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CALIFORNIA FISH AND WILDLIFE PLAN

VOLUME III

Supporting Data

PART B

INVENTORY (SALMON-STEELHEAD AND MARINE RESOURCES)

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PART B

CALIFORNIA FISH AND WILDLIFE INVENTORY

OF

ANADROMOUS SALMONID RESOURCES

INTRODUCTION

The word "anadromous" comes from a Greek word that means "running upwards." A salmon or steelhead must run up from the ocean into fresh water to complete its life cycle. These anadromous species have several critical links in their life cycle:

1. The ocean: Conditions must be favorable for survival and growth.

2. Estuaries and lower reaches of rivers: Conditions must be favorable for the upstream passage of adults and for the downstream passage and feeding of juveniles.

3. Headwaters of rivers: Conditions must be favorable for upstream passage and spawning of adults and the incubation of their eggs, as well as for juvenile survival and growth (this is especially critical for silver salmon and steelhead juveniles which normally spend a year or more in the freshwater nursery areas). Finally, the young must be able to move downstream out of the area.

Some races of king salmon and steelhead trout enter the streams many months before their spawning time and must have suitable pools and suitable temperatures in which to rest while their sex products ripen. The spring-run kings of the Sacramento River system are an example.

The data and estimates on which this inventory is based were furnished, for the most part, by Department of Fish and Game Regional staff. Data on king salmon spawning stocks in the Central Valley and landing statistics for the coastal sport and commercial fisheries were provided by the Marine Resources Branch. The data were compiled and the text organized by the Research Analysis Section.

SPECIES OF FISH INCLUDED

Three species of fish are included in this section of the Inventory: king salmon, silver salmon, and steelhead trout.

KING OR CHINOOK SALMON (Oncorhynchus tshawytscha)

"King" is the legally accepted common name in California, but the other Pacific Coast states and Canada have officially accepted "Chinook". In California, this is the most important of the three species considered in terms of numbers or weight of fish landed. In the ocean off California, 90 percent of the commercial salmon catch and 85 percent of the sport salmon catch is of this species. In the rivers, it is second to steelhead. Kings are the largest of the salmons;

the average weight at spawning time is about 20 pounds (somewhat less in the Klamath); some individuals exceed 50 pounds, and the record is over a hundred.

Habits

King salmon spawn in cool or cold streams where there is a gravel bottom. Water over 70°F. is detrimental and 80° is lethal. For successful spawning, the water must be less than 58 degrees. Water of 50 or 52 degrees is ideal for spawning. Kings prefer gravel in which most of the larger rocks are about 6 inches in diameter or a little smaller. The preferred spawning area is the lower end of a pool where water is just beginning to pick up speed just above a riffle; the riffles themselves are also used. A water velocity of about 2 feet per second is excellent.

Redds (nests) are dug by the female who points her nose upstream, turns on her side on the bottom, arches her body slightly with nose and tail down, and goes through a violent swimming motion which washes gravel downstream and excavates a pit. She deposits eggs in the pit where they are fertilized by the waiting males. Then she moves upstream just beyond the pit and resumes digging. This extends the pit upstream and washes gravel over the eggs; finer materials are carried farther downstream. More eggs are deposited and the process repeated until she is completely "spawned out" and the last eggs have been covered. Pacific salmon (of all species) die within a few days after spawning. The only exceptions are a few precocious males which spawn when about five or six inches long without having been to the ocean. Larger precocious males (Jacks) and adults invariably die.

Eggs hatch in about 50 or 60 days at California temperatures, and in the next three or four weeks the young wriggle up through the gravel into the water above.

In California, most young king salmon migrate to the ocean in their first few months of life. This makes it possible for runs of king salmon to exist in streams which dry up or become too warm for salmon in the summer.

In streams which remain cool all summer, a small percent of the young kings remain till they are over a year old before migrating. These yearlings are often taken by trout fishermen, many of whom assume the fish is a trout.

In California, most king (chinook) salmon mature at four or three years. Five-year-olds are much less common and a six-year-old is relatively rare. Large numbers of "Jacks" mature at two years. These fish weigh about three pounds. Few females mature this young or this small. Occasional Jacks may weigh less than a pound.

Most runs of king salmon enter into fresh water in the fall; the exact time varies among rivers. Fall-run salmon normally enter a stream late enough so that a suitable supply of cool water is available for spawning. Spawning is usually between October and January.

Spring-run king salmon are so-called because they enter rivers in the spring. These fish move upstream until they find a cool area where they remain throughout the summer to spawn in the fall. The time of the spring run corresponds with the snowmelt and the spring runoff which provide fish with an ample

supply of cold water in which to reach the upper parts of the stream. In streams which are too warm for salmon during the summer, there is no spring run, but there may be a good fall run.

Winter-run king salmon are peculiar to the Sacramento River system, and about 98 percent are in the Sacramento Main Stem. The remaining 2 percent appears to be confined to Battle Creek, Mill Creek, and Deer Creek. Small numbers of winter-run kings have been seen in several other Sacramento tributaries but because of the summer temperatures of those streams, we suspect that the fish are strays rather than established runs, and that they are not reproducing themselves. The "winter-run" has flourished since the building of Shasta Dam and has recently become more abundant than the spring run. The winter run reaches the upper Sacramento about Christmas; the fish remain until their spawning time which is primarily in May and June. Most California salmon streams are too warm for successful spawning at this time of year.

SILVER OR COHO SALMON (Oncorhynchus kisutch)

"Silver" is the legally accepted common name in California, but the other Pacific Coast states and Canada have officially accepted "Coho". "Coho" is seldom heard in California. In this State, the silver salmon is the least important of the three species considered here. Silver salmon catches make up about 10 percent of the commercial salmon catch and 15 percent of the sport salmon catch in California waters. In fresh water, its landings are exceeded by both the steelhead and king salmon.

At spawning times,silver salmon average about 7 to 12 pounds. The record is about 30 pounds but silver salmon above 15 pounds are real trophy fish.

The silver salmon in this State is primarily an inhabitant of the smaller coastal streams. It is not native to the Central Valley and no success has resulted from attempts to establish it in seemingly suitable valley streams.

The spawning habits of silvers are quite similar to those of king salmon described above. Silvers prefer somewhat smaller streams, but many places are used by both species.

Silver salmon, after hatching, spend about a year in fresh water. This means that the species cannot survive in streams which dry up or become too warm in the summer time.

Some silver salmon males return to the stream as two-year-old Jacks; the remaining males and the females mature at three years. The fish run into streams in the fall and early winter, shortly before spawning. There are no spring-run silvers. Migration into individual streams depends to a large extent on the time when fall rains make it possible for the fish to start their migration.

STEELHEAD TROUT (Salmo gairdnerii gairdnerii)

Steelhead are very rarely taken at sea, but in fresh water the numbers of steelhead taken exceed those of both species of salmon combined.

Steelhead have been known to reach a weight of over 30 pounds, but most

weigh between 2 and 10 pounds. Runs of young steelhead which enter some streams - notably the Klamath - are referred to as half-pounders; actually, these fish average over a pound in weight.

The spawning habits of steelhead are similar to those of king salmon as described above except that the fish being smaller prefer somewhat finer gravel. Unlike the salmons, steelhead do not necessarily die after spawning.

Along the coast, most steelhead enter streams in the winter and spring, but in the Sacramento River the principal migration is during the early fall and winter. In the Eel and Klamath rivers, steelhead may enter throughout most of the year. In large coastal streams, some steelhead enter in the spring or summer and remain until the following spring to spawn.

Young steelhead normally remain in the stream for a year or two or even more before migrating to the ocean; thus, like silver salmon, they are unable to survive in streams which become too warm or which dry up during the summer. In spite of this, they are the most adaptable and most ubiquitous of the three species under discussion. Most steelhead mature at three or four years of age, but two-year-olds are common, five-year-olds less so, and older first spawners are relatively rare.

METHODS USED IN ASSEMBLING THE INVENTORY

Because of time limitations, almost no field work was undertaken in connection with this Inventory, and this report is largely a compilation of existing information. On streams where accurate figures were available, they were used. When they were not available, the men most familiar with the problem made the best estimates they could by various methods including comparison with more carefully studied streams.

RATING THE QUALITY OF CATCH, EFFORT, AND ESCAPEMENT DATA

An estimate of the catch, effort and spawning run of each stream and a rating of the quality of each estimate is given in Table S-3. The quality of the information is designated as follows:

A = The most reliable. Includes catch studies involving several years of intensive field work; also population studies involving years of fishway counts or tag and recovery experiments.

B = Less reliable because of shorter duration, less precise methods, or less complete coverage. Includes population estimates made annually for several seasons by field survey crews.

C = Estimates made by men who are familiar with the stream and who made comparisons with better-studied streams. "C+" is used when the men making the estimate had some data to assist them.

The estimates are also given in the text, but the rating of estimate quality is given only in Table S-3.

NEED FOR LATER STUDIES

It should be kept in mind that those estimates given here which are based on little or no data should be used only in outlining the major and critical factors of the resource. Adequate studies must be made in the future and doubtless will change the picture in some places.

DATE OF COUNTS, ESTIMATES, AND MEASUREMENTS IN THIS INVENTORY

It is the intent of this inventory to show conditions as they existed at about 1963. Because salmon and steelhead runs are notoriously erratic, the use of a single year would in many instances give a very erroneous impression. Whenever it was available and seemed appropriate, an average of the period from 1959 through 1963 was used. In most instances, five years of data were not available so we used what was available or made estimates as described under "CATCH AND USE ESTIMATES" and under "SPAWNING POPULATIONS" In other instances, some figures were available but were from considerably before 1959. We included such material if, in our estimation, it gave a good picture of present conditions, otherwise we used it to assist in giving an estimate of more recent conditions. In some instances where there were data, the conditions had changed so much since 1959 that a five-year average would give an entirely erroneous impression of present conditions. For example, the San Joaquin tributaries had good salmon runs in 1959 but conditions degenerated very rapidly after that date. In this instance, we used an average over a shorter period.

In a few instances where conditions have drastically and irreversibly

changed since 1963, it seemed advisable to describe 1965 conditions. (The Oroville Dam project partially blocked the Feather River salmon and steelhead runs in 1963 and was a total block in 1964.)

AMOUNT OF HABITAT

It was necessary to develop a quantitative measure of the habitat present in 1963. This quantitative value is to be used to compare the amount of habitat from river to river and species to species. It will also be used to compare the 1963 habitat with the amount expected to be present in 1980.

The habitat listed for each stream includes the lineal miles of stream habitat in each of 5 width categories and the miles of stream available to fishermen.

Procedure

Regional staff members, using U.S.G.S. 15-minute topographic maps, located as nearly as possible the upstream limit of migration for adult king salmon, silver salmon, or steelhead in each stream in their area.

Lineal Miles of Habitat

A wheel-type map measure was used to measure the total number of stream miles (including tributaries) downstream from the upper limits. This stream mileage total was a measure of the gross habitat utilized by the species.

On a majority of the streams, we do not know how much of this gross habitat is used as spawning grounds for the adults, as nursery areas for the juveniles, as travel routes between the spawning grounds and the sea, or as a combination of these.

As the stream miles of habitat were measured, they were recorded in tabular form by estimated strean-width categories. The points at which anglers had physical access to the stream were also noted, and the number of miles that were accessible were recorded. Tabulation is by river system. The data were sent to the Research Analysis Section where statewide summaries were made.

Stream Width

The stream width in mid-summer was first chosen as the standard for measuring the habitat of all inland and all anadromous species of fish discussed in this Inventory. This period was chosen because, in general, summer flows are lowest and most constant. Summer is also the most critical period for most species including steelhead and silver salmon, but excluding fall-run king salmon. In California, most young kings leave the streams in late winter or in spring, and some good king salmon streams are completely devoid of these fish in summer. A stream which is dry or intermittent in the summer is placed in the O-7 foot width category regardless of whether the drying is due to a diversion or to natural causes. It is usually far wider than seven feet when the adult kings arrive in the fall.

Using this system to categorize the widths of king salmon streams has one advantage -- it makes possible a direct comparison of the lineal miles of stream frequented by each of the three anadromous species. It gives a very poor picture of the size of streams when actually inhabited by king salmon. To provide this additional information, we have also included the king salmon habitat available during the fall spawning season for this species.

The percent of the habitat accessible to anglers was also calculated.

Fishermen Access

For anadromous species, a point on a stream was considered accessible only if it was within 1/2 mile of a road that was both passable by a two-wheel drive passenger car and open to public use 1/. Because of the way in which the fish move upstream, salmon and steelhead fishermen normally do not have to hike very far to get good fishing. It was therefore assumed that most of these people will fish for anadromous species within a half mile of an access point. A section of stream is considered accessible if either bank is accessible. Because many North Coast roads are not passable by passenger car during the steelhead season, roads were considered to provide steelhead access only if they normally remain open during the majority of the fishing season. Angling regulations were not considered in determining accessibility.

Area of Watershed

The U. S. Geological Survey Water Supply Papers list the area of watershed upstream from many gaging stations. The area above the lowest usable station on each stream was taken from these publications, when it seemed appropriate and practical to do so.

1/ In many areas, landowners post their property and refuse permission to those who ask to fish, but make no effort to eject those who fish without asking. Such streams may be well known and well fished, but in this Inventory we have classed them as "closed to public use."

METHODS USED TO ESTIMATE SPAWNING POPULATIONS

DEFINITION OF SPAWNING POPULATION

The estimates of numbers of spawners given in this Inventory are exclusive of all catches. They are intended to include only those fish which escaped all hazards and spawned. "Jacks" or precocious male salmon are included in the total.

SOURCE OF ESTIMATES

Whenever fish populations have been determined by fishway counts, by tag and recovery experiments, by aerial redd counts, or by estimates based on carcass counts, such data were used. Most of the fall-run salmon population estimates in the Central Valley were based on several years of carcass counts 2/.

On the coastal streams, fishway counting stations are scattered and counts usually include the run of only a part of the river. Tag and recovery experiments of some magnitude have been made on the Eel and Trinity rivers. Most of the estimates on the coast have involved no field work done for this specific purpose; they were made by men who are familiar with the streams in question and who compared them with similar streams on which more studying had been done.

CATCH AND USE ESTIMATES

Illegal Fishing

Catch and use estimates given in this inventory refer to legal fishing only. They do not include fish taken illegally or time spent in illegal fishing.

Snagging, spearing and gaffing on the spawning beds are a serious threat to many salmon runs. The threat is most serious in small streams and during periods of low flow. Poachers have little trouble taking spawning fish when the entire riffle is shallow. Fish on a deep, fast riffle are much safer. Even if they are spawning in shallow water near the bank, they are only a tail flip away from safety.

A small run often suffers much more from poaching than a large one. The poachers take what they want and if the run is small, this may exceed half the available spawners.

Adequate law enforcement can make the difference between an adequate run and a pitiful remnant of a run in some streams. The enforcement depends in part on the local warden, the stream patrolling he does or does not do, and the arrests he does or does not make. It depends in part on the local judge and the punishment he does or does not hand out. Most of all, it depends on public education and public opinion. If the public wants conservation, it will get it. Much of this public sentiment is influenced by the local warden.

2/ Survey crews make several trips per season over the spawning beds, count (and cut in half) each spawned-out carcass, and estimate the proportion of carcasses not seen. The method is not used on steelhead and is of little use on most coastal streams where erratic turbid floods often sweep most of the carcasses into deep water.

Protection of spawning salmon and steelhead in California ranges from very good to very poor. No master plan for anadromous salmonids can succeed without adequate consideration of the law enforcement and public opinion problems involved.

Inland Catches

The catch and use (effort) estimates given here cover a wide range of accuracy and reliability. Several years of creel count data are available on the Sacramento and the lower Klamath rivers. Shorter studies and spot checks were made on about 20 other streams (including tributaries). Where no catch and effort figures were available, men who were familiar with the area compared each stream with others on which some studies had been made, and estimated the total catch, total effort and catch per angler-day.

Ocean Catches

The commercial ocean catches recorded in this Inventory are based on the total weight of salmon landed as recorded on fish landing receipts. The weights are converted into numbers of fish and split into species by use of an extensive sampling system. The period used is 1959 through 1963.

The sport ocean catch figures are about as accurate as the best of the inland data. They are based on partyboat catches (as counted daily by the boat captains) plus the private boat catch as estimated from samples.

Sport ocean effort figures can only be approximated at present.

STATEWIDE SUMMARY

The salmon and steelhead habitat of the State has been divided into the Central Valley River Systems and the Coastal Streams.

The Central Valley rivers are snow-fed to a larger extent and are more completely controlled by dams. They include our best king salmon habitat, no silver salmon habitat, and produce only a moderate number of steelhead.

The Coastal Streams include some which are good producers of king salmon. In general, these are the larger rivers. Many coastal streams, both small and large, are producers of silver salmon. There are steelhead in almost all the coastal streams that reach the ocean and flow the year-around.

AMOUNT OF HABITAT

A statewide habitat summary is given in Table S-l on the next page. A detailed habitat breakdown is in Table S-2.

King Salmon

There are 2,304 miles of king salmon habitat in the coastal streams and 1,076 in the Central Valley. The latter figure does not include any of the Sacramento-San Joaquin Delta or any of the Sacramento River below Sacramento. Even without these downstream channels, the valley streams show a greater area of habitat than the coast -- 23,000 acres to 21,000 3/

Silver Salmon

There are about 3,720 miles of silver salmon habitat, all of it in the coastal streams. The estimated area was 17,000 acres.

Steelhead

These fish are by far the most widely distributed of the three. There are 7,301 miles of habitat in the coastal streams and 1,101 in the Valley. The acreages are 23,000 and 19,000 respectively. The area of Valley habitat of steelhead is markedly less than that of king salmon because there is no steelhead habitat in the San Joaquin River System, or in the Cosumnes River.

ESTIMATED ABUNDANCE OF SPAWNERS (EXCLUSIVE OF CATCH)

Statewide, there are estimated annual spawning stocks of 677,000 king salmon, 99,000 silver salmon, and 603,000 steelhead trout. It was estimated that approximately 421,000 of the king salmon and 30,000 of the steelhead spawn in the Central Valley or in streams tributary to San Francisco Bay. The Coastal River Systems support estimated annual runs of 256,000 king salmon, 99,000 silver salmon and 573,000 steelhead (Table S-3).

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3 To estimate habitat areas, it was assumed that streams classed as 0-7 feet wide would average 5 feet in width; streams classed as 8-20 feet wide would average 14 feet; 21-100 foot streams would average 60 feet; 101-300 foot streams would average 200 feet; and streams over 300 feet would average 400 feet.

TABLE S-l STATEWIDE HABITAT SUMMARY

	MILES OF STREAM						
	Stream Width in Feet						
	-0 to 7	8 to 20	21 to 100	101 to 300	Over 300	Total Stream Miles	Total Acres
KING SALMON 1/							
TOTAL	220	654	1,551	617	338	3,380	44,000
Coast	220	586	996	502		2,304	21,000
Central Valley 3/	-	68	555	115	338	1,076	23,000
SILVER SALMON 2/							
TOTAL	2,026	643	651	400	-	3,720	17,000
Coast	2,026	643	651	400	-	3,720	17,000
Central Valley	none	none	none	none	none		
STEELHEAD 2/							
TOTAL	5,151	1,302	1,145	460	344	8,402	42,000
Coast	4,835	1,026	1,013	427		7,301	23,000
Central Valley 3/	316	276	132	33	344	1,101	19,000

1/ Stream widths during fall spawning period.

2/ Stream widths at midsummer.

3/ Does not include Sacramento-San Joaquin Delta or the Sacramento River below the City of Sacramento, but does include streams tributary to San Pablo and San Francisco bays.

Areas were calculated using the assumption that habitat streams 0-7 feet wide averaged 5 feet wide, those 8-20 feet wide averaged 14 feet, those 21-100 feet averaged 60 feet, those 101-300 feet averaged 200 feet, and those over 300 feet averaged 400 feet.

AVAILABILITY

Of the lineal miles of habitat, 38 percent of the king salmon, 30 percent of the silver salmon, and 31 percent of the steelhead habitat is accessible to the angler (Table S-2).

PRESENT USE

River Fishing for Adults

Salmon anglers expend an estimated 222,000 angler-days of effort per year. Most of this is for king salmon, but we do not have a detailed breakdown by species.

Steelhead anglers spend an estimated 304,000 angler-days per year.

Stream Fishing for Juveniles

Salmon: Very little; most king salmon migrate to sea as fingerlings and most silver salmon yearlings migrate before season opens.

Steelhead: About 440,000 angler-days per year, most of it in the coastal counties.

Ocean Sportfishing

Salmon: About 100,000 angler-days per year.

Steelhead: Almost none; very few steelhead are taken at sea.

Commercial Salmon Fishing (all in the ocean)

About 33,000 deliveries per year. Commercial salmon boats are operated by one or two men.

PRESENT YIELD

River Fishing for Adults

Salmon: About 63,000 fish per year at a rate of about .28 fish per angler-day of effort; i.e., about 3.6 days of river fishing per salmon caught.

Steelhead: About 122,000 fish per year at a rate of about .40 fish per angler-day; i.e., about 2-1/2 days of effort expended per steelhead caught.

Stream Fishing for Juveniles

No meaningful estimates are available at present.

Ocean Sportfishing

Salmon: About 91,000 fish per year at a rate of about .9 fish per angler-day; 85 percent of catch is king salmon - the remainder is silver salmon.

Commercial Salmon Fishing (all in the ocean)

An average of 676,000 fish per year at a rate of about 20 fish per delivery. About 90 percent kings and 10 percent silvers.

CRITICAL FACTORS IN THE HABITAT (Present factors only)

In the Central Valley the most critical factors include dams, reduced flows, unscreened diversions, pollution (including pollution by return irrigation water), gravel removal, channelization of streams, and siltation.

On the coast, the most critical factor is habitat degradation due to improper logging followed by massive siltation, log jams, etc. Road building also causes massive siltation in some places. The other factors (mentioned above) are present, but to a much lesser extent than in the Central Valley.

CENTRAL VALLEY STREAMS

SACRAMENTO RIVER SYSTEM

SUMMARY -SACRAMENTO RIVER SYSTEM AS A WHOLE

The Sacramento System carries an average annual runoff of over 17 million-acre feet, which is almost one--third of the runoff of all California streams. The Sacramento drainage area is nearly 27 thousand square miles, nearly 20,000 of which lie below Shasta Dam.

The present upstream limit of salmon and steelhead migration is Keswick Dam. Shasta and Keswick dams were completed in 1942. Keswick is located about 7 miles downstream from Shasta Dam and 4-1/2 miles upstream from the Anderson Cottonwood Irrigation District Dam at Redding.

The main tributaries to the Sacramento System utilized by anadromous salmonids are the Feather, Yuba, and American rivers. Some of the other tributaries (from north to south) are Cow, Battle, Antelope, Mill, Deer, Big Chico, and Butte creeks on the east side, and Clear and Cottonwood creeks on the west. Many other minor tributaries are available to anadromous species during those years when early rains supply enough flows during the spawning migration period.

The great bulk of the precipitation in the Central Valley falls during the period from October through May. The higher elevations of the Sierra and the Cascade mountains east of the valley receive a large part of their annual precipitation as snow. Snowmelt prolongs the period of higher runoff into May and June in many areas. By late summer, flows are very low or non-existent in many of the smaller tributaries. This is especially true of the west-side. tributaries which depend mainly on rainfall for their runoff. Summer showers are not uncommon in the higher elevations of the Sierra and Cascades; are less common at lower elevations and on the valley floor. Their total contribution to the runoff is slight.

The flow pattern in the Central Valley in most years is adequate for fall-run king salmon. These fish normally enter the streams after temperatures have dropped and flows have increased in the fall, The adults then spawn and die and their young hatch and migrate downstream in greatest numbers in February and March. The downstream migration is practically over by the end of May. By way of contrast, juvenile steelhead normally spend a year or more in fresh water before migrating to the ocean. Low flows and high summer temperatures make it impossible for steelhead to survive in many of the Central Valley streams. The main stem of the Sacramento River and some of its cooler tributaries do have good runs of steelhead. Silver salmon, like steelhead, spend a year in fresh water before migrating to the ocean. They do not occur naturally in the Central Valley, and attempts to establish them, even in streams with suitable summer temperatures, have met with complete failure. The young which are planted return as adults in good numbers but are unable to successfully reproduce themselves.

Amount of Habitat

There is a total of 789 stream miles of king salmon and 745 miles of steelhead habitat in the Sacramento River System. There is no silver salmon habitat. The Sacramento ranks third in miles of habitat, but ranks first in habitat area with about 18 thousand surface acres of king salmon and steelhead habitat.

Estimated Abundance of Spawners (Exclusive of Catch)

Spawning stock estimates made over the last five years indicate that an average of 417,000 king salmon and 26,000 steelhead use the Sacramento System each year.

Availability

The Sacramento System has an average of 40 percent of its king salmon and 43 percent of its steelhead habitat accessible to the angler.

Present Use

It was estimated that the Sacramento River System receives approximately 100,000 angler-days of use by salmon fishermen and 39,000 days of use by steelhead fishermen per year.

Present Yield

In the Sacramento System as a whole, salmon anglers average .19 salmon per day of fishing; i.e.,it takes the "average" salmon angler a little over 5 days to catch a salmon. There are a great many totally unskilled fishermen who greatly lengthen the average time between fish. Steelhead fishermen average .27 fish per angler-day, a little less than 4 days per fish. The total annual catch is approximately 19,000 salmon and 10,000 steelhead. The salmon landings given above do not include the hundreds of thousands of Sacramento River king salmon which are taken each year in the ocean off California, Oregon, Washington, and the extreme southern part of Canada.

Critical Factors in the Habitat

Stream flows in the Main Stem of the Sacramento are adequate and temperatures are generally satisfactory for salmonids. On the tributaries, flows are often inadequate and temperatures too high during low flow periods. Fall-run king salmon are often unable to enter the smaller tributaries until after the fall rains have provided an adequate flow. If the rains are late, relatively few fish use the tributary.

At present, water quality is satisfactory (except for temperature), but there has been trouble from heavy metal pollution near Keswick. Other forms of pollution are threatening.

Dams have cut off many miles of spawning area and will cut off more.

Unscreened diversions cause heavy losses, especially the Glenn-Colusa Canal on the main stem, the Sutter Butte and Western canals on the Feather, and the Hallwood-Cordua Canal on the Yuba. Even though it is screened, the Delta Mendota Canal probably causes large losses of Sacramento, Mokelumne, and San Joaquin fish.

Gravel removal from spawning beds is serious on some streams - particularly so on the American River.

Channelization of streams degrades habitat. Some tributary streams have been left impassable to salmon at low flows. Usually this is temporary, but it may result in the loss of a year's run.

MAIN STEM SACRAMENTO RIVER

Amount of Habitat

The main stem provides about 250 stream miles of king salmon and steelhead habitat between Keswick Dam and the City of Sacramento. Below Sacramento, the river is of course used as a travel route by both salmon and steelhead but with the exception of a few winter-run salmon, the fish are seldom taken by anglers. From Sacramento to Hamilton City, the river is still only a travel route but fair numbers of salmon are taken by anglers. There is some salmon spawning as far downstream as Hamilton City, but most of the spawning is between Red Bluff and Redding. A few steelhead are taken as far downstream as the mouth of the Feather River, but most of the steelhead fishing is from Colusa upstream.

Estimated Abundance of Spawners (Exclusive of Catch)

Spawning stock estimates made over the last five years give an average of 187,000 fall-run king salmon per year. It is estimated that 60,000 winter-run, 15,000 spring-run salmon,,and 10,000 steelhead also spawn in the main stem.

Availability

The main stem of the Sacramento has 64 percent of its king salmon and steelhead habitat accessible to the shore angler. The entire river is open to boat fishermen and most of it is utilized by them.

Present Use

The main stem receives 63,000 angler-days of use by salmon fishermen, and 21,600 days by steelhead fishermen. There is salmon fishing some place in the main stem twelve months per year.

Present Yield

Salmon: 11,000 fish per year at a rate of about .19 fish per angler-day.
Steelhead: 6,700 fish per year at a rate of about .31 fish per angler-day.

Critical Factors in the Habitat

With the construction of Shasta and Keswick dams, many miles of anadromous habitat were eliminated. However, the relatively large and constant flows of cold water released from Shasta have greatly enhanced the remaining habitat of the main stem. Additional cool water from the Trinity diversion will help to assure a favorable temperature regime even in dry years.

Large losses of downstream migrants and sometimes of adults as well are known to occur at the Glenn-Colusa pumping plant near Orland and lesser losses at the Anderson-Cottonwood Irrigation District Canal at Redding. The Glenn-Colusa diversion has a capacity of over 2,000 cfs.; the remains of the original fish screen is of no use whatever at stopping either young or adult fish. To replace it would cost about a half-million dollars. The A.C.I.D. Canal has a capacity of about 400 cfs.; new screening has been proposed but never undertaken.

The Red Bluff diversion dam is now nearing completion. The pool will extend upstream for several miles and will flood out some spawning beds. Fishways on the dam appear to be entirely adequate but have not yet been tested by fish. The huge Tehama-Colusa Canal will take off from the river above the Red Bluff Diversion Dam. Careful consideration has been given to the design of the fish screen and to the construction of an artificial spawning channel which is

intended to do more than mitigate the losses caused by flooded-out spawning beds: it is intended to enhance the salmon runs of the Sacramento. It will, of course, be essential to keep close watch on all these fish facilities and make certain that they do operate as planned.

The Coming Canal which now takes off upstream from the Red Bluff Diversion Dam has a worthless fish screen, but it is planned to re-align that canal so that it will use the same headworks and the same fish screen as the as-yet-unfinished Tehama-Colusa Canal.

Heavy metal pollution (copper and zinc) has been a serious problem on the Sacramento River at times. Spring Creek is a small stream which enters the river a short distance above Keswick Dam. The drainage of this stream includes a vast jumble of abandoned copper mines. Drainage from these mines so pollutes the stream that, in periods when there is a heavy runoff from Spring Creek, it has killed fish in the main stem of the Sacramento. The U. S. Bureau of Reclamation has recently constructed a debris dam on Spring Creek so that flows into the Sacramento can be kept at a safe level. The success or failure of this plan will depend primarily upon the men who are operating it.

The new pulp mill at Anderson could have a detrimental effect on the runs of salmon and steelhead in the river. However, water quality standards have been set by the Pollution Control Board, and a monitoring program has been established.

The maintenance of water quality suitable for fishlife is a problem that may become more serious as the State continues to grow. Dissolved oxygen sags have become more pronounced in recent years although no known fish kills can be attributed to oxygen deficiency in the Sacramento River as yet. Serious fish kills due to oxygen deficiency have occurred in other Central Valley streams. The Department must plan to anticipate happenings which will lead to the worsening of pollution and take steps before it gets serious.

BATTLE CREEK (TRIBUTARY TO SACRAMENTO RIVER)

Amount of Habitat

There are about 21 stream miles of king salmon and steelhead habitat in the Battle Creek drainage.

Estimated Abundance of Spawners (Exclusive of Catch)

Spawning escapement into Battle Creek is estimated at 21,000 fall-run, 1,000 spring-run and 1,000 winter-run king salmon, and 5,300 steelhead. This includes both natural spawners and the Battle Creek fish spawned at Coleman Hatchery.

Availability

Battle Creek has 21 percent of its king salmon and steelhead habitat available to the angler. Much of the land along the stream is private and-posted.

Present Use

Battle Creek is closed to salmon fishing; it receives an estimated 2,400 angler-days of use by steelhead anglers yearly.

Present Yield

Salmon: None, because of angling regulations.
Steelhead: About 700 fish per year at a rate of .3 per angler day.

Critical Factors in the Habitat

Some six miles above the Sacramento River, Coleman Fish Hatchery maintains a dam where fall-run salmon and steelhead are diverted into the Federal hatchery. Spring-run salmon and some steelhead are allowed to go above the dam to spawn naturally. Some fall-run kings are able to surmount the dam during periods of high flows. A number of unscreened diversions are present above the dam, but the one diversion below the hatchery is screened.

The stream above the hatchery dam is lightly used and could probably support a far larger run than presently exists. (The Department is currently surveying the available spawning area.) It is not a good sign that the fish returning to Battle Creek are insufficient to fill both the hatchery and the natural spawning beds. A reasonably disease-free hatchery should be producing more than enough fish for both. Coleman has severe disease problems.

The Pacific Gas and Electric Company plans to overhaul its power-generating system in the Battle Creek drainage.

BUTTE CREEK (TRIBUTARY TO SACRAMENTO RIVER)

Butte Creek is a small stream originating on the west slope of the Sierra in Lassen National Forest. It flows west to its confluence with the Sacramento at Wards Landing (Butte Slough Outfall). The maximum flow of record near Chico is 18,700 cfs. Portions of the stream are dry in the summer as a result of irrigation diversions. The stream channel is relatively narrow and bordered by levees in many areas where it flows through agricultural lands. During high runoff periods, overflow waters from the lower river spill into the Sutter By-pass. The average annual discharge at Chico is 283,100 acre-feet per year. This includes considerable water which Butte Creek receives from the West Branch Feather River by way of DeSabla and Centerville power plants.

Amount of Habitat

There are 44 stream miles of king salmon habitat in Butte Creek drainage.

Estimated Abundance of Spawners (Exclusive of Catch)

Butte Creek has a yearly spawning run of about 3,300 spring-run king salmon. There are no fall-run salmon or steelhead. Fall flows are usually-too low to permit fall-run salmon to enter the stream. The spring run has become adjusted to the flow regime of the stream in that adult salmon migrate upstream in late winter and early spring before irrigation demands deplete the stream flow. Spawning takes place in late September and early October, and the young emerge and begin theirseaward migration in December and January.

Availability

Butte Creek has 41 percent of its king salmon habitat accessible to anglers.

Present Use

Salmon fishing : About 2,100 angler-days per year.
Steelhead fishing: None.

Present Yield

About 400 salmon at a rate of .19 fish per angler-day. Access is available at many locations and, because of the stream's small size, anglers are able to take a substantial toll of migrating salmon. Devising adequate angling regulations for Butte Creek has always been a problem.

Critical Factors in the Habitat

At the present time, the DeSabla diversion dam, located seven miles upstream from Centerville powerhouse, is the upstream limit of salmon migration. Downstream from Centerville are seven diversion dams. All of the dams have fishways, but none of the diversions are screened.

There is a hazard to the spring run which takes its toll every year. During high runoff periods in the spring, salmon migrate into the stream between the Centerville powerhouse and the DeSabla diversion dam. During the summer they succumb as a result of low flows and high water temperatures in this section. In 1964, a barrier was installed to keep salmon out of this, but it was washed out by the record floods in December of that year.

A control structure known as the Butte Slough outfall is located at the mouth of the stream. This consists of a series of conduits which convey the flow of Butte Creek through the Sacramento River levee. The conduits are provided with flap gates which automatically close if the level of the Sacramento

River is higher than the level of Butte Creek. One of the gates has been equipped with a manual control apparatus which can be operated to permit fish passage when all the gates would normally be closed.

There are no water projects planned for early construction which would add to the present deficient water supply in Butte Creek. Salmon runs will be benefited if the barrier is rebuilt at Centerville.