UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Sacramento Area Office
650 Capitol Mall, Suite 8-300
Sacramento, California 95814-4706

December 15, 2004

In Reply Refer To:
151422SWR04SA9238:JSM

Arthur G. Baggett, Jr.
Chair, State Water Resources Control Board
P.O. Box 100
Sacramento, California 95812

Dear Mr. Baggett:

This letter provides comments from the National Marine Fisheries Service (NOAA Fisheries) concerning periodic review of the 1995 Water Quality Control Plan (WQCP) for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. NOAA Fisheries participated in the October 28, November 15, and November 16, 2004 workshops regarding the Delta Cross Channel Closure Objective and the Salmon Protection Objective, as part of the Water Quality Objectives for Fish and Wildlife Beneficial uses. Separate letters regarding amendments to both objectives were submitted to the Board from NOAA Fisheries on October 26, 2004 (NOAA-EXH-01,02). We refer you to these letters as they complement this correspondence.

Attached as enclosures, we are providing information requested from NOAA Fisheries by the Board during recent workshops concerning the Viable Salmonid Population (VSP) concept and recommended measures used to evaluate recovery of listed fish. Also included in the enclosures are recommended narrative changes for both objectives and numerous other specific recommendations.

Our general comments regarding the Delta Cross Channel Closure and Salmon Protection objectives follow:

- State and Federal Endangered Species Acts. It is NOAA Fisheries understanding that the Board must comply with the requirements of the California Endangered Species Act (CESA). This would require the Board to ensure that any action it undertakes is not likely to jeopardize the continued existence of any State endangered or threatened fish, or result in destruction or adverse modification of essential habitat. Current CESA listed fish include winter-run Chinook salmon (endangered, 1989) and spring-run Chinook salmon (threatened, 1999). All races of Chinook salmon and steelhead are also included in the California Salmon, Steelhead Trout, and Anadromous Fisheries Program Act (Fish and Game Code Sections 6900-6924).

Because the Environmental Protection Agency (EPA) will endorse the Water Quality Control Plan, Federal ESA compliance is also required and the EPA would be the lead Federal agency consulting with NOAA Fisheries regarding listed salmonids. Federal agencies cannot undertake or authorize an action that is "likely to jeopardize the continued existence" of a species listed under the ESA (ESA Section 7). It is under this mandate that NOAA Fisheries is responding to the Board's request for comments related to the Water Quality Control Plan. We are submitting these comments to the Board in an effort to communicate our concerns prior to formal section 7 consultation.

- Salmonid Population Status. In 1987, NOAA Fisheries expressed its concern to you that fish habitat in the Central Valley and Delta has suffered grievous damage and the fish populations had declined to dangerously low levels (referenced in expert witness testimony of Roger Wolcott, Jr., for NOAA Fisheries, July 6, 1992). In 1989, NOAA Fisheries took emergency action to list winter-run Chinook salmon under the ESA. In 1992, we again informed you of the increased threats and losses to salmon stocks and habitat (expert witness testimony of Roger Wolcott, Jr., for NOAA Fisheries, July 6, 1992). Since 1992, several salmonids inhabiting the Sacramento-San Joaquin Delta have become listed. The winter-run Chinook salmon population continued to decrease and was reclassified to endangered status in 1994, Central Valley steelhead was listed as threatened in 1998, and spring-run Chinook salmon was listed as threatened in 1999.

  During the November 15, 2004 workshop, we indicated that despite much of the resources spent on restoration, salmonid stocks in the Central Valley remain at risk. We indicated that the spring-run Chinook population and the Central Valley steelhead population are continuing to decline. In addition, NOAA Fisheries was petitioned to list the North American green sturgeon in 2001, which inhabits areas subject to the Water Quality Control Plan (FR 4433, January 29, 2003). NOAA Fisheries determined the green sturgeon population did not warrant listing as a threatened or endangered species, but warranted designating them as a candidate species under the ESA. The U.S. District Court set aside the finding and remanded the matter for re-consideration. NOAA Fisheries is currently evaluating the status of the population based on recent scientific and commercial information (FR 34135, June 18, 2004). The U.S. Fish and Wildlife Service is currently evaluating a petition to list four species of lamprey, all of which inhabit the Central Valley. Additional listings in the future may occur if substantial action is not taken now. NOAA Fisheries urges the Board to maintain consistency with provisions of the State and Federal ESA to avoid continued listings in the future, aid in recovery of listed species, and to fully attain designated beneficial uses.

- Ecosystem Principle. During 1992 testimony (expert witness testimony of Roger Wolcott, Jr., for NOAA Fisheries, July 6, 1992), NOAA Fisheries indicated the importance of utilizing the ecosystem principle when managing Central Valley fisheries. The management of individual species, tributaries, or basins at the expense of others is not an effective approach, and an ecosystem approach is needed to address the entire Central Valley ecosystem. Restoration programs such as the California Bay-Delta Program are applying the ecosystem concept to restoration efforts.

Unfortunately, the benefits of these planning efforts, land acquisitions, and restoration projects toward recovery of many fish species have yet to be quantified, and plans to withdraw additional water from the Central Valley continue. Specific flow and temperature conditions believed sufficient to attain the population objectives and recovery of listed fish should be determined and implemented as soon as possible. We recommend the Board's Implementation Plan for the 2004 periodic review include recommendations that the Central Valley Regional Water Quality Control Board set specific flow and temperature conditions necessary for fish doubling and eventual recovery. The Central Valley Project Improvement Act's Anadromous Fish Restoration Program, conducted by the Bureau of Reclamation and U.S. Fish and Wildlife Service and California Department of Fish and Game developed instream flow and temperature recommendations for many of the tributaries of the Central Valley. Considerable effort and fishery biologist expertise was used to develop these flow and temperature recommendations. These flow and temperature recommendations should be implemented by the Central Valley Regional Water Quality Control Board and other applicable agencies.

NOAA Fisheries requests that the Board develop an integrated, Central Valley-wide ecosystem management plan to ensure the survival of anadromous fish, the recovery of listed species, and attainment of all designated beneficial uses. We believe this management effort can be accomplished through periodic review, revision, and implementation of programs in the Water Quality Control Plan. The Central Valley Regional Water Quality Control Board would also play a critical role by setting water quality and temperature objectives that fully attain all designated beneficial uses in the tributaries.

- <u>Monitoring</u>. Substantial monitoring efforts in the Sacramento-San Joaquin Delta have been carried out for many years through the Interagency Ecological Program (IEP); however, these efforts as well as efforts to monitor upstream fish populations are continually at risk due to funding and staff shortages. NOAA Fisheries is very concerned about the threats to this long-term monitoring due to budget constraints and/or reallocation. Though other avenues are currently available to fund such monitoring programs, no long-term commitments have been made to secure this funding. NOAA Fisheries recommends the Board add a narrative requiring monitoring by the responsible agencies, designed in cooperation with fisheries agencies, to provide information used to evaluate fish populations using VSP criteria.

- <u>Central Valley Project and State Water Project Long-term Operations</u>. NOAA Fisheries recently completed the biological opinion for the Central Valley Project (CVP) and State Water Project (SWP) long-term operations (OCAP) as described in the Long-term CVP and SWP Operations, Criteria, and Plan biological assessment developed by the U.S. Bureau of Reclamation and California Department of Water Resources. The OCAP biological opinion assessed the effects of CVP and SWP operations to listed species only and determined if the action was likely to result in jeopardy. It did not address non-CVP and non-SWP streams, and species not presently listed by the ESA. Though the OCAP biological opinion does overlap in portions of the Central Valley, it does not cover the entire Central Valley ecosystem.

We refer you to the enclosed material for specific recommendations from NOAA Fisheries regarding the Delta Cross Channel Closure and Salmon Narrative objectives as well as VSP criteria and recommended recovery assessment methods.

We appreciate the opportunity to provide the Board with comments related to the 1995 Water Quality Control Plan revisions and look forward to future workshops and topics. If you have any questions regarding this correspondence including the enclosed information, or if NOAA Fisheries can provide further assistance, please contact Mr. Jeff McLain in our Sacramento Area Office, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814. Mr. McLain may be reached by telephone at (916) 930-5648, or by Fax at (916) 930-3629.

Sincerely,

Michael E. Aceituno
Supervisor, Sacramento Area Office

Enclosure(s)

cc: NOAA Fisheries-PRD, Long Beach CA
Joe Dillon - Santa Rosa Area Office, CA.
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Enclosure

Delta Cross Channel Closure Objective
NOAA Fisheries submitted a detailed letter of our recommendations to the Board on October 26, 2004, and presented information to the Board during the October 28, 2004, and November 15, 2004, workshops concerning the effects of gate operations on listed Chinook salmon. We indicated that the existing closure criteria has been found to be an important and effective tool in protecting winter-run Chinook salmon, spring-run Chinook salmon, and Central Valley steelhead. We also reviewed recent scientific research supporting the fact that tidal and/or diel operations of the gates does not appear feasible to provide salmonid protection and water quality benefits. Feedback from agencies responsible for implementing and evaluating this research during the periodic review has mostly indicated that more time is needed to determine the effects of gate operation on salmonids. We must continue to prevent the diversion of salmonids from their natural migration route in the Sacramento River while the Delta Cross Channel studies continue and recommendations from responsible agencies are submitted. This includes the continued use of Cross Channel Gate closures and the continued pursuance of Georgiana Slough closures and or screening.

We offer these specific recommendations concerning the Delta Cross Channel Gate Closure Objective.

1. Closure Objective. We recommend enhancing fisheries protection measures prior to the start of closure criteria on November 1 to allow protection during the month of October. The existing Salmon Decision Process starts October 1, and the gate closure criteria should also start during this time. The movement and identification of Chinook salmon in the vicinity of the Delta Cross Channel and in the Delta, including the recoveries at the pumping plants should be actively studied to identify the race of these yearling migrants during September and October. The Salmon Decision Tree process should be adaptively managed and remain flexible to accommodate new science. This may include potentially extending to September. We recommend the following changes to the Closure Criteria time period for November to January.

    a. **The time period for the November to January gate closure objective should be changed from October to January.**

    b. **Table 3 footnote 26 should read as follows. "For the October - January period, close Delta Cross Channel gates for up to a total of 45 days, as needed, for the protection of fish. The timing of the gate closure will be determined by the Data Assessment Team by incorporating the Salmon Decision Process. Final approval of Delta Cross Channel gate operations will be approved by the Water Operations Management Team and the Calfed Operations Group established under the Framework Agreement."**

2. 45-day Accounting. To reduce scour in the channels on the downstream side of the DCC gates and to reduce potential flood flows that might occur from diverting water from the Sacramento River into the Mokelumne River system, the radial gates are

closed whenever flows in the Sacramento River at Freeport reach 25,000 to 30,000 cfs on a sustained basis. Limited fisheries benefits may be realized under such circumstances; however, the closures to reduce scour are inappropriately applied toward the 45-day closure. If all 45 days of closure were executed to maximize benefits to salmonids, it is likely that the scheduling would be different. Only closures intended for fisheries protection benefits should be counted in the 45-day limit as scour avoidance decisions are not made with the intent to benefit salmonids. This distinction of Delta Cross Channel gate closure accounting should be adequately described in the Water Quality Control Plan with a footnote.

2. Required Monitoring. The Salmon Decision Process is dependant on salmonid monitoring activities across the Central Valley, including efforts in the Sacramento River and its tributaries as well as the Delta and Suisun Bay. It is critical for this monitoring to remain intact to ensure the Salmon Decision Process has the necessary information to make timely, informed decisions. NOAA Fisheries recommends the Board add an additional narrative requiring monitoring to be designed in cooperation with fisheries agencies, to provide information used to evaluate fish populations related to the Delta Cross Channel Closure Objective.

Salmon Doubling Narrative Objective

During workshops on October 28, 2004, and November 15, 2004, NOAA Fisheries recommended amending the Salmon Protection Objective to include Central Valley steelhead protection measures, tributary streamflows, Viable Salmonid Population (VSP) concepts, and specific measures to achieve recovery. Specific comments regarding the VSP are below.

1. Central Valley Steelhead Protection Measures. Central Valley steelhead were listed as threatened in March 1998 after issuance of the 1995 Water Quality Control Plan, and thus should be included in the Salmon Protection Objective in order for the Water Quality Control Plan to remain consistent with the ESA. Steelhead have variable and complex life history patterns, and utilize freshwater habitats of the Sacramento-San Joaquin Delta Estuary and its tributaries during all times of the year. These variable life history strategies overlap with Chinook salmon, but also have specific instream flow and temperature requirements throughout the year which should be carefully considered by the Board and the Central Valley Regional Water Quality Control Board during development of flow and temperature conditions necessary for protection and recovery.

2. Salmon Doubling Effort. The Central Valley Project Improvement Act requires the Secretary of the Department of Interior to develop and implement a program which makes "all reasonable efforts to ensure that, by the year 2002, natural production of anadromous fish in Central Valley rivers and streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967-1991" (Section 3406[b][1]). The resultant program, known as the Anadromous Fish Restoration Program (AFRP) has presented and submitted a considerable amount of information to the Board during the periodic review concerning the doubling goals and the AFRP program. The Department of Interior is still evaluating whether or not

the doubling goal has been met. Preliminary conclusions indicate that doubling has occurred in several watersheds, and that the goal is far from being met basin wide (DOI EXH-17B-J).

NOAA Fisheries recognizes the importance of the doubling effort and is supportive of the objective as it will likely contribute to the recovery of listed salmonid populations and may prevent additional listings (i.e. green sturgeon). Consequently, NOAA Fisheries recommends the continuation of the doubling effort, and in addition, the incorporation of specific doubling goals for all watersheds in the Central Valley. It is critical to provide separate doubling goals for independent watersheds as described in the AFRP Working Paper to keep track of the progress of all watersheds.

NOAA Fisheries recommends replacing the Board's salmon narrative with VSP concept criteria, and recommends an additional footnote referencing and describing the doubling goal. The incorporation of the VSP criteria will ensure consistency with our Federal process. This should also help streamline future section 7 consultation resulting from this action. The specific recommendation for such notation is included in the Recommended Narrative section of this letter.

3. <u>Viable Salmonid Population Concept</u>. NOAA Fisheries evaluates the risk of a salmonid population's viability by using the Viable Salmonid Population concept (NOAA-EXH-12). The VSP is an integral part of NOAA Fisheries recovery planning efforts and contains four components that must be addressed collectively: abundance; productivity; spatial structure; and genetic diversity. Each of these components is a critical factor in determining whether or not a population has reached recovery. Thus, a doubled population could fail to be viable because it does not satisfy the other components necessary for population viability. The utilization of abundance solely as a protective measure fails to meet the recovery standards as it does not consider the other components of the VSP concept.

Technical recovery teams are currently establishing specific criteria to be used in evaluating the viability of specific salmonid ESUs; however, management actions still need to be taken while recovery goals are being developed. NOAA Fisheries recommends utilizing interim criteria prior to full adoption of recovery plans, and acknowledges that a full population assessment may not be possible. In these situations, agencies are recommended to adopt population definitions already available in fish conservation reports or similar stock-based management plans, provided that these definitions are consistent with the VSP concept. The AFRP doubling goal is a good example of such a management plan that could be used to assess the abundance factor of the VSP. In addition, the burden of determining salmonid ESU population viability is not to be placed on local and/or State agencies, but is assessed by the NOAA Fisheries Recovery Team during population status reviews. Thus, the guidelines presented in this report, briefly describe the process in which the NOAA Fisheries Recovery Team assesses population viability.

The NOAA Fisheries VSP document (NOAA-EXH-12) focuses on scientific/biological aspects of populations, but also provides information on its application at local, State, national, and international levels. It should first be noted that typical evaluation principles of populations involve regulatory language such as "survival," "recovery," and "extinction:" however, the VSP introduces a new term called viability. The viability of a population is the negligible probability of extinction over a 100-year period.

NOAA Fisheries requests the inclusion of the VSP concept in the Salmon Protection narrative of the Water Quality Control Plan. Our specific narrative recommendation is included in the Recommended Narrative section below.

4. Compliance Benchmarks and Measures to Achieve Recovery. Specific measures should be developed to achieve recovery, and compliance benchmarks should be developed in an effort to evaluate progress toward recovery of salmonids and compliance with the protection measures. Potential measures include: specific streamflow and temperature requirements for tributaries; barrier operations; and water quality indicators. We intend to introduce the methods used to measure the four aspects of the VSP in this letter; however, this discussion is extremely brief and those seeking additional detail are referred to the guidelines in the NOAA Technical Memorandum titled Viable Salmonid Populations and the Recovery of Evolutionary Significant Units (NOAA-EXH-12). It is NOAA Fisheries' responsibility under ESA to evaluate recovery of listed species.

a. *Abundance.* In determining population abundance levels, NOAA Fisheries does not utilize specific numeric criteria, but offers a set of discrete guidelines broken into two categories: 1) viable population definitions for those populations meeting all other VSP criteria, and 2) critically low abundance levels for populations in which any of the VSP criteria are met (in terms of being a concern). Guidelines for assessing population abundance are attached in (Figures 1 and 2).

b. *Growth rate.* A number of statistical techniques exist for evaluating time series parameters for the evaluation of growth rate; however, no standardized guidelines exist, particularly with regard to these model assumptions. As an alternative, NOAA Fisheries recommends utilizing multiple statistical approaches to discern temporal patterns such as trends in growth magnitude. Keeping this approach in mind, NOAA Fisheries recommends three types of approaches in evaluating growth rates: methods to estimate population growth rate and detection of trends, detecting other patterns in time series such as auotocorrelation, interventions, and epochs, and methods to estimate intrinsic productivity and density dependence estimating procedures. Figure 3 contains population growth rate and related parameter guidelines.

c. *Spatial structure.* The spatial structure of a population consists of the physical distribution of individuals, and the processes that generate this distribution. The science of evaluating spatial structure involves the determination of subpopulations and patch existence as well as spatial structure and temporal scales. Measures to address distribution structure include straying rates and habitat dynamics. Figure 4 contains spatial structure guidelines.

d. *Diversity.* Diversity, in the context of VSP evaluation refers to the distribution of traits within and among populations. Traits can be exhibited in terms of DNA sequence variation at single gene levels to complex life-history traits. Examples of life-history traits include anadromy, morphology, fecundity, run timing, spawning timing, juvenile behavior, age at smolting, and development rate. Some traits are genetically based, while others, particularly behavioral and morphological traits are a combination of genetics and environmental influences. Spatial structure, as discussed previously, also play an important role in diversity. A loss or alteration of diversity reduces a populations viability as it is essential to conserve the inherent variability that allows salmonids to adapt to changing environments. In addition, the natural processes of regeneration and disturbance should be allowed to occur. Figure 5 contains spatial structure guidelines.

Once all four factors of the VSP are assessed, the viability of a population may be evaluated. NOAA Fisheries takes three factors into consideration when evaluating the viability of an ESU: catastrophic events, long-term demographic processes, and long-term evolutionary potential. Figure 6 contains ESU viability guidelines.

5. Recommended Narrative. To be consistent with Federal and State law, NOAA Fisheries recommends changing the doubling narrative to include Central Valley steelhead and VSP criteria as its deterministic methodology. The new recommended narrative follows.

"Water quality conditions shall be attained and maintained, together with other measures throughout the watersheds of the Central Valley, Delta, and Bay, sufficient to achieve sustainable viable salmonid populations, which will aid in the recovery of listed salmon and steelhead populations, consistent with State and Federal law. "

Figure 1. Viable Population Size Guidelines.

1. **A population should be large enough to have a high probability of surviving environmental variation of the patterns and magnitudes observed in the past and expected in the future.** Sources of such variation include fluctuations in ocean conditions and local disturbances such as contaminant spills or landslides. Environmental variation and catastrophes are the primary risks for larger populations with positive long-term average growth rates.

2. **A population should have sufficient abundance for compensatory processes to provide resilience to environmental and anthropogenic perturbation.** In effect, this means that abundance is substantially above levels where depensatory processes are likely to be important and in the realm where compensation is substantially reducing productivity. This level is difficult to determine with any precision without high quality long-term data on population abundance and productivity, but can be approximated by a variety of methods.

3. **A population should be sufficiently large to maintain its genetic diversity over the long term.** Small populations are subject to various genetic problems (including loss of genetic variation, inbreeding depression, and deleterious mutation accumulation) that are influenced more by effective population size than by absolute abundance.

4. **A population should be sufficiently abundant to provide important ecological functions throughout its life-cycle.** Salmonids modify both their physical and biological environments in various ways throughout their life cycle. These modifications can benefit salmonid production and improve habitat conditions for other organisms as well. The abundance levels required for these effects depend largely on the local habitat structure and particular species biology.

5. **Population status evaluations should take uncertainty about abundance into account.** Fish abundance estimates always contain observational error, and therefore population targets may need to be much larger than the desired population size in order to be confident that the guideline is actually met. In addition, salmon are short-lived species with wide year-to-
year abundance variations that contribute to uncertainty about average abundance and trends. For these reasons, it would not be prudent to base abundance criteria on a single high or low observation. To be considered a VSP, a population should exceed these criteria on average over a period of time.

Figure 2. Critical Population Size Guidelines.

1. A population would be critically low if depensatory processes are likely to reduce it below replacement. The specific population levels where these processes become important are difficult to determine, although there is theory on mate choice, sex-ratios, and other population processes that may be helpful in placing a lower bound on safe population levels. In general, however, small-population depensatory effects depend largely on density rather than absolute abundance. A species' life-history and habitat structure play large roles in determining the levels at which depensation becomes important.

2. A population would be critically low if it is at risk from inbreeding depression or fixation of deleterious mutations. The most important genetic risks for very small populations are inbreeding depression and fixation of deleterious mutations; these effects are influenced more by the effective breeding population size than by absolute numbers of individuals.

3. A population would be critically low in abundance when productivity variation due to demographic stochasticity becomes a substantial source of risk. Demographic stochasticity refers to the seemingly random effects of variation in individual survival or fecundity that are most easily observed in small populations. As populations decline, the relative influences of environmental variation and demographic stochasticity changes—with the latter coming to dominate in very small populations.

4. Population status evaluations should take uncertainty regarding abundance into account. Fish abundance estimates always contain observational error, and therefore population targets may need to be much larger than the desired population size in order to be confident that the guideline is actually met. In addition, salmon are short-lived species with wide year-to-year abundance variations that contribute to uncertainty about average abundance and trends. For these reasons, it would not be prudent to base abundance criteria on a single high or low observation. To be considered critically low, a population should fall below these criteria on average over a short period of time.

Figure 3. Population growth rate and related parameters guidelines.

1. A population's natural productivity should be sufficient to maintain its abundance above the viable level. A population meeting or exceeding abundance criteria for viability should, on average, be able to replace itself. That is, spawner ratios or cohort-replacement ratios should fluctuate around 1.0 or above. Natural productivity is typically measured as the ratio of naturally produced spawners born in one broodyear to the number of fish spawning in the natural habitat during that broodyear. Population abundance estimates at other life-history stages may also be used, provided such estimates span the entire life cycle (e.g., smolt to smolt estimates).

2. A viable salmonid population that includes naturally spawning hatchery fish should exhibit sufficient productivity from naturally-produced spawners to maintain population abundance at or above viability thresholds in the absence of hatchery subsidy. In a strict sense, this guideline suggests that the mean Natural Return Ratio (NRR) for a viable population should fluctuate around 1.0—indicating negligible hatchery influence on the population. In a practical sense, the requirement that a viable population be demographically independent of a hatchery population suggests that a viable population's mean NRR not be less than approximately 0.9, but this estimate neglects other issues related to the influence of hatchery fish on natural production. A viable population should not exhibit a trend of proportionally increasing contributions from naturally spawning hatchery fish.

3. A viable salmonid population should exhibit sufficient productivity during freshwater life history stages to maintain its abundance at or above viable thresholds—even during poor ocean conditions. A population's productivity should allow it both to exploit available habitat and exhibit a compensatory response at low population sizes. When spawner abundance is below the long-term mean, there should be a corresponding increase in per capita smolt production, even though such an increase may not suffice to offset declines in marine survival.

4. A viable salmonid population should not exhibit sustained declines in abundance that span multiple generations and affect multiple broodyear-cycles. "Sustained" declines are those that continue longer than the typical lag in response associated with a population's generation time. Thus, sustained declines differ from rapid transitions between one stable level and another (e.g., changes in abundance related to large-scale, low frequency environmental forcing such as those related to oceanic regime shifts). They also differ from short-term, severe perturbations in abundance (such as those related to strong El Niño events) that are followed by relatively rapid recovery.

5. A viable salmonid population should not exhibit trends or shifts in traits that portend declines in population growth rate. Changes in such traits, such as size and age of spawners, that affect population growth rate are often more easily and precisely quantified than are changes in abundance and thus, may provide earlier indication of declining population growth rate. For example, reduced size of mature individuals in a population may indicate reduced fecundity, lessened ability to reach spawning grounds, a decreased capacity for constructing redds that are deep enough to resist bed scour, or other factors that contribute to reduced production of offspring. Likewise, increasing age-at-return may reduce a population's intrinsic productivity by exposing

Figure 3 cont.

adults to greater pre-reproductive spawning risk.

6. Population status evaluations should take into account uncertainty in estimates of population growth rate and productivity-related parameters. To estimate long-term trends and spawner recruit ratios, it is important to have an adequate time series of abundance. Unfortunately, such time series, when they exist at all, are often short and contain large observational errors, or both. These constraints may greatly limit the power of statistical analyses to detect ecologically significant trends before substantial changes in abundance have occurred.

Figure 4. Spatial Structure Guidelines.

1. **Habitat patches should not be destroyed faster than they are naturally created.** Salmonid habitat is dynamic, with suitable habitat being continually created and destroyed by natural processes. Human activities should not decrease either the total area of habitat OR the number of habitat patches. This guideline is similar to the population growth rate criterion—i.e., a negative trend has deterministically negative affects on viability—though the relationship between decreasing number of patches and extinction risk is not necessarily linear.

2. **Natural rates of straying among subpopulations should not be substantially increased or decreased by human actions.** This guideline means that habitat patches should be close enough together to allow appropriate exchange of spawners and the expansion of the population into underused patches during times when salmon are abundant (see Guideline 3). Also, stray rates should not be much greater than pristine levels because increases in stray rates may negatively affect a population's viability if fish wander into unsuitable habitat or interbreed with genetically unrelated fish.

3. **Some habitat patches should be maintained that appear to be suitable or marginally suitable, but currently contain no fish.** In the dynamics of natural populations, there may be time lags between the appearance of empty but suitable habitat (by whatever process) and the colonization of that habitat. If human activity is allowed to render habitat unsuitable when no fish are present, the population as a whole may not be sustainable over the long term.

4. **Source subpopulations should be maintained.** Some habitat patches are naturally more productive than others. In fact, a few patches may operate as highly productive source subpopulations that support several sink subpopulations that are not self-sustaining. Protecting these source patches should obviously be of the highest priority. However, it should be recognized that spatial processes are dynamic and that sources and sinks may exchange roles over time

5. **Analyses of population spatial processes should take uncertainty into account.** In general, there is less information available on how spatial processes relate to salmonid viability than there is for the other VSP parameters. As a default, historic spatial processes should be preserved because we assume that the historical population structure was sustainable but we do not know whether a novel spatial structure will be.

Figure 5. Diversity guidelines.

1. **Human-caused factors such as habitat changes, harvest pressures, artificial propagation, and exotic species introduction should not substantially alter variation in traits such as run timing, age structure, size, fecundity, morphology, behavior, and molecular genetic characteristics.** Many of these traits may be adaptations to local conditions or they may help protect a population against environmental variation. A mixture of genetic and environmental factors usually causes phenotypic diversity, and this diversity should be maintained even if it cannot be shown to have a genetic basis.

2. **Natural processes of dispersal should be maintained. Human-cased factors should not substantially alter the rate of gene flow among populations.** Human caused inter-ESU stray rates that are expected to produce (inferred) sustained gene flow rates greater than 1% (into a population) should be cause for concern. Human caused intra-ESU stray rates that are expected to produce substantial changes in patterns of gene flow should be avoided.

3. **Natural processes that cause ecological variation should be maintained**. Phenotypic diversity can be maintained by spatial and temporal variation in habitat characteristics. This guideline involves maintaining processes that promote ecological diversity, including natural habitat disturbance regimes and factors that maintain habitat patches of sufficient quality for successful colonization.

4. **Population status evaluations should take uncertainty about requisite levels of diversity into account.** Our understanding of the role diversity plays in Pacific salmonid viability is limited. Historically, salmonid populations were generally self-sustaining, and the historical representation of phenotypic diversity serves as a useful "default" goal in maintaining viable populations.

Figure 6. ESU viability guidelines.

1. **ESUs should contain multiple populations** . If an ESU is made up of multiple populations, it is less likely that a single catastrophic event will cause it to become extinct. Also, ESUs may function as "metapopulations" over the long term and the existence of multiple populations would be necessary for the operation of sustainable population-level extinction/recolonization processes. In addition, multiple populations within an ESU increase the likelihood that a diversity of phenotypic and genotypic characteristics will be maintained, thus allowing natural evolutionary processes to operate and increasing the ESU's viability in the long term. Obviously, this guideline does not apply to ESUs that appear to contain a single population (e.g., Lake Ozette sockeye). In ESUs containing a single population, Guideline 6 becomes increasingly important.

2. **Some populations in an ESU should be geographically widespread.** Spatially correlated environmental catastrophes are less likely to drive a widespread ESU to extinction. This guideline also directly relates to the ESA mandate of protecting a species in a "significant portion of (its) range."

3. **Some populations should be geographically close to each other.** On long temporal scales, ESUs may function as "metapopulations" and having populations geographically close to one another facilitates connectivity among existing populations. Thus, a viable ESU requires both widespread (Guideline 2) AND spatially close populations.

4. **Populations should not all share common catastrophic risks** . An ESU containing populations that do not share common catastrophic risks is less likely to be driven to extinction by correlated environmental catastrophes. Maintaining geographically widespread populations is one way to reduce risk associated with correlated catastrophes (Guideline 2), but spatial proximity is not the only reason why two populations could experience a correlated catastrophic risk.

5. **Populations that display diverse life-histories and phenotypes should be maintained.** When an ESU's populations have a fair degree of life-history diversity (or other phenotypic diversity), the ESU is less likely to go extinct as a result of correlated environmental catastrophes or changes in environmental conditions that occur too rapidly for an evolutionary response. In addition, assuming phenotypic diversity is caused at least in part by genetic diversity, maintaining diversity allows natural evolutionary processes to operate within an ESU.

6. **Some populations should exceed VSP guidelines.** Larger and more productive ("resilient") populations may be able to recover from a catastrophic event that would cause the extinction of a smaller population. An ESU that contains some populations in excess of VSP threshold criteria for abundance and population growth rate is less likely to go extinct in response to a single catastrophic event that affects all populations. It is important to note that the abundance guidelines do not take catastrophes into account. This guideline is particularly relevant if an ESU consists of a single population.

Figure 6 cont.

7. **Evaluations of ESU status should take into account uncertainty about ESU-level processes.** Our understanding of ESU-level spatial and temporal process is very limited. ESUs are believed to have been historically self-sustaining and the historical number and distribution of populations serve as a useful "default" goal in maintaining viable ESUs.