Summary of CALFED's Workshop on Splittail

Workshop organizers:	Paul L. Angermeier (Chair; USGS)
	Samuel N. Luoma (CALFED)
	Peter B. Moyle (UC-Davis)
Invited panelists:	Randy Baxter (DFG)
	Larry Brown (USGS)
	Tom Cannon (Consultant)
	Ted Foin (UC-Davis)
	Chuck Hanson (Hanson Environmental)
	Ted Sommer (DWR)
	Robin Stewart (USGS)
	Tina Swanson (Bay Institute)
	Kim Taylor (CALFED)

On January 29, 2001, CALFED sponsored a technical workshop on the state of knowledge pertaining to biology and management of splittail (Pogonichthys macrolepidotus). The purpose of the workshop was to bring together splittail experts and stakeholders to 1) review the knowledge base and uncertainties currently guiding splittail management and 2) seek consensus on future directions for splittail research and management. Workshop organizers believed such efforts were warranted because recent studies have generated numerous untested hypotheses related to population dynamics of splittail and because CALFED and other funding sources are poised to support significant management actions to enhance and/or restore splittail populations. Although the workshop was not convened to address whether splittail should be listed under the Endangered Species Act, organizers expected the discussions and outputs of the workshop to inform that decision.

Morning session

The workshop was held at the Sterling Hotel in Sacramento, CA and was attended by about 100 people. After the Chair (Paul Angermeier) called the workshop to order, he briefly discussed the primary outcomes that might emerge from participant consensus. First, the workshop was a forum for identifying the revisions needed to enhance the utility of the CALFED white paper on splittail (authored by Moyle, Baxter, Sommer, Foin, and Abbott). Additional potential outcomes were identification of foci for future data acquisition, modeling exercises, and on-the-ground restorative actions. Workshop participants could select foci based on criteria such as relevance to management, feasibility, cost-effectiveness, and ability to reduce uncertainty. A final primary outcome was that participants might identify major conflicts and/or benefits for splittail management associated with other Bay-Delta programs and objectives. A secondary potential outcome was development of a "fact sheet" on splittail.

Sam Luoma talked briefly about the workshop's relevance to the listing controversy and the need for science to inform resource managers, even in the face of uncertainty, so they can avoid costly errors.

Next, several experts gave brief presentations on selected aspects of splittail life history, population dynamics, and potential threats. Peter Moyle gave an overview of the current conceptual model of splittail life history and discussed the derivation of the hypotheses listed in CALFED's draft white paper on splittail. Randy Baxter discussed current knowledge of splittail spawning and larval requirements. Ted Sommer described the primary sources of data on splittail abundance and summarized knowledge of young-of-year dynamics, as well as implications for population dynamics. Tom Cannon presented relations among splittail salvage (entrainment), hydrologic regime, and water export at the South Delta pumping plants and discussed their implications for population dynamics. Robin Stewart presented data on selenium and isotopic signatures in splittail and discussed the potential for depressed egg viability.

These brief presentations were followed by a longer presentation by Ted Foin on a recently developed population model for splittail. The model, based on a complex Leslie-matrix approach, comprised four population sectors (fecundity, larval production, juvenile survival, and adult survival) and an environmental stochasticity sector. The model assumed density independence and spatial homogeneity, and many of the parameters used in the simulations were necessarily expert guesses based on information in the white paper.

Ted Foin summarized results of numerous simulations in which various parameters were incrementally varied one at a time. Although preliminary, key results of this sensitivity analyses include 1) adult survival has greater influence on population size than does fecundity; 2) spawning success along channel margins can maintain the population during dry years; and 3) the population is inherently highly variable through time. Model results were intriguing and some were not intuitive. All results should be treated as testable hypotheses rather than reliable projections until additional data on critical parameters and assumptions are gathered. Nevertheless, the model strongly influenced subsequent discussion.

Afternoon session

The afternoon was filled with relatively informal discussions aimed at developing the consensus outcomes described by Paul Angermeier before the

expert presentations. First, workshop panelists were divided into two groups. Panelists included the chair and presenters, as well as Larry Brown, Chuck Hanson, Tina Swanson, and Kim Taylor. Other workshop attendees were free to participate in discussions of either or both groups. Each group was initially given a list of about half of the hypotheses (or uncertainties) discussed in the draft white paper. From these or other topics of the group's choosing, the group was to select 3-4 topics for detailed discussion, with the goal of moving toward consensus outcomes. Sam Luoma facilitated one group; Paul Angermeier facilitated the other.

Sam's group identified four focal discussion topics. The first topic, channel-margin habitat for spawning, consumed the bulk of the time allotted for discussion. Several questions about channel-margin habitat were discussed, including 1) What is its spatiotemporal distribution? 2) What does it look like? 3) How does it function for larvae? And 4) Does it differ between the Sacramento and San Joaquin rivers? Actions that may warrant high priority include 1) restore areas at different elevations on a floodplain to compare splittail use of them, 2) restore areas likely to function as spawning habitat during dry years (e.g., Cosumnes River, lower Sutter Bypass), 3) analyze data from California Department of Fish and Game's Egg and Larval Survey to learn about distribution of larvae in dry years, 4) improve edge habitat along migration corridors for young-of-year to see if survival can be enhanced, and 5) establish a series of sites specifically to sample juveniles and relate abundance to vegetation, wetland area, elevation, water quality, and inundation regime.

The second discussion topic of Sam's group was sources of adult mortality, including fishery, pumps, predation, and contaminants. Needed actions that were identified included 1) establish well designed annual survey to index abundance of spawners and 2) analyze the data pertinent to the relation between water export regime and abundance of adult splittail.

The third discussion topic of Sam's group was the importance of spring flows as spawning cues. A potential action is to emphasize restoration projects at low floodplain elevations, where sufficient inundation is more likely.

The fourth discussion topic of Sam's group was young-of-year mortality. A potential action is to restore tidal marsh on the southern edge of Suisun Marsh to enhance young-of-year survival.

Paul's group also identified four focal discussion topics. First, they discussed spawning habitat, including physical features, spatiotemporal distribution, and distinctness of floodplain versus river-channel habitat. A high-priority action was to more precisely characterize (biotically and abiotically) suitable spawning habitat. Such a characterization seemed essential to monitoring where and how much spawning habitat exists and to guiding manipulations of flow and channel/floodplain morphology to enhance spawning and minimize stranding. Another important action was to restore river channel complexity to enhance splittail spawning.

The second discussion topic of Paul's group was the habitat needed by adult splittail when they were not spawning. Because adults are highly mobile and sampling gears are relatively ineffective, there is considerable uncertainty about what constitutes suitable habitat. Moreover, relations between habitat features and adult mortality due to the food fishery, bait fishery, pumps, predation, and contaminants are largely undocumented. Needed actions identified by the group included 1) more precisely characterize the biotic and abiotic features contributing to habitat suitability and 2) estimate mortality rates associated with fisheries, pumps (including transport to Delta), and post-spawning. The group suggested that large-scale study units, such as Suisun Marsh and Grizzly Bay, might be more appropriate for studying mobile adults than would smaller-scale units such as patches of tidal wetland.

The third discussion topic of Paul's group was spatial structure of the splittail population including the possibility of distinct genetic stocks, fidelity of individual spawners for the Sacramento versus San Joaquin rivers, and differential mortality among portions of the species' range during a given year. The group recognized that the potential existence of multiple genetic stocks had important management implications beyond the effects on population dynamics. In particular, individual stocks could be viewed as conservation-worthy, thereby placing additional demands on managers. Needed actions included 1) use genetic and isotopic markers to characterize

stock structure and 2) track individuals over multiple years to establish patterns of fidelity.

The fourth discussion topic of Paul's group was the integration of existing data into models of splittail distribution and abundance. The group suggested that more efficient use of available data, as well as more rigorous analysis, would be valuable. Needed actions included 1) critically evaluate (e.g, via correlation analyses) which data sets are suitable for use in population models, 2) apply multi-factor statistical tools (e.g., analysis of covariance, multiple linear regression) to analyses of relations between abundance and environmental factors, and 3) establish a splittail-specific monitoring program (perhaps using fyke traps and beach seines) to document spatiotemporal variation in abundance. The group recognized that the latter action would be constrained by measures imposed to protect co-occurring salmon.

Despite very different trains of thought, both discussion groups identified three high-priority topics: spawning habitat, adult mortality, and monitoring specifically for splittail. These topics should figure prominently in future research and management efforts.

After the breakout-group discussions, all workshop participants convened for a general discussion of splittail management/restoration. The relative effectiveness of opportunistic versus pro-active restoration was debated. Apparently, there is a role for both approaches in the Bay-Delta ecosystem. High-priority actions that were identified included restoring river-channel and floodplain habitats and restoring tidal salt marsh. These actions were believed likely to benefit splittail as well as other valued species.

Listing issues

Although the workshop was not convened to specifically address issues related to listing splittail under the Endangered Species Act, some of the discussion was germane. Below, we briefly relate workshop discussion and outcomes to six specific issues.

1) Species status

The degree of splittail imperilment was not discussed explicitly at the workshop. However, evidence indicates that the abundance of splittail is reduced relative to pre-European levels. The significance of the reduction remains debatable because abundance is inherently highly variable through time and most data available to index abundance were not collected for that purpose. Consequently, statistical power to detect real population trends in the past 30 years is low, thereby undermining confidence in *any* estimates of extinction risk based on abundance.

2) Population viability

Ted Foin's population model cannot currently assess viability, but it could probably be developed to do so. For such an analysis to be credible, however, considerable work needs to be done to provide empirical estimates of key parameters and empirical validation of key assumptions.

3) Selenium threat

Their diet and use of habitat in Suisun Bay apparently make splittail relatively vulnerable to selenium contamination. However, existing data are preliminary, and additional fish from additional life stages and geographic areas are needed to estimate the extent of contamination. Moreover, relations between contamination and the reproductive fitness of individual fish and between fitness and population dynamics need to be examined.

4) Relations among habitat, flow, and population

High-flow years seem to be necessary but not sufficient to produce large year-classes of splittail. The Foin model suggests that the population can be maintained through low-flow years by spawning that occurs in river channels (as opposed to floodplains). Although this hypothesis is based on many undocumented assertions, it probably should be tested. For model outcomes to be viewed as robust projections rather than testable hypotheses, more validation of model parameters and assumptions is needed. The model results also do not speak to the vulnerability of small populations to unexpected disasters, such as a pesticide spill, or to selenium effects on reproduction.

5) Pump effects

The pumps may incur significant direct mortality to splittail in certain years, and may also indirectly elevate mortality (e.g., via predation). Unfortunately, the sampling design is inadequate to provide an unambiguous assessment of pumping effects on the population. Consequently, the biological significance of entrainment, even the dramatic events, is highly debatable, especially when splittail populations are low. The Foin model may be able to shed light on this significance if model parameters are more rigorously defined.

6) Efficacy of restoration

Because floodplains provide critical spawning and nursery habitat to splittail, floodplain restoration is expected to enhance splittail persistence, especially if restoration occurs at floodplain elevations low enough to facilitate inundation during dry years. The pervasiveness of nonnative predators suggests an additional constraint on the ability of restoration actions to enhance splittail. In particular, the most effective actions may be those that improve edge habitat or otherwise enhance survival of migrating juvenile splittail. Improving edge habitat may often include reducing the extent of Egeria beds, which can limit splittail access to the channel edge and harbor nonnative fish predators. Other effective actions may include restoration of brackish tidal marshes, which are apparently key nursery areas.