RECOMMENDATIONS REGARDING COMPREHENSIVE AQUATIC MONITORING IN THE SACRAMENTO-SAN JOAQUIN ESTUARY AND ITS TRIBUTARIES

Results of a Workshop on August 5-7, 1996 Marconi Conference Center, Marshall, California

Compiled by
Patrick Coulston, Program Manager
Interagency Ecological Program

Technical Report 58

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Interagency Ecological Program for the San Francisco Bay/Delta Estuary

A Cooperative Program of:

California Department of Water Resources
State Water Resources Control Board
U.S. Bureau of Reclamation
U.S. Army Corps of Engineers
California Department of Fish and Game
U.S. Fish and Wildlife Service
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U.S. Environmental Protection Agency
National Marine Fisheries Service

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Summary

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Gabriele Marek of the San Francisco Estuary Institute, for assisting with arrangements with the Marconi Conference Center;

Jim Cloern, Chris Foe, Steve Ford, Wim Kimmerer, Sharon Kramer, Terry Mills, and Leo Winternitz for contributing individual elements of the "Implementation" section of this report.

Finally, I wish to thank all the participants, listed on the cover page, who prepared themselves for the workshop, gave three days of their valuable time, and contributed many excellent ideas to further the goal of better, more comprehensive aquatic monitoring of the Sacramento-San Joaquin estuary and its tributaries.

Introduction

The Sacramento-San Joaquin estuary and its tributaries form an aquatic system for which there is no distinct, comprehensive aquatic monitoring program to support decision making by the system's managers and regulators and to inform the public about the system's condition. Rather, the system is monitored by a diverse set of academic, private sector, agency, and interagency monitoring programs — each with its own limited scope and objectives.

In recent years more and more emphasis has been placed on a comprehensive approach to solving the ecological problems of the system, including the San Francisco Estuary Project, the Central Valley Project Improvement Act, and the CALFED Bay/Delta Program. As part of these restoration programs, and coincident with them, there have been increasing efforts to expand, coordinate, and integrate monitoring programs, including

- Establishment of the San Francisco Estuary Institute,
- Development of a Memorandum of Understanding between San Francisco Estuary Institute and the Interagency Ecological Program,
- Establishment of the IEP's Central Valley Salmon Project Work Team,
- Development of the CVPIA's Comprehensive Assessment and Monitoring Program (CAMP).

There is a high probability that aquatic monitoring in the system will continue to be accomplished by a large number of entities. However, it has become critically important that the collective activities of those entities provide an adequately comprehensive data set to use in defining conditions of the aquatic system.

In its work plan for 1996, the Interagency Ecological Program included efforts to promote more comprehensive monitoring of the system. The specific goal was to examine current aquatic monitoring efforts in the system, identify significant gaps in those collective efforts, and report these findings internally and to other monitoring entities for use in future planning. Toward this goal, the Interagency Program conducted a workshop on August 5-7, 1996. This report summarizes the findings of that workshop.

Workshop Process

The fundamental objective of the August 5-7, 1996, workshop was to identify key deficiencies in aquatic monitoring of the system. To accomplish this, it was important to invite those who have a detailed understanding of the system's monitoring information needs and of current monitoring programs. It was also important to establish a clear definition of the subject of the workshop. Before the workshop, its subject was referred to as "community monitoring", a term brought forward from discussions with IEP stakeholders during the planning of Interagency Program's 1996 activities. With input from participants, "community monitoring" was defined as:

> "An ecosystem-wide, long-term, routine sampling program that monitors the abundance and distribution of commercially, recreationally and ecologically important estuarine and aquatic organisms, and appropriate environmental variables, with sufficient accuracy, precision, and time scales to identify and interpret status and trends in important biological resources and ecosystem structure and function."

Among the first topics discussed at the workshop was the aptness of the term "community monitoring". The group agreed that for several reasons the term was confusing and that "comprehensive aquatic monitoring" would better fit the definition. The term "community" is used ambiguously by ecologists to mean either the biotic portion of an ecosystem (textbook definition) or the collection of populations with similar taxonomic affinities or vulnerability to sampling gear (*eg,* "copepod community" or "benthic community"; *ie,* an operational definition). Sampling for more than one species or other variable usually involves a compromise in gear, timing, frequency, or location, such that concurrent sampling for a wide variety of variables is neither necessary nor desirable. Temporal and spatial variability in the ecosystem could be depicted adequately by combining results of numerous individual sampling efforts.

It was also necessary early in the workshop to determine how to address research and special study efforts associated with system monitoring. Although the subject of the workshop was "routine" monitoring, research and special studies play an important role in monitoring the system by:

- Identifying key components of the ecosystem to monitor,
- Developing effective monitoring methods, and
- Explaining important trends observed through monitoring.

It was resolved that routine monitoring would remain the focus of the workshop, but that key special studies identified during workshop discussion would be noted.

Another decision made early in the workshop was to <u>not</u> arbitrarily set limits on the geographical area to be discussed. The aquatic area between the major dams and the Golden Gate was to be the area of primary focus, but it was agreed that we should identify and discuss information from outside that area required to address issues relating to resources living within that area.

The workshop was conducted in six phases.

- <u>Orientation</u>: Participants were introduced and the workshop topic and format were clarified.
- <u>Listing and discussion of specific monitoring needs and techniques</u>: Participants presented specific ideas on specific monitoring needs focusing on "unmet" needs. To facilitate this phase, each participant was asked to come to the workshop prepared to present (in 5 minutes, or so) at least one monitoring need (or suite of similar needs), associated techniques, and the

type and amount of data required to respond adequately to the need.

- Categorizing proposed monitoring efforts: Identified specific monitoring needs were divided into three categories developed at the workshop:
  Physical Habitat, Non-Fish Biota, Contaminants and Water Quality
  Estuarine Fisheries Resources
  Riverine Fishes and Salmonids
- Fleshing out monitoring categories in breakout groups: Breakout groups were established to discuss each category and flesh-out any unmet needs in each category. The breakout groups then come back together to present their findings for overall group discussion.
- Developing approaches to implementation: The first part of the last morning was devoted to the subject of "comprehensive monitoring" implementation. The discussion included opportunities for collaboration and integration, priorities for implementing components of a program, and potential funding difficulties and opportunities.
- Recommending monitoring priorities: The end of the last morning was devoted to identifying a few unmet monitoring needs that some or all of the participants thought were a high priority for near-term implementation. Brief implementation plans developed for each of these are presented later in this report.

Recommendations

During the first two days of the workshop, many ideas were presented and discussed relating to the goal of more effective and comprehensive monitoring. These ideas were recorded, and Appendix B of this report is a raw list of them. On the morning of the third day, the group addressed which of the many monitoring improvement ideas were most in need of implementation. Eight high priority monitoring improvement concepts were identified, and an implementation strategy was developed for each. The eight concepts are listed below and the implementation strategy for each described in the following section of this report.

It would not be correct to characterize the eight concepts listed below as the consensus on highest priority monitoring improvement needs because the group did not "vote" on the eight, and there was no systematic effort to sort through all the possible improvement concepts and narrow the field to these eight concepts. The list is better characterized as eight monitoring improvement concepts that the assembled experts generally felt were important to propose for implementation at this time. The "raw" list in Appendix B is presented, so that others can review all the ideas and consider them for implementation. The eight priority concepts are divided into two categories, global and specific.

Global Concepts

1 Implementation of a systematic monitoring program sampling design review process.

Resources will never be sufficient to support all the monitoring and research that IEP member agencies and stakeholders might want to do. Also, ecosystem information needs are constantly changing. To properly allocate limited resources in a dynamic management setting, an ongoing, systematic process of program element design review is needed. This review process should examine the power (detection limits) and relevance of all IEP program monitoring elements relative to current management issues on a regular cycle and recommend an optimal allocation of sampling resources.

2 Evaluation of the "representativeness" of sampling by current and future monitoring.

Information provided by monitoring programs should accurately represent species abundance and distribution patterns in space and time. Since virtually all ecosystem sampling methods have biases, these biases must be understood and documented. Existing and new monitoring programs should be designed to provide adequate information on distribution and abundance patterns in time and space for key species and life stages. This assessment should include consideration of spatial bias (*ie,* lack of sampling in shallow water habitats) and temporal bias (tidal, diurnal), and should also evaluate gear efficiency. Gear evaluations should be included in metadata files to provide users with information on potential gear bias. All new programs should be developed with an understanding of gear efficiency and sampling representativeness. New monitoring elements should focus on gaps in knowledge, including incomplete information on species assemblages, shallow water sampling, and the effectiveness of restoration efforts under CALFED. Introductions of new species and the resultant effects of

species assemblages should also be closely monitored.

3 Appropriate integration of the system's existing and future monitoring.

Optimal use of the resources supporting bay/delta ecosystem monitoring requires integration of monitoring efforts by the various agencies and programs to avoid problems such as duplication of sampling and incompatibility of data. A systematic review of current monitoring activities (by IEP and others) should be undertaken to determine how individual monitoring efforts can be integrated to provide more useful information at a lower cost, freeing resources for use in addressing information gaps.

4 Development and implementation of a systemwide basic water quality monitoring program.

Although a number of programs in the estuary and tributaries routinely collect basic water quality information (temperature, salinity, turbidity, *etc*), the programs are not integrated and collectively do not provide complete system coverage. This represents a fundamental flaw in system monitoring that ought to be addressed.

5 Comprehensive analysis of existing aquatic monitoring data.

Existing monitoring programs have generated a large amount of data that, for the most part, has not been subjected to a comprehensive, integrated analysis. In general, monitoring programs are initiated and conducted for fairly narrow objectives, and the resulting data are analyzed independently by investigators focused on those individual objectives. A distinct effort to do a comprehensive, integrated analysis of existing data has an excellent chance of providing partial or complete answers to some of the questions being asked about the condition and function of the estuary.

Specific Concepts

6 Development and implementation of a comprehensive coded-wire-tagging and tag recovery program for Sacramento and San Joaquin River drainage salmon and steelhead hatcheries.

The effective protection and management of Central Valley Salmon stocks is substantially hindered by the inability to distinguish between stocks at various points in their life history. For example, accurate harvest rate estimates cannot be made for some stocks because too few tags are returned from the fishery. Expanding CWT tagging programs at Central Valley hatcheries and associated recovery efforts is one, very feasible, way to greatly improve this situation.

7 Implementation of an adequately supported, comprehensive, effects-oriented monitoring program for aquatic toxins.

Recent reviews of existing bay/delta toxicity sampling programs indicate that contaminant concentrations are high enough to influence population dynamics of some species. Support for toxicity sampling is inadequate to provide for a clear understanding of contaminant effects and , in some cases, funding is in danger of being lost. A comprehensive toxicity monitoring and toxicity effects research program should be developed and supported.

8 Development and Implementation of a systemwide monitoring program for fish health and condition.

There is evidence that contaminants are affecting fish health and survival in the bay and delta. Sampling for contaminants in fish flesh and organs, water, and sediments is costly, but it could be augmented by field and laboratory visual examination for health anomalies (*eg*, presence of tu-

mors) in fish collected during routine monitoring. The IEP Contaminant Effects Project Work Team should design a program and protocols for including these fish health assessments in routine sampling efforts.

Implementation of High Priority Recommendations

This chapter discusses the eight high priority ideas for monitoring improvement. The discussions are patterned, each having a statement of the question addressed by the type of monitoring, some background information on the issue, a rationale for the improvement suggested, and recommended actions for implementing the improvement.

Systematic Monitoring Design Review Process

Question: How should resources be allocated among programs and how should effort be allocated within programs to determine number of stations, frequency, and number of samples?

Background and Rationale

The importance of this component transcends efforts sponsored through the Interagency Ecological Program and should apply to virtually all aquatic habitat and species monitoring. This component gives us the opportunity to critically review recent and existing monitoring programs and to judge or reevaluate their need, efficiency, success, reliability, and utility for management purposes.

We are moving into a critical period of implementing large-scale and expensive habitat restoration and species recovery programs. We expend to spend well over a billion dollars in the next 10 years to improve the ecological health of the bay/delta system. The magnitude of that expenditure intensifies our need to understand the status of habitats, ecological processes, and species status and to be reasonably confident in the recommendations to management stemming for research and monitoring.

Existing monitoring programs need to be dissected, discussed, and improved. We believe many monitoring programs are insufficient, under-staffed, under-funded, or unnecessary. We need to clearly identify the type of ecological information we will need to successfully restore and maintain ecological health of the aquatic system.

To design an optimum monitoring program, one would conduct pilot studies to establish the variability in the thing being monitored, then conduct power or correspondence or similar analyses to determine the sampling frequency and density needed to answer the question being asked. In the case of most IEP monitoring, that question is something like: what is the temporal and spatial pattern of variable x? In that case, some limits of detection of temporal and spatial trends need to be established, *eg*, a 25% change in annual mean of variable x should be detected 90% of the time at the 95% confidence level.

Limits of detection should be based on management needs, but it is unlikely that the comprehensive monitoring program can arrive at a rational way to set those limits for all variables measured at the level that provides for the most cost-effective monitoring. Therefore, a practical method for allocating effort is outlined below.

Since resources will never be sufficient to support all the monitoring that IEP members might want, some method of setting the effort for each program element needs to be established.

Recommended Actions

- For existing monitoring program elements, establish a review cycle to examine results and reevaluate the sampling design.
- As part of this review and in any proposal for new monitoring, include a statistical power analysis that predicts detection limits for the level of change in the variables being measured. The sampling design should include an estimate of sampling cost and a description of the analytical method and other inputs used to set the number of stations, frequency of sampling, and number of replicates if any. This analysis needs to be presented clearly and explicitly. Qualified statisticians should participate in the design reviews.
- Where the monitoring program already exists or where it is set up to be integrated with an existing program, a clear discussion should be presented of the merits of maintaining continuity versus improving the design of the program. This discussion should include a description of what has been learned that would be lost if the program were altered.

Special Studies

- New monitoring programs will need pilot studies of about 2 years' duration to provide the information necessary to conduct the above analyses.

Evaluation of the "Representativeness" of Current and Future Monitoring Efforts

Question: Do current monitoring programs provide sufficient information to accurately represent temporal and spatial variability of species distribution and abundance?

Background and Rationale

It is important to assess whether the information provided by monitoring programs accurately represents species abundance and distribution patterns in space and time. Monitoring programs provide basic information on species distribution and abundance that is used to make management decisions; thus it is important to assess if the information provided by these programs is representative. Information needs include efficiency and bias of gear used to sample organisms, adequacy of sampling in key habitats used by species, and adequacy of sampling at appropriate temporal scales (*eg*, accounting for diurnal or tidal behaviors).

Because monitoring costs are high, we need to maximize sampling efficiency, accuracy, and precision in both long-term and new monitoring efforts. Management decisions should be based on monitoring data that is representative of the species and life stages of concern.

Recommended Actions

- Assess whether existing and new monitoring the programs provide adequate information on distribution and abundance patterns in time and space for key species and life stages. This assessment must include consideration of spatial bias (*ie*, lack of sampling in shallow water habitats)and temporal bias (tidal, diurnal), and should evaluate gear efficiency.
- Gear evaluation should be included in metadata files to provide users with information on potential gear bias. New programs, in particular, should be developed with an understanding of gear efficiency and sampling representativeness.
- New monitoring should address gaps in knowledge, including incomplete informa-

tion on species assemblages (*eg*, demersal sampling on sturgeon and crayfish; shallow water sampling). Monitoring should provide high-quality, cost-effective information on the effects of restoration efforts under CALFED. Introductions of new species and the impacts on species assemblages should also be monitored closely.

Special Studies

- A pilot study to assess gear efficiency and representativeness for development of a monitoring program of species assemblages in shallow water habitats.

Integration of Monitoring Components

Question: How can existing and new monitoring be better integrated to assure we are getting the best information for the management of the estuary in the most cost effective manner?

Background and Rationale

The Interagency Ecological Program and similar programs spend millions of dollars each year to monitor the bay/delta estuary. Monitoring elements are periodically added, deleted, or modified and are implemented and carried out by several agencies. IEP monitoring elements are overseen by several project work teams.

Users of the monitoring data have encountered problems where spatial and/or temporal differences in monitoring elements have impaired the use of two or more data sets to answer important management questions. For example, toxicity and *Neomysis* abundance are not monitored at the same sample sites, making it difficult to identify potential relationships between the two. Such problems may be encountered more often when using data from different monitoring elements and programs or from elements carried out by different agencies. A more coordinated, synoptic approach might be appropriate.

Several groups are sometimes monitoring different things at the same or nearby sampling sites. The Interagency Program and other programs should see if we can collect the same information more cost effectively by better coordinating activities (for example, should toxicity and *Neomysis* be monitored at the same site by the same boat).

We need to assure ourselves and others that the monitoring data are as useful as possible and that they are obtained in a cost-effective manner. Funds saved by making existing programs more efficient might be used to expand monitoring to fill information gaps. Also, more useful information and evidence that existing activities are cost effective should aid in getting additional funding to fill monitoring gaps.

Recommended Actions

- Undertake a comprehensive review to determine if and how monitoring programs should be integrated to provide more useful information. Recently the Compliance Monitoring and Salmon work teams have significantly improved integration of their activities with those of other programs. Such efforts should be broadened to include the Interagency Program's other monitoring elements and activities of other programs. A process should be established to repeat such a comprehensive review periodically (possibly every 5 years).
- As part of the revision approval process, proposed changes to the scope of existing monitoring should also be evaluated specifically to assess the degree to which such changes can be integrated with other monitoring, both within elements and across elements and programs.

Systemwide Basic Water Quality Monitoring Program

Question: What is the general condition of water quality in the estuary?

Background and Rationale

Measurement of basic water quality variables is essential for interpreting almost any sampling data from the estuary and is, therefore, an essential component of any comprehensive monitoring effort. We need data from sampling locations for fish and other variables of interest. We also need more general space and time descriptions of the variation in the responses of the water quality variables.

The basic water quality variables are:

Salinity — Descriptor of habitat, key physiological and ecological variable, indicator or tracer of mixing and water movement.

Temperature — Key physiological variable. Critical determinant of habitat suitability in tributaries.

Turbidity — Limits primary production, may be important in visual predation, and required to detect position of turbidity maximum.

Suspended Sediment — Sources and transport of sediment through estuary, which effects basic system productivity.

Oxygen — Indicates net metabolism, low values indicate problems.

Recommended Actions

- Immediately establish a small group of investigators (Leo Winternitz, Larry Smith and Jim Cloern volunteered to lead this effort) to review the current coverage of general water quality monitoring and develop specific recommendations for enhancement, including recommended sampling responsibilities and funding sources.
- Continue and expand the continuous monitoring station program to better assess temporal variability in the system, including a variety of channel and shoal stations throughout the estuary, particularly shoals of major subembayments (South, San Pablo, Suisun bays) and several additional stations (T, turbidity, flow) in tributaries.
- Continue and expand CTD profiles or samples to improve assessment of spatial variability. Ensure that all monitoring program elements use calibrated CTDs for determining water quality at their sampling stations, channel and shoal stations.
- Establish a team to produce and distribute integrated analyses and reports (maps, contour plots, and time series plots) of the water quality variables an annual basis and to make sure there is an analysis plan for the data, especially for the CTD samplers, which generate large amounts of data. Establish a centralized database for storage and retrieval.

Special Studies

- Determine the grid for continuous monitoring and establish protocols for data analysis and presentation.

Comprehensive, Integrated Analysis of Data from Existing Monitoring Programs

The approach suggested here has the potential to answer many questions about the system's aquatic resources and functions.

Background and Rationale

Existing monitoring programs have generated a large amount of data, which for the most part has not been subjected to a comprehensive, integrated analysis. A distinct effort to do a comprehensive, integrated analysis of existing monitoring data has an excellent chance of providing partial or complete answers to some of the questions being asked about the condition and function of the estuary. Because monitoring personnel are generally committed full-time to their specific program needs, bringing in new resources and people to facilitate this comprehensive, integrated analytical approach would greatly improve its prospects for success.

Recommended Actions

- Seek interagency support (*ie*, agreement to cooperate with and help fund) to hire independent scientists for a 5-year period (beginning around January 1, 1997) to work with existing monitoring staff to identify high priority "comprehensive" questions that can be addressed by existing monitoring data and work with agency staff to facilitate completion and reporting of that analysis, preferably in refereed journals.
- Establish an interagency "steering committee" to guide the efforts of the independent scientists and ensure agency staff involvement and support of analytical and reporting efforts. Alternatively, use the steering committee to identify analysis that needs to be done and coordinate agency staff, or let RFPs, to accomplish the analysis.

Special Studies

- The proposed effort will generate many important, specific hypotheses that should be tested by special studies.

Comprehensive Coded-Wire Tagging Program for Chinook Salmon

Questions: How can we assess the contribution of hatchery stocks to ocean and inland fisheries, spawning escapements, and hatchery returns? How can we distinguish between hatchery and naturally produced chinook stocks at the population level? How can we assess long-term changes and improvement in Central Valley aquatic habitats? How can we identify individual fish as to hatchery of origin? How can we assess progress toward meeting state and federally mandated goals of doubling salmon populations?

Background and Rationale

Management and restoration of Central Valley chinook salmon populations should be based on the best available scientific data regarding life history, survival, and return. One the best sources of science-based facts is a comprehensive coded-wire tagging and recovery program for hatchery produced chinook salmon. Such a program can be designed to provide useful data that meets expected levels of precision and accuracy. A comprehensive CWT program has never been implemented in the Central Valley, although tags have been applied to some representative or experimental groups every year since 1972. A comprehensive CWT program for Central Valley chinook salmon will provide the long-term data necessary to evaluate cohort-based (year class) salmon survival and return rates.

A carefully planned tagging and recovery program should sample at least 20% of ocean sport and recreational landings, 20% of inland harvest, 100% of hatchery returns, and 20% of naturally spawned adults.

Alternatives to marking representative samples of all hatchery chinook release groups such as marking large numbers or all hatchery produced chinook salmon are too expensive or may be infeasible. Marking but not applying tags to all hatchery produced fish would eliminate the ability to distinguish between stocks and between cohorts.

An *ad hoc* interagency coded-wire tagging group is developing recommendations for a comprehensive Central Valley coded-wire tagging program. This group has several issues to address: (1) the comprehensive hatchery CWT program, (2) recommendations on marking all hatchery fish, (3) recommendations for experimental studies and release group, and (4) development of a CWT program for naturally produced chinook stock.

Because of the cost to apply and recover tags, the interagency group advocates development and implementation of a first phase, which would include tagging representatives of all 15 release strategies for chinook salmon produced in Central Valley hatcheries.

It is generally believed that most of the cost to implement this comprehensive program will be covered by existing programs and funding sources and augmented by the CVPIA's Comprehensive Assessment and Monitoring Program. Additional funding may be available from water agencies that support hatchery operations, such as the Department of Water Resources (Feather River Hatchery) and East Bay Municipal Utilities District (Mokelumne River Hatchery).

Recommended Actions

The CWT program has four broad components: CWT application, harvest recoveries, spawning stock recoveries, and hatchery recoveries. This comprehensive CWT program includes the following program elements:

- CWT application at Coleman National Fish Hatchery (USFWS/CAMP)
- CWT application at Feather River Hatchery (DWR/DFG/CAMP)
- CWT application at Nimbus Hatchery (DFG/CAMP)
- CWT application at Mokelumne River Hatchery (DFG/EBMUD/CAMP)
- CWT application at Merced River Hatchery (DFG/CAMP)
- CWT recovery from ocean commercial fisheries (coastwide) (DFG)
- CWT recovery from ocean recreational fisheries (coastwide) (DFG)
- CWT recovery from inland sport fisheries (DFG/CAMP)
- CWT recovery from naturally spawning stocks (individual watersheds) (DFG/CAMP)
- CWT recovery from each hatchery (USFWS/DFG)
- Implementation of a centralized interagency CWT processing laboratory (DFG/USFWS)

CWT application and recovery are long-term efforts, and analysis of individual cohorts requires at least 4-6 years to complete the coastwide and inland recovery of tags and summarize the data. In addition to tag application, recovery efforts, including staff and equipment, need to be increased for all program elements. Some elements exist but need varying levels of augmentation; other program elements need to be established.

Toxicity Monitoring

Background and Rationale

The bay/delta system has several toxicity sampling programs, including the SFEI Regional Monitoring Program, the USGS NAWQA and San Francisco Bay Program, the Department of Pesticide Regulation TSMP, and others. The Central Valley Regional Water Quality Control Board has been conducting a surface water bioassay monitoring program in the Central Valley and delta since 1988 using the EPA three-species bioassay protocol. The test is considered a screen for possible instream impacts with the three test organisms being surrogates for local species. Follow-up studies were undertaken when toxicity was identified to determine the chemicals and their sources. The results have recently been reviewed by Bailey *et al* (1995), Fox (1996), Foe (1995), and Bennett (1996). Three of the four reviews have concluded that contaminant concentrations appear sufficiently elevated to influence population dynamics of sensitive local species. Toxicity monitoring needs to be continued, expanded, and integrated.

Past Regional Board monitoring has been funded primarily by the Bay Protection Toxic Cleanup and State Board Surveillance and Monitoring programs. Both programs are likely to terminate this year, and so will the Regional Board's monitoring effort.

Recommended Actions

Workshop participants had two recommendations for the IEP Coordinators.

- A letter should be sent from the Directors of the nine agencies to CALFED, CAL EPA, MET, and CUWA, emphasizing the importance of continuing the toxicity testing program and of regulating contaminants that are present in surface water at concentrations likely to impact local organisms.
- The IEP Contaminant Effects Project Work Team should be directed to draft a long-

term contaminant and contaminant effects monitoring program for review by the IEP Science Advisory Group. The program should emphasize an evaluation of contaminant impacts on populations of local organisms and an identification of chemicals causing the toxicity and their sources.

Water Quality Associated Fish Condition Index

Question: Is toxicity in ambient waters of the estuary affecting the health and survival of pre-juvenile and juvenile stages of local species?

Background and Rationale

Evidence suggests that toxicity in ambient waters of the estuary may be affecting local fish populations. This evidence includes correlations with pesticide applications and abundance indices, bioassay with EPA test species, and laboratory histopathological work on field-caught specimens.

Sampling for contaminants in fish flesh and organs, water, and sediments is usually costly. Studies to determine potential effects at the genetic or molecular level (bioindicators) is also costly. A less costly, easily performed approach that provides a consistent indicator of fish health is recommended here.

A Fish Condition Index (can also be called a Health Assessment Index) is a field necropsy method that provides a health profile of fish based on the incidence of anomalies observed in the tissues and organs of individuals sampled from the population (Bevelhimer 1996; Adams 1993). The assessment includes internal and external visual examination for tumors, discoloration, hemorrhages, and other aberrations. It may also include simple blood measurements (*eg*, hematocrit, leukocrit, and plasma protein). This method can be used to detect gross changes in the health of fish populations and can be performed annually to develop a dataset for long-term monitoring.

Recommended Actions

- The Contaminant Effects Project Work Team, in cooperation with the Estuarine Monitoring Project Work Team, should be responsible for developing a protocol for this work and developing a proposal for implementation.
- As part of the protocol/proposal development, the teams should review prior health work on striped bass and assess the value and expense of any similar nationwide work being done by others.
- Sub-samples of fish collected in current IEP sampling programs should be subject to health/condition investigations as conceptually described above.
- Sub-samples of fish collected in current IEP sampling programs should be subject to health/condition investigations as defined by this program review and development process.