 COMMENTS BY THE
SAN LUIS AND DELTA-MENDOTA WATER AUTHORITY
on the
WEST COAST SALMON HARVEST DRAFT PROGRAMMATIC EIS
by the
NATIONAL MARINE FISHERIES SERVICE

November 22, 2002

William Robinson
Northwest Region
NOAA Fisheries
7600 Sand Point Way N.E.
Seattle, WA 98115-0070

Subject: Comments of the San Luis and Delta-Mendota Water Authority on the West Coast Salmon Harvest Draft Programmatic Environmental Impact Statement (DPEIS)

Dear Mr. Robinson:

Our comments apply to the Pacific Coast Management scheme. We suggest that different alternatives might be preferred for different regions.

We understand that while no preferred alternative need be selected for the draft PEIS, the final PEIS must contain a preferred alternative. Our reading of your draft PEIS indicates that for the Pacific Coast fishery, Alternative 2, the mark selective fishery, is by far the best alternative except for the problem of catch-and-release mortality. We note your comment, "(M)ost problems associated with mechanically mass-marking young-of-the-year chinook salmon have been overcome," (PEIS, page 4-1161, Chapter 4)

Therefore, we recommend that the draft be modified to discuss the need for a program to reduce catch-and-release mortality and that development of this program be included as part of Alternative 2. As stated in the DPEIS, NMFS has a legislative mandate to encourage "development of practical measures that . . .
a) minimize bycatch and b) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch."

Such a program could consist of the development of "best management practices" (BMPs) for the reduction of catch-and-release mortality. These BMPs could be developed cooperatively with fishing organizations, fishermen, state fishery agencies, environmentalists, and other interested parties. BMPs could be selected based on their effectiveness, cost, and feasibility of implementation. Information on candidate BMPs could be developed from the experience of NMFS experts, fishermen, state fishery agencies, interested parties, or by special experiments in cases where reliable information is not yet available. Fishermen education would be a key element of such a program, perhaps something similar to the education program being used in the State of Washington. Certainly more education of fishermen to reduce catch-and-release mortality is needed in California. For example, a mandatory minimum trolling speed would serve to reduce "mooching," a significant source of catch-and-release mortality in California.

A system of monitoring the implementation of selected BMPs would be necessary. If incentives are needed, the allowable catch of marked hatchery fish could be made contingent on the degree to which selected BMPs are implemented.

Marking of hatchery fish, monitoring of BMP implementation, and other activities could be funded at least in part by revenues from fishing, provided that this program resulted in general increases in revenues for fishermen. Other sources of funds could be explored.

Such a program could initially be established as an experimental program, using adaptive management to refine the program over the next several years.

We concur with the comment of the Pacific Coast Federation of Fishermen's Associations and the Institute for Fisheries Resources concerning the need to evaluate cumulative effects of fisheries along with all other factors that might affect salmon populations. We also concur with statements in the report of the NMFS Salmon Recovery Science Review Panel, report for the meeting held August 27-29, 2001, "... it makes little sense to consider factors one at a time. The effectiveness of a harvesting strategy, for example, will depend upon assumptions about hydropower, hatcheries, and habitats. Similarly, decisions about hatcheries must be based upon assumptions concerning the other three H's (habitat, hydropower, and harvest). We were frustrated, therefore, to hear discussion of optimal harvesting strategies, as if no other factors were involved,
just as we were previously frustrated to hear discussions of hatcheries in a vacuum.”

We advocate development of comprehensive plans for salmon, plans that consider all actions that might be taken, the costs, benefits, and feasibility of those actions, and how their effects compare with natural factors that cannot be controlled. We advocate that comparisons of benefits be based on population level effects.

This PEIS should describe how such comprehensive plans might be developed and how the effects set forth in this PEIS might compare with effects of other actions in such a plan.

In your list of factors affecting decline for listed chinook salmon in Table 4.5.2, page 4-139 in Chapter 4 of the DPEIS, you list "water diversion/extraction" as the first among these factors. We refer you to recent work by Newman and Rice (Modeling the Survival of Chinook Salmon Smolts Outmigrating Through the Lower Sacramento River System, December 2002, Journal of the American Statistical Association, available from Newman at newman@uidaho.edu) that refutes or casts doubt on that priority of water diversion/extraction, at least for exports from the Sacramento-San Joaquin Delta by the state and federal water projects. Newman is also finishing up another paper that leaves open the possibility of some, albeit, weak effects of Delta exports on outmigrating smolt survival.

Finally, we are attaching comments by the California State Water Contractors, “Reconsideration of the Listing Status for Sacramento Winter Run Chinook Salmon.” These comments are relevant to your DPEIS, and we incorporate them in our comments by reference.

Sincerely,

[Signature]

Daniel G. Nelson
Executive Director

Attachment: Reconsideration of the Listing Status

cc: Board of Directors
    Member Agencies

DGN/slm
RECONSIDERATION OF THE LISTING STATUS
FOR SACRAMENTO WINTER RUN CHINOOK SALMON

Response to NMFS’ Request for Information on
Re-initiation of Status Reviews
(Fed. Reg. 67(28): 6215-6220)

Submitted by

California State Water Contractors
455 Capitol Mall, Suite 220
Sacramento CA  95814

SUMMARY

Following population declines that led to listing of the Sacramento River Winter-run Chinook as “Endangered” under the federal Endangered Species Act in 1994, escapement of this stock has trended upward. This increase began slowly in the middle of the 1990's from less than 200 escaped spawners to numbers ranging from 6,500 to 10,500, depending on the method used to estimate escapement. Many factors likely contributed to this new winter-run population trend. For this reason, and based on information presented and discussed below, we make the following recommendations to NMFS:

· Based on information presented here, and in consideration of other information at NMFS’ disposal, the Service should reconsider the listing status of the Sacramento River Winter-run Chinook ESU and change the status from “Endangered” to “Threatened”.

· Based on quantitative analyses whenever possible, such as those presented here, NMFS should place most emphasis in both the management and regulatory arenas on those actions most likely to produce the largest beneficial changes in mortality (reduction) or production (increases).

· Those actions with large benefits and relative certainty should be implemented without delay; if already implemented, they should be continued.

· Those actions with small or uncertain benefits for winter-run should be de-emphasized.

Additional recommendations regarding specific actions are contained in a “Recommendations” section near the end of this document.

This document reviews some of the factors we feel are most relevant to NMFS status review. Some appear to have been much more important than others. For the purpose of this document, we have ranked factors according to their capability to “leverage” population recovery: “high leverage” factors are capable of great influence on recovery; “medium leverage” factors are capable of contributing significantly, but with less certainty or to a lesser degree; “low leverage” factors are unlikely to contribute materially or persistently.
High Leverage Factors

The following factors are judged to have strongly influenced the recent reversal of winter-run population declines or to be capable of exerting a strong recovery influence in the future. These factors are ranked in order of importance, although all are important:

1. **Battle Creek – Opening / Restoration of a New Spawning Stream (permanent)** – The Battle Creek Salmon and Steelhead Restoration Project presently underway will open up an additional 42 miles of excellent spring-fed habitat for winter-run chinook. This will provide both an expansion of habitat and a population refuge in the event of severe drought conditions elsewhere in the Sacramento River system.

2. **Inter-decadal Ocean Regime Changes (NAPS) (expected 20-30 years duration)** – Through knowledge gained over the last 6-10 years, it is now known that chinook salmon populations are profoundly influenced by multi-decadal ocean condition cycles. An adverse condition (for coastal chinook populations) cycle persisted in the North Pacific Ocean from 1977 to 1998. This condition has now become reversed, with exceptional production of salmon and their food supplies.

3. **Harvest Management Plan Modifications (PFMC) (ongoing; long term)** – Changes in the management strategies employed by PFMC, including conservation measures, have allowed increased percentages of maturing winter-run to escape to spawn. This has been a very significant contributing factor to increases in the cohort replacement rate, a key indicator of recovery status.

4. **Red Bluff Diversion Dam Operation Changes (permanent)** – Historical operation patterns at Red Bluff Diversion Dam contributed significantly to the decline of winter-run chinook by blocking or impeding upstream passage of adult fish and exacerbating predation on outmigrating juveniles. New operations have effectively removed the threat to upstream migrants and have very significantly diminished risks to downstream migrants.

5. **New Fish Screens on Major Diversions (permanent)** – Prior to 1996, the vast majority of water diverted from the Sacramento River was through unscreened diversions, some diverting from many hundreds to several thousand cfs. The great majority of the larger diversions on the Sacramento River main stem are now screened, eliminating winter-run entrainment threats at these sites.

6. **Improved Temperature Control at Shasta Dam (permanent)** – Temperature control measures for the benefit of winter-run have been greatly improved since inception in 1975. A large temperature control device was installed in 1997 which significantly improved capabilities to provide temperatures necessary for maintaining good survival conditions for winter-run incubation and early rearing.

7. **Ecosystem Restoration under the CalFed Bay/Delta Program (continuing; long term)** – CalFed’s Ecosystem Restoration Program (ERP) provides a Sacramento River, Delta and San Francisco Bay regional approach to habitat restoration for at-risk species, including winter-run
chinook. Additional opportunities for specific measures to benefit winter-run undoubtedly exist beyond those already identified in the Recovery Plan.

8. **Spring Creek Dam and Minnesota Flats Treatment Plant (permanent)** – Acid mine drainage from the abandoned Iron Mountain Mine complex historically created chronically and occasionally acutely toxic conditions in the Sacramento River below Keswick Dam. Emergency treatment of mine discharges during the 1989-1993 drought, followed by construction of a permanent treatment plant in 1994 has greatly reduced or eliminated risks to winter-run associated with mine discharges.

**Medium Leverage Factors**

The following factors are judged to have moderately influenced the recent apparent reversal of winter-run population declines or to be capable of exerting a significant, if less certain influence on recovery in the future:

1. **Livingston Stone Hatchery (interim)** – Completed in early 1998, the Livingston Stone Hatchery released 150,000 winter-run smolts produced using genetic conservation protocols from that brood year in 1999. In 2001, production had increased to 250,000 smolts. Coded wire tag returns indicate that these releases are making significant contributions to spawning populations.

2. **Improved Enumeration and Population Estimation Techniques (long term; improving)** – Very significant advances in enumeration methods has allowed fishery managers to more accurately estimate populations of both juvenile and adult life stages. This has resulted in improved management of both the fish and their environment, reducing risks associated with management practices.

3. **Improved Passage at the Anderson Cottonwood Irrigation District Weir (permanent)** – Poor fish passage conditions at this weir impaired distribution of winter-run spawners relative to available habitat. This condition has been rectified.

**Low Leverage Factors**

The following factors are judged to have exerted minor population-level influences on winter-run or are capable of only minor influences in the future:

1. **Environmental Water Account (EWA) for Winter Run Protection (unknown duration)** – In 2001, the EWA applied approximately 300,000 acre-feet of export cuts at the SWP on behalf of fish. Of that volume, approximately 200,000 acre-feet were used to benefit chinook, primarily winter-run.

2. **Delta Cross Channel and South Delta Water Project Operations (OCAP) (unknown duration)** – Operations adjustments at the south delta water projects (Central Valley Project; State Water Project) have been made since 1992 to protect a variety of fish species, including winter-run chinook, by reducing entrainment/salvage and associated predation losses.
3. **Spawning Gravel Replenishment (as needed)** – A program for replenishment of spawning habitat in the Sacramento River downstream of Keswick Dam was begun by the USBR in 1997 and continued through 2000. Although this material, intended to replenish natural movement of spawning gravel now blocked by Shasta and Keswick dams, is distributed downstream by high flows, actual benefits are undocumented and likely to be minor.

**BACKGROUND**

The Sacramento River Winter-run Chinook Salmon ESU was listed by NMFS as threatened under the Endangered Species Act by promulgating an emergency rule on 04 August 1989. This status was officially revised to endangered on 04 January 1994 following an initial determination to do so on 19 June 1992. This action followed dramatic declines in estimated population of this species which appear to have begun in the late 1960's and early 1970's from tens of thousands in the beginning of this time period to several hundred in the mid-1990's. The last detailed status review for winter run chinook was conducted by NMFS in 1996; this was followed by publication of a draft Recovery Plan in August of 1997. Since that time, the estimated population of winter run has increased, with a significant upward trend from 1997 through 2001, approaching or exceeding ten thousand adults in 2001, depending on the estimation procedure used.

Historically, run strength estimates from a variety of sources (in-river gillnet landings; creel census data, etc.) occasionally exceed 100,000 fish. Limited data in the late 1800's (9 years of record between 1872 and 1900) suggest run strength between 70,000 and 120,000. Gillnet landing data between 1915 and 1950 suggest run strength declining from 20,000 - 40,000 fish to several hundred in the middle of that time period, then rising again to the vicinity of 20,000 in the middle and late 40's. Creel census data and, later, passage counts over Red Bluff Diversion Dam (which was completed in 1964) indicated population levels had rebounded to the 50,000 - 80,000 range, with run strength in two years (1962 and 1969) exceeding 100,000.

The recent decline in winter run population levels has been attributed to a variety of causes. These include dams and dam operations, water diversions, altered river flow patterns, water pollution, and natural environmental variability. The completion of Shasta Dam in 1942, coupled with earlier hydroelectric development on Battle Creek, blocked access to all or nearly all of what is thought to be winter-run ancestral habitat. Delta diversions, including both the Central Valley Project (CVP) (established in 1958) and the State Water Project (SWP) (established in 1962) are cited as contributing factors, along with changes in the management of Sacramento River flows after 1965 which produced deleterious warm water conditions below Shasta Dam, and the establishment of Red Bluff Diversion Dam, which significantly impeded upstream migration of adult winter-run and downstream migration of juveniles. Water pollution from Iron Mountain Mine resulted in toxic conditions and documented fish kills in the 1960's and 1978, and is thought to have had chronic effects on an ongoing basis.

In-river commercial harvest exploited winter-run chinook from the middle of the 19th century into the early part of the 20th century. Subsequently, the offshore commercial troll fishery exploited winter-run chinook, but the proportion of the total catch represented by this stock is uncertain. In the late 60's and early 70's, tagging studies suggested that about 9% of this stock was taken in the offshore troll fishery. During this same time period, the ocean sport fishery took an estimated 26% of this
stock (NMFS 1997). Inland sport harvest peaked at an estimated 11,000 fish taken in 1969, but declined rapidly to about very low levels in 1970 and remained at or below this level through the early 1990's (NMFS 1997).

At the time of the last status review of winter-run chinook, natural environmental variability, especially drought and El Niño conditions, were thought to be seriously exacerbating factors in the observed population declines. Much new scientific information has been developed on the nature of inter-decadal sea surface temperature oscillations and the influence of this phenomenon on populations of Pacific salmon. It is likely that ocean conditions associated with these long-term cycles have played an even more important role in driving winter-run and other salmon populations than previously thought (see below).

The geometric nature of the latest winter-run population decline suggests that survival, not episodic habitat limitation, is the primary driving factor for the most recent population decline (NMFS, 1997). At the time of the last status review for the winter-run chinook (1996), extinction modeling performed on data then available suggested that extinction was certain. However, this analysis was unable to take into account a variety of protective measures that had been only recently implemented, and extinction projections were, of necessity, equivocal (NMFS 1997).

**POPULATION TREND SINCE LAST STATUS REVIEW**

Since the last detailed status review for winter-run chinook conducted by NMFS in 1996, the population of this stock as measured by a variety of indicators has shown significant increases in most years. There are many potential contributing factors to this apparent change in winter-run survival and recruitment success (see below), and it is very difficult to determine the relative contributions of individual factors. Nevertheless, both the population and its trend are up.

**Enumeration and Population Estimation**

Enumeration techniques for winter-run have changed, of necessity, since 1996. Before that time, and since the closure of the Red Bluff Diversion Dam (RBDD) gates in 1964, counts of winter-run were made in the fishways associated with that structure. This gave a relatively accurate estimate of the portion of the run proceeding upstream to suitable spawning grounds in the Redding area below Keswick Dam. Starting in 1989, however, operational changes made at RBDD involving raising gates to improve passage conditions for winter-run. These sequential changes resulted in decreasing percentages of the run using ladders where they could be enumerated, reducing the reliability of the upstream migration estimates. By 1995, such a small percentage of the run was counted at RBDD that other enumeration methods had to be employed. Starting in 1996, CDFG conducted carcass counts in the winter-run spawning areas. These counts have proven to be a suitable substitute for the once more accurate RBDD counts (USFWS 2001). Figure 1 shows the adult spawner population estimates from 1970 through 2001 using RBDD count data through 1995 and carcass count data thereafter (Petersen estimates). The regression line is included as an indicator of trend.

Although the Petersen mark-recapture method for estimating spawning populations through carcass counts is a superior method to the presently highly restricted ladder counts at RBDD, it tends to overestimate the population. Other mark-recapture methods are available, but require a robust data
set. Two alternative methods are the Schaefer method and the Jolly-Seber method, which tends to underestimate the spawning population (Snider et al. 1997, 1998, 1999, 2000, 2001). Since the Petersen method is the only one which can be applied to carcass count data in all years, it is preferred for spawner population trend analysis (Snider, pers. comm.). Figure 2 compares the results of all three tag-recapture analysis methods for the years in which each was completed. Although the results can differ significantly, the indicated trends across years are consistently upward, with an exception for the Petersen method in 1999. Although far from the recovery goal of 10,000 spawners for a 13-year period, this trend is encouraging.

The ratio of males to females has been consistently higher than the 1:1 anticipated in the Recovery Plan. The following data have been compiled for adult winter-run (excluding grilse) from the carcass surveys:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>MALE : FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>6.1 : 1</td>
</tr>
<tr>
<td>1997</td>
<td>3.2 : 1</td>
</tr>
<tr>
<td>1998</td>
<td>8.9 : 1</td>
</tr>
<tr>
<td>1999</td>
<td>8.4 : 1</td>
</tr>
<tr>
<td>2000</td>
<td>5.0 : 1</td>
</tr>
<tr>
<td>2001</td>
<td>2.5 : 1</td>
</tr>
</tbody>
</table>

These data are used to compute the “effective spawner” population, shown in Figure 3. It is this population estimate which is used to assess recovery status, and which is also used to calculate winter-run juvenile production estimates.

Two procedures have been used since 1995 to estimate the production of winter-run juveniles from spawning grounds in the Sacramento River above RBDD. The “Juvenile Production Estimate” (JPE) is calculated from effective spawner population estimates described above, along with assumptions regarding female fecundity, percent spawned/unspawned, the percent of spawning within the carcass survey area and survival of early life stages, and, in recent years, contributions from the Livingston Stone supplementation facility (see below). The “Juvenile Production Index” (JPI) is computed by USFWS from screw trap data collected during the juvenile out-migration period at RBDD. Paired comparisons between the JPE and the JPI show remarkably consistent results, suggesting that both are reasonably reliable predictors of winter-run juvenile production. Results from these two methods suggest that juvenile production between 1995 and 2001 has ranged from around 500,000 in 1996 to over 5 million in 2001. The data from the two analytical methods are compared in Figure 4.

Increased spawner escapement and consequent increases in juvenile production along with improving survival at sea (see below) have resulted in generally increasing adult populations through time since 1995. The Recovery Plan notes that in the geometric mean cohort replacement rate (the rate at which each generation replaces itself generally 3 years later) was 0.779 between 1969 and 1991. A cohort replacement rate must, on average, be above unity for a population to sustain itself over time. Since 1995 the cohort replacement for winter-run has increased dramatically and stayed well above unity. A general cohort replacement rate analysis was performed using adult spawner populations estimated from RBDD counts between 1970 and 1995 and carcass survey data (Petersen) from 1996 onward. The results of this analysis are shown in Figure 5. The very high replacement of 10.26:1 shown for
1997 may be anomalous, but reasons for this are not clear at this time. These data show a consistent very positive cohort replacement ratio since 1995. This change in cohort replacement is due to increased survival, probably at more than one stage in the life cycle, and probably resulting from changes in several factors affecting winter-run (see below).

**EVALUATION CATEGORIES**

The foregoing suggests that the population trend for winter-run chinook salmon has undergone a change from downward to upward since the last status review in the mid-1990's. This reversal of the population trend is likely due to a variety of factors, both those under human control and those reflecting changes in natural cycles. We discuss what we believe to be improvements in some of the more important factors influencing the upward winter-run population trend below. We have organized these factors into the following evaluation categories, which correspond to those used by NMFS in the listing process:

- Habitat / Range
- Utilization
- Disease / Predation
- Regulatory Adequacy
- Other Factors

Within these categories, we have ranked factors influencing the winter-run population according to their capability to “leverage” population recovery. Thus, a “high leverage” factor is capable of exerting great influence on winter-run recovery, and should, in our view, be strongly emphasized by NMFS in both the management and regulatory arenas. A “medium leverage” factor should be addressed and implemented at a lower priority; a “low leverage” factor is unlikely to exert much influence on population levels or trends, and management or regulatory emphasis is likely to be masked by other factors.

**HABITAT / RANGE**

The closing of Shasta Dam and hydroelectric development in the Battle Creek watershed blocked access to all or nearly all of what is thought to be winter-run ancestral habitat. The range of this stock was compressed into those portions of the Sacramento River main stem below Shasta Dam which exhibited temperature and other habitat characteristics necessary to support the population. Changes in management of the Sacramento River associated with the full build-out of the Central Valley Project further compressed the suitable habitat and range of winter-run until remedial measures, many of which are contained in the Recovery Plan, were implemented.

**Battle Creek – Opening / Restoration of a New Spawning Stream – High Leverage**

The Battle Creek Salmon and Steelhead Restoration Project is an extremely important component of winter-run recovery. Battle Creek is a tributary to the Sacramento River at RM 272, about 20 miles downstream of Redding. The 356 sq mi Battle Creek watershed drains the western slopes of Mt. Lassen. A substantial proportion of Battle Creek discharge is from springs, resulting in stable, cool water year-round, even in drought years. These characteristics are typical of winter-run ancestral
habitat; in fact, it is considered likely that a winter-run population was historically supported by Battle Creek. Hydroelectric development of Battle Creek early in the 20th century and subsequent deterioration of fish passage facilities eclipsed runs of anadromous fish into that system except for the lower reaches. Major improvements or restoration actions are to be implemented at the following sites:

- Coleman Diversion Dam – decommission, removal
- Inskip Diversion Dam – fish screens, fishway
- South Diversion Dam – decommission, removal
- Wildcat Diversion Dam – decommission, removal
- Eagle Canyon Diversion Dam – fish screens, fishway
- North Battle Creek Feeder Diversion Dam – fish screens, fishway
- Soap Creek Dam – decommission, removal
- Lower Ripley Creek Dam – decommission, removal

Re-establishment of access to an estimated 42 miles of habitat in this system, including fishways and screens at various hydroelectric facilities and improved flow conditions, is considered a major contribution in the re-opening of suitable spawning and early rearing habitat for winter-run chinook. Some successful movement of winter-run into presently accessible areas in Battle Creek has already been documented. Successful completion of passage and screening anticipated in the near future. This project will cut the risk of extinction considerably by providing winter-run a second spawning stream and a major expansion of very suitable winter-run habitat, but an excellent refuge for the population in event of extended adverse (e.g. drought) conditions elsewhere in the Sacramento system.

**Improved Temperature Control at Shasta Dam – High Leverage**

In 1975, in order to protect salmon spawning and incubation, the State Water Resources Control Board adopted a temperature criterion of $\leq 56^\circ \text{F}$ (daily average) for the reach of the Sacramento River main stem between Keswick Dam and Hamilton City. This criterion was incorporated into the NPDES permit for the CVP for the spawning reach between Keswick Dam and Red Bluff in 1987, with some relaxation provided for drought years. The temperature criterion was modified in NMFS’ 1992 Biological Opinion related to operations of the CVP and SWP. The Biological Opinions call for providing $\leq 56^\circ \text{F}$ between Keswick Dam and Bent Bridge (40 mi downstream) from 15 April to 30 September to protect winter-run incubating eggs and $\leq 60^\circ \text{F}$ during October to protect post-emergent fry, with relaxation of the distance upstream about 5 mi to Jelly’s Ferry during dry years when temperature control ability is limited. In addition, NMFS required a minimum storage carryover of 1.9 million acre-ft in the Shasta pool to assure sufficient cold water in all but the driest 10% of water years.

Temperature control operations at Shasta Dam and at the Whiskeytown complex (part of the CVP) began in 1987 with releases of cold water through low level outlets. Although these measures were very helpful, and were judged by NMFS to be sufficient (from a water temperature perspective) to prevent extinction, a large Temperature Control Device was installed at Shasta Dam in 1997. This device has markedly improved the ability of USBR to regulate temperatures in the winter-run spawning and early rearing areas in the Sacramento River, significantly increasing survival potential.
Presently, temperature control capability is very good. For example, the 2001 water year, designated “critical” due to low inflow forecasts, began with nearly 3 million ac-ft of storage in Shasta Reservoir and nearly 1.8 million ac-ft of storage in Trinity Reservoir. These amounts peaked later in the water year with a combined total of approximately 6 million ac-ft. This resulted in sufficient storage in spite of expected inflows significantly less than average, for good temperature control. Temperature model projections made by USBR indicated that, in spite of the critical nature of the water year, temperature objectives could be met or very nearly met (within about 0.5-1.5°F) at both Jelly’s Ferry and at RBBD (USBR 2001). It is likely that temperature regulation has played a significant roll in reversing the downward population trend of winter-run chinook and continues to support an ongoing increase in escapement.

**Livingston Stone Hatchery – Medium Leverage**

An artificial propagation goal was identified in the Recovery Plan as being essential to prevent extinction of winter-run by supplementing natural reproduction in the Sacramento river. After problems encountered at Coleman National Fish Hatchery on Battle Creek, which involved imprinting on Battle Creek water and large adult returns to that facility instead of to spawning grounds in the Sacramento River, a dedicated artificial propagation facility was constructed at the base of Shasta Dam. The Livingston Stone facility was completed in February, 1998 and began releasing winter-run smolts from that brood year in 1999. The output (smolts released) from Livingston Stone Hatchery is shown in Figure 6. All smolts are marked with coded wire tags. Tag return data indicate that these fish enjoy good survival rates and are returning to spawn naturally with their cohorts in the Sacramento River main stem. Special genetic conservation protocols are followed in the artificial propagation of winter-run at this facility to help insure against untoward genetic impacts of the supplementation program. A captive broodstock program, which made its first contribution to artificial propagation in 1995, is presently regarded as a lower priority component of the Recovery Plan due to recent upward trends in winter-run spawning escapement and the success of the Livingston Stone facility, and may be discontinued in the near future.

**Improved Enumeration and Population Estimation Techniques – Medium Leverage**

Great improvements have been made in enumeration and population estimation techniques for winter-run chinook, and the increased utilization of these techniques shows increasing promise for assisting management of both the fish themselves and their environment. For example, The spawning, rearing, and downstream river areas offer potential for substantially increasing the winter run population. The recent NMFS-approved winter-run salmon Juvenile Production Estimate (JPE) indicates that 92% of the total viable eggs spawned in the Sacramento River never made it to be smolts entering the Delta (McInnis 2002). Although the JPE involves considerable uncertainty due to assumptions and the source-data, the extreme loss value indicates that most winter run production dies before ever reaching the Delta. Any of several factors can influence mortality of these winter run embryos, fry and smolts, including redd disturbance, water temperature, predation, water diversions, food availability, etc. Based on the high loss rate, it is likely that evaluation of the potential for modification of controllable factors in the Sacramento River to improve survival and abundance of juvenile winter run will lead to the discovery of significant opportunities to significantly enhance survival potential.
Improved Passage at the Anderson Cottonwood Irrigation District Weir – *Medium Leverage*

Poor fish passage conditions at the ACID weir near Redding impaired upstream movement of winter-run to much important spawning habitat upstream of that facility. This condition was corrected by construction of two new fish ladders, one along each bank of the Sacramento River, in 2001. Monitoring indicates that fish movement is good, especially through the pool-and-chute fishway located along the west bank. Improved fish passage results in improved distribution of fish relative to available spawning habitat.

**Spawning Gravel Replenishment – *Low Leverage***

Shasta and Keswick Dams intercept the natural movement of spawning-sized sediment down the Sacramento. The reach immediately downstream of Keswick Dam has become depleted of this habitat element. Following initial experimental gravel replenishment trials by DWR (Red Bluff) and CDFG (Redding), a program for replenishment of spawning habitat in the Sacramento River downstream of Keswick Dam was begun by the USBR in 1997 and continued through 2000. The record of spawning gravel replenishment activities undertaken by the Bureau is given below:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>LOCATION</th>
<th>AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>Keswick Dam (RM 302)</td>
<td>700 tons</td>
</tr>
<tr>
<td></td>
<td>Salt Creek (RM 301)</td>
<td>24,000 tons</td>
</tr>
<tr>
<td>1998</td>
<td>Keswick Dam (RM 302)</td>
<td>302,000 tons</td>
</tr>
<tr>
<td></td>
<td>Salt Creek (RM 301)</td>
<td>15,000 tons</td>
</tr>
<tr>
<td>1999</td>
<td>Salt Creek (RM 301)</td>
<td>25,000 tons</td>
</tr>
<tr>
<td>2000</td>
<td>Keswick Dam (RM 302)</td>
<td>9,000 tons</td>
</tr>
<tr>
<td></td>
<td>Tobiasson (RM 291)</td>
<td>23,000 tons</td>
</tr>
</tbody>
</table>

Monitoring has shown that the gravel deposited at these sites is carried downstream by high river flows and deposited naturally on gravel bars. It is also filling certain deep points in the river channel, which may be useful in enhancing invertebrate production in these areas.

**UTILIZATION**

**Harvest Management Plan Modifications (PFMC) – *High Leverage***

Winter-run chinook have historically been taken in both mixed-stock offshore fisheries and in inland fisheries. Offshore fisheries are subject to management by the Pacific Fisheries Management Council, which was authorized under the Magnuson Fishery Conservation and Management Act of 1976. This act, now known as the Magnuson-Stevens Act, was last amended by the Sustainable Fisheries Act of 1996 (PL 104-297). The Council developed a comprehensive Fisheries Management Plan (FMP) and an associated Environmental Impact Statement (EIS) in 1978 and issued annual Amendments through 1983 to assure sustainable marine fisheries under its purview. In 1984 the
Council adopted a multi-year framework for its FMP using fixed management objectives and flexible elements which could be varied in response to stock abundance and other factors.

Since 1984, the most significant change affecting ocean salmon fishery management within Council jurisdiction has been the chronically declining status of many Pacific Coast Salmon stocks, including the Sacramento River winter-run (PFMC 2000). Beginning in 1990, West Coast salmon fisheries have been modified to accommodate special requirements for the protection of salmon species listed under the federal ESA. These stocks are often harvested incidentally with more abundant “healthy” stocks in mixed-stock offshore fisheries. The Council’s pre-season assessment and rule-making process has increasingly focused on protecting listed stocks. In some cases, however, the information necessary for stock-specific management is lacking, leaving some listed stocks without adequate protection. For these stocks, it became necessary to use conservative management principles in order to provide necessary protection.

The Sacramento River winter-run chinook stock has had a significant impact on Council management actions. In 1999, NMFS guidance to the Council in various Biological Opinions required the Council to meet the following objective to avoid jeopardizing the recovery of winter-run (PFMC 2000):

Sacramento River winter chinook – Achieve a 31% increase in the age-3 adult cohort replacement rate relative to the 1989-1993 mean rate of 1.35. Such an increase would result in a 1.77 adult cohort replacement rate.

Amendment 14 to the Pacific Coast Salmon Plan was adopted in May 2000 (PFMC 2000). The amended plan provided that special consideration be given to meeting the jeopardy or recovery standards for winter-run in the area south of Point Arena, where most of the offshore harvest impact was occurring. Central Valley fall chinook is the Council’s primary management unit in this area. Protective management measures have been adopted by the Council in the past few years to deal with certain declining salmon stocks, including winter-run. These include time and area closures, size limits, gear restrictions and conservative pelagic bait fish management (to assure adequate food supplies for predator species such as salmon). In the late 90’s, opening dates for both commercial troll and recreational fisheries were adjusted to reduce interceptions of winter-run in the mixed stock fishery. Since 1999, commercial troll openings have started on 01 May (PFMC 2002a). Commercial troll minimum size limits in the area between Horse Mountain have been 26 inches; in the area south of Point Arena, minimum size limits have been 26 inches through 30 June and 27 inches thereafter. Gear restrictions include single point, single shank, barbless hooks for all fisheries with no more than six lines per vessel off California. When using bait, barbless circle hooks are required. Recreational measures in the area between Horse Mountain and Point Arena have included minimum size restrictions of 24 inches through 31 May and 26 inches thereafter. In the area south of Point Arena, the minimum size limit has been 24 inches through 30 June and 20 inches thereafter. Gear restrictions applied to recreational fisheries include mandatory use of barbless circle hooks if angling with bait by any means other than trolling (e.g. mooching) with a limit of two hooks which must be 5" or closer together (PFMC 2002b).

From the mid 80’s through 1995, the ocean commercial troll fisheries harvested high percentages of the central valley chinook mixed stocks, composed mostly of fall run chinook (PFMC 2000). The abundance of these fish is usually measured as the “Central Valley Index” (CVI) which is composed
of estimates of both hatchery and naturally reproducing chinook. The harvest pressure applied to the 
CVI is the “CVI Harvest Index, which is the overall harvest expressed as a percent of the CVI. 
While winter-run are thought to have comprised a small percentage of the overall harvest, their 
depressed status made this stock particularly sensitive to harvest pressures. Both winter-run 
escapement estimates (Red Bluff counts from 1970 through 1995; Petersen estimates thereafter) and 
the CVI Harvest Index over the same time period are plotted together in Figure 7 (PFMC 2002a). 
During the period from 1986 through 1995, the CVI Harvest Index remained in a range between 70 
and 80 percent. This is a very high harvest rate for any stock, especially naturally producing stocks 
(much of the CVI is supported by a large hatchery component) which are harvested in a mixed stock 
fishery. As a result, many naturally reproducing chinook stocks appear to have been seriously 
depleted (PFMC 2000). Protective measures adopted by the Council since 1995 appear to have 
reversed this trend. The CVI Harvest Index dropped to below 65% in 1996 and 1996 and to 54% for 
the three years thereafter. Preliminary data for 2001 show a CVI Harvest Index below 30%, due to 
exceptionally high overall chinook returns in that year (PFMC 2002a). Compounding this series of 
events, ocean productivity for Pacific salmon in the Pacific Northwest and off the California coast 
suffered a sharp decline (see below), apparently exacerbating the depressing effects of high harvest 
rates. These ocean conditions appear to have reversed to a more favorable status in 1999, potentially 
assisting conservation management in affecting rebounds in depressed chinook stocks, including 
winter-run.

The Council has been unable to manage winter-run separately because of insufficient information on 
this stock. In 2001 the PFMC’s Salmon Technical Team expressed official concern about the lack of 
a preseason forecast for the winter-run. “The jeopardy standard for winter chinook is to achieve an 
adult cohort replacement rate of 1.77. This jeopardy standard has not been met in the past two years 
[sic.], and the STT cannot evaluate proposed fishery management measures with respect to achieving 
this jeopardy standard without a preseason forecast” (PFMC 2001). Some data on the relative impact 
of commercial troll and recreational fisheries are available. Coded wire tag return data for ocean 
sport and ocean troll landings have confirmed that winter-run are disproportionately represented in 
the sport fishery (Regional Mark Information, http://www.rmis.org/) This is probably primarily due 
to timing of the fisheries relative to occurrence of winter run in target areas. According to expanded 
estimates based on tagged fish from Livingston Stone Hatchery, the following numbers of fish from 
that facility were harvested in the sport and ocean troll fisheries in 1999-2000:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>FISHERY</th>
<th>HARVEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>Freshwater sport</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Ocean sport</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Ocean troll</td>
<td>–</td>
</tr>
<tr>
<td>2000</td>
<td>Freshwater sport</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Ocean sport</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>Ocean troll</td>
<td>15</td>
</tr>
<tr>
<td>2001</td>
<td>Freshwater sport</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Ocean sport</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Ocean troll</td>
<td>13</td>
</tr>
</tbody>
</table>

12
As a result of conservation management practices, assisted since 1999 by favorable ocean conditions, the replacement rate for winter-run has increased significantly. As computed from Red Bluff counts through 1995 and by Petersen estimates from carcass surveys thereafter, the adult cohort replacement rate for winter-run has exceeded the PFMC objective of 1.77 for the last five years (see Figure 5). It should be noted that the cohort replacement rate data plotted in Figure 5 are calculated by comparing run estimates from two different methods for three of the years displayed (1996, 1997 and 1998). Differences in the estimation methods can lead to results that are not strictly comparable, and there is some likelihood of anomalous ratios for these three years (especially the very high rate calculated for 1997). Nevertheless, while not strictly proper statistically, we believe that the calculated rates presented here are more likely to represent actual replacement rates than those calculated using only RBBD counts after gate operation changes were implemented, resulting in questionable extrapolations from only a small fraction of the run (Snider et al. 2001). It is expected that continuation of conservation measures by the Council, coupled with favorable ocean conditions, will result in a continuation of this trend.

In addition to implementing conservation harvest measures, the Council adopted conservative pelagic prey species management through the adoption of Amendment 14 to the HMP. These measures are intended to increase and conserve the populations of prey species such as sardines, herring, anchovies, squid, smelt, groundfish (juveniles) and crab (larvae) for the utilization of salmon and as substitutes for juvenile salmon in the diets of other marine predators (e.g. pinnipeds, mackerel, whiting). The Council’s groundfish and coastal pelagic management plans will include provisions to prevent overfishing and protect this component of Essential Fish Habitat for salmon and other species in these management units. In addition, harvest formulas proposed for anchovy and sardine will set aside a portion of the biomass as forage reserves for salmon (PFMC 1999).

Conservative management of salmon fisheries has progressed greatly in the last few years, and this progress appears to be reflected in increasing populations of many salmon stocks. The winter-run populations appears to be among those reaping these benefits.

**DISEASE / PREDATION**

**Spring Creek Dam – High Leverage**

Acid mine drainage from Iron Mountain Mine has historically been the largest source of pollution to the Sacramento River. This drainage, which contains very high concentrations of copper, zinc, cadmium and other metals, produced chronically and occasionally acutely toxic conditions in Spring Creek and the Sacramento River between Keswick Dam and Redding, in the heart of winter-run spawning habitat. In 1963, the USBR constructed Spring Creek Dam, a small embankment on the Spring Creek Arm of the Keswick pool to control contaminated sediment loading. However, under certain conditions, this sediment was mobilized and toxic elements were delivered to the Sacramento River. Spring Creek Dam was also used to accumulate peak discharges of acid mine drainage and gradually meter this water out into the system, reducing the frequency of acutely toxic episodes. However, uncontrolled spills from the Spring Creek impoundment still resulted in toxic conditions in the Sacramento River, with associated fish kills. During the 1989 - 1993 drought, emergency chemical treatment ameliorated much of the toxicity from Iron Mountain Mine discharge, but Basin
Plan objectives were still not met. In 1994, the Minnesota Flats water treatment plant replaced the emergency treatment plants and currently treats discharges from the three largest sources of acid mine drainage. Modifications and additions to this facility, along with efforts to reduce accumulated contaminated sediment delivery to the Sacramento River continue to improve performance. These measures have effectively removed or reduced to a low order of probability potentially catastrophic sources of mortality to early life stages of winter-run chinook.

**REGULATORY ADEQUACY**

A variety of regulatory actions have been taken by NMFS, in conjunction with state and other federal agencies, to reduce the adverse impacts of human activities on winter-run chinook.

**Red Bluff Diversion Dam Operation Changes – High Leverage**

The 52 ft high, 740 ft long Red Bluff Diversion Dam (RBDD), located about 2 mi southeast of Red Bluff, began operations in 1964. The structure was originally supplied with fish ladders on both abutments, but local hydraulics associated with “undershoot” gates and inadequate attraction flows reduced the efficiency of these facilities, rendering them of limited effectiveness. A supplemental ladder was added to the center of the RBDD in 1984, which resulted in marginal improvement in overall fish passage efficiency. Water diverted from the pool behind RBDD enters the Tehama-Colusa Canal, which is fitted in 1992 with large rotating drum screens and a bypass conduit designed to eliminate entrainment of juvenile fish into the canal system. This system replaced ineffective louvers originally installed in 1964.

NMFS determined that operation of the RBDD “substantially contributed” to the winter-run population decline by impairing both adult and juvenile passage and contributing significantly to pike minnow predation on juvenile migrants at the discharge of the screen bypass conduit (NMFS 1997). Radio tagging indicated that over 40% of upstream migrating winter-run chinook were blocked by the dam when gates were in operation (Vogel *et al.* 1988). In order to relieve this problem, gates at the RBDD were raised (opened) according to a variety of schedules, starting in 1986:

<table>
<thead>
<tr>
<th>Year Range</th>
<th>Gates Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 1966 - November 1986</td>
<td>Gates closed year-round</td>
</tr>
<tr>
<td>December 1986 - 1990</td>
<td>Gates open 01 Dec - 01 Apr</td>
</tr>
<tr>
<td>1991-1992</td>
<td>Gates open 01 Dec - 01 May</td>
</tr>
<tr>
<td>1993</td>
<td>Gates open 15 Oct - 01 May</td>
</tr>
<tr>
<td>1994</td>
<td>Gates open 15 Sep - 01 May</td>
</tr>
<tr>
<td>1995 - present</td>
<td>Gates open 15 Sep - 15 May</td>
</tr>
</tbody>
</table>

These changes in operations are presented graphically in Figure 8, along with adult winter-run estimated escapement data to provide temporal perspective. The last of the operational changes at RBDD (1995) produced conditions of substantially unimpaired adult passage for the great majority of the run period. Juvenile passage is still significantly impaired, however, with an estimated 26% of outmigrants having to negotiate the operating facility, and being subjected to elevated predation rates from pike minnow and striped bass (Vogel *et al.* 1988). Other means for increasing protection of winter-run are presently under investigation, including installation of a “fish-friendly” lift and bypass system, which would allow gates to remain open during the entire juvenile migration period.
New Fish Screens on Major Diversions – *High Leverage*

Prior to 1996, the great majority of water diverted from the main stem Sacramento River was unscreened. Screening diversions to protect downstream-migrating winter-run chinook was identified as a high priority objective/action in the Recovery Plan. Since the publication of the Recovery Plan, an aggressive diversion screening program has been undertaken on the main stem Sacramento River. Ten of the largest diversions on the river have been screened or screens are under construction. Seven additional large diversions are in the feasibility analysis or design phase of implementation, with completion anticipated in the near future:

<table>
<thead>
<tr>
<th>DIVERSION OWNER</th>
<th>CAPACITY (cfs)</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of Redding</td>
<td>50</td>
<td>Feasibility</td>
</tr>
<tr>
<td>Anderson-Cottonwood ID</td>
<td>400</td>
<td>Done</td>
</tr>
<tr>
<td>Tehama Colusa Canal Auth.</td>
<td>3,000</td>
<td>Done (pre-1996)</td>
</tr>
<tr>
<td>(Replacement screens)</td>
<td>(3,000) Feasibility</td>
<td></td>
</tr>
<tr>
<td>Glenn Colusa ID</td>
<td>3,000</td>
<td>Done</td>
</tr>
<tr>
<td>Princeton Codura Glenn</td>
<td>650</td>
<td>Done</td>
</tr>
<tr>
<td>RD 1004</td>
<td>360</td>
<td>Done</td>
</tr>
<tr>
<td>Sutter Mutual Water Co.</td>
<td>900</td>
<td>Final design</td>
</tr>
<tr>
<td>RD 108</td>
<td>830</td>
<td>Done</td>
</tr>
<tr>
<td>RD 108 Consolidation</td>
<td>400</td>
<td>Feasibility</td>
</tr>
<tr>
<td>Natomas Mutual Water Co.</td>
<td>650</td>
<td>Design</td>
</tr>
<tr>
<td>RD 2035</td>
<td>300</td>
<td>Design</td>
</tr>
<tr>
<td>City of Sacramento</td>
<td>240</td>
<td>Under construction</td>
</tr>
<tr>
<td>Meridian Farms</td>
<td>70</td>
<td>Feasibility</td>
</tr>
<tr>
<td>Maxwell, Pelgar Mutual</td>
<td>200 - 300</td>
<td>Done</td>
</tr>
<tr>
<td>Family Water Alliance (several)</td>
<td>150</td>
<td>Done</td>
</tr>
</tbody>
</table>

**TOTAL** 8,400

Although this list represents most of the larger diversions on the Sacramento River, there are an additional 23 diversions with capacities over 100 cfs (most between 100 and 200 cfs) which remain to be screened, and an additional 739 smaller unscreened diversions on the main stem. While the risk of entrainment of juvenile winter-run chinook into diversions has been substantially reduced, it has not been eliminated. This continuing risk is being addressed by the active Anadromous Fish Screening Program authorized by the CVPIA and managed by USFWS and USBR with active participation by NMFS and by CalFed in their Ecosystem Restoration Program.

**Ecosystem Restoration under the CalFed Bay/Delta Program – *High Leverage***

CalFed’s Ecosystem Restoration Program (ERP) provides a Sacramento River, Delta and San Francisco Bay regional approach to habitat restoration for at-risk species, including winter-run chinook. The ERP has provided funds for Sacramento River fish screens (see above), Battle Creek restoration needs (see above), Sacramento River riparian habitat restoration, and other projects with high likelihood of benefitting winter-run. The CalFed program also operates with a Federal Multi-Species Conservation Strategy to ensure winter-run protection as part of the mix.
Additional opportunities for specific measures to benefit winter-run undoubtedly exist beyond those already identified in the Recovery Plan. NMFS’ continuing direct participation in the CalFed process will help assure that appropriate emphasis is given to this species.

**Environmental Water Account (EWA) for Winter Run Protection – Low Leverage**

Since 1992, exports at the Banks and Tracy pumping plants (operated by the State Water Project and the Central Valley Project respectively) have been curtailed during many years in order to reduce mortality of winter-run chinook within the pumping facilities, including predation at the SWP. Many of the export curtailments at Tracy have been made using “b(2) water” which is water allocated from agricultural and urban use to environmental use by the Central Valley Project Improvement Act. Export curtailments at the State Water Projects were made voluntarily by the State Water Project from 1993 through 2000. In 2001 and 2002, export cuts at the state Banks pumping facility were funded using water in the "Environmental Water Account". In 2001, the EWA applied approximately 300,000 acre-feet of export cuts at the SWP on behalf of fish. Of that volume, approximately 200,000 acre-feet were used to benefit chinook, primarily winter-run chinook.

The EWA is a new tool in the midst of a four-year test. NMFS can use the EWA to curtail pumping to protect winter-run chinook. NMFS used the EWA in 2001 to save an estimated 6,000 winter-run smolts from entrainment. However, the population level effect of the use of EWA water to reduce mortality of winter-run salmon was, based on the analysis above, very small (probably fractions of a percent).

**Delta Cross Channel and South Delta Water Project Operations (OCAP) – Low Leverage**

The population-level effects of south delta water projects, by any account, are small. Indirect effects due to changes in operation of the Delta Cross Channel are calculable, but data are based on experiments with hatchery-produced fall run chinook, and the statistical relationship is weak, and driven by one data point. Direct effects due to take at the export facilities themselves are consistently below the 2% incidental take limits set by NMFS in accordance with its Biological Opinion.

Delta operations of the State Water Project and Federal Central Valley Project are controlled in part to protect outmigrating winter run smolts. Two general actions are required:

- Closure of the Delta Cross Channel to reduce the number of smolts entering the Central Delta;
- Reduction in the rate of export at the southern Delta pumping plants, the Banks Pumping Plant (state) and the Tracy Pumping Plant (federal).

Closure of the Delta Cross Channel is implemented to reduce the percent of winter-run and other salmonids that enter the delta and suffer what is thought to be elevated mortality in that environment. The export rate is reduced for two reasons:

- To limit direct mortality, that is, the mortality occurring within the export and fish salvage facilities, including predation in Clifton Court Forebay and at the trash booms at the Tracy
Pumping Plant. If the direct mortality at the export pumping plants reaches 2 percent of the outmigrant population, reconsultation concerning pumping operations is required under the state and federal Endangered Species Acts.

- To limit export-related indirect mortality, that is, the mortality thought to occur in the Delta outside the export facilities as a result of subtle hydrodynamic changes thought to result from operation of the two pumping plants.

Direct mortality is monitored each year and rarely reaches two percent of the outmigrating population, especially when estimates are based on genetic analysis. However, there is concern about export-related indirect mortality and about the effect of Cross Channel gate closures and river flow, for which, until now, no estimates have been prepared.

It is now possible to estimate the combined direct and indirect mortality effects of these actions on outmigrating smolts. In the past several years, experiments have been conducted in December and January using coded wire tagged late fall run smolts as surrogates for winter run. By releasing and recapturing groups of these smolts, survival under different conditions of river flow, export rate, and Cross Channel gate position can be estimated. The change in survival is the negative of the change in mortality (mortality equals 1.0 minus survival). Smolts are released at the head of Georgiana slough and at Ryde, downstream of Georgiana Slough. Data are reported as the ratio of survival from these pairs of releases (Georgiana to Ryde). These results should be considered as preliminary because only seven data points have been obtained. The seven data points and straight line of best fit are shown in Figure 9. [N.B.: if one data point with a survival slightly above 0.7 were eliminated, there would be no correlation between survival ratio and export rate.]

The relationship between export rate and the percent change in smolts surviving the Delta can be developed using this equation and making the following assumptions:

- That the percentage of flow entering the Cross Channel (with the gates open) and Georgiana Slough depends on the rate of flow in the Sacramento River and is given by the equations used in the “Dayflow” hydrodynamic model (available at http://iep.water.ca.gov/dayflow/index.html).

- The percentage of fish entering these channels is the same as the percentage of net flow (conservative assumption, based on monitoring data; C. Hanson, pers. comm.).

- Net flow is a surrogate for the strength of tidal flows that sweep fish into these channels.

- No smolts passing Sacramento fail to reach the Cross Channel (conservative assumption; Snyder and Titus 2000).

- About 15 percent of the smolts enter the Delta every two weeks.

With these assumptions, which would tend to produce a high estimate of the population effect of export reductions, river flow increases, or Cross Channel Gate closures, the estimates shown in the following table can be obtained:
<table>
<thead>
<tr>
<th>Action</th>
<th>Other Conditions</th>
<th>Estimated Increase in Population of Smolts Surviving Delta</th>
<th>Amount of Water Required (export reduction or river flow increase) acre-feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close the Delta Cross Channel</td>
<td>River flow=20,000 cfs Export Rate=8,000 cfs Duration of the action=14 days Percent of outmigrants affected=15</td>
<td>3.6</td>
<td>0, unless water quality problems result</td>
</tr>
<tr>
<td>Close the Delta Cross Channel</td>
<td>River flow=30,000 cfs Export Rate=4,000 cfs Duration of the action=14 days Percent of outmigrants affected=15</td>
<td>2.4</td>
<td>0, unless water quality problems result</td>
</tr>
<tr>
<td>Curtail Exports from 8,000 cfs to 4,000 cfs</td>
<td>River flow=10,000-40,000 cfs Cross Channel Gate closed Duration of the action=14 days Percent of outmigrants affected=15</td>
<td>0.4</td>
<td>110,000</td>
</tr>
<tr>
<td>Increase River Flow from 20,000 to 40,000 cfs</td>
<td>Export rate=8,000 cfs Cross Channel Gate closed Duration of the action=14 days Percent of outmigrants affected=15</td>
<td>0.3</td>
<td>550,000</td>
</tr>
<tr>
<td>Increase River Flow from 20,000 to 40,000 cfs</td>
<td>Export rate=8,000 cfs Cross Channel Gate open Duration of the action=14 days Percent of outmigrants affected=15</td>
<td>0.8</td>
<td>550,000</td>
</tr>
</tbody>
</table>

Note that the effects of export curtailments and river flow increases is small (less than one percent) and the water cost is high. Closing the Cross Channel also produces relatively low effects (less than five percent) but does not require water unless water quality problems result. Then, reservoir releases and/or export curtailments would be required.

Other adjustments in South Delta water project operations (usually in the form of water export curtailments) have been made pursuant to NMFS’ Biological Opinion to help protect outmigrating winter-run smolts. Winter run take at the SWP and CVP export facilities in the south Delta, "the pumps" probably has complied with the 2 percent incidental take limit (ITL) in the Biological Opinion. This statement is based on analysis of the best available or reliable data used to estimate the ITLs with winter run carcass survey data or RBDD counts (McInnis 2001, Snider et al. 2001, CALFED 2001, Greene, S. pers. comm.). In all years with carcass survey data and the Peterson estimate as the basis for the ITL, take at the pumps ranged from 6-25 percent of the ITL (Figure 10). For 2001, when the carcass survey data was used with the more conservative and robust Jolly-Seber estimate, take at the pumps was 38 percent of the ITL. Estimates based on RBDD counts of winter run escapement were made but are no longer utilized as they are too unreliable and less preferred than carcass survey data (McInnis 2002). RBDD counting probably only samples the last portion of
the run, perhaps 15 percent or so, and RBDD-based escapement estimates are highly variable (+200%). Take levels were less than the RBDD-based ITLs for six of the nine years, and in 2001, were way off of the carcass survey estimates. In fact, the carcass survey for the 2001 ITL observed more winter run than the entire escapement estimate based on the RBDD counts.

Potential take at the pumps is reduced through weekly DAT calls between fish agencies, project operators and stakeholders, when winter run observations in the river and Delta, losses at the pumps, and operations plans are reviewed. The DAT recommends operation changes, to the Federal/State Water Operations Management Team, comprised of senior management from fish and project agencies.

OTHER FACTORS

Inter-decadal Ocean Regime Changes (NAPS) – *High Leverage*

A great deal has been learned in the last 6-10 years about multi-decadal scale fluctuations in ocean mixing conditions and the effects of these processes on salmon survival and growth at sea. Beamish (1983) and Beamish and Bouillon (1983) published papers linking “exceptional” salmon production off the west coast of North America to a major “regime shift” in ocean conditions. This regime shift was in response to a long cycle change in the Aleutian Low pressure system which dominates the North Pacific in winter and spring, and accompanying regional changes in sea surface temperatures. In subsequent years, the physics of ocean mixing responses to long-cycle meteorological shifts and the biological responses to these phenomena were further explored. Francis and Hare (1996) identified four distinct inter-decadal regimes that occurred in the North Pacific in the 20th century, with abrupt shifts occurring in 1925, 1947 and 1977. The last inter-decadal regime ended in 1999. Hare and Francis (1995) showed that regime conditions were closely linked to production dynamics of Alaskan salmon, and Francis (1993) noted that the Alaskan and Californian current systems fluctuate in opposition to each other. It has also been shown that zooplankton production in the Gulf of Alaska and in the Coastal Upwelling Domain off the California coast tend to move in opposite directions: while the zooplankton biomass in the Gulf of Alaska more than doubled in the regime starting in 1977 compared to the earlier regime, zooplankton in the California Current system decreased by as much as 70% (Brodeur and Ware 1992, Brodeur et al. 1996, Roemmich and McGowan 1995).

It is now recognized that the major intensification and eastward expansion of the Aleutian Low occurred in 1977 along with an associated wind-driven cooling of the central North Pacific and warming of the eastern North Pacific (Parrish c.1995) triggered a decrease in the supply of nutrients delivered by the west wind drift to the California Current (in favor of the competing Alaska Current) and a sharp increase in the mixed layer depth (which governs primary productivity and nutrient availability to shallower water layers) along with a change in upwelling intensity (Polovina et al. 1995, Francis and Hare 1996). These changes produced a steep decline in salmon productivity along the Pacific coast from Vancouver Island south (Beamish et al. 1995). The effects on salmon production and survival along the California Bight of the strong 1983 *el Niño* were probably intensified by its superimposition on the regime extant at that time (Brodeur 1992, Brodeur et al. 1996). This condition reversed itself in 1999 and, as an apparent result, productivity of chinook salmon stocks in this region have experienced very significant rebound.
The inter-decadal shift in ocean regimes has very likely had a profound effect on ocean survival and recruitment of winter-run chinook. The stock declined sharply following the 1977 regime shift to unfavorable conditions and stayed at low levels throughout the 80's and 90's (see Figure 11). Efforts to improve survival and habitat conditions for winter-run got into full swing in the mid 90's, and it is seductive to suppose that these efforts alone are responsible for apparent recent upswings in spawner returns. An apparent dramatic shift in cohort replacement rate starting immediately after the end of the last inter-decadal regime suggests, however, that more favorable ocean conditions may be playing a very significant role. We feel that this should be viewed as an opportunity to take full advantage of favorable ocean conditions in seeking additional ways to stimulate a recovery of winter-run.

CONCLUSIONS

Since the last NMFS status review of the Sacramento River winter-run chinook salmon the population has reversed the trend which led to its listing in 1994 and is now increasing. Of the many factors which have likely contributed to this reversal and subsequent population increases, the most important are an inter-decadal ocean regime shift in the North Pacific Ocean, harvest management changes by the Pacific Fisheries Management Council, changes in operations of Red Bluff Diversion Dam, new fish screens at major main stem Sacramento River Diversions, improved temperature control at Shasta Dam and pollution control at Spring Creek Dam and the Minnesota Flats Treatment Plant. New factors with continuing important and positive influence on winter-run chinook include the re-opening and restoration of Battle Creek and the CalFed Ecosystem Restoration Plan. It is important to note that all of these changes are permanent with the exception of the ocean regime shift, which is expected to last another 20-30 years. Factors of lesser but significant importance are the Livingston Stone Hatchery, improved enumeration and population estimation techniques, improved passage conditions at the Anderson Cottonwood Irrigation District weir and the Environmental Water Account. Of minor or insignificant importance are south Delta water project operations and spawning gravel replenishment.

RECOMMENDATIONS

General

- In light of the above information regarding both the change in population levels and trend for winter-run and changes in important conditions influencing survival and recovery of this species, most of which are permanent or long-term in nature, we feel it is appropriate for NMFS to reconsider the listing status of the Sacramento River winter-run chinook, and to change that status from “endangered” to “threatened” under the Endangered Species Act (ESA). While it is clear that recovery of this stock is not yet at hand, we conclude that both conditions and the population itself are moving in that direction.

- Based on quantitative analyses whenever possible, such as those presented here, NMFS should place most emphasis in both the management and regulatory arenas on those actions most likely to produce the largest beneficial changes in mortality (reduction) or production (increases).

- Those actions with large benefits and relative certainty should be implemented without delay;
if already implemented, they should be continued.

- Those actions with small or uncertain benefits for winter-run should be de-emphasized.

**Specific**

Although major strides have been taken on the road to providing for recovery of winter-run chinook salmon, there are many opportunities to make substantial additional progress. The following recommendations are made for NMFS’ consideration:

- **Fold interdecadal (NPSST) regime change into winter-run (and other species) management at all levels** – The critical importance of inter-decadal cycles in ocean conditions for salmon growth and survival at sea is becoming increasingly appreciated. This new appreciation has very profound management implications, both for fisheries and for recovery strategies in other parts of the salmon life cycle. Folding this understanding into winter-run management, both the fish and their habitats, will result in increased reliability of management actions and increased management flexibility. This will improve the long-term prospects for winter-run.

- **Continue progressive commercial and recreational fishery management** – While major strides have been made in the protection of winter-run and other depressed salmon stocks since the adoption of Amendment 14 by the PFMC, additional actions can be taken which will result in increased ocean survival and spawner escapements. The following areas need attention and would benefit winter-run chinook as well as other salmon stocks.
  
  - Move toward selective fisheries coast-wide; implement mass marking of all hatchery fish
  - Maintain conservative bait fish (sardine, anchovy) management
  - Prohibit mooching during periods of high winter-run encounter probability
  - Use JPE and CWT data to assist in developing a preseason forecast for winter-run

- **Refine enumeration techniques, both adult and juvenile** – Although strides have been made in this area, more progress is needed. This action will result in increased reliability of population estimates and trends and reduced uncertainty in management and other administrative actions. Encouragement and direct support should be given to CDFG, DWR and USFWS. This will require additional funding, personnel. The following areas need attention and would produce significant benefits to winter-run.

- **Restrict rainbow trout fisheries on winter-run spawning grounds** – California Department of Fish and Game (CDFG) has balked at NMFS’ suggestions to restrict angling for rainbow trout during the winter-run spawning period to areas not immediately associated with spawning activities. This action would result in increased survival of females (especially) and reduced stress on actively spawning fish. NMFS should enter into active discussions with CDFG and implement actions to solve this problem.

- **Modify factors in the Sacramento River to improve juvenile survival and abundance** – Using juvenile monitoring and enhanced enumeration techniques, identify factors between spawning grounds and the Sacramento-San Joaquin confluence which presently appear to result
in juvenile mortality rates approaching or exceeding 90%, according to the NMFS-approved Juvenile Production Estimate procedure. Work with CalFed to implement changes as part of the Ecosystem Restoration Program.

- **Provide year-round flow in Yolo Bypass and fish passage at Fremont Weir** – This project is presently in the feasibility and preliminary design phase, but needs strong support from NMFS. Habitat, fish passage (both upstream and downstream) and poaching issues are all involved and can all be addressed. Species benefitting from this action include not only winter-run, but also spring run chinook and green sturgeon. Benefits would include increased rearing and outmigrant habitat, reduced upstream passage impairment, enhanced downstream migration and reduction or elimination of a popular poaching site for salmon and sturgeon.

- **Raise Shasta Dam** – This action, which is presently undergoing feasibility evaluation by the Bureau of Reclamation, would provide more storage, enhanced water management and temperature control capability at Shasta Dam. Benefits to winter-run would be significant.
  - Carcass count techniques, effort
  - Juvenile distribution monitoring (screw traps; other)
  - More aggressive use of CWT information (Livingston Stone fish)
  - Accelerate both genetic analysis and CWT data acquisition at the CVP and SWP

- **Continue screening of main stem water diversions** – Over 20 water diversions on the Sacramento River main stem with capacities at or in excess of 100 cfs remain unscreened. Continuation of the screening program at a high priority level will further the reduction of winter-run entrainment into unscreened diversions. This will result in increased survival of downstream migrants. NMFS should coordinate activities with the Central Valley Fish Facilities Review Team, the Anadromous Fish Screening Program and CalFed.

- **Consider a variable temperature regime below Keswick Dam** – Although it is obvious that temperature control at Shasta Dam has very significant benefits for winter-run, especially in dry or critical water years, there is the possibility that significant downstream migration delays being observed this year (at the time of writing) are due to either failure of winter-run juveniles to thrive (grow) at a sufficient rate or the lack of a warming temperature cue to begin migration (or both). A variable temperature control regime could result in a closer mimic of ancestral habitat conditions. NMFS should coordinate this action with USBR, CDFG and USFWS.

- **Work to determine partitioning of survival between freshwater, estuarine and marine habitats** – Understanding the sources and rates of mortality of winter-run and other salmon stocks in various components of their life cycles is critical to intelligent management of habitats and fisheries and the relative importance to assign to these areas. Progress in this area will reduce uncertainty of management and restoration actions and improve the long term prospects for winter-run. This activity should be coordinated with PFMC, CDFG, DWR and USFWS.
REFERENCES


February.

NMFS 1993. Winter-run chinook salmon Biological Opinion for the operation of the federal Central Valley Project and the California State Water Project. NMFS Southwest Region. Long Beach CA.


FIGURE 1
ADULT WINTER RUN CHINOOK TOTAL FRESH WATER ESCAPEMENT
(RBBD COUNTS THROUGH 1995; CARCASS COUNTS, 1996-2001)

Return from 108,855 Adult Escapement in 1969
Return from 74,115 Adult Escapement in 1968
RBDD Closes, 1964

R² = 0.8531
FIGURE 2
ADULT WINTER RUN SPAWNER POPULATION
COMPARISON OF PETERSEN, SCHAEFER AND JOLLY-SEBER ESTIMATES

YEAR

EFFECTIVE SPAWNER POPULATION
(000's)
0 2 4 6 8 10 12

PETERSEN
SCHAEFER
JOLLY-SEBER
FIGURE 3
EFFECTIVE WINTER RUN SPAWNER POPULATION
COMPARISON OF PETERSEN, SCHAEFER AND JOLLY-SEBER ESTIMATES

YEAR

EFFECTIVE SPAWNER POPULATION (000's)
0 1 2 3 4 5 6 7 8

PETERSEN
SCHAEFER
JOLLY-SEBER
FIGURE 4
WINTER RUN JUVENILE PRODUCTION ESTIMATES (NMFS) AND JUVENILE PRODUCTION INDICES (USFWS)
FIGURE 5
WINTER-RUN CHINOOK COHORT REPLACEMENT
(RBBD + PETERSEN ADULT SPAWNER ESTIMATES)

YEAR

COHORT REPLACEMENT RATE

1:1 REPLACEMENT
FIGURE 6
LIVINGSTON STONE HATCHERY WINTER RUN SMOLT OUTPUT
(Number Released)
FIGURE 7
WINTER RUN ADULT ESCAPEMENT AND CVI HARVEST INDEX

YEAR


WINTER RUN ESCAPEMENT (000's)

CVI HARVEST INDEX (%)
FIGURE 8
ADULT WINTER RUN CHINOOK ESCAPEMENT
RED BLUFF DIVERSION DAM OPERATIONS CHANGES
(Various run estimate procedures)

Return from 74,115
Adult Escapement in 1968

Return from 108,855
Adult Escapement in 1969

RBDD Closes, 1964

R^2 = 0.8531
Figure 9
FALL CHINOOK SMOLT SURVIVAL
DECEMBER - JANUARY EXPERIMENTS

Survival ratio = -0.000034(export rate) + 0.52
$R^2 = 0.47$
$P=0.06$
Figure 10
Winter run chinook salmon take at the SWP and CVP Delta pumps as a percent 2% of different estimates of the juvenile population entering the Delta

Percent of "Red Light" (2% of juveniles)

Year


"Red Light"
FIGURE 11
ADULT WINTER RUN CHINOOK
TOTAL ESCAPEMENT AND OCEAN CONDITION REGIME SHIFT
(RBBD COUNTS THROUGH 1995; CARCASS COUNTS, 1996-2001)