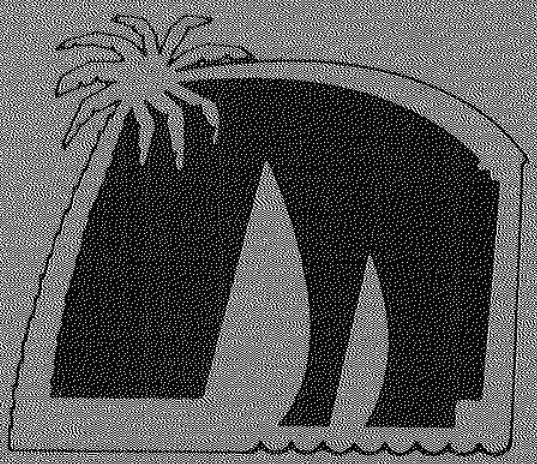
SAN DIEGO BAY
1989/1990 REPORT

Including:

Report of the 1990
San Diego Bay Symposium



December 1990

Prepared by

San Diego Interagency Water Quality Panel
(AB 158)

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SAN DIEGO BAY
1989/1990 REPORT

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Report of the 1990
San Diego Bay Symposium

Prepared For:

THE CALIFORNIA LEGISLATURE

and

THE CALIFORNIA STATE
WATER RESOURCES CONTROL BOARD

Prepared By:

SAN DIEGO INTERAGENCY WATER QUALITY PANEL
(AB 158)

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December 1990

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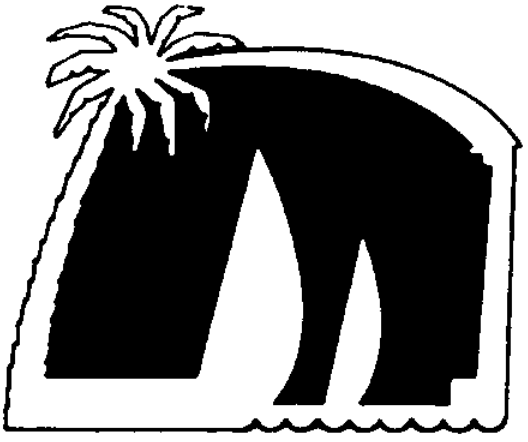

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EXECUTIVE SUMMARY

BACKGROUND

Issues affecting the health of San Diego Bay have evolved considerably over the past fifty years. In the 1940's and 1950's, biological contamination from the input of sewage was the major problem facing the bay. Sewage treatment, instituted in 1963, produced a dramatic improvement in the quality of the bay's waters, and by the 1970's San Diego Bay was considered much cleaner than most other industrialized harbors. However, in the 1980's, public concern grew over contamination from toxic chemicals. Since the 1980's, attention has focused on locating and cleaning up toxic chemical hot spots, and assessing threats they pose to human health and the environment.

During her tenure in the California Assembly, Senator Lucy Killea established the San Diego Interagency Water Quality Panel through the introduction of Assembly Bills 158 and 2325. Among its responsibilities, the 25 member Panel is charged with improving communication among organizations responsible for San Diego Bay. To help accomplish this goal, the panel recommended in its 1988 Report that a "State of the Bay" symposium be held to discuss issues affecting the health of San Diego Bay.

In response to this recommendation, the San Diego Bay Symposium was organized during 1989 and 1990[1] and held on June 15-16, 1990, at Shelter Island in San Diego. The Symposium brought together many diverse individuals and groups with responsibility for, or interest in, the water quality issues facing San Diego Bay. The 270 symposium participants included the following:

- elected and appointed officials with jurisdiction over San Diego Bay,
- scientists and educators from government agencies, consulting firms and universities,
- attorneys with expertise in environmental issues,
- business people affected by water quality concerns,
- members and staff of environmental groups active in resolving water quality problems,
- representatives of the mass media, and
- citizens with an interest in San Diego Bay.

The San Diego Bay Symposium provided a forum for:

- scientists to exchange information on the past, present and future of San Diego Bay's water and sediment quality,
- scientists to summarize extensive technical data and recommendations and present them to policy makers, the public and mass media,
- policy makers to gain ready access to data on water and sediment quality issues and discuss them with scientists and the public, and
- a knowledgeable cross-section of the San Diego community to achieve a fact-based consensus on the nature of San

1 During this period, the Panel also assisted in coordinating and updating the San Diego Bay oil and hazardous materials spill response plans of San Diego County and the U.S. Coast Guard. In addition the Panel provided technical assistance to the San Diego Association of Governments 205(j) San Diego Bay Cleanup Project.

Diego Bay's water and sediment quality problems and priorities for acting on them.

Following the Symposium, the San Diego Interagency Water Quality Panel considered the technical, legal, social, and economic concerns presented at the meeting. The analysis encompassed Symposium workshop reports and recommendations, findings of the forum policy makers panel discussion and symposium participants opinion survey, additional data and concerns, and issues and concerns raised by the Panel since the Symposium. The results of these deliberations are presented below. A summary of the San Diego Bay Symposium is presented in the section following the Interagency Water Quality Panel's Conclusions and Recommendations.

CONCLUSIONS AND RECOMMENDATIONS OF THE SAN DIEGO INTERAGENCY WATER QUALITY PANEL

Many primary concerns have been identified for water and sediment quality issues affecting San Diego Bay and for promoting a balance of the bay's many uses. However, bay pollution issues are complex and several factors impede their resolution:

- Policy making is hindered because information to support wise decisions is incomplete.
- Pollution monitoring has been conducted on a project-by-project basis and a comprehensive picture is lacking.
- Agency responsibilities have developed through many separate actions at many levels of government, resulting in overlap and conflict.
- Data are scattered among many repositories, so access to information is difficult for policy makers, scientists and the public.
- Pollution monitoring and cleanup projects are delayed by high costs, technical difficulties and cumbersome procedures.

With these issues in mind the San Diego Interagency Water Quality Panel has developed the following recommendations as necessary elements of a structured plan to address contamination problems in San Diego Bay:

1. **Develop a Comprehensive Monitoring and Data Analysis Program**
   - A. Coordinate monitoring efforts
   - B. Identify gaps in monitoring and how they should best be filled
   - C. Promote data analysis to develop a meaningful understanding of biological and physical systems of the bay
2. **Collect Additional Data to Fill Information Gaps**
   - A. Human health risks
   - B. Ecological risks
3. **Improve Coordination Between Agencies and Other Groups**
   - A. Coordinate monitoring activities and other research efforts to fill information gaps
   - B. Establish a scientific review panel
   - C. Prepare an annual report on proposed and ongoing projects on San Diego Bay
4. **Promote Effective and Economical Management of Contamination Problems**
   - A. Encourage the development of new and alternative methods, products and technologies that aid in the management of contamination problems
   - B. Encourage the development of legislation, policies and management practices to deal with key areas that are presently unaddressed

C. Encourage the development of clearly defined sediment criteria

D. Encourage the use of risk assessment procedures in defining regulatory and cleanup criteria

E. Encourage recognition and preservation of endangered species and sensitive habitats

5. **Encourage Public Education on San Diego Bay Water Quality Issues**

REPORT OF THE 1990 SAN DIEGO BAY SYMPOSIUM

The June 15-16, 1990, San Diego Bay Symposium on which the preceding conclusions and recommendations are primarily based, consisted of the following elements:

Symposium Plenary and Technical Sessions.

Symposium plenary speakers offered thought-provoking commentaries on a number of issues related to San Diego Bay water and sediment quality. While the following reports represent the speakers' own views, they reflect the diversity of perspectives on issues and opinions surrounding San Diego Bay. The commentaries are presented in full in the San Diego Bay 1989/90 Report.

1) **Water Quality History.** Sewage was a major bay water quality problem in the 1940's and 1950's. Improvement of the sewage treatment system in 1963 produced a dramatic improvement in water quality and in the 1970's San Diego Bay was considered much cleaner than other industrialized harbors. Since the early 1980's public concern has grown to locate and clean up toxic chemical hot spots and to assess threats they pose to human health and the environment.

2) **Risk-based Decision Making.** Risk-based decision making is a method for evaluating environmental effects and courses of action based on risk assessment, risk management and risk communication. These components provide a basis for interaction between the concerned public and people in technical, policy and decision making positions.

3) **Legal Framework for Cleanup Decisions.** The legal system has a mechanism for identifying environmental objectives to use in making decisions on environmental protection and remediation. Placing the heavy financial burdens associated with environmental programs on a given section of society may be unfair, create disputes and slow remediation. Environmental regulatory efforts need better communication and focus so that San Diego Bay problems can be addressed more efficiently. Pollution sources should be controlled to avoid the need for repeated, expensive remediation of contaminated sediments.

4) **Technical Framework for Cleanup Decisions.** San Diego Bay sediments, water, and marine life are contaminated with PCBs, petroleum hydrocarbons and some metals. Some biological damage is apparent, but the lack of evidence for links between diseased fish and contaminated hot spots means that pollution cleanup cannot guarantee disease reduction or increases in abundance of marine life. Research is needed to ensure cleanup actions cure real problems without creating new ones elsewhere. Extensive, longterm coastal environmental monitoring has shown that some chemicals which are pollutants on land or in fresh water are not a problem in the sea. Because only 0.3% of the earth's water is fresh surface or ground water, ocean disposal of contaminants should be studied as an alternative to land disposal.

Symposium Technical Workshops.

A full day of concurrent technical workshops and plenary session discussions were conducted on the following four topics:

1) **Pollution Sources Workshop.** A number of human activities present potential sources of contamination to San Diego Bay. The state of knowledge of these sources was evaluated and recommendations were developed for managing them.

2) **Pollution Monitoring and Environmental Risk Assessment Workshop.** The principal technical issues relating to pollution monitoring and environmental risk assessment in San Diego Bay were discussed. Current and recent monitoring programs that have provided information on San Diego Bay, and the findings of those programs, were evaluated. Specific recommendations were developed for filling information gaps and for future monitoring efforts.

3) **Human Health Risks Workshop.** Existing information concerning human health risks, such as the San Diego Bay Health Risk Study, was summarized. Areas that lack adequate information were identified. Recommendations were developed for filling information gaps, and for future monitoring of areas that may present human health risks.

4) **Cleanup Technology and Consequences of Remediation Workshop.** The principal issues relating to cleanup and remediation of contaminated sites in San Diego Bay were discussed. The legal and regulatory framework, as well as technical requirements and alternative strategies for cleanup actions were evaluated. Barriers to rapid cleanup were discussed, and recommendations were made for improving the overall efficiency of the cleanup process.

Each workshop included presentations and discussions of technical issues by speakers and workshop participants. Workshop groups exchanged commentary during the plenary sessions. Extensive technical data and recommendations from these workshops are presented in the San Diego Interagency Water Quality Panel's 1989/1990 Report.

San Diego Bay Water Quality Opinion Survey.

Opinions on bay water quality and preferred uses of the bay were assessed at the Symposium through a survey of 106 participants. About one-half of the survey respondents thought San Diego Bay pollution was comparable to that of other industrialized bays, but expressed some concern about the safety of eating bay fish or whether the bay was a healthy habitat for marine life. About one-third of the respondents expressed concern about the safety of swimming in the bay.

Survey respondents indicated their top preferences for bay uses were commercial and naval shipping, habitat for marine life, and recreational use with body contact. About one-fifth commented on the importance of maintaining a balance or mix of bay uses. Because conflicts are inherent in mixing these uses, achieving such a balance will challenge policy makers, agencies, industries, scientists and the public to cooperate in finding innovative and effective solutions to complex problems.

Forum Policy Makers Panel Discussion.

A primary element of the San Diego Bay Symposium was the Forum Policy Makers Panel Discussion, which included a dozen policy makers from federal, state, and local entities with responsibility for bay water quality issues. They are recognized in Appendix D of the full report.

The Forum Panelists received reports from the four technical workshops and then responded to two key questions:

1) What are the highest and best uses of San Diego Bay?

2) What steps should be taken to protect these uses?

Forum Panelists differed somewhat in their comments, but several concerns and recommendations were mentioned often and stressed as important. These topics were:

- **Monitoring.** Monitoring was stressed as the basis for restoring the bay to full health. An effective monitoring plan

should be based on an excellent model of the physical functioning of the bay, including flushing and residence times of chemicals.

- **Prevention.** Future efforts to preserve the health of San Diego Bay must include pollution prevention as an important element. Controlling urban runoff and the dewatering of underground structures were considered necessary to mitigate urban impacts on the bay.

- **Cleanup.** Improving the bay's environment and reducing health risks were a priority. Cleaning up toxic hot spots may be necessary to achieve these goals.

- **Human Health Risks.** Risks from swimming in the bay or eating fish and shellfish from the bay were a concern. Accurate information is needed on the nature of these risks and some felt that they should be compared to risks from other activities.

- **Habitat Concerns.** Fish and wildlife habitat in the bay should be protected, including protection, enhancement and restoration of wetlands. One panelist suggested setting minimum ecological health standards for the bay.

- **Bay Uses.** Although panelists differed somewhat about which bay uses were more important, they agreed that current uses will continue, but that the emphasis will change. Military and commercial activities will remain and recreational activities will continue to increase. A productive natural habitat coexisting with human use should be maintained. Mixed use of the bay is important, and a balance between competing uses should be achieved.

- **Coordination of Efforts.** Planning, monitoring and other bay activities should be coordinated by a central body that includes policy makers, scientists and the public.

Despite some differences, there was a consensus among Forum Panelists that a coordinated effort including monitoring, prevention, and cleanup is necessary for San Diego Bay. This effort should focus on creating an environment suitable for marine life habitats, as well as continued military, commercial, and recreational use.

FUTURE DIRECTIONS FOR SAN DIEGO BAY

The information presented in this report can be considered a summary of the "State of San Diego Bay" with respect to issues affecting its environmental status and management. The recommendations presented should be considered a general summary of the critical steps needed to restore and maintain the health of San Diego Bay. Achieving a healthy bay will require a sustained and cooperative effort by many individuals and organizations.

The San Diego Interagency Water Quality Panel is charged with advising the State Water Resources Control Board and the State Legislature and with assisting the California Regional Water Quality Control Board, San Diego Region in resolving San Diego Bay water quality concerns. The recommendations presented here are addressed to the Regional Board, the State Board, the State Legislature, and to the Panel, itself.

None of these groups, alone, has the resources to accomplish all of the stated goals. The Panel may undertake activities or encourage other groups in the San Diego community to act on these recommendations. They may also work in cooperation with other groups at various levels to promote attainment of the goals and objectives stated in the recommendations.

In conformance with Section 2, Chapter 820, Statutes of 1987, this report is respectfully submitted to the California Legislature, the State Water Resources Control Board and California Regional Water Quality Control Board, San Diego Region.

ACKNOWLEDGEMENTS

The San Diego Interagency Water Quality Panel wishes to acknowledge the many individuals and organizations who contributed to the success of the San Diego Bay Symposium, on which this report is primarily based. We especially wish to thank Senator Lucy Killea for her vision and support, and Judge Gordon Cologne for his guidance in the forum panel discussion. Many other individuals and organizations were instrumental in the success of the San Diego Bay Symposium and the preparation of the 1989/90 Report. Please refer to the appendices of this report for names of individuals and groups who supported this effort.

INTRODUCTION

In its 1988 report the San Diego Interagency Water Quality Panel[1] identified the need to develop a framework for San Diego Bay water quality information and recommended that a symposium be convened for this purpose. Planning for the 1990 San Diego Bay Symposium began early in 1989.[2] The meeting's goal was to bring together scientists, policy makers, industries, environmental groups, educators, and other interested members of the public to address bay water quality problems and how to solve them.

The San Diego Bay Symposium was held June 15-16, 1990 on Shelter Island in San Diego. The 270 participants included: elected and appointed officials with jurisdiction over San Diego Bay; scientists and educators from government agencies, consulting firms and universities; attorneys with expertise in environmental issues; businesses affected by water quality concerns; members and staff of environmental groups active in resolving water quality problems; mass media representatives; and citizens with an interest in San Diego Bay.

The Symposium provided a forum for:

- scientists to exchange information on the past, present and future of San Diego Bay's water quality;
- scientists to summarize extensive technical data and recommendations and present them to policy makers, the public and mass media;
- policy makers to gain ready access to data on water quality issues and discuss them with scientists and the public; and
- a knowledgeable cross-section of the San Diego community to achieve a fact-based consensus on the nature of San Diego Bay's water quality problems and priorities for acting on them;

Following the Symposium, the San Diego Interagency Water Quality Panel examined information presented at the meeting and developed conclusions and recommendations for action.

Report of the 1990 San Diego Bay Symposium

The 1989-1990 Report of the San Diego Interagency Water Quality Panel contains the following major elements:

- technical reports summarizing data and recommendations from Symposium workshops;
- papers by Symposium plenary session speakers regarding general water quality history, risk-based decision making, and legal and technical frameworks for cleanup decisions; these papers represent the speakers' own views;
- opinion survey of Symposium participants on Bay water quality and preferred uses;
- summary of discussions by policy makers during the Forum Panel on uses of the Bay and recommended actions to achieve them; and

Conclusions and Recommendations of the San Diego Interagency Water Quality Panel

- recommendations by the San Diego Interagency Water Quality Panel based on analysis and discussion following the Symposium.

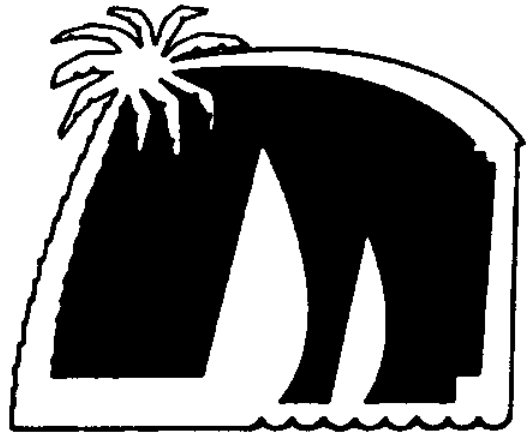
The findings contained in this report can be considered a summary of the "State of San Diego Bay" with regard to environmental status, management, and recommendations for the future.

In conformance with Section 2, Chapter 820, Statutes of 1987, this report is respectfully submitted to the California Legislature, the State Water Resources Control Board, and the California Regional Water Quality Control Board, San Diego Region.

1.The San Diego Interagency Water Quality Panel was sponsored by California Senator Lucy Killea, during her tenure in the Assembly, under Assembly Bills 158 and 2325. It includes representatives from 25 organizations with interests in and expertise on San Diego Bay. The Panel's purposes are to advise the State Legislature and the Regional Water Quality Control Board and to assist the Regional Board in resolving water quality problems. Appendix A contains a complete list of panel members and the organizations which they represent.

2.During this period, the Panel also assisted in coordinating and updating the San Diego Bay oil and hazardous materials spill response plans of San Diego County and the U.S. Coast Guard. In addition the Panel provided technical assistance to the San Diego Association of Governments 205(j) San Diego Bay Cleanup Project.

REPORT OF THE 1990
SAN DIEGO BAY SYMPOSIUM



PERSPECTIVES ON SAN DIEGO BAY

This section contains papers by San Diego Bay Symposium plenary session speakers which place San Diego Bay water and sediment quality issues in perspective regarding general water quality history, risk-based decision making, and legal and technical frameworks. These papers represent the speakers' own views.

WATER QUALITY HISTORY OF SAN DIEGO BAY

Peter Michael
California Regional Water Quality Control Board
San Diego Region

San Diego Bay has undergone changes in its water quality during the mid to late twentieth century. Because of the rapid increase in population related to the arms buildup immediately preceding World War II, sewage collection and treatment facilities which discharged into the bay became severely overloaded. By the 1950's, coliform bacteria concentrations in some parts of the bay were regularly ten times the standards now accepted for swimming and one hundred times the standards for shellfish harvesting. The high nutrient loading contributed to creating offensive red tides, sludge banks up to six feet thick, and dissolved oxygen levels approximately half normal levels. It has been said that during the post-war years the only consistent uses of the bay were navigation and sewage disposal.

In 1951, up to fifty million gallons-per-day of domestic and industrial wastes were disposed of in the Bay. In response, the newly formed California Water Pollution Control Board undertook a water quality characterization project. The project defined existing bay water quality, uses of the bay, sources of waste, and types of waste entering the bay. The disposal of sewage and industrial waste directly into the bay was determined to be inappropriate.

After an unsuccessful attempt in the 1950's to fund an improved sewage system, the City of San Diego was able to fund construction of a new system by the next decade. In 1963, the Metropolitan Sewerage Agency system came on line with force mains ringing the bay, a treatment plant on Point Loma, and a two-mile ocean outfall which discharged at a depth of more than two hundred feet. The improvement in bay water quality was immediately noticeable. During the 1960's, sludge banks were seen to disappear, valuable sport fish were observed recolonizing the bay as dissolved oxygen levels returned to normal, and bacteria levels were measured to be dramatically reduced. The new "beneficial uses" were consistently available and included swimming, fishing, and preservation of wildlife habitats. Recreational and boating industries, industrial water users, and military commands also observed benefits. During the 1970's San Diego Bay was considered to be much cleaner than most other industrial harbors.

During the 1980's, there has been a new public concern for toxic chemical effects on marine life and human health. Using data obtained from bioaccumulation studies and sediment sampling, "hot spots" of contaminated sediments were identified in San Diego Bay. Many of these chemicals were also known to be present in other west coast harbors. A characteristic of most of these chemicals is the propensity for attachment to particles such as plankton, bottom mud, and suspended sediment, rather than for dissolving in sea water. This property explains why the highest levels of toxic chemicals are usually found in bottom sediment and in tissues of fish and shellfish but not the water column. Some activities were subsequently questioned such as consumption of fish caught in the bay, while the threat of chemicals to swimming was not perceived to be great. Public demand grew to locate and clean up toxic hot spots, as well as to assess any threats to human health and the environment.

To improve the communication between organizations, the Honorable Lucy Killea, member of the California Assembly, introduced legislation to bring together groups with interests in San Diego Bay. The San Diego Interagency Water Quality Panel, with representatives from 25 organizations, is now in its third year of operation. This year the panel co-sponsored a Bay Symposium to discuss water quality issues.

RISK-BASED DECISION MAKING

Bill Wild
Naval Ocean Systems Center
Computer Science Corporation

Risk-based decision making is a process that is relevant to the evaluation of San Diego Bay environmental quality data. This presentation offers a perspective on the elements of the San Diego Bay Symposium as viewed through a risk-based decision making framework. The objective of this discussion is to offer a method for evaluating environmental effects in San Diego Bay that any interested person without a technical background can understand.

Risk-based decision making requires the following:

- **Risk Assessment**-- A study to determine if organisms might be affected by a particular chemical, product, or practice;
- **Risk Management**-- A determination on whether mitigation and/or remediation is needed; and
- **Risk Communication**-- A public forum in which human or ecological risks are accurately explained.

These three components of risk-based decision making constitute a broad basis for interaction between the concerned public and technical, policy and decision making individuals.

On the first day of the San Diego Bay Symposium, both human health risk assessment and ecological health risk assessment were discussed. It became apparent that a great deal of overlap and interrelation existed between human health and ecological risk assessment. There was also a consensus of opinion that a completely valid risk assessment for San Diego Bay would not be possible because of time constraints and limited resources. Discussion on risks to human health centered around the County Health Department's report on the possible chemical contamination of edible fish in the Bay. Dialogue on ecological risks focused primarily on: (1) pollution monitoring, (2) pollution sources, and (3) pollution cleanup.

The management and communication of this risk was the focus of the second day of the Symposium. Discussion was limited to the characteristics of human and ecological risk. This was followed by recommendations to invited forum panel members (risk management). In addition, a set of criteria from a recent environmental monitoring document (NRC, 1990) formed the nucleus for discussion during the technical committee sessions. The following was considered:

1. Is there actually a problem?
2. Who is responsible for the problem?
3. Why and/or how did the problem occur?
4. Who has the authority to stop the problem if it is continuing to occur?
5. Who has the authority to clean it up?
6. How do you clean it up?
7. How much will it cost?
8. Is it worth the cost to clean up?
9. If so, who will fund it?

In answering question 1, one must consider that human or ecological risk assessment requires:

- a review of hazard data to identify and evaluate the nature of the hazard;
- identification and evaluation of the relationship between chemical concentration or exposure and the response of an organism; and

- information necessary to determine the probability that populations will be adversely affected or that food chain accumulation may pose a hazard to higher level organisms, including man.

In addition, a determination must be made of the point at which the degree of risk becomes significant or important (This is also a risk management and a risk communication issue).

Questions 2-9 are risk management issues; however, these questions only become relevant if the answer to question 1 (is there actually a problem?) is yes. Recent legislation concerning community right-to-know issues should ensure that the public has the opportunity to participate in the process of decision making. This means that industry and government officials will increasingly be called upon to explain information on chemical risks and to put this information into perspective in terms of risk to the environment and human health.

Risk communication issues were given a high priority at the Symposium, since one of its objectives was to allow interested members of the public to participate in decisions which affect San Diego Bay, and, ultimately, the quality of their lives. In order to create a framework for further discussion, the following documented characteristics of risk communication involving environmental controversy (Krimsky and Plough, 1988) were presented in the opening session of the Symposium:

- Diverse opinions must be crafted into a consensus, so that a solution can be developed. If this is not possible, the primary agreement, as well as the dissenting opinions, needs to be presented.

- Science rarely dominates the formulation of policy in a highly politicized environmental event.

- Cultural issues may be more diverse than technical issues and may "carry more weight."

- Expect the media to emphasize the issues and, in some cases, fail to offer an objective review of the scientific evidence. (On the other hand, little or no coverage can be equally detrimental if an environmental problem is harmful.)

Finally, a multi-faceted discussion between legislators, regulators, scientists, and other interested parties ensued throughout the San Diego Bay Symposium (risk communication). Additionally, a media interface was established during and after the Symposium. Television and printed media representatives attended and covered the Symposium. The San Diego Oceans Foundation used information from the Symposium to prepare a documentary on San Diego Bay.

The San Diego Bay Symposium provided a forum where many interested parties were able to convene to discuss the health of San Diego Bay. Its value in terms of risk communication can be judged in two ways: the success of the actual Symposium, and the programs being planned as a result of it. The Symposium represented the communication of risks between scientists, legislators, regulators, and, to a lesser degree, the public. The San Diego Interagency Water Quality Panel, recognizing that the Symposium was only the beginning of a public education process, is planning a program to more fully educate the public about San Diego Bay.

Bibliography

Krimsky, Sheldon, and Alonzo Plough. Environmental Hazards, Communicating Risks as a Social Process. Auburn House Publishing. 1988, p. 298-307.

National Research Council (NRC). Managing Troubled Waters, The Role of Marine Environmental Monitoring. National Academy Press. 1990, p. 35.

LEGAL PERSPECTIVE ON SAN DIEGO BAY

Karl Lytz
Latham & Watkins
Attorneys at Law

I would like to share with you several lessons and perspectives I have learned in the process of resolving environmental disputes. At best, environmental problems are complicated matters, seldom capable of rapid solutions. Frustrations run high, misunderstandings can occur, and bad decisions are frequently made. There are three points I would like to make which, if followed, would facilitate future productive decision-making on issues concerning the environment of San Diego Bay.

First, we actually have within the legal system a very good process by which to identify environmental objectives to implement decisions concerning environmental protection and remediation. The existing system should not be abandoned.

Second, we need to allocate more fairly the financial burdens that are associated with implementing the programs developed pursuant to the right legal process. Efforts to force the costs of environmental compliance or remediation on any particular section of society are frequently unfair, create disputes and slow progress.

Third, there is a need to increase the coordination of environmental regulatory efforts, and to focus these efforts so that problems in San Diego Bay can be more efficiently addressed. Senator Killea's San Diego Interagency Water Quality Panel is an example of the type of coordination we need.

The process of environmental regulation is a relatively recent phenomenon. Not until the later 1960's was our society ready to grapple with environmental problems. Because of the complicated nature of environmental issues, the legislative process did not necessarily have all the answers. Our legislative processes had focused on social and economic considerations instead of environmental issues. As a result, there was extremely limited legislative expertise in environmental regulation, and a prudent decision was made to involve scientists and technical experts in the process who could help identify problems and provide solutions. Environmental policies were to be based upon the interaction of scientific and technical input from administrative agencies within a social and economic framework structured by the legislature.

This process has worked extremely well. The cleanup of San Diego Bay, for example, has been a remarkable accomplishment. The bay is in much better condition than it was 20 years ago. Although there are problems in the Bay today, they are manageable problems. While we must deal with these problems and not become complacent about them, they are not so compelling as to warrant an abandonment of a process which balances environmental issues in the context of social and economic considerations of the surrounding community.

I have been concerned by the trend I have observed in the last two years to move away from this process. Administrative agencies and legislatures are now responding to pressures from constituents, in ways that are not always in the best interests of the people. In my judgement, the worst thing that we can do is to engage in a process of "underground regulation" in administrative agencies which avoid the more deliberate and admittedly laborious process of trying to balance environmental concerns with social and economic considerations. Yet, that is exactly what is happening in our administrative agencies today. Scientists and technocrats are now developing policies which are enforced as though they were regulations. While this practice might highlight an environmental issue, the defect is that it may not balance that issue with important social and economic considerations.

On the other hand, the legislature, also growing impatient, has begun to overstep its proper bounds by attempting to mandate legislatively scientific and technical conclusions. Last year,

for example, the Bay Protection and Toxic Cleanup Act was passed by the State of California. The law requires the State Water Resources Control Board to establish concentration-based sediment quality standards that will be protective of the most sensitive species in the environment. Many scientists believe, however, that sediment concentrations are not an appropriate way to protect the environment, and there may be little benefit gained from protecting the most sensitive species in sediments. In short, the legislation we now have in California may compel us to make decisions that are irrational, or which do not protect beneficial uses of the environment in a cost-effective manner.

In San Diego Bay, there is no need of such proportion as to require us to abandon a full and reasoned approach to solving the problems. We have problems, but they are not imminent and substantial threats to human health, welfare, and the environment. We should not abandon a reasoned approach to identifying and solving our problems in order to meet a perception of need. What may be wrong is that perception!

As to my second point, there is no better way to slow the solution to an environmental problem than to make it a money issue. Environmental solutions cost money, which is fine if you are getting positive results and the right people are carrying the economic burden. However, the costs are unacceptable if you ask some people to bear an unfair proportion of the expense of environmental protection or remediation. In my view there has been a tendency to unfairly allocate financial burdens to private enterprise while avoiding the use of public funds or tax increases. Yet in many instances, the problems that require resolution were created by the general public, not by some isolated part of the public.

For example, there are many sources of pollution in San Diego Bay, and it is very difficult to identify them individually. The largest remaining source of contaminant loading into the bay, however, may be storm water runoff, something that is not associated with a particular industrial activity, and in large measure consists of runoff from private homes and public roads. Who will pay for monitoring the impacts of storm water runoff on the bay? Industries are paying for the monitoring even though there are relatively few industrial sources of contaminated runoff. This is not a fair allocation. We need to consider public financing of some or all of the required programs.

The third point I would like to make concerns coordination. San Diego Bay is only one bay, yet there are myriad agencies that exercise some form of jurisdiction over it. The process of regulating the bay needs to be consolidated and streamlined to avoid the piece-meal approach to regulation that we have had in the past.

The final point I want to mention is that we need to approach the problem in the right sequence. Take care of pollution prevention first. If we do not, any remediation conducted is likely to be repeated. Right now there are still unabated pollution sources entering the bay, notably storm water runoff. We should address that problem before we engage in any expensive remediation of contaminated sediments.

PERSPECTIVES ON THE CLEAN UP OF SAN DIEGO BAY

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National Oceanic and Atmospheric Administration
Seattle, Washington

Never before has mankind been so protective of the ocean. We are striving to do everything in our power to keep civilization's byproducts out of the sea, even to the extent of stockpiling outdated but clean, nuclear submarines in the desert sands. That protection extends to all scales, including the reporting of a single gallon of spilled oil and the severest constraints on releases of nitrogen, the sea's most limiting material to production of life. When subsurface sediment deposits of copper or PCBs from old discharges are discovered, we rush to sue the responsible party and develop expensive schemes to remove the contaminated material to a drier place, usually with little equal thought about the alternative consequences to land dwellers, including us.

While this may be an exaggeration of reality, it is not without a basis in experience. Our concern about polluting the sea stems directly from real damage we have seen inland in lakes, streams and upper reaches of urban estuaries. That damage has been directly visible and includes filthy-looking water, large kills of fish, birds, plants and invertebrates, animals bearing tumors and lesions, and people chronically ill from eating contaminated fish and shellfish. In contrast to inland environments, pollution is much less visible to us along the seacoast and under the sea so the uncertainty about what is happening there is naturally greater and our meager knowledge much more dependent on whatever scientists and monitoring agencies dredge up from tiny points along the coast. When they report back high levels of copper or PCBs in the sediments, we assume damage is occurring to marine life to the same extent we have witnessed ashore. Our response is similar.

My mission this afternoon is to provide some perspective on pollution in San Diego Bay and what we should do about it. I am not going to review all the recent data on contaminants in San Diego Bay: that is the purpose of this conference and there are many people here presenting new data and information. What I will do is go beyond the data and local information and try to present several kinds of perspectives that should make us stop and think about the far-reaching implications of various management and clean-up actions. Specifically, I will try to evaluate existing and forthcoming data in a framework of management options. I draw upon experience gained during more than 20 years of research on the sources, fates and effects of contaminants in the Southern California Bight and elsewhere along the Pacific, Atlantic and Gulf of Mexico coasts.

A brief overview of management opportunities is needed to set the stage for evaluating contaminant data and information. Assuming there is contamination in San Diego Bay, what do we do about it? Pollution may be defined as a damaging excess of contaminants: that is, pollution is more than simply elevated levels of substances - it is damage or unacceptable risk to resources (or to resource uses) caused by increased contamination. Therefore, I argue that the next two steps are to (1) find out which contaminants are now at a damaging excess (are people or marine life in fact threatened?), and then (2) determine the sources of those materials in damaging excess.

Seafood consumption surveys, comparison of existing levels to various criteria and guidelines, and a battery of confirmatory biological toxicity and bio-accumulation tests represent a collective approach to the first question. Source determination may require not only surveys of existing known and suspected flows (inputs) but also special investigations of sediment-bound contaminants to see if old deposited material is leaking back at ecologically-significant rates.

When the risks, contaminants and sources are identified to our satisfaction, we act. The alternatives include: (1) no action, (2) removal of

the source material, and (3) capping of submerged sediments. "No action" might be a choice if it is determined that removal poses more potential total ecological and human health risk than leaving the sediments in place. Such a choice must be accompanied by monitoring so warnings can be offered and trends anticipated. If removal is the choice, then we must consider disposal in one or more of three media: land, air (combustion), and the sea.

There are several aspects of this management scenario that give today's policy makers heartburn. First is the need for confirmation that contamination is or could be causing significant biological damage or causing human health problems. If there is excess contamination of pesticides, PCBs or metals in sediments of San Diego Bay, why delay action for additional demonstration of biological effects? The answer is that while in excess, the contamination may not be at biologically significant levels, so that no action is necessary, other than monitoring to make sure levels aren't increasing. Moreover, if there is some risk or damage, it may not be as bad, in the long run, as that resulting from cleanup alternatives. Delay for the cause of study is not a popular way to go in this age of action, but such delay may result in setting better priorities for clean-up.

Another source of heartburn is the ocean disposal alternative. Quite simply, it is illegal. However, that does not mean we can't think about it and change the laws if there is substantial benefit.

It is to both of these "unpopular" alternatives that I would like to address the balance of my comments.

STATUS AND TRENDS OF CONTAMINATION IN THE BAY

What contaminants are now in San Diego Bay? Various surveys conducted during the past several years indicate this answer: nearly any chemical we have looked for to date is found in unusually high concentrations somewhere in the Bay. South of Downtown, sediments contain excess concentrations of several metals, such as copper, and petroleum hydrocarbon residues, such as PAHs (polycyclic aromatic hydrocarbons). Inshore of Harbor Island sediments are contaminated with PCBs (polychlorinated biphenyls). Water inside Shelter Island contains high but declining concentrations of TBT (tributyl tin) residues. The harder question is: what is out there that we haven't looked for? Could there be other kinds of potentially toxic hydrocarbons, solvents, metals in excess? The answer is probably yes. The only way to find out is to expand our measurements.

How does contamination in the Bay compare with other comparable areas and other adjacent areas? Several years ago San Diego Bay was heralded in the press as the hottest bay in the Northern hemisphere for one pollutant: PCBs. In reality, it is not unlike most other urban bays. Using comparable data from other regional and national studies, we can say that levels of PCBs in sediments of San Diego Bay are among the highest in the Southern California Bight, but also are comparable to the levels seen in other major U.S. urban harbor areas (Figure 1). A similar ranking for other pollutants places San Diego sediments among the cleanest areas of Southern California for DDT, high for copper and PAHs and about average for other metals (compare data in NOAA, 1989). Moreover, the immediate coast of Point Loma and the County is among the cleanest areas of the U.S. with respect to the contaminants reviewed here.

Is contamination decreasing or increasing? This is tough to answer because there have been no long-term contaminant monitoring programs in San Diego Bay. NOAA's National Status and Trends Program has sampled a few sites in the Bay since 1984, but the data are not yet available to evaluate trends over this time period. While there have been many other surveys at various locations, few have been repeated over a long enough time to observe trends. In the case of tributyl tin, there is good evidence that levels in water have been declining since 1987. Additional data that do exist have not been subjected to trend analysis.

This is an unfortunate situation in light of information outside the Bay. Off Point Loma, in the Channel Islands and off Los Angeles, there is abundant data to show that levels of DDT, PCBs, PAHs and some metals have been declining considerably over the past two decades after reaching peak levels in the late 1960's and early 1970's (Mearns et al., 1988 and

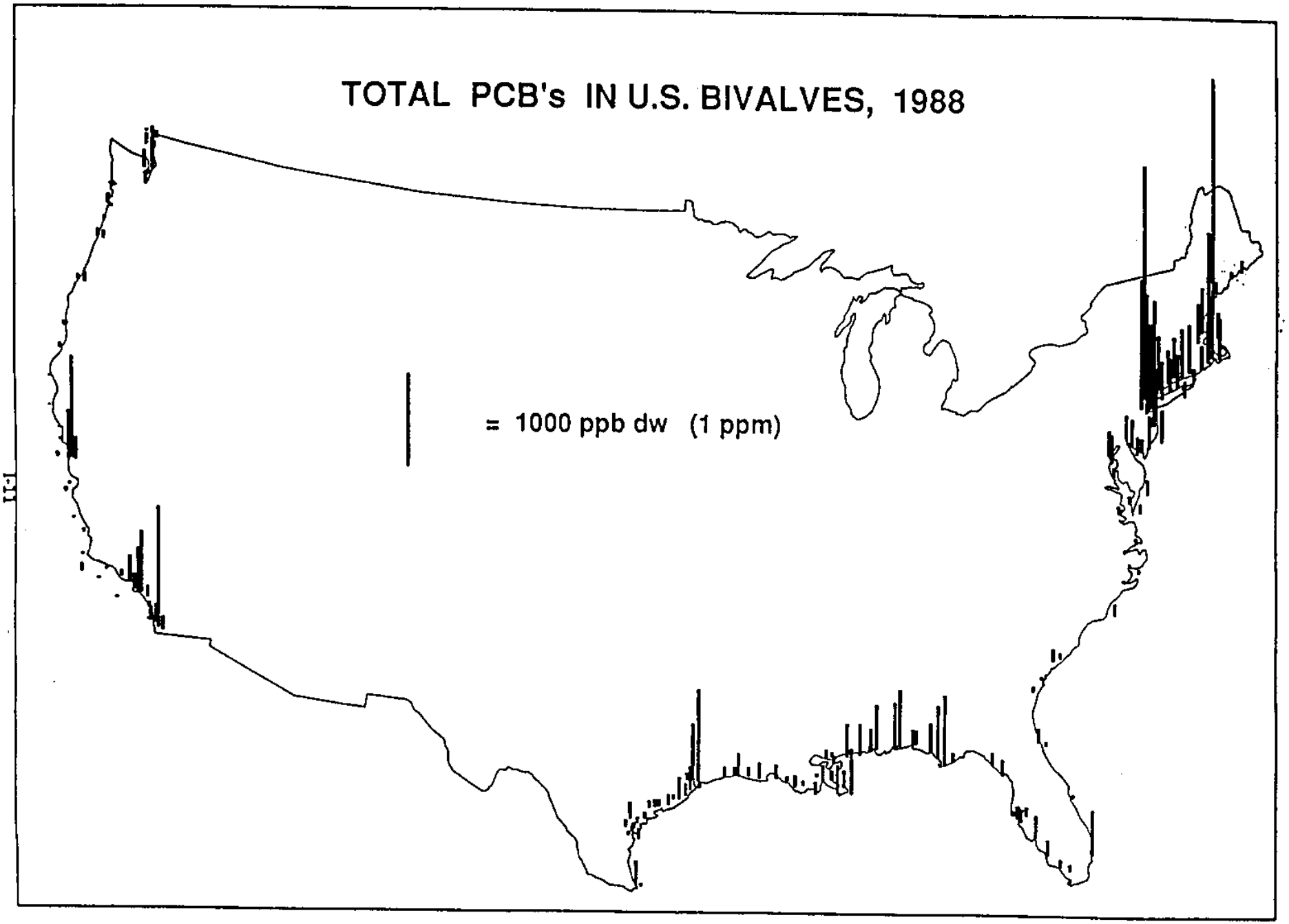

Figure 1. Concentrations of poychlorinated biphenyls (PCBs) in bivalve mollusks (mussels and oysters) at over 175 sites sampled around the US coastline in 1988. Data from the NOAA National Status and Trends Program.

Mearns et al., in prep). Table 1 shows that PCBs in mussels from offshore areas have been declining considerably during the late 1980's, whereas levels within several bays have remained unchanged.

Ecological and Public Health Effects of Contaminants in San Diego Bay: A Damaging Excess?

Are there any signs that contaminants are causing ecological or public health problems in San Diego Bay? Based on data presented at this conference, there are signs of contaminant-related ecological damage, while at the same time there is additional evidence that the public is at little risk. Of the various studies completed to date on biological damage (sediment toxicity, fish health studies), one stands out - fin erosion in barred sandbass as summarized by McCain et al. (1989). Although more information is clearly needed, the nature and appearance of this disease in sandbass is similar to a fin erosion disease that once affected a large percentage of flatfish and smaller percentages of rockfish, croakers and basses along several miles of the Palos Verdes shelf off Los Angeles. That disease was cured when inputs of contaminants were reduced and concentrations of contaminants in surface sediments declined during the late 1970's and early 1980's (Buchman, in press and J. Stull, County Sanitation Districts of Los Angeles County, personal communication). We still do not know the specific agent(s) causing the disease. Fin erosion is, however, a sign of an unhealthy fish population. It may be caused by microorganisms or chemical toxicity to some biochemical or wound repair system in the bass. At Palos Verdes, we were able to rule out microbial pathogens and bioaccumulation of metals as causes, but not chlorinated hydrocarbons (such as PCBs) or petroleum hydrocarbons in fish or levels of any material in sediments. There is a lot we don't know about the disease in San Diego Bay - whether it is getting better or worse, whether fish reproduction and production is affected, etc. But we have enough to place a check in the "effects" column and to seek information about its significance and cause. Something is out there affecting the fish, but we do not know if it is related to any of the current sources or chemical hot spots that draw our attention from chemical data alone.

On the larger scale of the Southern California Bight, we now have good evidence that contaminants discharged offshore have apparently had little to do with the long-term fluctuations in the sizes of stocks of important fisheries such as sardine, mackerel and anchovy (Prager and MacCall, 1990). Climate change is the major factor affecting them and it may be an equally strong factor for local fishery resources in the Bay.

Contaminants of Concern and Non-Concern In San Diego Bay

We have not yet assimilated enough specific data on San Diego Bay to define conclusively the contaminants of utmost concern and their sources. That is not to say we don't have the data; we may have enough, but have yet to put it in a regional decision-making framework. I have attempted to do this as part of a yet-to-be completed assessment report for the Southern California Bight where we examined hundreds of data sets from various monitoring and research programs conducted over the past 25 years.

Table 2 is a short-hand version of what we have learned about a number of contaminants in the Southern California Bight at sites mainly outside San Diego Bay. Various contaminants are listed down the left hand side. Across the table, from left to right, various kinds of information about each contaminant are checked. The first column indicates if the contaminant occurs somewhere in excess concentrations in sediments. To the right I indicate the extent to which each contaminant is also found in excess in various well-monitored marine organisms, and whether that contaminant has occurred in sediments in toxic concentrations. Finally, I note, from all available information, the extent to which inputs and concentrations are getting worse (increasing). This kind of summary helps determine which contaminants are of most and least concern now, and, perhaps, which need more information.

Although all these contaminants have been discharged to the Southern California coast, several - namely arsenic and selenium - do not occur in excess in sediments anywhere they

Table 1. Changes in overall concentrations of polychlorinated biphenyls (PCBs) in mussels from the Southern California Bight between 1986 and 1988 as measured in NOAA's National Status and Trends Program.

AREA	No. of Sites	Median Concentration, ppb ww 1986	1988	% of 1986	%Decrease
ISLANDS [A]	2	125	17	6	86
OPEN COASTAL [A]	7	210	85	40	60
BAYS AND HARBORS:					
COASTAL MUSSELS [A]	5	530	270	51	49
BAY MUSSELS [B]	2	240	415	172	0

A = Coastal mussel, *Mytilus californiensis;* B= Bay mussel, *Mytilus edulis*

Table 2. Summary of knowledge concerning bioaccumulation, biomagnification and longterm trends of 15 chemicals condsidered pollutants in the Southern California Bight. Based on assessment of monitoring and research data as summarized in Mearns et al (in preparation).

> > > > > > > > INCREASING CONCERN > > > > > > > >

CHEMICAL	ACCUMULATION IN: SEDIMENT?	MUSSELS	MACRO-INVERTEBRATES?	FISH?	BIOMAGNI-FICATION?	INCREASING?
ARSENIC	+					
ZINC	+					
LEAD	+	+	?			
CADMIUM	+	+	+			
CHROMIUM	+	+	+			
COPPER	+	+	+			
SELENIUM	+	?	?			
SILVER	+	+	+			
MERCURY	+	+			+	
TIN	+	+	?	+	?	
PAH'S	+	+	?	+	?*	
PCBS	+	+	+	+	+	
DDT	+	+	+	+	+	
CHLORDANE	+	+	+	+	+	?
DIELDRIN	+	+	?	+	+	?

+ = YES; ? = UNCERTAIN; NO ENTRY = NO

have been looked for. All the others have definitely accumulated in sediments near sources, such as outfalls and vessel maintenance areas. In terms of bioaccumulation (accumulation of contaminants in animals and plants) two contaminants, arsenic and zinc, have never appeared in excess in mussels, nor three (arsenic, mercury and zinc) in other macro invertebrates while seven (silver, arsenic, cadmium, chromium, copper, mercury and zinc) have never appeared in excess in tissues of fish collected from otherwise metal contaminated areas. Unfortunately, we still have poor knowledge about what is happening with lead, selenium, tin, PAHs and non-DDT chlorinated pesticides in macroinvertebrates and for lead and selenium in fish.

Of no scientific surprise, only four contaminants - mercury, PCB, DDT and chlordane - actually appear to have undergone biomagnification (progressive buildup of contaminant concentrations up the food chain) in marine foodwebs of the Southern California Bight. Even so, one - mercury - does not occur in excess above what would be expected naturally. Our information about biomagnification for lead, tin and dieldrin is too sketchy to make a call, but there is good independent evidence that lead does not biomagnify in food webs leading to albacore tuna. Of greater curiosity, and possible concern, is that some metals, notably cadmium, actually occur at lower concentrations in animals from "contaminated" areas than in those from relatively remote clean reference areas! Indeed, some metals in livers of fish from San Diego Harbor are lower than in comparable fish from a reference site off Dana Point! This is in total disregard of our textbooks, popular press and regulatory assumptions!

Trend analysis reveals that, outside San Diego Bay, inputs and accumulation of 11 contaminants have not been increasing; some have experienced dramatic decreases in inputs and in levels in surface sediments during the past 10-15 years (Schafer, 1989). However, trends for several - silver, mercury, selenium and dieldrin - are uncertain due to a lack of reasonable long-term data.

In terms of potentially toxic levels of contaminants in sediments, there are only a few spots where existing levels may actually be toxic. At the handful of NOAA NS&T sites in San Diego County, PCBs, copper and chromium in sediments at a site south of Downtown (SDA) equal or exceed the median level (ER-M in Figure 2) associated with toxic effects as reviewed by Long and Morgan (1990; Figure 2). For arsenic, cadmium and silver, no site has concentrations that even approach the lower toxicity limit (ER-L), while all but one site are below that limit for PAHs, copper, lead and zinc.

When all this information is pulled together, we can begin to identify contaminants of most and least concern. For the Bight as a whole, I conclude eight are of concern: PAHs, PCBs, DDTs chlordane, organotin compounds, arsenic, lead and mercury. DDT may be eliminated as a chemical of concern in San Diego Harbor. The organic chemicals - PAHs, PCBs, chlordane and organotins - occur at concentrations of biological concern in both sediments and organisms from the Bay and their sources are clearly from recent or past regional inputs. In contrast, mercury and arsenic are of concern everywhere in the Bight only because risk assessment studies suggest that even the levels that occur naturally in local fish approach health effects guidelines: there is simply no waste management actions that can be taken in the Bight or in San Diego Bay that would influence these levels. Lead may be of concern in San Diego Bay and along the Los Angeles coast where levels in mussels are still far above natural background levels; the question is, are existing concentrations of biological or health significance?

Despite evidence of sediment contamination, several other metals can almost summarily be eliminated as contaminants of direct management concern anywhere in the Bight, including San Diego Bay. There is no management action that will change levels of cadmium, chromium, copper, silver or zinc in fish in the area (except possibly by causing them to increase!). Chromium is a dilemma because even natural levels in sediments of the Bight appear to overlap toxic levels from other toxicity studies. In contrast, PCBs, PAHs and possibly organotins and chlordane are problematic; marine life might benefit from reductions and controls if we want to solve the most important problems first. Thus, any efforts being expended on

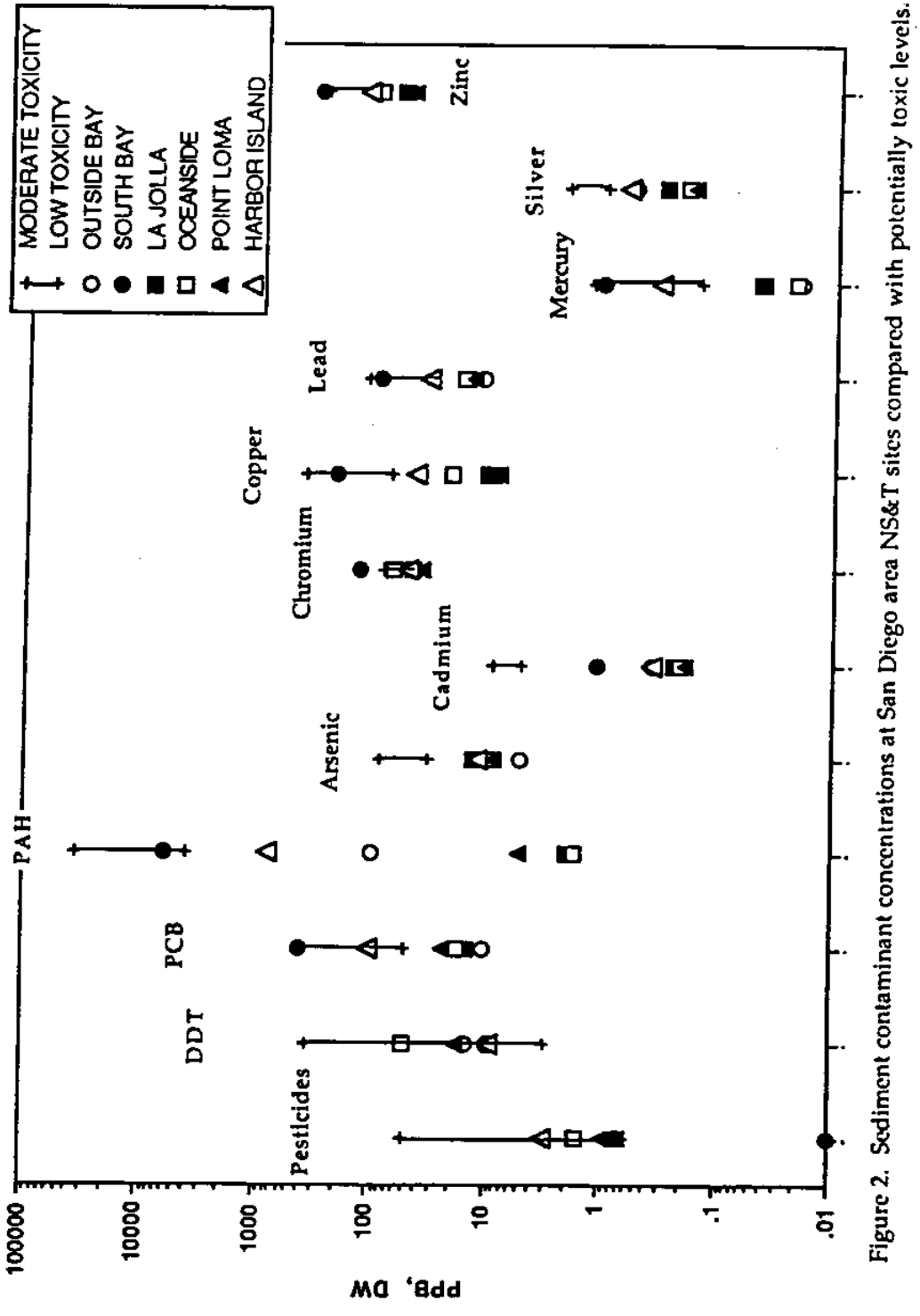

Figure 2. Sediment contaminant concentrations at San Diego area NS&T sites compared with potentially toxic levels.

control of the metals might be better expended toward control of the organics.

Summary of Contamination

Of those contaminants looked for in the Bay, most are found in excess somewhere. However, it is not clear that all occur in damaging excess, an observation that should begin helping us place priorities on what to clean up. The north and eastern shoreline of San Diego Harbor has clearly been contaminated to the extent of causing fin erosion or fin rot disease in bass and probably other fish as well, but it is not clear if any of the contaminants measured to date are the actual causes of this damage or if proposed cleanup actions will cure that disease. It is the continuing mission of this conference to evaluate existing information and to pass judgement on the Bay. The analysis done here is only a beginning and I hope the framework provided will be used to evaluate all the information.

MANAGEMENT OPPORTUNITIES ON A DESERT COAST

To reduce concentrations of ecologicallyrelevant contaminants, it is necessary to find out if they are coming from existing point or non-point sources (discharges, runoff) and/or old sediment deposits. That requires targeted surveys, some of which have been underway recently.

Where discharges and runoff are identified as the dominant sources, options for control include no action, source control or some kind of final treatment prior to discharge. To me these seem self evident, but where residues are removed, where do they go?

Where subtidal sediments are identified as sources of contamination or toxicity, alternatives include no action, capping, and removal. Here we face more serious uncertainties. To what extent should we evaluate the "no action" alternative? The answer is, no action should be invoked if capping, removal or other disturbance results in more damage in the Bay, or elsewhere, than it attempts to cure. The disposition of removed sediments may be onshore or in the ocean. Who will insure that no additional damage is created by either? Here is where I open the perspective door, arguing for some consideration of the additional constraints on land disposal and the additional benefits of ocean disposal.

San Diego is one of only five metropolitan areas that sits on the Pacific edge of the North American Continent. That edge, from Unimak Pass in the Alaska Peninsula to Cabo San Lucas at the tip of Baja California, Mexico, is almost unrelieved for over 7400 kilometers and is part of the longest unbroken line on Earth, bordering the largest ocean on Earth, as seen from space (Kelley, 1971). It is also one of the narrowest coastal margins on Earth, with the deep sea literally only a few tens of kilometers from nearly any shoreline. From far out in space, only the embayments of San Francisco, the inland sea of Puget Sound and the Straits of Juan de Fuca and Georgia, Alaska's inside passages, Yakutat Bay, Prince William Sound, and Cook Inlet interrupt the narrow doglegged coastal shelf. From this perspective, San Diego Bay is a minor indentation bordering a great and deep seacoast.

But there is more. San Diego Bay also is a small indentation into an artificially-watered desert sea coast. The shoreline and hills look lush now, but prior to the great importation of water, it was not so. By withdrawing water from the Colorado River, the inhabitants of San Diego and Southern California have placed a great burden on an area thousands of times larger than the municipality itself. The cities, plus the requisite agriculture in the Imperial Valley, require much of the flow of that river, and the withdrawal has helped destroy the largest estuary in the Pacific southwest: the Colorado River Delta in Baja California and Sonora, Mexico. That withdrawal may have contributed to the decline of the totoaba, a giant, now-rare commercial fish of the northern Sea of Cortez (Flanagan and Hendrickson, 1980). We do, however, return something to the intervening lands - mainly garbage, pesticides, heavy metals and a growing amount of sludge that we remove from the wastewater as it continues to run unnaturally into the sea off Point Loma and various points to the north. Inland fish, especially in the Imperial Valley, are at least, if not more contaminated with pesticides and metals than are coastal and ocean fish (see data from various reports of the California Toxic Substances Monitoring Program, State Water Resources Control Board, Sacramento). We should even wonder if some

of the wastes we have or will send east to landfills or croplands might eventually find their way into the Colorado river drainage and cause disorders to estuarine fish, such as the melanoma disease described by Barrera et al. (1984) in croaker of the upper Gulf of California. We are now required at yet greater expense (several billion dollars) to remove even more nitrogen, phosphorus and BOD from that treated sewage, putting those nutrients on land while the cleanest possible wastewater continues to run off to the desert sea coast. In short, we are withdrawing from the ocean what it needs for production (nutrients, organic matter and trace elements) and giving it what it doesn't (fresh water). Likewise, inland waters get what they don't need (contamination, Superfund sites) and are denied what they do need (flow).

Therefore, before summarily relegating contaminated wastes and sediments to land sites (landfills, croplands or wetlands) we should consider that such action may lead to long-term contaminant effects that might otherwise not occur under some ocean disposal alternative. Onshore, these effects may include subsequent ground and surface water contamination and contamination of rare and endangered fish and wildlife. At sea, by contrast, a 1979 review of the assimilative capacity of the oceans at a national workshop concluded that the waste capacity of U.S. coastal waters is not now fully used (Goldberg, 1981). Moreover, after extensive review, the National Advisory Committee on Oceans and Atmosphere (NACOA, 1980) concluded that, while the federal government should establish as a priority goal the reuse and recycling of wastes, it should also adopt and encourage an integrated approach to waste management, including the disposal of wastes in the manner and medium that minimizes the risk to human health (Knauss, 1981). Specifically, NACOA urged that the EPA policy that no ocean dumping permit will be issued when any land based alternative exists should be reversed. There remains a real need to continue research in support of ocean disposal (Kester et al, 1981; Kullenberg, 1986). The recently-reported lack of relationship between pollution trends and fishery stock trends of the Southern California Bight (Prager and MacCall, 1990) would seem to add impetus to the hypothesis that we haven't approached the assimilative capacity of Bight.

A BAY-WIDE MONITORING PROGRAM?

Lack of a region-wide (bay-wide) monitoring program is one of the reasons why we are just now becoming aware of contamination and contaminant effects in the Bay. There have recently been a lot of good pollution and toxicity surveys in the Bay, but individual survey efforts, even when taken together, do not constitute a regional assessment for setting cleanup priorities. Regardless of the actions taken to clean up and protect San Diego Bay, there must be a new region-wide monitoring program initiated to:

1-Establish a baseline for setting clean-up priorities and for judging benefits of clean-up actions,

2- Measure real reductions in Bay pollution, and

3- Provide a base of information for fairly comparing conditions in San Diego Bay with other urban bays.

It is clear from experience elsewhere in Southern California and the nation that an even half-way decent region-wide, long-term monitoring program can go a long way toward defining water quality problems, determining real trends and helping prioritize management needs. By integrating a Bay monitoring program with national efforts, conditions in the Bay can be placed in a national perspective.

Adopting a systems approach to monitoring now, such as recommended by the National Research Council (NRC, 1989 and 1990), would immediately benefit San Diego Bay users and managers because it would place monitoring squarely in the center of a management program, not at its periphery.

In addition, mangers should come to place high value on existing and historical data, developing a human system that supports and solicits the work and views of "old timers" and accumulates their data and methods. Every effort should be made to avoid breaking time-series. Older synoptic surveys should be repeated occasionally. All data should be evaluated on a

continuing basis to watch for mid-course corrections needed in management. An important endpoint, often overlooked in other monitoring programs, is the importance of scale - i.e., defining the true size of affected areas, whether their size is increasing or decreasing and how those scales relate to inputs or sources of pollutants (Mearns and O'Connor, 1984).

SUMMARY AND LESSONS

There is no question that sediments, waters and biota of the Bay are and have been contaminated with PCBs, petroleum hydrocarbons and some metals for many decades. Furthermore, there is some evidence of biological damage (such as fin rot and liver lesions in basses) caused by one or more groups of these chemicals. Unfortunately, we don't yet know if there is any link between the diseased fish population and the contaminant hot spots. Therefore, we can't yet guarantee that clean-up of hot spots, or control of contaminants in runoff, will cure the disease or result in additional benefits such as increases in abundance of fish and shellfish. Additional biological effects research, unpopular as it sounds (Mearns, 1984), could provide the needed assurance or point to as-yet-unmeasured chemicals or sources whose clean-up would make a difference in improving the health of Bay marine resources. The caution is to avoid "cures" that, in total, cause more long-lasting damage than the "disease" itself, to be sure that any actions taken to clean up the Bay cure real problems in the Bay without creating new ones elsewhere.

In evaluating clean-up strategies, it is important to consider the Bay in the wider scope of this region's limiting factors, assets and assimilative capacities. Freshwater is the most important factor limiting humans and wildlife in this desert coast. San Diego and L.A. take most of their water from sources hundreds of miles away, seriously affecting freshwater and estuarine ecosystems such as the Colorado River Delta, the Owens River system and San Francisco Bay. The Columbia may be next. In return, we are sending increasing amounts of sludge and solid wastes inland. What is the total ecological cost of moving additional Bay-area wastes and residues inland?

A major lesson from monitoring elsewhere along the coast is that not all materials we consider pollutants on land or in freshwater are pollutants in the sea. This was predicted by Isaacs (1969, 1976a, 1976b and 1978) who pointed out the great differences between land and sea ecosystems that seem to get lost in the bureaucratic melee of the day. Among those materials are organic matter, nutrients and most metals. Whether recognized in law or not, there is a demonstrated assimilative capacity for these materials in marine environments. If this desert society wishes to reduce or prevent inputs of these into the sea coast, it ought to do so in the context of solving water management problems and in a way that does not inhibit those solutions (such as continued adherence to concentration-based quality criteria for wastewaters). The clean-up of San Diego Bay should proceed with serious comparison and recognition of long-term consequences to terrestrial, freshwater and ocean ecosystems.

To underscore this point one more time, consider the messages San Diego could send to the rest of the world which often tries to emulate U.S. actions. As Figure 3 illustrates, nearly 71% of the Earth is covered by water, leaving 29% as exposed land. However, as few well-educated people seem to realize, 98% of the water is saltwater which is toxic to mammals, birds and reptiles, and most other land and aquatic animals and plants. Of the 2% that is freshwater, nearly all of it - 1.7% - is locked up as glacial ice, principally in Antarctica. Of the remaining 0.3% that is liquid, part is fresh surface water (0.016% of all water) and part is ground water (0.011% of all water), which most of humanity depends on for drinking water. As articulated by Osterberg (1986), ten to 100 times more food has and will continue to come from the land, not the sea. I do not advocate contaminating sea-life of nearshore ecosystems in order to keep terrestrial food clean. However, it seems ironic then that modern civilization is set on a course of denying the ocean's assimilative capacity for innocuous materials while doing our utmost to threaten the value of the one ten thousandth of all water that is potable and that otherwise supports all terrestrial and aquatic life.

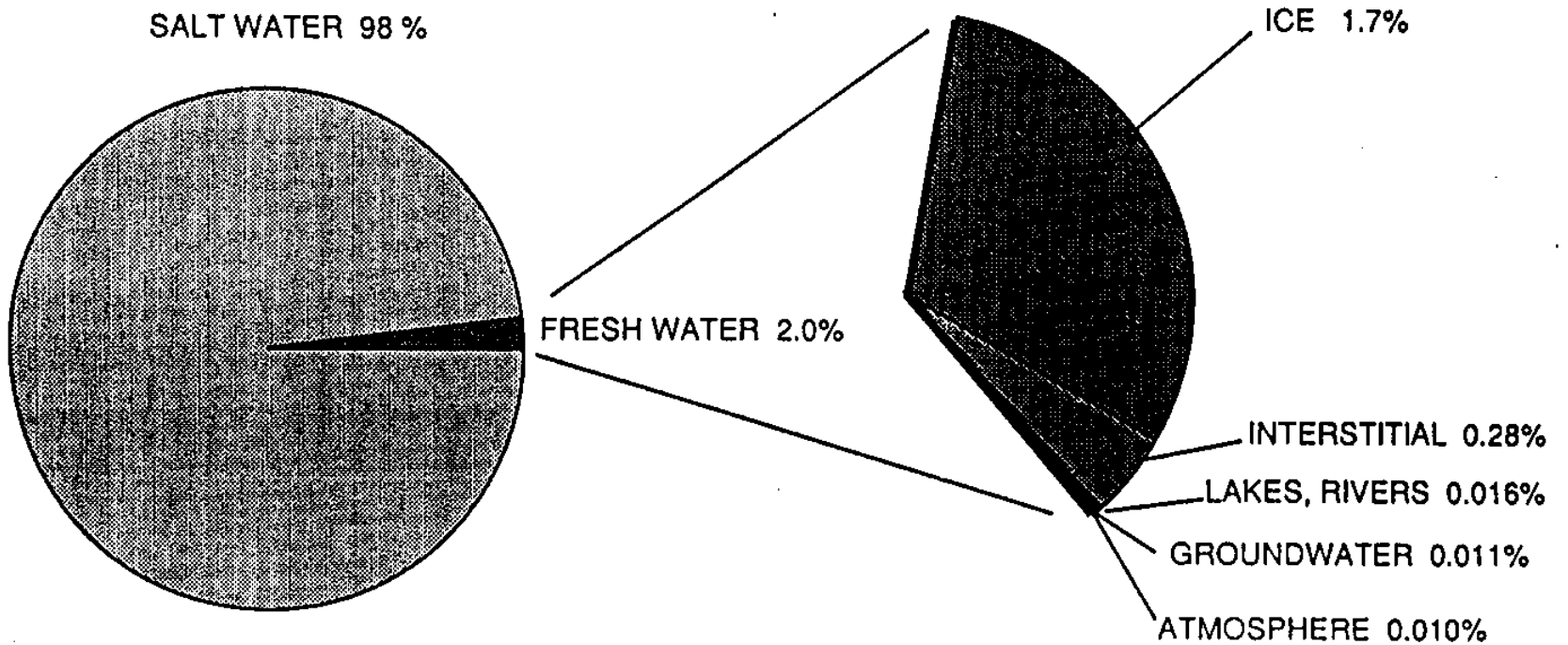

Figure 3 . Distribution in per cent of volumes of water on earth. Total 1400 million cubic kilometers. From various sources.

RECOMMENDATIONS

Here are some actions I think are important to pursue:

1) Develop a Region-wide (Bay-wide) monitoring program as an integral if not central part of a regional management plan: make it part of the management system at the onset.

2) Compile existing information about contaminants and biological conditions in the Bay into a single framework to help set priorities and identify information gaps. Include areas adjacent to the Bay (including Point Loma) for perspective.

3) Evaluate and publicize consequences to both ocean and terrestrial ecosystems of waste management options as part of the evaluation process. Especially evaluate possible long-term impacts of disposal and source control options on surface and groundwater resources.

In all three cases, move toward evaluation criteria that focus on the health of biological resources and not just on reducing chemical concentrations alone.

ACKNOWLEDGEMENTS

I would like to acknowledge the contributions of people here. This conference is part of a continuing saga of research, monitoring and pollution control successes along the U.S. west coast. Most of the technical speakers have been working and interacting with one another for over 15 years. They have witnessed numerous debates and watched as their data has been used, debated, discussed, transformed and challenged by all segments of coastal society. Today, as part of a continuing story, they are focusing for the first time on this bay, San Diego Bay. It is good to keep in mind the hundreds of man years of experience they, their technicians and supporting staff bring to this conference. We must salute them for continuing their vigil!

The opinions expressed in this presentation are solely those of the author and do not represent the views or policy of the National Oceanic and Atmospheric Administration.

References

Barrera, J.C., L.T. Findley, A.J. Mearns and J.C. Harshbarger. 1984. Melanotic neurofibroma in demersal fishes in the Gulf of California. p 276 In R.A. Montoya, W.A. Cornelius (eds). International inventory of current Mexico-related research. Volume 4. Center for U.S.-Mexican Studies, University of California at San Diego, La Jolla, California.

Flanagan, C.A. and J.R. Hendrickson. 1976. Observations on the commercial fishery and reproductive biology of the totoaba, Cynoscion macdonaldi, in the northern Gulf of California. Fish. Bull. (US) 74(3): 531-544.

Goldberg, E.D. (ed). 1979. Proceedings of a workshop on assimilative capacity of U.S. coastal waters for pollutants. Crystal Mountain, Washington, July 29-August 4, 1979. U.S. Dept. Com, National Oceanic and Atmospheric Administration, Boulder, Co. 284 pp.

Hendrickson, J.R. 1979. Totoaba: Sacrifice in the Gulf. Oceans 12(5): 14-18.

Isaacs, J.D. 1978. Testimony of Prof. John D. Isaacs, Director, Institute of Marine Resources, University of California, San Diego. Modification of secondary treatment requirements for discharges into marine waters. Hearings before the Subcommittee on Water Resources, Committee on Public Works and

Transportation, House of Representatives, Ninety-Fifth Congress, Second Session. May 25-25, 1978. U.S. Government Printing Office, Washington D.C.

Isaacs, J.D. 1969. The nature of oceanic life. Scientific American 221(3):146-162.

Isaacs, J.D. 1976a. Sanity and other factors in aquatic resource development. 72-85 In R.F. Scagel (ed), Mankind's future in the Pacific. The University of British Columbia.

Isaacs, J.D. 1976b. Reproductive products in marine food webs. So. Calif. Acad. Sci., 75:220-223.

Kahrl, W.L. (ed). 1978. The California Water Atlas. Governors Office, Office of Planning and Research, State of California, Sacramento. 118 pp.

Kelley, D. G. 1971. Edge of a Continent: The Pacific Coast from Alaska to Baja. American West Publishing Company, Palo Alto, CA. 288 pp.

Kester, D.R., B.H. Ketchum and P.K. Park. 1981. Future prospects of ocean dumping. 505-517 In B.H. Ketchum, D.R. Kester and P.K. Park, Ocean dumping of industrial wastes. Plenum Press, New York.

Knauss, J. A. 1981. A special report to the President and the Congress: The role of the ocean in a waste management strategy. National Advisory Committee on Oceans and Atmosphere, January 1981.103 pp + append.

Kullenberg, G. (ed). 1986. The role of the oceans as a waste disposal option. NATO ASI Series C: Mathematical and Physical Sciences Vol 172. D. Reidel Publ. Co., Dordrecht, Holland.

Mearns, A.J. 1985. Biological implications of the management of waste materials: the importance of integrating measures of exposure, uptake and effects. 335-343 In R.D. Cardwell, R. Purdy and R.C. Bahner (eds) Aquatic Toxicology and Hazard Assessment: Seventh Symposium. ASTM STP 854, American Society for the Testing of materials, Philadelphia, PA.

Mearns, A.J. and T.P. O'Connor. 1984. Biological effects versus pollutant inputs: the scale of things. 693-722 In H.H. White (ed), Concepts in Marine Pollution Measurements. Maryland Sea Grant Publication UM-SG-TS-84-03, College Park, Maryland.

O'Donnel, J.R., B.M. Kaplan and H.E. Allen. 1985. Bioavailability of trace metals in natural waters. 485-500 In R.D. Cardwell, R. Purdy and R.C. Bahner (eds) , Aquatic toxicology and hazard assessment: Seventh Symposium. ASTM Special Publication 854. American Society for the Testing of Materials, Philadelphia, PA.

Osterberg, C. 1986. Basic factors affecting the land/freshwater versus the sea option for waste disposal. 39-53 In G. Kullenberg (ed). Proceedings of the NATO Advanced Research Workshop on Scientific Basis for the Role of the Oceans as a Waste Disposal Option. Vilamoura, Portugal, April 24-30, 1985. NATO ASI Series C, Mathematical and Physical Sciences, Vol 172. D. Reidel Publishing Co., Dordrect, Holland.

Osterberg, C.L. 1982. The Ocean - Nature's trash basket. Waste management Conference, Tucson, Arizona. March 11, 1982.

Prager, M.H. and A.D. MacCall. 1990. Biostatistical models of contaminant and climate influences on fish populations of the Southern California Bight. Old Dominion University Technical Report 90-04.

Schafer, H.A. 1989. Water quality: Improving Southern California's coastal waters. Journal Water Pollution Control Federation 61(8):1395-1401.

TECHNICAL WORKSHOP REPORTS

POLLUTION SOURCES

Technical Workshop Report

This paper represents the collective input of participants in the Pollution Sources Workshop of the San Diego Bay Symposium. Although some participants may not agree with all of the statements and recommendations presented here, this paper is presented as a consensus of that workshop. The following persons are the primary authors of this paper: Peter Michael, San Diego Regional Water Quality Control Board; Jack Anderson, Southern California Coastal Waters Research Project; and Jay Powell, Environmental Health Coalition.

POLLUTION SOURCES TECHNICAL WORKSHOP REPORT

INTRODUCTION

A number of chemical and biological contaminants are capable of affecting the beneficial uses of San Diego Bay. Over the past few decades, bay habitats have been substantially affected by both urban activities and natural events. Fish and wildlife habitats have been altered by shoreline development. Eel grass beds have been impacted by fertilizers washing into the bay, and salt marshes have been found to serve as traps for a number of pollutants. Similarly, many fish taken from the bay have been found to contain some chlorinated hydrocarbons.

The magnitude and extent of these problems is not entirely clear. However, it is obvious that a better understanding of the factors contributing to them will be necessary. This includes information on water movement, fish migration patterns, and sediment transport within the bay. More importantly, though, if pollution problems in the bay are to be minimized or eliminated, a thorough understanding of the sources of these contaminants is essential. The current state of our knowledge of pollution sources affecting San Diego Bay is discussed here.

A number of human activities present potential sources of contamination to the bay. The following issues are currently thought to be the most significant, and are discussed below:

1) Underground Dewatering
2) Industries on the Bay and Upstream from the Bay
3) Marinas and Anchorages
4) U.S. Naval Installations
5) Underwater Hull Cleaning and Vessel Antifouling Paints
6) Urban Runoff

In addition to identifying and discussing these areas of concern, specific recommendations are provided for managing each.

UNDERGROUND DEWATERING

Activities such as construction dewatering and maintenance dewatering of underground structures can provide pathways for the movement of underground contamination into San Diego Bay. Dewatering operations associated with construction activities may pump pollutants into the bay either temporarily during foundation construction, or continuously throughout the life of the building. In addition, contamination from leaking underground tanks has already entered the bay, and is an ongoing problem.

Although other contaminants may be found in soil and groundwater, the contaminants of primary concern from dewatering activities are petroleum hydrocarbons. Several sites near San Diego Bay contain petroleum products which have leaked from underground tanks or pipelines. Two major sites currently under investigation are the downtown "blob" and the Lindbergh Field airport fuel farm. These sites are being addressed by regulatory efforts currently underway.

Under the San Diego Regional Water Quality Control Board's new general permit for dewatering projects around San Diego Bay, new buildings must be designed so that dewatering is no longer necessary upon completion of the building. Existing buildings, such as the San Diego Convention Center, and buildings already designed, will be allowed to pump groundwater into the bay. However, in these cases, the National Pollutant Discharge Elimination System (NPDES) and California Water Code permits would require continuous monitoring and reporting. If pollutants are encountered in groundwater, treatment will be required.

Recommendation:
General permit NPDES monitoring data should be carefully reviewed to assure that petroleum and other wastes are not discharged into the bay.

INDUSTRIES ON THE BAY AND UPSTREAM FROM THE BAY

Industry Permitting

Most industries around San Diego Bay handling hazardous materials or producing hazardous wastes are required to obtain a permit from the County of San Diego. This local agency provides guidance for businesses to ensure that all hazardous substances are handled and disposed of in an appropriate manner. Under the Federal Pretreatment program, the Metropolitan Sewerage Agency (City of San Diego) also issues permits for industries discharging wastes into sanitary sewers.

Both federal and state law prohibit the release of unpermitted wastes to surface waters. It is therefore the responsibility of industries around San Diego Bay to assure that permitted discharges will not affect bay uses. Permits issued under the California Water Code or the Federal Clean Water Act are not usually required unless an industry's waste stream or potential discharge threatens water quality. An example of such a "threatened discharge" would be bay water pumped from a dry dock.

Industry Accomplishments

Industries have made significant progress in abating the discharge of pollutants to the bay. However, it is important to note that not all industrial waste problems are caused directly by permitted facilities. Although shipyards and boat yards provide the space for performing work, many contractors who work at these facilities are not directly regulated. Individuals may also perform boat maintenance at marinas which do not have NPDES permits, and therefore are not permitted under this system.

For those industries that do have NPDES permits, monitoring programs are being upgraded to require sampling, lab analysis, and reporting to the Regional Water Quality Control Board. This should provide an early warning of potential problems.

The following new practices and programs have also resulted in reductions of industrial discharges to the bay:

1. Boat yards have constructed waste containment facilities, provided interior drainage, outfitted vessels with tarps for topside sanding and painting work, or have changed operating procedures to prevent the release of wastes. The effects of past releases of wastes adjacent to boat yards are unknown.

2. Shipyard operators have outfitted dry docks with tarps to prevent the release of airborne paint spray and sandblasting waste, changed dry dock flooding procedures to assure that the deck is swept and vacuumed before submerging, and trained employees to avoid placing wastes where they might pollute the bay. These best management practices have minimized the potential for discharges to the bay.

3. Under the Source Reduction and Review Act of 1989, many California industries, such as aerospace firms, will be required to implement programs for reducing the production of wastes.

Recommendation:
Industries should continue to implement source control measures, and to require that all persons doing work in boatyards and shipyards use best management practices to prevent the release of pollutants.

MARINAS AND ANCHORAGES

Oil changes, bilge pumping, and the release of sewage at marinas and anchorages are all examples of activities that provide potential sources of contamination to the bay. Marinas are currently not required to provide facilities for oil and paint storage recycling or disposal.

Additionally, few sewage holding tank pump out stations around the bay are installed or operable, and existing facilities are infrequently used by boaters. It is not known whether illegal releases of sewage from vessels are producing conditions considered unsafe for swimming.

Recommendation:
All marinas and docks should be required to provide storage or recycling facilities for oil and paint.

Recommendation:
Marinas should be required to provide easily-accessible and fully-maintained sewage pump out services.

U.S. NAVAL INSTALLATIONS

The U.S. Navy controls much of the shoreline around San Diego Bay. Much of what is known has been provided by the Navy. For example, the Naval Ocean Systems Center marine environmental laboratory has made valuable contributions to our knowledge of San Diego Bay.

Currently, little is known about urban runoff components and the makeup of surface films near Navy fueling facilities. However, sampling programs are being conducted which may provide more information on existing water quality conditions near major U.S. Naval installations.

In the past, the Navy has interpreted federal Clean Water Act NPDES permits as applying to facilities located along the shoreline. However, progress is expected in providing adequate information to evaluate pollution control programs for entire installations, both inland and along the shoreline.

Recommendation:
Frequently-observed surface films and sources of spills near Navy fueling facilities should be identified and monitored.

UNDERWATER HULL CLEANING AND VESSEL ANTIFOULING PAINTS

Significant reductions in tributyltin (TBT) concentrations found in marinas have been seen due to new registration and application programs. New paint formulations are also being developed which may prove to be less toxic than current antifouling paints.
Best management practices designed to reduce the environmental effects of antifouling paint removal have been proposed by some underwater hull cleaning companies. The Regional Water Quality Control Board is currently conducting a survey of commercial divers to evaluate the nature of this industry.

Recommendation:
The development and testing of completely non-toxic coatings for boat bottoms should be encouraged.

URBAN RUNOFF

Storm water runoff conveys many materials, such as heavy metals, organic compounds, and bacteria and viruses into the bay from upland areas. These materials may be toxic or contribute to nuisance problems. The potential effects of industrial and household hazardous waste discharges have not been quantified.

Under the Clean Water Act, urban runoff was originally considered a non-point pollution source. However, the courts have now required that NPDES permits should be issued for urban storm drains. "Early permits" for drains 36 inches or greater in diameter are now being processed for all civilian and military jurisdictions around the bay. These permits contain monitoring and reporting requirements that will provide valuable information for understanding the complexity of urban runoff.

To date, most of the drains around San Diego Bay have been mapped, and areas tributary to the drains have been identified. Upstream industries capable of spilling toxic wastes have also been identified.

Recommendation:
Innovative approaches should be devised to reduce the effects of urban runoff on San Diego Bay.

CONCLUSIONS

Effective management of contamination problems in San Diego Bay will require a more thorough understanding of pollution sources. The following steps are recommended for managing pollution sources in San Diego Bay:

- **Underground Dewatering.**
  General permit monitoring data should be carefully reviewed to assure that petroleum and other wastes are not discharged into the bay.

- **Industries on the Bay and Upstream From the Bay.**
  Industries should continue to implement source control measures, and to require that all persons doing

work in boatyards and shipyards use best management practices to prevent release of pollutants.

- **Marinas and Anchorages.**
  All marinas and docks should be required to provide storage or recycling facilities for oil and paint.

  Marinas should be required to provide easily-accessible and fully-maintained sewage pump out services.

- **U.S. Naval Installations.**
  Frequently-observed surface films near Navy fueling facilities and the sources of these films should be identified and monitored.

- **Underwater Hull Cleaning and Vessel Antifouling Paints.**
  The development and testing of completely non-toxic coatings for boat bottoms should be encouraged.

- **Urban Runoff.**
  Innovative approaches should be devised to reduce the effects of urban runoff on San Diego Bay.

In addition to the identification and characterization of the sources of pollution, it is important to increase our understanding of bay habitats and the movement of pollutants within them. Many areas require further study in order to adequately characterize these issues. Especially important are the movement of water, fish migration patterns, and sediment transport in the bay. It is difficult to characterize patterns of pollutant transport in the bay. Tides, winds, currents, topography, and water density all contribute to pollutant transport. Although certain sediment "toxic hot spots" have been identified, it is not clear how chemical pollutants are incorporated into the tissues of fish and wildlife. Diseased fish have been examined, but the magnitude of the problem is not clear.

The effect of fertilizers washing into the bay on valuable eel grass beds also needs further study. These fertilizers have been found to enhance plankton growth. While drought conditions over the last four years have promoted eel grass growth due to lower concentrations of suspended solids and nutrients entering the bay, a better understanding of the interaction of these parameters is necessary.

It is possible that some characteristics of the bay's ecosystems may be utilized to help combat pollution source problems. For instance, in addition to providing valuable habitat for fish and wildlife, salt marshes also serve as effective traps for many pollutants. This feature could be utilized in planned source control programs for urban runoff. However, such programs should be undertaken with caution. In the event that salt marshes are lost, replacement has been seen to occur very slowly.

POLLUTION MONITORING AND ENVIRONMENTAL RISK ASSESSMENT

Technical Workshop Report

This paper represents the collective input of participants in the Pollution Monitoring and Environmental Risks Workshop of the San Diego Bay Symposium. Although some participants may not agree with all of the statements and recommendations presented here, this paper is presented as a consensus of that workshop. The following persons are the primary authors of this paper: Peter Seligman, Naval Ocean Systems Center; Art Coe, California Regional Water Quality Control Board, San Diego Region; Doug Diener MEC Analytical Systems; John Duffy, California Department of Fish and Game; Richard Ford, San Diego State University, Department of Biology; Bruce McCain, National Marine Fisheries Service; Alan Mearns, National Oceanic and Atmospheric Administration; Ken Richter, Naval Ocean Systems Center; Mike Salazar, Naval Ocean Systems Center; Mark Stephenson, California Department of Fish and Game; Rick Swartz, U.S. Environmental Protection Agency; and David Young, U.S. Environmental Protection Agency.

POLLUTION MONITORING AND ENVIRONMENTAL RISK ASSESSMENT TECHNICAL WORKSHOP REPORT

INTRODUCTION

Environmental monitoring is an essential component of any program established to evaluate and manage the effects of chemical and/or biological contamination. Programs such as the California State Mussel Watch (SMW) and the National Oceanic and Atmospheric Administration (NOAA) Status and Trends Program have clearly demonstrated the efficacy of monitoring information in evaluating and managing contamination problems in the marine setting, and specifically in San Diego Bay.

A well-designed monitoring program can provide a number of benefits. This includes establishing priorities for environmental protection and for the assessment of status and trends, providing an early warning system that allows for lower-cost solutions to environmental problems. Even more importantly, monitoring information can provide environmental managers with the necessary scientific rationale for making decisions to protect the public health and the environment.

The principal technical issues related to pollution monitoring and environmental risk assessment of San Diego Bay are described here. Additionally, the role of environmental risk assessment in this process is examined, and the data requirements necessary to make risk assessment evaluations for remediation/ cleanup decisions are defined. Specific recommendations are provided where appropriate. The following issues are discussed below:

1) What do we currently know about the environmental status of San Diego Bay?

2) What information do we need to increase our understanding of the status of the Bay?

3) What role should ecological risk assessment play in determining cleanup/remediation requirements versus simply using chemical contaminant levels as determinants?

4) How can we more effectively utilize the monitoring data that has been collected? What are the data sharing and data base requirements?

5) Who has the responsibility for monitoring? (point and non-point sources, receiving waters and sediments removed from sources, biological resources, and ecological status)

6) How can agencies better coordinate monitoring activities to optimize limited resources and prevent duplication. Who has oversight, and can procedures be standardized for intercomparability?

Current and recent monitoring programs that have provided information on San Diego Bay, and the findings of these programs, are also evaluated. Additionally, an overview is provided of the bay's present biological status.

WHAT DO WE CURRENTLY KNOW ABOUT THE ENVIRONMENTAL STATUS OF SAN DIEGO BAY?

The question of the environmental status of San Diego Bay is a complex issue for which there are no easy answers. However, there is no uncertainty that significantly elevated levels of many pollutants are found in some industrial and vessel maintenance and berthing areas. Among the more significant pollutants are the following:

- chlorinated hydrocarbons such as polychlorinated biphenyls (PCBs),
- toxic components of petroleum hydrocarbons and related polynuclear aromatic hydrocarbons (PAHs),
- heavy metals, and
- organotins (such as Tributyltin [TBT]).

Many contaminant "hot spots" have been located or confirmed using mussel tissue values

from the State Mussel Watch Program and NOAA Status and Trends Program. However, a serious shortcoming of this and other monitoring data is that most efforts have been limited to areas such as pollution sources and contaminant hot spots. Little attention has been given to determining either the overall status of San Diego Bay or long-term contaminant trends. There has also been very little sampling in the southern portion of the bay, and even less in central open areas, to determine the extent of contamination and possible effects.

Sediment toxicity has been verified in laboratory tests from some of these areas, and fish showing signs of pollution-related diseases such as fin rot and liver tumors have been collected from the bay. However, this information has also been collected primarily near contaminant sources.

A survey of much of the existing data suggests that San Diego Bay suffers from the typical problems of urban harbors surrounded by large population centers, especially the following:

- effluents from non-point storm drain runoff carrying chlorinated and petroleum hydrocarbons, PAHs, metals and pesticides,
- vessel-related contamination from marinas, maintenance activities, antifouling paints, and discharges consisting primarily of copper and other metals, organotins, oily wastes and occasional sewage, and
- residues of prior and possibly existing industrial discharge practices such as PCB's, solvents and some metals.

However, San Diego Bay has shown positive signs of continuing improvement since the mid-1960's, when steps were first taken to remedy sewage and industrial discharges into the bay. For example, recent surveys have documented that species composition of fish is similar to a survey taken in the 1880's and eelgrass, an important component of the bay ecosystem, has made a comeback over the last 20 years. In addition, there are few if any industrial discharges remaining in the bay. Tributyltin concentrations have also been significantly reduced in the last two years because of restrictive legislation directed towards the painting of small craft.

San Diego Bay likely represents a "typical" urban harbor in its pollutant profile. The relatively high levels of PCBs and PAHs, while of concern, are far below levels found in highly contaminated hot spots reported in some other harbors and estuaries.

WHAT INFORMATION DO WE NEED TO INCREASE OUR UNDERSTANDING OF THE STATUS OF THE BAY?

Two types of information are needed to improve our knowledge of San Diego Bay. First, research should be directed at filling critical information gaps that currently exist. Secondly, a comprehensive monitoring program should be instituted to more fully evaluate spatial and temporal trends of contaminants in the bay, and their effects on bay habitats.

Further Research to Fill Critical Information Gaps.

1) **Identification of contaminants that are not traditionally measured should be made.** Currently, only a small portion of the contaminants that could be measured are analyzed. Some unidentified compounds may represent equal or possibly greater environmental risks. A state-of-the-art scientific literature survey should be made, as well as a thorough review of hazardous substances used in manufacturing in the bay region. Results of this evaluation should be used to recommend whether or not additional contaminants should be added to those compounds that are currently monitored.

2) **Ecological studies are needed to better understand the effects of pollution and disturbance at the population and community levels.** Large scale seasonal studies should be performed in representative areas of the outer and central bay. These studies should be designed to characterize the bay's ecological systems and to assess the degree of ecological degradation caused

by past and present pollution. Agencies that manage and regulate marine pollution sources and water quality in San Diego Bay should be responsible for coordinating these studies.

3) **Food-chain biomagnification studies for selected organic compounds such as PCBs, PAHs and certain organometals should be conducted.** These compounds may directly threaten marine organisms in the bay. In addition, they may bioaccumulate, presenting a risk to local marine and shore birds that feed on bay organisms, or to human consumers of fish or shellfish that are collected in the bay. An evaluation of the biomagnification of these contaminants should be made.

4) **A comprehensive, bay-wide hydrodynamic-fate model should be developed for use as a tool in predicting both the dispersion and fate of contaminants into different sections of the bay.** The development and testing of such models have been proposed by both the Naval Ocean Systems Center (NOSC) and the Regional Water Quality Control Board. NOSC has already initiated the development of a model. Cooperative development of a model between these two agencies and other interested organizations is recommended.

5) **A comprehensive study of the toxicity and bioavailability of contaminants associated with San Diego Bay sediments is needed.** It has been recommended to the State Water Resources Control Board that San Diego Bay be used as a test harbor for evaluating and defining sediment criteria and standards based on toxic response to sediments and state-of-the-art chemistry. San Diego Bay is ideal for such a project because of its reasonably well-defined toxic hot spots and toxicity gradients. A joint agency group, as well as the necessary funding, should be identified to proceed on this project.

Monitoring Information.

Why is monitoring needed? Monitoring information meets many needs, including the following:

(From NRC report on Managing Troubled Waters - The role of Marine Environmental Monitoring. National Academy Press, 1990.)

- Monitoring provides the information needed to evaluate pollution abatement actions.
- Monitoring information can provide an early warning system allowing for lower-cost solutions to environmental problems.
- Monitoring contributes to our knowledge of marine ecosystems and how they are affected by human activity. This knowledge aids in the establishment of priorities for environmental protection and for the assessment of status and trends.
- Monitoring information helps answer such question as "Is it safe to swim or eat the fish?"
- Monitoring information is essential to the construction, adjustment and verification of quantitative predictive models which are an important basis for evaluating, developing and selecting environmental management strategies.
- Monitoring information provides environmental managers the scientific rationale for setting environmental quality standards.
- Monitoring determines compliance with conditions set forth in discharge permits.

Monitoring Recommendations for San Diego Bay. The following measures should be instituted as elements of a comprehensive monitoring program for San Diego Bay: (NOTE: Monitoring recommendations that deal specifically with human health risks are discussed in Section III: Human Health Risks)

1) **A comprehensive biological and chemical baseline should be established from which to evaluate changes.** An effective baseline simplifies and reduces the costs of follow-on monitoring programs because it reduces the required sampling effort. The objectives of the baseline, as well as the parameters to be studied, should be clearly defined. The baseline should be updated every 5-10 years.

2) **Long-term trend monitoring should be initiated at a larger number of sites in all regions of the bay.** Measurements should be made at least annually to evaluate changes in the bay, as well as the magnitude and extent of pollution in all bay habitats. A recommended approach would be to follow the basic parameters of the NOAA Status and Trends program at a greater number of sites than are now utilized. State Mussel Watch data should also be expanded to include a more comprehensive set of stations. These should be constant throughout time and allow for a closer following of trends.

3) **A pollutant loading survey should be conducted to evaluate the relative importance of potential contaminant input routes.** This survey should include storm drain runoffs, vessel discharges and maintenance activities, industrial discharges, and desorption from contaminated bottom sediments. This information is essential in designing a cost-effective remediation program for San Diego Bay.

WHAT ROLE SHOULD ECOLOGICAL RISK ASSESSMENT PLAY IN DETERMINING CLEANUP/REMEDIATION REQUIREMENTS VERSUS SIMPLY USING CHEMICAL CONTAMINANT LEVELS AS DETERMINANTS?

Ecological and human health risk assessment should be used to formulate risk-based remediation and cleanup decisions. Regulatory and cleanup decisions are often based solely on the level of a contaminant in sediments adjacent to a facility or discharge. Little, if any evaluation of the direct environmental risk of the contaminant or of the cleanup procedure is made.

Environmental risk analysis procedures have been and are continuing to be developed, and can be used as a guide in developing risk assessment strategies to support risk management decisions (See Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference, U.S. EPA/600/3-89/013, March, 1989).

For many reasons, confidence in cleanup and monitoring decisions is greatly enhanced when they are based on a combination of chemical, ecological, and toxicological data. These include the following:

- Ecological and toxicological data can be used to assess the aggregate toxicity of all toxic constituents at a contaminated site.
- The bioavailability of toxic chemicals is measured with ecological and toxicological assessments, but not with chemical analyses. Therefore, the use of chemical data alone may over- or underestimate the toxicities of single chemicals.
- Ecological and toxicological assessments link chemical-specific toxicity with measured biological responses. This provides a realistic assessment of environmental effects.
- Ecological and toxicological assessments provide information on the magnitude and variation of toxic effects which may be useful in developing cleanup and monitoring strategies.

The following aspects should be incorporated in the development of ecological risk assessment protocols:

- A link should be established between the ecological effects and the toxicity of contaminants by evaluating both the toxic effects to biota and chemical constituents of the sediments.

- Both water column and sediment parameters should be studied with the following questions in mind:

  1) Are the toxicants moving from sediments to the water column?

  2) What is the environmental partitioning of contaminants between water, suspended particulates, bottom sediments and pelagic and benthic organisms?

- When possible, field studies, laboratory toxicity tests, and bioavailability studies should be conducted to establish accurate risk estimates. These estimates can then be used to make informed remediation decisions.

- Ecological surveys should be used to establish if adverse ecological effects have occurred.

HOW CAN WE MORE EFFECTIVELY UTILIZE THE MONITORING DATA THAT HAS BEEN COLLECTED? WHAT ARE THE DATA SHARING AND DATA BASE MANAGEMENT REQUIREMENTS?

Data compilation from all monitoring programs should be centralized and maintained in a consistent computer format and data base. Efforts to establish a baseline and monitoring program are currently weakened because an adequate mechanism for accessing information in a format that allows reanalysis does not exist.

The Ocean Data Evaluation System (ODES), developed by the EPA, should be considered here because it already provides a format for organizing data that is being standardized for the entire country. The planned development of a water quality data base may be the appropriate repository for the ODES.

The design of monitoring programs and their results should also be peer reviewed. The establishment of a scientific review panel for both monitoring and special studies should be considered. There should be a single coordinator with the responsibility for maintaining monitoring and other water quality data on San Diego Bay.

WHO HAS THE RESPONSIBILITY FOR MONITORING? (POINT AND NON-POINT SOURCES, RECEIVING WATERS AND SEDIMENTS REMOVED FROM SOURCES, BIOLOGICAL RESOURCES, AND ECOLOGICAL STATUS)

Monitoring in San Diego Bay is conducted under regulatory authority of the California Porter-Cologne Water Quality Control Act, as well as various state and federal studies and special programs. Under Porter-Cologne, the California Regional Water Quality Control Board has historically imposed monitoring programs on discharges to San Diego Bay. These California Water Code and NPDES point source permitting programs continue for the duration of the discharges. This program is currently limited because most industrial discharges have terminated.

The Board also requires monitoring as part of many enforcement programs. These include the ongoing efforts relative to discharges of copper ore, PCBs, and antifouling paint wastes from boat yards.

Monitoring of non-point sources in San Diego Bay is also a major concern. A non-point source monitoring program should be established by the Regional Board.

HOW CAN AGENCIES BETTER COORDINATE MONITORING ACTIVITIES TO OPTIMIZE LIMITED RESOURCES AND PREVENT DUPLICATION? WHO HAS OVERSIGHT, CAN PROCEDURES BE STANDARDIZED FOR INTERCOMPATIBILITY?

The San Diego Interagency Water Quality Panel, set up by AB 158, is the appropriate forum for improving coordination between agencies. Further efforts toward this goal should be made by the panel in the future. In addition, a scientific advisory subpanel should be added to support standardization, and for peer review and oversight of monitoring and special studies.

AN OVERVIEW OF MONITORING ACTIVITIES IN SAN DIEGO BAY

Table 1 provides a summary of the general types of monitoring currently being conducted in San Diego Bay, and the agencies responsible for these efforts. The following summaries describe the major monitoring programs and special studies that are currently being conducted, or that have recently been completed in San Diego Bay:

NOAA National Status and Trends Program.

Program Description. The principal objective of this program is to determine the current status of, and to detect any changes that are occurring in, the environmental quality of the nation's coastal and estuarine waters. The program is divided into the following:

1) **Benthic Surveillance Project.** This program was initiated in 1984. Concentrations of toxic chemicals are determined in sediments and bottom-dwelling fish taken from the same areas. The frequency of external disease conditions and internal lesions (liver tumors) are documented at about 75 sites nationwide.

2) **Mussel Watch Project.** Initiated in 1986, this program involves the annual collection and analysis of mussels or oysters for an identical suite of chemicals at about 200 sites. Sediments are also analyzed at some sites.

The list of chemicals encompassed in these analyses includes polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), chlorinated pesticides (DDT and 9 others), butyltins, and 12 trace elements.

Program Findings. Two NOAA sediment sample sites within San Diego Bay, one near Harbor Island and the other in the south bay, near the Coronado Bridge, were found to be contaminated with elevated levels of cadmium, lead, zinc, copper mercury and arsenic. The south bay site also had levels of PCBs and PAHs that ranked in the top 20 in the U.S. Sites outside the harbor had few, if any, elevated levels of contaminants.

Elevated levels of PCBs and PAHs were measured in mussels from the Harbor Island site. Slightly elevated levels of cadmium and copper were also noted.

Toxicopathic diseases (liver lesions and fin erosion) in fish were evaluated at several sites in San Diego Bay. Sites in the south and central bay yielded elevated concentrations of PCBs in fish livers, and PAH metabolites in bile. Some fin erosion, commonly associated with toxic compounds, was noted in several benthic fish species. Liver neoplasms (tumors) were found in 13.8% of the black croaker from one site.

The NOAA data seems to indicate the existence of certain pollution problems. For instance, some of the metal and organic contaminants are at, or exceed, levels that have shown toxicity in sediment tests. However, this very limited testing has tended to be near contaminated hot spots. Therefore, significantly more intensive monitoring will be needed to define the overall status of the bay.

California Mussel Watch (State Water Resources Control Board/ Calif. Dept. of Fish & Game).

Program Description. The California State Mussel Watch Program (SMW) was initiated in 1977 to monitor long-term trends in pollutant concentrations in marine organisms, to identify locations where higher than expected concentrations of pollutants exist, and to provide the evidence needed to initiate follow-up actions for detecting, correcting, and cleaning up pollution sources. Since 1980, the SMW program has monitored PCBs, and chlorinated pesticides at 43 stations, and toxic trace metals at 28 stations in San Diego Bay.

Program Findings. The focus of this program within San Diego Bay has been to identify contaminant hot spots. The following locations have repeatedly shown elevated concentrations of contaminants in mussel tissues:

1) **East Basin storm drain.** This area receives surface runoff from Lindbergh Field and related industries. Since 1980, it has consistently shown the highest levels of the PCBs Arochlor 1254 and 1248 in San Diego Bay.

Table 1. MONITORING ACTIVITIES IN SAN DIEGO BAY

	PAST	PRESENT	FUTURE
1. CONTAMINANT BACKGROUND AND SOURCE IDENTIFICATION:			
A. SEDIMENTS	1 (TBT) 2 (ORG, MET) 4,5,8 (ORG, MET)	1 (TBT) 2 (ORG, MET) 4 (ORG, MET) 7 (ORG, MET, RAD)	1 (TBT) 2 (ORG, MET) 4 (ORG, MET)
B. TISSUE	3 (ORG, MET) 4 (ORG, MET) 8 (ORG, MET)	3 (ORG, MET) 4 (ORG, MET)	3 (ORG, MET) 4 (ORG, MET)
C. WATER			2 (ORG, MET) 2 (PET)
2. LONG TERM CONTAMINANT TRENDS:			
A. SEDIMENTS	1 (TBT) 2 (ORG, MET) 4 (ORG, MET) 11 (TBT)	1 (TBT) 2 (ORG, MET) 4 (ORG, MET) 7 (ORG, MET, RAD) 11 (TBT)	1 (TBT) 2 (ORG, MET) 4 (ORG, MET) 11 (TBT)
B. TISSUE (MUSSELS)	3 (ORG, MET) 4 (ORG, MET) 11 (TBT)	3 (ORG, MET) 4 (ORG, MET) 11 (TBT)	3 (ORG, MET) 4 (ORG, MET) 11 (TBT)
C. TISSUE (FISH)	4 (ORG, MET)	4 (ORG, MET) 9 (ORG, MET)	4 (ORG, MET) 9 (ORG, MET)
D. WATER	11 (TBT)	11 (TBT)	11 (TBT)
3. BIOASSAYS-SEDIMENT AND WATER COLUMN	1 (TBT) 5,8 (ORG, MET)	1 (TBT)	1 (TBT) 2 (TBT) 3 (TBT)
4. FISH HISTOPATHOLOGY	4	4	4
5. DEGRADATION AND RELEASE RATE IN SEDIMENTS	1 (TBT)	1 (TBT)	1 (TBT) 5 (ORG)
6. MASS BALANCE ESTIMATES OF INPUTS	1 (TBT)	1 (TBT)	
7. HYDRODYNAMIC MODELING STUDIES	1 (TBT)	1 (TBT)	1 (TBT) 2
8. BIOACCUMULATION IN BIRDS	6 (?)	6 (?)	1 (TBT) 5 (ORG)
9. IDENTIFICATION OF ADDITIONAL CONTAMINANTS	2 (PCTs)		
10. BIOLOGICAL SURVEYS	10	10	10

KEY TO AGENCY CODE:

1 = NOSC
2 = RWQCB & CFG
3 = SWRCB
4 = NOAA
5 = EPA
6 = USF&W
7 = SANDAG
8 = SCCWRP
9 = PORT DISTRICT & S.D. COUNTY DOHS
10= SDG&E, PORT DISTRICT & CA COASTAL CONSERVANCY
11= CDFA; CDFG

KEY TO CONTAMINANT CODE:

TBT - TRIBUTYLTIN
ORG - CHLORINATED ORGANICS (PESTICIDES) AND PCBs
MET - METALS
RAD - ALPHA AND BETA RADIOISOTOPES
PCTs- POLYCHLORINATEDTERPHENYLS

2) **24th St. Marine Terminal.** SMW surveys from 1981 to 1983 identified a significant source of copper and zinc in this area. Acting on this information, the Regional Water Quality Control Board determined than an ore transfer facility at the Terminal was responsible for these high concentrations.

3) **Coronado Bridge industrial area.** This industrial and naval area near the eastern base of the Coronado bridge has shown repeatedly high level of PCBs and polychlorinated terphenyls (PCTs). The mixtures of PCBs suggest that cutting oils may be the source.

4) **Commercial Basin boat yards.** This area is high in tributyltin (TBT), copper, zinc and lead. This indicates that bottom paints from both maintenance practices and direct leaching are likely the source.

Although the SMW program has not concentrated on long-term trend monitoring in San Diego Bay, several of the stations were sampled 4-5 times between 1980 to 1989. However, no trends have been documented that identify a need for increased sampling of these stations.

San Diego Bay Cleanup Project (San Diego Regional Water Quality Control Board).

Program Description. The purpose of this 5-year project is to characterize sources of pollution in San Diego Bay that can be regulated by the Regional Water Quality Control Board. The following elements were or are being evaluated in the first and second years of the study:

- Characterization of tributyltins in water, mussel tissue, oyster tissue, and sediments. Efforts have been concentrated near boat-yards. The effects of TBT on oysters and attached invertebrates was also studied.
- Shipyard monitoring.
- Storm Drain Monitoring; includes the characterization of contaminants in and near the end of storm drains.
- Characterization of contaminants in sediments at Naval Facilities.
- Hull Cleaning Surveys; includes interviewing vessel owners about methods used to clean hulls.

The following areas will be studied in the future:

- Bay Circulation Study. In cooperation with the Bay model being developed by the Naval Ocean Systems Center (NOSC) a predictive circulation and flushing model will be refined.
- Oil fingerprinting. Petroleum hydrocarbons in the bay will be sampled so that sources can be identified.
- A complete underwater hull cleaning survey will be conducted.
- Background concentrations of pollutants in sediment and water will be determined in the bay.

San Diego Association of Governments Project.

Program Description. The purpose of this project, funded by the U.S. EPA under the Section 205(j) of the Clean Water Act, was to identify contaminant hot spots in sediments in the vicinity of Navy facilities at the Submarine Base and North Island, and to determine background concentrations of radioactivity in the bay. The study is currently underway.

U.S. Navy Statutory Organotin Monitoring Program (NOSC).

Program Description. This program, carried out by the Naval Ocean Systems Center, provides quarterly monitoring of butyltin concentrations in water, as well as semiannual measurements of sediments and mussel tissues at about 18 stations in San Diego Bay (Norfolk and Hawaii are also monitored).

Program Findings. Tributyltin (TBT) concentrations have been monitored in the bay since 1983 and more intensively since 1986. TBT concentrations increased, particularly in yacht harbors, until about 1987. At this time,

concentrations exceeded 100 ng/l (parts per trillion) in the water column at yacht harbors and was generally in the range of 5 to 20 ng/l in the rest of the bay. At times, concentrations in the most contaminated yacht harbors exceeded 500 ng/l, levels that are acutely toxic to some organisms.

Since restrictive legislation was passed in 1988, average concentrations have decreased to less than 40 ng/l in the most impacted yacht harbors (i.e., Shelter Island and Harbor Island), with an overall average of 17 ng/l in yacht areas. Concentrations in most of the bay are now below the proposed water quality objective of 5 ng/l. TBT tissue burdens have also been reduced over the last two years. However, sediment concentrations have not yet shown a downward trend.

TBT levels were once high enough in yacht harbors to cause some alterations in local species. However, legislative and regulatory efforts have reduced TBT loading to the point that it may no longer be a significant problem. The overall reduction of TBT appears to be a regulatory success story in which intermediate action (restricted use to craft greater than 25 meters and lowered paint release rates) has significantly reduced toxicant levels without a total ban.

Mussels as Bioindicators in San Diego Bay (NOSC).

Program Description. Transplanted juvenile mussels were studied in diverse areas of San Diego Bay over eight 3-month periods between 1987 and 1989. The effects of TBT on survival, bioaccumulation and growth under natural conditions, as well as the refinement of the use of mussels as bioindicators for environmental assessment were examined. Mussels and other mollusks are known to be among the most sensitive organisms to TBT. Average concentrations of TBT at the transplant sites varied from 5 to 530 ng/l.

Program Findings. No increased mortality was observed from TBT concentrations in water up to 530 ng/l. However significant reduction in growth rates were measured at concentrations in the range of 100-200 ng/l and higher, and where TBT concentrations in the mussel tissue exceeded 1.5-2.0 ug/g.

TBT concentration in tissues was found to be related to water concentration. However the relationship is not linear, and estimating water column TBT concentrations from tissues is not straight forward. In general, laboratory estimates of TBT effects tended to over estimate effects measured in the field.

Southern California Coastal Water Research Project (SCCWRP) Studies.

Program Description. Two studies were conducted in San Diego Bay and other southern California harbors in 1986 and 1987 to evaluate levels of toxic organic compounds and their relationship to sediment toxicity. Concentrations of 38 PAH compounds, DDTs, PCBs and metals were measured. San Diego Bay sites included one near the East Basin storm drain (an area of known PCB contamination), and three in the central bay near a shipyard, the Naval Station and urban runoff activities.

Program Findings. Sediments collected at sites near potential sources were found to be contaminated with relatively high levels of PAHs, chlorinated hydrocarbons and metals. PAH values were higher than those of less industrialized harbors in southern California, but similar in range to Los Angeles and Long Beach Harbors. Measurement of individual PAH compounds indicated a relative dominance of combustion compounds in the San Diego samples, suggesting atmospheric deposition and urban runoff as the principal sources. A greater abundance of petroleum compounds was found in Los Angeles Harbor sediments.

Biological testing, including amphipod survival, sea urchin growth and Microtox (a measure of toxicity to bacteria), demonstrated considerable toxicity. The amphipod survival test yielded the greatest toxicity response. The combined influence of PAHs, organotins, lead and zinc were to some degree correlated with amphipod toxicity. The bottom community of organisms did not appear to be strongly impacted by the observed contamination levels. No significant differences in community structure and abundance were noted when compared to a relatively uncontaminated reference site.

U.S. EPA, Environmental Research Laboratory, Studies.

Program Description. Sediment contamination, toxicity, and benthic communities were surveyed in San Diego Bay in 1987 and 1988. Sediment toxicity was evaluated using both 10-day amphipod mortality and the species richness of the benthic community (the number and density of bottom dwelling organisms). A total of 56 sites, covering most of the Bay, were analyzed in the first study. Nine locations were more intensively investigated in the second.

Program Findings. Amphipod mortality exceeded 50% at eight of the 56 sites, with one site (near the 7th St Channel) yielding 100% mortality. The overall mean amphipod mortality in the bay was 29%, This was less than several other harbors (eg. south San Francisco Bay, Commencement Bay, WA or Black Rock Harbor, CT), but somewhat greater than other areas such as the Palos Verdes Shelf near a sewage outfall. Relationships were identified between the natural abundance of amphipods in the bay, normalized contamination levels, and laboratory toxicity to the test amphipod. Pollution sensitive and pollution tolerant species that may be useful as indicators in future studies were identified.

Artificial Radioactivity Monitoring (U.S. Navy, Port of San Diego).

Program Description. Water, sediments and organisms are sampled quarterly by the Navy in the vicinity of nuclear vessels in San Diego Bay and other harbors. Additionally, an independent survey of radioactivity in mussels and sediment from the vicinity of Ballast Point, Bravo Pier at North Island and the B St. Pier was completed for the Port of San Diego Toxics Subcommittee during February and April, 1990.

Program Findings. The Navy monitoring program found no buildup of Cobalt-60 in water from gamma activity. Cobalt-60 is used as a sentinel for all of the possible artificially induced radionuclides because it has the most restrictive concentration limits. The Navy also found no buildup of Cobalt-60 in sediments or tissues, and levels were far below naturally occurring radioactivity for both.

In agreement with the Navy report, no artificially induced radioactivities were detected by the Port District. However, the spectra revealed nuclides derived from naturally present thorium, uranium and potassium at low activity levels.

California Department of Fish and Game/California Department of Food and Agriculture Joint Project

Program Description. State legislation enacted in 1988 restricted the use of TBT-based paints on boats shorter than 25 meters, thus practically eliminating the release of TBT in freshwater harbors and greatly reducing the release in saltwater harbors. The State Department of Fish and Game and Department of Food and Agriculture jointly monitored Shelter Island Yacht Basin in 1988, 1989 and 1990 to determine the effectiveness of the new regulations in lowering TBT residues, and limited monitoring may continue in the future. Specifically, the monitoring is being carried out to determine significant change over time in the TBT and DBT (Dibutyltin) concentrations in water, sediment and biological tissue.

THE BIOLOGICAL STATUS OF SAN DIEGO BAY

Information on the biological status of San Diego Bay is available from a number of sources. These include various studies supported by San Diego Gas & Electric, the Port of San Diego, the California State Coastal Conservancy, and the California Department of Fish and Game, as well as the evaluation of environmental impact reports.

San Diego Bay is the largest semi-enclosed embayment along the west coast between San Francisco and Central Baja California. The bay supports a diverse and important marine ecological system. Although much of the northern and central portions of the bay have been heavily developed over the last century, some natural habitats have been retained or re-established in the southern portion of the bay, thus maintaining some of the estuarine character of the bay ecosystem.

Historical changes in the marine habitats of San Diego Bay have recently been examined. Among those changes documented are a 92% reduction in salt marsh habitat, an 81% loss of

intertidal sandflats and mudflats, and more than an 81% increase in deep water habitat between 1856 and 1987. These changes are obviously causing large changes in the bay's ecology.

After 1963, following the recovery of the bay from the severe effects of sewage and industrial pollution, essentially all of the fish species originally described from the bay in the late 1800's became re-established. At the present time, 90 fish species are known to occur in San Diego Bay, compared to at least 56 species reported in the late 1800's. There is however, not enough available information to compare the relative abundances of these species between the 1980's and 1880's.

San Diego Bay also supports communities of benthic and open water organisms that are characteristic of both disturbed and relatively undisturbed bays and estuaries elsewhere in southern California and Baja California. The invertebrate fauna are dominated by polychaete worms, crustaceans, and mollusks. Their distribution and abundance are influenced greatly by specific physical and chemical characteristics of the sediment, and are therefore, generally good indicators of natural or disturbed conditions. Dredged and otherwise disturbed habitats contain faunal communities which include fewer species and differ markedly in structure from those of more natural areas.

Over the last 20 years, natural propagation has markedly increased eelgrass bed habitats in the inner bay and off of Coronado. Expanses of eelgrass and benthic algae are very important habitat features because of their high biological productivity and the cover and food resources they provide for fishes and invertebrates, such as lobsters. The bay provides important habitats for both the reproduction and migration of a number of marine species. Lobster and halibut use the bay for portions of their life cycle, and many fish species are resident to the bay for their full reproductive cycles. The only commercial fishery in the bay is a small mullet catch for local markets.

In a recent study, 127 species of birds were recorded in southern San Diego Bay. Limited, but important habitat for waterfowl and shore birds exists primarily in the inner bay and in protected areas of the Silver Strand in the central bay.

Coastal salt marshes have nearly been eliminated from much of the bay and are now restricted almost entirely to the inner portion of the harbor. Work is currently being conducted to rehabilitate and develop artificial wetlands and to evaluate the success of such endeavors. If existing wetlands and other natural estuarine habitats are lost through pollution or development, we will be left with only an artificial system of reduced ecological value and productivity.

CONCLUSIONS

Future efforts to evaluate and manage pollution in San Diego Bay will require increased and improved environmental monitoring. The following elements are recommended for monitoring in San Diego Bay:

- Identification of contaminants that are not traditionally measured should be made.
- Ecological studies are needed to better understand the effects of pollution and disturbance at the population and community levels.
- Food-chain biomagnification studies for selected organic compounds such as PCBs, PAHs and certain organometals should be conducted.
- A comprehensive, bay-wide hydrodynamic fate model should be developed to be used as a tool in predicting both the dispersion and fate of contaminants into different sections of the bay.
- A comprehensive study of the toxicity and bioavailability of contaminants associated with bay sediments is needed.
- A comprehensive biological and chemical baseline should be established from which to evaluate changes.

- Long-term trend monitoring should be initiated at a larger number of sites in all regions of the bay.

- A pollutant loading survey should be conducted to evaluate the relative importance of potential contaminant input routes.

- A non-point source monitoring program should be established by the Regional Water Quality Control Board.

- Ecological and human health risk assessment should be used to formulate risk-based remediation and cleanup decisions.

- Data compilation from all monitoring programs should be centralized and maintained in a consistent computer format and data base.

- The establishment of a scientific review panel for both monitoring and special studies should be considered.

- The San Diego Interagency Water Panel, set up by AB 158, should work to improve coordination between agencies.

- A scientific advisory subpanel should be added to the San Diego Interagency Water Panel for peer review and oversight of monitoring and special studies, and to support standardization.

Clearly, more information will be needed in the future to thoroughly assess the biological status of the bay, as well as the ecological and human health effects of chemical and biological contamination. A well-designed monitoring program can provide answers to these and many other questions. The recommendations presented here should all be considered as necessary elements of a comprehensive and coordinated monitoring program for San Diego Bay. Steps should be taken to ensure the initiation of such a program.

HUMAN HEALTH RISKS

Technical Workshop Report

This paper represents the collective input of participants in the Human Health Risks Workshop of the San Diego Bay Symposium. Although some participants may not agree with all of the statements and recommendations presented here, this paper is presented as a consensus of that workshop. The following persons are the primary authors of this paper: Chris Gonaver, County of San Diego, Environmental Health Services; Elaine Hiel, County of San Diego, Environmental Health Services; Phil Swartzell, California Department of Fish and Game; and Jon Van Rhyn, County of San Diego, Environmental Health Services.

HUMAN HEALTH RISKS TECHNICAL WORKSHOP REPORT

INTRODUCTION

San Diego Bay has recently been the focus of much concern due to a growing body of evidence of chemical contamination. Beginning in the 1970's, and continuing to the present, periodic scientific monitoring studies have demonstrated chemically contaminated problem areas within the bay. However, due to the limited scope of such studies, their public health significance has remained poorly understood.

A great deal of knowledge has recently been added to this area with the April, 1990 release of the San Diego Bay Health Risk Study by the San Diego County, Department of Health Services. This study, funded by the Board of Port Commissioners at the request of County Supervisor Brian Bilbray, is the first to thoroughly examine the health risks that may be associated with the consumption of chemically contaminated fish from San Diego Bay. Results of this study are discussed here, as well as the possible risks associated with other recreational uses of the bay. Some of the benefits thought to be associated with fish consumption are also discussed. Specifically, three questions are addressed:

1) Is it safe to eat fish from San Diego Bay?

2) What remains to be done to fully evaluate the potential risks from the consumption of fish from San Diego Bay.

3) Is it safe to use the Bay for recreational purposes (e.g., swimming, water skiing, etc.)?

IS IT SAFE TO EAT FISH FROM SAN DIEGO BAY?

Although some other studies have briefly touched on the possible health risks of eating bay fish, most of our current knowledge comes from the San Diego Bay Health Risk Study. This section discusses the results of that study, as well as the current status of San Diego Bay as a source of seafood. Additionally, a brief discussion of the health benefits thought to be associated with fish consumption is provided.

The Status of San Diego Bay as a Source of Seafood

California spiny lobster season is open from early October through mid-March. Sport divers hunt for lobster along Zuniga Jetty, near the bay's entrance, but diving is prohibited up-bay from Ballast Point. Above there, baited hoop nets are used from boats and piers to catch lobsters. Lobster fishing effort decreases as the season progresses, due to diminishing lobster populations.

In the opinion of the Department of Fish and Game, little fishing for clams or mussels occurs in the Bay. Clam beds, located at each end of Shelter Island appear depleted. Mussels are quarantined throughout California from May 1 through October 31. Consequently, people may fear that mussels in the bay are contaminated year-round.

The vast majority of fish taken from San Diego Bay are caught and consumed by local anglers and their friends and families. Sport fishing for a variety of fish species takes place year-round from boats, piers, and the shore.

Boat Fishing. On weekends or holidays 50 to 70 sport fishing boats can be seen anchored or drifting on the bay. On weekdays, about 20 boats can be seen fishing at any one time in the spring or summer. Most of these boats are in the 16 to 25 foot range, with an average of about two and one half anglers each. Approximately 125 to 175 people on weekend days and 50 people per weekday fish from boats on San Diego Bay. While fishing from boats occurs throughout the bay, the majority fish within three miles of the entrance. This is where the highest concentrations of desirable fish are found.

Pier Fishing. Five public sport fishing piers provide fishing opportunities on San Diego Bay.

These piers are located at:

- Shelter Island,
- Embarcadero Marina Park,
- L. M. "Pep" Pepper Park on Sweetwater Channel,
- Old Ferry Landing at Coronado, and
- Chula Vista Small Boat Basin.

The pier at Shelter Island is by far the most popular fishing location. Although it is prohibited, fishing may also occur from the many military piers, especially at NAS North Island. Typically, wider varieties of fish are seen among the catch from piers compared to that of boat anglers. This may be due to the diversity of fishing styles used on piers. No fishing license is required on publicly owned piers, which provide fishing opportunities for people of all ages and experience levels.

Shore Fishing. Some of the most popular areas for shore fishing are along the riprapped shores of Shelter Island, Harbor Island and Spanish Landing. Much of the shoreline surrounding San Diego Bay is not accessible to sport fishermen.

Commercial Fishing. Since the release of the San Diego Bay Health Risk Study, a great deal of concern has been expressed by many local residents regarding the source of fish consumed in local restaurants and purchased from local retail markets. Up to five gill net fishermen may be issued permits annually for striped mullet in San Diego Bay. However, only one commercial fishery currently exists in the bay. Commercially caught striped mullet are distributed solely through local ethnic retail markets, and none are consumed in restaurants. Commercial landings for mullet have averaged only 18,000 pounds over the last five years. For the past three years the catch has been declining, but this season's catch is ahead of that of last year at this time. In contrast, it is estimated that between 50,000,000 and 75,000,000 pounds of fish, from other world-wide sources, are consumed by San Diego County residents each year.

The San Diego Bay Health Risk Study

Study Design. The overall design of this study incorporated the collection of two sets of information to estimate the potential health risk from consuming San Diego Bay fish. First, an estimate of the amount of fish consumed from the bay and a characterization of consumption patterns was made by interviewing anglers who fish in the bay. Secondly, the concentration of chemical contaminants in those fish was determined by laboratory analyses. These two sets of data were then combined to yield an estimate of both the carcinogenic and noncarcinogenic potential risk to consumers of bay fish.

Fishing and Consumption Patterns. Three hundred and sixty-nine (369) anglers were surveyed over a one year period, from October 1988 to October 1989. An average cumulative consumption rate of 31.2 g/day, or about 1.1 oz./day, was determined for the entire angler population.

The ethnic composition of interviewed anglers was determined to be as follows:

Ethnicity	% of total anglers
Caucasian	42.0%
Filipino	20.1%
Hispanic	12.5%
Asian	11.1%
Black	6.5%
Other ethnic groups	2.2%
Unidentified	5.6%

The ethnic composition of the population consuming San Diego Bay fish is estimated as follows:

Ethnicity	% of total consumers
Asian	25.6%
Filipino	24.6%
Caucasian	24.0%
Hispanic	8.9%
Black	4.7%

Fishing Success. Considerable variation of fishing success was observed between specific ethnic populations. The most successful groups were Asians and Filipinos who caught fish 93.9% and 80.6% of the time, respectively.

Factors Effecting Levels of Risk. In determining potential risk, two other factors are especially worthy of consideration. First, the parts of the fish that are consumed should

be considered. Individuals who consume a greater portion of the fish, especially internal organs, may be at a greater potential health risk. Approximately 40% of both Filipinos and Asians consume the entire fish. About the same percent of each consume muscle only. However, 66.7% of Caucasians eat only the muscle, with 5.6% eating the entire fish.

Secondly, it is important to consider the methods of preparation utilized by consumers. Previous studies indicate that a significant decrease in some contaminants may be seen in cooked vs. raw fish. Almost all anglers surveyed cook their fish. Approximately 70% of the total indicated frying as the preferred method of preparation, while only 1.5% consume their fish raw.

Estimates of potential risk determined in this study do not consider the individual variation that may result from these factors. However, it should be noted that individuals may be able to significantly decrease the amount of chemical contaminants they consume by taking simple precautions, such as avoiding the ingestion of raw flesh or of internal organs.

Risk Characterization. Assuming a 70-year exposure duration, two chemical contaminants were found in concentrations that may pose significant health risks to consumers of bay fish. Elevated levels of mercury are thought to pose the following risks:

- Using average concentrations and average consumption rates, mercury was found to represent a potential health hazard (Hazard Index ≥1.0) to unborn or young children through the consumption of bay fish by pregnant and/or breast-feeding women. [NOTE: A Health Hazard Index (HI) greater than or equal to 1.0 represents a dose that may be expected to induce adverse health effects.]

- For most adult consumers, consumption of mercury contaminated fish at average rates would not likely cause adverse health effects.

- A potential health risk may exist for adults who consume mercury-contaminated barred and/or spotted sandbass from the bay over a lifetime at a rate near 165 g/day (5.8 oz/day). However, it should be noted that the value of 165 g/day represents an estimate of the upper 99.9th percentile consumption rate of the U.S. population from marine, estuarine, and fresh waters. Therefore, very few people would be expected to consume fish at this high of a rate.

In addition to mercury, PCBs were found to represent the following potential adverse health effects in consumers of bay fish:

- When consumed at a bay-wide average rate (31.2 g/day, 1.1 oz/day), PCBs were found to represent a potential excess lifetime cancer risk (1.1 to 2.9×10^{-4}, depending on the fish species) greater than the level of concern of 1 per 100,000 (1.0×10^{-5}).

- Using species-specific average consumption rates, excess cancer risk estimates ranged from 4.4×10^{-6} to 5.8×10^{-5}.

- A maximally exposed individual eating a mixed diet of San Diego Bay fish (165 g/day or 5.8 oz/day), has an estimated excess lifetime risk of between 5.8×10^{-4} to 1.0×10^{-3}.

Using average consumption rates and average contaminant levels, no other chemicals detected were present at levels high enough to cause potential health risks above the level of concern for human noncarcinogens (HI ≥1.0) or above the level of concern for an estimated excess lifetime cancer risk of ≥1 per 100,000. Nevertheless, there are some chemicals for which the potential risks have not completely been assessed by this study. These include arsenic, selenium, dioxins, furans, and radionuclides.

Comparison of Estimated Health Risks. Estimated excess lifetime cancer risks from a variety of common human consumption activities were compared to those determined for consumers of San Diego Bay fish. The estimated excess lifetime cancer risk resulting from typical consumption of fish from San Diego Bay falls between the estimated risks

resulting from the consumption of four tablespoons of peanut butter per day ($5.6x10^{-4}$) and from the average saccharin consumption in the U.S. or drinking one pint of milk per day (both at $1.4x10^{-4}$).

Study Conclusions. The results of the San Diego Bay Health Risk Study pertain only to the sportfish and mullet taken from the bay. As previously mentioned, fish served in San Diego restaurants, or purchased from San Diego retail markets (except for striped mullet), do not come from San Diego Bay.

For the majority of consumers, it is not thought that eating fish from the bay constitutes a significant health risk. No results from this study would indicate that the existing recommendation of consuming 1-2 fish meals per week should be modified for the majority of the adult population. However, it is recognized that certain populations, such as pregnant or breast-feeding women and young children, may be more sensitive. Additionally, adults who consume fish from the Bay on a daily basis may be at an increased risk of adverse health effects.

General Health Advisory. Based on the results of this health risk assessment, the general public shall be informed, through the distribution of public information, of the potential health risks associated with the consumption of fish from San Diego Bay. This information will address both the potential health hazards associated with mercury, in addition to the potential excess lifetime cancer risk attributed to the presence of PCBs.

It is recommended that consumers of San Diego Bay fish, as well as fish from all other sources, take the following general precautions to minimize any potential risk that may be incurred:

- **Heed advisories that tell you to limit consumption of certain recreationally caught species.** Before going fishing, check with state environmental, fish and wildlife, or public health organizations to see if any warnings have been issued.

- **Vary your fish intake.** Pick your weekly fish meals from a mix of high-, medium-, and low-fat fish. Don't eat too much of any one fish species, particularly if it has a history of on-and-off contamination. For example, make swordfish and bluefish occasional rather than everyday items.

- **Avoid eating the internal organs, skin and fatty sections of fish.** Contaminants tend to concentrate here.

- **When eating fish that you're suspicious of, take precautions that may lessen intake of fat-soluble contaminants.** Specifically, you should remove the fatty sections from fish flesh. Start by skinning the fish, cutting away a shallow layer of flesh under the skin. Then cut away the strip of fat that runs along the lateral lines on each side of the fish. Likewise, remove the fatty portion along the top of the fish's back, as well as any dark-colored sections of flesh. To allow some of the fat to drip off while cooking, grill, bake or broil fish on a rack. Don't use pan drippings to baste fish. If you poach or steam suspect fish, be sure to discard the cooking liquid.

The Health Benefits of Fish Consumption. Although some risk of adverse health effects may potentially exist from the ingestion of San Diego Bay fish, it is important to balance the potential risks with the known benefits of eating fish 1-2 times per week. These include the following:

- A 3 1/2 ounce serving of baked cod, at 105 calories, is half as fattening as the same amount of the leanest portion of sirloin steak.

- Fish oil is more effective than vegetable oils in lowering both cholesterol and triglycerides.

- The protein in fish is easier to digest than the protein in meat.

- The leanest cuts of meat contain more fat than the leanest types of fish.

- Smoking, canning, freezing, or frying do not destroy the Omega-3 fatty acids in fish.

- The American Heart Association, the American Cancer Society, the Dietary Guidelines and the National Academy of Sciences endorse the frequent consumption of fish.

- At least two fish meals per week (3 1/2 ounces each) are recommended in order to receive the heart-healthy benefits of eating fish.

WHAT REMAINS TO BE DONE TO FULLY EVALUATE THE POTENTIAL RISKS FROM CONSUMING SAN DIEGO BAY FISH?

Collection of Additional Data

Based on results of the San Diego Bay Health Risk Study, certain areas have been identified as requiring the collection of additional data.

A. Assess the extent to which shellfish (e.g., mussels, clams, lobster) are collected and consumed from San Diego Bay. If it is found that significant amounts of shellfish are caught and consumed from the Bay, collect and perform analyses to determine the potential risk to the public resulting from their consumption.

B. Analyze for, and evaluate the levels of polychlorinated dibenzo-p-dioxins/ polychlorinated dibenzofurans in the fish from San Diego Bay.

C. Analyze for, and evaluate the levels of specific radioisotopes in the fish from San Diego Bay.

D. Perform speciation-analyses to determine the organic vs. inorganic constituents of the total arsenic and total mercury found in the fish from San Diego Bay.

Establishment of a Bay-Wide Monitoring Program

An on-going, bay-wide monitoring program of selected fish species (and shellfish if warranted) should be instituted to evaluate the temporal trends of the levels of the chemical contaminants of concern identified in the fish from San Diego Bay. This program should follow the issuance of a report by the State Department of Health Services regarding San Diego Bay, with this study serving as a baseline. Future monitoring should include, but not be limited to, analyses for arsenic, mercury, selenium, PCDDs/PCDFs, total PCBs, total DDTs, and organotins.

IS IT SAFE TO USE THE BAY FOR RECREATIONAL PURPOSES?

It is recognized that recreational uses of the Bay other than fishing exist, such as swimming and skiing. While it is generally thought that the potential health risks from these activities are minimal, further study is needed to quantify the risks from biological and/or chemical contaminants. Since the populations engaging in these activities are generally thought to be small, epidemiological studies may not be feasible. Therefore, it is recommended that additional studies to determine the extent of these potential risks address water quality criteria.

CONCLUSIONS

The recent release of the San Diego Bay Health Risk Study by the San Diego County, Department of Health Services has added a great deal of knowledge to our understanding of the possible human health risks associated with the consumption of bay fish. However, two points should be kept in mind. First, although some risks may be incurred from consuming bay fish, the magnitude of these risks should be compared to other similar risks. For instance, the estimated excess lifetime cancer risk resulting from typical consumption of fish from San Diego Bay falls between the estimated risks resulting from the consumption of four tablespoons of peanut butter per day (5.6×10^{-4}) and from the average saccharin consumption in the U.S. or from drinking one pint of milk per day (both at 1.4×10^{-4}).

Secondly, there are many well documented benefits associated with eating fish. For instance, fish oil is more effective than vegetable oils in lowering both cholesterol and triglycerides. The protein in fish is also easier to digest than the protein in meat. The American Heart Association, the American Cancer Society, and the Dietary Guidelines of the National Academy of Sciences endorse the frequent consumption of fish.

In addition to providing a comprehensive baseline for future studies, the San Diego Bay Health Risk Study has identified areas where additional data should be collected. This includes an assessment of the consumption of shellfish from the bay, and, if necessary, chemical analyses of their tissues. Additionally, fish species similar in habitat characteristics to round stingray should be analyzed for selected contaminants.

A number of specific contaminants were also identified as requiring further analysis. These include dioxins and furans, and specific radioisotopes. Speciation of inorganic vs. organic arsenic and mercury should also be performed in bay fish.

An on-going Bay-wide monitoring program of selected fish species (and shellfish if warranted) should be instituted to evaluate the temporal trends of the levels of the chemical contaminants of concern identified in the fish from San Diego Bay. This would include, but not be limited to, analyses for arsenic, mercury, selenium, PCDDS/PCDFs, total PCBs, total DDTs, and organotins.

The potential health risks associated with other recreational uses of the bay should also be investigated. Because limited sample sizes prohibit epidemiological investigations, water quality criteria should be used.

CLEANUP TECHNOLOGY AND CONSEQUENCES OF REMEDIATION

Technical Workshop Report

This paper represents the collective input of participants in the Cleanup Technology and Consequences of Remediation Workshop of the San Diego Bay Symposium. Although some participants may not agree with all of the statements and recommendations presented here, this paper is presented as a consensus of that workshop. The primary author of this paper is David Barker, San Diego Regional Water Quality Control Board. John Lormon, Gray, Cary, Ames, and Frye, and Deborah Jayne, San Diego Regional Water Quality Control Board provided valuable input to this report. The following persons also contributed: Sonya Holmquist, Environmental Health Coalition; Leigh Taylor Johnson, University of California Sea Grant Extension Program and San Diego County Farm and Home Advisor Department; Commander Don Blake, COMNAVBASE San Diego; Rick Gersberg, San Diego State University; Roy Hobbs, Dock Masters Group; Deborah Lee, California Coastal Commission; Bill Lester, ERC Environmental and Energy Services; and Wendy Longley-Cook, Rohr Industries.

CLEANUP TECHNOLOGY AND CONSEQUENCES OF REMEDIATION TECHNICAL WORKSHOP REPORT

INTRODUCTION

Contaminated bottom sediments have emerged as an important environmental issue in the cleanup of pollution in San Diego Bay. These sediments can pose either immediate or potential threats to the diversity and abundance of marine life in San Diego Bay, as well as to beneficial uses of the bay such as fishing, navigation, commerce and recreation. There is also some concern that contaminated sediment sites may present a risk to the public health through the consumption of contaminated seafood collected from the bay. Clearly, the assessment and management of contaminated sediments in San Diego Bay is critical to the health of the bay and the preservation of its beneficial uses for present and future generations.

Cleanup or remedial actions can cost millions of dollars. Determining appropriate cleanup or remediation levels and methods, as well as whether to require such actions at all, is a formidable technical, legal and economic problem. This is further complicated by constantly-evolving state-of-the-art cleanup and remedial action technologies, environmental regulations, and by our limited understanding of the impacts of contaminants on the environment.

In the absence of clear cut sediment quality objectives, the uncertainty inherent in evaluating risks to the public health and the environment can impede the selection of an appropriate cleanup or remediation action strategy for a contaminated sediment site. In some cases, failure by regulatory agencies and industry to make a timely cleanup or remediation decision may cause a sediment contamination problem to spread to other previously uncontaminated areas of the bay. In other cases, a hasty decision by regulatory agencies to require the physical removal of contaminated sediment by dredging may in itself cause further pollution in the bay through the disturbance of the contaminated sediments by the dredging process.

This paper examines the legal and regulatory framework for addressing contaminated sediment issues in San Diego Bay. It describes the current legal mechanisms employed by regulatory agencies and industry to realize the potential cleanup or remediation of contaminated sediment sites in the bay. It also describes several contaminated sediment cleanup and remediation technologies that are commonly employed, and identifies the technical and legal roadblocks that currently impede contaminated sediment cleanup and remediation projects. The following specific issues are examined below:

1) The Significance of Sediment Contamination

2) Legislative and Regulatory Framework

3) Historical Perspective

4) Recent Legislation: The Bay Protection and Toxic Cleanup Program

5) Sediment Contamination Problems in San Diego Bay

6) Cleanup and Abatement Orders

7) Cleanup and Remediation Action Technology

8) Barriers to the Rapid Cleanup of Contaminated Sediment

THE SIGNIFICANCE OF SEDIMENT CONTAMINATION

"Contaminated sediments" are defined as those sediments containing chemical substances at concentrations which pose known or suspected environmental or human health threats. Environmental threats may be associated with contaminated sediments, because many discharged chemical substances tend to attach to sediment particles. Many of these

substances can accumulate to very high levels in sediments.

Bottom sediments support biological communities of benthic or bottom dwelling organisms (e.g., worms, clams, bottom feeding fish), that live in and/or eat marine sediment. Sediments may also serve as a spawning habitat for many pelagic species that inhabit the water column (e.g., invertebrates and fish). Elevated concentrations of chemicals in these sediments can cause acute mortality or affect reproductive behavior, egg hatching characteristics, and the early life development of organisms.

Contaminated sediments can also lead to the bioaccumulation of contaminants in organisms. Bioaccumulation is the process of biological uptake and retention of chemical contaminants obtained from food, water, contact with sediments, or any combination of exposure pathways. Contaminants can biomagnify in the food chain when small contaminated organisms are consumed by higher trophic level species, including man.

The threat to the public health from contaminated sediments centers around three principal exposure pathways:

- Consumption of fish and shellfish contaminated by chemicals in the sediment through the processes of bioaccumulation and biomagnification.
- Direct contact with contaminated sediments by swimmers or divers.
- Incidental ingestion of contaminated sediment or associated waters by swimmers or divers.

The most significant public health risk associated with contaminated sediments is probably the ingestion, over time, of contaminated fish and shellfish. However, the overall extent of contaminant transfer from sediments to humans in marine waters is currently not well understood by the scientific community.

LEGISLATIVE AND REGULATORY FRAMEWORK

The cleanup or remediation of contaminated sediment in San Diego Bay is governed by a number of state and federal statutes. Some of the potentially applicable laws are listed in Table 1. The chief statutory law pertaining to the regulation of water quality and sediment quality control issues in San Diego Bay is the Porter-Cologne Water Quality Control Act, contained in Division 7 of the California Water Code.

Table 2 lists federal, state and local regulatory and governmental agencies with authority and responsibility for contaminated sediment issues in San Diego Bay. Regulation of water quality and contaminated sediment issues in San Diego Bay is conducted primarily by the State Water Resources Control Board and the California Regional Water Quality Control Board, San Diego Region.

State Water Resources Control Board (State Board).

The State Board consists of five full-time members appointed by the Governor for four-year terms. The work of the State Board is conducted by technical, legal and administrative staffs and is supervised by an Executive Director. The chief regulatory duties of the State Board include the following:

- issuing rights for the appropriation of surface water,
- preventing waste and unreasonable use of water,
- adjudicating water rights at the request of water users or the courts,
- adopting state-wide water quality control policy,
- reviewing actions of the Regional Boards, and
- overseeing the state-wide implementation of the federal Clean Water Act.

California Regional Water Quality Control Board (Regional Board).

California's water quality control program is divided into nine regions. Each region is administered by a California Regional Water Quality Control Board. Each Regional Board is

TABLE 1

FEDERAL AND STATE OF CALIFORNIA STATUES
GOVERNING CONTAMINATED SEDIMENT

Federal Statues	State Statues
Clean Water Act	California Water Code, Division 7
Rivers and Harbors Act of 1899	California Health and Safety Code
Marine Protection Research and Sanctuaries Act	California Fish & Game Code
National Environmental Policy Act	California Environmental Quality Act
Fish And Wildlife Act	California Food and Agricultural Code
National Historic Preservation Act	California Harbor and Navigation Code
Endangered Species Act	California Coastal Zone Management Act

TABLE 2

REGULATORY AGENCIES WITH JURISDICTION OVER SAN DIEGO BAY

Federal Agencies	State Agencies	Local Agencies
Environmental Protection Agency	State Water Resources Control Board	San Diego Unified Port District
U. S. Fish and Wildlife Service	Regional Water Quality Control Board	San Diego County Department of Health Services
Army Corps Of Engineers	California Department of Fish and Game	San Diego County Department of Agriculture, Weights and Measures
National Marine Fisheries Service	California Department of Health Services	
Department of the Navy	California Department of Food and Agriculture	
	California Coastal Commission	

composed of nine part-time members appointed by the Governor for four-year terms. Each Regional Board consists of technical and administrative staffs supervised by an Executive Officer.

The primary functions of the Regional Boards are:

1) To ensure reasonable protection of beneficial uses. Beneficial uses are those necessary for man's well being and/or uses of water to enhance the quality of man's well being. Protection of these uses is accomplished through the establishment of appropriate numerical and narrative water quality objectives. These uses include the following:

- industrial uses for water supply,
- commercial and naval shipping,
- recreational uses involving body contact with water,
- non-contact water recreation,
- ocean and sport fishing,
- saline water habitat,
- habitat for rare or endangered species, and
- habitat for marine life.

2) To ensure the prevention of nuisance and pollution conditions in waters of the state resulting from excessive discharges of waste. Waters of the state, such as San Diego Bay, are protected from excessive discharges of waste through the issuance of waste discharge requirements (called National Pollutant Discharge Elimination System [NPDES] permits in federal law), which must be adhered to by waste dischargers. Under the requirements of the federal Clean Water Act, persons discharging waste to navigable waters of the United States are required to obtain an NPDES permit. California has received authority from the U. S. Environmental Protection Agency to issue NPDES Permits under the authority of Division 7, Chapter 5.5 of the California Water Code. NPDES permits set limitations on the volume of each discharge and the quantity of pollutants within it. This ensures that the discharge does not cause an exceedance of water quality objectives in the receiving water, and that beneficial uses are not adversely affected.

The Regional Board may take enforcement action against parties who violate waste discharge requirements or discharge prohibitions prescribed by the Board, or who discharge waste in a manner causing pollution or nuisance. Administrative enforcement remedies available to the Board include:

- cease and desist orders,
- cleanup and abatement orders, and
- administrative civil liability monetary penalties.

Under authority of the California Water Code Section 133304, the Regional Board can require persons who cause or permit the discharge of waste in violation of waste discharge requirements (or in a manner causing pollution or nuisance) to "cleanup" or "abate the effects of" waste discharged into waters of the state. Upon the failure of a discharger to comply with an administrative enforcement order, the Board may request the State Attorney General to petition the superior court for an injunction or monetary penalties.

HISTORICAL PERSPECTIVE

The environmental consequences and cleanup of contaminated sediment is a relatively new area of concern in the water pollution field in both California and across the United States. In the past, state and federal water pollution regulatory policies focused on waste discharges and the related effects on the water column. This focus was based on the premise that chemicals discharged into receiving waters were generally water soluble and that the emphasis of regulatory programs should therefore center on analyzing the effects of chemicals on the water column. This water quality control philosophy did not consider the ultimate fate of chemicals in the marine environment. Marine sediments were, in fact, often considered to be a safe repository for chemicals.

Several factors were responsible for the demise of the overly simplistic philosophy that emphasized only dissolved chemicals and the water column. In the late 1960's and early 1970's, water quality managers became aware that some of the sediments dredged from U.S. waterways contained high concentrations of a wide variety of potentially toxic chemical

constituents, such as heavy metals and pesticides. With the advent of the Clean Water Act Priority Pollutant list in 1976, the water quality field became concerned with a wide range of organic and inorganic chemicals that were found to be water insoluble. Findings from programs such as the California State Mussel Watch Program and the National Oceanic and Atmospheric Administration's National Benthic Surveillance Project confirmed that contaminated sediment sites in California's bays and estuaries were contributing to the elevated levels of contaminants such as organics, pesticides and heavy metals in shellfish and fish tissue.

RECENT LEGISLATION: THE BAY PROTECTION AND TOXIC CLEANUP PROGRAM

In response to the findings described above, the California legislature passed Senate Bill SB 475 and Assembly Bill AB 41, adding Sections 13390 -13396 to the California Water Code. These statutory revisions mandate the establishment of the Bay Protection and Toxic Cleanup Program. The program has seven main goals:

1) Provide for the protection of beneficial uses of bay and estuarine waters.

2) Adopt a workplan by July 1, 1991 for the adoption of sediment quality objectives. Sediment quality objectives are levels of constituents in sediment that provide reasonable protection of beneficial uses and prevention of nuisance, with an adequate margin of safety.

3) Identify and characterize existing contaminated sediment "hot spots" by January, 1992. "Toxic hot spots" are areas where hazardous substances have accumulated to sediment or water levels which (a) may pose a substantial present or potential hazard to aquatic life, wildlife, fisheries, or human health, (b) may adversely effect the beneficial uses of the bay, estuary or ocean waters as defined in water quality control plans, or (c) exceed adopted water quality or sediment quality objectives [California Water Code Section 13391.5(e)].

4) Prioritize and rank sediment hot spots for cleanup by July, 1992.

5) Develop a cleanup plan for the region by July, 1993.

6) Adopt a state plan for cleanup of contaminated sediment for all identified sites in the State by January, 1994.

7) Contribute to the development of effective strategies to prevent the creation of new toxic hot spots and the further pollution of existing hot spots.

CONTAMINATED SEDIMENT PROBLEMS IN SAN DIEGO BAY

The process of identifying and addressing the cleanup or remediation of contaminated sediment sites in San Diego Bay has been underway since the late 1970's through the efforts of several different agencies. These efforts include:

State Mussel Watch Program.

Since 1979 the State Water Resources Control Board, in concert with the Department of Fish and Game, has established mussel watch stations at various locations in San Diego Bay. In this ongoing program, clean mussels are taken from pristine marine waters in Northern California and transplanted to San Diego Bay. Four to six months later the mussels are collected to determine concentrations of chemical substances in the shellfish tissue. This program has been instrumental in determining the location of contaminated sediment areas in San Diego Bay.

National Oceanic and Atmospheric Administration's (NOAA) National Benthic Surveillance Project (Status and Trends Survey).

NOAA'S Status and Trends Survey has done some limited sampling in San Diego Bay at two locations since 1984 to evaluate sediment quality and fish contamination at the sampling stations.

San Diego Bay Health Risk Study. (County of San Diego, Department of Health Services)

The purpose of the San Diego Bay Health Risk Study was to estimate the potential risk to human health caused by consumption of fish caught from San Diego Bay. Results of this study are discussed in the section on Human Health Risks.

San Diego Bay Cleanup Project.

The Regional Board is currently in the third year of its ongoing five year San Diego Bay Cleanup Project. The overall objectives of the Project are to investigate toxics contamination in San Diego Bay, identify waste discharge sources, and locate toxic hot spots in the bay for possible cleanup or remediation.

As a result of information from the State Mussel Watch Program and the San Diego Bay Cleanup Project, the Regional Board has issued nine cleanup and abatement orders involving contaminated sediment pollution problems attributed to various parties. The cleanup and abatement orders alleged that various parties have discharged waste to San Diego Bay causing the creation of contaminated sediment zones in the bay. The locations of cleanup and abatement order sites are shown in Figure 1.

The currently known major contaminants found in elevated concentrations in San Diego Bay sediments include:

- arsenic
- mercury
- copper
- chromium
- lead
- manganese
- silver
- zinc
- tributyltin
- petroleum hydrocarbons
- polynuclear aromatic hydrocarbons
- polychlorinated biphenyls/Polychlorinated terphenyls (PCBs/ PCTs)

CLEANUP AND ABATEMENT ORDERS

The California Water Code, Section 13304, grants the Regional Board the authority to issue cleanup and abatement orders. These orders are the chief enforcement tool used to effect contaminated sediment cleanup or remediation.

Issuance of Cleanup and Abatement Orders.

To issue a cleanup and abatement order, the Regional Board must first establish that an identified responsible party(s) caused or permitted the discharge of the chemical constituent(s) present in the contaminated sediment. The Board must also establish that an identified responsible party caused or permitted waste containing the chemical constituents to be discharged in violation of waste discharge requirements, or other prohibitions prescribed by the Regional Board, or discharged waste in a manner causing pollution or nuisance in the receiving water.

Determination of the responsible party(s) and issuance of cleanup and abatement orders can be a difficult and time-consuming process. In some cases, responsible parties may no longer be operating or financially solvent. In other cases, it may not be possible to determine responsible parties because the chemical constituent cannot be traced from the sediment back to its origin. Additionally, some types of sediment contamination may not originate from a single source but may be of "non-point source" origin. For example, storm runoff from city streets enters the bay through storm drains during rainstorm events. Storm runoff can contain a host of materials that contaminate bay sediments, including grease, oils, and polynuclear aromatic hydrocarbons (residues of petroleum combustion).

Once a responsible party has been identified by the Regional Board's Executive Officer, a cleanup and abatement order may be issued requiring the responsible party to:

- Abate the waste discharge that caused the creation of the contaminated sediment.
- Cleanup or remediate the contaminated sediment.
- Take appropriate remedial actions to bring the discharge into conformance with the terms and conditions of the

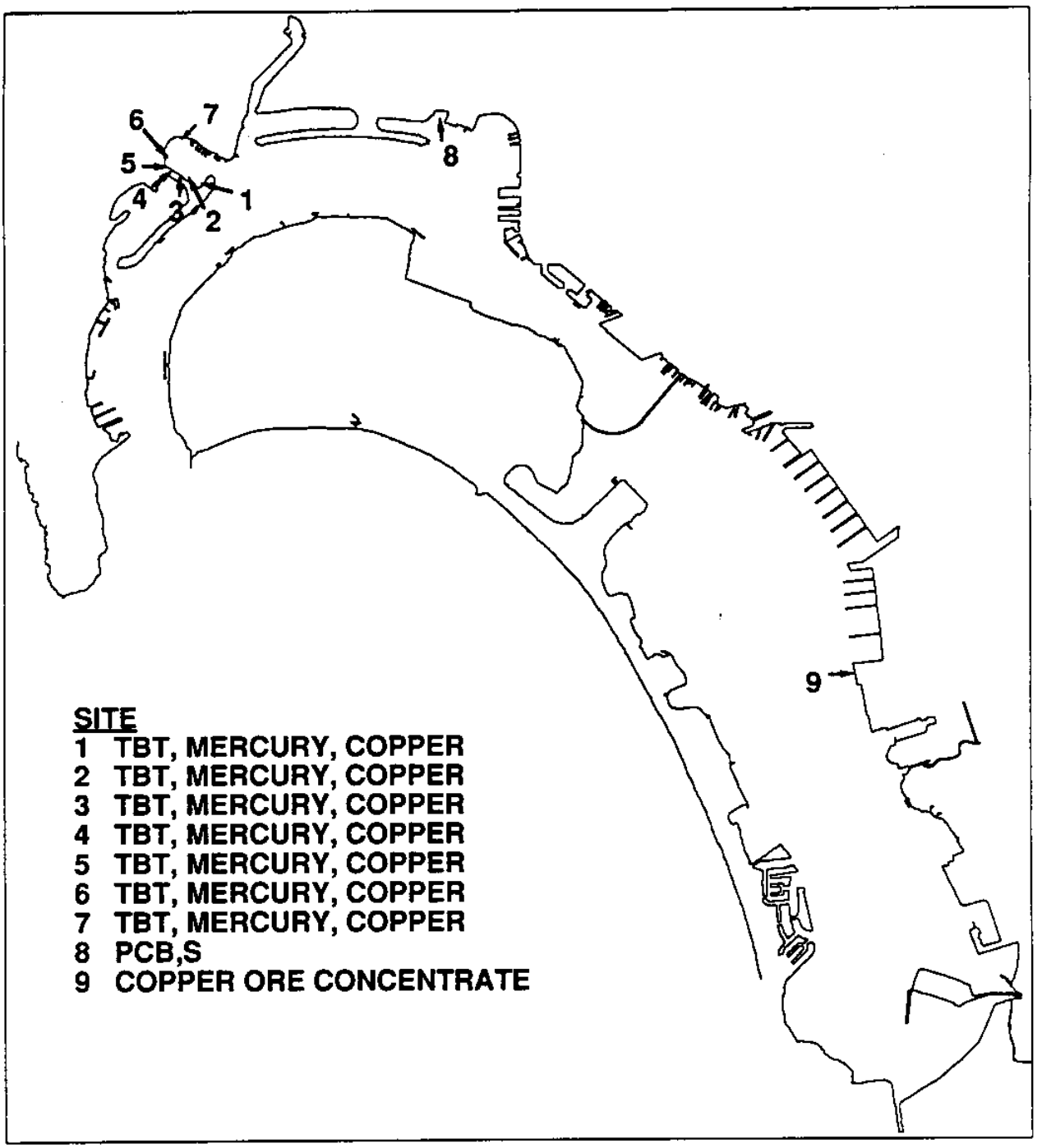

FIGURE 1.
LOCATIONS OF CONTAMINANED SEDIMENT CLEANUP INVESTIGATIONS REQUIRED UNDER CLEANUP AND ABATEMENT ORDERS IN SAN DIEGO BAY.

NPDES permit (if the discharge is under regulation by an NPDES permit).

- Submit an application for an NPDES permit if the discharge is currently unregulated by an NPDES permit and is expected to continue in some manner.

Specific directives of the cleanup and abatement order typically direct the responsible party to do the following:

1) Quantify the lateral and vertical extent of the contaminated sediment

2) Examine the engineering feasibility of the following alternate sediment cleanup/remediation strategies:

   - complete removal of all contaminated sediment,
   - removal or remediation of contaminated sediment to a level that will conform with water quality objectives and protect/restore beneficial uses, and
   - no action alternative level: The "no action" alternative level involves reliance upon natural processes for the remediation of contaminated sediment sites.

3) Examine the cost of sediment cleanup/remediation to various cleanup/remediation levels.

4) Examine the environmental consequences of sediment cleanup/remediation to various cleanup/remediation levels.

Enforcement of Cleanup and Abatement Orders.

The Regional Board may enforce the terms and conditions of a cleanup and abatement order by imposing administrative civil liability monetary penalties. The Regional Board may also petition the superior court for a restraining order or injunction mandating compliance with the cleanup and abatement order.

Appeal of Cleanup and Abatement Orders.

The responsible party, or any aggrieved person, has the right to a public hearing before the Regional Board to object to the issuance or directives of the cleanup and abatement order. They may also appeal the Regional Board's decision within 30 days to the State Water Resources Control Board. The State Board will review the record before the Regional Board, along with any other evidence that the State Board deems appropriate for consideration in regard to state policy for water quality control. The State Board may take any of the following actions:

- refuse to review the petition if it fails to raise substantial issues,
- uphold the cleanup and abatement order,
- remand the cleanup and abatement order back to the Regional Board for modification or reconsideration,
- rescind the cleanup and abatement order,
- take appropriate action itself, or
- any combination of the above.

During review and consideration of the petition, the State Board may stay the cleanup and abatement order, either in whole or in part. Within 30 days of the State Board's decision on an appeal, an aggrieved party may appeal the State Board's decision to the state superior court.

Determination of Final Cleanup or Remediation Action Level.

Once the cleanup and abatement order has been issued, a second public hearing is held to select an appropriate contaminated sediment cleanup level or remedial action. During this hearing the Board will set a minimum reasonable cleanup or remedial action level to ensure the protection of the beneficial uses of the receiving waters. This determination is based on a review of alternatives developed by the responsible party. During this hearing the Regional Board examines the costs, feasibility, and environmental consequences associated with alternative cleanup/remediation strategies. These alternatives can range from 100% removal of the contaminated sediment to the "no action alternative".

The Regional Board is prohibited by Water Code Section 13360 from specifying the cleanup methodology to be employed by the responsible party. However, the Board may set a "performance standard" in the cleanup and abatement order, such as a cleanup level for a chemical constituent to be attained by the cleanup method. This approach also serves to encourage innovative application of available technology to produce the most effective and economical solution to the sediment contamination problem.

It is important to note that the lack of an immediate demonstrated threat to the beneficial uses of the receiving water does not in itself justify the selection of a no action cleanup alternative. In 1968 the State Water Resources Control Board adopted Resolution 68-16, the "Statement of Policy With Respect to Maintaining High Quality of Waters in California", as part of the state water quality control policy. This policy is intended to protect the high quality of State and federal waters by establishing a test that must be satisfied before any reduction in water quality may be permitted. The policy provides in part that:

> ". . . . the existing quality of water . . . will be maintained until it is demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial uses of water and will not result in water quality less than that prescribed (by other applicable water quality objectives)."

In determining whether a cleanup level in San Diego Bay which does not require a return to the preexisting water quality (i.e., the water quality existing before the waste discharge took place) is consistent with "the maximum benefit to the people of the state," the Regional Board is guided by the Environmental Protection Agency's antidegradation policy contained in 40 CFR 131.12. The federal antidegradation policy requires that changes in water quality be consistent with the following 3-part test:

"(1) Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.

(2) Where the quality of the waters exceed levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the state finds... that allowing lower water quality is necessary to accommodate important economic or social development.

(3) Where high quality waters constitute an outstanding National resource.... that water quality shall be maintained and protected."

CLEANUP AND REMEDIATION ACTION TECHNOLOGIES

There are presently a wide range of strategies and technologies for removing, treating and disposing of contaminated marine sediments. These are presented in Figure 2. Remedial actions can be divided into removal actions and non-removal actions. Removal remedial actions involve the physical removal of contaminated sediment from the bay. Treatment of these sediments can render contaminants less toxic and/or less mobile through physical, chemical, biological, or thermal alteration. Conversely, disposal actions involve the final disposition or containment of treated or untreated contaminated sediment removed from the bay.

Contaminated Sediment Remedial Actions: Removal Actions.

Sediment Dredging. Dredging is the process of removing bottom sediments from a water body. This process has been used for many years to deepen harbors and waterways. In recent years dredging has been employed in the removal of contaminated sediments from water bodies. No single dredge technology is universally applied for cleaning up contaminated sediment.

Research and development is needed in the area of dredge equipment for removing contaminated sediment. In some respects, incentives for U.S. companies to develop dredging equipment has been lacking because of a perceived limited market for such equipment. However, with the increased

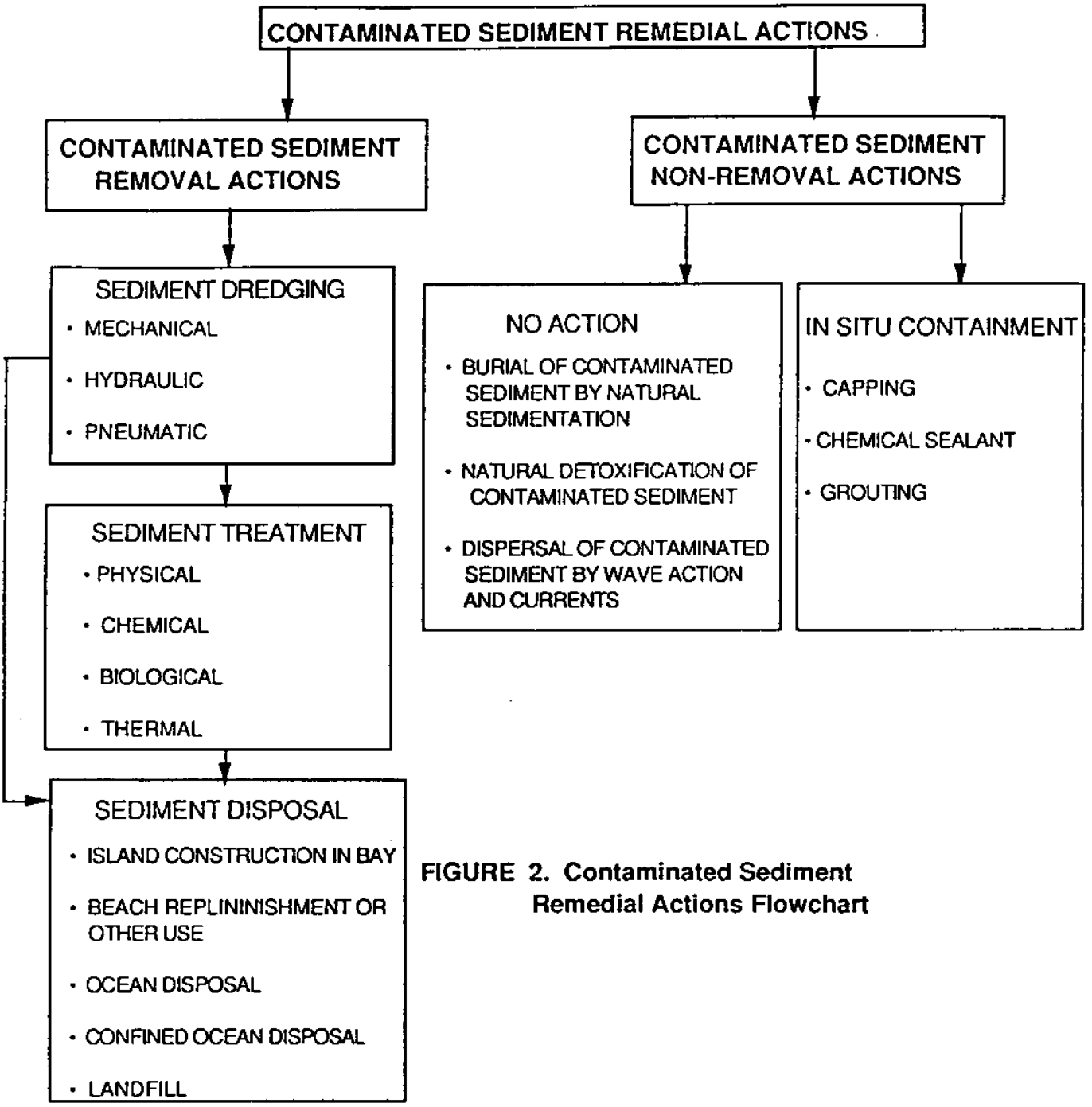

FIGURE 2. Contaminated Sediment Remedial Actions Flowchart

proclivity of environmental agencies across the U. S. to require cleanup or remediation of contaminated sediment, new dredging markets may soon open. Several factors should be considered in the selection of dredging equipment:

- physical characteristics of the contaminated sediment to be dredged,
- quantity of contaminated sediment to be dredged,
- depth of water overlying the contaminated sediment,
- distance to an authorized contaminated sediment disposal area,
- concentration of contaminants in the sediment to be dredged,
- mobility of contaminants in the sediment,
- method of disposal for the dredged material, and
- types of dredging equipment available.

The dredging process can disturb bottom sediments in a manner leading to the release of pollutants into the water column. This may occur through resuspension of contaminated sediment particles, dispersal of interstitial water in the sediment pores, or desorption of chemicals from the contaminated sediment. It is critical that dredging processes be designed to limit sediment resuspension. This reduces the potential for contaminant release to the water column during dredging, thus minimizing the possibility that contaminants will spread to previously uncontaminated areas.

The three types of dredging equipment generally used in the removal of contaminated sediments are mechanical, hydraulic and pneumatic.

Mechanical Dredging. Mechanical dredging involves the use of excavation equipment such as backhoes, draglines, clamshells and bucket ladder dredges. The main advantage of mechanical dredges is that contaminated sediments can be removed in a very concentrated form. This minimizes the size of facilities needed for dredged sediment transport, treatment and disposal. However, mechanical dredging often causes a high degree of sediment resuspension due to the direct application of mechanical force to dislodge the contaminated sediments.

Hydraulic Dredging. Hydraulic dredges remove and transport contaminated sediment in liquid slurry form. The slurries generally consist of 10 to 20 percent solids by wet weight. Contaminated sediment slurries may be pumped many thousands of feet through floating or pontoon-supported pipelines to a dredged material treatment/storage area. Hydraulic dredges are usually barge mounted. Types of hydraulic dredges include plain suction, cutterhead, dustpan, and hopper. (The cutterhead is considered a very efficient and versatile dredge and is in widespread use in the United States.) The major disadvantage of hydraulic dredging is the large liquid flow rate associated with pumping at low sediment solids concentrations. This results in the need for large areas of land to serve as settling/dewatering areas for the dredged material. Hydraulic dredges capable of removing sediments at high solids concentrations (minimizing the water content of the pumped slurry and thereby lowering the land requirements for sediment dewatering) are under development.

Pneumatic Dredging. Pneumatic dredges have a pump that operates on compressed air and uses hydrostatic pressures to draw sediments to the collection head and through the transport piping. These dredges are similar to hydraulic dredges. Types of pneumatic dredges include the airlift, the pneuma, and the oozer. Pneumatic dredges can be operated in shallow or deep water and can yield denser slurries than conventional hydraulic dredges, while maintaining lower levels of turbidity and sediment particle resuspension. One of the major disadvantages of the pneumatic dredging process is that it is capable of only modest dredge sediment production rates. Pneumatic dredges are currently not in widespread use in the United States, and may not be as readily available as other types of dredging equipment.

Dredge Waste Streams. After contaminated sediment is removed from the water, it must be separated from the slurry. This results in two distinct waste streams;

- dredge spoil return water, and
- concentrated contaminated sediment.

Methods for separating the sediment solids from the water include settling basins, clarifiers, impoundment basins, screens and cyclones.

Dredge Spoil Return Water. The dredge spoil return water consists of a substantially liquid waste stream. This may need to be subsequently treated by physical, chemical or biological methods to remove dissolved and suspended pollutants. Discharge of the liquid waste stream back to the receiving water would mandate Waste Discharge Requirements, and possibly extensive treatment. It may be possible to discharge modest volumes of treated or untreated dredge spoil return water into the sewer system. However, this will not be a viable alternative if the sewering agency is unwilling to allocate valuable sewer system capacity to accommodate the discharge.

Disposal of Contaminated Sediment. Disposing of contaminated sediments is a complex problem that poses a number of difficulties. For instance, jurisdiction over dredging projects in San Diego Bay is divided between several governmental agencies (See Figure 2). Long lead times are necessary to obtain the necessary permits or approvals from the many agencies having jurisdiction over the various aspects of a dredging project.

Dredging contaminated sediments can also be very costly. This cost can vary from several hundred thousand dollars to tens of millions of dollars. Dredging and disposal costs at contaminated sediment sites have been estimated to vary from $500,000 to $1,000,000 per acre or more. On a cubic yard basis total costs (average costs across the U. S.) would be $11.50 - $23.00 per cubic yard. For purposes of comparison, average maintenance dredging costs across the U. S. vary from $1.00 to $2.00 per cubic yard (See Contaminated Marine Sediments - Assessment and Remediation, National Research Council, 1989).

Another major problem is locating an authorized ocean or land disposal site for contaminated sediment dredged from the bay. Contaminated sediment often may not meet the EPA's criteria for disposal in ocean waters. There may be no local landfills to dispose of the material, especially if it is classified as a hazardous waste. There are no local landfills licensed to dispose of hazardous waste in San Diego County.

Even in cases where contaminated sediment is authorized for disposal in local landfills, the landfill operators may still be unwilling to use scarce landfill capacity to dispose of large quantities of dredged sediment.

Alternatives for disposing of dredged contaminated sediment from San Diego Bay include:

- **Ocean disposal.** Ocean water disposal involves placing the dredged contaminated sediment in open ocean waters at an EPA approved site.

- **Ocean disposal with treatment.** Ocean disposal with treatment refers to situations where the contaminated sediment will not meet EPA or the Army Corps of Engineers criteria for ocean disposal without the employment of physical, chemical, biological or thermal treatment methods.

- **Incineration.** Incineration of disposal of dredged contaminated sediment involves the use of high temperature oxidation under controlled conditions to degrade contaminated sediment into products that include gases, vapors and ash. Due to factors such as the high cost of incineration, the extremely low fuel value of most dredged sediment slurries, and the difficulty of siting a contaminated sediment waste incinerator because of public concern with potential health risks, incineration is not generally considered a viable option.

- **Landfill disposal.** Landfill disposal involves transporting the dredged contaminated sediment material to a state authorized landfill for disposal.

- **Landfill disposal with treatment.** Landfill disposal with treatment refers to situations where the contaminated sediment will not meet state criteria for landfill disposal without employing physical, chemical, biological or thermal treatment methods.

- **Disposal at reuse sites.** Disposing of dredged contaminated sediment at a reuse site involves the use of contaminated sediment for purposes such as construction material or for beach replenishment. Sediment reuse involves extensive study to determine the environmental and public health threats associated with the proposed reuse. For this reason, sediment reuse is not generally considered a viable option.

Contaminated Sediment Remedial Actions: Non-Removal Actions.

In certain instances it may not be technically possible, economically reasonable or environmentally sound to remove contaminated sediment by dredging. In these instances the contaminated sediment can be addressed by remedial actions involving non-removal strategies. Non-removal actions employ biological, chemical or physical treatment technologies to contain, isolate or treat contaminants in the sediment without removing the sediment from the bay.

Capping. Capping refers to the placement of a clean cover material over the contaminated sediment. The cover material minimizes or prevents the migration of contaminants from the sediment to the water column. A wide variety of materials can be used to cover contaminated sediments. Cover materials often include inert materials such as silt, clay, or sand. However, "active" materials can also be employed. These materials react with contaminants in the sediment to neutralize or reduce their toxicity. "Active" cover materials include:

- limestone, alum, or greensand for neutralization,
- oyster shells, or gypsum for precipitation of metals, and
- ferric sulphate for both precipitation and base neutralization.

In remedial actions involving capping, monitoring is needed to ensure that the integrity of the cap is maintained. The key elements of the monitoring program may include the monitoring of:

- changes in cap thickness,
- erosion around cap boundaries, and
- possible leakage of contaminants from the cap.

Surface-Sealing. Cement, quicklime, or other grouting materials can either be applied to the contaminated sediment surface or mixed with the sediment. Following completion of a sealing project, the sediment can be restored to its natural grade and composition to assist in the restoration of the habitat for benthic organisms. A well-focused monitoring program, during and after implementation, is necessary to measure the effectiveness of a sealing project.

The biggest advantages of non-removal remedial actions such as capping or surface sealing is that these actions are generally much less costly than dredging, they eliminate the need for disposal sites for dredged material, and they may minimize problems associated with resuspension of contaminated sediment. However, there are some practical limits to the feasibility of capping and surface sealing. To date these projects have generally been limited to shallow quiescent waters. It might be very difficult to apply these technologies to contaminated sediment problems in San Diego Bay because of the potential need for channel maintenance dredging. These and other present and future harbor development projects, and activities such as mechanical disturbances from vessel traffic and vessel anchoring, could disrupt the integrity of a cap.

Remedial actions involving capping or surface sealing of contaminated sediment are relatively new technologies. The long term effectiveness and reliability of these methods are not well known.

No Action Alternative. The "no action" alternative involves relying on natural processes for managing contaminated sediment. Examples of these processes include:

- burial of the contaminated sediment by natural sedimentation,
- dispersal of contaminants by currents or wave action, and

- natural detoxification of contaminated sediments.

The "no action" alternative should always be considered a potential alternative for cleanup of contaminated sediment. This may be the preferred alternative in cases where dredging the sediments may result in more biological or environmental damage than would occur if the material is left in place. The ultimate environmental fate of the contaminants must be quantified to give proper consideration of the no action alternative. The time required for natural processes to isolate the contaminant from the bay environment should also be considered.

BARRIERS TO THE RAPID CLEANUP OF CONTAMINATED SEDIMENT

"Quick fix" solutions for the cleanup or remediation of contaminated sediments in San Diego Bay do not exist. Some of the reasons for delays in cleaning up contaminated sediment in San Diego Bay are summarized below:

Rights of Appeal.

The cleanup cost of contaminated sediments can vary from several hundred thousand dollars to tens of millions of dollars. Due to this cost, parties alleged by the Regional Board to be responsible for the cleanup of the sediment may, for legitimate legal or economic reasons, wish to oppose or delay cleanup through various administrative and court appeals. Resolving administrative and court appeals can be a lengthy process. In some cases, the cleanup and abatement order may be stayed until the appeal is resolved.

Limited Staffing.

Limited staffing at regulatory agencies precludes the possibility of addressing all contaminated sediment sites in San Diego Bay at one time. Sites can only be addressed on a prioritized basis at current staffing levels. Limited staffing can cause delays in a number of areas, including the following:

- assessing the contaminated sediment sites,
- issuing cleanup and abatement orders,
- determining cleanup or remediation action levels,
- issuing project approvals or permits, and
- resolving cleanup and abatement order appeals and petitions.

Complexity of Cleanup Level Decision.

Determining the cleanup level to be attained at a site can take a substantial amount of time. Careful consideration of the costs and benefits associated with various cleanup levels is necessary to ensure that an environmentally and economically sound decision is made. Because of the lack of clear criteria, such as sediment quality objectives, on which to base cleanup decisions, determining public health and environmental risks can involve considerable uncertainty.

Cleanup or Remediation Action Technology.

The cleanup or remediation of a contaminated sediment site often involves substantial technical difficulties and unknowns. This is true both in applying a new or innovative technology, and with known technologies under new conditions.

Lack of Sediment Quality Objectives.

There are currently no numerical sediment quality objectives to ascertain the environmental and public health risk of a contaminated sediment site. This leads to delays in the site assessment, in the issuance of the cleanup and abatement order, and in the selection of a cleanup or remediation action level.

Lack of Contaminated Sediment Disposal Sites.

The current lack of nearby authorized land or ocean disposal sites to dispose of contaminated sediment dredged from the bay can cause cleanup costs to run in the tens of millions of dollars. This is due primarily to the high cost of transporting large quantities of contaminated sediment long distances to disposal sites in other states.

Regulatory Agency Approval and Permits.

Long lead times are necessary to obtain permits or approvals from the multiple governmental agencies having jurisdiction over various aspects of contaminated sediment cleanup. This can cause substantial delays, often beyond the control of the responsible party named in the cleanup and abatement order.

CONCLUSIONS

Next to the weather, San Diego Bay provides San Diego's most significant environmental signature. The need to protect and preserve this valuable resource is paramount. This belief has not always been fully appreciated. Restructuring of San Diego's sewer system in the 1960's has greatly improved the biological condition of bay. However, improved sampling and detection technology in the following decades has allowed the identification of toxic hot spots in San Diego Bay. These hot spots are now in the process of being identified and/or remediated.

Numerous studies have allowed us to identify bay areas in need of cleanup and remediation. Additionally, the legal and regulatory framework, including recent amendments to the California Water Code now mandates that regulatory agencies identify and remediate toxic hot spots in the bay.

The cost of accomplishing cleanup and/or other remediation can be very high. Therefore, the decision to require the cleanup raises significant environmental, economic, policy and political concerns. There are currently many significant hurdles to accomplishing contaminated sediment cleanup. The time and cost associated with identifying contaminated sites, assessing the environmental, natural resources and public health impacts, the appropriate degree of remediation, the proposed cleanup and remediation alternatives, obtaining the necessary permits and accomplishing cleanup or remediation are all significant. As a result, both the agencies and the responsible parties are subject to criticism for foot dragging. In reality, the legal and technical issues associated with cleanup and remediation of contaminated sediment are cutting edge issues. The parties are "feeling their way" through these projects. At the same time, statutory and regulatory requirements are constantly changing.

Because cleanup and remediation of contaminated sites is necessarily a complex and costly issue, the following steps are recommended to increase the efficiency of this process in San Diego Bay:

1. **Accelerate Research On Innovative Technologies.**
   Cleanup technologies exist; However, there are no universal solutions for the effective management of contaminated sediments. Research on innovative cleanup and remediation technologies should be accelerated.

2. **Define Standards and Cleanup Levels.**
   A satisfactory definition of sediment standards and cleanup levels should be established.

3. **Comprehensive Cleanup Strategies.**
   Elimination of the pollution source(s) and consideration of interim remedial actions should be an integral part of every cleanup strategy.

4. **Alternative Strategies.**
   All available alternatives for remediation should be considered, including natural recovery processes (detoxification).

5. **Regional Disposal Facility.**
   Consideration should be given for development of a regional disposal facility for contaminated sediments.

6. **Coordination of Agencies.**
   Close coordination should occur between all federal and state agencies regarding potential remedial actions.

7. **Funding Mechanisms.**
   Additional funding mechanisms for remediation should be pursued including possible legislative relief.

8. **Transfer of Information.**
   Technical information transfer should be expedited.

The San Diego Bay situation is not unique; however, San Diego has an opportunity to be a model for other cities to follow. The State legislature has recognized the importance of a cooperative effort in San Diego Bay through the establishment of the San Diego Interagency Water Quality Panel. These types of efforts should be continued in San Diego Bay.

REFERENCES

U. S. EPA. 1985. Removal and Containment of Dredged Sediment. Remedial Action at Waste Disposal Sites. Hazardous Waste Engineering Research Laboratory, Office of Research and Development. Cincinnati, Ohio

National Academy Press. 1989. Contaminated Marine Sediments -- Assessment and Remediation. Committee on Contaminated Marine Sediments, Marine Board, Commission on engineering and Technical Systems, National Research Council. Washington D. C.

SAN DIEGO BAY SYMPOSIUM:

SUMMARY OF TECHNICAL WORKSHOP RECOMMENDATIONS

SAN DIEGO BAY SYMPOSIUM:
SUMMARY OF TECHNICAL WORKSHOP RECOMMENDATIONS

I. POLLUTION SOURCES WORKSHOP

1. **Underground Dewatering.** General NPDES permit monitoring data should be carefully reviewed to assure that petroleum and other wastes are not discharged into the Bay.

2. **Industries on the Bay and Upstream from the Bay.** Industries should continue to implement source control measures, and to require that all persons doing work in boatyards and shipyards use best management practices to prevent release of pollutants.

3. **Marinas and Anchorages.**

(a) All marinas and docks should be required to provide storage or recycling facilities for oil and paint.

(b) Marinas should be required to provide easily-accessible and fully-maintained sewage pump out services.

4. **U.S. Navy Installations.** Frequently observed surface films and their sources near Navy fueling facilities should be identified and monitored.

5. **Underwater Hull Cleaning and Vessel Antifouling Paints.** The development and testing of completely non-toxic coatings for boat bottoms should be encouraged.

6. **Urban Runoff.** Innovative approaches should be devised to reduce the effects of urban runoff on San Diego Bay.

II. POLLUTION MONITORING AND ENVIRONMENTAL RISKS WORKSHOP

1. **Collection of Additional Data.**

(a) **Identification of Contaminants Not Traditionally Measured.** Currently, only a small proportion of contaminants that could be measured are analyzed. Some unidentified compounds may represent equal or possibly greater environmental risk. A state-of-the-art scientific literature survey and a thorough review of hazardous compounds used in manufacturing in the bay region should be made to evaluate and recommend whether additional contaminants should be added to currently monitored compounds.

(b) **Ecological Studies at the Population and Community Levels.** Large-scale seasonal studies in representative areas of the outer and central bay, designed to characterize ecological systems and to assess the degree of ecological degradation caused by present and past pollution should be done. Such studies should be coordinated by agencies whose responsibility it is to manage and regulate marine sources and water quality in San Diego Bay.

(c) **Food-chain Biomagnification Studies for Selected Organic Compounds, such as PCBs and PAHs, and Certain Organometals.** While these compounds may or may not represent direct threats to marine organisms in the bay, they could represent a risk to local marine and shore birds which feed on bay organisms, or to human consumers of fish and shellfish collected in the bay.

(d) **Comprehensive Hydrodynamic Fate Model.** A comprehensive bay-wide hydrodynamic-fate model should be developed for use as a tool in predicting both the dispersion and fate of contaminants into different sections of the bay. The development and testing of such a model has been initiated by the Naval Ocean Systems Center and has been proposed by the Regional Water Quality Control Board. Cooperative development of the model

between these two agencies and other interested organizations is recommended.

(e) **Comprehensive Study of Toxicity and Bioavailability of Contaminants in Sediments.** It has been recommended to the State Water Resources Control Board, at a joint agency meeting in Monterey, that San Diego Bay be used as a test harbor for evaluating and defining sediment criteria and standards based on toxic response to sediments and state-of-the-art chemistry. San Diego Bay is ideal because of reasonably well-defined toxic hot spots and toxicity gradients. A joint agency group and funding should be identified to proceed on this project.

2. **Monitoring Studies.**

(a) **Comprehensive Biological and Chemical Baseline.** A comprehensive biological and chemical baseline should be established from which to evaluate changes. An effective baseline simplifies and reduces the costs of follow-on monitoring programs because less sampling is required. The objectives of the baseline, and the parameters to be studied, need to be identified and clearly defined. The baseline would need to be periodically updated (every 5-10 years).

(b) **Long-term Trend Monitoring at a Number of Sites.** Long-term trend monitoring should be initiated at a larger number of sites in all regions of the bay and measured at least annually to evaluate changes in the bay and the extent and magnitude of pollution in all habitats of the bay.

(c) **Pollutant Loading Survey.** A pollutant loading survey should be conducted to evaluate the relative importance of potential input routes. The survey should include storm drain runoffs, vessel discharges and maintenance activities, industrial discharges, and desorption from contaminated bottom sediments. This information is needed to design the most effective remediation program for San Diego Bay.

(d) **Non-point Source Monitoring.** A non-point source monitoring program should be established by the Regional Water Quality Control Board.

3. **Use of Risk Assessments.** Ecological and human health risk assessment should be used to formulate risk-based remediation and cleanup decisions. Often regulatory and cleanup decisions are based solely on the level of a contaminant in sediments adjacent to a facility or discharge. Little, if any evaluation of the direct environmental risk of the contaminant or the cleanup procedure is made. Environmental risk analysis procedures have been and are continuing to be developed, and can be used as a guide in developing a risk assessment strategy to support risk management decisions.

4. **Centralization and Maintenance of a Data Base.** Data compilation from all monitoring programs needs to be centralized and maintained in a consistent computer format and data base. Efforts to establish a baseline and monitoring program are weakened by the lack of an adequate mechanism for information access in a format that allows reanalysis.

5. **Establishment of a Scientific Review Panel.** The design of monitoring programs and their results should be peer reviewed. The establishment of a scientific review panel for both monitoring and special studies should be considered. There should be a single coordinator with the responsibility for maintaining monitoring and other water quality data on San Diego Bay.

6. **Interagency Coordination.** The San Diego Interagency Water Panel, set up by AB 158, is the appropriate forum for improving coordination between agencies, and further efforts toward this goal should be accomplished.

7. **Scientific Advisory Subpanel.** A scientific advisory subpanel should be added to the San Diego Interagency Water Quality Panel for peer review and oversight of monitoring and special studies, and to support standardization.

III. HUMAN HEALTH RISKS WORKSHOP

1. **Collection of Additional Data.**

(a) **Shellfish.** Assess the extent to which shellfish (e.g. mussels, clams, lobster) are consumed from San Diego Bay. If it is found that significant amounts of shellfish are caught and consumed from the Bay, collect and perform analyses to determine the potential risk to the public resulting from their consumption.

(b) **Dioxins and Furans.** Analyze for, and evaluate the levels of polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans in the fish from San Diego Bay.

(c) **Specific Radioisotopes.** Analyze for, and evaluate the levels of specific radioisotopes in the fish from San Diego Bay.

(d) **Speciation of Arsenic and Mercury.** Perform speciation analyses to determine the organic vs. inorganic constituents of the total arsenic and total mercury found in the fish from the Bay.

(e) **Other Recreational Uses.** Perform additional studies to determine the extent of the potential risk from other recreational uses of the Bay, such as swimming and skiing. Because small sample sizes prohibit the performance of epidemiological studies, water quality criteria should be addressed.

2. **Establishment of a Bay-wide Monitoring Program.**

(a) **Evaluation of Temporal Trends.** An on-going Bay-wide monitoring program of selected fish species (and shellfish if warranted) should be instituted to evaluate the temporal trends of the levels of the chemical contaminants of concern identified in the fish from San Diego Bay. This would include, but not be limited to, analyses for arsenic, mercury, selenium, PCDDS/PCDFs, total PCBs, total DDTs, and organotins.

(b) **Other Recreational Uses.** Any areas of concern identified from studies of other recreational activities in the bay (such as swimming and skiing) should be addressed in the future as part of a comprehensive monitoring program. This would include, but not be limited to, monitoring of bacterial indicators and viral pathogens.

IV. CLEANUP TECHNOLOGY AND CONSEQUENCES OF REMEDIATION WORKSHOP

1. **Accelerate Research On Innovative Technologies.** Cleanup technologies exist; However, there are no universal solutions for the effective management of contaminated sediments. Research on innovative cleanup and remediation technologies should be accelerated.

2. **Define Standards and Cleanup Levels.** A satisfactory definition of sediment standards and cleanup levels should be established.

3. **Comprehensive Cleanup Strategies.** Elimination of the pollution source(s) and consideration of interim remedial actions should be an integral part of every cleanup strategy.

4. **Alternative Strategies.** All available alternatives for remediation should be considered, including natural recovery processes (detoxification).

5. **Regional Disposal Facility.** Consideration should be given to development of a regional disposal facility for contaminated sediments.

6. **Coordination of Agencies.** Close coordination should occur between all

federal and state agencies regarding potential remedial actions.

7. **Funding Mechanisms.** Additional funding mechanisms for remediation should be pursued including possible legislative relief.

8. **Transfer of Information.** Technical information transfer should be expedited.

SAN DIEGO BAY WATER QUALITY AND USES OPINION SURVEY

SAN DIEGO BAY WATER QUALITY AND USES OPINION SURVEY

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INTRODUCTION

San Diego Bay Symposium participants were asked their opinions on bay water quality issues during the Forum. The survey was taken before and after the meeting, in order to see if the technical reports and policy discussions influenced opinions. One hundred and six people responded to the pre-Forum survey and 64 people responded to the post-Forum survey. The "post" survey showed very little change in opinions. As these changes were smaller than shifts in relative proportions of environmental group members and non-members, they will not be considered significant. Therefore, the discussion will consider results only for the "pre" survey.

WHOSE VIEWS ARE REPRESENTED?

Job experiences of symposium participants were closely related to marine sciences, education, policy making, industries and/or pollution management, according to registration records. Survey results showed 38% held a government position, 18% were consultants, 12% worked in industry, and 11% were academic professionals. Another 9% were in service industries and 8% were self-employed. Staff of non-profit organizations comprised 4% and attorneys comprised 1% of the total. (See Table 1).

A wealth of training and experience was represented by people responding to the survey. Seventy-two percent had more than four years of college education and another 20% held at least a bachelor's degree. Fifty-four percent were between 41 and 60 years of age and 38% were from 26 to 40 years old.

Environmental group members accounted for 54% of the respondents and many belonged to more than one group. The groups with the most members responding to the survey were Sierra Club (13), Environmental Health Coalition (9) and Nature Conservancy (8). Three to five people belonged to each of the following groups: Audubon Society, Industrial Environmental Association of San Diego County, Oceanic Society, Natural Resources Defense Council, National Wildlife Association and Greenpeace. Twenty-five other groups and associations were represented by one or two people.

The symposium had a strong local turnout; 62% lived in San Diego, 5% lived in other cities on the bay, 12% lived in the north county coastal area, and another 12% lived in other parts of San Diego County. Nine percent were from out of county or out of state.

HOW GOOD IS BAY WATER QUALITY?

When asked directly about the water quality of San Diego Bay, 53% of the people said that it was about as polluted as other bays its size (Table 2). Nineteen percent thought it was barely polluted and another 19% thought it was badly polluted. Only 7% felt the bay was clean.

The survey also asked about bay water quality in terms of eating fish from the bay, swimming in it, and its suitability for marine life (Table 2). There was no consensus on these questions. Opinions were about evenly divided on the safety of eating bay fish: 47% thought it was not safe or somewhat unsafe; 45% thought it was safe or somewhat safe. People tended to favor safety of swimming in the bay: only 34% felt it was unsafe or somewhat unsafe to swim in the bay, but 58% felt it was safe or somewhat safe. In contrast 52% said the bay was an unhealthy or somewhat unhealthy environment for fish and wildlife and 41% thought the bay was healthy or somewhat healthy for them.

HOW SHOULD THE BAY BE USED?

A key element of discussion by Forum policy panelists was the priority of uses for the bay. The survey also asked people to give their opinions on the top three "highest and best uses" of the bay. Choices were taken from the list of "beneficial uses" described in the San Diego Basin Plan prepared by the California Regional Water Quality Control Board, San Diego Region. They included: industrial uses, commercial and naval shipping, recreational uses involving body contact with water (swimming, wading, water skiing, etc.), non-contact water recreation, fishing (sport and commercial), saline water habitat, habitat for rare and endangered species, and habitat for marine life.

The top three highest and best uses of the bay, according to survey respondents, were: commercial and naval shipping (59% ranked it in top three, 20% ranked it number one); habitat for marine life (56% ranked it in top three, 27% ranked it number one); and recreational uses involving body contact (45% ranked it in top three, 13% ranked it number one). See Table 3.

Nineteen percent of the respondents suggested that strong consideration be given to mixed or balanced uses of the bay, instead of one or a few uses.

A number of people chose more than three uses of the bay as their top priorities. Where they selected too many choices and also included more than one type of habitat, the habitat choices were lumped under "habitat for marine life" as the most general habitat type.

DO OPINIONS OF ENVIRONMENTAL GROUP MEMBERS DIFFER FROM THOSE OF NON-MEMBERS?

Opinions of environmental group members were compared to those of non-members to see whether group membership might affect attitudes on bay water quality, safety of eating fish from the bay, safety of swimming in the bay, whether the bay is a healthy environment for marine life, and what are the most desirable uses of the bay. The comparison found that environmental group membership made little difference in the proportions of people holding different opinions on survey questions.

CONCLUSIONS

Participants in the San Diego Bay Symposium were people with a tremendous collective knowledge of marine pollution issues and technical information. Because of their expertise, data presented at the meeting can be considered to represent the "State of San Diego Bay" with regard to environmental status, management, and recommendations for the future.

About half of the participants thought that San Diego Bay pollution was in line with that of other bays its size, but expressed some concern about the safety of eating bay fish or swimming in the bay and about whether the bay was a healthy habitat for marine life.

The top three highest and best uses preferred by Symposium participants were commercial and naval shipping, habitat for marine life, and recreational use with body contact. Ironically, these uses are somewhat conflicting. Achieving a mix or balance of bay uses will challenge policy makers, agencies, industries, scientists, and the public to cooperate and innovate in finding effective solutions for complex problems.

Table 1. WHOSE VIEWS ARE REPRESENTED?

Employment	
Government Employee:	38%
Consultants:	18%
Industry Employee:	12%
Academic Professionals:	11%
Service Industry Employee:	9%
Non-Profit Organizations:	4%
Attorneys:	1%

Education	
> 4 years College:	72%
4 year Degree	20%
< 4 year College:	8%

Age Range (years)	
41-60:	54%
26-40:	38%
<26 or >60:	8%

Environmental Group Affiliations	
Member:	54%
Non-Member:	46%

Location of Residence	
City of San Diego:	62%
Other San Diego Bay Cities	5%
No. County Coastal:	12%
Other Areas of County:	12%
Outside County:	9%

Table 2. HOW GOOD IS SAN DIEGO BAY WATER QUALITY?

Overall Bay Water Quality	
Badly Polluted:	19%
As Polluted as Other Bays Its Size:	53%
Slightly Polluted:	19%
Clean:	7%

Swimming Safety	
Unsafe:	9%
Somewhat Unsafe:	25%
Neutral:	9%
Somewhat Safe:	25%
Safe:	33%

Fish Consumption	
Unsafe:	23%
Somewhat Unsafe:	24%
Neutral:	9%
Somewhat Safe:	21%
Safe:	24%

Fish & Wildlife Habitat	
Unhealthy:	23%
Somewhat Unhealthy:	29%
Neutral:	7%
Somewhat Healthy:	31%
Healthy:	10%

Table 3. HOW SHOULD SAN DIEGO BAY BE USED?

(Best Use of Bay)

	Ranked in Top Three Choices	Ranked Number 1 Choice
Shipping (Commercial & Navy):	59%	20%
Marine Habitat1	56%	27%
Recreational (Body Contact):	45%	13%
Recreational (Non-Contact):	27%	6%
Fishing (Commercial & Non-Commercial):	25%	3%
Industrial:	18%	4%
Saline Water Habitat:	17%	6%
Species Habitat (Rare & Endangered):	14%	3%

Stressed Multiple Uses	
Mixed & Balanced Uses:	19%

1. Where too many choices were selected and more than one type of habitat was included, the habitat choices were lumped under "Marine Habitat" as the most general habitat choice; otherwise, specific habitat choices were tallied separately.

SAN DIEGO BAY WATER QUALITY & USES OPINION SURVEY

San Diego Bay Symposium
June 16, 1990

AGE:

____ to 25
____ 26-40
____ 41-60
____ 61 and above

EDUCATION:

____ High School
____ Some College
____ College Graduate
____ Post Graduate

EMPLOYMENT:

____ Non-Profit
____ Government
____ Consultant
____ Service Industry
____ Industrial
____ Self-employed
____ Academic
____ Attorney

SOURCE OF NEWS:

____ Newspaper
____ Magazines
____ TV
____ Radio

CITY YOU RESIDE IN? _____

HOW DID YOU HEAR ABOUT THE SYMPOSIUM?

____ Mail
____ Radio
____ TV
____ Newspaper

ARE YOU A MEMBER OF ANY ENVIRONMENTAL GROUP? ____ Yes ____ No
If yes, which one(s)?

IN YOUR OPINION, WHAT IS THE WATER QUALITY OF THE SAN DIEGO BAY:

____ Clean
____ Barely Polluted
____ About as Polluted as Other Bays its Size
____ Badly Polluted
____ No Answer

IN YOUR OPINION, IS IT SAFE TO EAT FISH CAUGHT IN SAN DIEGO BAY? (circle one)

NO	DISAGREE SOMEWHAT	NEUTRAL	AGREE SOMEWHAT	YES
1	2	3	4	5

IN YOUR OPINION, IS IT SAFE TO SWIM IN THE BAY?

1	2	3	4	5

IN YOUR OPINION, IS THE BAY A HEALTHY ENVIRONMENT FOR FISH & WILDLIFE?

1	2	3	4	5

WHAT DO YOU FEEL IS THE HIGHEST AND BEST USE OF THE BAY?
(Please mark your first, second, and third choice)

____ Industrial Uses
____ Commercial & Naval Shipping
____ Recreational Uses - Body Contact (swimming, wading, water skiing, etc.)
____ Non-Contact Water Recreation
____ Ocean, Sport & Commercial Fishing
____ Saline Water Habitat
____ Habitat - Rare & Endangered Species
____ Habitat - Marine Life

FORUM POLICY MAKERS PANEL DISCUSSION

FORUM POLICY MAKERS PANEL DISCUSSION

The Forum Panel of the San Diego Bay Symposium included policy makers (See Appendix D) with responsibility for San Diego Bay water quality issues. Forum panelists listened to technical reports on San Diego Bay pollution monitoring and ecological risks, pollution sources, human health risks, and contaminated sediment cleanup technology and the consequences of remediation. They then responded to two key questions:

- What are the highest and best uses of San Diego Bay?
- What steps should be taken to protect these uses?

Forum Panelists differed somewhat in their comments, but several recommendations or topics of concern were mentioned frequently and stressed as important. These topics were:

- **Monitoring**
  Monitoring was stressed by several panelists as the basis for future efforts to restore the bay to full health. Before a monitoring plan can be designed, however, we should determine the physical functioning of the bay, including flushing/residence times, through an excellent numerical model.

- **Prevention**
  Control of urban runoff and dewatering of underground structures were important topics to the panelists. These two activities were considered necessary to mitigate urban impacts on the Bay.

- **Cleanup**
  Several panelists indicated that improving the bay's environment and reducing health risks were a priority. According to some panelists, accomplishing these goals may require cleaning up toxic hot spots.

- **Health Risks**
  According to the panelists, health risks posed by swimming in the Bay or eating food from the Bay are a concern, and accurate information is needed on risks from these practices. Health risks, some felt, should be comparable to risks from other common activities.

- **Habitat Concerns**
  Panelists were concerned about protecting the Bay as habitat for fish and wildlife. This includes protection, enhancement, and restoration of wetlands. One panelist suggested setting minimum standards for the ecological health of San Diego Bay.

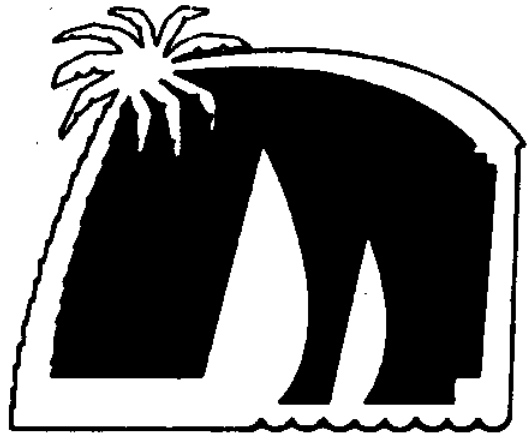
- **Uses of the Bay**
  Although panelists had differing ideas about which uses of the Bay are more important, many agreed that the current uses will continue, but the emphasis on certain uses will change.

  Mixed use of San Diego Bay is important, according to the Panelists, and a balance needs to be achieved between competing uses. Military and commercial uses will remain, while recreational use of the Bay is increasing and will continue to do so. A productive natural environment coexisting with human use should be maintained.

- **Coordination of Efforts**
  Planning, monitoring, and other activities concerning the Bay need to be coordinated by a central body. This effort should include scientists, policy makers, regulatory agencies, and the public.

Although some of the Forum Panelists' ideas about San Diego Bay differed, there seemed to be a consensus that a coordinated effort that would include monitoring, prevention, and cleanup is necessary to create an environment in San Diego Bay that is suitable for military, commercial and recreational use and as habitat for marine life.

SAN DIEGO INTERAGENCY WATER QUALITY PANEL
CONCLUSIONS AND RECOMMENDATIONS



SAN DIEGO INTERAGENCY WATER QUALITY PANEL CONCLUSIONS AND RECOMMENDATIONS

The June 1990 San Diego Bay Symposium brought together many individuals and organizations to develop a consensus on the primary contamination issues facing San Diego Bay. Among the primary concerns identified at the symposium were the management of non-point source pollution and contaminated sediments. Symposium participants rated shipping, recreation with water contact, and habitat for marine life as the most important uses of the bay. They also expressed a strong interest in maintaining a mixture of beneficial uses. The conclusions and recommendations presented here represent both the input of the symposium participants and the further deliberations of the San Diego Interagency Water Quality Panel since the conclusion of the Symposium.

The San Diego Interagency Water Quality Panel is charged with advising the State Water Resources Control Board and the State Legislature, and with assisting the Regional Board in resolving San Diego Bay water quality concerns. The recommendations presented here are addressed to the Regional Board, the State Board, the State Legislature, and to the Panel itself. None of these groups alone has the necessary resources to accomplish all of the goals stated here. The Panel may undertake activities, or may encourage other groups in the San Diego community to act on these recommendations. They may also work in cooperation with other groups at various levels to promote the attainment of the goals and objectives stated in the recommendations.

A number of factors impede both the resolution of the primary concerns identified for water and sediment quality, and the promotion of a balance of desired uses. The recommendations presented here are a result both of these concerns and of the principal technical and scientific issues facing the bay. First, policy making is hindered because the information necessary to support wise decision-making is incomplete. Bay pollution monitoring has been conducted on a project-by-project basis and a comprehensive picture is lacking. Agency responsibilities have developed as the result of numerous, separate actions by federal, state, and local governments, often resulting in overlap and conflict. Additionally, bay pollution issues are complex. Data are scattered among many repositories, making access difficult for policy makers, scientists, and the public. Finally, pollution monitoring and cleanup projects are delayed by high costs, technical difficulties, and cumbersome procedures.

With these issues in mind, the San Diego Interagency Water Quality Panel has developed the following recommendations as necessary elements of a structured plan to address contamination problems in San Diego Bay:

1. **Develop a Comprehensive Monitoring and Data Analysis Program**

   A. Coordinate Monitoring Efforts
   B. Identify Gaps in Monitoring and How They Should Best Be Filled
   C. Promote Data Analysis to Develop a Meaningful Understanding of Biological and Physical Systems in the Bay

2. **Collect Additional Data to Fill Information Gaps**

   A. Human Health Risks
   B. Ecological Risks

3. **Improve Coordination Between Agencies and Other Groups**

   A. Coordinate Monitoring Activities and Other Research Efforts to Fill Information Gaps
   B. Establish a Scientific Review Panel
   C. Prepare an Annual Report On Proposed and Ongoing Projects On San Diego Bay

4. **Promote Effective and Economical Management of Contamination Problems**

A. Encourage the Development of New and Alternative Methods, Products, and Technologies That Aid in the Management of Contamination Problems
   - TBT-Containing Paints
   - Urban Runoff
   - Cleanup Technologies

B. Encourage the Development of Legislation, Policies, and Management Practices to Deal With Key Areas That Are Presently Unaddressed
   - Marinas and Anchorages
   - Urban Runoff
   - Regional and Deep Ocean Sediment Disposal
   - Unified Permitting Process For Remediation Activities

C. Encourage the Development of Clearly Defined Sediment Quality Criteria

D. Encourage the Use of Risk Assessment Procedures in Defining Regulatory and Cleanup Criteria

E. Encourage the Recognition and Preservation of Endangered Species and Sensitive Habitats

5. **Encourage Public Education On San Diego Bay Water Quality Issues**

RECOMMENDATION 1: DEVELOP A COMPREHENSIVE MONITORING AND DATA ANALYSIS PROGRAM

In her keynote address at the San Diego Bay Symposium, Senator Lucy Killea stated that monitoring will be the basis for future efforts to restore San Diego Bay to its full health. Monitoring in San Diego Bay is currently undertaken by various organizations and agencies, some of which have little detailed knowledge of other monitoring activities in the Bay. There are two inherent difficulties in this "piecemeal" monitoring program: 1) Monitoring efforts can be duplicative, wasting limited resources; and 2) A lack of uniformity in study parameters can make it difficult or impossible to compare data obtained from uncoordinated monitoring studies.

A. Coordinate Monitoring efforts.

Policy makers and scientists at the Symposium strongly recommended that monitoring programs for San Diego Bay be comprehensive, coordinated and compatible. Coordinated regional monitoring is under development for the ocean, bays and estuaries in Southern California. It is essential that San Diego Bay be a significant element of this regional effort. Coordination of monitoring efforts in San Diego Bay is discussed further in RECOMMENDATION 3. A.

There are many current and developing monitoring programs in San Diego Bay. The San Diego Interagency Water Quality Panel should work with other groups to identify participants, evaluate objectives and make recommendations on how to develop a comprehensive monitoring program. A series of workshops may be the most effective approach to accomplish these goals, and should be investigated.

B. Identify Current Gaps in Monitoring and How They Should Best Be Filled

Past monitoring efforts in San Diego Bay have focused on locating pollution sources and "hot spots" in the Bay and not the overall status of the bay or long-term trends. This fills important short term information gaps, but does little to identify early warning signs of long-term impacts. Long-term monitoring is necessary to determine cost effective solutions to chronic pollution problems. Such a program should be initiated at a larger number of sites, which should be measured at least annually to evaluate changes from the baseline.

Some geographic areas of the bay, such as the south bay and the central open areas, have traditionally been under-represented in monitoring efforts. The extent and magnitude of pollution in all areas and habitats of the bay should be determined and a pollutant loading survey should be conducted to evaluate the relative importance of potential input routes.

Non-point sources, such as storm drain runoff, should be given greater attention. Surface films around storm drains, as well as civilian and military fueling and docking facilities should all be monitored as part of a comprehensive program.

The basis for a comprehensive monitoring program should be a common database and software to standardize monitoring data. Currently, there is no central repository of analyzed data on historical efforts and results of past monitoring. This makes it difficult to review past efforts in order to avoid duplicating sampling and wasting resources. A comprehensive biological and chemical baseline from which to evaluate changes should be established as a part of this program. Funding sources for developing and maintaining a centralized system would be necessary, as well as the manpower to operate the program. Design of the data base might be based on the Ocean Data Evaluation System (ODES) developed by EPA. This system could also eventually be integrated with that of the Bay Protection and Toxic Cleanup Program (SB 475 and AB 41).

The Regional Water Quality Control Board has issued an early Joint National Pollutant Discharge Elimination System (NPDES) permit for storm drains to the County of San Diego, all 18 cities in the County, and the Port of San Diego. This will require the establishment of a joint monitoring program. This program and the Bay Protection and Toxic Cleanup Program may provide opportunities to fill some gaps in monitoring programs. The Bay Protection and Toxic Cleanup Program (SB 475 and AB 41) mandates the development of a water quality database, numerical standards for monitoring, and monitoring protocols. Both of these programs should be considered as elements of a coordinated monitoring program.

A comprehensive monitoring program for San Diego Bay should include, but not be limited to, the following areas:

- monitoring of storm drains and accompanying run-off,
- continued monitoring of toxic hot spots,
- further monitoring of human health risks posed by recreational activity in the Bay, and by consumption of seafood taken from the Bay,
- fish, wildlife, and plant monitoring,
- contaminant mapping, including a sediment monitoring program that goes beyond monitoring of toxic hot spots,
- air quality monitoring,
- comprehensive determination and continuing updates on flushing and residence times of contaminants in the Bay, and
- monitoring of sufficient reference sites to provide comprehensive background data for the entire Bay.

Any monitoring program for San Diego Bay must take a long-term approach to future management of San Diego Bay's water and sediment quality.

C. Promote Data Analysis to Develop a Meaningful Understanding of Biological and Physical Systems in the Bay.

The development and maintenance of an efficient and cost-effective monitoring program will require a better understanding of the bay's physical and biological systems. As our knowledge of these systems increases, this information should be used to update monitoring studies in the bay. Without these necessary steps, the possibility exists that the monitoring data collected in the bay will be inadequate and/or not thoroughly understood. Analysis of existing and future data should therefore focus on achieving a better understanding of many elements of the bay's physical oceanography, such as tidal and wind-driven water circulation, salinity, and temperature. Likewise, biological systems should be understood to a degree that allows a meaningful interpretation of monitoring data. These data should be used to optimize and validate contaminant hydrodynamic and fate models of San Diego Bay.

RECOMMENDATION 2: COLLECT ADDITIONAL DATA TO FILL INFORMATION GAPS

In the past few years, many areas have been identified where specific actions can and should be taken to evaluate and manage contamination problems in San Diego Bay. However, important information gaps do still exist.

Human Health Risks.

The evaluation of possible human health risks associated with using San Diego Bay is an area that requires the collection of additional information. The San Diego Bay Health Risk Study has provided a comprehensive baseline from which to estimate the risks of eating bay fish, and from which to initiate further studies. However, some health risks remain either incompletely evaluated or not addressed at all.

Only two of the chemicals evaluated in the study, mercury and PCBs, were detected in concentrations high enough to be considered possible threats to human health. However, further evaluation of some contaminants may be necessary. For instance, concentrations of dioxins and furans in bay fish have not been thoroughly evaluated. Similarly, specific radioisotopes in bay fish should be differentiated, and levels of organic vs. inorganic arsenic and mercury should be determined.

Some health risks not addressed by the San Diego Bay Health Risk Study should also be evaluated. An evaluation of shellfish consumption patterns in the bay should be made. If it is found that individuals are harvesting and consuming significant amounts of shellfish, then analyses of pollutant concentrations should be performed to determine potential risks. An attempt should also be made to evaluate the possible risks incurred from recreational contact with the bay's waters during activities such as swimming and water skiing.

Ecological Risks.

In addition to evaluating human health risks, it is necessary to expand our present knowledge of many areas of the bay's ecology. In contrast to methods of investigation that have been previously applied, future investigations should expand their focus with respect to the range of pollutants and organisms investigated.

An evaluation should be made of contaminants that are not traditionally measured, but that may present an equal or greater risk than chemicals that presently are. This determination should be made through a state-of-the-art scientific literature survey and a thorough review of hazardous substances handled or generated in the bay region.

Ecological studies should be conducted at both the community and population levels. Such studies are necessary for a broader understanding of the effects of pollution and disturbance in the bay. Large scale seasonal studies, designed to characterize ecological systems and to assess the degree of ecological degradation caused by present and past pollution, should be conducted in all areas of the bay. In contrast to past investigations, special care should be given to including representative areas of the outer and central bay.

The biomagnification of selected chemicals, especially PCBs, PAHs, and some organometals, should be evaluated more completely. This would fill important gaps in our present knowledge as to whether such compounds may represent direct threats to marine organisms in the bay, and/or indirect threats to other organisms that feed on bay fauna, such as shore birds and humans.

A closely related, and also much needed, area of research is the toxicity and bioavailability of contaminants in bay sediments. Because San Diego Bay contains reasonably well-defined toxic hot spots and toxicity gradients, it is ideal for use as a test harbor in evaluating and defining sediment criteria and standards based both on toxic response to sediments and state-of-the-art chemistry.

The transport and fate of pollutants within the bay should also be evaluated. A better understanding of bay water movement and sediment transport is necessary for predicting the effect of pollutants on fish and wildlife. Work should be continued on the joint development of a comprehensive hydrodynamic-fate computer model by Naval Ocean Systems Center and the San Diego Regional Water Quality Control Board. This model is a necessary tool in predicting the movement of contaminants throughout different sections of the bay. It is also necessary to more completely assess the degree to which pollutants are retained in the water column, become buried in the sediments, and accumulate in marine life.

Deep ocean disposal should be evaluated as an option for remediating contaminated sediments. Research needed to evaluate effective disposal technologies and the fate and impact of pollutants in deep ocean environments should be identified.

It is critical that efforts to evaluate and fill short-term information gaps also consider long-term trends. For this reason, study protocols should consider, or be developed jointly with, monitoring programs. This also underscores the need for increased coordination of efforts. This issue is discussed further in RECOMMENDATION 3.

RECOMMENDATION 3:
IMPROVE COORDINATION BETWEEN AGENCIES AND OTHER GROUPS

A. Coordinate monitoring activities and other research efforts to fill information gaps.

A shortcoming of research and monitoring efforts in San Diego Bay has been the absence of a comprehensive coordination and review process. Research projects involving San Diego Bay have been conducted at the federal, state, and local levels of government, as well as numerous public and private research facilities. Presently, there is no mechanism in place for coordinating these efforts, causing both a duplication of efforts and a lack of uniformity in the parameters applied to studies.

Investigating pollution problems in San Diego Bay is a very costly and time consuming process. To minimize waste of valuable resources, steps should be taken to ensure the greatest possible efficiency. Data sharing among monitoring and research programs should be improved. To accomplish this, opportunities for standardizing data collection should be evaluated.

A comprehensive monitoring program would require a central coordinating agency that could serve as a clearinghouse for monitoring information on San Diego Bay. This organization could maintain historical monitoring data, as well as records on all current and future monitoring programs. The San Diego Interagency Water Quality Panel should work with other groups to evaluate and make recommendations on how a coordinating body should be established. The coordinating body could be an existing entity, for example:

- State Water Resources Control Board and the San Diego Regional Water Quality Control Board. These are the principal State agencies with responsibility for regulating the discharge of waste to San Diego Bay. In order to take on this task, the Boards would need funding for additional staff and operations.

- San Diego Interagency Water Quality Panel. Created by AB 158 and AB 2325, this group is made up of representatives of government agencies having jurisdiction over various activities involving the Bay, and other interested environmental groups and private organizations. AB 158 specifies that the Panel shall remain in effect only until January 1, 1993. To delete or extend that date, another statute would have to be enacted. All Panel members currently serve at the expense of their respective organizations. If the Panel were to take on the task of coordinating monitoring for San Diego Bay, staff and other resources would be required.

Existing and developing monitoring programs are numerous and complex. No one organization has the mandated responsibility or the resources to organize and develop a coordinated monitoring system at this time. To undertake such a project, the agencies mentioned above, or any other suitable group, would need stable, long-term funding for staff and operations.

It is important to note here that the need for increased coordination goes well beyond investigating and monitoring contamination problems. Equally important information gaps exist in all areas of managing bay pollution problems. This includes pollution prevention, and initial investigation and final cleanup of contaminated sites. This issue is discussed further in RECOMMENDATION 4.

B. **Establish a Scientific Review Panel.**

In addition to increasing the coordination of research and monitoring efforts, a mechanism should be established to ensure that such efforts are subject to an adequate scientific review process. Even in cases where coordination is not a problem, the quality of the work may be compromised in the absence of adequate review. A scientific review panel should be established to provide technical guidance on present and future research and monitoring efforts in San Diego Bay, and to aid in the coordination of these projects.

A possible approach to this would be to establish a scientific advisory subpanel to the San Diego Interagency Water Panel. As previously mentioned, the Interagency Panel is scheduled to remain in effect only until Jan. 1, 1993. This means that either an extension of the Panel past this sunset date should be examined, or a new framework for continuing these efforts should be established.

C. **Prepare an Annual Report on Proposed and Ongoing Projects on San Diego Bay.**

Several studies are in progress or planned on San Diego Bay water quality. However, there is no resource to which scientists, regulatory agencies, and the public can refer for information on these projects. Such a document repository or database could help shape future research on the Bay, since investigators and agencies could more easily determine which areas are being adequately studied, and concentrate on those that are deficient in information.

An Annual Report should be prepared by the agency or consortium that is chosen to coordinate monitoring, research and other efforts on San Diego Bay, and should include information on each known project, such as:

- purpose and scope,
- research goals,
- timeframe for commencement and completion,
- study protocols,
- study sites, and
- groups undertaking the research and contact information for key scientists.

Information from this yearly study should be used to update the database discussed in RECOMMENDATION 1. B.

Central to the success of such a system are the resources to create and operate it. Staff and funds would be necessary to prepare, publish, publicize and distribute the annual report, which should be made available to the public. Mass media and interested organizations should be advised of the contents and availability of this report.

RECOMMENDATION 4:
PROMOTE EFFECTIVE AND ECONOMICAL MANAGEMENT OF CONTAMINATION PROBLEMS.

Proper assessment and management of contamination problems in San Diego Bay is critical to both the health of the bay and the preservation of its beneficial uses for present and future generations. However, a number of barriers make this process less efficient and costlier than it could be.

A. **Encourage the development of new and alternative methods, products, and/or technologies that aid in the management of contamination problems.**

Although many options exist for dealing with pollution problems in San Diego Bay, the development of new and alternative methods, products, and technologies should be encouraged. This approach should be part of an overall program to ensure that the most efficient and cost-effective solutions to contamination problems in the bay are utilized.

A possible approach to realizing this goal would be for the State Legislature to either direct an existing agency, or create a new one, to serve as a clearinghouse for information on new and innovative research and technologies, and provide grants to address specific pollution problems facing the State of California that are not being studied. An example of an existing agency that might be able to take on these responsibilities is the Alternative Technologies Division of the State Department of Health Service's Toxic Substances Control Program.

TBT-Containing Paints. An example of an issue where changes in practices have helped is the problem of boat bottom antifouling paints containing tributyltin (TBT). TBT concentrations have been monitored in the bay since 1983, and at times have been found at concentrations that are acutely toxic to some marine organisms. Restrictive legislation was passed in 1988, banning the use of these chemicals on vessels less than 25 meters in length. However, many boat bottoms are still coated with TBT-containing paints. Some underwater hull cleaning companies have taken the lead in this area by proposing the use of best management practices, and should be encouraged to implement them. The Regional Board is also conducting a hull cleaning survey to assess the nature of this industry. Although these steps have helped to reduce levels of TBT in San Diego Bay, other steps should be taken to continue this trend.

The development of new products could be instrumental in continuing to remedy this problem. The formulation of completely non-toxic vessel antifouling paints would not only help to reduce future concentrations of TBT, but could prevent potential problems that other toxic paint formulations may pose. Wherever possible, steps should be taken to facilitate the exchange of information necessary to ensure the use of best management practices and to aid in the development of safer products.

Urban Runoff. Another area where the need for innovative strategies is apparent is in managing the effects of urban runoff on the bay. In recent years, the magnitude of this problem has become increasingly clear. Urban runoff conveys numerous materials, such as heavy metals, organic compounds, and bacteria and viruses into the bay from upland sources. These materials can be toxic or contribute to nuisance problems.

A very important area for combating urban runoff problems is pollution prevention. The County Department of Health Services, Environmental Health Coalition, City of San Diego Water Utilities, and Encina Water Pollution Control District are all working to educate businesses and the public about reducing the use of household toxic materials and to recommend the use of safe substitutes. These efforts should be continued.

Other innovative strategies to combat urban runoff in the bay should also be examined. For example, the assimilative capacity of salt marshes might be used as part of a planned source control program to trap some pollutants.

Cleanup Technologies. Many cleanup technologies exist; most involve dredging or capping (sealing in place) contaminated sediments. However, dredging can spread pollutants by resuspending contaminated materials. Pollutants can also migrate through the sealing materials used to cap sediments. Cleanup actions are extremely expensive and may bankrupt responsible parties. Suitable disposal sites are difficult to find, and it is hard to obtain the necessary permits.

Development of innovative technologies, policies, and procedures should be accelerated. Emerging innovative technologies include areas such as natural and biogenic detoxification of contaminated sediments. Solutions to cleanup problems specific to San Diego Bay should be encouraged. For example, a pilot program could be initiated using contaminated sites in San Diego Bay to develop these technologies. Funding would be necessary, and could be provided by a consortium of industry and government.

B. Encourage the development of legislation, policies, and management practices to deal with key areas that are presently unaddressed.

Problems contributing to pollution of San Diego Bay that are not addressed in the regulatory and legislative framework should be identified. If new policies or legislation could remedy these shortcomings, then they should be developed. This is true both from a regulatory and private perspective. Although government agencies often provide the impetus for such changes, bay users can save time and money by taking a proactive stance on pollution issues. Industrial, commercial and recreational users should be encouraged to develop and adopt voluntary practices for managing pollution in the bay.

Marinas and Anchorages. Marinas and anchorages can take an active role in preventing and minimizing bay pollution problems. Oil changes, bilge pumping, and the

release of sewage are all examples of activities that can contribute to bay pollution. Marinas and docks should add or expand facilities for oil and paint storage, recycling, or disposal. Marinas should provide easily available and fully maintained sewage pump out services. Mobile facilities for oil and sewage waste should be encouraged. More reception facilities are needed for disposal of oil, bilge, and sewage wastes collected from marinas and anchorages.

Urban Runoff. Another area where such measures might be taken is in controlling urban runoff. This problem will have to be addressed through many different approaches, such as the upcoming issuance of NPDES permits for urban drains. The complexity and scope of urban runoff ensures that legislative, policy, and practice changes will all be needed to control it.

Many pollution sources can contribute to urban runoff, and a comprehensive approach that considers the entire watershed of the bay should be considered. As these sources are more clearly defined, and their relative contributions to the overall problem are more thoroughly evaluated, legislative or regulatory actions will be needed to more adequately control them.

Regional and Deep Ocean Sediment Disposal. Several alternatives exist for disposing of contaminated marine sediments. These alternatives can present problems in any of three environmental media; air (incineration), land, and water. Implementing each option is a complex and costly process that requires long lead times. Recent trends in legislation and public opinion have made it especially difficult to utilize incineration and landfilling. In view of such trends, it may be prudent to devote more attention to the future management of marine sediments.

An especially acute problem in this area is the difficulty of locating authorized ocean or land disposal sites for dredged sediments, especially those classified as hazardous wastes. San Diego County has no local landfills licensed to dispose of hazardous wastes. The cost of transporting and disposing of sediments out of state is very high, and often prohibitive. Consideration should be given to developing a regional disposal facility for contaminated sediments.

The idea of deep ocean sediment disposal should also be considered. As mentioned in RECOMMENDATION 2, many research needs concerning deep ocean disposal are still unaddressed. These include the fate and impact of pollutants in deep ocean environments and the necessary technologies to implement ocean disposal practices. Disposal of uncontaminated sediments from routine maintenance dredging should also be considered. Steps should be taken to evaluate these scientific and technological uncertainties, as well as relevant social and economic concerns.

Unified Permitting Process for Remediation Activities. Many government agencies have jurisdiction over various aspects of contaminated sediment cleanup and remediation. Long lead times are frequently necessary to obtain permits and approvals from these agencies, and their requirements may often conflict or overlap. This can confuse responsible parties, and may cause substantial delays in cleaning up sites. To reduce these problems, a unified permitting process should be developed to coordinate the requirements of all agencies.

C. Encourage the Development of Clearly Defined Sediment Quality Criteria.

Sediment standards and cleanup levels lack clear definition. The lack of numerically defined objectives to use in evaluating the environmental and public health risk of a contaminated sediment site can lead to a number of delays. These include delays in site assessment, in the cleanup and abatement order, and in selecting the level to which the site will be cleaned. Furthermore, this can lead to a lack of consistency in determining cleanup levels from site to site. Clearly, a satisfactory definition of these standards is necessary.

D. Encourage the Use of Risk Assessment Procedures in Defining Regulatory and Cleanup Levels.

In addition to lacking definition, regulatory and cleanup objectives are often based solely on the levels of contaminants present in sediments. A critical problem in this approach is the lack of information on the relationship of sediment contaminant levels to actual environmental or human health risks. Risk assessment procedures should be used to a greater degree in formulating remediation and cleanup decisions. Little, if any, evaluation of the direct environmental risk of sediment contaminants which remain in place or of cleanup procedures is generally made. For this reason, unnecessarily high cleanup levels may be established for contaminated sites that do not present a real threat to the public health or the environment. Conversely, levels may also be established that are not protective of the environment. Without the use of risk assessment procedures, it cannot be determined which of these is the case. A more thorough characterization of these relationships is necessary.

E. Encourage Recognition and Preservation of Endangered Species and Sensitive Habitats.

San Diego Bay is home to at least seven endangered species. These include the California brown pelican, the California least tern, the peregrine falcon, the light-footed clapper rail, the green sea turtle, the belding savannah sparrow, and the salt marsh bird's-beak. Many other species are currently under consideration for listing. The continued existence of these plants and animals in the bay depends in large part on the presence of suitable habitat free of significant contamination. Species that forage on bay fish, such as the California least tern, can accumulate heavy body burdens of many contaminants like PCBs, DDTs, and PAHs. These compounds can progressively bioaccumulate to very high concentrations as they move up the food chain i.e., from water to invertebrates to fish to birds. In fact, DDT concentrations have been seen in some species as high as four million times those found in water.

A recent study has shown DDT egg residues for nesting caspian terns in San Diego Bay as high as 56 parts per million. Sensitive species, such as the California brown pelican have shown reproductive effects, such as eggshell thinning, at concentrations as low as 0.5 parts per million. This illustrates how relatively small concentrations of contaminants can bioaccumulate through the food chain to levels that are high enough to cause significant impacts. Because of this, it is imperative that contaminants in the bay be evaluated as to how they might impact endangered species.

To accomplish this, it will be necessary to supplement research and monitoring efforts being planned or conducted in San Diego Bay. To ensure that impacts on, or threats to, all endangered species from contaminants present in San Diego Bay are adequately addressed, future monitoring efforts should consider forage/food items of endangered species. In addition, a comprehensive literature search should be conducted to assess the risk to endangered species from contaminants in the bay. Research should also be conducted in areas lacking adequate information.

In addition, there are many sensitive habitat areas located in or along the bay, such as mud-flats and wetlands, that are necessary to support the nesting and foraging of endangered species, as well as other wildlife. In some instances, the plant species are themselves a unique and critical habitat. These sensitive resource areas should be recognized, protected, and preserved from both direct and indirect impacts.

RECOMMENDATION 5: ENCOURAGE PUBLIC EDUCATION ON SAN DIEGO BAY WATER AND SEDIMENT QUALITY ISSUES.

San Diego Bay water and sediment quality issues are of growing concern to the San Diego region. As indicated by attendance at the Symposium, the public, regulatory agencies, scientists, environmental groups, and private industry all recognize the importance of these issues. Educating the public on issues affecting San Diego Bay water quality should continue, building on the success of the Symposium.

The process of educating the public on San Diego Bay water quality, like many other issues surrounding the bay, is complex. The San Diego Interagency Water Quality Panel has neither the personnel nor the funds to take on

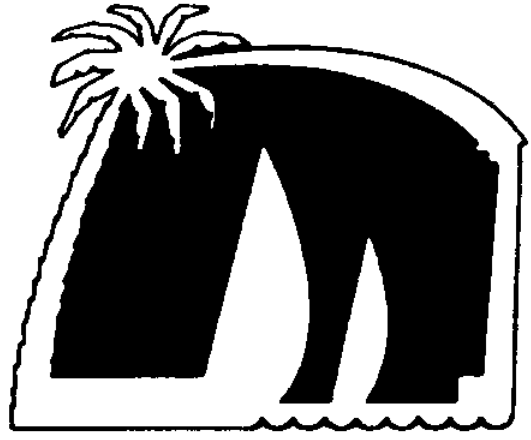
the entire task. Extending information through a variety of groups could help to accomplish this goal. Suitable participants might include Environmental Health Coalition, Scripps Aquarium-Museum, San Diego Oceans Foundation, Bay Front Conservancy Trust, 4-H Youth Development Program, Southwest Marine Educators Association and the Science Education Coordinators for local schools. Other qualified organizations may also be interested in a San Diego Bay public education program.

The San Diego Interagency Water Quality Panel could establish an education committee to develop a plan and to communicate with public education groups to ensure accurate interpretation of panel data. The attention paid to the Symposium by the media illustrates the need to accurately inform and educate this group. Fostering relationships with reporters and media persons who are particularly interested in San Diego Bay water quality issues can ensure future attention is paid to San Diego Bay-related projects. The San Diego Interagency Panel could facilitate this process by appointing a public information contact.

Education of the public could include Panel activities as well as coordination and collaboration with other knowledgeable, credible sources of information on water quality and San Diego Bay. In addition to offering information concerning the current state of the Bay and ongoing water quality programs, the public should be encouraged to participate in cleanup solutions. For example, a public education program could promote techniques to reduce the amount of toxic substances and other pollutants that are commonly used in households and eventually find their way into San Diego Bay.

As stated in RECOMMENDATION 3, it is critical that all efforts concerning San Diego Bay, including education of the public, be coordinated among those agencies having jurisdiction over or knowledge of these issues.

APPENDICES



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SAN DIEGO BAY SYMPOSIUM SPEAKERS

Alan J. Mearns, Keynote Speaker and Moderator
National Oceanic and Atmospheric Administration

Pollution Sources Workshop

Session Moderator:

Jack Anderson, Director, Southern California Coastal Water Research Project

- Urban Runoff: Overview of Southern California sampling.

Speakers:

Manuel Aceves, Port of San Diego

- Airport fuel farm underground petroleum.

David Allsbrook, Centre City Development Corporation

- Downtown underground petroleum "blob."

Dana Austin, Southwest Marine

- Example of a shipyard pollution control program.

Dave Bear, Bear Underwater Services

- Commercial underwater hull cleaning.

Anne Bleier, Keco, Inc.

- Sewage pump out

Jay Bower, Marine Trades Association

- Marine trades and communication with boat owners.

Victoria Gallagher, County of San Diego Hazardous Materials Division

- County of San Diego underground petroleum sites.

Richard Gilb, San Diego State University/California Regional Water Quality Control Board, San Diego Region

- San Diego Bay storm drain sediment sampling.
- Upstream industry location.

Mark Gold, Heal the Bay (Santa Monica)

- Santa Monica Bay storm runoff.

Lynwood Haumschilt, National Steel & Shipbuilding/Ship Repair Association

- Ship Repair Association pollution control measures.

Frederik Jacobsen, SDG&E

- Fossil fuel power plants

Keith Merkel, Pacific Southwest

- Non-point source effects on marine communities.

John Largier, Scripps Institution of Oceanography

- Oceanography of San Diego Bay.

Peter Michael, California Regional Water Quality Control Board, San Diego Region

- Boating and Shipping overview.
- Sampling at Naval facilities and underwater hull cleaning.

Thomas Oakes, Fuzetron

- A non-toxic hull coating.

Bruce Posthumus, California Regional Water Quality Control Board, San Diego Region

- U.S. Navy Overview.
- Underground Dewatering wastes: Overview and regulatory considerations.
- NPDES permits.

Jay Powell, Environmental Health Coalition

- Household and upstream hazardous materials users.

Al Skiles, General Dynamics

- Industry source reduction.

Ernie Soeteric, Proline Paint Co.

- Antifouling and non-toxic hull coatings.

Joy Zedler, San Diego State University

- Natural and artificial habitats.

Pollution Monitoring and Environmental Risks Workshop

Session Moderators:

Richard Ford, San Diego State University

- The biological status of San Diego Bay as a dynamic ecosystem.

Mark Stephenson, California Department of Fish and Game

- Mussel Watch and related monitoring in San Diego Harbor.

Rick Swartz, U.S. Environmental Protection Agency Environmental Research Laboratory

- Sediment toxicity and contamination toxicity, and benthic communities in San Diego Bay.

Speakers:

Steven Bay, Southern California Coastal Water Research Project

- Relationships between chemical and biological measures of San Diego Bay sediment quality.

Art Coe, California Water Quality Control Board, San Diego Region

- Regulatory basis and requirements for monitoring in San Diego Bay and ongoing programs.

Doug Diener, MEC Analytical Systems

- Practical sampling strategies for San Diego Bay.

John Duffy, California Department of Fish & Game Marine Resources Division

- Marine biological resources in San Diego Bay.

Alan Mearns, National Oceanic and Atmospheric Administration, Ocean Assessment Division

- Overview of the NOAA Status and Trends Program with emphasis on San Diego Bay.

Bruce McCain, National Marine Fisheries Service, Northwest Fisheries Center, Environmental Conservation Division

- Chemical contamination and associated fish diseases in San Diego Bay.

Ken Richter, Naval Ocean Systems Center

- Modeling of San Diego Bay: What data we need and how do we get it?

Michael Salazar, Naval Ocean Systems Center

- Mussels as bioindicators in San Diego Bay: Tributyltin as a case study.

Peter Seligman, Naval Ocean Systems Center

- Monitoring strategies and risk based decision making: Tributyltin as an example.

David Young, U.S. Environmental Protection Agency, Environmental Research Laboratory

- Historical perspectives and thoughts on future monitoring in San Diego Bay.

Human Health Risks Workshop

Session Moderator:

John Conway, San Diego State University, Graduate School of Public Health

Speakers:

Phil Swartzel, California Department of Fish and Game

- Status of San Diego Bay as a source of seafood.

Chris Gonaver, San Diego County Environmental Health Services

- Health risks associated with the consumption of fish from San Diego Bay.

Jon Van Rhyn, San Diego County Environmental Health Services

- Who fishes and eats fish from the bay?

Elaine Hiel, San Diego County Department of Health Services

- The health benefits of seafood consumption.

Cleanup Technology and Consequences of Remediation Workshop

Session Moderator:

Leigh Taylor Johnson, University of California Sea Grant Extension Program/San Diego County Farm and Home Advisor Department

Panel Discussion Moderator:

John Lormon, Gray, Cary, Ames and Frye, Attorneys at Law

Speakers and Panelists:

David Barker, California Regional Water Quality Control Board, San Diego Region

- San Diego Bay beneficial uses, major pollutants.
- Decision process for selecting sites for cleanup in San Diego Bay; Current sites slated for cleanup.

Panelists:

Sonya Holmquist, Environmental Health Coalition

Bill Lester, ERC Environmental and Energy Services Co.

Michael Palermo, U.S. Army Corps of Engineers Waterways Experiment Station

- Cleanup Technologies Review.

Douglas Allen, ABB Environmental Services, Inc.

- New Bedford Harbor Case Study.

John Dohrmann, Puget Sound Water Quality Authority

- Puget Sound model for setting sediment standards.

Craig Wilson, California Water Resources Control Board

- Setting sediment standards in California.

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