SALMON IN CALIFORNIA

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Abstract: Historical data indicating the magnitude of the California salmon population are presented. Environmental factors affecting the fresh-water portion of the salmon's life cycle are discussed in an attempt to determine the factor having the most impact. Measures being employed and those needed to assure continued salmon population are presented. No single activity of man can be blamed for the decline in salmon populations over the past century, but all of man's activities which affect the fresh-water environment must share the indictment.

Along the West Coast of North America the salmon is perhaps the most prized fish sought by anglers. It also figures prominently in commercial catches from Alaska to California. Of the five species of salmon inhabiting the eastern Pacific Ocean, two--the chinook or king (Oncorhynchus tshawytscha) and the coho or silver (Oncorhynchus kisutch)--spawn in California rivers and streams. Being an anadromous species the salmon are subjected to more environmental variations than are nonanadromous fishes. Several years ago this study was started by reviewing literature concerning California salmon in an attempt to quantify the effect of dams on the salmon populations of the Sacramento River.

Historical populations of salmon in California can be determined from two sources: spawning surveys and commercial catch records. The commercial catch record provides nearly a century of data while spawning surveys are of more recent vintage. Figure 1 presents the historical picture of the Sacramento-San Joaquin River commercial fishery from 1874 to 1957 when commercial taking of salmon in the rivers was prohibited. The salmon landings at San Francisco area ports and for the State as a whole from 1916 to 1968 are also shown (Heimann and Carlisle 1970).

Until 1937 few attempts were made to determine the size of the salmon runs in the Central Valley. The pending construction of Shasta Dam on the Sacramento River and Folsom Dam on the American River inspired limited population surveys of these waterways, but until 1953 most counts and estimates were incomplete. That year the California Department of Fish and Game initiated a systematic river survey which has resulted in estimates of the size of the annual fall spawning run of chinook slamon in the Sacramento-San Joaquin River System. Any attempts to count winter- and spring-run salmon usually coincided with high river flows and until the completion of the Red Bluff Diversion Dam, no real means of counting the fish was available. Records of the past four years indicate the presence of large numbers of winter- and spring-run salmon far in excess of the amount thought previously. As many as 5,557 salmon have been counted past Red Bluff in one day (April 17, 1969). The highest single day record of the fall-run was 2,260 fish on October 26, 1969. High turbid flows and construction have resulted in an incomplete record but the accumulated totals exhibited on Figure 2 reveal for the first time the magnitude of the heretofore mysterious winter-run. Figure 3 presents graphically the annual variations in fall spawning chinook salmon in the Central Valley from 1953 to 1970, as compiled from California Department of Fish and Game reports (Menchen 1970).

Very limited data are available on the historical runs of salmon in the rivers of northwestern California. Certain tributaries have dam and weir counts, but many of the streams of the north coast have never been studied adequately to obtain reasonable estimates of the anadromous fish populations. The estimated average annual spawning escapement for northwestern California salmon streams is illustrated on Figure 4 (California Department Water Resources 1965).

The fresh-water portion of the salmon's life cycle is most critical to the perpetuation of the species. This is also the portion of the cycle most affected by man's activities. All of the remaining 3,355 river miles of chinook habitat and 3,687 river miles of coho habitat have been subjected to man's influence--from native fisheries and gold mining to, more recently, pollution, irrigation and power dams, agricultural and municipal water diversions, siltation, overfishing, logging debris, road construction and gravel removal. It is difficult or impossible to single out a factor of the environment and point to it as the most critical element affecting the life cycle of the salmon. The alteration of one ecological element can affect other elements; either compounding a detriment, or, as an end result, mitigating or obviating the initial effect. For example, the construction of a dam could block some spawning grounds, but the controlled and sustained flows below the dam could improve the remaining spawning grounds by providing water each year even during a dry cycle or when fall rains are late, thereby mitigating to a degree for the lost spawning areas by creating a live stream where previously low or intermittent flows prevailed. The interaction of environmental changes on salmon ecology deserves some discussion.

California comes under the influence of a Pacific atmospheric high-pressure system each summer, resulting in little or no precipitation during the hottest portion of the year. To provide water for agriculture, municipal, industrial and power needs during this period of drought, major dams have been constructed on every sizeable Central Valley stream. Few such structures have been built on North Coastal streams, but as the State's last untapped source of water, this area is being intensively studied by many agencies as the water source to supply California's growing demand.

For whatever purpose they are built, dams virtually affect the natural regimen of a stream and, therefore, the inhabitants of that stream. Dams without adequate provisions for fish passage prevent spawners from ascending and utilizing miles of ancestral spawning gravels. The large multipurpose dams constructed during the past quarter century have made provision for lost spawning beds through construction of hatcheries and spawning channels. But earlier dams, initially crude barriers thrown up by gold seekers and subsequently, particularly between 1910 and 1930, power and irrigation dams, obstructed miles of habitat with almost no allowance made for the displaced salmon.

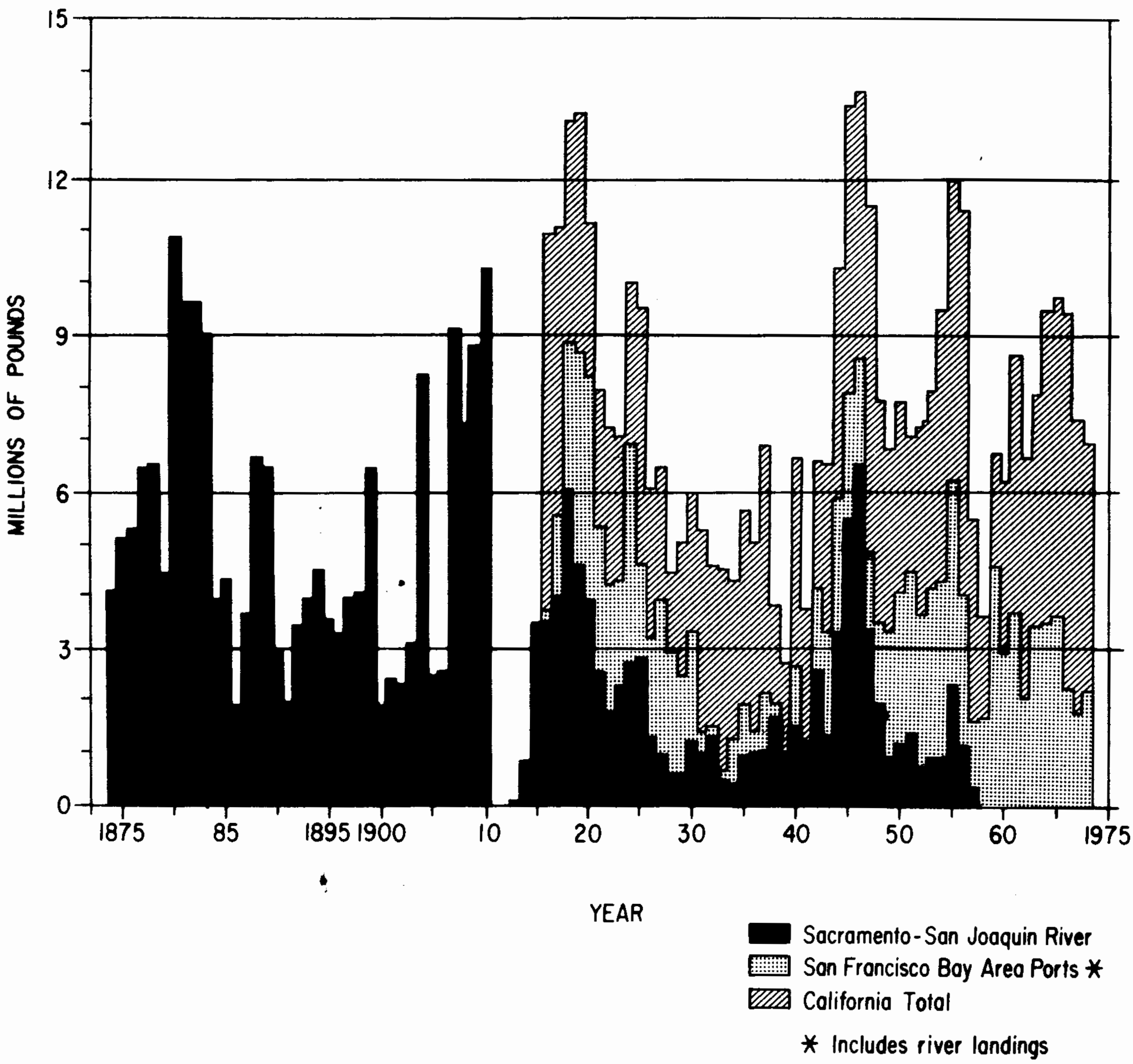
In a number of cases, however, the dams, while eliminating many linear miles of spawning stream, actually inundated or made unusable for salmon comparatively few acres of spawning gravel. If adequate flows of water of the desired temperature are maintained below the dams, as in the case of Shasta Dam, the remaining gravels, although shorter in length, are more efficiently utilized by the spawners than prior to the dam construction. In some cases this control of flows has resulted in an increase in the salmon production.

There is often a complex interaction of several critical environmental criteria when just one element of the natural conditions is altered. Dams retain high, sediment-laden flows and normally release clear water. This clear water prevents fish eggs from being suffocated by silt before the fry emerge from the gravels, but allows greater visibility postemergence and results in greater predation. Regulated flows, while assuring consistent water levels over the spawning gravels, can permit vegetation encroachment upon the gravels and gravel compaction because the pre-project periodic normal high flushing flows caused by storms and snowmelt, which cleaned out the streambeds and stirred up the gravel, are not being controlled.

Powerplants are oftentimes appurtenances of the larger dams utilizing the head of stored water to generate power during release downstream. Smaller dams sometimes function to divert natural riverflows to a downstream or cross-drainage powerplant. Aside from problems created by the dam, demand for electric power is never constant and water is released through powerplants in accordance to peaking demands resulting in alternating high and low flows. The diversions sometimes occur some distance upstream, causing a drastic reduction in dry season streamflows or even worse, may completely dewater entire reaches of stream. Transmountain diversion may benefit salmon of the receiving watershed at a detriment to salmon of the watershed of origin. A case in point here is the diversion of the Eel River at Van Arsdale to the Russian River drainage, thereby materially benefitting the flows in the Russian River at the expense of the Eel.

Figure 1.

CALIFORNIA COMMERCIAL SALMON LANDING
1874 - 1968



A 1959 study (Hallock and Van Woert 1959) revealed more than 900 irrigation, industrial and municipal water supply diversions above the Sacramento-San Joaquin River Delta. Most of the diversions were for irrigation and most of the water was pumped. Many young salmon pass through diversion pumps alive and meet their demise similarly to those detoured by unscreened canals, dead-ended in an irrigation ditch or in amongst the tomatoes. Fortunately, most of the juvenile salmon in the Sacramento River system, during years of normal runoff, migrate out of the upper river before the start of the main irrigation season. The San Joaquin juvenile salmon are not so lucky, as the migration and the irrigation season coincide and significantly greater losses occur.

Young salmon move through the estuary in proportion to flow. In the Central Valley's Delta area, increased diversions from the Bureau of Reclamation's and California Department of Water Resources' pumping plants near Tracy draw Sacramento River water to the southern Delta. As the volume of water pumped increases, more Sacramento and most Mokelumne River salmon will be attracted along with San Joaquin River salmon toward the pumps. Presently, screens keep most salmon out of the canals, but the volume of diversion and periods of new flow reversal can delay or completely block downstream migrants.

The construction of roads, both rail and automobile, has had its effect on spawning grounds. Roadbuilders have notoriously been guilty of disregarding where their cut and fill material ended up and its subsequent effect on the stream. There are now regulations prohibiting this practice, but much damage has resulted both from siltation and from stream obstructions.

Land use, or rather land abuse, is a major contributor to the sediment load of California's salmon streams. Improper logging practices, particularly in the North Coastal area, result in erosion and clogging of stream channels with debris. Over-grazing and its attendant erosion and agriculture with its return irrigation flows containing pesticides and nutrients affect the ability of both young and mature salmon to survive.

The gold seekers of 1849 dealt the Pacific salmon the first blow of what has been a 12-decade fight for survival. The miners built reservoirs to supply water power to the hydraulic mining operations after scouring the streams for traces of the precious metal. Besides obstructing the streams, these mining operations made the rivers boil with mud and silt. Gravel mining for concrete aggregate is a modern-day detriment to salmon. Gravel is removed from spawning areas and silt is produced during washing activities.

Hard-rock mining, mainly for copper, zinc, and iron, has contributed heavy metal and acid pollutants, originating in abandoned and operating mines, waste dumps and exposed mineral deposits, to some spawning streams. Spring Creek, the major contributor of mine polluted water to the Sacramento River, has a debris dam, constructed by the Bureau of Reclamation, to control the volume of polluted water entering the main stream.

Throughout the world from time immemorial, waterways have been the convenient and traditional method of waste disposal. Rivers transported unwanted material away regardless of the effect on downstream inhabitants or on the flora and fauna of the stream itself. California has been no exception to the worldwide pollution ethic with municipal, industrial and agricultural waste freely deposited in the State's waterways. Sewage with various degrees of treatment; thermal, chemical and organic effluent from industry; and chemical, organic, and pesticide residue from agricultural operations all combine to place an additional impediment to the critical fresh-water portion of the salmon's life cycle.

Poor water quality can kill salmon directly, affect their food chain, or lower their resistance to unfavorable temperatures, dissolved oxygen levels, and disease. Some pollutants act individually while others act synergistically. The combination of effects is not well established. Pollution may also hide or alter directional clues which the salmon use to migrate upstream. Pollutants, particularly of organic origin, can appreciably decrease the amount of dissolved oxygen. At dissolved oxygen levels below 8.0 p.p.m., salmon have demonstrated reduced growth rates and poorer swimming performances. Poor swimming capability affects the ability of young salmon to capture food and escape predators, thus affecting their survival.

Figure 2.

ACCUMULATED CHINOOK SALMON COUNTS PAST RED BLUFF DIVERSION DAM

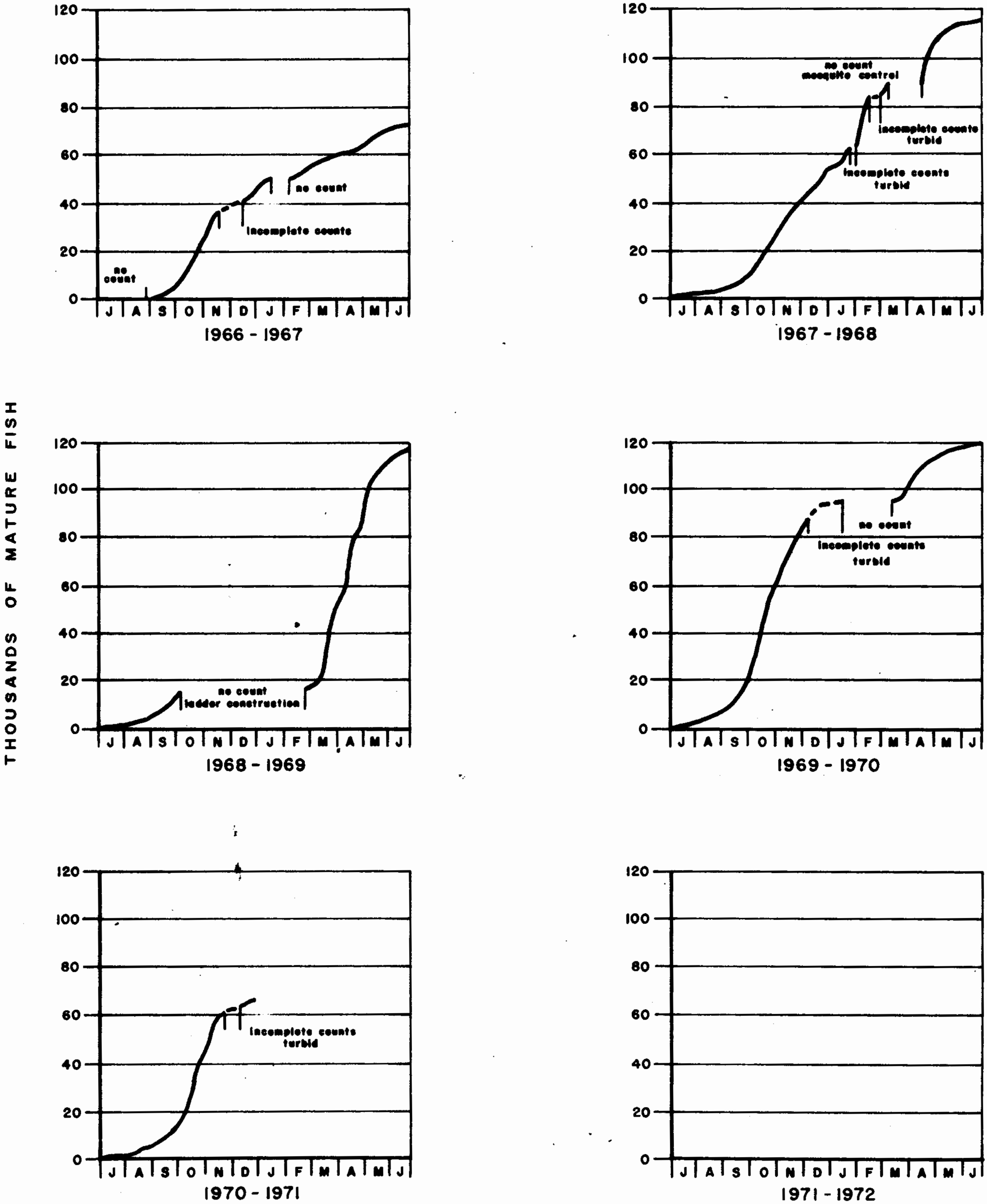
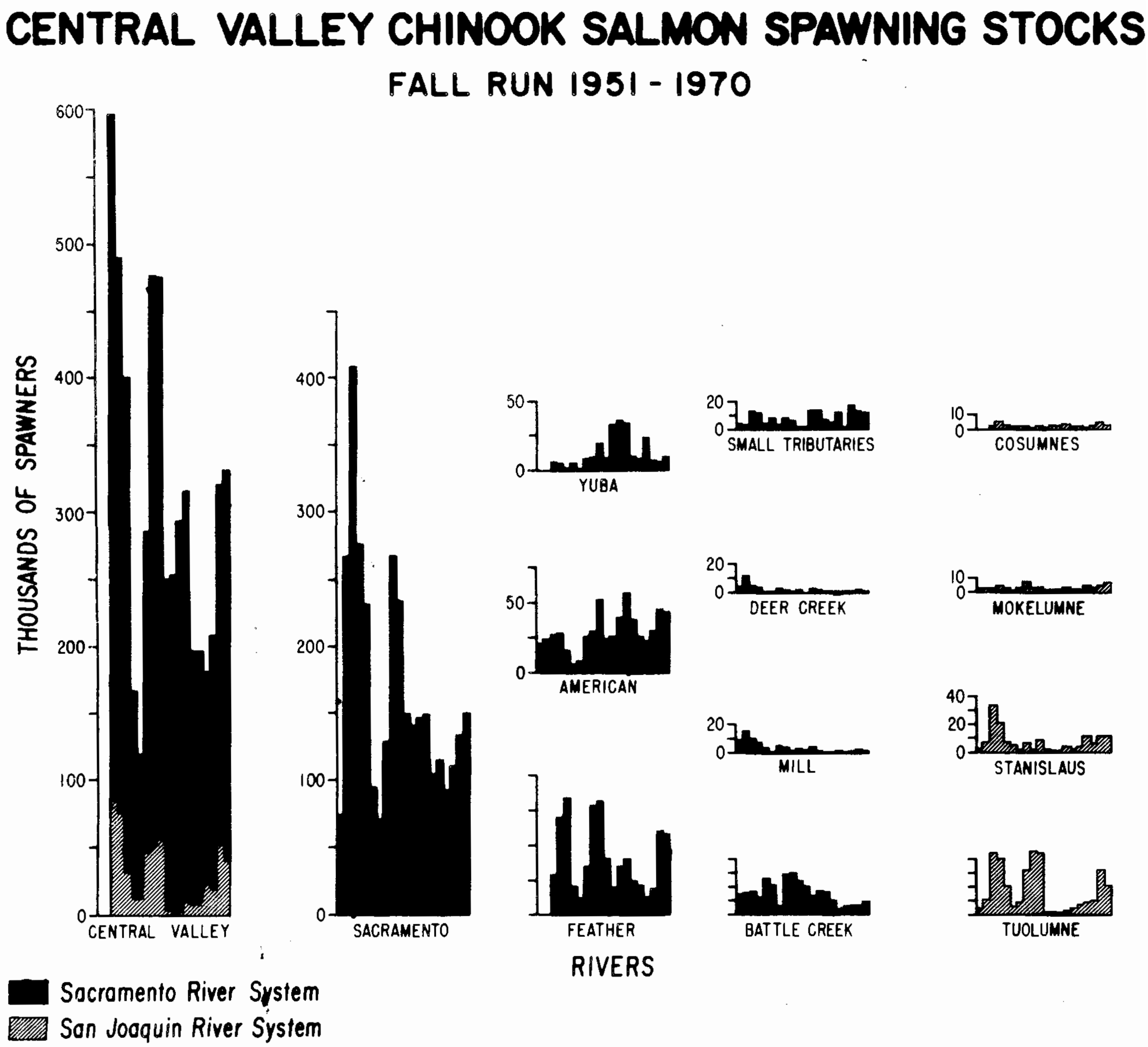


Figure 3.


CENTRAL VALLEY CHINOOK SALMON SPAWNING STOCKS
FALL RUN 1951 - 1970
THOUSANDS OF SPAWNERS
600
500
400
300
200
100
0
CENTRAL VALLEY
SACRAMENTO
YUBA
AMERICAN
FEATHER
SMALL TRIBUTARIES
DEER CREEK
MILL
BATTLE CREEK
COSUMNES
MOKELUMNE
STANISLAUS
TUOLUMNE
50
20
10
40
RIVERS
Sacramento River System
San Joaquin River System

A critical pollution problem occurs in the San Joaquin River near the rapidly expanding city of Stockton. There, the remnant fall-run chinook faced extinction until steps were taken, including release of water from the Bureau of Reclamation's Delta-Mendota Canal into the San Joaquin River via wasteways and the physical blocking of the Old River channel by the California Department of Water Resources. The elimination of the pollution block was first accomplished in 1963 and significant increases in fall-run San Joaquin salmon have occurred since then. Increases in flows eliminated the oxygen deficient block, but the discharges of effluent high in organic material still continue.

Although no singular reason can be blamed exclusively for the decline in salmon abundance, G. H. Clark (1929:23) states, "The greatest single cause (for depletion), and certainly the most important, is without a doubt the extensive overfishing during the last fifteen or twenty years. The salmon fishery has been carried to the ocean without sufficient regulation or control." Regulation of the salmon fishery started in 1870, when the California Fish and Game Commission became alarmed at the declining abundance. Since that time, there has been increasing tightening of restrictions on seasons, limits, and gear, both commercially and sport, to reduce the impact of harvest on the remaining resource.

The majority of California's annual precipitation occurs during the months of October through April with the remaining months being hot and dry. Thus the stage is naturally set for low seasonal flows in streams not spring or snow fed. These naturally occurring low flows were always critical to early migrating fall salmon and when the fall rains were particularly late or insufficient to produce much runoff, the entire run was jeopardized. Diversion of water for many purposes magnified the lack of water in dry years and created dry-year conditions in stream sections even during wet years. Water is now stored specifically for downstream fish release purposes in many of the larger dams recently constructed in the State. Flows of water for fish transportation and to cover spawning gravels enhance the gravels remaining below the dam by assuring flows regardless of whether the storms are early or late or light or intense.

Water temperatures are largely a function of volume of streamflow with higher stream temperatures resulting from slow sluggish flows. Streams having no water control structures and, therefore, having frequent low flows with high temperatures are often avoided by the fish until sufficient water of suitable temperature is available. Dams can provide water of desired temperatures for salmon if water can be drawn from various levels in the reservoir through multiple-level outlets or shutter systems.

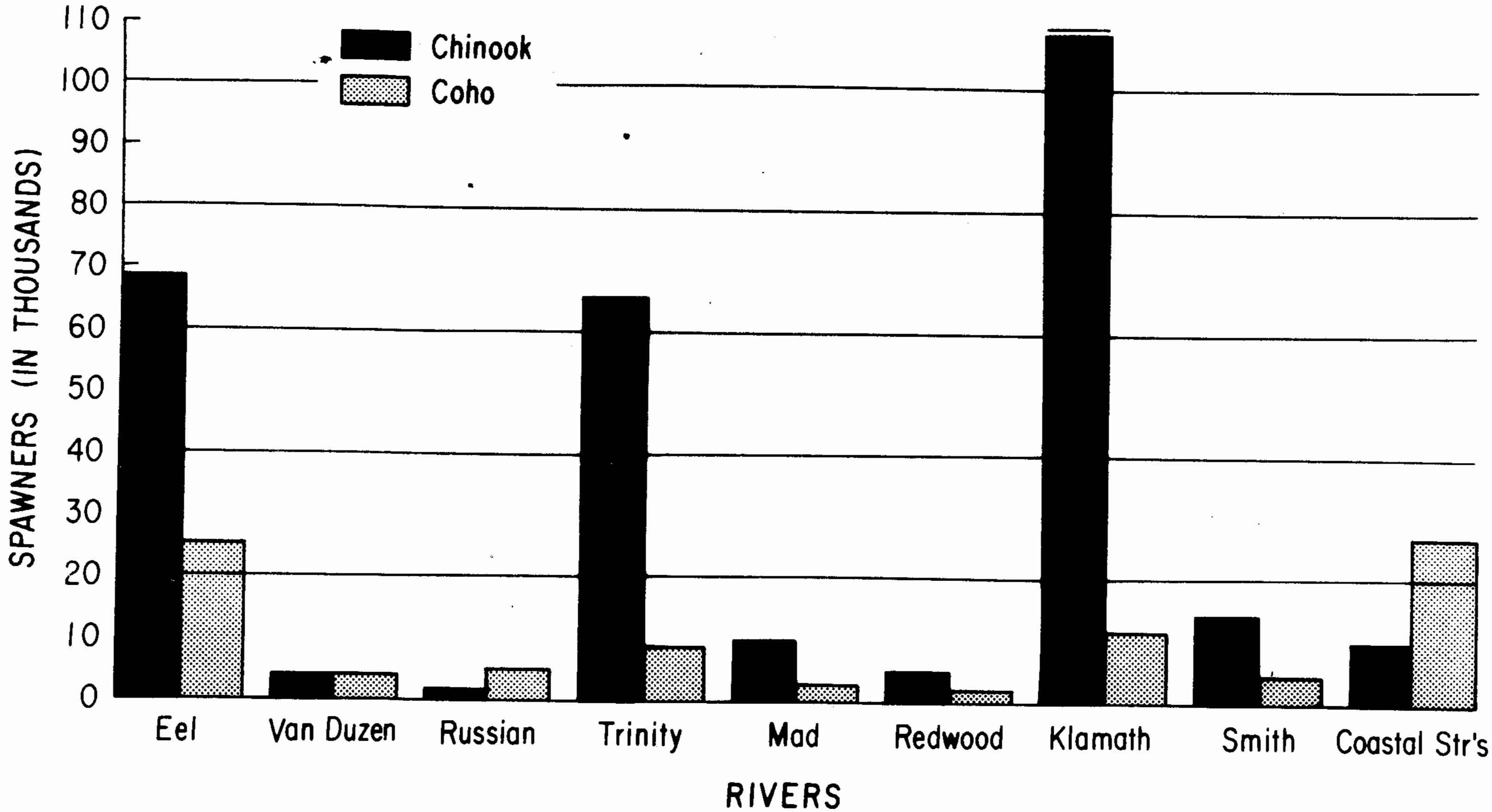
As California's population continues to spiral upwards, the pressures placed on the salmon and its environment continue to increase. At least now man realizes some of the critical elements in the fresh-water portion of a salmon's life cycle and generally will take into account the effect of his actions upon the fish. If a gravel operator or stream diverter fails to recognize the impact of his actions, the weight of public opinion and action by fish and game agencies is often brought to bear to focus attention on the problem. Now fish and wildlife agencies, both State and Federal, are consulted concerning the effect of proposed developments on the anadromous fishery resource. They have more authority than at any time during more than a century of water development to compel specific measures be taken to protect the salmon migrants.

Man is learning what needs to be done to protect and enhance salmon. The twin equalizers of law and economics govern the institution and continuance of the needed measures. Legislation is needed to provide measures to diminish the impact of the activity of polluters, diverters and obstructors of salmon streams. Money is needed to correct long-standing abuses, such as improperly laddered obstructions or inadequate diversion screens, and to construct enhancement features such as spawning channels and hatcheries. Appropriate legislation, regulation and funding will play an important role in the future of salmon in the State.

Perhaps the most significant conclusion that can be drawn is that the salmon's environmental conditions have been so greatly modified by man's activities that it is virtually impossible to ascertain the relative effect of any one factor on the resource. It is, therefore, impossible to blame any one factor, such as pollution or dams, but rather man and his activities, from mining to irrigation to logging, must accept the indictment for the decline

Figure 4.

NORTH COAST OF CALIFORNIA
ESTIMATED ANNUAL SALMON SPAWNING ESCAPEMENT



in a valuable resource. The decline has not been abrupt, but has been steady since the first expressions of alarm by the California Fish and Game Commission in 1870. Several sharp declines have occurred and have been ascribed to railroad building in the 1880's, overfishing in the early 1900's, and dams in the 1930's. The past 15 years, which, at least in the Central Valley, might be described as being under almost complete utilization of the fresh-water environment, witnessed spawning escapements as high as 600,000 and as low as 100,000 fish.

Man's activities in California have generally been counter to the best interests of the anadromous fish resource. Substantial segments of the resource have been destroyed, with oftentimes only token efforts taken to ameliorate the damages. The unmitigated and uncontrolled (from a fishery standpoint) water development and water utilization are conditions of the past. Hatcheries, and water flows of specific temperatures and quality are now required of developers and utilizers of waterways.

Wrongs are being corrected and some enhancement is being undertaken. Diversions are being screened, hatchery cultural methods improved, riffle areas protected, gravel restored, predators controlled, water releases increased, water quality improved, and debris-choked streams cleared. These corrections of long-existing detriments to salmon in fresh water should result in increases in the resource. This will depend upon the interaction between the salmon and, we hope, an environment more suited for its reproduction and survival.

Since 1870 the fate of California salmon has been deplored. The ecologic requirements have been determined and corrective measures delineated. Steps, oftentimes limited by politics and economics, can and are being taken to increase the salmon population. Man now knows what will probably occur if he alters the salmon's environment; he wants the salmon to remain and will employ measures to assure the salmon's survival. The future will determine if the measures are too little and too late.

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