Review of the Bay Program by the Science Advisory Group of the Interagency Ecological Program, October 1999

Overview

The SAG appreciated the opportunity to study and learn about the IEP's Bay Program. We also appreciated the efforts of the Bay Program personnel in providing the data report and the first drafts of their white papers for the workshop. It is obvious that the Bay Program has collected an extremely impressive, comprehensive and high quality set of data on Bay fisheries and environmental factors that might influence those fisheries. We commend the dedication and professionalism of the Bay Program staff and the quality of their work. The field capabilities of this program are an extremely valuable state and national asset and should be preserved under all circumstances.

Comments and Recommendations

The SAG had several comments and recommendations for the IEP, with regard to the Bay Program.

I. Fisheries monitoring (both fish and macroinvertebrates) is an extremely important component of the IEP, and the monitoring throughout San Francisco Bay should be continued into the future. The geographical boundaries of the program should not be reduced in size. In fact, it would benefit interpretations to expand the boundaries to the mouth and the coastal plume of the Bay, if the opportunity for such expansion presented itself.

II. It is apparent that resources (both people and funding) have been diverted from the Bay program by competing demands for DFG expertise. This diversion of resources has been to the detriment of the program, through: (a) elimination of critical elements (e.g. sampling for larval stages of fishes), (b) redirection of staff, precluding the essential steps of data interpretation, and (c) reduction of total effort at monitoring fisheries resources in the San Francisco Bay estuary. Given the critical importance of reliable assessments of the status of living resources in the Bay, we recommend that IEP management consider a renewed commitment to the Bay program that: (a) provides continuity of resource allocation, even in the face of external pressures to redirect those resources; (b) re-instates some elements that have been eliminated, and (c) ensures sufficient staff time, with appropriate support, so that this invaluable data set can be analyzed, synthesized, published, and converted into the scientific information required for effective management of the Bay-Delta ecosystem.

III. The SAG identified 4 goals that have guided (or should guide) the Bay Program:

1. Identify trends in abundance indices for the major fishes (including macroinvertebrates) in the Bay.
2. Identify and characterize effects of freshwater flows on fish populations of the Bay.
3. Strive to understand causes of variation in fish populations; with emphasis on separating natural from anthropogenic causes of variation.
4. Use fish data to evaluate (and report to the public) the status of the Bay environment and trends in that status.

We suggest that Bay program formally adopt and publish these as their explicitly stated goals (or some minor modification of them). The goals should be consulted frequently to make sure the program is maintaining focus, and should provide the guideline whenever modifications of the program are considered.

IV. Data collection and enumeration of fishes has dominated the first 20 years of activity of the Bay Program. This monitoring must continue in a fashion comparable with the past. However, the program must also evolve. The SAG suggests two directions guide that evolution:

1. The resources that are expended for analysis and synthesis should be increased to better match the resources expended on sampling. It is the public responsibility of a mature program to expend a significant effort taking advantage of its historical data. Emphasis must increase on reporting, publishing and otherwise increasing the availability of the Program's data to all users (from the scientific community to the public). A primary guideline should be converting this high quality *data* to widely useful *information*.
2. The program should begin to evolve beyond description and enumeration toward explanation of the mechanisms behind the patterns that are observed.

The evolution of new directions does not mean that monitoring should end; nor does it mean that staff should simply be assigned those new directions on top of existing and collateral duties. It is the responsibility of the managers of the Bay Program to find a way to give priority to data analysis, interpretation and writing that is equal to the priority given data collection. Direct allocation of staff time, reducing diversionary assignments of Bay Program staff, and contracting are mechanism to reflect that priority. The nature of at least part of the on-going data collection and the programs accompanying the monitoring should become more mechanistically oriented and more explanatory. The visibility, usefulness and importance of the Bay Program will inevitably increase if the relationships observed from monitoring can be rigorously and convincingly explained, and if those explanations are widely published.

The suggested directions could partly be met by internal modifications of the Bay Program approach and budget. To that end, a careful analysis of the existing data should be undertaken to evaluate the effects of potential cost saving changes in the program on data quality and explanatory power. The SAG believes that IEP and CALFED must maintain and increase the budget of the Bay Program to insure that its important goals

and public responsibilities are met with respect to: for routine data collection by Bay Program as is necessary to facilitate the specific steps recommended below,

- moving some mechanistically oriented special studies into the permanently funded program,
- setting up a system and establishing a culture that will allow mentoring, collaborating and contracting between Bay Program staff and professionals, students and postdoctoral associates from outside the IEP.
- An evolution of the culture that includes growth of serious collaborations with contractors is the way to incorporate rigorous, specialized explanations and analysis. This evolution is necessary to fully meet the goal of converting the rich fisheries data of the Bay Program to information (i.e. it is not realistic to expect the Bay Program Staff to do this alone and/or while they are being assigned numerous other tasks).

Specific Recommendations for the Evolution of the New Directions

1. ***Shift focus of data interpretation to groups of species and the community, using representative species to understand the groups.*** The initial interpretations of Bay Program data involved descriptions of life history and enumeration of individual species, with some accompanying explanatory analysis. In the future interpretations should move toward an emphasis on striving to understand trophic guilds, major consumer groups, etc. "Community analysis" (description and analysis of interrelationships among species and among groups) should be an important part of such interpretations. In fact, a paper analyzing the overall changes in the Bay fish (and macroinvertebrate) community, as an entity, was an important point in our oral discussion. The focus of the Bay Program should be more than following trends of individual species--it is to "evaluate the status and trends of Bay resources and their wellbeing."

To help accomplish this goal, interpretative efforts might take advantage of what appear to be similarities in trends among certain species. Variations and trends of abundance within the pelagic planktivore guild, benthic feeders, or feeding guilds of shrimp may be sufficiently similar that trends in one species may be useful as representative of trends for the group. Monitoring should not be shifted to the representative species and species of special interest (this would save very little time or money). But interpretation, special studies and reporting to the scientific community could be focused on a limited number of species, each of which represents a critical group within the resource base. Thus, some species might be included on the "A" list for interpretation because they are represent a group. It would also be expected that other species might be included because the species itself is inherently of interest; i.e. they are potentially listed, have strong or peculiar environmental responses, are important fishery species, or for other suitable reasons. The goal is to provide a basis for expanding interpretations toward a more community-based approach, but doing so by narrowing the choices of species to be included in special studies and allocation of interpretive effort .

2. ***Immediately institute one project that signifies the beginning of the evolution toward synthesis and mechanism.*** The SAG suggests that the Bay Program immediately incorporate a program element designed to develop a population model to help explain the relationship between longfin smelt populations and freshwater flows. Model

development is explicitly suggested because models are the basis for hypothesis generation and then testing to expand knowledge of sensitive life stages or events in life history. The model should focus on *understanding* the causes of the patterns of variability and the mechanisms that control effects of (or links between) flow on population. Studies of sensitive life stages, early development and/or feeding ecology of the species would be important. Model development would involve looking at existing data (e.g. growth rates, biomass or condition) and conducting new studies on relationships and effects of salinity, temperature and feeding (perhaps even some study of contaminant effects). This could be a multi-faceted effort that greatly expands Randy Baxter's excellent analytical work to date. A thesis (or theses) might be solicited and developed by discussions between Randy B. and an established university fish population biologist (Bennett, Moyle or equivalent), to work on some of the specialized problem(s) associated with longfin life history that might explain sensitivities to flow. Longfin Smelt is a good choice for this effort because:

- it is a relevant, charismatic species (it was almost "listed");
- Randy B. has shown that its population index changes with flow, but the reasons for the relationship are not known;
- The relation to flow is changing but the cause of that change is unknown.

This should begin as a single, clearly defined effort. But the SAG hopes this will be a pilot program that will lead to a series of studies of fish (and macroinvertebrates) whose abundances show the strongest statistical relationships with flow (or studies that contrast species/groups related and unrelated to flow). The emphasis of these programs should be on identifying patterns and understanding why animal abundances respond to flow. The programs should all involve consideration of interactions among species (include predator-prey relationships and feeding relationships), as well as direct influences of environmental factors. These mechanistic efforts will require additional funding for the Bay Program from IEP or from CALFED; but they will ultimately greatly strengthen the usefulness and the justification for the program.

3. An effort that monitors fish larvae needs to be added back to the program.
There are two reasons that monitoring of fish larvae is important to IEP. First, if fish populations are linked to flow it is quite likely that link is going to involve larvae. Even connections between flow and adult fish are linked via larvae. The program is developing a sophisticated view of the effects of hydrodynamics upon fishes in the Bay. But it is not sampling the biological element most affected by hydrodynamics (larvae). The program is calculating physical indices designed to evaluate effects of flow changes (most directly on larvae), but the program is not sampling larvae. These are major disconnects in goals that need to be corrected. It is probably necessary to expand finances to include monitoring of fish larvae. This should be done.

Finally, important feeding relationships and interactions among species are manifested through the zooplankton as a whole. However, a full sampling, identification and analysis of the zooplankton could be onerous in its requirements. The SAG is not recommending that IEP should undertake its own full zooplankton component. However, the program may be able to find ways to interact with other programs to obtain data on

zooplankton, or components of the zooplankton beyond larval fish, for use in interpretations.

4. Interaction of hydrodynamics and biology.

IEP Managers should not have unrealistic expectations from a three-dimensional hydrodynamic model in the immediate term. The next critical step in the development of this model is its application to describe the distribution of salt (as a conservative tracer and as a dynamic quantity that influences the density field and nontidal circulation). It is premature to consider applications of the 3D hydrodynamic model to predict/describe transports of particles (such as larval stages of fishes) until this model has been refined to describe the transport of salt. As this next phase of model development proceeds, the IEP management should consider a parallel effort to use direct measurements of currents and circulation to identify the linkages between transport processes and population dynamics of key species. This effort will require new initiatives to connect, explicitly, the hydrodynamic components of IEP with the Bay program. As an example, the USGS hydrodynamic program in Grizzly Bay could be used as a model for establishing biologically-relevant physical measurements in the critical habitats of San Pablo Bay and Central Bay. Members of the SAG believe that success in the application of hydrodynamic measurements and simulations to understand the physical bases of population dynamics will require several IEP commitments to: (1) support a dedicated person (or team) having the responsibility of integrating results from the 3D model and the Bay monitoring program; (2) design a coherent program that integrates hydrodynamic model development and measurements and (3) collect biological data appropriate to identified hypotheses concerning modes of physical biological coupling, i.e. data that would allow analysis of how flow variability affects egg/larval fish/plankton transport.

5. Additional analytical approaches will aid in developing mechanistic explanations using existing data.

One of the highest priority immediate analytical needs is to expand the use of size data to estimate growth from length frequency (R. Baxter's use of data in this way is good example). Growth is the easiest mechanistic process to infer from existing data. A focus could be on understanding annual variability in growth rates and how this variability relates to controlling factors. Estimates of indices of production can be developed from existing data on relative abundance, relative biomass and growth rates. This is a low cost endeavor that could yield great benefits.

The program should also begin to employ visualization software, PCA analyses (to explain commonalities and interactions among species) and other modern tools to approach the questions raised by the initial enumeration of trends and patterns. For example, PCA should be initiated to separate patterns in time and space, possible interspecific interactions among co-occurring species of fishes and shellfishes and correlations with environmental factors. As another example, the SURFER software package has been used in the Chesapeake Bay to effectively show contoured abundances and to illustrate annual and seasonal changes in abundance and biomass distributions.

Explanations, explanatory statistics and explanatory graphics will be necessary in some of the papers for them to be suitable for peer-reviewed publication .

Secondary or more Detailed Issues.

- A rationalization of the existing program design might be undertaken as a way to prepare for the evolution of the program. For example, a group might address the question: are existing stations representative? This could be determined from existing data by evaluating variability among stations within a region. It might also be considered to analyze data by depth or other aggregation procedures to evaluate whether stations are representative of one another. There might also be opportunities to work side by side with EMAP in such evaluations?
- The Bay study should explore alternative ways of calculating abundance indices to account for the extreme skewness of the raw data. This might include, for example, the use of geometric means or measures of central tendency based on alternative statistical descriptions (e.g., see paper by Pennington M. 1996, Estimating the mean and variance from highly skewed marine data. *Fishery Bulletin, U.S.* 94:498-505). The objective should be to reduce within-year variance, thereby potentially increasing the explanatory power of environmental factors or trends.
- The scope of factors considered in interpretations might be broadened.
  i.) A regional perspective should be considered in interpretations, where data are available (Is SF Bay different from other areas in the region with regard to a specific trend?)
  ii.) What are trends in fish outside the Bay? What are Bay effects and what effects are west-coastwide? This question might be especially important to understand for perch.
  iii.) How do broad interactions with predators or other species affect trends.
  iv.) A more thorough use of other Bay data sets might be advantageous.
- Analysis of existing data involves dealing with a number of sophisticated statistical problems. It is the experience of the SAG that the best type of person to consult and collaborate in such circumstances is someone with extensive experience studying complicated data sets or monitoring data. Such professionals typically have knowledge of the applications of statistics and models that go beyond the typical biometrician.
- Data from the literature might be used or proposals might be solicited for experimental studies on responses of key species to salinity, temperature or other variables, to accompany monitoring data. Eventually, iteration between experiment (contracted and special studies) and monitoring should become the paradigm of the ecological studies of IEP.
- Opportunities exist to immediately formulate publishable journal papers. A paper describing changes in the Bay community of fishes could have very broad interest (long-term and interannual trends and changes in the community in time and space). This should include data from other IEP/F&G programs, including striped bass, delta smelt, sturgeon and salmon as well as analyses of all species collected by the Bay program, including those that are rare. This is an instance where PCA analysis might be used to try to quantify justification of the categories that observations suggest differentiate different groups of fishes.
- The Bay program should begin determining jellyfish biovolume in routine sampling program (displacement). Important questions are being raised globally about shifts

from fish to jellyfish. It is important to start understanding that relationship in San Francisco Bay.

- The program should recognize that trawling in the daytime is probably dramatically underestimating catches. Relative abundance for the common species is probably reasonable from to obtain from day trawling, but uncommon species may be poorly estimated. If it is necessary to determine abundance or biomass the effects of the day trawling must be analyzed or determined. The SAG recognizes that routine night trawling may not be feasible in a long-term monitoring program, but special studies could be solicited to analyze this factor.