guidelines are recommended when conducting the annual population counts of summer steelhead:

1. Surveys should be conducted by at least two people. In addition to the obvious safety considerations, this allows for more accurate counts. Surveyors should have first aid training, including CPR (Cardio-Pulmonary Resuscitation). Surveyors should maintain visual contact both while in the water and when walking downstream.

2. Surveyors should wear wetsuits. Cold divers are not as willing to stay in the water for prolonged times in search of fish, thus reducing survey accuracy. When it is necessary to dive 2-3 m or more while wearing a wetsuit, additional weight is helpful. Weight belts can be used, but obviously must be carried. Fanny packs fitted with a quick release buckle can be filled with rocks or gravel and used as a weight belt, then emptied after use.

3. All available cover in the stream reach being surveyed should be examined. This includes caves, ledges, turbulent areas beneath falls and rapids, under boulders, and in vegetation such as tree roots, aquatic and riparian plant cover. A waterproof flashlight is helpful for locating fish in caves and under boulders.

4. Surveyors should enter pools head first and with a minimum of disturbance. This is particularly important in pools harboring few fish, as these fish are more easily disturbed and driven into hiding than are large groups of fish.