

the NMFS to add the winter run of chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River California to the U.S. list of threatened species. The Assistant Administrator for Fisheries, NOAA, determined that substantial information was presented to indicate that the petitioned action might be warranted, and conducted a status review to determine whether a listing was in fact warranted. Based principally on the actions State and Federal agencies have adopted and are implementing, NMFS has determined that a proposed listing of the winter run of chinook salmon in the Sacramento River is not warranted at this time.

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SUPPLEMENTARY INFORMATION:

Background

On November 7, 1985, the American Fisheries Society petitioned NMFS to add the winter run of chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River California to the U.S. list of threatened species. In accordance with section 4 of the Endangered Species Act of 1973 (ESA) and 50 CFR Part 424, the Assistant Administrator for Fisheries, NOAA, determined that substantial information was presented to indicate that the petitioned action might be warranted. On February 13, 1986, NMFS announced its intention to conduct a status review to determine whether a listing was in fact warranted and solicited information and comments on the petition (51 FR 5391-5392). The results of the status review are presented below. Based principally on the actions State and Federal agencies have adopted and are implementing, NMFS has determined that a proposed listing of the winter run of chinook salmon in the Sacramento River is not warranted at this time.

Status Review

The status review is based on a consideration of available information on the run relative to the five criteria specified in section 4(a) of the ESA and a consideration of the efforts of the State of California and Federal resource management agencies to restore the run. Information was provided by the petitioner, the State, Federal agencies that affect the run or its habitat, and the public. Most of the information provided by the petitioner is contained in a report

National Oceanic and Atmospheric Administration

[Docket No. 70225-7025]

**Endangered and Threatened Species;
Winter Run Chinook Salmon**

AGENCY: National Marine Fisheries Service (NMFS), NOAA, Commerce.

ACTION: Notice of determination.

SUMMARY: On November 7, 1985, the American Fisheries Society petitioned

by the California Department of Fish and Game (CDFG) on the status of the run (Hallock and Fisher 1985).

Four runs of chinook salmon are extant in the Sacramento River. They are separated by differences in spawning and migration seasons. The distribution and abundance of each run is limited by the availability of suitable habitat during their respective spawning seasons. Essential elements for suitable spawning habitat are the availability of clean gravel which provides a substrate for spawning, adequate flow of oxygenated water through the gravel to aerate the eggs, and water temperatures between 42.5 and 57.5 °F which are optimal for egg development (Combs and Burrows 1957). The amount and location of spawning habitat available in the river varies with seasonal changes in flow patterns. The various runs have evolved life history patterns that are adapted to the environmental conditions that exist when they are in the river. For example, suitable spawning conditions exist throughout much of the Sacramento drainage when the fall run is spawning. Consequently, fall-run chinook are the most numerous and widely distributed run in the drainage. On the other hand, when spring and winter-run salmon are migrating or spawning, river flows are not sufficient to maintain a broad distribution of suitable spawning habitat. Historically, these have been small runs limited by the availability of spawning habitat. The spring run migrates to the head waters of tributary streams and holds over the summer in cool pools where temperatures remain below debilitating levels. They spawn in the fall when water temperatures in the gravel beds fall to below levels lethal to eggs. Juvenile spring-run salmon out migrate after the fall rains begin and there is sufficient water to complete the migration to the sea. Historically, the winter run employed a different strategy for spawning at what might be considered a less than optimal time. It entered the river in December and migrated to the spring-fed head waters of the McCloud River where they spawned from April through June. The spring water provided a consistent source of water at a temperature suitable for egg development and enough water to ensure passage of juvenile fish to the mainstem of the Sacramento in the late summer when the out migration began.

These differences in the timing of the runs and spawning behavior serve to isolate the various runs reproductively. Therefore, assuming that the various runs are separate breeding populations

that have evolved distinctive genomes is reasonable. An analysis of genetic variants in polymorphic protein systems has been used to describe the population structure of chinook salmon on the Pacific Coast of North America. Utter (in litt.) has identified eight genetically distinct geographic regions in the spawning range of chinook salmon. The Sacramento drainage is one of these regions. Populations within each region are genetically more similar to one another (though still statistically different) than to those in other regions (Utter in litt.). This supports the hypothesis that the species was established in each river system by an ancestral run which subsequently differentiated distinct genetic stocks in response to varying environmental conditions in the river system. The CDFG has contracted a study to quantify the genetic distinctness of the chinook runs in the Sacramento River (Odemar pers. comm.). NMFS anticipates that the results will demonstrate, as in other river systems, that the various runs in the Sacramento River are genetically distinct and that there is likely sufficient reproductive isolation to maintain the runs as distinct races of chinook salmon. NMFS agrees with the petitioners that considering winter-run chinook as a "species" in the context of the ESA is appropriate.

Winter-run chinook in the Sacramento River have a varied and interesting history. The run was excluded from its historical spawning habitat by the construction of Shasta and Keswick Dams in the early 1940s. Prior to the construction of the dams water temperatures in the vicinity of and down river from the dam sites was above lethal limits for salmon eggs at the time of year that winter-run salmon spawn. Cold hypolimnetic water is released from these dams year round to generate electricity. This release of cold water changed the temperature gradient in the river and created suitable spawning habitat for winter-run chinook in the mainstem of the Sacramento that exceeded what had previously been available in the head waters of the McCloud River (Slater 1963).

Trends in the in-river sport catch and observations of spawning activity at various locations in the upper Sacramento River Drainage indicated that the winter run increased in abundance between the 1940s and mid 1960s (Slater 1963). What had been a small run of probably several hundred fish had increased to over 80,000 fish by the mid 1960s. This increase in population size was attributable to the increase in habitat that resulted from

human-induced changes in the flow of the Sacramento River.

In 1966, installation of Red Bluff Diversion Dam (RBDD) was completed approximately 50 miles down river from Keswick Dam. RBDD was designed to be a passable dam. Fish ladders were installed to allow salmon to migrate up river past the dam. The ladders provide a mechanism for counting salmon and estimating the size of salmon runs to the upper Sacramento River (above Red Bluff). Since the late 1960s and early 1970s, the winter run has declined. The estimated number of winter-run chinook salmon migrating past RBDD for the three year period, 1967-69, averaged 83,916 fish annually. During the three year period, 1982-84, the run averaged only 2,056 fish annually.

The reasons for the decline in the winter-run chinook population and a discussion of the factors affecting the population are analyzed below in the context of the five criteria specified in section 4 of the ESA for determining whether or not a species should be listed.

Listing Procedures

Section 4 of the ESA requires the Secretary of the Interior or Commerce, depending upon the species involved, to determine if any species is an endangered or threatened species for any of the following reasons: Present or threatened destruction, modification or curtailment of its habitat or range; overutilization for commercial, recreational, scientific or educational purposes; disease or predation; inadequacy of existing regulatory mechanisms; or other natural or manmade factors affecting its continued existence. The ESA requires such listing determinations to be made solely on the basis of the best scientific and commercial data available after conducting a review of the status of the species and taking into account any efforts being made to protect the species under consideration.

NMFS considered the criteria given above in determining whether or not winter-run chinook salmon in the Sacramento River should be listed as a threatened species. These factors and their relation to the winter-run chinook population are discussed below.

1. *The past, present, and threatened destruction, modification, or curtailment of winter-run chinook salmon habitat or range.*

The most serious problem affecting the habitat of winter-run chinook is the barrier that the RBDD presents to salmon that are migrating upstream to

their spawning grounds. Hallock et al. (1982) investigated the effect of the RBDD on migrating salmon and found that the RBDD blocked the upstream migration of 37.5% of the salmon they had tagged. The fish that passed the dam were delayed an average of 18 days in their migration by the dam. These problems are likely a ramification of the hydrodynamics of the dam.

The spawning migration of winter-run chinook salmon coincides with periods of peak flows in the river. During high flows the gates in the dam are partially raised. The acceleration of the flow as it passes through the constraints of the partially raised gates creates a great deal of turbulence downstream from the dam. This turbulence obscures the hydrodynamics of the fish ladders to the point that salmon have difficulty finding the entrances.

The blockage and delays experienced by the winter run have an adverse effect on the population. The extra time added to the migration to overcome the barrier created by the dam prolongs the physiological stress of migration and presumably reduces fecundity by some unquantified amount. Blockage has a more severe effect.

Winter-run salmon that are blocked at the RBDD spawn downstream from the dam. During the spawning season for winter-run chinook salmon (April-June) water temperatures below the dam are usually at levels that are lethal to salmon eggs. Hallock and Fisher (1985) reviewed seasonal temperature variations in the river for a period of 18 years (1967-1984) and found that in 14 of those years water temperatures in the river below the dam reached seasonal highs that were lethal for salmon eggs.

Even in years of relatively light flows, the RBDD interferes with the migration of winter-run chinook. In 1985, 27% of the salmon redds (spawning areas) counted in an aerial survey were located downstream from the dam (Fisher, pers. comm.). If this is assumed to be representative of the population, then over a quarter of the run spawned in a section of the river where egg survival would be expected to be near zero.

The RBDD is operated by the U.S. Bureau of Reclamation (USBR). The purpose of the dam is to create a headwater for diversion into the Tehama-Colusa canal which delivers irrigation water to agricultural lands on the west side of the Sacramento Valley. Peak diversion occurs in the summer and early fall, times of the year that are least likely to affect the winter run. The dam is operated in the winter to provide water to west side National Wildlife Refuges and to meet two small contracts

for water deliveries during February and March.

NMFS and the CDFG requested the USBR to raise the gates in the dam during the winter to facilitate the passage of adult winter run to suitable spawning habitat. Until recently, the USBR has been reluctant to comply with these requests because of their commitments for water deliveries in the winter. To assist the USBR in complying with the request to open the gates in the RBDD, the U.S. Fish and Wildlife Service identified alternative water sources for their west side refuges. On October 23, 1986, the USBR informed NMFS that alternative sources of water had been identified for meeting their winter obligations for water and that beginning on December 1, 1986, the gates in the dam would be raised for a period ending on March 31, 1987. The USBR further agreed that the gates could be raised during the same period in subsequent years, if monitoring programs during the first year demonstrated that raising the gates is beneficial.

This will remove the barrier to upstream migration of winter-run chinook salmon. With unrestricted access to suitable spawning habitat, the run should begin rebuilding. NMFS has funded a monitoring program to document that the salmon are passing the RBDD and that the stocks are rebuilding. The four year program will encompass one complete life cycle for the run so the benefit of raising the gates can be quantified in terms of increased returns from the 1987 year class. Documentation of increased returns will allow the USBR to implement a long term change in operations so that the gates are raised during subsequent winter-run migrations.

Other passage problems are created by the operation of the Anderson-Cottonwood Irrigation District's (ACID) diversion dam upstream from Red Bluff. The ACID dam is an antiquated structure that was built in 1917. The gates consist of a series of flash boards that are put in place and manipulated manually. Generally, the dam is operational from mid-March to mid-November. Thus, it is only the tail end of the run that is affected by the dam. There is a fish ladder at the dam but it is inadequate to facilitate passage of all the salmon that encounter the dam when it is operational. This excludes some fish from spawning habitat that exists above the dam (USBR 1983a). Blockage at the ACID dam is not as severe a problem as the blockage at the RBDD because suitable spawning habitat exists below the ACID dam. Consequently, the problem has not been

fully investigated and the effect of the blockage on the population remains unquantified.

The seasonal operation of the ACID dam creates an additional problem. When salmon migrate past the dam before it is put into operation and spawn immediately upstream of the dam, the small reservoir created by the dam when it is put into operation covers the salmon redds. This reduces the flow of aerated water over the eggs and can reduce the survival of the eggs (T. Richardson, USFWS, pers. comm.). The effect of this problem on the winter-run chinook population also remains unquantified.

A third problem is created by the operational and structural limitations of the ACID dam. The flash boards can be manipulated only in river flows of 6,000 cubic feet per second (cfs) or less, and they can only withstand flows of up to 12,000 cfs. Because of these limitations the ACID dam must be operated in conjunction with Keswick Dam. The ACID and the USBR have an informal agreement to coordinate their operations. Any time the flash boards have to be manipulated at the ACID dam the releases from Keswick are reduced to 6,000 cfs. When releases from Keswick must exceed 12,000 cfs the flash boards at the ACID dam must be raised. This requires that the releases from Keswick be reduced to below 6,000 cfs before they are raised to above 12,000 cfs. Fluctuating flows in the river to coordinate the operation of the dams has an adverse affect on developing salmon eggs. Reduced flows can result in dewatering of redds or inadequate flows through the interstitial spaces of the gravel to keep developing eggs adequately aerated. Since the winter run's spawning season is encompassed by the irrigation season, this problem likely has some effect on the run. The USBR, the ACID, and the CDFG are negotiating a formal agreement to improve coordination of operations and to factor consideration of the winter run needs into making operational decisions. This agreement will mitigate the problem to some extent, recognizing that situations may arise where adverse effects on the winter run are unavoidable.

While the ACID dam may have an effect on the rate of restoration of the winter run, NMFS doubts that the ACID was a significant contributing factor to the decline of the run. The ACID dam was in operation during the time the winter run was being relocated from the McCloud River and expanding in the Sacramento River (1940-1969). Therefore, NMFS thinks that given

remedies to other factors affecting the population, such as the passage problems at the RBDD, the run will recover in spite of the problems at the ACID dam.

Spawning habitat has been degraded by decreases in the rate of replenishment of gravel suitable for spawning. Construction of Shasta and Keswick Dams precluded the recruitment of new gravel from the river and its tributaries above those dams, and gravel mining in the tributary streams below those dams has slowed the recruitment of new gravel into the Sacramento (CDWR 1980). Consequently, the amount of suitable spawning habitat has been shrinking. In 1985, the CDFG began a spawning gravel replenishment program. The CDFG is purchasing gravel and placing it in the river to restore degraded spawning riffles in areas of the river used by the winter run. In addition to replenishing degraded riffles, the CDFG is working with the California Department of Water Resources to modify gravel mining permits to ensure adequate stores of gravel are left in the tributary streams to replenish naturally the spawning areas in the main stem of the river with new gravel.

In September, 1986, the State of California approved the Sacramento River Fisheries Habitat Restoration Act (SB 1086) which sets aside funds for identifying and rectifying factors degrading habitat of salmonid species in the Sacramento River. This bill will provide a source of funding upon which the CDFG can commit to continued efforts to restore the habitat of winter-run chinook in the Sacramento River.

Much of the Sacramento River has been ripped, leveed, or otherwise channeled to prevent erosion of agricultural lands. Studies of bank protection projects in the upper Sacramento River have demonstrated that juvenile salmon show a marked preference for non-ripped areas over ripped areas (Schaffter, et al. 1983; Michny and Hampton 1984). Therefore, bank stabilization may affect the quality of rearing habitat. The effect of this on the productivity of the winter run is unclear, however the run does not appear to be limited by the availability of rearing habitat. NMFS, the USFWS, and the CDFG coordinate with the U.S. Army Corps of Engineers on a project-by-project basis to ensure that bank stabilization projects are adequately mitigated to ensure conservation of suitable rearing habitat.

Pollution also has degraded the spawning habitat of the winter run. Runoff from inactive mining operations, at Iron Mountain Mines in the vicinity of

Spring Creek, leaches heavy metals which can reach levels that are lethal to juvenile fish, alevins, and eggs. A debris dam was constructed on Spring Creek in the 1940s to collect debris washed down from the mine sites and to control the release of toxic water into the mainstem of the Sacramento River. Under normal conditions releases from Spring Creek Dam are diluted by releases from Keswick Dam so that concentrations of heavy metals in the Sacramento remain below toxic levels. During years of heavy precipitation spills from Spring Creek Reservoir result in uncontrolled releases of toxic water. Generally, this occurs in the winter when fall-run chinook alevins are hatching and fry are emerging from the gravel. These are the life stages most sensitive to pollution and large kills of these life stages have been attributed to spills of toxic water. Winter-run adults are subjected to these spills. While kills of adult fish have not been reported, sublethal effects such as reduced fecundity are probable. The Environmental Protection Agency has identified Iron Mountain Mines as a location for the expenditure of Superfund monies. The EPA has allocated 70 million dollars to cleaning up the site. They will cap old mines, fill open pits and reroute streams around tailing to reduce rates of leaching.

In addition to cleaning up the major source of pollution affecting the upper Sacramento, the California Water Quality Control Board (CWQCB) has established discharge standards for the release of toxic water from Spring Creek Reservoir. This will reduce further the problems emanating from the Spring Creek Reservoir.

Future threats to winter-run chinook habitat include increasing demands for water from the Sacramento River for agricultural and industrial uses and water development projects. Increased deliveries of water from the Sacramento River are likely to affect the flow regime of the river which, without careful planning, may result in increased water temperatures (USFWS 1984a). NMFS is currently in the process of quantifying the value of water left in the river for maintaining anadromous fishery resources. This information will allow the resource management agencies to compete for water on an equal basis with other users so that adequate flows in the river are maintained.

There are several water development projects proposed for the upper Sacramento River. If they are implemented they will likely result in further destruction, modification, or curtailment of winter-run chinook habitat or range. These proposed projects include the USBR's Enlarged

Shasta Dam Project, the U.S. Army Corps of Engineers' Cottonwood Creek Project, and the City of Redding's Lake Redding and Lake Red Bluff hydroelectric projects. The Enlarged Shasta Dam Project would result in an enlarged Keswick Dam downstream from the existing structure which would reduce the winter run's range. The Cottonwood Creek Project would probably result in some warming of the Sacramento River which would adversely impact the winter run spawning downstream of the Sacramento River-Cottonwood Creek confluence. The Lake Redding Project would adversely impact spawning habitat upstream and downstream of the proposed dam. The Lake Red Bluff Project would adversely affect both upstream and downstream winter-run salmon passage at RBDD (USFWS 1984a). NMFS and the USFWS are able to work through laws such as the Fish and Wildlife Coordination Act to protect the habitat from degradation by Federal activities. The State of California has similar mechanisms in place to ensure that habitat is not degraded by State activities.

2. Overutilization for Commercial, Recreational, Scientific or Educational Purposes

The winter-run chinook from the Sacramento River are probably subjected to a harvest rate that is less than that for the other three races of Sacramento River chinook. This generalization is based on two observations. First, winter-run chinook return to the upper Sacramento River at a younger age and smaller size than the other three runs. This indicates that winter-run chinook are available to ocean sport and commercial fisheries for a shorter period of time than the other runs and receive greater protection from the size limits imposed by the Pacific Fishery Management Council (PFMC). Second, the separation in timing of the adult spawning migration from the ocean, between the winter-run and the fall run (the target run for the ocean fishery), is almost complete. Data concerning the relative timing and distribution of winter-run chinook in the ocean is scarce and the data that is available is flawed. Nevertheless, the inference from these data is that a significant separation exists and the ocean fishery has a relatively small impact on the winter run.

According to Hallock and Fisher (1985), winter-run chinook mature almost exclusively as two and three year old fish (25% age-two, 67% age-three, and 8% age-four), whereas fall-run

chinook tend to mature somewhat later. Winter-run chinook are generally smaller at a given age than fall chinook salmon. Juveniles from a given fall chinook brood generally migrate from the upper Sacramento River in February and March, while winter-run juveniles, from the same brood, migrate to the ocean in July and August. Consequently, in the ocean, the fall chinook are half a growing season ahead of the winter run. Ocean fishing regulations call for a minimum size limit of 20 inches for the sport fishery and a 26 inch size limit for the commercial fishery. These facts help explain why the sport catch of winter-run chinook is almost exclusively two-year-old fish, whereas the commercial catch is mostly three-year-old fish. This also explains why the ocean sport fishery is responsible for 71 percent of the ocean harvest of winter-run chinook, while only representing 29 percent of the total ocean harvest. Winter-run chinook are not available to the ocean fisheries for as long as the "target" species (fall chinook) and thus experience a lower harvest rate.

Hallock and Fisher (1985) report hook-scarring percentages for chinook that were released in the ocean fishery. Hook scars occur when fish under legal size limits are released alive. Of the fish examined at the trapping facility at the RBDD, the spring, fall, and late-fall runs experienced 38 percent greater hook-scarring than the winter run. In addition, the scarring rate of the winter run has declined over the past four years. Hook-scarring cannot easily be used to infer harvest rates or even "shaker mortality" (associated with the release of undersized fish), but it does show a reduced interaction between the winter-run chinook and the ocean harvest.

Nearly all data about the time, growth, distribution, and mortality of stocks in the ocean are based upon tagging experiments at hatcheries, using coded wire tags (cwt). Winter-run chinook are exclusively a naturally spawning race and there have been no cwt studies. However, Hallock and Fisher (1985) report a marking study, conducted in 1969-71, in which juveniles from three broods were seined from the Sacramento River, fin-clipped, and released. Recoveries of the adults from these releases were tabulated, and estimates made of age at harvest and harvest rate. Their results confirmed that winter-run chinook mature almost exclusively as two and three year olds and produce an estimated catch to escapement ratio of 0.53:1.0 and an ocean harvest rate of 34.6 percent.

These are likely conservative estimates because during the study a

duplicate mark was used unintentionally in other California and Oregon chinook studies. Consequently, the mark returns in the ocean fishery that were attributed to the Sacramento River winter run were too high by some unknown amount. Also, the harvest rate has likely declined since the study was completed. The ocean fishing regulations are currently more restrictive than they were during the early 1970s. The total harvest rate in the ocean fishery and the landings from the ocean sport fishery have declined since 1970 (PFMC 1986). The effect of each of these factors is an over estimation of the ocean harvest of winter-run chinook.

Data on inland sport harvest of adult winter-run chinook are scarce; estimates are available from 1968-73 and 1975. Hallock and Fisher (1985) report data for this period that show Sacramento River sport harvest rates for winter-run chinook averaging 8.5 percent of the in-river run. No data have been collected in the last ten years.

Hallock and Fisher (1985) reported that 85 percent of the total catch of winter-run chinook from the 1969-1971 broods were caught in the ocean and 15 percent in the Sacramento River. The total catch to escapement ratio was 0.58:1.0 and a total harvest rate was 38.0 percent based on this data.

The harvest rate of winter-run chinook is substantially below that managed for any other chinook stock on the Pacific coast. The PFMC reports an index of ocean fishery harvest rates south of Point Arena for California Central Valley chinook. The 16-year average for this index is 64 percent. The CDFG (L. B. Boydston, personal communication) estimates that the total harvest rate for these stocks (including areas north of Point Arena) is about 30 percent greater than the reported "index," or 82 percent. This represents a catch to escapement ratio greater than 4:1. In Washington State, where, in addition to "conservation" management, the ocean fishery is restricted to achieve court-ordered allocations of chinook to inside Indian fisheries, the ocean catch to escapement ratios are managed between 1:1 and 2:1 (}. Coon/PFMC staff, personal communication).

NMFS believes that any stock (even a marginally healthy one) should be able to maintain stable population levels at the moderate harvest levels to which winter-run chinook are subjected and that harvests have not been instrumental in the decline of winter-run chinook in the Sacramento River. Nevertheless, NMFS is supporting the CDFG's plans to implement additional restrictions on the in-river sport fishery

to curtail the harvest of winter-run chinook as they approach their spawning habitat. The CDFG intends to implement these restrictions beginning January 1, 1987.

3. Disease or Predation

There are no data to indicate that winter-run chinook salmon experience unusual levels of disease. The impact of this factor on winter-run salmon is probably negligible.

There is insufficient data available on the life history of winter-run chinook to predict what effect predation has on the population. The reproductive strategy employed by salmon is to produce large numbers of offspring that can sustain high rates of mortality in the young age classes, with only a small percentage of the brood stock surviving to reproduce. Hallock and Fisher (1985) reported that the average fecundity of winter-run females is 3,353 eggs per female. Presumably, the population can grow if 0.1% of these survive to reproduce. This type of reproductive strategy makes it difficult to determine if predation is excessive or is operating to the disadvantage of a population. There are several predator-prey relationships involving winter-run chinook and piscivorous fish that may be unbalanced as a result of human activities in the river. These particular predation problems may be inhibiting the population's ability to grow, especially when combined with the factors affecting spawning success.

The most important in-river predator on winter-run chinook is probably the Sacramento River squawfish (*Ptychocheilus grandis*). Large numbers of squawfish have been observed below the RBDD where they forage on young salmon that are passing under the dam. As the juvenile salmon pass under the dam, they become disoriented by the turbulence and are unable to escape predation for some period of time. Vogel (unpublished data) has observed squawfish foraging below the dam on juvenile fall-run chinook and he has observed large schools of squawfish below the dam in the fall when winter-run chinook are migrating down stream. It is reasonable to expect that squawfish are exploiting the winter run as well.

Striped bass (*Morone saxatilis*) are another predator on juvenile salmon (USBR 1983b) that has been observed in large schools below the dam (Vogel 1982). Presumably they are taking advantage of the situation also.

Another modification to the flow in the river that exposes juvenile salmon to excess predation exists in front of the CDFG fish screens at the Glenn-Colusa

Irrigation District's (GCID) pumping plant. Changes in the river channel in the vicinity of the GCID plant have altered the hydrodynamics of this section of the river. During periods of low flows, juvenile salmon are diverted from the main stem of the river to a position in front of the fish screens where they remain because flows are inadequate to flush them back out into the main stem. Periods of low flows usually occur in the fall when winter-run fry are migrating. Ward (CDFG, Pers. comm.) has observed winter-run fry in front of the fish screens in September. This delay in the downstream migration exposes juvenile salmon to predation by squawfish and striped bass for an undefined but extended period of time. Specific data on the magnitude of this problem are lacking, but it is likely that predation rates near the GCID pumping plant are artificially high.

Other piscine predators on juvenile salmon include rainbow trout (*Salmo gairdneri*; J. Hanson, USFWS, pers. comm.), American shad (*Alosa sapidissima*; Vogel, USFWS, in lit.), and large juvenile salmon released from hatcheries (Hallock and Fisher 1985). Few data are available to quantify the magnitude of predation by these species. Therefore, whether they represent a resource problem remains uncertain.

Salmon fry and smolts are also preyed upon by birds (gulls, cormorants, and herons) and older age classes and adults are preyed upon by marine mammals, and larger predatory fish in the ocean. The effects of this mortality are also unquantified.

The squawfish population appears to have the greatest potential for interfering with the growth of the winter-run population. It is the only one of the predator species in the river for which there is little interest among fishermen. Consequently, the population of squawfish is relatively large. The NMFS is developing a management strategy to reduce the size of the squawfish population and therefore the effect of the predation on winter-run chinook.

4. The Inadequacy of Existing Regulatory Mechanisms

Laws relevant to the protection and restoration of the winter run are the Magnuson Fishery Conservation and Management Act (MFCMA), the Fish and Wildlife Coordination Act (FWCA), the Clean Water Act, the National Environmental Policy Act, Anadromous Fisheries Conservation Act, and various State laws administered by the CDFG and the California Department of Water Resources. These laws provide for the conservation of living resources through

wise use and management or the consideration and mitigation of adverse impacts from water and land use projects on living resources such as winter-run chinook salmon.

An example of the effectiveness of these mechanisms is the "Fish Passage Action Program for Red Bluff Diversion Dam". This is a multi-agency cooperative effort that was implemented, in part, because of the requirements of the FWCA. This program was designed to identify and develop solutions to fish passage problems. Several actions have already been implemented through the USBR's "Interim Action Measure Program." While these actions have been beneficial primarily for fall-run chinook, they indicate that a viable mechanism exists for dealing more specifically with winter-run problems.

The Federal Energy Regulatory Commission's (FERC) regulations for authorizing water related energy projects contain provisions which allow the resource agencies to intervene in the permitting process. This provides the resource agencies with a clear voice in the decision to issue or deny a specific permit or to apply special conditions to the permit to protect fish resources. NMFS has used this process to intervene in the FERC process for the City of Redding's proposed Lake Redding and Lake Red Bluff hydro-electric projects.

NMFS thinks that the available laws and regulations provide adequate mechanisms for restoring the winter run in the Sacramento River. However, the precipitous decline in the size of the run since the late 1960s indicates that these regulatory mechanisms have not been applied effectively with respect to winter-run chinook. For example, the PFMC has established escapement goals for the major salmon runs and has implemented management measures to achieve those goals. They have not established a goal for the winter run, nor have NMFS or the CDFG used their authority under the MFCMA or State law to investigate the effects of commercial and sport harvests on winter-run chinook.

Most of the management measures implemented by Federal and State agencies under existing authorities have been directed at maintaining a harvestable fall run of chinook salmon. Benefits to other runs have been largely incidental to those management measures. The resource agencies are now applying existing authorities to the specific restoration of winter-run chinook salmon. NMFS, the USFWS, and the CDFG are planning field studies to quantify the benefits of these recent actions.

5. Other Natural or Manmade Factors Affecting the Continued Existence of the Species

Winter-run chinook salmon are particularly sensitive to the effects of drought. As was discussed above, water temperature is a critical factor in the development of salmon eggs. During drought years, the water levels in Lake Shasta are drawn down to the point that releases from Shasta Dam become too warm to support a successful spawn. This happened during the 1976-77 drought. Winter-run chinook from those year classes returned during the 1979 and 1980 runs at a rate of 0.07 fish per parent. Water management practices could be modified to maintain cool temperatures in the river during droughts and mitigate the adverse effects of droughts on winter-run chinook. The USBR has identified several options for maintaining adequate river temperatures during droughts. Among the options are a modification of the intake structure at Shasta Dam so that cold water is pulled from the bottom of the reservoir or plan for increased releases from cool reservoirs on tributary streams. The options identified are expensive in terms of funds expended, lost revenues, or unmet obligations for water. Therefore, whether or not the USBR will implement one of the options remains uncertain.

Very little year class overlap occurs for winter-run salmon (25% 2-year-olds, 67% 3-year-olds, and 8% 4-year-olds). The year class overlap is much less for females because the 2-year-olds are predominantly males. The significance of this is that the near loss of two consecutive year classes (1976 and 77) combined with the winter run's low fecundity (relative to the other runs) will make it difficult for the run to rebound to previous population levels.

The 1978 brood stock was the last remaining strong year class. It returned in 1981 in large numbers indicating a potential for rebuilding the run. The progeny of the 1981 year class were adversely affected in the ocean by the 1982-83 El Nino event. They returned to the river in poor numbers in 1984. Consequently, no strong year class remains in the population.

An additional problem at Keswick Dam affects winter-run chinook. During high winter and spring releases, salmon swim into the stilling basin below the dam. As flows subside in the late spring winter-run chinook become trapped and cannot escape to suitable spawning habitat. Although the USFWS and the CDFG attempt to capture and release these fish, an undocumented amount of

winter-run mortality is associated with the problem.

A final factor contributing to the current status of the winter run is the technical difficulty in developing a hatchery stock of winter-run chinook. Most stocks that suffer a loss in productivity due to loss of habitat affected by water projects are supplemented by hatchery stock to compensate for the lost production. The winter-run chinook are fragile fish, and attempts to propagate them failed due to pre-spawning mortality of the brood stock. This mortality is attributable to inadequate adult winter-run chinook holding facilities which create stressful conditions during the several months the fish must be held until spawning maturation (USFWS 1985). The USFWS received 2.2 million dollars from Congress in 1987 to build holding ponds for winter-run chinook. These ponds should be completed by the 1988 run. The USBR has agreed to provide power to the hatchery for the operation of chillers that will be required to keep water temperatures in the holding ponds below lethal limits. Building a spawning program will take several years, but ultimately it will contribute to the restoration of the run.

Discussion

The winter run of chinook salmon in the Sacramento River has declined substantially from the 1960's level. The decline has been persistent over the last 17 years. The major cause of decline appears to be habitat degradation resulting from the operation of the RBDD and several independent factors that contribute to reduced availability of spawning and rearing habitat. These factors include the operation of other diversion facilities, gravel mining, bank stabilization, and pollution. These problems have been aggravated by severe droughts in 1976 and 1977 and a severe El Nino event in 1982 and 1983.

Allendorf and Ryman (unpublished report) suggest that the minimum population size needed to maintain the genetic integrity of wild stocks raised in hatcheries is 200 salmon, with a sex ratio of 1:1. This is a useful guide for establishing a minimum viable population size for wild runs in the river, but it should be increased by a factor of two to five to compensate for uncertainties in the estimated population size, fluctuating environmental parameters, and the fact that in the wild the effective population size (number successfully spawning) is less than the actual number of adult fish. An irretrievable genetic loss would likely result from a succession of four or five year classes falling below an

effective population size of 200 fish (Utter in litt.). The winter run is approaching this level, but remains above it. The actions taken by State and Federal agencies in 1986 will increase the effective population size by allowing more of the population to migrate to suitable spawning habitat.

Raising the gates in the RBDD will provide immediate access to suitable spawning habitat for a larger portion of the population. The CDFG habitat restoration project will provide additional spawning habitat and the CWQCB standards for releases of polluted water to the Sacramento River also will improve the quality of the spawning habitat, and the CDFG's in-river fishing regulations will ensure that salmon that arrive at the spawning grounds are not removed from the population before they spawn. Given the resiliency this population demonstrated subsequent to the construction of the Shasta and Keswick Dams, these actions should allow increased production of winter-run chinook.

Other actions that will benefit the population in subsequent years include the FWS' plans to initiate a winter-run hatchery program at the Coleman National Fish Hatchery, EPA's decision to apply Superfund resources to clean up the pollution problem emanating from the Iron Mountain Mines, and the State's enactment of SB 1086 to restore habitat in the Sacramento River. These are long term commitments that are likely to produce benefits into the 1990s and beyond. For example, SB 1086 provides the basis for the formation of a task force similar to the Klamath River and Trinity River Task Forces. These Task Forces have developed habitat restoration plans that are funded by the Federal government. House Bill 4217 authorizes \$42 million to implement the Klamath River Plan and Public Law 98-541 authorizes nearly \$60 million for accomplishing the tasks identified in the Trinity River Plan. Completion of a Sacramento River Restoration Plan should lead to comparable funding for implementation, but the actual benefit is not likely to be realized for several years.

Conclusions

The winter run of chinook salmon in the Sacramento River comprises a distinct breeding population and qualifies for consideration as a "species" under the ESA. Although it has declined persistently over the past 17 years, NMFS thinks that State and Federal resource management agencies are addressing the habitat problems that contributed to the decline of the run and that the management actions

implemented by those agencies ensure the restoration of the run to levels that will be able to withstand future droughts and other environmental perturbations. These actions, combined with other actions that will not produce measurable benefits for several years, should restore the run to a level approaching that which existed prior to the construction of RBDD.

The most important management action implemented is the USBR's revised operational schedule for the RBDD. Raising the gates in the dam during the winter run's spawning migration eliminates a major factor limiting the run's ability to grow. This action will ensure that salmon get to suitable spawning habitat. NMFS expects this action will be translated into greater spawning success, thereby increasing the potential for population growth. Resolving the fish passage problem at the RBDD will increase the benefits that will be derived from the CDFG habitat restoration project and new prohibitions on sport fishing because more fish will be able to migrate up stream to use the restored habitat. NMFS and the CDFG are initiating monitoring programs to verify these expectations.

Several long term programs have been implemented that ultimately will benefit the run. These include an expanded hatchery program at the Coleman National Fish Hatchery to produce additional winter-run chinook salmon, SB 1086 which will restore spawning habitat in the Sacramento River, and the EPA's plans to direct the Superfund resources toward resolving the pollution problems emanating from the Iron Mountain Mines. These long term programs will provide additional enhancement when they are implemented.

Based on the restoration actions that have been implemented or will be implemented prior to the 1987 run, NMFS concludes that the winter run of chinook salmon is not in danger of becoming extinct throughout all or a significant portion of its range, nor is it likely to become endangered in the foreseeable future throughout all or a significant portion of its range.

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