Finer focus on stocks at risk is being provided by case studies. Two case studies (South Umpqua and Grande Ronde river basins) are in progress. These case studies will review the history of the river basins and their salmon populations, identifying the human, environmental, and biological factors that led to the depletion of the salmon. They will identify natural habitat limitations and the human activities that further limited habitat. They will identify the good and bad solutions that were attempted in the past and suggest solutions that might work in the future. The case studies will serve as detailed examples of some of the commonalities among populations that will become evident as the prioritization process is carried out.

The case studies and prioritization process will provide a rational, scientific basis for a regional strategy that addresses the specific biological needs of at-risk salmon populations. This strategy will allow actions to be focused when and where they will do the most good. It can be used to organize regional work efforts, including recovery planning in response to Endangered Species Act listings.

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# The Decline of Anadromous Fishes in California

California contains the southernmost populations of a majority of the anadromous fishes of the Pacific coast of North America. The fact that all of these southern populations are in decline indicates that large-scale environmental changes are taking place, especially in river systems. The native species in decline include river lamprey, *Lampetra ayersi,* Pacific lamprey, *Lampetra tridentata,* green sturgeon, *Acipenser medirostris,* white sturgeon, *A. transmontanus,* delta smelt, *Hypomesus transpacificus,* longfin smelt, *Spirinchus thaleichthys,* eulachon, *Thaleichthys pacificus,* chinook salmon, *Oncorhynychys tshawystcha,* coho salmon, *O. kisutch,* pink salmon, *O. gorbuscha,* chum salmon, *O. keta,* rainbow trout (steelhead), *O. mykiss,* and coastal cutthroat trout, *Oncorhynchus clarki clarki.* In addition, two introduced species, striped bass, *Morone saxatilis,* and American shad, *Alosa sapidissima,* are in severe decline in the state.

Of the six *Oncorhynchus* species, pink salmon are already extinct in the state, chum salmon are reduced to three small populations, and coho salmon probably qualify for threatened species status. Only fall run chinook salmon and winter run steelhead still support real fisheries (albeit greatly reduced and dependent on hatchery fish); other runs of these two species are already listed as endangered or qualify for threatened status. Cutthroat trout distribution coincides with that of coastal rainforest and its populations are greatly depleted as a consequence.

The universal decline of anadromous fishes in California reflects the general decline in the quality of aquatic environments. However, each species may be declining for a different combination of anthropogenic reasons in conjunction with a period of naturally stressful conditions in both fresh and salt water. In an attempt to evaluate the relative importance of various factors affecting the fish populations, I lumped them into nine categories (Table 1):

1. **Watershed degradation,** encompassing the effects of logging, road construction, overgrazing, and urbanization;
2. **Diversions,** anything reducing or altering the flow of streams, such as large dams and irrigation diversions;
3. **Pollution,** toxic substances of all kinds;
4. **Overfishing,** excessive harvest by sport, commercial, and subsistence fisheries;
5. **Hatcheries,** negative effects of hatchery fish on wild populations;
6. **Oceanic conditions,** negative effects of changed oceanic conditions, e.g., el Niño effects, decreased coastal productivity;
7. **Precipitation,** negative effects of increased variability in precipitation in recent years, especially droughts;
8. **Predation,** negative effects of enhanced predator (e.g., marine mammals, introduced fishes) populations on declining wild stocks;
9. **Other factors,** including altered food supply (smelt, lampreys).

**Table 1. Relative importance of factors contributing to the decline of anadromous fishes in California. Subjective scores for each species range from 1 (major cause of decline) to 5 (not a cause).**

| *Species* | *Water Degradation* | *Diversions* | *Pollution* | *Overfishing* | *Hatcheries* | *Ocean Conditions* | *Precipitation* | *Predation* | *Other* |
|---|---|---|---|---|---|---|---|---|---|
| River lamprey | 1 | 3 | 3 | 4 | 4 | 3 | 2 | 2 | 3 |
| Pacific lamprey | 1 | 2 | 3 | 4 | 4 | 3 | 2 | 2 | 2 |
| White sturgeon | 3 | 2 | 3 | 2 | 4 | 4 | 2 | 4 | 4 |
| Green sturgeon | 2 | 2 | 3 | 1 | 4 | 3 | 2 | 4 | 3 |
| Delta smelt | 3 | 1 | 3 | 4 | 4 | 4 | 2 | 3 | 2 |
| Longfin smelt | 2 | 1 | 3 | 4 | 4 | 3 | 2 | 2 | 2 |
| Eulachon | 2 | 2 | 4 | 3 | 4 | 2 | 3 | 2 | 4 |
| Chinook | 1 | 1 | 3 | 2 | 2 | 3 | 2 | 2 | 3 |
| Coho | 1 | 1 | 3 | 2 | 1 | 2 | 2 | 3 | 3 |
| Pink | 2 | 3 | 4 | 4 | 4 | 2 | 2 | 2 | 2 |
| Chum | 1 | 3 | 4 | 4 | 4 | 2 | 2 | 2 | 2 |
| Steelhead | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 3 |
| Cutthroat trout | 1 | 3 | 4 | 3 | 3 | 2 | 2 | 3 | 3 |
| Total points | 21 | 25 | 42 | 44 | 45 | 43 | 27 | 33 | 34 |
| Rank | 1 | 2 | 6 | 8 | 9 | 7 | 3 | 4 | 5 |

For each species each factor was rated on a subjective 1–4 scale, where 1 indicates the factor was probably a major cause in the decline of the species; 2 a moderate contributing factor to the decline; 3 a minor cause; or 4 had no effect on the species. The scores for each factor were added and ranked from lowest to highest, with the lowest scores indicating the factors with the highest overall impact on anadromous fish populations. Watershed degradation, diversions, and variation in precipitation were ranked 1, 2, and 3, respectively (Table 1).

Decisions being made now will determine which species and stocks will become extinct in California in the near future and what segments of the original gene pools will be in existence for future use and evolution. It is possible that California stocks may be especially vulnerable if warming trends push oceanic and stream conditions to which salmonids are adapted further north. Conservation of California's anadromous fishes requires a systematic program of ecosystem protection (Moyle & Williams 1990; Moyle & Yoshiyama, 1994).

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# Past and Present Status of Central Valley Chinook Salmon

California's Central Valley chinook salmon populations are a fragment of their former abundance. Water development for hydroelectric production, irrigation, domestic water supplies, and flood control has restricted or eliminated much of the natural habitat formerly occupied by Central Valley salmon. Much of the species historical habitat has been replaced by hatcheries. Where certain runs are difficult to domesticate for hatchery culture, only isolated population remnants remain.

Adult chinook salmon in the ocean and juveniles in