Summary of proposed testimony on development of flow criteria for the Delta ecosystem necessary to protect public trust resources

Erica Fleishman, Ph.D.
Bren School of Environmental Science & Management
University of California, Santa Barbara
fleishman@bren.ucsb.edu • (805) 893-7352

About one percent of species listed under the U.S. Endangered Species Act have met recovery standards, generally understood as levels of abundance and reproduction at which the species can sustain itself without human intervention and protections of the Act no longer are necessary (Scott et al. 2005). Most listed species will, at best, require ongoing, species-specific management intervention to remain extant. The latter species, which likely include delta smelt (*Hypomesus transpacificus*), have been characterized as "conservation reliant" (Scott et al. 2005). Evidence suggests that longfin smelt (*Spirinchus thaleichthys*), striped bass (*Morone saxatilis*), and threadfin shad (*Dorosoma petenense*) in the San Francisco Estuary also are likely to require sustained management action to remain extant. Striped bass and threadfin shad are not native to the San Francisco Estuary, and therefore are not eligible for protection under the Endangered Species Act in that region. Nevertheless, striped bass supports a popular sport fishery, and threadfin shad is an important prey species for some native fishes. Therefore, striped bass and threadfin shad are of regional management concern.

Scott et al. (2005) identified five criteria to determine whether the abundance of a species may remain stable or increase over time if management actions of proven effectiveness are implemented and sustained. Demographic data (birth, death, emigration, and immigration rates) convey more information about probabilities of persistence and generally are preferable to data on abundance, but reliable time-series data on demographic variables rarely are available for species of concern.

1. Threats to the species' continued existence are known and treatable

2. Threats to the species are pervasive and recurrent

3. The threats render the species at risk of extinction, absent ongoing conservation management

4. Management actions sufficient to counter threats have been identified and can be implemented

5. Federal, state, or local governments—often in cooperation with private or tribal interests—are capable of carrying out the necessary management actions as long as necessary

Accordingly, determining whether a species may persist given ongoing management action first requires identification of major threats to its continued existence. Reduction in habitat quality is one of the most common and most substantial threats to persistence of imperiled species in the United States (Wilcove et al. 1998). Assessing habitat quality over time, in turn, requires that the concept of habitat be defined, components of habitat and drivers of those components identified, and the relation between habitat and individual or population-level measures of survival and reproduction quantified.

Concept of habitat. Habitat is the physical space within which an animal or plant lives and the abiotic and biotic resources in that space (Morrison and Hall 2005). Habitat is defined with respect to a given type of animal or plant; few if any species use resources in exactly the same way. The location, spatial extent, and quality of habitat for most species vary in time. The concept of habitat includes the assumption that resources are related in predictable ways to a where an animal or plant occurs and to its survival and reproduction, which in turn affects the viability of a population and the persistence of a species.

Drivers of habitat quality for delta smelt and other pelagic fishes. A team of experts recently identified a non-exhaustive set of 19 abiotic and biotic variables that reasonably were expected to directly or indirectly drive abundance of delta smelt, longfin smelt, age-0 striped bass, and threadfin shad and for which reliable data were available (Thomson et al. in press; also see Mac Nally et al. in press).

Some of the abiotic and biotic variables, like average summer water temperature, turbidity, and average biomass of multiple sources of prey, typically would be considered as components of habitat for aquatic species. Other variables, like the Pacific Decadal Oscillation Index, may affect abiotic and biotic components of habitat. The team also identified variables that may affect demography of declining pelagic fishes. For example, volume of water exported by the California State Water Project and Central Valley Project was expected to serve as a surrogate measure of entrainment of juvenile and adult smelt and juvenile striped bass (Mac Nally et al. in press). The relative influence of different abiotic and biotic variables on habitat quality for fishes (as for other taxonomic groups), and the relative association of such variables on abundances of fishes, varies among species and in space and time (Kimmerer 2009). These sources of variation have not been quantified empirically for most fishes in the San Francisco Estuary.

The team also noted the potential effect on abundance of declining pelagic fishes of the introduced clam *Corbula amurensis*, which ultimately reduces availability of prey (Alpine and Cloern 1992). In the team's informed opinion, contaminants (e.g., nutrients, metals, pesticides, and other chemicals present in the estuary) are too numerous and dispersed, and potential effects on abundance or fitness of declining pelagic fishes too poorly known, for analyses to provide useful correlative information (Thomson et al. in press).

Relation between abiotic and biotic variables and measures of survival and reproduction. Recent analyses (Thomson et al. in press) indicated sharp declines in abundance of delta smelt, longfin smelt, threadfin shad, and age-0 striped bass in the early 2000s. Abiotic variables including water clarity, position of the 2 psu (practical salinity units) isohaline (X2), and the volume of freshwater exported from the estuary explained some variation in species' abundances over the period of record, but no selected covariates could explain statistically the post-2000 change-points for delta smelt, longfin smelt, threadfin shad, and age-0 striped bass. A change-point is a point in time at which an abrupt change occurred in the functional relationship between the mean abundance of a species and time. A change-point may be either a step change, which is an abrupt change in abundance; a trend change, which is an abrupt change in the temporal trend in abundance; or both.

Potential ability of management actions to counter threats. Ability to evaluate whether management actions are likely to counter threats to persistence of declining pelagic fishes depends on both identification of threats and ability to counter those threats. There currently is no strong empirical evidence that abiotic and biotic components of habitat or drivers of abundance, including water clarity, X2, and the volume of freshwater exports, fully explain the so-called pelagic organism decline. Mac Nally et al. (in press) noted that before delta smelt, longfin smelt, threadfin shad, and striped bass declined abruptly in the early 2000s, abiotic drivers of their distribution in the San Francisco Estuary were represented mainly as X2 because position of the salinity field was associated with measures of resource availability and abundances of many organisms (Jassby et al. 1995). Several studies highlighted the importance of other abiotic variables, including water clarity and water temperatures, in the estuary (Feyrer et al. 2007, Nobriga and Feyrer 2008). It has been suggested that management actions are unlikely to sustain declining pelagic fishes in the absence of improved understanding of how water exports may interact with abiotic conditions and the food web (Mac Nally et al. in press).

There also is no strong empirical evidence that changes in water clarity, X2, and the volume of freshwater exports would have a high probability of stabilizing or reversing the decline. This does not mean there is no relation between these components or drivers of habitat and abundance of pelagic fishes. Instead, it means that in and of themselves, actions that affect these known components are unlikely to sustain pelagic fishes indefinitely.

Several feasible areas of future work might identify new or clarify currently understood components or drivers of habitat that are most strongly associated with abundance of pelagic fishes and that may be amenable to management. For example, Sommer et al. (2007) and Baxter et al. (2008) considered many hypotheses for declines in abundance, including changes in stock-recruitment relations and food webs, mortality from predation and water diversions, contaminants, and changes in the physical environment. Formal statistical methods (e.g., Green 1995) could be applied to existing data on attributes of habitat and abundances of fishes at different life-history stages to compare weights of evidence for the different hypotheses (Thomson et al. in press).

Many efforts have assumed that different abiotic and biotic attributes represent habitat for multiple species, then assumed that management of those attributes will benefit many species simultaneously (Hunter 2005). In theory, by emphasizing elements of the environment (for example, X2) or processes (for example, primary production) that provide resources for multiple species, the number of species that require individually tailored interventions may be reduced. But the effectiveness of this strategy relies on identificaton of environmental components that are critical to many species, and to predict the response of a high proportion of those species to perturbations in those key components.

Evidence is strong that long-term declines of delta smelt, longfin smelt, threadfin shad, and striped bass were caused in large part by human land uses that have altered California's ecosystems in irreversible ways. Given these circumstances, it is reasonable to assume that the species are at best conservation reliant. Science can help estimate probabilities that alternative management actions will result in certain biological responses. Nevertheless, determining the level of resources that should be allocated to management of species of concern ultimately is not a scientific decision by a societal decision (Scott et al. 2005).

Literature Cited

Alpine, A.E., and J.E. Cloern. 1992. Trophic interactions and direct physical effects control phytoplankton biomass and production in an estuary. Limnology and Oceanography 37:946–955.

Baxter, R., R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gingras, B. Herbold, A. Mueller-Solger, M. Nobriga, T. Sommer, and K. Souza. 2008. Pelagic organism decline progress report: 2007 synthesis of results. Interagency Ecological Program for the San Francisco Estuary, Technical Report 227.

Feyrer, F., M.L. Nobriga, and T.R. Sommer. 2007. Multi-decadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, U.S.A. Canadian Journal of Fisheries and Aquatic Sciences 64:723–734.

Green, P. 1995. Reversible jump Markov chain Monte Carlo computation and Bayesian model determination. Biometrika 82:711–732.

Hunter, M.L. 2005. A mesofilter conservation strategy to complement fine and coarse filters. Conservation Biology 19:1523–1739.

Jassby, A.D., W.J. Kimmerer, S.G. Monismith, C. Armor, J.E. Cloern, T.M. Powell, J.R. Schubel, and T.J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5:272–289.

Kimmerer, W.J., E.S. Gross, and M.L. MacWilliams. 2009. Is the response of estuarine nekton to freshwater flow in the San Francisco Estuary explained by variation in habitat volume? Estuaries and Coasts 32:375–389.

Mac Nally, R., E. Fleishman, J.R. Thomson, and D.S. Dobkin. 2008. Use of guilds for modeling avian responses to vegetation in the Intermountain West (U.S.A.). Global Ecology and Biogeography 17:758–769.

Mac Nally, R., J.R. Thomson, W.J. Kimmerer, F. Feyrer, K.B. Newman, A. Sih, W.A. Bennett, L.R. Brown, E. Fleishman, S.D. Culberson, and G. Castillo. In press. An analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modelling (MAR). Ecological Applications.

Morrison, M.L. and L.S. Hall. 2002. Standard terminology: toward a common language to advance ecological understanding and application. Pages 43–52 in J.M. Scott, P.J. Heglund, M.L. Morrison, J.B. Haufler, M.G. Raphael, W.A. Wall, and F.B. Samson. Predicting species occurrences: issues of accuracy and scale. Island Press, Washington, D.C.

Nobriga, M., and F. Feyrer. 2008. Diet composition in San Francisco Estuary striped bass: does trophic adaptability have its limits? Environmental Biology of Fishes 85:495–503.

Scott, J.M., D.D. Goble, J.A. Wiens, D.S. Wilcove, M. Bean, and T. Male. 2005. Recovery of imperiled species under the Endangered Species Act: the need for a new approach. Frontiers in Ecology and the Environment 3:383–389.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries 32:270–277.

Thomson, J.R., W.J. Kimmerer, L.R. Brown, K.B. Newman, R. Mac Nally, W.A. Bennett, F. Feyrer, and E. Fleishman. In press. Bayesian change-point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecological Applications.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience 8:607–615.