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COMMITTEE ON RESEARCH IN PUGET SOUND

Final Report
March 1988

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217 Pine Street, Suite 1100
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**COMMITTEE ON RESEARCH IN PUGET SOUND
MEMBERSHIP LIST**

David W. Jamison, Chair	Director, Marine Research & Development Center Washington Department of Natural Resources
Marcia Lagerloef	Staff to the Committee on Research Puget Sound Water Quality Authority
Jim Abernathy	Puget Sound Water Quality Authority
Hal Beecher	Manager, Technical Services Washington Department of Wildlife
Philip J. Carpenter	Washington Office Chief U.S. Geological Survey
Megan N. Dethier	Friends of the San Juans, Puget Sound Alliance Friday Harbor Laboratories, Institute for Environmental Studies University of Washington
Alyn C. Duxbury	Assistant Director for New Programs Washington Sea Grant Program
Jacques Faigenblum	Washington Department of Social & Health Services
William H. Funk	Director State of Washington Water Research Center
Jack H. Gakstatter	Director, Office of Puget Sound U.S. Environmental Protection Agency
Maryanne Guichard	Senior Environmental Health Specialist Seattle-King County Health Department
Ronald E. Hermanson	Extension Agricultural Engineering Specialist Washington State University
Marsha L. Landolt	Associate Dean, College of Ocean & Fishery Sciences University of Washington
Mary Lou Mills	Regional Manager for Salmon Habitat Management Washington Department of Fisheries
Tom Rainey	Director of Masters in Environmental Studies Program Evergreen State College
Ron Stapley	Research Director Carnation Research Farm
John A. Strand	Manager, Marine Sciences Section Battelle Marine Research Laboratory
Stephen D. Sulkin	Director, Shannon Point Marine Center Western Washington University
Rudy N. Thut	Senior Scientist Weyerhaeuser Company
Sally Van Niel	Washington Environmental Council, Puget Sound Alliance Everett Community College
Usha Varanasi	Director, Environmental Conservation Division National Oceanic and Atmospheric Administration
William E. Yake	Supervisor, Toxics Investigations Unit Washington Department of Ecology

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Executive Summary

MANDATE FOR THE COMMITTEE ON RESEARCH IN PUGET SOUND

In 1986 the Puget Sound Water Quality Authority reviewed the Puget Sound research effort and identified several issues that needed to be addressed. Among these issues were the planning, coordination, and funding of research and the access to and use of research results by decision-makers. In the 1987 Puget Sound Water Quality Management Plan the Authority established the Committee on Research in Puget Sound and asked the Committee to make recommendations to the Authority on these issues.

The Committee was formed in February 1987. It is composed of 20 individuals representing academic institutions, state and federal agencies, the business community, agriculture, environmental groups, and private research organizations. This report presents the findings and recommendations of the Committee. The recommendations will be presented for comment and discussion by participants at the First Annual Meeting on Puget Sound Research, which will be convened in Seattle on March 18 and 19, 1988.

FINDINGS OF THE COMMITTEE

The Committee finds that there is no comprehensive and coordinated program for research on Puget Sound. While various federal agencies currently support most of the Puget Sound research, each agency must give first priority to meeting its own needs. None of these agencies claims responsibility for Puget Sound as a whole. Consequently, the scope of the research is limited. State agencies generally have limited budgets that usually can only support short-term and site-specific studies. The result of this fragmented approach is:

- 1) There is limited coordination among agencies to optimize how research dollars are spent;
- 2) No planning activity identifies the research needs for the whole Sound as a complex system and sets these in the context of the most urgent and serious problems;
- 3) There is no stable and continuous source of support for research questions that require a long-term effort; and
- 4) There is little research that looks at the cumulative effects of our decisions on the Puget Sound system as a whole.
- 5) There is no medium for interaction among researchers to discuss the results and the implications of their work.

The Committee also finds that the present system falls short of delivering the research results to the decision-makers and other involved parties in a form and time frame that allows the results to be used in decisions. A significant percentage of agency-sponsored research resides in internal reports that receive limited distribution. Agency managers have little opportunity to stay abreast of the multiple professional journals that might contain Puget Sound-related research. Staff at the local planning level have a particularly strong need for research results that are translated into operating guidelines or models that they can readily adapt to their specific circumstances.

RESEARCH PRIORITIES FOR PUGET SOUND

The Committee developed a process to produce a comprehensive list of research priorities for Puget Sound and used the process to develop the list of priorities that is included in this report. The process was keyed to using the information needs of decision-makers and managers as the starting point for identifying research priorities. Work groups of technical experts were convened to take the information needs of the managers and refine and translate these into the research that is appropriate to address those needs. After considering the recommendations of the work groups, the final list was compiled by the Committee. It includes research priorities in six major research areas:

- 1) The distribution and physical/chemical factors related to toxic chemicals;
- 2) Biological effects of toxic chemicals;
- 3) Habitat modification;
- 4) Conventional pollutants and nutrients;
- 5) Microbiological contamination; and
- 6) Environmental and regulatory policy.

INSTITUTIONAL ISSUES RELATED TO RESEARCH

The Committee concluded that the magnitude of the problems related to coordination, funding, and application of research results requires an institutional structure to achieve the research goals identified by the Committee. Policy changes alone cannot accomplish this. The Committee identified seven functions that would need to be carried out by this institution:

- 1) Managing a process to set research priorities;
- 2) Generating research funding;
- 3) Managing a research grants program;
- 4) Translating and disseminating research results;
- 5) Facilitating access to data;
- 6) Coordinating with the Puget Sound Ambient Monitoring Program; and
- 7) Providing recommendations on the establishment of research reserves.

Existing Puget Sound institutions and institutions in other coastal areas were examined to see if they could provide models for the functions outlined. In its review the Committee looked for several critical characteristics:

- 1) Participation in the process for setting research priorities by all the parties involved in decisions to manage the Sound;
- 2) An ability to generate substantial new funding that is regionally (not federally) controlled;

- 3) An ability to communicate research results from an unbiased position;
- 4) A primary focus on Puget Sound; and
- 5) Independence from the programmatic and policy influence of a single agency or entity.

A PROPOSAL FOR THE PUGET SOUND RESEARCH FOUNDATION

The Committee proposes creation of a new institutional structure that combines many of the desirable features of other model institutions. The Puget Sound Research Foundation is proposed as an independent nonprofit corporation consisting of representatives of colleges and universities, government agencies, industry, tribes, citizens' groups and nonprofit foundations. An appointed board of trustees would oversee management of the Foundation and would be responsible for fund raising to generate broad-based support for the research program. A scientific council composed of 12 scientists familiar with Puget Sound would be responsible for identifying and ranking research needs for Puget Sound and for reviewing and ranking proposals for research funding. A management council would be composed of representatives of the key agencies and jurisdictions involved in Puget Sound management decisions. This council would provide the primary avenue for input of management needs to the scientific council in setting research priorities and coordination with the Foundation's research grants program in implementing and funding the final list of research priorities.

The proposed Puget Sound Research Foundation provides, for the first time, a mechanism to coordinate research priorities that cuts across the issue- or mission-specific perspective of any one group or agency and focuses on the entirety of Puget Sound. This approach will help ensure that the resources that are devoted to research are focused on the most important problems for the protection of the Sound. The improved information base generated by this effort will provide agencies with the tools they need to make realistic and defensible regulatory decisions. Reducing regulatory uncertainty reduces the cost and time spent in litigation for all parties.

Through its research grants program the Foundation will fill gaps in ongoing agency research and will serve as a regional sponsor for innovative research that has potential for long-term benefits for Puget Sound. Finally, the Foundation will serve a translation and dissemination role, assisting in the publication of research results and in making research a tool in helping to resolve present and future problems in Puget Sound.

Chapter 1:

Introduction

In 1986 the Puget Sound Water Quality Authority reviewed the current Puget Sound research effort--the kinds of research underway, the types of support available, the needs of agencies for research information, and how the results of that research are used in decision-making. The Authority concluded in the 1987 Puget Sound Water Quality Management Plan that funding for research is not well coordinated with Puget Sound research needs. In addition, research results often are not made available in a time frame or form that can be used in making resource management decisions.

To address these problems the plan required that the Committee on Research in Puget Sound be established. The Committee was asked to make recommendations on eight issues important to Puget Sound research:

- 1) The short-term and long-term research needs and priorities for Puget Sound;
- 2) The mechanism for setting research priorities in the future;
- 3) A structure to coordinate funding for research that is consistent with the priorities;
- 4) The appropriate state government role in funding Puget Sound research;
- 5) A mechanism to be used by public officials, state legislators, regulators, and resource managers for resolving scientific questions related to policy decisions on Puget Sound;
- 6) Methods of improving access to ongoing Puget Sound-related research, existing data, interpretive publications, and review articles by the scientific and regulatory communities and the public;
- 7) The need for additional geographic areas reserved for research (considering especially whether specific representative ecosystems are missing or under-represented in current areas used as reference areas for monitoring or for research); and
- 8) The need for incentives for the publication of research produced by state agencies, industry, and other organizations, which may be of use in policymaking but which ordinarily would not be published.

The Committee on Research in Puget Sound is composed of 20 individuals from academia, state and federal agencies, the business community, agriculture, environmental groups, and private research organizations who are researchers, managers of research, or key users of technical information. The Committee is chaired by Dr. David Jamison of the Washington Department of Natural Resources. It has been meeting on a monthly basis since February 1987. A list of Committee members can be found inside the front cover of this report.

In its early deliberations the Committee defined the nature of the problems (e.g., funding, communication of results, relevancy) as they related to Puget Sound research (Chapter 2). It also refined the goals and objectives for the research program (Chapter 3). The Committee identified two major tasks and assigned them to subcommittees.

The Subcommittee on Establishing Research Priorities developed a mechanism for establishing priorities and then developed the first priority list. The process developed by the subcommittee is discussed in Chapter 4 (Mechanism for Establishing Research Priorities). Chapter 5 presents the recommendations of the Committee on priorities for research in six topic areas: 1) habitat modification, 2) the distribution and physical/chemical factors related to toxic chemicals, 3) the biological effects of toxic chemicals, 4) conventional pollutants and nutrients, 5) microbiological contamination, and 6) environmental and regulatory policy.

The Subcommittee on Institutional Issues identified desired functions and characteristics of an institutional structure to address the problems related to research noted in Chapter 2. The Subcommittee then reviewed the structure, responsibilities, and operation of existing institutions in the Puget Sound region relative to these functions. They also looked at institutions elsewhere in the country to see what could be learned and adapted from them to suit the specific needs in Puget Sound. Chapter 6 (Review of Organizational Models) summarizes the results of this review and analysis. Chapter 7 (Recommended Organization) recommends an institutional structure to coordinate the setting of research priorities and funding of Puget Sound research. The proposed functions and policies of the institution address the tasks delegated to the Committee by the Authority.

Chapter 8 discusses the options for how the institution is created, the costs for funding the research program, and the options for funding.

Chapter 2:

Problem Statement

The Committee reviewed the assessment of research problems in the Puget Sound plan and broadened this discussion in light of the individual experience and perspective of the Committee members. A synthesis of those discussions follows, which constitutes the starting point for the Committee's work and recommendations.

THE NEED FOR RESEARCH

Managing the water quality of Puget Sound requires a careful balancing between the competing demands to use the resource (for waste disposal, recreation, fisheries, etc.) while protecting the ability of the resource to accommodate those uses. The quality and validity of management decisions is clearly a function of the quality and usefulness of the information available both to managers in making the decisions and to the public and affected parties in assessing those decisions. The information base should allow both regulators and those regulated to identify the important issues for water quality. Ideally, the information should be sufficient to project the consequences of alternative regulatory actions.

Research is scientific investigation in which a hypothesis, idea, or assumption is developed and tested through systematic collection and analysis of data. An effective program of research provides an understanding of the causes and effects of the changes in the Sound that are noted by a monitoring program. It also provides an understanding of the fundamental processes that regulate the natural system. This understanding of how the system works is a prerequisite to predicting the effects of human-induced changes on the system.

THE ADEQUACY OF OUR PRESENT RESEARCH BASE

There is a varied and, in some cases, fairly long-term body of research information that has been developed by the local colleges, universities, federal and state laboratories, and private research organizations for Puget Sound. In the past 10 to 15 years several federally-sponsored programs have focused research on Puget Sound. Among these are:

- 1) The EPA-funded study (managed by NOAA) to develop baseline information on environmental conditions in the Strait of Juan de Fuca and northern Puget Sound prior to the transshipment of Alaska crude oil;
- 2) The NOAA MESA (Marine Ecosystems Analysis) Project to assess the occurrence, fate, and effects of potentially toxic contaminants in the central and southern basins of the Sound; and
- 3) Part of the Puget Sound Estuary Program, funded by EPA, to develop action plans for toxic contaminants in urban bays, better systems and tools for managing Puget Sound, and a characterization of Puget Sound environmental conditions.

Through these studies our data base for all regions of the Sound has been expanded by the large number of field samples and laboratory analyses that have been completed. The results of these studies are responsible for alerting managers to much of what we know today about the water quality problems of the Sound. Studies for the siting of major sewage outfalls, by agencies like Metro, and ongoing monitoring of the environment by federal and state agencies have also contributed in recent years to the base of information that is used in making key water quality management decisions.

The studies referred to above have been driven primarily by immediate management needs to determine the presence and extent of a problem and potential sources of problem contaminants. Thus the studies have concentrated on intensive field sampling surveys, laboratory analyses, and syntheses of existing data. The time frame of the programs and funding constraints have limited how much these programs could sponsor the next level of study--the research that asks why and how certain changes and reactions in the environment occur under human-induced and natural perturbations. It is this latter information that is necessary to predict the effects of alternative courses of action in managing the Sound.

The process of developing a list of research priorities (to be discussed in Chapter 4) led to some general observations on the relative adequacy of our research base in certain areas:

- 1) We know more about the deeper waters of the Sound's central basin than about the southern Sound, the embayments, or the shallow nearshore zone;
- 2) We know very little about the natural variability in the living populations in the Sound (e.g., birds, fish and shellfish, algae, or bottom-dwelling fauna);
- 3) While our knowledge of the specific toxic chemicals that enter the Sound from point sources is growing, we know very little about the biological and geochemical processes that transform those chemicals in the estuarine and marine waters and therefore control their fate and toxicity;
- 4) We have limited knowledge of the movement and fate of dispersed contaminants from nonpoint sources such as agriculture, forestry, and failing septic systems. Therefore, we know little about the magnitude of most of these sources of contaminants or their effects on the water quality of the Sound.

Permit applications and state and federal laws often force managers to make decisions or implement management strategies with only limited information. To do an effective job, managers need to know the seriousness of the problems, the causes of the problems, and the most effective and equitable solutions. Some recent examples of regulatory issues illustrate this point.

- 1) Over the past 10 years several industrial development proposals have been evaluated that involve the use of subtidal and intertidal lands in the vicinity of Cherry Point in northern Puget Sound. The public and agency

responses to these proposals have repeatedly raised concerns about the disruption of eelgrass beds in the vicinity of the development. The responses have questioned whether the impacts to the eelgrass beds could be mitigated to reduce far-reaching effects on herring and other fish and wildlife species that are dependent on that habitat. Ultimately, the proposals have all been denied, but not without considerable cost to both the developers, who prepared the permit applications, and the agencies and public, who conducted thorough regulatory reviews. Future proposals will face the same uncertainty unless the information base is substantially improved.

- 2) Because of the ongoing need to maintain navigation channels through dredging, the disposal of dredged material in Puget Sound is a highly visible issue of high priority. Past practice was to designate open-water disposal sites in the Sound without completion of an environmental impact statement (EIS). Public concerns surfaced in 1984 about the long-term cumulative effects of disposal at existing sites. These concerns could not be fully addressed due to a lack of adequate data on the environmental conditions of the sites and adjacent areas. In addition, local governments sought to establish definitive criteria for determining what dredged material is environmentally safe for unconfined open-water disposal. As a consequence, most of the sites have been closed and their permits have been held in abeyance until completion of a joint state-federal planning effort, the Puget Sound Dredged Disposal Analysis (PSDDA). PSDDA is establishing the best locations for public multi-user unconfined open-water disposal, new procedures for evaluating the suitability of dredged material for open-water disposal, and specific disposal site management plans.
- 3) Stormwater management is another current issue of concern for the urban and suburban areas bordering the Sound. There is a need to better control the increasing contaminant loads that result from runoff from impervious surfaces and residential, commercial, and industrial areas. Many recent development proposals have included provisions for grassy swales or wetlands to capture stormwater and act as natural filters for contaminants that otherwise might directly enter streams and the Sound. Regulatory decisions on these proposals are being required before we have an adequate understanding of the wetland's ability to capture and retain contaminants over the long term or of the effects of stormwater flows and contaminants on wetland plants or wildlife using the wetland habitat. Urban areas are being pressed to implement stormwater-sewage separation systems (to avoid discharging untreated sewage into marine waters) without an adequate understanding of the contaminant loading that will result from the discharges of untreated stormwater. These decisions involve millions of dollars of capital construction projects.

CONSEQUENCES OF AN INADEQUATE RESEARCH BASE

The lack of adequate and accurate information for decision-making unquestionably can contribute to regulatory delay and uncertainty, ineffective and/or unnecessary regulation, excessive cost to all parties, and, ultimately, damage to the environment and natural resources. Regulatory delay can lead to other "costs":

- 1) Regulatory uncertainty has negative effects on growth and development; and
- 2) Damage to resources can occur in the intervening period that would be far more costly to correct later. Decisions related to managing Puget Sound water quality involve and affect the actions and decisions of individuals, industries, cities, counties, and the state and federal government. They also have vast economic implications for the expenditure of both public and private funds. Errors in managing Puget Sound water quality have the potential to affect the value that a clean Sound imparts to the development potential of the state, the property values of the surrounding shoreline, and the well-being of the area's residents.

The need for a sound information base for management and environmental regulation will continue to grow. The population in the Puget Sound basin is steadily increasing. In 1966 there were an estimated 1,965,000 people in the Puget Sound area. The 1987 estimated population of 2,985,800 is forecast to grow to 3.6 million by the year 2000. This population increase will be accompanied by an estimated 62 percent increase in lands developed for intense urban activities and a 73 percent increase in lands developed for rural non-farm use. These uses are likely to increase the contaminant loading to streams, the stormwater runoff to the Sound, and the number of direct industrial discharges. There will also be increasing demands to use the aquatic resources for recreation. The heightened demand to use the resource will increase the use conflicts and require that we fine-tune ever more carefully our understanding of what actions can be accommodated without degrading the water quality and resources below acceptable standards.

The variety of chemical contaminants is also changing at an alarming rate. As of 1979 the Environmental Protection Agency had placed 58,000 substances on the inventory of existing chemical substances for which permission had been requested to manufacture or import into the United States. By 1983 more than 2,000 had been added to the inventory and by 1987 another 5,000 had been added. It is expected that new additions will be made at an increasing rate in the future. It is not known how many of these chemicals might make their way to the waters of Puget Sound, what form they might take, or what effects they might have.

This is clearly not a static situation in terms of the potential pollutant inputs to the Sound or the level and complexity of the conflicts and questions that will arise.

ASSESSMENT OF THE PROBLEMS RELATED TO PUGET SOUND RESEARCH

COORDINATION

Puget Sound research planning is currently a fragmented activity, generally left to the individual investigator or the funding source. The result is that:

- 1) While in the past two years the Puget Sound Estuary Program Management Committee has increased communication between resource agencies, there is still limited coordination among agencies to optimize how research dollars are spent;
- 2) No research planning activity identifies the needs for the whole Sound as a complex system and sets these in the context of the most urgent and serious problems, as identified by managers;
- 3) There is no stable and continuous source of support for research questions that of necessity require a long-term effort (including understanding the processes involved in causing pollutant effects and the broad implications of those effects);
- 4) There is little research that looks at the cumulative effects of our decisions on the Puget Sound system as a whole; and
- 5) There is no medium for interaction among researchers to discuss the results and the implications of their work.

The Technical Advisory Committee (TAC) of the Puget Sound Estuary Program is the primary forum for research coordination and planning at present. The TAC is composed of scientists who contribute their time to review the direction of the EPA Puget Sound program as well as plans and reports related to the estuary program. As such, it is limited by the time these individuals feel they can contribute. The TAC's review efforts are largely concentrated on the studies supported directly by the estuary program, chiefly with EPA funding. The EPA program funding is intended to be terminated after five years, leaving the future of the TAC as a coordinating unit in question.

FUNDING

As suggested above, there is a lack of locally controlled funding for research on Puget Sound water quality. Most of the current support for research in Puget Sound is federal money. Directed or problem-oriented research is supported by funding from various sections of the National Oceanic and Atmospheric Administration (NOAA), EPA, the U.S. Army Corps of Engineers, the National Institutes of Health, and the Department of Energy. The U.S. Geological Survey, Food and Drug Administration, Fish and Wildlife Service, and U.S. Department of Agriculture also conduct some in-house research and monitoring related to the Sound and its watersheds. None of these agencies claim responsibility for Puget Sound as a whole or view their primary objective as the support of research. Rather, research and contract studies are funded specifically to provide information that supports the agency's ability to carry out its mission. This results in two critical constraints on the research: 1) the scope of the research is necessarily limited to the perspective of the agency, which may be either more global than Puget Sound or specific to only some aspects of the Sound; and 2) the research approach may be adjusted for the sake of national program consistency within the agency rather than the unique conditions that may exist in Puget Sound.

The National Science Foundation, the primary federal source of support for basic research, is most likely to fund proposals that are addressing a problem

that has broad applicability or advances the state of the science. A site-specific study of the properties of Puget Sound may not rate highly with these criteria.

State agencies clearly are not budgeted to support research. The contract studies that are supported are generally short-term and site-specific.

The stability of any of these funding sources is a concern. The Sea Grant program has been eliminated from the federal budget every year and ultimately reinstated after intense lobbying. The EPA estuarine program support is intended as a five-year effort in each of the designated estuaries.

APPLICATION OF RESEARCH RESULTS

The present system falls short of delivering research results to the decisionmakers and other involved parties in a form and time frame that allows the results to be used in decisions. A portion of agency-sponsored research resides in "gray" literature--internal reports that may not receive formal peer review and for which the distribution is limited. Academic research is generally published in peer-reviewed journals, but agency managers have little opportunity or encouragement to devote the time and effort to keeping abreast of these multiple literature sources. Staff at the local planning level have a particularly strong need for research results that are translated into operating guidelines or model programs that they can readily adapt to their specific situations.

Decision-makers and others concerned with Puget Sound have been confused by disputes among scientists about the appropriate interpretation of existing research. The scientists feel equally frustrated that their expertise and guidance is not requested or given appropriate weight in decision-making.

CONCLUSIONS

The problems encountered in the present research system were distilled into two questions considered by the Committee: 1) How can we ensure that the effort and resources that are devoted to research are commensurate with and appropriate for the problems we are confronting in managing the Sound? and 2) How can we ensure that the results of existing research are understood and available for the decisions we make on Puget Sound water quality? Because of the magnitude of the problems underlying these questions, the Committee suggested that an institutional structure (rather than policy changes alone) is needed to coordinate, foster, and serve as an advocate for changes in the present system.

Chapter 3:

Goals and Objectives

The goal for the research program, as set forth in the 1987 Puget Sound Water Quality Management Plan, is:

"To establish a system of priorities and funding for research that (1) adds to our knowledge of the physical and biological systems of Puget Sound; (2) identifies causes and solutions of pollution problems; and (3) assists decision-making activities of regulatory and management agencies while stimulating creativity and excellence in research."

The Committee on Research in Puget Sound assessed the original program goal in relation to the problems described in Chapter 2 of this report. This assessment produced the specific goals and objectives listed below. These goals recognize that research will be most productive if it is an ongoing activity and has a relatively stable base of support. The Committee's objectives under each of these goals relate to the institutional system or policies that need to be developed to achieve that goal.

GOAL 1: To understand the biological, chemical, and physical processes that control the overall health and character of the Puget Sound environment and its resources, and the effects of human actions on those processes and resources.

Objectives:

- o Establish a mechanism to set research priorities for the whole system that includes integration of our existing knowledge of the Sound and its watersheds;
- o Provide flexibility in the research funding system to support research on fundamental processes that may result in significant scientific breakthroughs in the long term;
- o Provide a mechanism for the direct coordination of research and monitoring activities that are underway;
- o Ensure that there are adequate natural research preserves (areas protected for long-term environmental study) in the range of environments occurring in Puget Sound.

GOAL 2: To provide resource decision-makers with the best information possible for management decisions.

Objectives:

- o Provide a mechanism for resource managers to communicate their research-related informational needs to those who set priorities for research;

- o Provide an institutional mechanism that gives agency personnel the ability to readily locate, communicate with, and engage individual technical specialists to help them solve specific problems;
- o Establish policies (tied to research funding) that encourage and support publication of research results in a timely manner and in a readily accessible form; and
- o Provide a forum for discussion of research results that are pertinent to policy issues.

GOAL 3: To ensure that there is an adequate (and stable) base of research.

Objectives:

- o Establish an institutional structure that facilitates developing multiple funding sources;
- o Establish a mechanism for setting research priorities that encourages follow-through support of research on the priority list by other institutions or agencies;
- o Develop a funding base for Puget Sound-specific (vs. national priority) research;
- o Conduct an annual meeting to increase public awareness of the benefits of and need for research, and to arrive at a consensus among research producers and users as to what the highest research priorities are.

Chapter 4:

Mechanism for Establishing Research Priorities

The research committee assigned two tasks to the Subcommittee on Establishing Research Priorities: 1) to develop a list of research priorities, and 2) to develop a mechanism to set priorities in the future. The Subcommittee simultaneously addressed both tasks by proposing and testing a process to generate the first list of priorities. The Subcommittee reviewed processes that have been used by other organizations to set research priorities for marine waters or other estuaries before deciding on the process described below. That review highlighted the importance of involving all of the concerned parties in the process. It was also apparent that a process that relied too heavily on an elaborate computerized ranking system (e.g., paired rankings and weighted ranking criteria) could result in a priority list that was inadvertently driven by a few criteria, did not make sense, or was not generally accepted.

Before starting the process to set priorities the Committee developed a working definition of research as the basis for what was or was not appropriate for inclusion on the list of research priorities. This definition is found in Figure 1.

The definition of research is keyed to the goal for the Puget Sound plan's research program quoted at the beginning of Chapter 3 of this report. To develop the definition several decisions and assumptions were made that are significant because they expand the breadth of the program beyond any that has ever been planned or coordinated for Puget Sound. Assumptions used in this definition of research include the following:

- 1) Research on processes in the watersheds that affect Puget Sound is included, so the program deals with both marine and freshwater systems;
- 2) Socioeconomic and policy studies are viewed as necessary and important to help make better management decisions;
- 3) While research that contributes to the management of Puget Sound water quality is emphasized, research that provides a better understanding of the basic processes and functions of the Puget Sound system is seen as critical for supporting the more applied work;
- 4) Habitat management to avoid/eliminate impacts on aquatic resources is clearly included in the governing statute of the Authority; and
- 5) Development of better methodologies for sampling and analysis or technologies for pollution control are potentially appropriate research needs.

The Committee adopted and began implementing at the end of July 1987 a process for setting research priorities that included the following steps:

FIGURE 1. Definition of Puget Sound Research

Research is scientific investigation in which a hypothesis, idea, or assumption is developed and tested through the systematic collection and objective analysis of data. Puget Sound research is viewed as scientific investigation which seeks to meet one or more of the following purposes:

- o Contribute to the understanding of natural processes and resources in Puget Sound;
- o Extend the understanding of the causes of actual or potential pollution-related problems in Puget Sound, including modeling and forecasting of pollutant inputs and their fate and effects;
- o Expand and refine the understanding of the effects of human activities on the physical, chemical, geological, and biological systems of Puget Sound;
- o Develop, test, or refine technologies for avoiding or correcting pollution-related problems;
- o Develop, test, or refine socioeconomic methods for evaluating potential approaches to pollution-related problems to assist in environmental and regulatory policy decisions.

Puget Sound is defined in the 1987 Puget Sound Water Quality Management Plan to include all salt waters of the state of Washington inside the international boundary line between Washington and British Columbia east of Port Angeles. Research on problems or processes occurring in the watersheds draining into Puget Sound is appropriate for consideration here when the problem or process affects Puget Sound water quality or the resources of Puget Sound.

Step 1. Identification of Research Needs and Questions

The Authority sent letters to 65 agencies and other organizations (environmental groups, county planning departments, industry groups, agricultural groups) that are involved regularly in making decisions about Puget Sound and its watersheds, and that therefore need information that might be generated by research. They were asked to identify the main concerns and questions where they felt additional research is needed to increase our understanding and ability to deal with particular problems. The draft list of research needs that was included in the Puget Sound plan, plus some additional research questions from other Puget Sound reports, was sent to these groups as a starting point for their response.

The Authority published a notice in *Soundwaves* (the Authority's monthly newsletter) requesting public input on concerns that might be addressed by additional research and asking the public to rank criteria that were being considered for setting research priorities.

To facilitate the remainder of the process, letter and survey responses were sorted into six general research areas: 1) distribution and physical/chemical factors related to toxic chemicals, 2) biological effects of toxic chemicals, 3) habitat modification, 4) conventional pollutants and nutrients, 5) microbiological contamination, and 6) environmental and regulatory policy.

The responses provided information on the research question, the respondent's opinion of the relative importance of that question, and the urgency of the need for the information. The response information is summarized in Appendix A.

Step 2. Expert Analysis of Research Questions

The Subcommittee recommended experts in each of the six general research areas who were then invited to become a member of a technical work group on one of the research areas. Due to lack of funding, scientists located less than a one-day trip from Seattle made up the membership of the voluntary work groups.

Each work group (generally 10 to 15 people) included individuals having specific disciplinary expertise related to the questions raised in Step 1, individuals having both a technical and regulatory perspective (and therefore first-hand knowledge of what information would be most useful), and individuals with a more general perspective who could help identify research priorities (see Appendix B).

Members of the technical work groups were assigned questions from the list generated as a result of Step 1 and asked to provide written input for dissemination to the other members of the work group. The written input consisted of a one-page summary describing the problem represented by the question, the current status of investigation or knowledge relative to that problem, other researchable questions that might address the problem more directly, and related research that is currently underway.

A one-day meeting of each technical work group was convened in Seattle and chaired by an expert in the field. The purpose of the meeting was to have the technical experts jointly reflect on and refine the Step 1 questions into the real researchable questions, and to produce a list of 5 to 10 research priorities.

The work group meeting format required each participant to briefly summarize a specific problem and then expand the discussion to address the problem in terms of:

- 1) *Management need for the information* (time frame of relevant management decisions, legal requirements, relevance to a priority environmental problem);
- 2) *Consequences if the research is not done* (significance of the problem in terms of geographic extent, resources/ecosystem affected, persistence of impacts, economic consequences, and likelihood that the problem will increase in the next five years); and
- 3) *Feasibility of the research* (technical feasibility, likelihood of defensible results).

The work group meetings were also an opportunity to identify work now underway on the research topics and to clarify what research needs to be done here in Puget Sound, versus what can be applied/adapted from elsewhere for use here.

Work group members voted or used a consensus process to develop a list of priority research questions or topics at the end of each one-day meeting. Where possible, they also provided the Committee with the scale of effort (total or annual cost) needed to mount a successful research program.

Reports of the meetings were prepared, using the initial written input and recordings of the meeting discussions. These reports were reviewed and commented on by the work group members, revised to accommodate their comments, and forwarded to the Subcommittee for its use. The work group reports are available by request from the Puget Sound Water Quality Authority.

Step 3. Ranking of Research Topics

The Subcommittee reviewed the technical work group reports and voted on each of the research questions listed by the work groups as a priority. The Subcommittee rated each question on a scale of 1 to 5 with respect to each of three criteria:

- 1) *Importance or significance of the problem* (implications to the ecosystem and natural resources, implications for human health, economic implications);
- 2) *Timeliness* (appropriateness of this step at this point in time) and urgency;

- 3) *Benefit from the resources committed* (feasibility of obtaining defensible results, cost/benefit, cross-issue applicability).

The Subcommittee reviewed and discussed the results of the voting and then developed a final ranked list for each of the general work group areas.

The list of research priorities agreed upon by the Subcommittee was reviewed by the full Committee and revised accordingly prior to adoption by the full Committee.

The Committee's recommended list of research priorities was circulated in draft form to:

- 1) The Technical Advisory Committee of the Puget Sound Estuary Program for their review and comment; and
- 2) The agencies and organizations that provided input in Step 1 of the process, to see how well the Committee had incorporated their input and accommodated their needs.

Their comments were reviewed by the full Committee and the descriptions of the research priorities were modified as appropriate for clarification purposes. New research priorities that were brought up during this review will be held for consideration as part of the next updating of the list of research priorities.

Based on the experience gained from developing the current list of research priorities, the Committee recommends that the process be modified for future use as follows:

- 1) Limit the number of topics/questions that an agency or organization can provide as input in Step 1 (five for most, 10 for Ecology) to force some initial prioritization;
- 2) Convene a meeting of management agency and user group representatives to further refine and focus the management needs;
- 3) Ensure that work group meetings have sufficient time and freedom to open the discussion beyond the questions introduced by the management agencies and allow for additional questions based on the knowledge of the work group members;
- 4) Convene work group meetings for two days to allow sufficient time to refine the assessment of research needs under each research priority;
- 5) Have work group members use a ballot similar to the one used by the Committee to assist in the task of selecting priorities and clarifying the rationale behind the choices (ranking system should indicate the degree of agreement); and
- 6) Put dollar constraints on work groups to help them make choices and narrow the discussion to specific questions.

Chapter 5:

Recommended Research Priorities

The list of research priorities presented here was generated by the process described in Chapter 4. The Committee used the three criteria described in that chapter--importance or significance of the problem, timeliness, and benefit for resources committed--to rank specific research topics within each of the six major research areas.

In developing the list of research priorities the Committee tried to differentiate between research from elsewhere that can be applied or adapted for use in Puget Sound, and research that must specifically be conducted in the Sound. Puget Sound has unique features (e.g., its depth, climate, water temperature, circulation patterns, industrial discharges, mix of forested and urban lands, and anticipated growth and development) that limit the degree to which research findings from other estuaries can be applied here. Research that must be conducted in Puget Sound therefore was given the highest priority.

Research priorities recommended by the work groups varied greatly in their specificity, which made comparable ranking difficult. For example, some of the topics are so broad and fundamental that they could be the subject of intense study for many years. Others are quite narrowly defined and could generate results from a single directed study. A well-rounded research effort for Puget Sound should include both long- and short-term research that ranges from "applied," or problem-oriented, research to "basic" research on the characteristics and functioning of the system. The most effective way to generate good research on the broad topics is to give the research community the opportunity to respond with specific proposals which can then be evaluated on their merit.

Some research topics recommended by the work groups were eliminated from the final list of priorities because the Committee felt that they were syntheses of existing information rather than true research questions or testable hypotheses.

Because of the breadth of some of the topics on the list of recommended research priorities, the work groups and the Committee had difficulty estimating the necessary costs to perform that research. However, some examples can illustrate the approximate level of required funding:

- o A high-priority topic under toxic chemicals is to develop a better understanding of the characteristics and behavior of toxic chemicals in the mixing zone. That research would require approximately \$200,000/year for several years.
- o Research to determine the significance of the sea-surface microlayer in exposing organisms to contaminants might require about \$100,000/year for two to three years to generate meaningful results.

By comparing the list of priorities identified for Puget Sound with the research program conducted in the Chesapeake Bay estuary, it is clear that between \$3 million and \$5 million per year would be required to develop a comparable

research program for Puget Sound that could be used by regional decision-makers.

Quality of research should be a strong factor in determining how this list of research priorities is ultimately funded and addressed. The Committee recommends:

- 1) Quality and timeliness of proposed research should be given prime consideration, with cost estimates considered only in the context of overall budgetary constraints;
- 2) Responsible investigators should be given as much freedom as possible to design and conduct the research after they have passed rigorous review of proposed programs; and
- 3) Researchers should use the Puget Sound Protocols (developed by the Puget Sound Estuary Program) for sampling, analysis, and quality assurance. High quality, comparable research results are essential to develop the data base needed to make defensible decisions.

Because research results may not be attainable within a one- to two-year time frame, the continuity of research programs is also very important in assigning research funding. However, as emerging problems are recognized and new techniques for investigating these problems become available, research priorities must be reevaluated and updated to ensure that the limited funds available for research in Puget Sound are spent on addressing the most significant problems. Reevaluation of research priorities should take place every three to five years.

The listing (and description) of the research priorities that follows is arranged in rank order of priority under each of the major work group headings. The following topics appeared as priorities for more than one work group, which provides one measure of their significance:

- o Focused studies in nearshore zones of contaminant concentration,
- o Determining the significance of microlayer contamination,
- o Impacts of urban stormwater on wetlands, and
- o Developing a basis for specifying buffer zones around sensitive habitats.
- o Establishing long-term protected study sites for conducting the research specified by many of the work groups.
- o Some of the more important conclusions and general observations of the work groups are included as an introductory paragraph under each work group heading.

RESEARCH PRIORITIES

TOXIC CHEMICALS: DISTRIBUTION AND PHYSICAL/ CHEMICAL FACTORS

Research recommended under this topic will contribute to our overall understanding of the movement and fate of toxic chemicals in Puget Sound. This research will also respond to some immediate management needs, such as the disposal of contaminated sediments and the source tracing of contaminants that have been observed in high concentrations in certain areas of the Sound.

Expanded efforts to generate an overall estimate of toxic chemical inputs to Puget Sound would require development of additional analytical approaches at considerable expense. In the absence of significant additional funding, the work group recommended focusing on characterizing the biologically active compounds (those demonstrated to have an effect on biota) and identifying the sources of these contaminant inputs.

1. Develop a better understanding of speciation, partitioning, and phase associations of chemicals in the mixing zone.

Significance: The fate and biological effects of a chemical are a function of the phase (liquid, particle, or gas) or speciation (electrical charge, which affects the reactivity) of that chemical. Processes such as flocculation (the aggregation of particles) that occur in the mixing zone, where the freshwater effluent or river mixes with the saltwater of the Sound, have a significant effect on the phase of the chemical. Knowledge of these processes will help permitting authorities to set more realistic effluent limits for protecting water quality.

Research needed:

- o Develop effluent testing procedures to determine or predict the changes in phase association that occur when complex effluents are discharged into the Sound;
- o Determine the conditions under which specific pollutants remain dissolved in the water column, become incorporated into flocs and settle, or rise to the sea surface;
- o Determine biological availability of effluent floc;
- o Determine rates of chemical reactions and the relationship between speciation and bioavailability for specific chemicals.

2. Investigate and quantify circulation processes in the near-surface and nearshore waters and at the sill zones.

Significance: Making decisions about the placement of new outfalls or judging the environmental impacts of contaminants, such as oil spills, requires a knowledge of contaminant transport. Circulation processes are least well known in the shallow depths and nearshore zone. Yet these areas are where humans and organisms are most at risk and where contaminant impacts will be felt first. Sill zones (the shallow areas between basins) are particularly critical to the overall circulation in the Sound because they cause much of the surface water and contaminants to recirculate into the deeper waters of the Sound.

Research needed:

- o Improve understanding of near-surface (upper 10 meters) and nearshore circulation;
- o Quantify mixing at the sill zones;
- o Investigate the application of numerical modeling and hydraulic models to understanding Puget Sound circulation.

3. Determine the significance of the microlayer.

Significance: The sea surface is an important habitat for early developmental stages of many fish and invertebrates. It is also a place where contaminants with low water solubility or those associated with floatable particles accumulate. The microlayer may be a transport mechanism by which bacteria associated with the floatable fraction of sewage effluent could contaminate beaches.

Research needed:

- o Conduct surveys to determine the temporal and spatial extent of the microlayer and neuston surveys to determine biological significance of sea surface contamination;
- o Improve understanding of microlayer movement to identify areas where contaminants may come ashore in the highest concentrations;
- o Evaluate the extent of contamination in these areas.

4. Improve the understanding of sedimentation processes.

Significance: Knowledge of the rates at which particles settle, the areas in the Sound where particles are deposited, and the length of time that contaminants in sediments are exposed and available to the biota is fundamental to making better management decisions on disposal of dredged material, outfall siting, and the necessary level of controls on contaminant loading to the Sound.

Research needed:

- o Improve understanding of how different chemicals partition (separate) onto different materials that settle;
- o Determine the background sedimentation rates for different parts of the basin;
- o Determine how other mechanisms (such as biological uptake and repackaging in fecal pellets) change the theoretical settling velocities for particles, and how these rates change for different locations in the Sound.

5. Assess the effectiveness of sediment capping.

Significance: Various forms of capping are among the most attractive options for managing contaminated sediments (or dredged material) because they appear to be environmentally protective and have modest costs. Widespread application of this technique as a remedial measure for areas of known contamination in Puget Sound will be limited until there is a better understanding of the effectiveness of the technique and the risks involved.

Research needed:

- o Assess the effectiveness of capping projects through field evaluation;
- o Field verify models of the contaminant flux (release and movement) within sediments;

- o Investigate plastic liners and thin caps as alternatives to deal with the shortage of appropriate capping material.

6. Investigate bacterial transformation and degradation in sediments.

Significance: Chemicals or waste products that enter the marine environment may be transformed or broken down by bacteria into quite different products, with potentially increased toxicity. These processes may be enhanced in organically rich sediments. Knowledge of these reactions and the conditions that foster them is necessary to assure that we can effectively trace back to the discharges that are responsible for the wastes and that effluent controls on those discharges are adequate to protect the receiving environment.

Research needed:

- o Determine the mechanism that results in the presence of elevated alkylated phenol concentrations in sediments enriched by effluents from secondary waste treatment processes;
- o Look at the transformation of inorganics and chlorinated organics in anaerobic conditions.

**TOXIC CHEMICALS --
BIOLOGICAL EFFECTS**

The work group reviewing this topic highlighted two major research needs: 1) the development of a new conceptual approach and methodology for measuring and assessing the biological effects of toxic chemicals, and 2) a focused study of zones where physical processes concentrate or reconcentrate contaminants in order to measure biological effects in Puget Sound or identify species at risk.

1. Develop a comprehensive methodology to measure and assess biological effects.

Significance: Concern about biological effects underlies most efforts to control the input of contaminants to Puget Sound. Research groups and regulatory programs have developed various biological tests for different purposes, but no well-accepted model exists to mesh these diverse efforts or guide the use and interpretation of bioassays. The lack of an agreed-upon system seriously affects public confidence in the results of these tests. Decision-makers and those seeking permits to discharge contaminants need faster and less expensive tests.

Research needed:

- o Develop sediment bioassays for brackish/estuarine conditions and "chronic" bioassays for sediments;
- o Develop a tiered testing protocol that includes simple inexpensive screening tests leading to more exhaustive tests for different levels of biological organization (subcellular, cellular, tissue, whole organism) and different life stages of plants and animals, and that addresses different types of chemicals;

- o Develop a new conceptual model to guide test selection, application of lab results to field situations, and a more rational approach to defining "damage" in the environment.

2. Identify and investigate zones of contaminant concentration.

Significance: Physical processes result in the creation of zones where contaminant concentrations are much higher than the average for all of Puget Sound. These zones include the sediment-water interface, the sea-surface microlayer, convergence and shear zones, the intertidal shoreline, and river mouths and small streams entering the Sound. Sensitive life stages of organisms that occupy these zones are at the greatest risk and provide the most sensitive indicators of potential problems. This information is needed both as an early warning that ongoing discharge practices are causing a problem and also to assess the impacts of accidental events such as oil spills.

Research needed:

- o Identify vulnerable species and life stages in each zone of contaminant concentration;
- o Determine the presence, severity, and extent of biological effects in the highest priority zones;
- o Identify the chemicals of concern and monitor for spatial and temporal patterns;
- o Initial work should focus on the microlayer--to determine if biological effects are already occurring there and to determine the extent and persistence of contamination in this zone;
- o Early priority should also be given to investigating toxic chemical levels in shellfish and exposure of salmon to toxic chemicals in river/estuarine areas.

3. Refine and confirm proposed sediment quality values.

Significance: Although biological tests are superior to chemical concentrations for assessing toxic effects, managers need numeric criteria (chemical standards) to assist in the decision-making process. Synoptic (single-time) measures of chemical concentrations, bioassay results, and assessments of benthic populations in marine sediments are being used in the Apparent Effects Threshold (AET) approach to develop proposed sediment quality values. These values need to be refined to confirm that the numbers are appropriate for application in the range of geographic environments and sediment types in Puget Sound.

Research needed:

- o Use multiple biological tests to refine and confirm the criteria proposed by the AET approach;
- o Develop a definition of "damage" in benthic species.

4. Select benthic infaunal indicator organisms.

Significance: The sediment/water interface is recognized as an important zone where contaminants may concentrate. Efforts to assess toxic effects have used

a combination of chemical concentrations, bioassay results, and assessments of populations of benthic infauna (bottom-dwelling organisms that live in the sediments). Benthic assessments would be far less costly if a few benthic species could serve as valid indicators for the health and level of disturbance experienced by the benthic community.

Research needed:

- o Review historical data along with recent studies to define reference conditions (i.e., based on salinity, depth, grain size, and organic carbon) in relatively uncontaminated areas of the Sound and to look for long-term trends in the presence and abundance of particular benthic populations.

5. Develop background data on the effects of toxics from urban stormwater on wetlands.

Significance: Wetlands are another potential concentration zone for contaminants. They have been lauded as filters for removing contaminants, including toxics, from urban stormwater that flows through them. However, impacts of toxics on wetlands and the possible transfer of the toxics to wildlife have not been well studied.

Research needed:

- o Review literature and collect background data;
- o Integrate field work with broader habitat modification studies (see Habitat Modification priorities).

6. Investigate reported eggshell thinning and increased liver weights in marine-feeding birds.

Significance: Because marine mammals, birds, and humans are high-level predators, they can provide an integrated measure of the movement of toxics through the food web. It is important to confirm or discount reports of possible toxic effects on these groups. Recent work has indicated that marine-feeding birds that nest in urban areas suffer eggshell thinning and increased liver weights, which are demonstrated responses to toxic chemicals in other locations.

Research needed:

- o Collect field samples from glaucous-winged gulls and blue herons to determine whether eggshell thinning and increased liver weights are present and, if so, whether these effects are related to exposure to toxic chemicals;
- o Track feeding areas to confirm the source of exposure.

HABITAT MODIFICATION

Fundamental research on the habitat functions and values of Puget Sound wetlands (both marine and freshwater) and other special aquatic sites is needed as a basis for management and regulatory actions related to modification of these habitats. However, the work group also recognized that regulatory decisions regarding management and monitoring cannot be delayed while a more complete knowledge of wetland functions is being developed. Rather, dedicated research sites need to be established, and permit actions (such as the requirement to create new habitats) need to be managed carefully as experiments. The results of these "experiments" can then be incorporated as they emerge into a conceptual model to build understanding of how wetlands function in altered and unaltered states.

1. Determine the characteristics of wetlands that contribute significantly to the survival and reproduction of fish and wildlife.

Significance: Wetlands serve important functions for fish and wildlife. They are nursery sites, foraging sites, and refuges from predation. Loss of these habitat values is a primary concern when regulatory decisions are made to allow placement of fill material under Section 404 of the Clean Water Act. Better information on habitat functions and values is needed for these decisions as well as to design successful habitat creation and rehabilitation projects.

Research needed:

- o Develop a list of fish and wildlife species with established or presumed wetland dependence. Based on this list inventory habitat types, identify habitat functions, develop quantitative measures of those functions, and manipulate wetland systems both in the laboratory and in the field. Long-term studies are needed to assess the full life cycle of the species in question.

2. Develop an understanding of the regional wetlands functions and their interactions, and objective criteria for their measurement and evaluation.

Significance: The value of wetlands is based on their multiple functions, including serving as habitat for fish and wildlife, protecting water quality, mediating flood flows, recycling nutrients, allowing aquifer recharge, and providing aesthetic enjoyment. To make decisions about whether or how these habitats can be manipulated, regulators and the public need an accurate assessment of wetland functions and values. Information from other regions of the country is not completely transferable because of the climate, geology, hydrology, and plant and animal species unique to this region.

Research needed:

- o For each major wetland type establish a study site with linked interdisciplinary studies including hydrology and biology;
- o Manipulate and evaluate these sites on long-term basis;
- o Evaluate and, if appropriate, adapt the national Adamus technique for assessing functions to the wetland environments in the Puget Sound region.

3. Develop a method to measure, monitor, and objectively quantify the cumulative effects of incremental wetlands loss.

Significance: There is an annual net loss of wetlands in Washington, and the cumulative effects of this loss are not known. Much of the loss occurs as a result of a number of small actions, but these projects are not reviewed in relation to what their cumulative effects may be.

Research needed:

- o Reconstruct the historical loss of wetlands based on permit tracking and inventories;
- o Conduct aerial inventories of wetlands every five years;
- o Conduct research (as discussed in #1 and 2 above) on functions and values of wetlands.

4. Investigate the impacts of changes in water quantity and quality on wetlands and the effects of wetlands on watershed hydrology and water quality.

Significance: Rapid urbanization is increasing the volume of contaminated runoff that flows to wetlands, resulting in more capital improvements that use wetlands as stormwater retention/detention basins. Changes in water quantity can change plant communities and microbial activity in the wetlands. Changes in water quality can cause bioaccumulation of toxics, groundwater contamination, and increased sedimentation.

Research needed:

- o Conduct multidisciplinary studies to look at how hydrologic changes affect the wetland functions.

5. Determine appropriate and defensible bases for defining/specifying habitat buffer zones.

Significance: Adjacent habitat is necessary to maintain wetland functions. Requiring an undisturbed buffer between development and wetlands or riparian (streamside) zones is an increasing regulatory practice that is being challenged in the courts.

Research needed:

- o Conduct experiments at dedicated research sites to look at the effects of different widths, vegetation types, densities, etc. as buffers;
- o Monitor established buffers to determine the buffer size required for particular types of disturbing activities.

6. Develop criteria and protocols for evaluating and monitoring the success of wetland creation-rehabilitation ("crehab") projects.

Significance: Wetland creation and rehabilitation is increasingly being relied upon to replace unavoidable losses of habitat that result from permitted

activities. There is an urgent management need to understand whether these projects are successfully replacing lost wetland functions and values.

Research needed:

- o Design "crehab" projects (that are required as permit stipulations) as experiments with a long-term seasonal monitoring component;
- o If project fails, determine why;
- o Set up a centralized data base for these projects;
- o Study effects of wildlife displacement that results during "crehab" construction.

7. Develop background data on the status of macrophyte communities in Puget Sound, and determine whether there are trends in their survival and exploitation.

Significance: There is increasing development pressure to fill or otherwise disturb areas vegetated by seagrasses or macroalgae (macrophytes). In the absence of a good data base, regulatory decision-makers either halt development, or they allow piecemeal activity that cumulatively could have long-term impacts on the environment and economic consequences for the fisheries of the Sound.

Research needed:

- o Inventory the physical extent of seagrass/algae beds;
- o Determine the functions of these beds;
- o Determine the relationship of surrounding communities to functions within the seagrass/algae beds;
- o Develop reliable "crehab" techniques.

CONVENTIONAL POLLUTANTS AND NUTRIENTS

High levels of conventional pollutants (suspended solids, biological oxygen demand, pH) and nutrients can have negative effects on water quality. As population and land development increases in the Puget Sound basin, more of these substances will enter the Sound. Areas of the Sound that are likely to be vulnerable to such adverse effects are known, but there is only a minimal data base to determine the significance of the different pollutant sources. There is also no data base to allow early detection of subtle changes in the biological communities of the Sound that may be caused by excess nutrient inputs. Research on these problems in the Sound should be combined with the nonpoint source pollution studies in early action watersheds around the Sound and with the research on streamside buffers and other improved forest practices as proposed under the Timber/Fish/Wildlife agreement. Modeling can serve as an important tool to improve understanding and prediction in this research.

1. Conduct embayment case studies.

Significance: The potential for conventional pollutant/nutrient problems (excess nutrients resulting in intense algal blooms and oxygen depletion) is greatest in poorly flushed inlets and embayments. Recent studies in Budd Inlet

suggest that inputs of nitrogen related to human activities are responsible for a 30 to 50 percent enhancement of algal blooms. This condition may be a concern elsewhere because of the increase in population and land use projected for the Puget Sound basin by the year 2000.

Research needed:

- o Long-term, interdisciplinary study of one or more sensitive embayments to establish the relationship between phytoplankton blooms and nutrient loading;
- o If possible, coordinate the study with an early action watershed and monitor upstream of a source, downstream of a source, and the saltwater receiving water to assess effects as pollutant controls are implemented.

2. Develop background data on the effects of agricultural runoff on off-site water quality.

Significance: There are many small farms in close proximity to Puget Sound. These farms are frequently located on poor quality, sloping land. There is no data base to predict accurately, for the soil and climatic conditions of western Washington, the effects of overgrazing and animal wastes on nutrient cycling, runoff, and downstream water quality.

Research needed:

- o Review available data and research on agricultural runoff to assess the scale of potential effects on water quality and to examine the effectiveness of best management practices.

3. Develop a Soundwide budget of total conventional pollutant and nutrient inputs.

Significance: Nutrient loading can result in enhanced algal blooms and can cause shifts in phytoplankton species, which can affect the rest of the marine food chain. There are no estimates of nutrient loading for Puget Sound as a whole. This information is needed to understand what controls are necessary (and feasible) when nutrient enrichment problems are detected in embayments.

Research needed:

- o Obtain information on nutrient loadings from discharge monitoring records, special embayment studies, the Puget Sound Ambient Monitoring Program, river monitoring, and modeling results;
- o Determine whether there are Soundwide changes in the intensity of algal blooms and shifts in the phytoplankton species composition that are directly related to the nutrient loadings.

5. Investigate and model the effects of the urban land conversion process on water quality.

Significance: Urban land conversion frequently consists of clearing forested land. To avoid impacts on water quality from the clearing, permitting

authorities generally require that a corridor (buffer) of undisturbed vegetation remain beside water bodies. Without a better data base for making decisions on buffer width and composition, these decisions increasingly will be litigated.

Research needed:

- o Study streamside buffers to relate characteristics such as width to effects on water quality;
- o Fine-tune the model of development effects based on site-specific parameters;
- o Develop protocols and criteria for monitoring activities in riparian zones.

MICROBIOLOGICAL CONTAMINATION

The work group discussions highlighted the fact that current monitoring practices typically measure only a few pathogens that may affect human health. Many pathogens cannot be easily cultured, so it is essential that microbial indicators be developed. Although research on a better indicator system is currently a national priority, there are unique conditions in Puget Sound (e.g., temperature, endemic species, soils) that require localized research on the issues of pathogen movement and die-off in water and sediments. It was also recognized in the work group meeting that aquaculture operations can potentially transmit fish and shellfish disease and can introduce excessive amounts of antibiotics into the environment.

1. Investigate and quantify the impact of marinas on water quality.

Significance: Marinas contain high densities of boats, in some cases with full-time, liveaboard populations. Coast Guard regulations that prohibit the discharge of untreated sewage are not strictly enforced, nor are there sufficient pumpout stations to receive wastes from shipboard storage and treatment systems. State permitting authorities generally close all commercial shellfish beds located in close proximity to marinas because high levels of fecal coliform bacteria and other contaminants are likely to be present. Before corrective actions can be targeted, marina impacts on water quality (relative to specific site conditions) need to be documented. In addition, better information is needed to guide the review of future marina siting and expansion proposals.

Research needed:

- o Review existing field data from surveys around marinas to determine under what conditions fecal coliform contamination becomes a problem.

2. Improve source tracing and develop a better understanding of the movement of contaminants through soil, surface water, and groundwater.

Significance: Bacterial and viral contamination from human and animal wastes has led to the closure of thousands of acres of commercial shellfish grounds and numerous recreational harvest areas. Many bacterial contamination problems are thought to be related to nonpoint pollution sources, but we lack a fundamental understanding of the movement of contaminants in soils and water. Understanding these processes is necessary to identify sources of problems and apply appropriate controls.

Research needed:

- o Conduct field experiments using a harmless microorganism as a tracer to follow movement of contaminants in soils and water (specifically, develop information on movement in the glacial soils typical of western Washington);
- o Develop a model of the movement of contaminating organisms in these media and calibrate and test the model.

3. *Develop better indicators of potential pathogens.*

Significance: Measurements of fecal coliform bacteria in the water column are required by regulatory authorities for certification of shellfish beds. Some shellfish growers feel that the present fecal coliform standard is excessively restrictive and is not necessarily reflective of bacterial concentrations in the shellfish meat. There is public concern that fecal coliform bacteria may not be an accurate indicator of the human health risks associated with other pathogenic organisms in the environment.

Research needed:

- o Investigate whether there are other groups of organisms that would be better indicators than the single group of fecal coliform bacteria;
- o Investigate whether there is a single organism that is a better indicator for specific pathogens, including viruses;
- o Develop tests that deal effectively with both human inputs of contaminants and those that occur naturally in the environment.

4. *Develop a better basis for detecting viral contamination in Puget Sound.*

Significance: There are well over 100 human viruses that can infect the gastrointestinal tract and thus be introduced into human wastewater. Some studies indicate that viruses found in wastewater are more resistant to chlorination than bacteria. The minimum infectious dose for viruses is very low compared to most bacteria, so measuring only fecal coliform bacteria may not adequately or accurately reflect the risk to human health. Unfortunately, many viruses are difficult (or impossible) to culture in laboratories.

Research needed:

- o Conduct background studies using available techniques to measure specific viruses near shellfish beds and beaches in Puget Sound;
- o Apply new colorimetric techniques to measure viral protein and develop improved measures of viral contamination in the Sound.

5. *Develop a better understanding of survival and die-off rates for different microorganisms.*

Significance: Regulatory action to protect public health from contaminated shellfish is based on numerical standards for fecal coliform bacteria in the water column. However, these standards do not take into account the potential for bacteria to "regrow" or reactivate in water or sediments under

certain environmental conditions. Bacteria attached to particles may accumulate in sediments, where the cold temperatures of Puget Sound may be particularly conducive for their survival.

Research needed:

- o Characterize the survival of indicator microorganisms (e.g., fecal coliform and enterococci bacteria) in the microlayer, upper layer sediments, and interstitial waters of shellfish growing waters;
- o Identify sources and trace the movement and pathways of indicator bacteria contaminating local recreational waters and shellfish beds;
- o Develop site-specific bacterial transport and fate models for a number of hydrographically different locations in Puget Sound.

6. *Determine the optimum nitrogen-to-phosphorus ratio (N:P) for Gonyaulax catenella. Define which of the N and P compounds commonly added to Puget Sound by point and nonpoint sources can be utilized by G. catenella.*

Significance: Paralytic shellfish poisoning (PSP) is a health threat to people who eat shellfish that have been contaminated with toxins produced by the organism *G. catenella*. The risk to human health might be reduced if population blooms of *G. catenella* (also known as "red tides") could be better predicted or controlled. Since these blooms can occur in areas unaffected by human activities, it is thought that factors such as nutrient inputs, temperature, and circulation processes may influence the start-up and intensity of blooms. The potential for the right combination of environmental factors to trigger a bloom appears to be highest in embayments.

Research needed:

- o Determine the N:P optimum for *G. catenella*;
- o Determine which N and P compounds commonly added to Puget Sound by point and nonpoint sources can be utilized by *G. catenella*;
- o Determine the effect of logging and agricultural runoff on blooms;
- o Investigate how trace metal concentrations may affect blooms.

7. *Determine the health risk associated with animal waste.*

Significance: Some of the pathogens associated with animal waste do not represent a direct health threat to humans, but there has not been a systematic examination of health risks associated with animal waste products. There are several areas in the Sound where marine mammals and birds aggregate and contribute significant quantities of fecal coliform bacteria. Our present system of using fecal coliforms as an indicator of contamination does not allow differentiation of sources and also does not give information on the other pathogens that may be present.

Research needed:

- o Develop better epidemiological information to correlate known disease problems with sources;
- o Improve the indicator system to help distinguish sources of contaminants.

ENVIRONMENTAL AND REGULATORY POLICY

There has been little or no focused research effort to address environmental and regulatory policy in relation to Puget Sound. The work group discussion highlighted the point that adequate and appropriate information for regulatory decision-making is only part of the problem. How a decision is implemented, and whether it is accepted, is equally important. There is information related to other problems (e.g., energy conservation) and from other regions of the country that should be the starting point for future research efforts here.

1. Investigate and develop mechanisms for the utilization/communication/translation of scientific information.

Significance: Conducting research to develop a better understanding of natural systems and processes in Puget Sound is recognized as only part of the solution to ensure that management decisions are appropriate and effective. It is important that there is a system for ensuring that the technical information, in a usable form, gets to the parties involved in a decision and is used by them in generating potential solutions to a problem.

Research needed:

- o Review how available scientific information is affecting current decisions for Puget Sound;
- o Develop a better mechanism to translate and communicate existing information for decision-makers and the public;
- o Synthesize the available information on people's preferences and values;
- o Identify how to increase the use of scientific information by decision-makers.

2. Develop a method for determining the costs and benefits of pollution control.

Significance: Substantial literature is available on cost/benefit analysis. However, agencies usually don't agree on how to systematically use cost/benefit analysis techniques. A new decision-making framework is needed where cost and benefit information is institutionalized into the policy options of the regulatory process.

Research needed:

- o Review available information on cost/benefit methods from other regions and media;
- o Develop a system for Puget Sound that includes factors that haven't been handled well to date, such as the public good versus individual costs, assessment of lost property value due to perceived pollution, and calculation of lost business opportunities due to regulatory uncertainty;
- o Create a more accurate accounting to show how Puget Sound cleanup costs relate to the comprehensive economic interests of the state;
- o Examine alternative ways to achieve cost efficiency in implementing regulations, e.g., marketing linked to recycling, incentives, and variable fee scales.

3. Develop a means to measure progress in achieving goals and develop methods for effective program implementation.

Significance: Decisions are not effective unless they are accepted and implemented; in some cases this may require significant behavior change on the part of institutions and individuals. Programs that address the problem of rural nonpoint pollution are particularly challenging to implement because they rely on voluntary choices by small farmers to use "best management practices." Implementation efforts are hampered by a lack of evaluation of the success of past programs. Information on the effectiveness of approaches needs to be incorporated into management decisions as that information becomes available.

Research needed:

- o Review and assess information from programs in other regions, and in fields other than water quality, that have been effective in order to answer the questions: What ought to work? What has worked? Why?;
- o Develop a means to integrate information from evaluation of program success into the decision-making process;
- o Develop recommendations for successful ways to communicate to decision-makers and the public to change behavior.

4. Assess the institutional environment and how it can be improved for decision-making relative to Puget Sound.

Significance: The effectiveness of both decision-making and implementation of decisions depends on the institutions that are involved in and manage those processes. The institutional framework in Puget Sound has not been analyzed recently to see if the specific roles and responsibilities of the various agencies result in an efficient decision-making process for the protection of Puget Sound and its resources.

Research needed:

- o Review the study done by Robert Bish in 1982 on governing Puget Sound to see if it still applies and is reflective of the roles of the various agencies and decision-making bodies;
- o Assess existing institutions to determine whether they are in fact fulfilling their required roles;
- o Determine what constitutes a healthy institutional environment for decision-making in Puget Sound (e.g., is there a supporting structure among agencies for sharing information; are there common goals) and how this can be fostered;
- o Look at new institutional arrangements that may be necessary to promote the research-management dialogue.

Chapter 6:

Review of Existing Institutions

Based on the discussion and analysis of problems in Chapter 2, the Committee concluded that an institutional structure is necessary to coordinate, foster, and serve as an advocate for Puget Sound research. The institution would facilitate changing the present system for determining research priorities, obtaining support for priority research, and making the results of that research accessible to the decision-making process.

APPROACH

The Committee examined existing institutions that play some role in coordinating, sponsoring, or managing research in the Puget Sound region to assess their responsibilities and functions relative to what is needed. They also looked at institutions in other coastal states that might serve as models or provide insight into how certain institutional problems can be addressed. Where possible, the directors of existing local institutions were asked to make a presentation to the Committee and discuss the present effectiveness and ability of that institution to fulfill the functions assigned to it as well as its ability to address the additional functions being considered by the Committee. Information on institutions from other regions of the country was acquired by phone, through the direct experience of some Committee members with those institutions, and by review of the bylaws, charter, and promotional materials available to the Committee for each institution. However, given this informal survey, it was somewhat more difficult to assess how effective individual institutions were in performing their chartered functions.

INSTITUTIONAL FUNCTIONS AND CHARACTERISTICS NEEDED

The institutional functions the Committee was looking for in its review closely match the tasks assigned to the Committee in the Puget Sound plan. These include: 1) managing a process for setting research priorities, 2) generating research funding, 3) coordinating research funding with the priorities, 4) assisting in better definition and discussion of the scientific issues behind policy questions, 5) improving access to data, and 6) improving the dissemination and translation of research results.

The characteristics the Committee was looking for include:

1. Research priorities must be established by both the scientific community and the parties involved in making management decisions in Puget Sound (natural resource managers, regulatory agencies, regulated entities, tribes, and the concerned public). The Committee feels very strongly that the research needs of managers and regulators must be taken into account in deciding on the expenditure of research funds. It is equally important that research priorities be set by an interdisciplinary group of scientists in an institutional framework that is independent of the agenda of any other organization. This approach will ensure technical rigor as well as sufficient flexibility to recognize and sponsor promising research that might result in breakthroughs in the long term.

2. The ability to generate research funding that is independent of and in addition to existing government and private sources of research money. The Committee recognizes that stable research support is necessary to make advances on the more complex problems. To accomplish this, a broad base of support is necessary. This could include federal, state, and private sources. The institutional structure needs to facilitate developing this permanent, regionally-controlled funding base.
3. The institution must have an ability to communicate research results easily, accurately, and simultaneously to lay audiences and professionals. This ability must be combined with sufficient public confidence in the independent scientific judgment of the institution so that it could also be viewed as an unbiased forum for the resolution of disputes over the meaning of research results.
4. The institution must be focused on Puget Sound and be in a position to look at the entire system, including its watersheds, in setting research priorities. Also, research support cannot be subject to extreme annual shifts in resources that might occur if an institution had to balance several competing programs.
5. Independence is implicit in each of the preceding four characteristics. The research priority list and the information base that will be developed are intended to serve the needs of the Puget Sound community (managers, those regulated, and the public). They must therefore be free of the agenda of a single organization and focused on the need to understand Puget Sound as a whole.

CONCLUSIONS

A description of the institutions reviewed by the Committee is found in Appendix C. The following discussion will summarize the general observations and conclusions from the institutional review.

PUGET SOUND INSTITUTIONS

The Committee examined the following institutions:

Institution	Location/Affiliation
Puget Sound Institute	University of Washington
Washington Sea Grant	University of Washington/ National Oceanic and Atmospheric Administration
Washington Water Research Center	Washington State University/ University of Washington Department of Interior

N.W. Hazardous Waste Research, Development, and Demonstration Center	Battelle/ Department of Energy, Environmental Protection Agency
Metro	Seattle/King County
Oceanographic Institute of Washington	Seattle/Oceanographic Commission
Puget Sound Estuary Program	EPA/EPA, Ecology, PSWQA

The primary drawback to many of these institutions is that they were established for other program purposes and a major portion of their funding comes from federal agencies. They therefore lack a primary allegiance to Puget Sound that could be derived from being independent and locally controlled. They are also subject to oversight and policy or programmatic changes generated by the federal agency involved. In addition, the Northwest Hazardous Waste Research, Development, and Demonstration Center and the Puget Sound Estuary Program have a finite life to accomplish their specific programs. A more permanent and stable structure is needed to foster research that will address fundamental processes in the Sound. Some of these entities, such as the Puget Sound Institute, Sea Grant, Puget Sound Estuary Program, or Washington Water Research Center might be modified to accommodate a larger mission, but this would require major adjustments to the stated purpose and focus of the current institution. The modification of an existing institution would also require a change in the governance (particularly when the director and staff are currently supported by federal monies) to provide the necessary independence and to allow for developing a major fund-raising capability. In addition, creation of the new institution at any existing institution would immediately raise concerns about favoritism towards that existing institution.

OTHER INSTITUTIONS THAT COORDINATE AND FUND RESEARCH

The Committee also reviewed the following out-of-state institutions:

Institution	Type/Affiliation
Hudson River Foundation	scientific institution/none
National Fish and Wildlife Foundation	private, nonprofit/Dept. of Interior
Aquatic Habitat Institute	independent, nonprofit corporation
Louisiana Universities Marine Consortium	state organization/La. Dept. of Education

Chesapeake Bay Research Consortium	nonprofit corp./Univ. of MD., VIMS, Johns Hopkins, Smithsonian
S. California Coastal Water Research Project (SCCWRP)	state-authorized special district/ five sanitation dists.
Virginia Institute of Marine Science (VIMS)	academic department/College of William & Mary

These institutions ranged from academic institutions to nonprofit corporations and foundations. All of the institutions are providing a service to resource managers and regulators. Some, like the Aquatic Habitat Institute or SCCWRP, do so directly, while others, like the Hudson River Foundation, engage in more academic research. Several of the institutions provide good examples of policies and mechanisms for disseminating research results and for public education.

Influence beyond the institution itself is a recurring concern. None of these institutions is viewed as the single or premier planning and coordinating entity for research on the estuarine system or area where it is focused. The academic consortia and the Aquatic Habitat Institute are in the best position to coordinate an effort to set research priorities and engage the broader support of a number of participating organizations in their regional area. As state or locally chartered institutions they are able to give priority to the regional perspective, but they may not be able to engage federal agency support and cooperation. In most cases they are dependent on federal as well as state dollars.

The foundation structure seems to provide a unique and desirable ability to establish an independent and permanent funding base that is not tied to a specific agency agenda or influenced by the vagaries of individual agency programs or legislative budget processes. The Congressional matching arrangement of the National Fish and Wildlife Foundation represents a good incentive and reward for successful fund-raising.

Independence on policy issues and technical credibility are particularly hard to maintain, even at academic institutions, when funding is obtained directly from single-source contracts. To avoid this problem the Aquatic Habitat Institute is considering requiring funding support from at least two sources for any study.

The organizational structures of the institutions reviewed typically consist of a governing/policy board. The board is composed of either an appointed membership, whose qualifications are based on technical expertise or money-raising abilities, or an institutionalized membership based on agency and/or industrial representation. The Virginia Institute of Marine Science and the Hudson River Foundation appear to have governing/advisory boards that are highly effective in engaging individuals from the private sector in commitments to preserve the vitality and usefulness of these institutions. The policies of the board are usually entrusted to an executive director and staff who are responsible for the day-to-day administration of institutional business. The

degree of power wielded by the director varies with the institution and the personalities involved.

None of these specific organizational structures is an obvious choice for Puget Sound. However, several of them have desirable features. The Aquatic Habitat Institute joins federal, state, and local government agencies with industry and citizen groups in governing and funding the institute. The Hudson River Foundation has a board of directors that is effective in sustaining and enhancing its funding base, and its research program has scientific independence and credibility. The Chesapeake Research Consortium and the Aquatic Habitat Institute both have close linkages with their respective EPA estuary programs. As a result, these institutions have a structure that can provide continuity in planning and coordination of research after the EPA funding ceases in five years. The Virginia Institute of Marine Science structure provides a recognizable center of research that is responsive to agency needs and therefore receives strong support from the state legislature.

The following chapter describes the Committee's recommendations for an institutional structure for Puget Sound.

Chapter 7:

Recommended Organization

After examining existing institutions in the Puget Sound region and elsewhere in the United States, the Committee concluded that a new institutional structure is the most appropriate option to accomplish the objectives desired for Puget Sound. The proposed structure will incorporate a unique combination of the successful features of other institutions. The Committee has kept foremost in its structure design the desired characteristics of permanence, independence, involvement by different parties, communication, and an ability to solicit and disburse funds. The structure attempts to balance the need for an independent scientific group that can develop research priorities and make grant awards with the need for involvement in those processes by the managers and regulators of the water and resources of Puget Sound. The Committee structured the organization with an eye toward Congressional and legislative appropriations as well as corporate and foundation support.

MISSION STATEMENT

The proposed Puget Sound Research Foundation will be an independent nonprofit corporation consisting of representatives of two- and four-year colleges, universities, government agencies, industry, tribes, citizens' groups, and nonprofit foundations. Its purpose is twofold: 1) to promote the coordination and support of research most needed to understand the character and functioning of Puget Sound and the significance of human impacts on natural processes and resources of the Sound; and 2) to assist in making the results of that research available and useful to the decision-making process.

FUNCTIONS

RESEARCH NEEDS AND PRIORITIES

The Puget Sound Research Foundation will establish a process that takes a comprehensive regional approach to identifying and setting priorities for research needs for Puget Sound (including problems or processes occurring in watersheds draining into and affecting Puget Sound). Specifically, this process will provide for:

- 1) Scientist/manager interactions in setting priorities;
- 2) Involvement by agencies who support research in order to foster their use of the priority list in deciding which research to fund in Puget Sound; and
- 3) Periodic updates of the priority list so that it is useful to federal, state, and local agencies in meeting their management needs.

RESEARCH GRANTS PROGRAM

The Foundation will establish and manage a competitive research grants program to support research on the priority list that is not already funded by government agencies or industry. Each year the Foundation will solicit peer reviews of proposals submitted in each high-priority research area. Proposals

will be selected on the basis of quality, significance of expected scientific contribution, importance to an affected Puget Sound resource, and cost. The Foundation will work cooperatively with agencies to allocate funds, including supporting basic or process-oriented research that may not be within a particular agency's mission but that is required to understand and use the results of directed (applied) research.

FUND RAISING

The Board of Trustees of the Foundation will manage a funding development program to establish a permanent and stable funding base from industry and other private sources as well as from federal and state entities for support of the research program and other functions of the Foundation.

TRANSLATION AND DISSEMINATION OF RESEARCH RESULTS

The Foundation will support timely dissemination and translation of research results useful to the public and resource managers. Specifically, this function includes:

- 1) Establishing a policy that research supported by the Foundation should undergo peer review and be published in appropriate technical and scientific journals;
- 2) Support for preparation of synthesis or review papers on key Puget Sound issues;
- 3) Publication of an annual report summarizing progress on Foundation-supported research and other activities;
- 4) Sponsorship of an annual meeting on Puget Sound research that includes presentations on current research, discussion of the implications of the research, and an assessment of research priorities for the coming year;
- 5) Sponsorship of forums for discussion of differences in scientific interpretation of research results, which should lead to consensus on points of agreement and identification of ways to resolve disparities; and
- 6) Efforts to increase public understanding of how research contributes to the resolution of current and future issues related to water quality in Puget Sound, thereby building public support for Puget Sound research.

DATA/INFORMATION MANAGEMENT

The Foundation will facilitate access to data and other information dealing with Puget Sound that is not readily available through the open literature, particularly unpublished research and data. The Foundation will not become a repository for raw data and publications, but it will act as a "broker" between those having information and those needing it, including the public, the scientific community, regulatory and resource management agencies, and environmental and community groups. This function will complement the function of the Puget Sound database created by the Puget Sound Ambient Monitoring Program. The Puget Sound database will serve as a source of information on what data are available and how they may be obtained.

COORDINATION WITH MONITORING PROGRAM

The Foundation will insure that, to the extent practicable, research and monitoring activities are coordinated.

INVENTORY AND RECOM- MENDATION OF RESEARCH RESERVES

The Foundation will inventory several geographic areas that are reserved for research, e.g., the University of Washington areas at Friday Harbor and Shaw Island, Western Washington University's Shannon Point Marine Center, federal and state wildlife refuges and parks, the Padilla Bay National Estuarine Research Reserve, and other public and private preserves. The Foundation will then recommend establishment of additional reserves if specific ecosystems are missing or underrepresented, either for use as reference areas for monitoring or for research.

ORGANIZATIONAL STRUCTURE

BOARD OF TRUSTEES

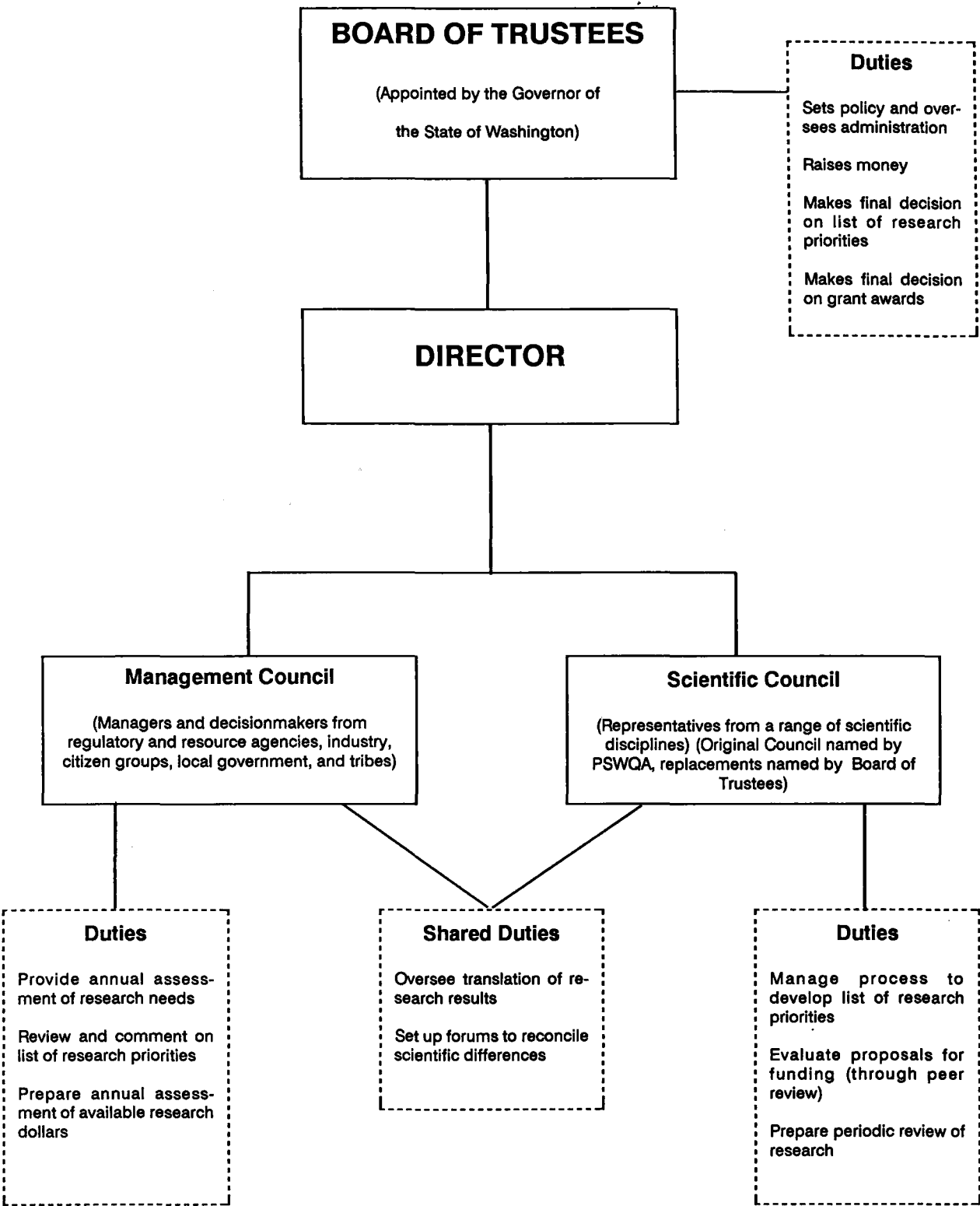
As shown in Figure 2, the Puget Sound Research Foundation will be governed by a Board of Trustees composed of nine (9) members who will oversee management of the organization and raise funds for both administration and the Research Grants Program. The trustees will establish and rule on general policy for the Foundation. For example, the trustees will be able to veto the annual research priority list if it is not consistent with Foundation policy, but they will not be able to delete or otherwise change any individual topic on the list. They will be able to reject individual grant proposals and return them to the Scientific Council (discussed below) for further review and evaluation. They will also have the power to appoint and remove, employ or discharge, prescribe the duties, and fix the salary of the director and the other employees of the Foundation. The director will serve as an ex-officio member of the Board of Trustees.

Eight members of the initial board will be appointed by the governor of Washington. The ninth member will be the chair of the Management Council (discussed below). All of the board members must be knowledgeable and have a strong interest in natural resources and Puget Sound, and at least three must have education and experience in natural resources and water quality. Members of the board must be both able and willing to seek government and private sources of funding for the Foundation. Members of the board will elect officers to serve as chairperson, vice-chairperson, secretary, and treasurer of the board.

DIRECTOR

The director will be a scientist with management and administrative ability. He or she will supervise the day-to-day work of all Foundation staff and will serve as the spokesperson for the organization. The director will coordinate the activities of both the Scientific Council and the Management Council and will be an ex-officio member of the Board of Trustees. The director will also bring recommendations of the Scientific Council to the Board of Trustees for policy level decisions. The director will have the opportunity to present a minority opinion if he or she disagrees with the Scientific Council. The director, with the assistance of the Scientific Council, will coordinate the annual research meeting and oversee publication of the annual report and other

FIGURE 2. Puget Sound Research Foundation Organizational Structure



topical reports. Also with the assistance of the Scientific Council, he or she may convene a forum to reconcile or debate scientific issues.

SCIENTIFIC COUNCIL

The Scientific Council will be composed of twelve (12) scientists with firsthand knowledge of Puget Sound processes and natural resources or with specific experience in a relevant discipline. Up to one-third of the council members may be drawn from outside the Puget Sound geographic area. The council may include, but will not be limited to: oceanographers, geochemists, chemists, biologists, ecologists, sanitary engineers, hydrologists, statisticians, and social scientists.

The Scientific Council's primary function will be to identify and prioritize research needs for Puget Sound. The council will also review and rank research grant proposals. The council will review the progress of research supported by the Foundation and assist the director and his or her staff with translation of the research for public use. Initial members of the Scientific Council will be selected by the Puget Sound Water Quality Authority. Council members will serve two-year staggered terms. As their terms expire, the Board of Trustees will name their replacements. Individuals serving on the council will be ineligible for Foundation funding of their own research and will not participate in the review of a project which they might be associated with.

MANAGEMENT COUNCIL

The Management Council will consist of representatives from federal and state agencies and local and tribal governments which either manage a program to fund Puget Sound research or have responsibility for managing Puget Sound water quality and natural resources (see Table 1). Representatives of industry, citizens' groups, and other associations or groups that use the results of research will be non-voting members of the Management Council. The period of an individual's appointment to the Management Council will be at the discretion of their organization.

The primary function of the Management Council will be to produce an annual assessment of research needs that reflects each organization's perspective and an annual assessment of available funds to sustain this research. This information will be forwarded to the Scientific Council for use in their process for setting research priorities. The Management Council will review and comment on the Scientific Council's list of research priorities. Where there are differences of opinion between the Management Council and Scientific Council, the former may choose to present an alternative list of research needs to the Board of Trustees. However, every effort will be made to achieve consensus between these two bodies. If this is not possible, the final report on research needs will reflect any differences of opinion.

The Management Council may also offer comment to the Scientific Council and the director on the progress of research funded by the Foundation and the publication function. The Management Council will provide recommendations to the Scientific Council on management and policy issues that can benefit by convening a scientific forum to examine the technical questions behind the issues. The Management Council will work with the Scientific Council in overseeing the translation function to interpret and discuss the implications of

TABLE 1. MANAGEMENT COUNCIL

Federal Agencies

National Oceanic & Atmospheric Administration
Environmental Protection Agency
U.S. Geological Survey
U.S. Coast Guard
U.S. Army Corps of Engineers
Food and Drug Administration
U.S. Fish and Wildlife Service
Minerals Management Service

Local

Representatives of Counties
Representatives of Cities
Metro (Municipality of Metropolitan Seattle)
Tribes

Non-Voting

U.S. Army
U.S. Navy
U.S. Air Force
Industry (5)
Environmental Organizations

State Agencies

Department of Ecology
Department of Social & Health Services
Department of Natural Resources
Department of Wildlife
Department of Fisheries
Puget Sound Water Quality Authority
Department of Agriculture

Organizations Funding Research

Washington Sea Grant Program
Washington Water Research Center
Northwest Hazardous Waste Research,
Development, and Demonstration
Center

research results. The chair of the Management Council will be elected by the members of the Council for a term not to exceed two years, and for the period of that appointment will be a member of the Board of Trustees. The chair may not serve two consecutive terms.

STAFF

The initial staff required to assist the director in day-to-day administration of the Foundation will include a senior scientist conversant in a range of technical disciplines (complementary to those of the director), an environmental intern, an administrative assistant/grants coordinator, and a secretary. The nontechnical positions may be less than full-time if funding for the Foundation-sponsored research program is limited.

EXPECTED BENEFITS

The Foundation, because of its coordination role, will offer for the first time a ranked list of research needs that will cut across the issue- or mission-specific perspective of any one group or agency and will focus on the entirety of Puget Sound (including watersheds). This approach will help set issues and problems in the proper context relative to their importance for the protection of the Sound. It will also help foster coordinated rather than duplicative research. The independent position of the Foundation will help assure that the research creates an objective and accessible information base for all parties. This improved information base will provide agencies with the tools they need to make defensible regulatory decisions that are realistic and to make maximum use of resources targeted to protect water quality. By reducing regulatory uncertainty, the regulated community will be less subject to arbitrary decisions, which will reduce the time and cost spent in litigation for all parties.

Through its grants program, the Foundation will fill gaps in ongoing agency research, particularly on topics designed to understand basic processes and mechanisms. The Foundation will serve as a regional sponsor for innovative research that has potential for long-term benefits for Puget Sound. In this sense the Foundation will not compete with or duplicate the efforts of government. It will help assure that we make the best use of scarce public funds.

The Foundation will foster open access to all data dealing with the quality of Puget Sound, even unpublished data. The Foundation will act as a "broker" between those having information and those needing it. The Foundation will also take on a translation role to interpret the meaning of research for decision-makers, the public, and other scientists. Through its annual meeting, annual report, and other topical reports, the Foundation will make it possible to understand the implications of the research and how it can help resolve present and future problems in Puget Sound.

Chapter 8:

Options for Funding and Implementing Committee Recommendations

This chapter presents an overview of the costs for creating and operating the Puget Sound Research Foundation. An initial analysis of alternative sources of funding and options for the type of organization that may be created are also discussed. How the Foundation is created will affect the type and level of public funding that may be earmarked and/or appropriated for this effort and the success that the Foundation will have in attracting private funding.

COSTS

A detailed cost breakdown for operating the Puget Sound Research Foundation has not yet been developed. The Committee has examined budgets for similar institutions and concluded that the research grants program can be managed for less than 10 percent of the total funds available for allocation as research grants. Depending on the availability of funds, the remaining functions and their operating costs will be scaled accordingly. As noted in Chapter 5, if the research program is funded at a level between \$3 million and \$5 million per year, it will significantly contribute to improving the existing information base and overall understanding of Puget Sound.

FUNDING OPTIONS

In order to provide continuity in research that is necessary for many of the research priorities, a stable long-term funding source is needed. The most desirable option is to create an endowment fund which can then be managed to generate the necessary annual income to support the research program.

1. State budget line item: This funding would require that both houses of the state legislature pass appropriations legislation for each biennium. This is a logical source of support for Foundation functions, since the functions are clearly aimed at assisting state decision-makers in their responsibilities for managing Puget Sound. The continuity of this funding will depend on how well the Foundation's programs are seen as meeting state needs in comparison with competing demands for funding from the Legislature. Generally, state funds must be expended during the biennium in which they are appropriated. It is unclear whether the legislature could specifically exempt the Foundation from this constitutional restriction so that an endowment could be created.

2. Centennial Clean Water Fund (cigarette tax) allotment: The authorizing legislation that created the cigarette tax (the Centennial Clean Water Act) included general provisions for how the funds are to be distributed. More detailed guidelines and regulations for the distribution of these funds are now being developed by the Department of Ecology in consultation with an advisory committee. It was the intent of the legislature in passing the act that a majority of this funding be used to provide relief to local jurisdictions in dealing with the costs of water quality management. Use of cigarette tax

funds to support the Foundation would require a change in the portion of the act specific to the use of "discretionary funds". These funds are to be used for "water pollution control activities," as determined by the Department of Ecology. Many of the research priorities can be seen as relevant to these activities.

3. Compliance penalties: Compliance penalties for violations of discharge permit limits currently go directly to the state treasury. Diverting these funds for support of the Foundation would require new legislation. This cannot be relied upon as a steady source of funding, as the amounts will vary depending on the number of violations and the intensity of the enforcement effort. Compliance penalties could be deposited with the state treasurer in a proprietary fund that could be distributed without specific legislative appropriation.

4. Permit fees: As with the compliance penalties, this would not necessarily be a steady source of funding but would depend on the number of permits processed. Legislation has recently been passed that increases the fees paid for discharge permits in order to improve the Department of Ecology's work in controlling pollution from these discharges. This legislation was the subject of significant controversy and was passed only after a special session of the legislature was called. It is also part of the proposed initiative to be voted on this fall. It may therefore be difficult to make use of this option.

5. Private gifts: Private or corporate philanthropic foundations or individual contributors generally do not like to contribute to what is perceived as ongoing operating support. These entities would likely be interested in support of specific research projects consistent with their interests. The success of a program to solicit individual donations will depend on the "leadership" of a few individuals whose personal contributions will encourage others to contribute. The board of trustees of the Foundation is a natural place to look for some of these contributions. The board of trustees should also be a key factor in the general constituency building that is necessary for either private gifts or ongoing legislative support.

6. Joint industry/agency (or state) sponsorship: There is a precedent for this type of support with the Washington Technology Center. The legislation establishing the Center requires that state funding be matched on a one-to-one basis with industry support. Industry has a direct interest in supporting specific research projects which are seen as having the potential for developing new technologies that can be commercially marketed. The Timber/Fish/Wildlife agreement is another example of a successful partnership between industry, environmental organizations, tribes, and agencies to support research and monitoring addressing some state resource management issues.

7. Federal budget line item: The National Endowment for the Arts is an example of a specific federal budget line item that goes directly to an endowment fund. The authorizing legislation states that these funds "shall remain available for obligation and expenditure until expended" regardless of fiscal year. The Historic Preservation Fund has similar language in its appropriations legislation. The National Fish and Wildlife Foundation was authorized appropriations not to exceed \$1 million for a 10-year period to match, on a one-for-one basis, private contributions made to the Foundation.

The Puget Sound Research Foundation could be chartered by Congress with a requirement for state matching funds before federal funds could be expended. The Congress has made significant direct appropriations for research in the Chesapeake Bay and other estuaries in recent years and might do so for Puget Sound in the future.

TYPE OF ORGANIZATION IN RELATION TO OPTIONS FOR FUNDING

1. Private nonprofit: This type of institution requires incorporation in accordance with RCW 24.03. A private nonprofit entity is independent of state control, but may be the recipient of state appropriations via contracts with other public agencies, such as the Department of Ecology. Private nonprofit corporations may obtain "preferred status" under state law and be designated to receive public monies for specific services performed on behalf of a government entity. A private nonprofit may also have some "standing" within a public agency. As an example, the Association of Washington Cities (a private nonprofit group) names board members to a public agency (Municipal Research Council), and Association projects are indirectly funded by the Council.

2. Public nonprofit: This type of institution may be created by the state and possess both public and private standing. If the responsibilities of a public nonprofit entity are designated as state authorized and mandated, the entity may directly receive state legislative appropriations. These appropriations may originate from general fund sources or from new revenues. A public nonprofit may also receive grant funds and solicit private donations.

3. State agency: A state agency provides the most direct means of receiving state financing, but creation of a new agency is not easily undertaken by the legislature. There are obvious alternatives of merging or appending the Foundation onto an existing state office or agency (with the drawbacks and complications in governance, focus, and fund-raising potential described in Chapter 4). Another method of creating a state entity is by executive order. This would, however, only be envisioned as a short-term entity that could set the stage for a more permanent institution.

4. State-federal public nonprofit: The Northwest Power Planning Council is an example of this type of entity. This is an innovative alternative that has the distinct advantage of allowing the entity to receive both federal and state line-item appropriations. It would also allow for private sector participation on the board of trustees. Establishing the Puget Sound Research Foundation with a federal charter would help in securing federal appropriations and would also give the organization more standing in its relations with the federal agencies involved in resource management and funding of related research. This is probably the most difficult and time-consuming type of entity to create.

APPENDIX A: IDENTIFICATION OF RESEARCH NEEDS (See Chapter 4)

RESEARCH QUESTIONS	AGENCY	TIMING	RELATIVE IMPORTANCE (1 HIGH)
<u>Nutrients and Conventional Pollutants (suspended solids, BOD, pH)</u>			
Is nutrient enrichment from anthropogenic sources causing or likely to cause decreases in water transparency and dissolved oxygen in Puget Sound in its entirety or in localized areas of the Sound?	COE		
What is the limiting nutrient in Puget Sound, and what is the critical level of that nutrient in the Sound which should not be exceeded?	EPA DNR ECOL	Immediate Ongoing	1 5 4
What are the spatial and temporal trends in parameters indicative of eutrophication, e.g. dissolved oxygen, water transparency, phytoplankton densities, primary production rates?	EPA DNR ECOL	Short-term Ongoing	1 5 5
What are the relative loadings of nutrients to Puget Sound from point and nonpoint sources including atmospheric inputs?	Port Angeles DNR ECOL	Short-term Mid-term	3 5 5
What are the relationships between specific forest practices (harvesting, fertilizing) and nutrient concentrations in adjoining rivers and streams?	Clallam County ECOL	Ongoing	4
Can data be generated in a relatively simple, cost-effective way which will allow reasonably accurate estimates of the flushing efficiency and stratification in inlets, embayments, and other potentially sensitive portions of the Sound? Can this information then be used to estimate the susceptibility of these inlets, etc., to nutrient inputs and other activities?	DNR ECOL	Short-term 2-4 years	3 2
What are the recycling patterns of nutrients in the Sound?	DNR ECOL	Short-term Mid-term	5 5
What effect would decreases in water transparency and dissolved oxygen have on Puget Sound uses?	EPA		
How do conventional pollutants in sediment affect benthic infaunal distribution, bioassay response, and fish histopathology?	ECOL DNR	Short-term Immediate	2 1
What mechanisms/factors affect the growth of micro-and macro-algae? How is their growth and distribution a reflection of the health of the marine environment?	Metro ECOL	Ongoing	5
If nutrient enrichment is expected to become a problem, what nutrient controls should be imposed to protect the Sound?	EPA COE		
What forest practices are appropriate to minimize nutrient impacts?	ECOL	Ongoing	4

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

What alternatives are available for on-site sewage disposal in areas that have physical limitations preventing use of conventional on-site systems?	WA Ass Realtors Vashon resident			
What effect does sedimentation/turbidity from various land use practices have on water quality?				
What are the sediment budgets for basins draining into Puget Sound, including all sources of sediment and quantification of storage and transport processes?	DNR SCS			
What are the relationships between specific logging practices, soil and terrain types and sedimentation/turbidity?	ECOL	Immediate	2	
What are the effects of different agricultural practices on offsite water quality? What are the effects of wind-eroded soil particles?	SCS			
How serious a water quality problem is caused by having a large number of overgrazed or abused pasture acres in a drainage basin? What happens when grass is grazed to the roots and no buffer strip is left bordering the county road ditch?	conservation district			
What is the nature and strength of interaction between development densities, degree of clearing, pattern of clearing, site topography, and runoff water quality?	King Cty Whatcom Cty	1-1.5	2	
What constitutes a damaging level of sedimentation and sediment transport into and through a stream? What parameters are relevant to measure the level of impact and what other characteristics, such as season of sediment delivery and particle-size delivery, are important?	King Cty ECOL	Ongoing Immediate	1 1	
What can be done to minimize these impacts?				
What is an adequate stream buffer size/width to protect the desirable characteristics of natural drainage features? Does adequate stream buffer size change with changes in adjacent land use? Do different stream sizes or configurations require different buffer sizes? Are sufficient public benefits derived from the preservation of stream corridors to justify the reduction in developable land?	Wildlife Thurston Cty King Cty	1-1.5 yr	2	
What is the role of natural wetlands in controlling nonpoint source pollution from urban stormwater, agriculture, silviculture, and highway maintenance? What potential do artificial wetlands hold for mitigating nonpoint source pollution from these sources?	King Cty ECOL	Ongoing short-mid-term	1 2-3	
Is there a threshold level of site vegetation cover below which the quality of surface water runoff markedly degrades? Other factors being equal, does this threshold level (if it exists) change with different plant species or vegetative communities?	King Cty	1-1.5 yr	2	

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

Toxics -- Distribution and Physical/Chemical Factors

What are the sources of toxic inputs to Puget Sound?	EPA		1
What is the best approach for identifying worst case chemicals of concern among the known Puget Sound contaminants based on their toxicity, persistence in the environment, or other factors that would give them a high probability of causing adverse effects on living resources?	EPA		1
What are the relative contributions of point and nonpoint sources of contamination?	ECOL		
	EPA		1
	WOGA	4 yr	3
What toxic chemicals enter residential and commercial on-site sewage systems?	ECOL	Ongoing	3
Could these chemicals be a potential hazard to ground or surface waters? What types of on-site systems could minimize contamination?	King Cty	1-1.5 yr	2
What agricultural chemicals are found in Puget Sound, and who is buying and applying the chemicals?	Ag Water Policy Committee		
What is the relationship between atmospheric contaminants and fallout? How are the inputs from shoreline industry affected by distance of the source from the shoreline and predominant wind patterns?	WEC/Sierra Club Whatcom Cty		
What are the impacts of high-temperature incineration on air pollution and the associated precipitation on the Sound?	PSWQA Committee Member		
What are the dominant sources of metals to Puget Sound (e.g. riverine transport, shoreline erosion, atmospheric inputs, advective input from the ocean)?	WOGA	3 yr	3
	ECOL		
What organic chemicals are formed by chlorination or other chemical treatments?	ECOL	5-10 yr	4
How can sources of toxic chemicals be effectively controlled?			
What are the removal efficiencies for various toxicants by septic tank/soil absorption systems in various soil types?	ECOL	Ongoing	4
Are there alternatives to chemical disinfection for municipal wastewater discharges into marine waters?	ECOL		
What is an efficient means of treating wastewater from high-pressure water spray removal of paint from boat hulls?	ECOL	Short-term	3
What effective means are available to retrofit existing stormwater detention facilities, originally intended for flood control only, to allow these facilities to be used for improving water quality?	King Cty	3 yr	3

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

What design and operational specifications are appropriate for projects treating urban runoff through biofiltration techniques in the Puget Sound basin? What size/flow rate/species/pollution mix relationships give optimal treatment? What are the useful lifespans of such treatment facilities in terms of pollution and runoff loading? What special maintenance and disposal requirements should be placed on such a project?	King Cty	Ongoing	1
What are the relative costs and benefits of various methods of dredge spoil disposal and the criteria for classifying something as contaminated? How well does the capping technique for dredged spoil disposal really work?	DNR	Immediate	3
What are the transport mechanisms moving toxics into various "compartments", i.e. microlayer, water column, sediments, biota, in Puget Sound?	EPA		1
What effluent components are partitioned into the microlayer (floating), suspended/dissolved, and settleable fractions of the water column?	COE		
	DNR	Short-term	3
	ECOL	Immediate	2
How do the chemical processes occurring at the saltwater/freshwater interface in the estuary affect the distribution and transport of contaminants?	ECOL	Ongoing	4
What are the coagulation/flocculation processes that occur with the discharge of specific effluents into Puget Sound?	ECOL	Immediate	2
	DNR	Short-term	3
What are the fluxes between basins of particulates and the pollutants associated with them?	EPA		1
	WOGA	3 yr	3
	DNR	Short-term	5
What are the characteristics and extent of the nepheloid layer? What is its role in contaminant transport?	ECOL		
	COE		
What role does the microlayer play in transporting toxics/bacteria/etc., particularly when combined with phenomena like on-shore winds?	ECOL		3
	DNR	Short-term	5
Do the models used to describe water circulation accurately predict pollutant transport and distributions?	EPA		1
	ECOL		
	WOGA	4 yr	3
	DNR	Immediate	3
What is the bottom water replacement rate and what are the driving mechanisms for flushing?	ECOL		
	EPA		1
	DNR	Immediate	3
What are the tidal and wind effects on mean flow, and what are the cross-channel differences in flow?	ECOL		
	EPA		1
	DNR	Immediate	3

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

What is the effect of tidal changes (rapid/periodic boundary condition fluctuations) on input parameters to contaminant transport models? Can simplified models be created which predict long-term contaminant transport without requiring the use of these short-term fluctuations of boundary conditions?	ECOL		
How is the mobility of contaminants in ground water affected by the saltwater/freshwater interface and the effects of tidal changes on ground water elevation at contaminated sites?	ECOL King Cty	Immediate 1-1.5 yr	2 5
What is the ultimate fate of toxics in Puget Sound?			
What are the historical levels of contaminants in sediments in specific basins of Puget Sound, and how do these relate to TOC and grain size?	EPA ECOL Tacoma-Pierce Health		1 3
What are the depositional areas in Puget Sound, and what are the sedimentation rates in each basin?	ECOL EPA DNR		1 5
What is the rate of removal of toxic substances from various portions of the Puget Sound basin through burial in sediments or transport to the ocean?	EPA WOGA ECOL		1 3 yr 5
How do chemical reactions in sediments change the speciation and bioavailability of metals over time?	ECOL WOGA DNR	Ongoing 3 yr Immediate	5 3 1
Which toxic chemicals in bottom sediments are broken down by microorganisms, light and other mechanisms, and at what rate? Can this rate be increased without creating undesirable side effects?	ECOL COE DNR	Short-term Immediate	3 3
How do different classes of organic compounds (e.g., low molecular weight/volatile versus high molecular weight) behave in the Sound?	ECOL DNR		5
What is the distribution in time and space of contamination of the sea surface microlayer?	ECOL		3
What range of "pollutants of concern" concentrations in the microlayer are natural, typical, elevated, or problem-causing?	ECOL DNR		2 5
What role does the sea surface microlayer play in the exposure of organisms to toxic substances, and how important is the microlayer compared to other routes of exposure (e.g. water column and sediments)?	ECOL EPA Metro		2 1
Do sediment effects go beyond the sediments? What is the relation between distribution of sediments/water toxics and distribution/abundance of mobile species? Are there any long-term and/or large-scale trends?			

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

How are pollutants assimilated into the trophic structure of estuarine communities, and what is their fate? Do biological sinks exist for certain pollutants?	King Cty	Ongoing	3
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Toxics -- Biological Effects

What populations are at risk?

What is the current status of living resources in Puget Sound?	EPA		1
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What is the natural versus perturbed three-dimensional structure of benthic communities in various Puget Sound subsystems; how do these vary with water depth, sediment grain size, organic content, etc.?	ECOL	Short-term	3
	COE		
	DNR	Immediate	3

What are the life cycles of key species at different trophic levels, and what is their exposure to specific contaminants at each stage? Which stages are most sensitive to pollution?	ECOL	Ongoing	3
	WOGA	3 yr	1
	DNR	Short-term	5

Are there spatial differences in the Sound in the levels of metals found in a particular species; are these differences related to biotic or abiotic factors? What processes control the level of trace metals in organisms?	Tacoma-Pierce Health		3
	ECOL	Ongoing	5
	DNR	Short-term	5

What is the relationship between toxic chemicals in the bottom sediments and the body burdens of these chemicals in fish?	EPA		1
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What are the migratory patterns of bottom-dwelling fish species, such as English sole? How do these migratory patterns affect the incidence and rate of tumor formation?	ECOL	5-10 yr	5
	Tacoma-Pierce Health		1

What are the effects of toxic inputs to Puget Sound on its living resources?

What is the significance of tumors and histopathological lesions to the survival and reproductive success of fish? Which toxicants are responsible and how do they cause adverse effects (via metabolism, etc.)?	EPA		1
	ECOL	Ongoing	3
	DNR	Immediate	3

Do body burdens of toxic chemicals have any adverse population-level effects on fish?	ECOL	Ongoing	3
	EPA		1
	DNR	Immediate	3

What is the relation between distribution of sediments/water toxics and distribution/abundance of mobile species? Are there any long-term and/or large-scale trends?	ECOL		
	COE		

What are the respective roles of dissolved (interstitial) versus solid (bound) pollutant phases in affecting sediment toxicity and benthic infaunal distribution?	ECOL	Immediate	2
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Are there synergistic effects between various chemicals or between chemicals and environmental conditions in the Sound that increase the magnitude of various biological abnormalities? Can pollutants be rendered "biologically inert"?	ECOL		
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APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

To what degree do resident and migratory marine birds or mammals show adverse effects (either in biological function or in bioaccumulation) from toxic chemicals in the water column or bottom sediments of Puget Sound?	ECOL DNR	Ongoing Short-term	4 5
Where migratory species show evidence of bioaccumulation of toxicants, was that accumulation in the Sound or elsewhere?	ECOL DNR	Short-term	5
Are there adverse effects of toxicants on endangered species?	ECOL DNR	Short-term	5
What is the reproductive success of marine mammals and birds in Puget Sound, and is there any change in that success related to observed toxicant levels in their tissues?	ECOL	Ongoing	4
Are waterfowl or other indigenous wildlife adversely affected by toxicants in bottom sediments in wetlands? Would this have implications on the use of wetlands in controlling urban runoff?	ECOL Wildlife	Ongoing	4
Do benthic organisms have higher levels of toxics near dredged material disposal sites?	ECOL DNR	Short-term Immediate	3 3
What are the long-term impacts of sediment remedial actions? After contaminated sediments are removed, will there be a resulting decrease in fish disease or increase in infaunal diversity?	ECOL	2 yrs	3
What is the contribution of plastics to wildlife mortality? Is recruitment affected by plastics?	Wildlife		
Are the chemicals used in agriculture, forestry, and highway maintenance being released in sufficient amounts to have an adverse effect on riverine, estuarine, or marine organisms? Do these chemicals affect shellfish or some critical part of the food web?	Tacoma-Pierce Health Pt Angeles ECOL King Cty	 1-2 yr	1 5 3
Do landfills, sludge disposal, and contaminated ground water have an adverse effect on estuarine or marine organisms?	ECOL King Cty	1-2 yr	3
In small streams of the Puget Sound watershed, what is the effect of stormwater-borne pollutants on algal and benthic invertebrate communities?	King Cty	Ongoing	5
Do tolerance levels exist that are species or community specific and, if so, what are these levels and species? Can such organisms be used as indicators before damage becomes severe or begins to affect upper trophic levels?	King Cty	Ongoing	5
What animals can be used as indicator species of chemical contamination problems in Puget Sound? How can we determine whether there are long-term cumulative effects?	ECOL EPA		1
Are bottom paints (particularly organo-tins) adversely affecting marine organisms, particularly juvenile salmon and cod and larval and juvenile shellfish?	WOGA ECOL COE	4 yr Short-term	5 2

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

How should the potential for effects on living resources be determined?

Which compounds or classes of compounds in contaminated sediments and/or the water column are associated with damage to marine organisms and wildlife?	EPA		1
	Pt Angeles		5
	WOGA	4 yr	3
	ECOL	Immediate	1
	DNR	Immediate	3

What is the best approach for developing acute and chronic sediment quality criteria both from a theoretical and practical viewpoint? Are AET's (apparent effects thresholds) the best practical approach?	Pt Angeles		5
	ECOL	Immediate	1
	COE		1
	EPA		1
	DNR	Immediate	3

What are reliable tests for rating the carcinogenic and mutagenic implications of sediment contamination?	ECOL	Immediate	2
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What acute and chronic water column criteria are needed for "pollutants of concern", and can these criteria be applied to the microlayer as well?	EPA		1
	ECOL	Immediate	1

What bioassays (in wastewater discharges and sediments), ambient measures, or other tools are best suited to assess acute and chronic effects to marine organisms and wildlife? What do the results of laboratory tests, e.g. bioassay results, mean in terms of field effects; how can the lab data best be extrapolated to the field?	EPA		1
	ECOL	Immediate	2
	Metro		
	DNR	Immediate	1

What are the effects of toxics inputs to Puget Sound on human health?

What are the relative health risks associated with discharges from various non-point sources such as septic effluent, stormwater runoff, underground storage tanks, etc.?	King Cty	1.5-3 yr	2
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What levels of organo-tins are found in edible fish/shellfish tissue? What are the human health implications of these concentrations?	ECOL	Short-term	2
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Microbiological Contamination

To what extent does bacterial and/or viral contamination from human and animal wastes impair the uses of Puget Sound?	EPA		1
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Does wastewater treatment plant effluent significantly contribute to fecal coliform contamination in marine shellfish? If so, are other fecal organisms also present (i.e. fecal streptococci, salmonella, viruses)? Are they a serious health hazard?	ECOL	Mid-term	4
	King Cty	1-1.5 yr	2
	DNR	Immediate	3

To what extent do bacteria (including indicator organisms) regrow in the environment (including sediments), and what environmental variables affect the extent and rate of regrowth?	Metro		
	DNR	Immediate	3
	DSHS		
	ECOL	Immediate	1

How long do bacteria survive in sediments (freshwater, saltwater), and what environmental variables affect the rate of die-off?	ECOL	Immediate	1
	DNR	Immediate	3
	DSHS		

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

What pathogens are present in the marine waters of the Puget Sound basin?	DNR ECOL	Immediate	3
What are the best methods for determining the source and magnitude of non-point pollution contributions to the loss of commercial shellfish beds?			
What are the best indicators to measure the degree of contamination?			
What are the most appropriate methods for determining bacterial indicator densities in shellfish growing waters and meats? What set of characteristics should be used to compare the effectiveness of one method with another? (DSHS)	EPA DSHS		1
Does bacterial contamination level in sediments correlate statistically with any other factors, such as bacterial level in water and/or shellfish?	DSHS Thurston Cty		3
Is the fecal coliform indicator an accurate reflection of water quality and is it appropriate to use in a preventive public health program, or are there better indicators available?	Tacoma-Pierce Health Metro King Cty DNR	1-2 yr Immediate	3 2 1
Are there legitimate uses for the fecal coliform:fecal streptococcus ratio in determining bacterial sources, or are limitations on its use (variation in die-off rates, lack of knowledge regarding the elapsed time between discharge and sampling, unknowns with respect to regrowth) so severe as to eliminate it as a practical tool?	Pt Angeles ECOL	Immediate Short-term	3 4
Are current mechanisms for detecting the presence and frequency of waterborne/shellfish-tissue borne diseases adequate? (Should there be a more rigorous means by which doctors and hospitals report the incidences of these diseases and data are collected and analyzed at a central location?)	ECOL	Ongoing	3
How can this contamination best be controlled?			
What effect does disinfection have on viruses in municipal wastewater?	EPA ECOL	Mid-term	1 4
What are the characteristics (size, width, cover, slope, etc.) of a buffer area that will effectively remove bacteria from runoff from an overgrazed pasture? How do these characteristics vary between areas with different climatic conditions/soil types/cover/etc.?	ECOL	Immediate	2
Are there situations where a roadside ditch between a pasture and a remote stream can be turned into a "grassy swale" for purposes of bacterial control?	ECOL	Immediate	2
What regulates population increases (blooms) of the organism that causes paralytic shellfish poisoning (PSP)?	Tacoma-Pierce Health DNR Pt Angeles DSHS	Short-term Immediate	1 5 3

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

Are there human causes as well as natural causes for these blooms?	ECOL		2
	EPA		1
	DNR	Short-term	5
Can these blooms be controlled so shellfish will not be contaminated with PSP?	ECOL		3
	DNR	Short-term	5
Are algal blooms (or toxics generated by blooms) responsible for intermittent herring spawn failure in areas such as Port Gamble?	ECOL	2 yr	4
<u>Habitat Modification</u>			
What changes to wetlands and other critical habitat have occurred or are occurring in Puget Sound? What are the causes of these changes?	EPA		1
To what extent do the increased (storm) flows associated with urbanization adversely affect (existing/natural) wetlands? Which wetlands can and cannot accommodate additional stormwater runoff within their watersheds?	Thurston Cty		2
	ECOL	Mid-long-term	2-4
How do urbanization and subsequent increases in stormwater quantity adversely affect stream habitat by subjecting streams to more frequent and more severe high flows? To what extent does urbanization reduce ground water recharge, ground water contributions to base stream flows, and thus aggravate summer low flow conditions in urbanizing streams?	ECOL	Ongoing	2
What are the adverse effects of pollutants from both point and nonpoint sources on wetlands (both natural and artificial)?	ECOL	Mid-long-term	2-4
What are early indicators of stress on wetlands?	ECOL	Immediate	2
How can we measure/monitor/objectively quantify the cumulative effects of incremental wetlands losses?	ECOL	Short-term	2
What are the interrelationships between wetlands functions and what are the trade-offs inherent in maximizing one or several uses (e.g. stormwater detention and treatment) to the detriment of other uses (e.g. wildlife habitat and productivity)?	ECOL	Mid-long-term	2-4
What is the status of sea grass communities in Puget Sound, and what are trends in their survival and exploitation?			
What is the impact of these changes on living resources?	EPA		1
What is the role of wetlands in the early marine life history and survival of economically and ecologically important animals?	Ecologist		
What is the importance of wetland production, e.g. detritus, to Puget Sound food webs?	Ecologist		
What characteristics of wetlands are most important determinants of fish and wildlife utilization?	Ecologist		

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

What parts of each wetland plant species are important as food to what wildlife species? What is the relative importance of different plant parts?.. Wildlife

What is the importance of each wetland plant species as structural habitat (cover, substrate for periphyton producers, nesting material) for each species of wetland wildlife? Wildlife

How can these impacts best be avoided or mitigated? WA Ass Realtors 1
EPA 1
Wildlife
ECOL Immediate 1

How can our understanding of currently recognized functions and values of wetlands be improved? COE

How can the importance of specific functions be relatively easily identified (predicted) at specific sites? Pt Angeles 5
ECOL 2
DNR Immediate 3

How can specific functions be objectively quantified and measured? EPA 1
ECOL 2
DNR Immediate 3

What is the role of wetlands in retaining runoff and augmenting/maintaining in-stream (low) flows? ECOL Mid-long-term 2-4

What is the role of wetlands in mitigating the downstream effects of pollutants (including bacteria) in (stormwater/other types of) runoff? ECOL Mid-long-term 2-4

What is the role of below-ground processes and microorganisms in allowing wetlands to function appropriately?

Are buffers effective in protecting specific wetland functions? Which functions can be protected with buffers? What characteristics constitute an adequate buffer (width, height, vegetation type)? ECOL Immediate 1

Which mitigation methods are effective/efficient; which are not; how can this knowledge be used to develop "best mitigation practices"? WA Ass Realtors
Wildlife
ECOL Immediate 2-4
COE
DNR Immediate 3
EPA 1

How can we design mitigation projects which are functionally equivalent to natural (native) ecosystems (i.e., effectively replace lost wetlands functions/values)? How does wildlife use of artificially created or restored wetlands compare with wildlife use of natural wetlands in terms of species density and density of wildlife? ECOL Immediate 2-4
Wildlife

Are there techniques that can be used to promote seed production in artificially established wetland plants? Can techniques be developed? Wildlife
ECOL Mid-term 3-4

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

Are mitigation efforts effective over long periods of time? Why? Why not?	Pt Angeles Wildlife EPA DNR	Immediate	5 1 3
What standardized methods should be used to monitor the success of wetland mitigation?	ECOL Wildlife	Ongoing	2
What remedies are available for failed mitigation projects?	EPA ECOL	Mid-term	1 3-4
What diurnal, seasonal, and "extreme event" changes occur in wetlands functions? How can artificial wetlands be engineered so they don't fail?	ECOL	Mid-long-term	2-4
What can be done to control the spread of <u>Spartina alterniflora</u> ?	Wildlife		
What other ways besides bulkheads can be used to protect property while at the same time preserving natural shoreline functions?	Thurston Cty		3
What role do seabirds play in the Puget Sound ecosystem? How can sufficient habitat be protected to allow their full functioning within this environment?	ECOL		
<u>Environmental/Regulatory Policy</u>			
How can systematic comparisons be made among the many pollution problems in Puget Sound in ways that will assist in ranking problems for funding and other actions?	ECOL EPA Pt Angeles	Ongoing	2 1 1
How can a better assessment of the benefits and costs of various programs be prepared to assist in making trade-offs in pollution management policies?	ECOL Pt Angeles	Ongoing	2 1
What role should quantitative benefit/cost comparisons play in light of scientific uncertainty and the difficulty of quantifying damage in a complex ecosystem?	ECOL Pt Angeles	Ongoing	2 1
Can quantitative links be established between demographic and land-use trends and marine pollution problems?	Pt Angeles ECOL	Mid-term	3 4
Can such trends then be used to design policies and programs for preventing and solving pollution problems?	ECOL Pt Angeles		3
What is the proper balance between pollution control strategies that restrict discharges before damage can be observed in the environment and programs that require reductions in discharges only after water quality degradation is shown?	Pt Angeles EPA King Cty ECOL	Immediate 1.5-3 yr Ongoing	1 1 2 2
How can pollution control programs be protective without being excessively restrictive and costly?	ECOL	Ongoing	2
What are the implications of allowing wetlands mitigation when we don't know the long-term viability of mitigation measures?	ECOL	Immediate	2

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

Are there strategies which minimize the risks of allowing the mitigation to replace natural wetlands?	ECOL	Immediate	2
How can mitigation programs be better administered to ensure long-term effectiveness of mitigation measures?	EPA Wildlife DNR		1
		Short-term	3
What are the appropriate measures of "reasonableness" or "affordability" relative to control/mitigation of private/industrial pollution sources?	ECOL	Immediate	2
How should natural wetlands, artificial wetlands, and wetland treatment facilities be defined to legally differentiate between them?	ECOL	Immediate	4
How should existing and new laws, regulations, standards and criteria apply to each?	ECOL	Immediate	4
What objective mechanisms can be employed to determine if current environmental regulation/policy/management is effective and efficient in resolving targeted/priority problems?	ECOL	2-4 yrs	3
How can such a mechanism be used to make mid-course corrections (reallocations of resources, changes in policies or regulations, etc.)?	ECOL	2-4 yrs	3
What kinds of social research can be done to maximize the chances of implementing successful strategies for the resolution of problems like nonpoint bacterial sources in threatened watersheds?	ECOL	Short-term	2
How can the participation of small and limited resource farmers in conservation activities be increased? What is the best mix of information, technical assistance, and financial assistance for small and limited resource farmers?	SCS		
What forms of communication are most effective with target groups such as large corporate farmers, absentee owners, and part-time farmers?	SCS		
What other incentives and strategies are needed to bring non-participants into conservation programs?	SCS		
What are the factors that influence conservation decisions?	SCS		
What are the likely biological, economic, and human habitation consequences (in Puget Sound and drainages) of the global warming trend (which now appears to be verified)?	ECOL	5 yrs	2
How should use conflicts and the NIMBY response to siting aquaculture facilities be dealt with? How can we affect the public acceptance of the results of any additional aquaculture research?			
How can mitigation programs be better administered to ensure the long-term effectiveness of mitigation measures?			
What alternative strategies and institutional approaches are available to solve specific marine pollution problems in Puget Sound?			

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

What are alternative funding arrangements that could be used?

What sorts of intergovernmental arrangements can be used to manage watersheds to reduce non-point sources of pollution?

What could be the role of economic incentives in reducing marine pollution problems?

How could the concept of special districts be used in Puget Sound?

To what extent can and should Washington State and the Province of British Columbia coordinate policies and management of the Puget Sound ecosystem, e.g. shipping and commerce, disposal of wastes/dredge spoils, prevention and cleanup of spills (oil, hazardous wastes, radioactive materials, etc.)?

To what extent can the concept of health risk assessment be used in environmental management of Puget Sound pollution?

How does the public's perception of pollution problems in Puget Sound compare to the "scientific" definitions of pollution problems? Will attention to perceived pollution problems like beach and harbor litter increase public support for solving the "invisible" problems?

What is the role of water quality in Puget Sound in attracting use by state citizens and out-of-state and international visitors?

APPENDIX A: (Continued) IDENTIFICATION OF RESEARCH NEEDS

AGENCIES AND ORGANIZATIONS THAT PROVIDED INPUT ON RESEARCH NEEDS

Agriculture Water Policy Committee
Clallam County Department of Community Development
King County Health Department, Public Works Department, and Parks, Planning, and Resource
Department
Metro
Northwest Pulp and Paper Association
Port of Port Angeles (Washington Public Ports Association)
Soil Conservation Service (SCS)
Tacoma-Pierce County Health Department
Thurston County Planning Department
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
U.S. Food and Drug Administration
Washington Aquaculture Council
Washington Association of Realtors
Washington Environmental Council/Sierra Club
Washington State Department of Ecology
Washington State Department of Game
Washington State Department of Natural Resources
Washington State Department of Transportation
Washington State Department of Wildlife
Western Oil and Gas Association
Whatcom County

Responses to the questionnaire on research needs published in Soundwaves were received from 45 individuals. Many of the research needs in these responses were similar to those received from agencies and organizations. Research needs not previously noted by agencies or organizations were incorporated in the above list.

Appendix B: Membership of Technical Work Groups

WORK GROUP ON MICROBIOLOGICAL CONTAMINATION

Jay Vasconcelos, Chair
Environmental Protection Agency, Region 10 Laboratory

Ken Chew/Terry Nosh
School of Fisheries, University of Washington

Rip Hayward
Metro Laboratory

Jack Lilja
Washington Department of Social and Health Services

Louisa Nishitani

Doug Pierce
Tacoma-Pierce County Health Department

Marleen Wekell/Steve Weagant
U.S. Food and Drug Administration

Provided Input to Work Group:

Ralph Elston
Battelle Marine Research Laboratory

WORK GROUP ON TOXICS -- DISTRIBUTION AND PHYSICAL/CHEMICAL FACTORS

Bob Dexter, Chair
EVS Consultants

Bob Barrick
PTI Environmental Services

Roy Carpenter
Oceanography Department, University of Washington

Eric Crecelius
Battelle Marine Research Laboratory

Curtis Ebbesmeyer
Evans-Hamilton, Inc.

John Ferguson
Department of Civil Engineering, University of Washington

Jack Hardy/Liam Antrim
Battelle Marine Research Laboratory

Bill Lavelle
National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory

Pat Romberg
Metro

Richard Vong
Department of Civil Engineering, University of Washington
Seattle, Washington

WORK GROUP ON TOXICS -- BIOLOGICAL EFFECTS

Bob Pastorok, Chair
PTI Environmental Services

John Armstrong
Environmental Protection Agency, Region 10, Office of Puget Sound

Scott Becker
PTI Environmental Services

John Calambokidis
Cascadia Research Collective

Peter Chapman
EVS Consultants, Inc.

Richard Kocan
Fisheries Research Institute, University of Washington

Bruce McCain
National Oceanic and Atmospheric Administration/National Marine Fisheries Service, Northwest
and Alaska Fisheries Center

Harvey Van Veldhuizen
Jones and Stokes Associates

Jack Word
Battelle Marine Research Laboratory

Provided Input to Work Group:

Ed Long
National Oceanic and Atmospheric Administration, Ocean Assessments Division

Dennis Mahlum
Battelle Northwest

WORK GROUP ON HABITAT MODIFICATION

Mary Burg, Chair
Washington Department of Ecology

Curtis Dahlgren
Washington Department of Fisheries

Paul Dinnel
Fisheries Research Institute, University of Washington

Ann Dold
Parametrix

Rich Horner
Department of Civil Engineering, University of Washington

Kathy Kunz
Environmental Protection Agency, Region 10

Linda Kunze
Natural Heritage Program, Washington Department of Natural Resources

Tom Mumford
Washington Department of Natural Resources

Charles Simenstad
Fisheries Research Institute, University of Washington

Alan Wald
Washington Department of Ecology

Bert Webber
Huxley College, Western Washington University

Fred Weinmann
U.S. Army Corps of Engineers

Bob Zeigler
Washington Department of Wildlife

Provided Input to Work Group:

Mary Kentula/Paul Adamus
Environmental Protection Agency, Environmental Research Laboratory

Dennis Paulsen
Jones and Jones

WORK GROUP ON CONVENTIONAL POLLUTANTS AND NUTRIENTS

Chuck Boatman, Chair
URS Corporation

Steve Brown
Environmental Protection Agency Region 10, Office of Puget Sound

Craig Cogger
Western Washington Research Extension Center

Ned Cokelet
National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory

Herb Curl
National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory

Paul Harrison
Department of Oceanography, University of British Columbia

Jim Rochelle
Weyerhaeuser Company

Lynn Singleton
Washington Department of Ecology

Ron Thom
Fisheries Research Institute, University of Washington

Eugene Welch
Department of Civil Engineering, University of Washington

Steve Wells
King County Planning Department

Provided Input to Work Group:

Steve Fransen
Western Washington Research Extension Center

WORK GROUP ON ENVIRONMENTAL/REGULATORY POLICY

Tom Leschine, Chair
Institute for Marine Studies, University of Washington

Peter Beaulieu
Puget Sound Council of Governments

Christy Branch
Battelle, Human Affairs Research Center

Dave Eaton
School of Public Health, University of Washington

Linda Hoffman
Thurston County Office of Water Quality and Resource Management

Ralph Johnson
School of Law, University of Washington

Jim Krull
Washington State Department of Ecology

Craig Partridge
Washington Department of Natural Resources

Gene Peterson
King County Planning Department

Sally Schauman
Department of Landscape Architecture, University of Washington

John Spencer
Municipality of Metropolitan Seattle

Bob Stokes
Institute for Marine Studies, University of Washington

Betty Tabutt

Appendix C: Review of Existing Institutions

Puget Sound Institute

The Puget Sound Institute was established by the president of the University of Washington in November 1985. The Institute's statement of purpose includes a recognition that stable independent funding is needed for long-term research on fundamental questions and a mechanism is needed to provide technical assistance to agencies in developing and reviewing short-term research needs and products. The Institute's objectives include research, education, and public outreach. To accomplish this the Institute proposes to draw on the researchers and faculty in the College of Ocean and Fishery Sciences and other organizational units at the University, such as Engineering, Law, Botany, Zoology, Health Sciences, and the Institute for Environmental Studies. The Institute does not have a permanent governing structure or funding base. The university has provided some internal funding, and the Environmental Protection Agency (EPA) has supported one post-doctoral researcher. Under Institute sponsorship a computer-accessed bibliography of Puget Sound research (Puget Sound Access), including agency "gray" literature, has recently been completed and installed in the EPA regional office and the library of the College of Ocean and Fishery Sciences.

Washington Sea Grant Program

Sea Grant is a federally funded program that receives annual allocations from National Oceanic and Atmospheric Administration to foster and support research, education, and outreach related to conservation and utilization of marine resources (including both Puget Sound and the coastal waters). Sea Grant has had a program based at the University of Washington since 1968 and has a substantial track record in supporting marine research and moving the results of that research into the public sector. The federal funding for the program requires a one-to-three match of other funding. The university has not succeeded in obtaining any funding from the state legislature for this matching amount. (In Oregon \$500,000 is appropriated annually by the legislature as matching funds.) The university has generally used administrative services and salaries to provide the match. The Sea Grant director makes project funding decisions with the advice of a steering committee and with the concurrence of the national program office of NOAA. Due to the poor local funding base the national NOAA Sea Grant office potentially has considerable influence on local program direction. The annual attempt by the federal executive branch to zero out the appropriation for Sea Grant raises concerns about the permanence of this institution.

Washington Water Research Center

The Washington Water Research Center was set up in 1964 to coordinate and administer the state program under the national Water Resources Research Act.

The primary purpose of the program is research, training, and application of research results to the problems of water management statewide. The Center director runs the program for both the University of Washington and Washington State University. Annual funding received in accordance with provisions of the Water Resources Research Act must be matched with a one-to-1.5 local match for each federal dollar. The Center has a varied base of support, including EPA and U.S. Army Corps of Engineers contract funds. A policy committee manages the peer review of research proposals and gives direction to the director on the program to be supported. The Center acts to coordinate and manage multi-institutional research efforts, such as the Mount St. Helens research that brought together 40 scientists from four states. While research supported with the funds from the Water Resources Research Act must fit the program guidelines, it is up to the Center, in conjunction with other centers in the Northwest, to develop the local program priorities. Program oversight and review is the responsibility of the USGS. There is a strong emphasis on disseminating the research in a form that is available to managers and regulators.

Northwest Hazardous Waste Research, Development, and Demonstration Center

Establishment of the Center was called for in federal Superfund (SARA) legislation that was passed in 1986. It is headquartered at the Battelle Pacific Northwest Laboratory in Richland, with the marine work managed from the Battelle laboratory at Sequim. The purpose of the five-year research program is to adopt and develop innovative technologies to assess the impacts of and remediate inactive hazardous and radioactive waste mixed-waste sites. The program receives funding and guidance from both the Department of Energy and EPA. An objective of the program is to transfer the technical results of the research program to agencies and the private sector. The center is in the process of developing a multi-year research and development program in concert with the local universities and industry.

Metro

The Municipality of Metropolitan Seattle (Metro) is a municipal corporation that was created in 1958. One of Metro's primary functions is management of wastewater treatment for the greater Seattle area. Metro conducts research and intensive studies as deemed necessary to support its management decisions. The focus of these studies is generally limited to discharge-related issues. In the past Metro has taken a fairly broad view in studying Puget Sound because of the significance of the size of its discharges to the Sound. The organization has an active component that translates the results of its studies for the public and provides opportunities for public debate of issues. Metro is run by the Metro Council, a body of appointed and elected officials from the city and county governments in King County.

Oceanographic Institute of Washington

Although the Oceanographic Institute no longer exists, it is worth examining because of its unique relationship with the state legislature. The Oceanographic Institute was chartered by the state legislature in the late 1960s with the concurrent formation of the Oceanographic Commission. It was created as a 501(c)(3) nonprofit corporation, giving it more operating freedom and quick response capability than a state agency. The Institute's primary function was to serve as the technical arm that would conduct contract studies at the request of the Commission to support Commission decisions. The Commission and the board of trustees of the Oceanographic Institute had six legislators in common, providing a good potential for moving recommendations of the Institute into legislation where appropriate. There was no direct legislative appropriation for Institute operation and studies. Besides the contract studies for the Commission, the director and staff of the Institute also secured funding directly from state agencies and other sources for studies relevant to Puget Sound and the Washington marine waters. The intermittent nature of the Commission's requirement for services strained the ability of the Institute to maintain a continuous workforce. The Institute's involvement in projects addressing controversial problems damaged its support in the legislature and ultimately the Commission failed to receive any legislative appropriation. Among its functions the Institute prepared an extensive annual compendium of ongoing marine research in the region.

Puget Sound Estuary Program

The Puget Sound Estuary Program (PSEP) is co-managed by the Puget Sound Water Quality Authority, EPA Region 10, and the Washington Department of Ecology. The program has been in existence three years, and through its efforts Puget Sound will soon be designated under the Water Quality Act of 1987 as an estuary of national significance. This designation carries with it a commitment to approximately five years of federal (EPA) support to study the estuary and develop a management plan. The monies available for research are EPA funds that in the past have been focused primarily on toxics problems in urban embayments. A management committee of program managers from state and federal agencies, local governments and the tribes ensures overall coordination of programs related to the Sound and to implementation of the 1987 Puget Sound Water Quality Management Plan. The committee also provides a forum for sharing information. The three primary agencies jointly chair the management committee. The technical advisory committee is a group of scientists that provides technical review and advice on plans, programs, and documents. This institutional structure is intended to have a finite lifetime (five years) corresponding with the funding from the EPA estuary program. The organizational structure helps promote coordination among the individual entities, although research priorities are generally decided by the individual sponsoring agency and follow agency priorities and objectives.

OTHER INSTITUTIONS THAT COORDINATE AND FUND RESEARCH

Hudson River Foundation

The Hudson River Foundation was established in 1980 with a \$12 million "endowment" from a lawsuit settlement agreement among utilities, government agencies, and environmental groups. Its purpose is to sponsor research on all aspects of Hudson River ecology. The Foundation is an independent scientific institution which is governed by a board of directors composed of representatives from both the public and private sectors who have a strong investment in the future of the Hudson River. The Hudson River Panel, which is made up of scientists, has full responsibility for developing the annual program and making decisions on the research proposals that will receive funding. The Foundation makes an effort to provide support to research that other agencies have difficulty funding, either because the work is in an early stage, or because it is outside the mandate of other funding sources. The Foundation sponsors an annual symposium as well as special workshops for scientists and educators. There is an emphasis on publishing the research results in journals that are accessible to an audience outside one discipline. The Foundation appears to have been very successful in enlarging the size of its endowment so that it can allocate at least \$1 million to new proposals each year. The peer review system for proposals draws on scientists from around the country and helps ensure the technical quality of the research that is supported. There is a relatively low level of agency representation on the governing structure, which raises two questions: 1) how relevant is the research for agency decision-making; and 2) can the Foundation coordinate a program that has broader support and involvement than the research it funds directly?

National Fish and Wildlife Foundation

The National Fish and Wildlife Foundation is a private, nonprofit 501(c)(3) conservation organization that was established by an act of Congress in 1984 in order to provide a vehicle for accepting private gifts and property that are donated for the benefit of the activities of the U.S. Fish and Wildlife Service. The Foundation seeks to be a catalyst for creative partnerships between the public and private sectors aimed at wildlife protection and enhancement. It has focused its initial program on supporting projects in the following areas: habitat protection and restoration, research, public awareness and education, and species and refuge management. The original legislation commits Congressional matching funds on a one-for-one basis up to \$1 million for the first 10 years. The Department of Interior provides administrative support for the organization. The Foundation was successful in attracting corporate support and private donations that totaled about \$750,000 in the first two years.

Aquatic Habitat Institute

The Aquatic Habitat Institute (AHI) was chartered by the state of California and formally incorporated in 1983. It is an independent, nonprofit corporation

that proposes to implement a scientific program to monitor and evaluate the present and potential effects of pollutants on the San Francisco Bay-Delta estuary. It is intended as a scientific data-gathering institution and is specifically prohibited in its bylaws from making recommendations on policy. AHI is governed by a board of directors consisting of representatives from state and federal agencies, the University of California, discharger associations from the Bay area, and the public. An executive director manages AHI and receives advice on the operating budget and work plan from an advisory committee with representatives including key state and federal agencies, the dischargers, and the public. The board of directors must annually adopt the master plan for monitoring and applied research. AHI does not yet have an adequate permanent funding base. Its current funding comes from dischargers, state agencies, and the EPA estuary program.

Louisiana Universities Marine Consortium

The Louisiana Universities Marine Consortium (LUMCON) was created by the Louisiana legislature in 1979 as an organization of the state's four-year public universities and higher education management boards. In addition, some state natural resource management agencies are affiliate members of the Consortium. The purpose of the Consortium is to provide coastal research facilities, research and education in marine sciences and technology, and public service to citizens. The Consortium is governed by a council within the Department of Education. An executive director appointed by the Council serves as the chief administrative officer of the Consortium and also fulfills the role of marine programs advisor to the board of regents. To date the focus of the Consortium efforts has been on acquiring and managing the facilities that are fundamental to a good marine research program. Ultimately, the Consortium hopes that its coordination of research at the universities and communication with local, state, and federal agencies will encourage more unified efforts toward resolving coastal problems, although an adequate long-term funding base is still a concern.

Chesapeake Bay Research Consortium

The Chesapeake Bay Research Consortium (CRC) is a nonprofit corporation that was chartered by the State of Maryland and formed in 1972 to facilitate inter-institutional programs among its member institutions (University of Maryland, Virginia Institute of Marine Science, The Johns Hopkins University, and the Smithsonian Institution). The Consortium can act as the grantee institution and allow researchers to compete for external contract and research dollars with a lower overhead than would be possible through their own institution. The CRC director serves as the chair of the scientific and technical advisory committee of the EPA estuary program of the Bay. The Bay program also contracts with the CRC staff for support services, including preparation of synthesis reports and handbooks on specific topics. The CRC has not coordinated a Bay-wide research program beyond the scope of the EPA program. However, the most recent agreement signed by the EPA administrator and the governors of the states adjoining the Bay requires that such a comprehensive research program be developed. There is no permanent base of funding

support, although the CRC has been quite successful in obtaining support from both mission agencies and the NSF over a long period of time.

Southern California Coastal Water Research Project Authority

The Southern California Coastal Water Research Project (SCCWRP) Authority was founded as a special district in 1969 by five local governments and sanitation districts in the Los Angeles-San Diego area. It was set up to be an efficient mechanism to produce high-quality technical information needed by the dischargers to help in monitoring and assessing the impacts of their discharges on the marine waters of Southern California. SCCWRP is governed by a commission of elected officials or civic leaders from the local governments that founded (and fund) it. Because of the governance and primary funding source of the organization, it is difficult to overcome the concern that its research is biased towards the discharger point of view. A director manages the research staff and receives overall guidance on the focus and quality of the technical program from a scientific consulting board of eminent scientists from elsewhere in the country. SCCWRP produces an annual report and hosts workshops that are designed to make the results of its research accessible to a broad public.

Virginia Institute of Marine Science

The Virginia Institute of Marine Science (VIMS) is located at the College of William and Mary. It was created and funded by the General Assembly of Virginia to conduct basic and applied research on the systems and resources of Chesapeake Bay and to provide information to the governor, state assembly, state and local agencies, citizens, and industry on the utilization, conservation, and enhancement of the Bay and coastal water resources. The state assembly has continued to expand these legislated duties since then. VIMS develops a 10-year internal research plan which it uses to identify personnel and equipment needs and the need for external funding sources to supplement state funding. VIMS has been in existence since 1940 and has become the acknowledged source of information for natural resource questions related to the Virginia portion of the Bay. Having the specific function of being "on call" to respond to legislature or agency needs and questions may serve to underscore the importance of the Institute's existence to these constituents, but it may also impinge on the ability to conduct more basic research. The director of VIMS also serves as the dean of the School of Marine Science. The Marine Science Development Council, a body of leaders from Virginia's business and industrial community, advises the director on planning and implementation of research and advisory services as they relate to the private sector and on the private sector initiative program to assist VIMS in securing private sources of funding.