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Report of West Coast Region Conference on Marine Pollution Problems

Portland, OR, June 17-19, 1980

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Prepared for:

Interagency Committee on Ocean Pollution Research, Development and Monitoring

Federal Coordinating Council for Science, Engineering, and Technology

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Working Paper No. 6: Federal Plan for Ocean Pollution Research, Development and Monitoring, FY 1981-1985

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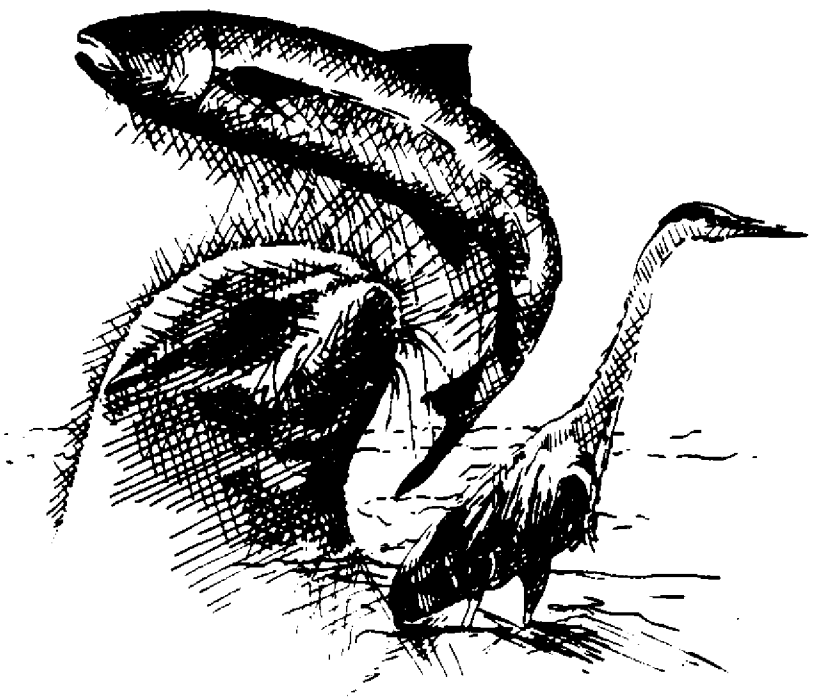

SECTION I

Introduction

Introduction

The Pacific Regional Conference to address problems and information needs regarding marine pollution of the U. S. Pacific coastal states and Hawaiian and Pacific Islands was convened in Portland, Ore., on June 16 through 19, 1980. The conference was one of five national regional conferences which assembled at approximately the same time for the purpose of developing the five-year Federal Plan for Ocean Pollution Research, Development and Monitoring 1981-85.

Development of the Federal Plan is mandated by the National Ocean Pollution Research and Development and Monitoring Planning Act of 1978, Public Law 95-273. The Federal Plan is used by various federal agencies, the Office of Management and Budget, and Congress in making funding decisions on federally supported marine pollution research, development and monitoring.

Sixty-five invitees from federal, state and local governments, academic institutions, public interest groups and private industry participated in the conference.

Prior to the conference, a steering committee was formed, panel leaders were chosen and summary "issue papers" were prepared on the subject of each panel.

At the conference, the participants were charged with the accomplishment of four objectives:

1. Develop a series of statements identifying significant marine pollution problems in the Pacific Region.
2. Define a set of information needs for each problem area which can be met through ocean pollution research, development and monitoring.
3. Recommend priorities for the sets of information needs.
4. Provide rationale for priorities assigned to the sets of information needs.

Due to the relatively vast area encompassed by the Pacific Region and because of the di-

versity of existing or potential marine pollution problems there, conference participants were assigned to panels representing five areas of the region having relatively indigenous problems. The five areas were: Mexican Border to Point Conception, California; Point Conception to Point Arena, California; Point Arena to Port Angeles, Washington; Port Angeles to Canadian Border; and Hawaiian and Pacific Islands.

In addition to the consideration of marine pollution problems by areas, each participant was assigned to a second panel which was charged with the responsibility of addressing significant marine pollution activities which exist, or have the potential to exist, within the entire region. Four such panels convened to discuss problems and information needs of:

1. land-use practices, recreation and boating
2. marine waste disposal
3. marine energy
   and
4. marine mining.

The Pacific Regional Conference for input into the Federal Plan was developed with the cooperation of the Sea Grant College Program at Oregon State University. This Regional document was produced by OSU Sea Grant Communications, the National Marine Pollution Program office of the National Oceanic and Atmospheric Administration and the Massachusetts Institute of Technology Sea Grant office.

SECTION II

Land-use Practices, Recreation and Boating

I Introduction

Land-use practices in coastal areas contribute substantial amounts of polluting materials to marine waters. The most significant causes of pollution originate from the following sources:

--discharges from industrial and sewage treatment facilities
--agricultural practices including forest management
--urban runoff
--major geologic events, such as the volcanic eruptions of Mount St. Helens
--siting of major industrial developments (primarily energy related) in coastal areas
--dredging, land transportation of hazardous materials and construction and operation of marinas.

Other problems considered minor in the region, but which can cause adverse local effects on coastal waters and habitats, include off-road vehicle (ORV) use of beaches and dunes, litter resulting from recreation, intensive beach use, vector control, control of aquatic vegetation and atmospheric fallout from industrial stacks.

There are existing laws and regulations (National Pollution Discharge Elimination System or NPDES) that govern discharges from sewage treatment and industrial plants within the region. Yet, toxicants often find their way into the marine environment from these sources. However, there is a distinction that should be emphasized between controlling toxic substances and controlling nontoxic (biodegradable) waste. The two present different problems and research needs.

The pollutant contribution of nonpoint sources is still not adequately controlled and must be addressed through land-use planning and other management plans as specified in section 208 of the Federal Water Pollution Control Act Amendments of 1972 (FWPCA) and the Coastal Zone Management Act of 1972 (CZMA). Nonpoint sources are regionwide in scope, with the greatest problems dealing with accelerated sedimentation, pesticides, fertilizers, animal wastes, litter and other

contaminants from urban, forest and agricultural runoff.

The recent volcanic eruptions of Mount St. Helens have caused significant impact on the lower Columbia River, estuary and near-ocean area, as well as parts of the Cowlitz River system. Physical changes in sedimentation and turbidity have occurred in the estuary, and valuable runs of anadromous fish have been adversely effected to an unknown extent. Emergency dredging will cause further impact on aquatic life and physical conditions in the estuary.

III Conclusions and Recommendations

A. General

The effectiveness of management authorities established under the FWPCA and CZMA of 1972 is limited because of inadequate information on the nature and levels of land-use induced marine pollution and on the relationship between the type and character of upland development and resultant pollution. There is also a basic need for studies on alternative land and water-use management approaches for minimizing marine pollution.

An advantage to using existing management systems for conducting research is that the research can be result (or solution)-oriented. The majority of the coastal states now have U. S. Department of Commerce approved programs and more will be approved in the next year. This program has fostered communication linkages between resource management and regulatory agencies at all levels of government. Unlike many problems where information is collected and analyzed and a management system is then devised to solve the problem, a management system is available and is largely in place to deal with land-use related marine pollution. What is lacking is basic information on such things as cumulative impacts, assimilative characteristics and land-use pollutant relationships which must be incorporated into management programs.

B. Recommendations Related to More than One Need

1. Uniform Data System--There is a need to develop a uniform data system which provides available resource information and/or maps to decision makers. The information should be in a form they can readily understand and use to make intelligent decisions when siting facilities and outfalls to minimize marine pollution. This recommendation applies to major industrial developments as well as sewage treatment facilities.

2. Monitoring Programs--Better, more comprehensive monitoring programs are needed to determine: (a) the effects of effluents from industrial sources on the marine environment; and (b) the individual and collective impacts on water quality and habitat from urban runoff, forest practices and different types of agriculture, so the most critical sources of pollutants can be dealt with on a priority basis.

C. Detail on High Priority Items

1. Industrial Sources--The new consolidated NPDES permits for toxic effluents will provide a new and different data base on constituents in effluents. This will presumably fulfill the need for characterization of wastes, but there are still needs for monitoring the marine environment and biota of the ecosystem to determine the effects of such effluents.

Regulation of wastes in the United States is technology based, and monitoring may be limited to measuring a few concentrations at the "end of the pipe" without evaluation of the ecosystem in the receiving waters. It is essential to formulate better, routine biological monitoring programs which will lead to understanding which effluents cause deleterious disturbances and which do not. This could lead to more cost-effective expenditures for control and relief of controls where they are not needed.

Nontoxic (biodegradable) wastes should not be regulated in the same fashion as toxic wastes.

Changes in regulations may be needed to permit development of alternative strategies in management of nontoxic wastes. Enormous capital funding costs, high operational costs and high loan service costs are translated into high tax burdens, which may not be related to improvement in the living marine environment. Nontoxic wastes could, in fact, be beneficial to ecosystems or may constitute resources that could be used for mariculture or other uses. Research which would lead to better utilization and accompanying regulatory changes would have a high cost-benefit relationship.

2. Sewage Discharge Locations and Treatment Processes--Many marine problems are caused by improperly siting sewage treatment facilities and outfalls. Sewage treatment facilities have been located on fragile shorelines. Major discharges to shallow embayments have severely damaged aquatic organisms in several areas. Decisions have been made without considering information collected by several organizations in the geographic area. This information was simply not available to the decision maker. Both adverse and beneficial effects of facility siting and treatment techniques need to be analyzed concerning their effects on shellfish, finfish and other important components of the marine environment.

3. Nonpoint Sources--Pollutants from nonpoint sources originating in coastal watersheds can cause significant impacts on estuary and near-shore areas. Accelerated sedimentation, litter and toxic chemicals in the form of pesticides and herbicides result in undesirable physical, chemical and biological changes.

a. Urban Runoff and Rivers--The drainage of storm waters through urban environments serves to accumulate a wide variety of toxic and nontoxic pollutants in the flow, whether it is delivered to river systems or directly to the sea. Flushing of streets and highways brings heavy metals and possible carcinogens from fuel and tires into the drainage system; pesticides, grass clippings and debris from home occupants are dumped or washed into drainage systems; accidental spills of toxic or flammable materials from industries or transportation vehicles and equipment are sometimes flushed into storm drains; and unpermitted disposal of wastes, which are otherwise difficult to dispose of, may occur through storm drains.

The cumulative impacts of the collection of diverse materials in storm water systems or natural tributaries which ultimately reach the sea are not known, but they have generally been regarded as unimportant when compared with point source discharges. The EPA, through 208 studies, is examining urban runoff and river systems. Apparently, no standardized set of parameters is being examined and comparability of data may be difficult.

b. Agricultural and Forest Practices--Agriculture and its specialized farm forestry are major sources of marine pollution. Forest practices are generally controlled by a "best management practices" (BMP) approach, and control of pollution caused by nonintensive agriculture appears to be going in the same direction. There is, however, no good consistent method of assessing the environmental impact of any of these BMPs. Section 208 of the Clean Water Act approaches are generally too use-oriented to be of much value for scientific evaluation.

4. Mount St. Helens' Eruptions--The large pyroclastic flows from recent eruptions of Mount St. Helens beginning in May of 1980, caused tremendous sedimentation and debris problems in parts of the Cowlitz River system and lower Columbia River. Parts of the Toutle River system and lower Cowlitz River were filled with sediments and debris to near bankfull levels. The ship channel of the lower Columbia River was filled to a depth of 15 feet (from 40 feet) for a distance of several miles, and excessive siltation occurred in the Columbia River estuary.

Anadromous fish, resident fish and other aquatic life were killed initially in the Toutle and Cowlitz rivers by catastrophic disturbances of habitat and lethal temperatures (90+ F). Fish were killed in the lower Cowlitz River by extreme physical damage to gill filaments due to abrasive action of volcanic ash for several weeks after the major eruption of May 18.

Following the initial eruptions, the U.S. Army Corps of Engineers had all available dredges operating in the lower Cowlitz and Columbia rivers to provide necessary ship passage conditions in the Columbia and to increase channel capacity for winter floods in the Cowlitz. As a result, the Columbia estuary and near-ocean area will be adversely impacted by this unusually large amount of dredged material.

Some research is ongoing in the estuary and immediately off-shore. Additional research, however, is needed to determine long-term effects on the estuary and the salmon and steelhead runs of the Columbia system. Uncertainties include the duration of both the volcanic activity (which could last over a decade) and restoration efforts (and magnitude) to rehabilitate the lower Columbia and Cowlitz rivers.

III Information Needs

A. High Priority

1. Industrial Sources--Monitoring strategies and correlation techniques should be developed to standardize and improve the

most useful methodology for determining effects of pollution of toxic wastes. Ecosystem studies are essential, rather than limiting monitoring to only a few parameters.

Research is needed on the management of nontoxic wastes as potential resources. It is also needed on better assimilation capacity models, on waste utilization and on the role of these effluents in the ecosystem.

Rationale

Improved management of nontoxic wastes is desperately needed. The handling and treatment of industrial wastes is a costly problem, involves many people, organizations, regulations, governmental agencies, and produces a high volume of effluents into marine waters over the entire region. The effectiveness of the NPDES permit system needs to be demonstrated. Results of monitoring and research are essential to provide the data base for intelligent future decisions.

2. Sewage Discharge Locations and Treatment Processes--A data system for compiling and synthesizing available resource information into an easily understandable format should be developed. It should be made available to decision makers when analyzing alternatives for facility siting and treatment measures. There is also a need to study alternative treatment methods.

Rationale

The treatment of sewage wastes is a costly program of great magnitude throughout the region that affects all coastal communities. Siting of facilities is critical to the marine environment. Information must be available when decisions are made for planning sites and treatment techniques.

3. Nonpoint Sources--An adequate monitoring program for nonpoint sources and their effects on marine waters should be established as described in Section II, B. 2.

Research should be conducted in selective city storm drain and river systems to determine pollutant loads, water quality and the condition of the biota in receiving waters. Only after such studies are made can anyone determine whether this is a generalized problem deserving high priority, or a local, site-specific problem of lesser regional significance.

An evaluation or monitoring method should be established to quantify the results of "best management practices" (BMPs) in agriculture and forestry. This is especially true for sediment, nutrients, pesticides and coliform bacteria. Such a tool is not only necessary from an environmental standpoint but could also prove valuable to optimize the cost/benefit aspects of a BMP. These factors will probably vary nationwide, and in some cases may vary from one large watershed to another. From the regional perspective, such studies should be conducted by agencies or contractors with regional responsibilities or capabilities for continuity of approach.

Rationale

As a result of major pollution abatement programs concerning point sources, nonpoint sources are now significant proportionate contributors to marine pollution. Since they are the last remaining unregulated (other than BMPs) type of source, identification and corrective actions for nonpoint sources must receive a high priority. In addition, nonpoint sources are of high magnitude throughout the region with high potential costs and large numbers of concerned people and agencies.

4. Mount St. Helens' Eruptions--Studies are needed to document physical changes (substitute, turbidity, velocity, circulation, etc.) in the Columbia River estuary due to deposition of volcanic material and subsequent dredging activities. Other research is needed to determine the effects of these physical changes on aquatic life in the estuary. Additional studies to develop a long-term spoil disposal plan (with possible mitigation) should be started immediately. The studies should consider the effects on survival and behavioral changes in salmon and steelhead runs attributable to this problem.

Rationale

Although somewhat qualified because the polluting effects are localized to the Columbia River estuary and near-ocean area, the problem of volcanic eruption was assigned a high priority due to: (a) high intensity of impacts; (b) high restoration costs; (c) no previous experience with effects of this type of volcanic material on estuary and fishery resources; (d) possible adverse effects on Columbia River salmon populations that are caught in the Pacific Ocean from Northern California to Alaska; and (e) results of some of the studies would be transferrable to future volcanic eruptions in other areas.

B. Medium Priority

5. Major Coastal Development Siting--Resource maps should be prepared for the coastal waters of Washington, Oregon, California and the Pacific Islands. They should describe areas of special environmental concern, existing levels of pollution, location of commercial, sport and aesthetically valuable fish and wildlife resources, refineries, shipping routes and other factors which must be considered for facility siting.

All agencies and users also need to adopt a uniform classification system to describe the habitat types that could be impacted by facility siting (e.g. classification of wetlands and deep water habitats of the United States*). A uniform system of classification will allow for systematic data collection and transfer, and the application of information between various agencies and users.

*L.M. Cowardin, V. Carter, F.C. Golet and E.T. La Roe. Classification of Wetlands and Deepwater Habitats of the United States. (Fish and Wildlife Service, FNS/OBS-79/31, 1979) 103 pp.

Rationale

Major developments include power plants, port facilities, liquid natural gas (LNG) facilities, platform fabrication yards and other facilities which require a coastal location. These developments may have major impacts upon the marine environment by increased waste discharges, urban runoff and other factors associated with construction, operation or associated population growth. Major developments requiring coastal locations must consider sites which are environmentally acceptable. Often energy and other facilities encounter prolonged legal and administrative procedures before construction and/or operation can proceed. Often delays and/or siting problems could be avoided if agencies, both permit granting and construction, were aware of existing resources that must be considered prior to construction and operation.

Although a facility siting is a major coastwide problem of a costly nature, it is long term and requires a substantial planning effort. (The problem was given a medium rating for these reasons but most panel members felt it was almost of high priority.)

6. Dredging in Coastal Waters--Consistent, detailed analysis of the spoil material is needed. It should be sufficient to delineate possible differences in character and composition. Specific projects should be selected as case studies to be monitored on a long-term basis. The long-term studies as well as intermittent checking of results of routine monitoring should be done by independent third-party contractors to insure consist nt and valid results. Third-party contractors should also be used for the limited required monitoring of actual dredging operations on a proportional sample basis.

Rationale

In recent years, 30 to 75 million cubic meters of dredged material have been dumped in U. S. coastal waters annually. In some areas, dredge spoils may exceed the contribution from natural erosion. It is apparent that, in the approximately 100 major disposal sites presently designated for use, this activity has the potential for significant environmental impact. Dredging can also have adverse physical and biological effects on wetlands and estuaries.

The Environmental Protection Agency and Army Corps of Engineers have set spoils characterization and environmental monitoring requirements as a general requisite for dumping. However, the degree and frequency of such testing is short term, at best, and procedures vary. (This cause received a medium rating because a fair amount of research has already been done, some criteria for controls have been established, and the present need is for monitoring to determine effects on marine waters and habitats.)

7. Land Transportation of Hazardous Materials--More information is needed on:

1. the nature of the cargoes,
2. land transportation modes and routes,
3. areas of high risk of damage to marine resources and
4. the types of damage to key species which could result from the escape of toxic substances during transit.

Rationale

Land transportation is a coastal land-use practice that causes marine pollution through spillage of hazardous materials. Ports are focal points in the transportation network where all transportation modes converge (marine, rail, truck, air and pipelines), involving tremendous varieties and quantities of hazardous cargoes. Acciden-

tal discharges of these pollutants have generated keen public interest and concern, particularly in terms of public health hazards, even though the total volume may be comparatively small.

Even though the magnitude of this problem is unknown, there is high public concern for health, safety and possible effects on marine resources. Accidents could cause catastrophic, short-term impacts to marine aquatic life in small localized areas. Public support for research, development and monitoring should be strong.

8. Impact of Marinas--Studies should be directed at designing marinas to reduce the effects of pollution by increasing flushing rates or other techniques.

Rationale

Marina construction and use are increasing at a rapid rate and are creating a variety of adverse ecological effects. Pollution problems associated with marinas include sewage, litter and petroleum products. Also of concern are changes in the natural circulation caused by structures and the effects of small boat prop wash on benthic communities.

While some marinas are seriously polluted, others have relatively little impact on the local marine environment. Problems associated with marinas are neither of the magnitude nor as serious as those listed as high priority for research needs.

C. Low Priority

9. Effects of Litter--Research is needed on the sources, fluxes and duration of litter as well as the ecological and aesthetic degradation of the marine environment caused by litter.

Rationale

Litter poses aesthetic and ecological problems. Land-use sources of litter include marinas, boat ramps, ORVs, all types of recreational beach use, as well as sources farther inland. Boating also contributes to the litter problem. Litter of particular concern includes not only the slowly degradable types, but also such things as petroleum, excrement (dog and human), and fish caught and discarded.

While litter can be a definite problem in relatively small, localized situations, it is not presently considered to be a serious cause of marine pollution.

10. Effects of Toxic Airborne Pollutants from Coal Plants--Studies on marine food chain organisms should be conducted to determine levels of input from airborne emissions into the marine environment. Supporting data and information can be used to supplement existing criteria on specific emission controls being achieved by coal plants under the Clean Air Act.

Rationale

Previous studies have been made on the aquatic environment which identified toxic substances, such as heavy metals, acid rains and other trace organics resulting from airborne emissions of coal plants. Concerns have been raised over the potential impacts of such pollutants in relationship to specific aquatic organisms, but additional concerns and research needs have not been addressed on similar problems with marine organisms and the open coast environment in general.

The importance to marine organisms of low level concentrations of highly toxic airborne pollutants has not been shown. This is more a potential than immediate problem. There is a relatively small number of coal plants now in operation in the region.

11. Effects of Control of Undesirable "Aquatic Weeds"--There is a need to know the effects of aquatic herbicides used for control of undesirable plants on marine vegetation and organisms. Recommended application rates as well as excessive rates need to be analyzed.

Rationale

Eurasian milfoil is typical of certain aquatic plants which grow profusely in freshwater shallows where they interfere with recreation uses, especially swimming, fishing and boating. Eurasian milfoil is now found extensively in certain lakes of Eastern and Western Washington, especially Lake Washington. METRO (a confederation of municipalities that handles Seattle area sewage) is currently experimenting with mechanical harvesting, opaque screens placed over specific bottom areas to block growth and use of aquatic herbicides. The threat to marine resources would occur where waters treated with herbicides flow into marine

environments, for example, from Lake Washington into Puget Sound, via the Ballard ship canal and locks.

This is a minor problem confined to a few specific localities, which is not life threatening.

12. Vector Control Surveys--Surveys should be conducted to determine the extent of chemical spraying for controlling disease carriers and the potential for marine pollution.

Rationale

Mosquitoes and other vectors of human and animal disease often occur in fresh water and estuarine habitats along the Pacific Coast. Extensive programs of vector control are in operation using chemical, physical and biological control measures. Some of the measures have the potential to impact the marine environment through the introduction of toxic materials into coastal waters.

The extent of this problem is unknown, but its potential for causing pollution in shallow marine habitats should be studied. Priority for this was rated low because the problem is confined to rather restricted geographic areas. Also, chemical treatments are relatively small compared to other causes of marine pollution and control programs are carried out under guidelines to minimize adverse effects on other water resources.

Panel Members

Land-Use Practices, Recreation and Boating

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SECTION III

Marine Waste Disposal

I Introduction

This summary identifies existing and potential marine pollution problems related to marine waste disposal for the Eastern Pacific (Mexico, Canada, United States), the Hawaiian Islands and the Pacific Trust Territories. Four general subject areas related to marine waste disposal were identified:

1. municipal waste disposal
2. industrial waste disposal
3. radioactive and hazardous waste disposal and
4. dredging and spoils disposal.

A list of problem statements was drafted by subcommittees on the four subject areas. Next, a list of information and research needs for the subject area was compiled. A priority index by numerical order ranked the proposed research needs into three categories - high, medium and low - to provide a rough scale of priority. Finally, rationale for the research need was prepared.

II Problems

A. Municipal Waste Disposal

1. Diseases and Health of Fish and Shellfish --Bottom fish and invertebrate disorders, including eroded fins and abnormalities to other external and internal organs, occur in certain coastal areas of California and Washington. The causes and factors maintaining many of the diseases are unknown.

Some of the disorders may be associated with sediments highly contaminated with synthetic and inorganic wastes and depauperate of certain benthic organisms. Affected marine populations occur near urban and industrial areas, but the range and distribution of the problem in unknown.

2. Coliform Bacteria Counts--Coliform bacterial counts are routinely made in the ocean and are presently used as priority indicators of water quality and public safety. However,

the meaning of coliform counts in the ocean is not understood, their value as indicators of the presence of pathogens is unknown, and their relation to pollution is not agreed upon.

3. Paralytic Shellfish Poisoning--The incidence of intense dinoflagellate blooms, specifically those producing saxitoxin and ciguatera, has been increasing in recent years. Observations of toxic dinoflagellate blooms in places where they, heretofore, have been unknown suggests significant environmental changes. Apparently, a typically nontoxic species under certain conditions can produce toxins capable of altering food webs and affecting coastal zone economies.

A link between the occurrence of toxic blooms and nutrient enrichment of coastal waters has been proposed by dinoflagellate ecologists, inferred from models and implied in bioassay studies. However, an organized Pacific Coast-wide effort to study toxic dinoflagellate blooms has not been made.

4. Marine Food Webs, Toxic Substances and Biomagnification--Ocean waste disposal may alter marine food webs. Changes in physical and chemical conditions can change the rates at which species increase (reproduction and recruitments), decrease (morbidity and mortality) and are maintained (feeding) in biological communities.

While toxicity certainly affects these processes, studies relating waste discharge to food web alteration should not be biased toward toxicity, ignoring the totality of processes in given food webs. Conversely, the kinetics of toxicant accumulation, transport and potential threat to man (outside the context of food web) must be understood.

5. Dilution and Circulation in Embayments, on Open Coasts and Around Islands--Data is still inadequate for understanding and predicting the distribution and fate of floatable, soluble and settleable constituents of wastes, yet there is no question that physical dispersion is much different in embayments, on open coasts and around islands.

6. Regional Differences in Capacity to Assimilate Wastes--Regulatory agencies still do not give significant recognition to the differing capacities of coastal waters to assimilate and detoxify wastes.

7. Applicability of Marine Water Quality Criteria to Hawaii and Pacific Islands--The marine water quality criteria were developed principally for the continental U. S. with evaluation using biota indigenous to the continental temperate zone. The Pacific Coast and Islands are typified by a short coastal margin, relatively deep, with nutrient-limited surrounding waters, containing biota ranging from semitropical to subarctic. Thus, the existing criteria and the organisms selected for bioassay purposes are not appropriate to the Pacific Basin and Coast.

8. Improve Ecological Monitoring Techniques--Existing methods for monitoring biological conditions in receiving waters are becoming exceedingly expensive. Cost-effective methods and meaningful biological indices are needed to alleviate the problem.

B. Industrial Waste Disposal

9. Thermal Impact of Power Plants--The plants that create this sort of problem have been largely discouraged. Their impact is not as important, from the purely thermal point of view in higher latitudes, as it is in tropical regions such as Hawaii. This is due to the fact that tropical species have a smaller tolerance to temperature fluctuations than others. However, the side effects associated with the operation of thermal plants deserve consideration. Some of these are:

a. Entrainment and pressure effects at the water intake: These processes bring about the impingement and screening of organisms from the water column as the water is pumped in.
b. Toxic substances present during clean-up operations: An example is the use of chlorine to keep parts of the plant clean. These operations can introduce potentially dangerous substances into the environment.
c. Organisms killed attract other organisms, compounding the problem.
d. Some sensitive areas are affected by thermal pollution itself, an example being thermal stress on coral.

10. Oil Refineries--The problems, information needs and priorities relating to waste discharges by oil refineries were addressed by the Marine Energy Panel. This panel concurs with their analyses of priorities.

C. Radioactive and Hazardous Materials

11. Low Level Artificial Radionuclides--The discharge of low levels of artificial radionuclides has serious potentially adverse

biological effects on the Pacific Ocean. Atmospheric fallout, nuclear power plants, nuclear waste sites and military installations are potential sources for these materials.

12. Adequate Storage of Radioactive and Hazardous Wastes--Recent studies suggest that "ultimate" disposal techniques for radioactive and hazardous chemicals are not adequate to prevent lateral and vertical movement to ground and marine waters. Examples of potential "problem" sites are Palmyra Island and Hanford, Washington.

13. Cenozoic-Tertiary Extinctions--Dinosaurs, annual terrestrial and aquatic plants and oceanic diatom communities suddenly disappeared at the Cenozoic-Tertiary boundary. Recent evidence suggests that a 10 km diameter asteroid collided with earth and suspended ash into the upper atmosphere which effectively reduced all photosynthesis for a period of two and a half years, leading to major losses of herbivores. It is not known if such an event is likely to occur again.

14. Petroleum of Unknown Origin--Petroleum of unknown origin affects beaches during certain seasonal periods in Washington, Oregon and California. Oiled dead sea birds and seals are also common during these periods when oil appears.

15. Chemical Dumping and Transport--Chemical dumping of tanker washings into international waters is a suspected (but inadequately estimated) contributor of hazardous substances to the Pacific Ocean water mass. Accidental spills during the transportation of hazardous materials constitutes a serious threat to the health of human and marine systems.

16. Oil Spill Trajectories/Cleanup--On-scene response teams have difficulties predicting trajectory and cleanup and/or mitigation measures.

17. Oil Spills--Limited information is available on the biological and ecological impacts of oil spills in San Francisco Bay, Los Angeles, Long Beach Harbor and Puget Sound. The partitioning and fates of petroleum hydrocarbons, as well as their long-term biological impacts, are poorly understood. There is also a question whether qualified biological impact assessment personnel are available to conduct appropriate studies.

D. Effects of Dredging

18. Stabilization of Denuded Substrate--Dredging activity physically removes the substrate along with the benthos, subjecting the denuded substrate to current erosion. Stabilizing denuded substrate depends on recolonization.

19. Scouring--Denuded sediments are subject to scouring by currents, further eroding the area and possibly covering down-current areas.

20. Turbidity--Resuspended sediments add to the turbidity of overlying waters with attendant interference, with light penetration, as well as physical obstruction of filter-feeders activity.

21. Leaching--In addition to redistribution, unconsolidated sediments are subject to leaching into the overlying waters. Absorbed toxicants, or those in the interstitial water, can be transferred to the water column and affect nearby populations.

22. Survival of Mobile Marine Organisms--Some mobile marine organisms are killed by dredge equipment. Resuspension of sediments may also affect organisms.

E. Effects of Dredge Material Disposal

23. Problem Site Selection--Sites for dumping of dredge spoils should be selected for minimum impact on the receiving environment.

24. Fates of Dumped Spoils--Fates of dumped dredge spoils should be determined.

25. Effects on Marine Organisms--Bioassay techniques and evaluation of results should be refined to assess the effect of spoils dumping on receiving communities.

26. Regulation of Dumping--Policies are needed to regulate dumping methods and site selection criteria.

F. Effects of Construction Materials

27. Construction and Development--Coastal construction and development is currently believed to have significant impacts on marine biota and resources. But there is still little comprehensive evaluation of biological effects and what they mean.

28. Habitat Modification: Disruption of Natural Cycles--Alteration of the ocean bottom by dredging or filling in of embayments can temporarily (or permanently) disrupt natural biological activities essential to life histories of marine species. Spawning migrations and activities, juvenile development and recruitment can be influenced by physical changes in shallow sub and intertidal areas.

G. Other Problems

The following problems were considered by the panel, but due to the magnitude of the other pollution problems and limited time for consideration, they were assigned lower priorities:

29. Introduction of Exotic Species During Habitat Modification

30. Regulatory Decisions Which Cause Trade-Offs Between Air and Water

31. Power Plant Cooling and Heating

32. Industrial Plant Cleaning

33. Data Availability

34. Pulp Mill Effluent Discharge

35. Plastics

36. Electrolysis of Sea Water - Mercury Pollution

III Information Needs

A. High Priority

1. Improve Ecological Monitoring Techniques --Using existing data and experience, biological indices should be developed that quantitatively document changing, degrading or recovering marine ecosystems. These indices should not be costly. They should be generated from relatively simple sampling methods that can be frequently undertaken and can be reported in a timely fashion.

Rationale

Self-monitoring agencies have been asked to use an increasingly complex array of biological methods in routine monitoring programs. The increasing costs can not be borne by many publicly-owned dischargers. This results in a lack of any biological surveillance at many sites (and limited surveillance at others) and longer reaction times, as well as reporting of changing conditions.

These agencies should be charged with monitoring indices of the more extensive biological changes, while regulatory agencies of the scientific community should continue to conduct long-range, long-term programs to answer questions of more penetrating biological effects. A mechanism is needed for feedback between these groups.

2. Regional Differences in Capacity to Assimilate Wastes--There is little data existing that demonstrates there are regional differences in assimilative capacities of coastal waters. Existing physical, chemical and biological data should be synthesized to model and forecast the ability of regional and local waters to assimilate different wastes, without changing organisms important to the ecology. Data on recovery rates and thresholds of ecological changes at existing and historical discharge sites should be used in the evaluation. The synthesis should lead to early identification of additional data needs. Those needs should be converted into new site-specific research programs.

Rationale

Energy conservation economics and maintenance of beneficial uses of coastal waters requires that waste management decisions be based on regional and local needs and attributes, as well as comparisons of alternative sites and methods of waste disposal. Region-by-region synthesis of coastal marine data is needed to objectively evaluate alternatives.

3. Diseases and Health of Fish and Shellfish--It is important to learn what agent (or agents) are causing the diseases, the sources of these agents and their fate. Specific studies should be undertaken to:

a. Determine species affected and their distribution in Pacific coastal waters
b. Determine what relationships exist between disease prevalence and water and sediment quality
c. Determine the potential impact of the diseases on population dynamics and abundance of affected species.
d. Confirm (via experiment) causative agents

Rationale

The public is concerned that affected and associated fish are unfit for consump-

tion. This concern must be met with a strong problem-solving effort.

4. Dilution and Circulation in Embayments, on Open Coasts and Around Islands--Continuing and new research is needed to define open coastal and insular current patterns and their variations over long periods of time.

Rationale

Much more is known about circulation in embayments than of open coastal zone and insular waters. Continued lack of data will limit man's ability to deal with waste discharges into these waters and to offer alternative methods of disposal.

5. Coliform Bacteria Counts--

a. If coliform counts are to be continued to be used, the basic effects of seawater on the organism must be known.
b. The relationships between coliform in the ocean and the presence of pathogens needs to be identified.
c. Since some pathogens commonly live in seawater (e.g., typhus, vibrio cholera) in low concentrations, and since there should be an increase in all marine bacterial flora in the presence of organic enrichment (as by sewage), a knowledge of fecal coliform survival in seawater would be useful. Also, knowledge about the relationship between coliform biomass and marine bacterial enhancement would be useful.

Rationale

Although the use of coliform counting is accepted as standard procedure, information is relatively useless unless it is tied to specific pathogenic effects. Thus, either the effort should be made to make the coliform test meaningful, or the use of the test dropped.

6. Marine Water Quality Criteria as Applied to Hawaii and the Pacific Islands--The region should be allowed to modify the criteria or develop their own criteria, based on data from completed site-specific studies in control and ocean discharge areas.

Rationale

The research is needed to determine regional water quality criteria.

7. Adequate Storage of Radioactive and Hazardous Wastes--Site-specific surveillance and monitoring should be conducted to assess fate and effects of materials.

Rationale

Adequate chemical and biological baseline information should be acquired prior to the development of storage facilities, such as are proposed for Palmyra Island. Intensive monitoring of existing storage sites will assure the public of site safety in each problem situation. Problems associated with the storage of radioactive and hazardous wastes are apparently more satisfactorily resolved on land. The solutions are also less costly than in the ocean.

8. Marine Food Webs, Toxic Substances and Biomagnification--A two-pronged approach is needed: first, the effect of waste discharge upon the processes which give rise to biological communities and marine food webs should be assessed without bias toward a single factor; and second, the effects of contamination to humans (including uptake concentration, etc.) should be identified.

In both cases, large-scale efforts are required. The determination of the structure of many natural food webs remains to be clarified, as do the conditions giving rise to specific community structures.

Contaminants (such as compounds from the lists of priority pollutants) need to be considered in the context of their actual presence in marine organisms and their observed or predicted effects upon and magnification through food webs of various complexities and structure.

Major needs include the comprehensive survey of biological communities, the development of realistic and reliable assays and the building of verifiable physical and mathematical models.

Finally, regional definitions of pollution must be established on the basis of sound scientific data.

Rationale

The understanding of food webs in marine communities is paramount to both the definition of pollution and the handling of the problem. It, therefore, deserves high priority.

9. Habitat Modification -- Disruption of Natural Cycles--Studies should be conducted on alternative mitigation and compensation (if needed) of lost beneficial amenities, such as shellfish gathering, fishing or non-consumptive activities.

Rationale

Elimination of highly visible wetlands and shorelines creates public relations problems. The law provides consideration for such mitigative efforts.

10. Effect of Construction and Development on Biota--Data from all kinds of near-shore construction projects needs to be assembled and evaluated in terms of biological problems, recovery rates and biological resource utilization. The compilation should focus on methods for forecasting future effects.

Rationale

Little is known about the biological "pros and cons" of salt marsh establishment on the West Coast in general, and the Pacific Northwest specifically.

11. Chemical Dumping and Transport--Needs identified with chemical dumping and transport are:

a. A survey of mass balances of ship tank cleanings discharged to international waters
b. Surveys of transportation (accidental) spills and ultimate fates and effects of hazardous materials in marine environments, and
c. Monitoring certain proprietary industrial discharges for toxicants

Rationale

There are potentially high risks of damages to marine ecosystems from acute toxicity and/or bioaccumulation from hazardous substances. There is high public awareness regarding toxins, as a result of recent publicity. Long-term chronic impacts are poorly known.

12. Oil Spill Trajectories/Cleanup--Oil spills - whether experimental or real - should be used to gather additional information about the way that oil travels. They should be analyzed with regards to both vertical and horizontal movement when studying the spill trajectories.

New techniques for oil recovery and dispersion should be tested and evaluated. The results of these tests can be applied to particular ecological situations, such as offshore and estuary spills.

Rationale

The site response team needs accurate, scientifically tested, prediction techniques to provide adequate mitigation for accidental spills.

13. Oil Spills--Spill response efforts should be focused on biological assessment in future spills of opportunity.

Rationale

Much current response efforts provide only cosmetic solutions to oil spills. Currently, most concern for oil spills centers around acute toxicity, beach and water surface cleanup, and saving oil-soaked birds.

14. Paralytic Shellfish Poisoning--There are needs for:

a. A separation of causes of dinoflagellate blooms by natural and anthropogenetic means
b. Studies on what causes generally non-toxic dinoflagellates to become toxic.
c. Well-coordinated surveys of saxitoxin and ciguatera in marine fishes (These surveys are presently uncoordinated.)
d. Models to explain why a species becomes toxic, and
e. Studies of the role and pathways of toxins in phytoplankton communities

Rationale

Dinoflagellate blooms have major ecological effects in that they alter species and community composition, thus altering marine food webs (not necessarily for the worse). Also, they may produce toxic compounds and seriously reduce dissolved oxygen levels over short periods.

Although toxic marine dinoflagellate blooms are not a serious or large health hazard, they presently reduce the value of fisheries and recreational areas and cause sickness and death to individuals.

15. Cenozoic-Tertiary Extinctions--There are needs to:

a. Confirm the theory via a world-wide terrestrial and undersea survey for 100 km diameter craters
b. Develop new predictive models incorporating asteroid-earth contact theories and food web structure of cenozoic and recent communities

Rationale

Imminent repeat of such an event could alter man's perception of marine pollution problems.

B. Medium Priority

16. Oil Refineries--The problems, research needs and priorities relating to waste discharges by oil refineries have been discussed by the Marine Energy Panel. This panel concurs with their analysis of priorities.

17. Fates of Dumped Dredge Spoils--Techniques should be developed to follow the fates of dumped spoils and the recolonizations and resuspension/redistribution of the spoils.

Rationale

Impacts on the receiving environment need to be kept to a minimum.

18. Effects of Spoils Dumping on Marine Organisms--Bioassay techniques and evaluation of results should be refined to assess the effect of dumping spoils on receiving communities.

Rationale

This would increase cost-effectiveness of monitoring and protection of receiving environments.

19. Dredging and Stabilization of Denuded Substrate--There is a need for qualitative and quantitative assessment of the succession of species recolonizing the area and the time the process takes.

Rationale

Until recolonization is complete, sediments are subject to scouring by currents and redistribution.

20. Scouring Effects from Dredging--Rates of resuspension related to current velocity and sediment size should be analyzed.

Rationale

Sources of resuspended sediments can impact adjacent undisturbed areas.

21. Turbidity Effects from Dredging--The effect of particle size and sediment load on turbidity as well as the degree of compaction of the sediments, should be assessed.

Rationale

Increased turbidity produces impacts at several trophic levels and could depress productivity.

22. Leaching of Sediments Following Dredging--Toxicant levels in disturbed, compared to undisturbed areas of sediment, should be analyzed to measure the degree of toxicant impact.

Rationale

All sources of toxicant load need to be identified and quantified.

23. Low-level Artificial Radionuclides--Monitoring efforts should be continued to establish time and geographic trends in the accumulation and distribution of low-level radionuclides and hazardous materials.

Rationale

The hazard and toxicity of these materials is poorly known. Diffuse sources, such as atmospheric fallout from weapons testing, are noncontrollable discharges. Public awareness of hazards and request for information emphasizes the need for data assessment.

C. Low Priority

24. Effects of Dredging on the Survival of Mobile Marine Organisms--There is a need to determine the biomass of mobile marine organisms destroyed by dredge operations in relation to the population present. If this is considered significant, screens or other devices should be designed to prevent organisms from being caught by the dredge. Procedures and devices should be designed and tested to increase efficiency of dredg-

ing and decrease sediment loss to resuspension.

Rationale

Decreasing impacts on natural populations is desirable, and improving efficiency of dredge operation is cost effective.

25. Site Selection for Dredge Spoils Disposal--Baseline studies are needed of biological, physical and chemical aspects of the receiving environment, as well as the areal extent of import and rates of colonization in dumped spoil material.

Rationale

Spoils should be dumped in areas of low biotic density.

26. Regulation of Dredge Spoil Disposal--There is a need to generate a series of regulations based on field analysis to minimize impacts on dump site communities.

Rationale

Protection and preservation of benthic communities is considered very important.

27. Petroleum of Unknown Sources--The sources and distribution of the stranded oil in intertidal areas should be identified. Pathological surveys of dead oiled animals may be useful in determining cause-effect relationships.

Rationale

The persistent occurrence of beached oil suggests that a chronic source of oil exists in certain coastal zone areas. The impact of these repeated oilings on pelagic and intertidal communities is not known.

Panel Members

Marine Waste Disposal

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SECTION IV

Marine Energy

I Introduction

The marine energy panel assessed the current and future status of energy production, transportation and generation in the region in terms of the major pollution and environmental concerns and the need for information to resolve these concerns. Categories considered were:

1. nuclear power plants (including waste disposal)
2. fossil fuel production and fossil fuel plants
3. ocean thermal energy conversion
4. energy transportation and
5. "other technologies".

The region was divided into Washington and Oregon, Northern California, San Francisco Bay, Southern California, Hawaii and the Pacific Trust Territories.

Distinctively different patterns of energy development characterize each of the sub regions as follows. Heavy reliance has been placed and will be placed on a combination of nuclear power plants and hydroelectric power systems in the Northwest region. Automotive transportation and other industrial uses require the importation of petroleum and liquid natural gas (LNG). A substantial number of naval nuclear power plants are present in submarines and surface combatant ships in the ports of Bremerton and Bangor.

In California, power production presently is a mixture of nuclear and fossil fuel plants. A current moratorium on new nuclear plants and the closing of existing plants suggests a "breather" for environmental planning, which anticipates any new construction. The introduction of coal as the major fuel for new power plants gives a new dimension to pollution concerns.

Significant production of offshore oil exists off the California Coast in the vicinity of Santa Barbara, Santa Monica and Long Beach. Although reserves are limited, additional drilling and exploitation of these resources is expected. With the increased

importation of Alaskan crude oil, oceanic and tidewater refineries and associated fossil fuel energy systems will be components of energy in the years to come.

The Hawaii region has in the past placed almost total reliance on oil-fired, steam-turbine power plants for prime power. Although a significant number of submarine nuclear power plants are present in Pearl Harbor at all times, the political pressure to keep commercial nuclear power plants out of the islands is intense. At present a euphoria exists in respect to alternate energy sources (wind, geothermal biomass and ocean thermal energy).

The expectation is that new energy demands can be met by alternate energy and without the introduction of coal. Fossil fuels are also introduced for automotive purposes and for aviation. Thus, two refineries are required in the coastal zone.

The major energy operation for Hawaii centers on ocean thermal energy conversion (OTEC), which at the very least will result in an intensive ten-year development program with pilot plants at the level of ten megawatts. Successful development implies substantial, if not wider, development of the resource in Hawaii and the tropical islands of the Pacific.

II Conclusions

The panel concluded that the major environmental problems and concerns stem from the interaction of energy systems with the living resources of the sea and in particular living resources in the delicate period of spawn and larval development. The concerns for hazard to public health and safety are largely mitigated by the present understanding of marine pollution but are nonetheless a continuing source of concern. The panel noted that many opportunities are currently overlooked for affirmative measures to enhance or utilize the changed environment which results from energy production and development.

Many problems are common to a number of systems, in particular that of biocides and changes in the local thermal environment. In summary, there are opportunities for protecting the living resources environment from adverse effects from both operation and catastrophy on the part of energy systems. These living resources can in fact be enhanced by appropriate development and deployment of technology. The following information needs and priority recommendations are based on these conclusions.

III Information Needs

A. High Priority

1. Locating Spawning Areas--There is a need to identify the locations (temporal and spatial) of spawning areas, larval and juvenile grounds and locations of adult marine animals with respect to energy production, transportation and generation facilities.

Rationale

The annual recruitment of marine animals is highly dependent upon local environmental conditions during periods of spawn and larval development. These processes are irregular and are confined to specific seasons. During these periods otherwise nondamaging activities associated with transportation (flushing of tanks, spills, generation of turbulence and artificial upwelling) can become highly destructive. Knowledge of the spawn and larval process would permit simple routing and operational changes that could prevent substantial damage to the year's recruits.

2. Locating Power Plants--Comparative environmental assessment of the siting of power plants should be done in either:
   a. a river or estuarine environment having access to the sea
   b. the coastal region, or
   c. on a floating or fixed platform at a distance from land in the relatively open ocean.

Rationale

Significantly different environmental and ecological problems are associated with operation and accidents in each of these environments. It is highly possible that substantial environmental benefits will occur if siting is moved seaward, but at the same time siting will probably occur in locations of inverse benefit. Comparative studies conducted now would go far to remove inhibitions on oceanic siting.

3. Categorizing Disturbances--The local environment needs to be characterized in terms of physical, chemical and biological effects resulting from disturbances which are common to energy activities. These common areas include the use of biocides, disposal of

energy wastes, installation of pipes and cables and changes in the local thermal and nutrient environment.

Rationale

Extensive site-specific studies are found to recur with respect to a number of common problems. These problems could be bounded by a study of the generic character of the environmental disturbance. In particular there is a recurrence of detailed plant-specific studies of the problem of biocides or the curtailment and/or the dilution of chemical and nuclear effluents and waste.

4. Coal Power Plants--Ocean environmental effects of the introduction of coal power plants needs to be assessed. In particular the interaction of airborne particulates with the marine environment should be evaluated.

Rationale

There has been little study in the ocean environment of the effects and distribution of particulate fallout and "acid" rain which are associated with coal power plants. Although this may not become a significant problem, an early determination is vital to the siting of these plants in the marine environment.

8. Medium Priority

5. Disposal of Nuclear Power Plants and Submarines--There is a need for a non-defense study of the use of the ocean as the final resting place for obsolete nuclear submarines and nuclear power plants or as the most available emergency disposal site for nuclear components, in the event of accident or unforeseen catastrophe.

Rationale

This region is the primary Pacific home of the nuclear fleet, and the obsolescence and disposal of fleet units is a recent phenomenon. Public concern about the safety of oceanic disposal, either in disperse or concentrated disposal areas, dictates a study by an agency without vested interest in the outcome.

6. Nuclear Monitoring in Ports--A non-defense agency should monitor the environment for nuclear effects in the home port area of nuclear submarine and surface ships.

Rationale

Rationale is again one of public concern for the public health and safety and the need for identifying fates and effects by an agency without vested interest.

7. Use of Ocean Water for Energy--A study should be made of the environmental effects of substituting ocean water for fresh water in energy production and processing.

Rationale

The shortages of fresh water for cooling, as a transport medium for slurries, as a heat storage and heat transfer process fluid, etc., will inevitably result in the substitution of seawater in order to alleviate competition for the water resource. Large volumes will be required and environmental effects will be associated with intakes and discharge of the resource.

8. Thermal Discharges--There is a need to expand studies of thermal discharges to include biological introduction designed to take advantage of the changed environment and to purposefully enhance the environment.

Rationale

Results are mixed on the effect of power plant effluent on aquaculture. There is also the promise of significant aquaculture yield from OTEC nutrient upwelling. Affirmative site-specific studies will uncover additional opportunities for environmental enhancement.

9. Limiting Biocides--There is a need for definitive bounds and limits on the use of biocides.

Rationale

In particular there are uncertainties with respect to the use of chlorine, its acceptance in waste water treatments and the nonuniform standards of acceptability in differing applications. Much can be done to speed the process of biocide permits where the use of the biocides will not have a major effect on the marine environment.

C. Low Priority

10. Patterns of Pelagic Fish--There is a need to assess the effects of widespread use of OTEC on the migratory habits and patterns of pelagic fish. This is of low priority, only because there is still time for assessment. The purpose would be to validate the analytical models which suggest little if any widespread climatic or weather implications of OTEC. It would also be to access other long-term effects of the development of OTEC as a major energy resource.

Rationale

OTEC platforms have proven effective as fish attracting structures for highly migratory species and have shown potential for increasing populations of nonmigratory marine animals. There is also a legitimate concern that the long-term effects of any major mechanism to extract energy from the environment may be significant, even though they may be difficult to assess.

11. Coal Wastes--Effects of the disposal of coal slag and ash wastes in the marine environment needs to be looked at. It is a low priority need only because there are adequate solutions and adequate time to arrive at solutions.

Rationale

The large amounts of this waste associated with coal power production and the significant land and ground water pollution problems associated with land fill and land disposal are of great concern. It is only a matter of time before ocean disposal is chosen as a preferred solution in specific sites.

Panel Members

Marine Energy

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SECTION V

Marine Mining

I Introduction

The panel evaluated potential pollution problems and other environmental damages that may arise from offshore mining of minerals and fossil fuels in the Pacific region of the Western United States, Alaska and Hawaii. In its discussions carried out to meet workshop objectives, the panel recognized that, with the exception of oil and gas drilling, little or no offshore mining of the region has occurred. The panel assumed, however, that other types of marine mining, particularly dredging sand and gravel on the continental shelf, will begin in the region in the near future.

II Potential Problems

To evaluate the potentially damaging effects of marine mining, the panel first considered the principal types of mining underway or likely to occur in the region. The kinds of activities that take place in mining operations that may cause pollution were then identified. The panel broadly interpreted marine pollution to include damages to the marine environment of all types (both chemical and physical), and attempted to assess major environmental changes that may be caused by marine mining activities. The following outline gives a brief summary of marine mining technology and the potentially damaging effects of the technology on the marine environment.

Marine Mining Technology

A. Principal Types of Marine Mining

1. Drilling for oil and gas, fresh water

2. Mining "hard minerals"

   a. Mining the deep ocean for manganese nodules, ferromagnesian crusts, phosphorites and metal-rich deep sea muds

b. Mining the continental shelf for high-value, low-bulk minerals, such as gold and platinum, tin, heavy mineral sands (ilmenite, rutile, zircon, magnetite, monazite, etc.), iron (vein deposits) and diamonds

3. Operations that produce heavy brines (not strictly marine mining)

   a. Removal of brines from undersea salt domes
   b. Seawater desalination
   c. Extraction of minerals/metals from seawater - bromine, magnesium, gold, etc.

B. Principal Types of Mining Activities

1. Exploration activities

   a. Geophysical studies (seismic, gravity, magnetic)
   b. Sampling (grab sampling) unconsolidated surface sediment
   c. Dredging surface sediment
   d. Shallow coring - various techniques; some allow shallow penetration of hard substrate
   e. Exploratory drilling; penetration hundreds of feet into hard substrate possible

2. Construction of equipment and facilities and support activities, for example, drilling platforms, construction of stable platforms for dredging, pipelines, processing plants; cleaning pipelines, activities of work boats and onshore facilities

3. Extraction activities

   a. Production drilling for oil and gas -- rotary drilling using mud as a lubricant
   b. Dredging
      1. Mechanical dredging -- grabbing or excavation type of activity (dipper, grab bucket, cutter head, bucket-ladder)
      2. Hydraulic dredging -- vacuum action to suck up materials from the seabed
      3. Submarine "bulldozer" -- now in experimental stage
   c. Shaft mining for iron and coal

4. Processing and transport -- separation, reduction, cleaning, etc.

   a. Processing at extraction site
   b. Transport to processing and transshipment facilities onshore or offshore
      1. Ship or barge transport
      2. Pipeline transport

Environmental Effects of Marine Mining

A. Principal Types of Environmental Change

1. Physical changes

   a. Modification of seafloor topography
   b. Modification of coastal morphology (coastal erosion)
   c. Change in particle size of bottom sediment (substrate)
   d. Resuspension of fine bottom sediment in water column (including nepheloid layer and bottom boundary layer)

2. Biological/chemical changes

   a. Removal and death of marine organisms related to physical causes
   b. Decrease in rate of photosynthesis in water column owing to decrease in sunlight
   c. Decrease in oxygen level in water
   d. Increase in trace elements, pesticides and biocides in water
   e. Increase in nutrients (nitrogen, phosphorus, carbon)
   f. Increase in salinity of seawater
   g. Increased hydrocarbon content in seawater

3. Socio-economic changes--These include changes such as damage to fishing grounds or interference with fishing operations or other commercial marine activities that may have a direct social and economic impact on humans.

B. Specific Sources of Pollution or Environmental Damage

1. Chemicals, fine sediment and drill cuttings released into seawater from drilling muds discharged during drilling operations

2. Oil released into the marine environment -- both chronic low-level discharge and occasional major spills; oil fumes released into air during petroleum offloading; exhaust fumes, etc., from support operations

3. Sound source for seismic prospecting; now mainly airgun or sparker -- probably of minor significance

4. Sliding and slumping of unstable areas of the seafloor owing to construction or exploitation activities; fault movements

5. Release of hydrogen sulfide gas, heavy metals, pesticides, biocides and nutrients (may be beneficial) from sediments stirred up from the seafloor and resuspended

6. Dredging operations, etc., that cause physical destruction of marine organisms and habitats

7. Rain of fine sediment from drilling muds, dredging operations, etc., covering benthos and larva

8. Increased turbidity in water column causing decreased rates of photosynthesis by marine plants

9. Oxygen uptake by minerals in sediment stirred up from the seafloor and resuspended in the water column -- reducing oxygen levels in the water

10. Changes in grain size of substrate (mud, sand, gravel) on which benthic organisms live; many biologic communities require a specific type of substrate

11. Ingestion of non-organic particulate matter by planktonic organisms

12. Dredging and other operations that destroy food supply of some marine organisms

13. Plumes of seawater of abnormally high salinity released by drilling into salt domes or caused by desalination or mineral extraction activities

C. Potential Impact of Environmental Changes on Marine Communities and Humans

1. Impact on marine organisms

   a. Disruption and loss of substrate (bottom sediment) which are critical habitats
   b. Disruption of feeding grounds; interference with visual feeding of fish, etc., caused by increased suspended sediment
   c. Loss of biomass
   d. Alteration or loss of physical/chemical environment; loss of breeding grounds
   e. Death or change in reproduction habits and rates owing to uptake of chemical pollutants to intolerable levels

2. Impact on humans

   a. Hazards to health arising from consumption of polluted marine organisms

   b. Loss of income or other damages arising from pollution, environmental damage or interference with commercial operations

III Information Needs

A. Basic Information Needs

1. Identification and Monitoring of Critical Marine and Coastal Populations and Habitats--Studies should be undertaken to identify marine and coastal biological populations and habitats that will be significantly affected by marine mineral development activities. The studies should concentrate on identification, prediction and mitigation of impacts on these populations and habitats. The timing and design of the studies should be integrated into the decision making framework for marine mineral development activities; in some cases, this will require many years of lead time.

Initially, these studies should focus on describing and identifying legally protected populations, critical habitats, sanctuaries and other protected areas, populations and habitats for which legal protection has been proposed and populations judged likely to be severely affected by marine resource development. The studies should include descriptions of normal and extreme variations in biological habitats and populations. Special emphasis should be given to coastal environments (nearshore, estuarine and wetlands).

The panel also recommends that the marine and coastal environment be the subject of a continuing monitoring program designed to assess changes resulting from offshore resource development. The monitoring procedures and techniques should be periodically examined to determine if the necessary parameters required for evaluating changes are being measured. Maximum feedback of monitoring results should be provided to regulatory and development agencies.

2. Identification of Seismic Hazards and Areas of Seafloor Instability--Prior to further offshore resource development, studies are needed to identify and describe

coastal and offshore geologic hazards that could have a detrimental impact on marine mining activities. The panel endorses, in general, the recommendations of the Seafloor Instabilities and Seismic Hazards Subgroup of the 1976 Bureau of Land Management conference/workshop relative to offshore resource development along Washington and Oregon (BLM, "Recommendations for Baseline Research in Washington and Oregon Relative to Offshore Resource Development," 1976, pp. 155-158).

Initial study should concentrate on identification of geologic hazards from existing information. Additional field studies should be carried out in areas where inadequate information exists or where site-specific definition is required.

Long-term geological, geophysical and geotechnical studies should be conducted to:

a. Establish the tectonic framework of the region from existing geologicel and geophysical data; identify faults, folds, diapirs and areas of uplift and subsidence. New high-resolution seismic profiling may be required in critical areas to identify zones of low structural integrity (fault zones) that may lead to drilling problems -- loss of drilling muds and inability to contain and control hydrocarbon flows.
b. Continuously monitor seismic events in coastal and offshore areas by means of a network of seismograph stations, including ocean bottom seismographs.
c. Identify and map areas of seafloor instability (slump blocks, areas of thick sediment on oversteepened slopes) that may lead to slumping, gravity slides, creep and flows during mining activities. Available bathymetric and seismic profiles should be adequate for general regional definition, but additional profiling and coring may be required in local areas of anticipated mining development.
d. Assess the geotechnical properties of sediments (texture, density, water content, shearing stress, etc.) in relation to facility design criteria. Again, additional coring and testing in critical areas may be required.

3. Physical Oceanographic Characteristics of Coastal and Continental Shelf Waters--There is a critical need to know the physical characteristics of the coastal and continental shelf waters. These characteristics will affect the design, construction and maintenance of offshore mining equipment and facilities, the nature of logistical support operations and the potential for accidental or planned pollution from marine mineral development activities. Characteristics of particular importance include surface flow (both mean flow and seasonal variations), subsurface currents (including near-bottom currents, because of their importance in understanding sediment transport), waves, tides and ocean meteorology (interaction of ocean and atmosphere; storm generation). The studies should be directed toward an understanding of the transport and circulation in the ocean of water-soluble pollutants, particulate suspensions and bedloads, which is necessary to predict the course pollutants will take.

Existing physical oceanographic data should be utilized where possible. Gaps in the data must be identified at the time of planning for marine mining development and prior to granting permits. Field studies should be carried out to gather additional needed data, particularly site-specific data, as rapidly as possible. The data must be translated to formats or statistical summaries appropriate for use by planning, regulatory, permit and pollution response agencies.

4. Identification of background levels of toxicants and other pollutants and analysis of effects of pollutants on specific representative groups of marine organisms

a. Ambient levels of pollutants and current sources of pollution
To better understand the possible detrimental effects of developing mineral and fossil fuel resources in the offshore area, it is necessary to establish the present level and variability of pollutants in the marine ecosystem: water, sediment, air and marine organisms. Baseline concentrations of hydrocarbons, trace metals and synthetic organic compounds should be determined, particularly in key representative organisms ("control" organisms), such as certain bottom feeders (bivalves, crustaceans, flatfish). Major current sources of pollution should also be identified (refer to recommendations of other pollution panels), as future pollution from mining activities must be differentiated from pollution from these sources.
b. Effects of pollutants on marine organisms
Once the present pollution levels and current pollution sources are identified, it is important to carefully and periodically monitor changes in pollution levels in the marine ecosystem, particularly in control organisms, to determine the effects on marine organisms of pollution caused by marine mining activities.

The rate at which pollutants are distributed and transformed along environmental gradients by natural processes must be better understood (especially any process that may result in magnification of pollutants in any part of the ecosystem). Present knowledge of the sublethal effects of single or multiple pollutants is grossly inadequate. It will be necessary to develop and perform controlled experiments on individual marine species or entire local ecosystems in order to evaluate the complex effects of long-term, low-level (chronic) exposure to a single pollutant or a mixture of pollutants.

5. Experimental and Theoretical Modeling Studies to Predict Pollution Effects--The capability of predicting the environmental impact of developing offshore resources can be improved by using existing data banks and theoretical-experimental studies and models. However, it must be recognized that models are inherently limited in nature, and their use must be coupled with critical analysis of such limitations. Attention should be given to how other models may supplement, complement, or in some cases even reverse or negate the results of a given model.

Expediency, low cost or simplicity should not be the overriding factors in selecting models. Innovations in modeling continue; assessment agencies must keep pace with these innovations so that they are constantly working with the best possible techniques.

6. Evaluation of hazards to human health--Human health should be considered in assessing the impact of any marine mining operation. The immediate and long-term effects of marine mining operations on human health, other than accidents, are unknown. Potential health hazards include air pollution and eating contaminated marine organisms.

The nature, type and concentration of air pollutants should be determined and evaluated in terms of a potential human health hazard. Particular attention should be placed on any mining operation involving a new process which may introduce a new pollutant into the atmosphere.

The potential always exists for a contaminant to be magnified as it moves up the food web, possibly to humans. Body burden levels should be measured on representative organisms of the food chain to determine whether biomagnification of the organism has occurred. Particular emphasis should be placed on determining the levels of any synthetic organic compound discharged into the ocean. Existing data sources, such as the mussel watch, should be used whenever possible.

Rationale

The most urgent information need is for baseline studies. Identification of marine populations and habitats and assessment of geologic hazards are the most critically needed baseline studies and are, therefore, assigned first priority (the panel regarded the two needs to be of equal importance).

Identification of marine populations was given high priority because the first step in evaluating pollution damage to the environment must be to study and identify (prior to initiation of significant mining activity) those marine organisms and habitats most likely to be adversely affected by marine mining activities.

Assessment of geologic hazards was also given high priority because of the potential danger to both humans and marine organisms from mining operations conducted in seismically active or unstable areas of the seafloor.

Characterization of the physical oceanography of the coastal and marine area and determination of ambient pollution levels in the marine ecosystem were considered next in importance (and of about equal importance). Evaluating possible increases in pollution levels owing to marine mining and assessment of the potential damage to marine organisms arising from such pollution, requires that pollution levels be known prior to mining development. Evaluation also requires that the mechanisms and routes by which pollutants may be dispersed within the marine environment be understood.

The need to assess possible pollution hazards to human health was given lower priority than the above baseline studies. The lower priority was not given because of disregard for human health. Rather it was assigned because it was judged that baseline studies to determine the biological, physical and chemical characteristics of the marine ecosystem would be needed for early planning, design and regulation of marine mining operations - long before any serious hazards to humans caused by marine mining activities would likely arise. Also, data provided by baseline studies will be a critical element in assessing potential hazards to human health and must be available before reliable assessment can be made. Once mining activities are underway, monitoring and evaluating those activities that pose potential threats to human health will be of

primary importance.

B. Socio-Economic Information Needs

1. Data availability and cooperative use--The location and availability of existing data dealing with marine mining pollution must be known to identify gaps in the data base that should be filled through the design and conduct of new studies. There is a strong need for development of a data sharing system to locate (and make available for planning and management use) more marine pollution information. Such a system probably should be developed on a region-by-region basis rather than on a national scale.

Of central concern to identification and use of existing data is the ability to retrieve all relevant information, even though that information may not have been generated through research on marine mining pollution. Such identification may require formulating special interrogation and data entry formats. The problem of data gathering and shared use is discussed further below.

2. Interdisciplinary approaches--Scientific data are generated by specialists and institutions often operating independently of one another. Because marine pollution causes problems that involve complex and widespread ecological systems, the need will arise for greater cooperation and communication between specialists and institutions at national and international levels. Some cooperation proceeds as a matter of course; however, conscious effort must be directed towards formulating interdisciplinary research programs. Other efforts should be made to create interdisciplinary, inter-institutional and international teams required to carry out these programs. Such an interdisciplinary research approach will improve both data gathering and decision making processes.

A great deal of support is already being given to environmental impact assessment. However, more emphasis should be placed on technological innovation, following the maxim that prevention is the best cure. An integrated approach is valuable as well in this regard. Cooperative problem solving ventures which bring together scientists and engineers along with representatives of industry, public interest groups and regulatory agencies are most likely to provide the necessary technology for safe, sophisticated marine minerals pollution prevention and control. A cooperative approach in resolution of multiple-use conflicts (see recommendation below) is also essential.

3. Multiple-use conflicts--Studies are needed to identify onshore, nearshore and ocean uses and users which may conflict with ocean mineral exploitation and extraction activities. Studies should assess the social and economic effects of such conflicts, as well as the tendency for any specific use to preempt or eliminate other uses or users.

a. These multiple-use studies should be specific as to geographic area and uses in conflicts, and should focus on the nature of the impacts. It should be determined whether impacts are from pollution, space-use conflicts, or of a complimentary, cumulative nature.
b. The studies should attempt to predict when a marine mining activity will be a use new to a particular area and a set of ocean users. Prediction is needed so that communications can be established between traditional users of the ocean and new users. Establishing effective communications between the various users of the ocean is essential to reducing or eliminating social and economic conflicts and in controlling cumulative adverse impacts that may arise.
c. The studies should also identify ways in which essential information can be exchanged between both cooperating and competing users of the ocean, especially in nearshore areas. Solutions should be sought to the problem of withholding proprietary information by some users.
d. The studies should review and assess the potential for making some dominant or exclusive-use designations on specific ocean areas (for example, marine sanctuaries, sensitive wildlife habitats, national parks, petroleum reserves). Impacts from other uses - especially pollution created by these uses - could be minimized or eliminated in these specific, set-aside areas.

4. Damage assessment studies--Damages to marine, coastal and human resources and activities resulting from marine minerals development should be studied to determine if they are compensable. These studies are essential to assess compensation for pollutant accidents after the fact and to predict social costs of marine mining activities before development decisions are made.

Damage assessment studies should build on the results of available information and should be continually evaluated as better predicative information is generated from other studies. Damage assessment should be

done on both short and long-term bases (presently most dollar amounts are based on short-term costs only).

Rationale

These information needs were ranked as they are listed above because the identification of existing pollution data and coordination of research studies aimed at providing information for planning and management decisions are needs that must be met early in the marine mining development process. Resolving user conflicts and assessing fiscal damages caused by marine mining are activities that will require a strong data base, as well as cooperation among all agencies involved in planning, managing and regulating marine mining operations.

C. Special Recommendation -- Timing and Adequacy of Research Funding--The results of marine pollution studies should emerge at or before the time they are needed for decision making. Such timing requires that most biological studies and some physical studies be initiated long before decisions are required, because biological cycles and responses are commonly long-term processes. Policy makers and budget officers often fail to appreciate the need for long-term studies, preferring to gather information over a shorter period (one or two years). Consequently, it is difficult to get necessary studies funded far enough in advance to provide reliable information for decision making.

Funding for studies needs to be timely, in adequate amounts and, in most cases, provided on a multi-year (perhaps five-year) basis. Means should be sought to improve communications between scientists and policy/budget personnel to overcome existing problems of "too little research money, too late" in the planning and decision making process.

Rationale

The panel feared that funds would not be allocated sufficiently, far in advance or in adequate amounts to carry out baseline studies and other pollution research prior to the time research results would be needed for planning and design decisions. Those persons or agencies in a position to influence funding decisions should make the strongest possible effort to insure timely and adequate funding for marine mining pollution research.

Panel Members

Marine Mining Panel Members

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SECTION VI

Mexican Border to Point Conception, California

I Introduction

The marine area of Southern California is unique in comparison to the region north of Point Conception. It is characterized by a warmer climate, less rainfall, lack of year-round river flow and virtual absence of major estuaries. More than 15 million people inhabit the region, most of whom live within a 25-mile distance from the ocean.

Most marine environmental problems in Southern California can be attributed to the large population which has increased rapidly. The people of Southern California have had to solve these problems quickly and generally without the benefit of similar experiences elsewhere. If wise environmental decisions can be made in Southern California, not only will this area be improved, but it may assist in solving problems elsewhere.

Future research in this area should emphasize the following:

A. While some marine areas in Southern California have been monitored for many years, there is a need for compiling and analyzing both from a single site and from a regional area perspective. A greater use of existing data should be encouraged to assist in evaluating present environmental conditions and to determine gaps in man's knowledge.

B. Regional environmental libraries would be valuable in making this information more accessible.

C. Periodic reviews of existing monitoring programs should be encouraged to assess their value, their applicability to answer questions and to determine whether addition or deletion of samples and/or parameters is required.

D. Standardized techniques in collecting and analyzing data gathered in baseline and monitoring studies should be developed which will facilitate data synthesis on a regional and national basis.

E. The effect of land disposal of solid wastes should be measured to determine if it causes more potential harm to human health and the terrestrial environment than oceanic disposal.

F. Greater emphasis should be placed on the prevention of pollution prior to its occurrence.

G. There is a need to develop alternative methods of waste water treatment and sewage disposal. This should include evaluation of legislative and/or regulatory restrictions for waste alternatives.

H. The potential impact of wastes discharged into the marine environment on human health and marine living resources should remain a high priority.

II Problems

Sources of marine pollution in Southern California are:

A. Petroleum activity

B. Mineral development

C. Nonpoint sources (e.g., storm runoff, agricultural practices, vessel wastes, aerial fallout)

D. Municipal wastes

E. Geohazard effects on marine structures (e.g., platforms, pipelines)

F. Thermal pollution

G. Dredging and disposal

H. Ocean dumping

I. Habitat modification

J. Red tides

K. Nonbiodegradable industrial wastes

L. Biodegradable industrial wastes

III Information Needs

A. High Priority

1. Petroleum activities--The panel recognized the greatest research need for the region to center around petroleum activities. The sources of petroleum entering the environment need to be divided. Sources of petroleum entering the marine environment include spills from tankers, pipelines and platforms, blowouts, chronic release related to boat and ship activities in harbors and marinas, refinery waste, natural oil seepage, urban runoff and aerial deposition.

There is a need to:

a. Study the effect of drilling muds and cuttings on marine organisms and a need for evaluation of existing data and information concerning this activity.

b. Develop methods of risk assessment for man, environmental protection and prevention of pollution, and properties.

c. Develop contingency plans regarding petroleum activity equipment, models, weather data (especially offshore winds) and oceanography of the region.

d. Determine impacts of controlling methods such as dispersants and detergents.

Rationale

Southern California is an area of significant petroleum activity, and the potential environmental impact of oil spills and blowouts is great. The potential impact of mud on the marine environment resulting from drilling is not completely understood and needs further study. Refinery wastes and shipping could impact this area which imports large quantities of gasoline and other petroleum products.

2. Municipal wastes--There is a need to determine:

a. alternative methods of municipal waste disposal
b. the effect of ocean disposal of raw, primary and secondary waste
c. better methods for siting outfalls, and
d. the effects of excessive rain runoff on sewage treatment plants and the environment.

Rationale

The ocean is the primary receiving body of municipal waste in Southern California. The area is the location of the largest municipal marine outfalls in the world. Degradation has occurred in the vicinity of each of the major outfalls. Municipal wastes contain a number of highly toxic elements and compounds

which seriously compromises man's capability to safely dispose of such wastes.

3. Dredging and Disposal--Evaluating the biological, chemical and physical effects associated with dredging activities in the marine environments is an important need. Studies should also concentrate on the recolonization of benthos following dredging activity and the effects of dredging on commercial fisheries.

Regarding disposal of dredged materials, there is a need to study the nature of the disposal site and of the material itself. There is also a need for studies of:

a. disposal methods
b. the environmental effects of disposal (including possible bioaccumulation)
c. the concentration of wastes in surrounding areas and
d. the oceanography and sedimentation rate of the area.

Rationale

There is an inadequate data base to evaluate the effects of dredging and dredge spoil disposal. Large scale dredging activities are anticipated in the larger ports of Southern California.

4. Ocean Dump Sites (abandoned chemical dump sites)--There is a need to undertake the same studies for ocean dump sites as for dredging and disposal.

Rationale

There is a lack of data concerning what has occurred at these dump sites.

5. Habitat Modification--The effect of habitat modification on birds, fisheries, man and other organisms should be studied. Ongoing studies are needed of natural and modified ecosystems and the effect of habitat alteration on the ecosystem needs to be studied.

Rationale

Man does not know the natural variability of the ecosystem, nor the effects of habitat modification. Maintaining pristine areas in a heavily populated area such as Southern California is important. An additional reason such studies should be conducted is to comply with federal and state wildlife regulatory agencies' requirements.

6. Nonbiodegradable Industrial Wastes--These wastes should be studied to determine:

a. persistence
b. toxicity
c. transformation
d. bioaccumulation and biomagnification
e. magnitude of the problem
f. an inventory of waste products and methods for control of their disposal.

Rationale

Most nonbiodegradable industrial wastes are toxic and potentially able to accumulate in marine organisms. They may ultimately affect mankind. Southern California is a heavily industrialized area. New synthetic compounds appear each year and need to be evaluated for their potential impact.

B. Medium Priority

7. Nonpoint Sources--There is a need to determine the type and composition of these sources, their rate of input, how and where they are distributed, the impact of these pollutants on the marine environment and how to control them.

Rationale

The magnitude of nonpoint source pollution is unknown. Until the time that such data are available, it will remain difficult to determine the seriousness of this pollution source.

8. Thermal Pollution--Studies should be conducted about the impacts of heated effluents in the marine environment, entrainment of marine organisms, alternative uses of waste heat and the effects of biocides (e.g. chlorine).

Rationale

All thermal and nuclear power plants in Southern California are located on the coast where they circulate sea water through the plant as cooling water and discharge the heated water into the ocean. The effect of entrainment and heated effluents on the marine environment is not understood.

9. Biodegradable Industrial Wastes--Understanding the assimilation capability of the environment is an important need. Likewise, it is important to determine methods of using biodegradable wastes and to develop methods of managing those wastes.

Rationale

Since biodegradable wastes can be decomposed, they do not pose as great a threat as nonbiodegradable wastes. The effect of these products on biological oxygen demand (BOD), eutrophication, etc., needs to be evaluated.

C. Low Priority

10. Mineral Development--There is a need to determine the impact of mining minerals and the impacts of processing minerals.

Rationale

No large scale deep-water mining is feasible in Southern California.

11. Geohazard Effects on Marine Structures--A need exists to understand how natural earth processes affect man-made structures. Studies should include the nature of geohazards, the effect of hazards on construction and methods of control of geohazard effects.

Rationale

Good engineering practices would minimize the effects of geohazards.

12. Red Tides--Basic research is needed on the causes and effects of red tides and to distinguish between natural and man-made causes of red tides.

Rationale

While the causes of sporadic red tides in Southern California are important to determine, the potential solution of this problem is considered low.

Panel Members

Mexican Border to Point Conception, California

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SECTION VII

Point Conception, California to Point Arena, California

I Introduction

Much of the California Coast between Point Conception and Point Arena is undeveloped, so the majority of marine pollution problems lie in the San Fransisco Bay and estuary system, and to a lesser extent in Monterey Bay. Exceptions to the problems are offshore oil and gas development (OCS Lease Sale 53) and some forestry activity on the North Coast.

While the panel focused on ocean pollution, members agreed that to understand problems in the enclosed ocean called San Fransisco Bay, it was necessary to consider the Sacremento and San Joaquin rivers, the Delta, San Fransisco Bay and the Gulf of the Farallones as a single unit.

Most of the problems in this area are not new. The exceptions are offshore oil and gas development and the addition of the Peripheral Canal to the existing diversions of fresh water from the Bay/Delta system. With these two activities, adequate baseline data can be collected so that any changes related to drilling rigs and/or the canal can be measured against conditions that existed prior to either activity.

Marine pollution problems in San Fransisco and Monterey bays have multifaceted information needs. The panel, therefore, gave priorities to the problems. The information needs are listed in general order of priority. A single information need may support the solution of several problems, although more than one priority may be involved.

II Problems

A. High Priority

1. Offshore Oil and Gas Development--The problem refers specifically to OCS Lease Sale 53, subsequent federal lease sales and the possibility of state leases within the three-mile limit.

The major problem with the present OCS Lease Sale program is that there is insufficient time to complete baseline studies, and there is too little time for feedback from concerned groups and individuals.

Rationale

There is a danger that the focus on impacts will be on oil spills. While attention to spills is important, the nature of the offshore drilling process has impacts throughout the environment. Affected by the activity are:

a. air and water quality
b. land use
c. urban growth stimulation
d. displacement of commercial fisheries
e. adverse impacts on migrating cetaceans through physical obstruction and noise pollution disrupting their navigation
f. reduction of recreational use of the coast and
g. danger of extinction of fragile species

2. Hazardous Waste Disposal and Existing Storage--The problem includes the disposal and storage of heavy metals, radionuclides, pesticides and other known toxicants and the identification of unknown toxicants.

Rationale

Hazardous wastes are also a part of the consideration of point and nonpoint source discharges. Dump sites in the Gulf of Farallones have been a problem for some time, as have nonpoint sources of industrial hazardous materials. Impacts may be long lasting and may be accumulated in the food chain.

3. Point Sources, Municipal and Industrial Wastes--This problem overlaps hazardous waste to some extent. The concern here is with the level of treatment. San Francisco is still releasing effluent with only primary treatment, particularly during the rainy winter months. San Francisco is upgrading some of its treatment facilities to the secondary treatment process and is planning to use an ocean outfall.

Rationale

An additional problem is the reliability of existing plants, since treatment plant failures have occurred recently in the Bay. Besides the problem of plant maintenance and reliability, there is a shortage of personnel qualified to operate the plants.

There is disagreement about the effectiveness of secondary treatment, as well as about the necessity of the offshore outfall, in light of the current patterns estimated for the Bay just inside the Golden Gate Bridge.

4. External Pollution Sources--The panel felt it useful to consider impacts from outside the area. These include tanker accidents, which constitute a major source of oil pollution, and the introduction of pollutants into longshore currents from the north and south.

5. Diversion of Fresh Water from the Bay/Delta System--Included here are the existing California Aqueduct and Delta-Mendota Canals, the projected Peripheral Canal, the San Luis Drain and the further deepening of the Baldwin Ship Channel.

Rationale

Diversion of water out the Bay/Delta to the south reduces water quality in the San Joaquin Valley and reduces dilution of wastes and flushing of the Bay itself. Particularly vulnerable is the shallow South Bay. Migratory fishes, as well as resident populations of fishes and invertebrates, depend on continuous flows of fresh water for survival. The injection of nutrients and sediment load into the Bay from the Delta is important to the continued productivity of the Bay.

There is also a consideration that the transportation of waste loads from the Delta south to Los Angeles may have an impact on the water quality of Southern California. The Peripheral Canal would greatly decrease the amount of water flowing into the Bay. The consequences of this are far reaching. It is not known whether they are reversible.

B. Medium Priority

6. Nonpoint Sources--Agricultural activity in the Central California Valley introduces salts, pesticides, pheromones and biostimulants into the Bay. Urban runoff also leads pesticides, biostimulants, oil and organic material directly to the receiving waters, as well as through combined sewer systems. There are small amounts of mine drainage from mercury mines in the South Bay and silver from Page Mill Creek, which empties into the Central Bay.

C. Low Priority

7. Harbor Operations--Construction and maintenance of docking facilities, ship channels and marinas produce dredge spoils. The disposal of the dredged material produces increases in turbidity and disruption of ocean bottom communities. Fuel docks, off-loading of materials and bottom points on ships and boats add a variety of pollutants to the Bay.

8. Power Plants and Liquid Natural Gas Plants--Operation of these plants produces thermal pollution, as well as impacts on the biota through entrainment in the cooling waters. Biocides are used to clean the cooling systems.

III Information Needs

1. Monitoring Program--A continuing monitoring program of key characteristics in the physical, chemical and biological aspects of the ecosystem would contribute most to the solution of major area problems. The selection of the parameters, which would be keys to the state of the ecosystem, is a problem in itself. This program should last for one to two years to describe the variability of the ecosystem. Only after the natural fluctuations are known can the effect of man-made alterations be measured.

Of particular importance for oil spill cleanup is increased data on nearshore currents (i.e., expansion of the NSF CODE program) in the Bay and along the coast. Further site-specific studies and monitoring of biostimulants are needed.

In the interest of coordinating data, as well as cost effectiveness, the panel suggests that the Oceanic Province, including the Gulf of Farallones, San Francisco Bay and the Delta, be included in a separate authority for the comprehensive continuing synoptic survey. Examples of ecological topics are:

a. reduction of oyster populations and their closure to commercial harvesting
b. histopathology of striped bass and mussels
c. elevated levels of organics and
d. heavy metals in invertebrates and fishes.

Any monitoring program should include the effects of fresh water diversions from the Delta on water quality, water transport and ecological conditions in the Bay and coastal nearshore waters.

The uninhabited coast of Baja California is suggested for use as a control area for Central California.

2. Offshore Oil and Gas Development--There is a need to:

a. Analyze present oil (hydrocarbon) levels in biota.
b. Catalogue by geographic area and time ocean climates that would affect dispersal of a spill.
c. Catalogue resources that would be affected by chronic low-level, as well as catastophic spills by area and time.
d. Develop scenarios for reacting to a spill based on the above catalogues. It is assumed that the technology to handle spills in coastal waters is developed.
e. Develop a damage assessment team and a plan to survey the damage after the initial cleanup. There should be a system "ombudsman" to ensure that reported impacts are investigated and not covered up. This program should include pollutants other than oil.
f. Generate charts and a rating scale of the salvageability of beaches. The cleanup process itself may cause more damage than the oil in some situations.
g. Determine under what conditions dispersants should be used, recognizing their toxicity.

3. Hazardous Materials--A new fine-scale survey of hazardous materials in the coastal area needs to be developed. It should not be limited to the EPA priority pollutant list. The conditions under which hazardous materials can be dumped on this coast should also be determined.

A large number of chromatographic analyses have been made of environmental samples, and not all of the peaks have been identified. It would be wise to do this as a way to explore for possible new toxicants.

4. Aquaculture--Aquaculture will be an increasingly important industry. There is a need to examine how high-density fish culture will affect pathogen levels, water quality and biostimulation.

5. Data Availability--Much potentially useful information is being held by scientists and commercial enterprises. Techniques should be developed to make this information widely available. Computer data banks are not easily made compatable and this impedes retrieval and utilization.

In the future, data collection should be structured and data points sufficiently identified, so as to be useful to answer questions other than those for which the data were initially gathered. The answers to current questions may already be known, and it is ineffi-

cient to spend time and money struggling to retrieve existing data or even to find out if data exist.

6. Museums--There is a need for facilities to store collections of environmental samples for future analysis.

Panel Members

Point Conception to Point Arena, Calif.

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SECTION VIII

Point Arena, California to Port Angeles, Washington

I Introduction

The coastal region in the sector of Point Arena, California, to Point Angeles, Washington, is unique in that it is the most pristine and least impacted by man's activities of any sector of such length in the continental United States. Such relatively undisturbed status could be considered advantageous, but it also means that probably there exists less information about the conditions along this sector than in other more developed regions of the nation.

Careful consideration was given by this panel regarding information gaps that exist in the region. Additional basic information about the area's estuarine and offshore ecosystems is required in order to effectively respond to marine pollution problems.

The present state of knowledge is such that certain issues can not be effectively addressed without more basic knowledge being developed for particular topics. This sometimes rather broad information is essential for dealing with specific pollution problems.

The marine environmental conditions of the area are such that the region's undeveloped nature affords a unique set of considerations in evaluating pollution problems. Relevant information is lacking for such undeveloped areas.

This lack of information should be considered in pollution monitoring and assessment programs and in the evaluations of proposals. User groups of pollution research information must convey their needs to researchers, and researchers, in turn, must consider the users' level of technical knowledge and the level of data they will require in order to make decisions.

The panel recommends the use of a conceptual model approach to organize the collection, synthesis and presentation of data to be collected under the Federal Plan. The model or models should include the physical-chemical, biological and socio-economic environments. The qualitative models should

describe regional ecosystems and their component resources, processes and relationships.

In addition, the models should be used to introduce and explain the concepts, methods and approaches used in the conceptual modeling process. Conceptual models for many ecosystems and processes have already been developed (for example, Ecological Characterization of the Pacific Northwest Coastal Region) and should be used as a starting point for the proposed work.

II Problems and Information Needs

1. Currents, Sediment Transport and Phytoplankton--Baseline studies concerning ocean circulation (currents), sediment transport and phytoplankton (primary productivity) are recommended for the continental shelf from Yaquina Head, Oregon, to Point Arena, California. In particular, present information is inadequate to predict or even to understand events in the nearshore ocean. Although the problems are often specific, only the development of a better data base will produce the background needed to provide answers to the specific problems.

Ocean circulation studies are needed immediately to allow for the prediction of pollutant transport in the case of a major oil spill, for example. Since the Coast Guard must make an early decision on the use of dispersants at a spill site, the information is needed immediately. In the longer term, increased knowledge of circulation patterns will be important in the siting of future outfalls as required by the growth of the region.

Sediment transport information is also required in the near term. The possible development of oil and gas exploration in the region requires additional information for proper construction of structures associated with that development. Basic information on ecosystem productivity is needed in advance of development and before any major pollution event. Such information is essential to the general understanding of the impact of pollution in the region.

Present knowledge of these oceanographic conditions is inadequate for decision makers at all levels to make intelligent decisions concerning the impacts of future major resource developments (oil and gas, seabed mining, etc.), even such as oil spills or disposal of dredged material. To be most useful and cost effective, these data must be obtained before major developments begin or large catastrophic events occur.

2. Trace Heavy Metals--In order to assess the impact of trace heavy metals as possible pollutants in the marine environment, it is recommended that:

   a. Research be carried out to establish ambient levels of heavy metals such as copper, lead and mercury that are potentially toxic to marine organisms in the water column and bottom sediment of major estuaries and the intertidal zone. Initial baseline levels should be determined at different seasons of the year (high runoff vs. low runoff), and thereafter rechecked periodically (no period specified at this time) to monitor changes in concentration levels. Baseline studies should include analysis of water and sediment--both upstream and downstream from suspected point sources (e.g. cities, industrial complexes, large agricultural areas)--of heavy metals.
   b. Concurrent studies be initiated to assess the impact of dissolved heavy metals on biologic communities in the marine, estuarine and intertidal environment, and be periodically monitored to see if changed concentration levels alter behavior or physiological states of marine biota.

3. Tar Balls--During the late winter there is an increase in the number of tar balls which reach the beach. Often they are accompanied by an increase in the number of dead birds, some of which are oil soaked.

Research and monitoring should identify whether the increased number of tar balls reaching the beach result from seasonal weather, which deposits more of those normally present in the ocean upon the shore, or from an increase in the total number of tar balls present in offshore waters. Additionally, the cause of the tar balls should be determined.

Since there is often a demand by local commercial interests for federal cleanup of the tar balls, the environmental effect to the beach should be examined to ascertain whether there is justification for such a cleanup. This research would aid in determining what attenuating or remedial measures are appropriate and whether cleanup is appropriate.

4. Trace and Low-Concentration Pollutants--Basic research should determine baseline levels of toxic heavy metals and organic pollutants in marine sediments and water. It

should also establish the levels of these pollutants that may alter physiological processes in marine organisms in significant ways. Examples are alteration in behavior and changes in timing of developmental stages that can affect the productivity and survival potential of species. Monitoring of marine and estuarine waters should be carried out with sufficient precision and frequency to identify changes in concentration which result from periodic fluctuations caused by climatic conditions and changes in management practices.

Efforts should be made to apprise managers of research results which identify effect versus noneffect levels of the pollutants and to indicate where observed values are too high.

III Columbia River Problems and Information Needs

5. Offshore Oil and Gas Development--A program of baseline studies should be initiated to evaluate the effects of exploration for and exploitation (drilling, recovery, transport) of oil and gas on the biota of the continental shelf and major estuaries of the area. Studies should include establishing:

a. sediment characteristics and distributions (texture, composition, hydrocarbon content, geochemistry)
b. sediment dynamics (current and wave patterns, nature of bedload and suspended load transport, rates of deposition and erosion) and
c. the character and distribution of marine and estuarine biologic communities

Studies should also include analyzing possible areas of seafloor instability (slumping, gravity slides) and seismic hazards (faults).

Continued monitoring of sediment and seaflow characteristics and biologic communities should take place once offshore operations are underway. It should evaluate short and long-range effects on marine organisms from exploration (geophysical surveying, exploratory drilling), drilling (release of drilling muds into water) and release of hydrocarbons into the water from production and transport activities and spills or blowouts. Guidelines for such a study are contained in the report from a 1976 Bureau of Land Management conference.

6. Exportation of Coal--It appears highly possible that the Columbia River estuary region may become a site for the export of coal from the U.S. to overseas markets (most likely Japan). Since such activity has never been experienced on the West Coast, it is necessary to determine, as soon as possible, the potential impact that such an activity would have on the Columbia River estuary and the adjacent N.E. Pacific Ocean. Such an effort would begin by reviewing the known impacts at East Coast coal exporting ports.

With such information at hand, the possible problems with siting such a facility on the Columbia could be reviewed. Such questions as the following could then be answered:

a. Is adequate area available for such an operation?
b. Are any toxic substances released and what effects do they have on the ecosystem?
c. What special constraints and control steps are necessary?

7. Dredge Spoils Disposition--Larger ocean-going vessels tend to be more energy efficient. As the tendency to large vessels continues, the possibility of additional dredging to maintain a deeper channel is possible.

Such dredging will increase the volume of dredge spoils that must be handled. Since on-land storage of spoils is already limited by the available space, the available options for dredge spoil disposal (consistent with the protection of the functioning estuarine ecosystem) must be looked at anew. The obvious alternative of open ocean disposal will tend to be countered by the higher energy costs. The recent eruption of Mount St. Helens has increased this problem.

8. Use of Resuspension Dredging--This mode of dredging is highly energy efficient. Increased pressures to use such dredging will be felt in the future. It is already being used to a limited extent in certain areas.

The extensive use of such a program in the Columbia River and estuary could have a major impact on the biological resources of the system. Careful research studies are needed to evaluate the impact of the large-scale use of such a technique in a major river like the Columbia.

9. Energy Impacts of Human Population Growth--Information should be collected to determine the impacts upon the estuarine and marine environments of the Pacific Northwest from increased population growth associated with energy development. Studies should address the impacts associated with community service demands including energy, water, in-

dustrial and municipal waste disposal, automobile and vessel traffic and air pollution. These studies should be correlated with those completed for similar activities where adverse impacts are already known.

10. Energy Impacts of Liquid Natural Gas Transportation and Storage--Studies should be conducted to determine the effects of the construction of liquid natural gas (LNG) storage facilities and the transportation and storage of LNG upon the productivity of estuarine areas in the Pacific Northwest.

These studies should address the most probable location of effects of any discharges from the storage facilities and impacts associated with the construction operation and maintenance of the facilities.

11. Reduced Stream Flows in the Columbia River--Future water uses will no doubt have impacts on the Columbia River estuary. Research should be conducted to determine what changes might be expected from growing and increasing numbers of cities, farms, industries and power generating facilities. The impact from such growth on the estuary would likely be a significant reduction in total fresh water discharge, as well as a reduction of discharge during seasonal fluctuations in precipitation.

Such a reduction could result in adverse physical and biological changes in both the river and estuary. Therefore, minimum flow levels should be established for the river that reflect the amount of fresh water needed to maintain the river and estuary in what is considered to be a "healthy" condition.

Presently the Columbia River is not expected to become important in the refining of petroleum products or in the shipment of petroleum to inland refineries. However, if such activities should occur in the Columbia, additional research efforts will be required.

IV Special Research Need

12. Coliform Bacteria Concentrations--State water quality standards set low limits for total bacteria, as well as fecal coliform bacteria concentrations in estuarine waters. The primary purpose is to protect the unsuspecting public consumer of poorly cooked shellfish. The coliform bacteria monitoring system does not effectively identify individual, warm-blooded animal fecal sources. Thus, animal sources other than man may cause violations of bacterial standards.

Subsequent to implementation of the 1972 Marine Mammal Protection Act, Oregon is experiencing a major increase of seals in the estuaries. Herds of several hundred are common. There is some belief that these herds may be causing localized bacterial standards violations.

The crux of the regulatory problem is that human waste sources are being subjected to more rigid treatment and disinfection under the belief that these are the only significant sources of bacterial contamination. While such treatment is effective on those wastes entering the estuaries, it is very costly and still may fall far short of assuring bacterial standards compliance.

Consequently, it has become apparent to state water pollution control agencies that the marine mammal contribution of coliform bacteria in estuarine congregating areas should also be assessed.

Likewise, there is indication that major resting/feeding areas for large flocks of migratory waterfowl and shorebirds should be evaluated for bacterial coliform contamination. The results of such research will be used in determining whether special consideration must be given to the presence of seals and birds in bacterial standards for water pollution control purposes.

V Integration of Proposed Research Program with Existing Information

The panel is aware of the need to develop research programs in the most cost-effective manner possible. For example, the panel made several references to the need to integrate the data collection into the conceptual framework developed in the existing Ecological Characterization of the Pacific Northwest Coastal Region (developed by the U.S. Fish and Wildlife Service).

By the continued use and strengthening of such a systems approach, the data collected will become a part of an integrated conceptual model, and will have much broader application than if it were collected only to resolve a single isolated problem.

This area is particularly fortunate since such a conceptual model is available. Other regions are currently considering the development of similar frameworks. With the experience gained in applying this conceptual

model in this region over the next two years, it is hoped that it will be logical to recommend the development of similar models for other regions. The panel strongly feels that it is essential to develop research efforts that can be well integrated into such existing models.

VI Offshore Resource Development

In December, 1976, the Bureau of Land Management (BLM) held a major conference in Portland, Oregon, to identify the research needed to support future offshore resource development. Over 100 scientists devoted three days to considering such issues.

The report of this conference, Recommendations for Baseline Research in Washington and Oregon Relative to Offshore Resource Development, was issued by BLM in February, 1977. The recommendations developed have not been implemented, at least partially because of a current lack of interest by oil companies in drilling in this region.

In general, the panel supports these recommendations and recommends they be implemented as soon as possible.

More scientifically, the panel endorses the following recommendations for the five-year plan. Several of these recommendations are already stated above, but they are restated to emphasize their importance accorded by this large conference. The topics omitted are largely specific to offshore development of oil and natural gas resources.

Bureau of Land Management Conference Recommendations

No. 2. Baseline studies should be coordinated with ongoing programs sponsored by the Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), Department of Energy (DOE) and other agencies in order to avoid duplication of effort. This is especially important in Puget Sound where extensive research programs are currently underway. Results of these programs should assist in the identification of critical habitats that should be considered in the BLM environmental studies program. In addition, the Outer Continental Shelf (OCS) baseline studies should be coordinated with similar studies on the Northern California OCS.

No. 3. The literature survey being conducted by the Oceanographic Institute of Washington should be kept current and made available to serve as a point of departure for any data collection effort that may result from these conference/workshop recommendations.

No. 8. A regional study should be undertaken to establish ambient levels of hydrocarbons and trace elements within the sediments on the shelf, beaches and estuaries. Sediment samples archived at Oregon State University and the University of Washington should be used for this purpose, providing that they have not been contaminated during the collection process. Additional sample collection should be initiated to fill any data gaps that may be identified.

No. 9. Currently available data on clay and mineral content of bottom muds should be compiled and supplemented with data obtained from X-ray diffraction analysis of existing mud samples to determine the gaps in available data. Additional sample collection should fill any data gaps that may be identified.

No. 11. A study of composition, concentration and movement (vertical and horizontal) of suspended sediments should be done. These data will complement the data developed by studies recommended in No. 10 of the BLM conference by identifying materials causing turbidity. Laboratory analysis of selected water column samples collected with Niskin bottles should be the primary analytical technique.

No. 12. Textural data for unconsolidated surface sediments on the Washington-Oregon OCS should be compiled on a regional basis. A large body of textural data is available from previous work at Oregon State University and at the University of Washington. Gaps in existing data should be identified and additional data collection programs should be initiated as required.

No. 13. A sampling program should be initiated to fill gaps in sediment texture and clay mineralogy bases identified under BLM recommendations 8, 9 and 12. Samples for textural and clay mineralogy should be collected by grab sampler and shallow corer. Box cores should be used for samples taken for chemical analysis.

No. 14. Seabed drifter studies should be undertaken to determine long-term, near-bottom movements of sediments and any negatively bouyant oil that may settle to the bottom. In addition, bottom photographs obtained as part of any biological studies should be analyzed for sediment bed forms.

No. 21. The shelf circulation of Southern Oregon should be studied. The study should consist of direct current measurements at several locations along the 100 meter isobath: for example, off Brookings, Cape Blanco, Reedsport, Florence and Cascade Head. Wind and sea-level measurements should also be made at several exposed locations along the coast.

The current meter moorings off Florence and Cape Blanco should be maintained for a full year; the others should be maintained at least six weeks in each of three seasons --winter, spring and summer. Suitable arrays would consist of three or more Aanderea current meters with the main subsurface flotation at about 20m and additional current meters (designed to reduce contamination from surface waves) above 20m to measure the near-surface flow. The near-surface flotation would be streamlined to reduce drag. Near-bottom currents should be measured to estimate sediment transport.

No. 22. The shelf circulation over Heceta Bank should be studied. This study should consist of direct current measurements over and near the bank. The strong coastal current observed farther north is certainly modified significantly in this region, where the shelf width changes by a factor of two in 16km. A suitable array might consist of six moorings--four in a line across the bank at about 44° 05' N between the shore and the 500m isobath, and two on the northern flank of the bank. Drogue studies would provide additional information on recirculation in this region.

Since the bank is asymmetrical, it probably affects northward currents very differently from southward currents. Observations of at least six-week durations should be made in each of three seasons--winter, spring and summer, because the mean flow regions, as well as the biological regions, are different in each season. Sea level and wind should both be monitored during these periods, so that results can be generalized in order to be applicable to other years.

No. 23. Upstream penetration of marine source water that might bear contaminants should be determined through salinity measurements. These measurements should be taken upstream to the point where negligible sea salt is encountered. The study should consider variations in salinity from such factors as tidal influences, seasonal changes and storm and river runoff.

No. 24. A study should be conducted on vertical mixing in estuaries. Salinity distribution in the water column, along with concurrent temperature measurements, should allow computation of water density and rigorous definition of mixed layers. This includes current and river runoff measurements to permit estimates of vertical movements that could transport contaminants from bottom waters into the photosynthetic zone. Currents should be measured concurrently with river flow observations at two cross sections of the estuaries.

No. 27. Seasonal variations of suspended matter associated with biota should be established.

No. 32. Biomass distribution studies, production rate, nutrient chemistry and advection studies of phytoplankton and zooplankton should be conducted in the Southern Oregon area during the upwelling season.

No. 33. An inventory should be conducted for seasonal abundance of seabirds in the area. Endangered species that may be affected by drilling should be identified. Population, nesting areas, rookeries and similar information should be defined. A synthesis of existing knowledge should be made and used to define inventory requirements.

No. 34. An inventory should be conducted for seasonal abundance of mammals in the area. Endangered species in areas that may be impacted by drilling should be identified. Stocks, migration routes, reproductive locations and similar data should be defined. A synthesis of existing knowledge should be made to define inventory requirements.

No. 36. Baseline studies should be conducted in the intertidal and shallow subtidal habitats to quantitatively describe community structure and its natural variation over space and time. Community processes such as predation, grazing and competition affecting the quantitative structure should be described, so as to predict the consequences of changes in populations of key species involved. Seasonal and annual variations should be assessed. Selection of sites for baseline studies should be made after leasing tracts have been identified.

Siting and identification of important or the most sensitive areas for baseline inventories should be based on the following criteria, among others:

a. First priority should be given to undisturbed areas typical of their habitat type, both as the natural condition reference and as a control for less natural areas.
b. Areas that have a high potential for

being disturbed should have second priority.

c. Areas where certain species such as sea birds migrate or congregate should be of concern.

d. Some emphasis should be directed towards the study of areas characterized by previous or existing hydrocarbon contamination created by exploratory drilling or transportation activities.

Within the inventory studies, species that should receive special attention are:

e. Indicator species in either disturbed or undisturbed conditions and of a sensitive or nonsensitive nature.

f. Species occurring in great quantities.

g. Commercially or recreationally important species.

h. Rare, endangered or declining species.

i. Species of scientific or educational importance.

j. Species critical to community processes, whose removal or disturbance would cause major changes in community structure.

No. 39. Bottom photographs obtained as part of any biological studies should be analyzed for sediment bed forms. Biological programs should be coordinated to insure that, consistent with biological requirements, photographs are oriented so that direction can be determined.

No. 41. A baseline study should be conducted to determine the first order effects of pollution of fish populations. The study should focus on the time and space regimen defined by the egg and larval stages. Consideration should be given to how the eggs and larvae, through the juvenile stage, diffuse away from the release point until they develop in later stages and become motile.

The probability of the egg-larval patch intersecting with pollutants that may be released from outer continental shelf exploration and development should be addressed. This suggests that the study should be conducted in the LaGrangian mode. The study should be designed to answer the question: What is the probability of the intersection of a pollutant patch with an egg-larval patch, and what effect would this have on survival of the organism?

No. 42. Circulation of the nearshore zone should be studied. The nearshore zone for the purposes of this study lies between the surf zone and the 50m isobath. Alongshore coherence lengths are probably not as great here as in the midshelf regime and are probably shorter along irregular coastlines than along regular coastlines. A suitable study should encompass both types of coastline.

The smooth type of coastline could be studied in the region between Heceta Head and Cape Arago of moorings about ten to 25 km apart, which would be maintained in this area along the 20 or 30m isobath.

The irregular type of coastline should be studied in the region between Cape Blanco and Cape Ferrelo by maintaining an array along the 20 or 30m isobath. Arrays in the two regions should be maintained for about two months and simultaneously if possible. The current meters and the moorings should be designed to minimize contamination by high frequency waves. This program should be coordinated with the Puget Sound study in recommendation 64 (priority III) if the latter study is funded.

No. 43. Estimates should be made of slushing rates in estuaries. This will require a rigorous investigation of advection and diffusion within coastal estuaries. This approach requires an extensive field program incorporating current and salinity measurements in conjunction with wind, tide and river runoff. A far less sophisticated estimate of flushing rates would result from neglecting diffusive transfer and using only current measurements through the water column at the estuary mouth. Flushing associated with tidal motions can be estimated from tidal prism and river input data. Use of LaGrangian drifters, such as drift cards or seabed drifters, is also a fruitful approach, especially in specific smaller areas.

No. 45. Concentrations of trace metals in key organisms such as filter feeders (bivalves), deposit feeders (polychaetes), scavengers (crustaceans) and predators (flatfish) should be established. Collections of sample organisms should be coordinated with biological oceanography sampling programs.

No. 47. Baseline concentrations of aromatics, such as napthalene, phenanthrenes and selected aliphatic components should be determined for biotic tissues from samples collected under biological oceanography programs. Samples should be collected seasonally to establish seasonal variations.

No. 48. An intensive three-year sampling effort should be conducted in the Washington-Oregon OCS area to assess the year-to-year fluctuations on pelagic fish eggs and larvae. Sampling should be performed at monthly intervals at a grid of stations consisting of

about ten transects at 40-nautical-mile intervals. Each transect should have five stations extending over the shelf from the coastline. This grid of 50 stations should cover the area between the Straits of Juan de Fuca and the Southern Oregon border.

Sampling should be designed specifically for planktonic and neustonic eggs and larvae. The sampler for ichthyoplankton should obtain a quantitative sample and also filter a sufficient volume of water to survey the water column. A 60 or 70cm paired bongo sampler with 0.5mm mesh nets should be used for this purpose. Tows should be made obliquely through the water column from bottom to surface at vessel speed of two to three knots. The sampler for ichthyoneuston should sample the upper 15 to 20cm of the water column using the Bartlett-Haedrick type neuston net having a 100 x 35cm mouth opening and a 0.5 mm mesh net. Comparative day and night tows of 10 to 15 minutes duration should be made at a vessel speed of three to four knots. (This work may have already been funded.)

No. 50. Demersal fish stocks should be surveyed off the Washington-Oregon coast during late winter and early spring to map the spawning grounds of commercial target species and to map the winter distribution of assemblages of bottom-dwelling fish on the continental shelf and slope. (This work may have already been funded.)

No. 52. The temporal and spatial patterns of major productivity should be determined with respect to zooplankton and crustaceans, and, at a lesser priority, pinnipeds.

No. 53. Community processes affecting quantitative structure, such as predation, grazing and competition, should be defined and analyzed to enable prediction of the consequences of changes in the key species involved.

No. 61. Estimates should be made of the probable effects of winds on contaminants distributed on an estuary surface. Local topography and wind direction data may be used to estimate the effective fetch of the wind.

No. 62. Estimates should be made of lateral and longitudinal flow in broad, shallow estuaries. Drift cards, drift bottles, dye releases or current drogues are useful for this purpose.

No. 63. Seasonal and year-to-year variability of parameters should be assessed. Runoff, salinity, temperature, wind, pressure, storm frequency and intensity and storm tide and wave data over a period of time should be collected and analyzed for this purpose. As a minimum, observations are needed over a two-year period. Extreme values, as well as mean values, should be determined.

Panel Members

Point Arena, Calif., to Port Angeles, Wash.

Robert Holton, Chairman

Samuel Boggs

Glen Carter

G. K. Greiner

Irv Jones

Dick Mathews

Art Oakley

Jay Watson

SECTION IX

Port Angeles, Washington to the Canadian Border

I Introduction

Eight problems identified by this panel included most of the pollutant categories addressed in the previous Federal Plan (1979-1983) with the exception of artificial radionuclides and cooling water use. The problems are:

1. Petroleum and petroleum products
2. Metals and inorganic chemicals
3. Synthetic organic chemicals
4. Habitat modification and sediment deposition
5. Nutrients and biostimulants
6. Microorganisms and pathogens
7. Chlorination products
8. Other pollutants

The problems tended to focus on the pollutant effects on:

a. living marine resources
b. human recreational and aesthetic values and
c. human health

The panel found that the problems tended to be related to causes from human activities of the following major types:

1. Coastal land-use practices
2. Marine waste disposal
3. Marine transportation
4. Other sources

The problems discussed were largely technical in nature. However, concerns were also expressed by panel members for problems related to jurisdictional, institutional, planning and management matters.

II Problems

A. Coastal Land-Use Practices

1. Impacts of Development (existing and planned) and Major Construction Activities in the Coastal Zone

The Pacific Northwest, in particular Puget Sound and the Strait of Juan de Fuca, is the center of major devel-

opments either presently in progress or planned. There is a tendency for these projects to be studied independently. However, in view of the magnitude and/or frequency of projects, regional overall environmental impact assessments appears to be needed. The cumulative impacts of development in the coastal zone must be addressed.

2. Erosion and Deposition Processes, Nonpoint Sources and Pathways, and Cumulative Impacts Associated with Forestry, Agriculture and Storm Sewers--Certain forestry and agriculture methods lead to soil erosion. Often, eroded soil finds its way into marine waterways. Applied chemicals (e.g., pesticides), likewise, find their way into the marine environment. Urban areas also impact waterways through storm sewers, which do not pass through treatment plants but simply wash city street debris, oil and grease into marine waters. Many of these upstream contributors to marine pollution could be systematically reduced. A number of small effects can accumulate into a significant impact. A second cumulative effect is associated with gradual proliferation of structures or removal of wetlands.

3. Proposed Graving Dock Facility Near Bellingham--Washington State has no experience with the construction and operation of such a facility, and some attention should be given to its potential pollution impacts.

4. Siting for Major Developments--The permit process for siting such developments in Washington State starts with site selection by industry. One system is used for major energy facilities, such as thermal power plants and oil terminals, and another system is used for other developments. Siting criteria need further development.

5. Development of Cherry Point as Bulk Cargo Complex for the State--Few locations on the West Coast offer the combination of natural features, large industrially zoned land areas and intermodal transportation connections. Cherry Point is frequently under consideration for large new industries; such development could make this area the major bulk cargo complex for the state. Industries and commodities under consideration include oil, gas, aluminum, graphite, coal and others. Some attention should be given to the potential pollution impacts of such facilities and activities on fisheries and other uses and resources.

6. Impacts of Military Facilities and Operations--The U.S. Navy has facilities at numerous locations in this area, yet little is known about the pollution impacts associated with their construction and operation. These impacts are monitored by the Navy but often remain confidential, making impact assessment difficult or impossible.

7. Increased Pressure From Population Growth in Coastal Zone--While this is occurring in many locations, the potential pollution problems in Southern Hood Canal could soon become particularly significant due to poor water circulation in the area. It should be monitored. Of concern are septic tanks and other small sewage systems.

B. Marine Waste Disposal

8. Sources, Fates and Effects of Pollutants Currently Being Found in the Central Puget Sound Basin--Major urban Washington areas (Seattle, Tacoma, Bellingham and Bremerton) and numerous smaller towns have municipal ocean outfalls. In addition, major and minor industries also use the Greater Puget Sound to dispose of wastes. The dispersion characteristics of Puget Sound result in broadcasting the manifold products from man and machine to all parts of the Sound, making source identification difficult. In order to clarify sources, fates and effects of pollutants, an organized, designed approach is necessary.

9. Municipal Waste Discharge, Including Raw Sewage, in Urban Areas--The handling of municipal waste is a well-understood aspect of civil engineering. The principal difficulties are not conceptual but are economic, and processing is expensive. However, the safe disposal of effluents into oceanic receiving waters requires both thorough engineering and good oceanographic information. Compromise solutions may be possible in some areas, but there is a need to upgrade, redesign or resite existing outfalls and to carry out proper environmental studies prior to the construction of new outfalls. Removal of toxicants and pathogens also needs more attention.

10. Industrial Waste Discharges--These activities, although regulated, should continue to be monitored. Facilities discussed include pulp and paper mills, oil terminals and refineries, aluminum plants, boat manufacturing plants and shipyards, cement plants, fish processing plants, chemical plants and aquaculture facilities.

11. Dredge Disposal Sites and Impacts--Many existing and former sites (some marine, some on land) are not generally known, yet may be contributing to pollution problems. Some spoils may be contaminated. Not much is known about movement and impacts of these materials. Creation of wetlands with dredged material is a disposal technique which has not received much

attention in this area.

12. Relative Loading of Heavy Metals from Geochemical vs. Industrial Sources--This lack of perspective may lead to unnecessarily burdensome regulation. More should be understood about adsorption and leaching of sediments in areas such as Bellingham Bay, Commencement Bay, Liberty Bay, Sinclair Inlet and Hood Canal near Bangor. A priority system could be developed to focus on metals of most significant concern.

13. Abandoned Dump Sites in Commencement Bay and on the Tulalip Reservation--These two sites, one underwater and the other on land, are reportedly of substantial size and probably contain contaminants. Surveys should be conducted to determine the extent and intensity of toxicant leaching from these sites.

14. Pathogenic Pathways and Consequences--There has been some research done on viruses and bacteria in marine waters, but little has been done on the West Coast. Pollution problems associated with septic tank systems from housing subdivisions should receive more attention. Information is needed on the life spans and durability of key pathogens.

C. Marine Transportation

15. Impacts of Alternate Proposed Oil Transportation Systems (Low Point, Port Angeles, Cherry Point, Tacoma): Tankers, Storage Sites, Pipelines, etc.--The shipment of Alaskan crude oil from Valdez to a port in Washington (Low Point or Port Angeles) and of foreign oil to Cherry Point continues to be the single most conspicuous environmental issue in the State of Washington. Panel members were mainly concerned with the potential for oil spills in the region and the resulting impacts on the shoreline. Such events would affect marine mammals and birds, as well as commercial and recreational fish and shellfish.

Additional baseline inventories of both sides of the Strait of Juan de Fuca are necessary to identify sensitive areas. Further oceanographic research is needed to predict fates of oil and aid in its recovery. The associated infrastructure poses only variations on this theme.

16. Hazardous Materials Transportation, Spillage and Impacts--Any highly industrialized area may have an input of hazardous materials for its operation, and in turn may produce hazardous materials for export. Thus, there is a steady traffic of these materials in and out of Greater Puget Sound. Until now, these materials have been treated in a somewhat cavalier manner, as only a few people knew what they were or even knew of their presence. In consequence, contingency plans for emergencies or accidental releases have been lacking. The entire issue should be reviewed in depth.

D. Other Sources

17. Log Boom Storage at Port Angeles, Sequim, Shelton, Tacoma, Olympia, Everett, Anacortes and Bellingham--The Pacific Northwest has long been known for its evergreen forests and the industries they support. The logging industry often stores logs for varying periods of time before processing. Historically, log booming has been a common method. In general, this method is being replaced by land storage for economic reasons. However, some areas still have extensive booming grounds. A problem that has been neglected is to examine what processes occur within and underneath major booms, such as bark loss due to wave action, grounding and leaching.

III Information Needs

The 17 problems identified in the previous section may be expected to generate needs for certain information. These needs were identified and grouped into 13 sets. These information needs (not the problems) were then ranked according to criteria provided. Finally, rationale was developed addressing why each information need was ranked high, medium or low in priority.

A. High Priority

1. Oceanographic Information--Hydrographic and oceanographic information is needed on transport, erosion, deposition/fate of sediments, waste discharges and geochemical sources of pollutants.

Rationale

Resource use and management decisions are being made based on knowledge of processes that are only partially understood. Investigations for individual projects and activities are helpful, but do not replace long-term sustained efforts. Basic understanding of how the system works is fundamental in assessing and predicting pollution effects.

2. Toxic Substances--Information about

sources, fates and effects of toxic substances, including priority pollutants is needed.

Rationale

Pollutants have been introduced into the marine environment for many years with unknown consequences. Recent studies have shown that many contaminants do exist in measurable quantities throughout most of Greater Puget Sound. Knowledge should be obtained on the extent of the existing sources, how they are being distributed (by physical, biological, chemical and geological processes), and their effects on the system. Within the area, there are priority locations requiring earlier study than others, but ultimately these materials will reach all parts of the system. Therefore, a basic understanding must be developed for the whole area with time.

3. Food Web--Dynamics of food web transport and biomagnification of pollutants and pathogens needs to be understood.

Rationale

There is evidence of abnormalities (e.g., fish disease) in certain species (e.g., English sole, shrimp, crab) in Central Puget Sound. One of the most significant factors in the viability of the ecosystem and its importance to man is the movement of contaminants through the food web, with the potential for bioconcentration and possible direct deleterious effects on man through foodstuffs. The amount of information available on this topic for this area is minimal. Existing programs are inadequate to address the program in an effective manner. There is a need for identification and taxonomy of plankton and fishes, which are essential to all biological studies.

4. Upstream Pollutants--Characterization of upstream point and nonpoint sources of pollutants should be studied.

Rationale

This area has a relatively large amount of forestry and agricultural activities that use chemicals known to, or suspected of having long-term consequences in the marine ecosystem. Although this need is coupled with needs to know more about other discharges, it is singled out because it tends to receive lower research attention due to the greater visibility of major point sources and storm water systems. However, this source will be present for a long time and may become the major source of contaminants into the marine system. Consideration should be given to the net benefits and costs, in terms of marine pollution, of reducing sediment movements and thus, dredging requirements.

5. Shoreline Changes--Information about cumulative impacts of shoreline modification needs to be obtained.

Rationale

The above-mentioned high priority items tend to focus on selected pollutants. Research tends to examine a single item or action at a time and make judgements about its individual impacts on the ecosystem. However, information on the interactions of activities is needed.

"Combined effects" studies of impacts should not be limited to pollutants; they should also consider shoreline and upland developments that have relatively small incremental effects, but may in total have major impacts, such as fills, bulkheads, loss of wetlands and so forth. Areas where such accumulative processes are occurring should be identified, and development limits should be considered.

B. Medium Priority

Although medium priority items were considered important by the panel, it was agreed that such items should not preclude time spent on more high priority research concerns.

6. Research, Development, Monitoring--Strategy needs to be developed for structuring research, development and monitoring efforts, in terms of the best scientific investment.

Rationale

Policies concerning the above items should be developed with defined strategies, plans, goals and objectives. An effort should be made to identify those areas in which current scientific and technical knowledge could yield the best return on research dollar invested.

The present efforts, including this workshop series, have led to some systemization of the process. However, further efforts and techniques or tools (e.g., risk analysis, decision analysis and systems analysis) could be applied. Their intent would be to define the most appropriate and efficient ways to approach the problems of gathering information necessary for understanding how activities are affecting or can affect the marine system.

Pure research should not be subject to the same strategy developments.

7. Biological Vulnerability--A characterization of vulnerable marine communities should be made.

Rationale

There are insufficient funds and time to study all aspects of the marine ecosystem in equal depth and detail. The identification and characterization of vulnerable marine communities would provide a useful tool for management and monitoring strategies. This item fell with three others in the mid-range of the rankings and seemed to be of greatest concern for specific sites (e.g., Protection Island) that could be impacted significantly by major activities now being planned.

8. Oil Port Monitoring--Efforts should be made to develop and implement an oil port monitoring plan which includes a team to act promptly in assessing biological impacts of polluting events.

Rationale

If an oil terminal is located in the Port Angeles/Low Point area as proposed, its pollutant impacts should be well monitored. So should the capability to respond with timely damage assessments be well developed. It could be difficult to mount a comprehensive monitoring program between the time of permit approval and the beginning of construction and ultimate operation. Information needed to implement a monitoring plan will be useful (because of the similarities of a number of habitats in the region) even if the oil port is not approved.

9. Existing Data--A critical evaluation of existing data (by area) should be done.

Rationale

Periodically, efforts must be made to synthesize existing data and information from diverse projects and programs in order to ensure effective future efforts. The material generated in the past decade, with the advent of the environmental impact statement process and other environmental laws, regulations and processes, has been voluminous. A critical evaluation of existing data within the area would be most useful at this time in identifying information needs from a broad perspective instead of from the more usual single discipline approach.

C. Low Priority

10. Hazardous Materials Data--Baseline data on marine transportation of hazardous materials is needed.

Rationale

Acute spills of hazardous materials may be expected to increase as the population of Greater Puget Sound continues to grow and industrial and port developments also increase and diversify. High risk routes and areas should be well identified and controlled to minimize potential impacts to marine resources and man. Public concern about these spills is intense and is responsible for much public support of marine research.

11. Military Facilities--Data on military facilities needs to be made available.

Rationale

There are major Navy facilities in Washington State about which little is known in terms of ocean pollution. These facilities are located at Bangor, Manchester, Bremerton, Keyport, Indian Island and Whidbey Island. Construction and operation of these facilities probably contribute to the pollution problems of the area. More should be known about the significance of this contribution.

12. Measuring and Controlling--Better Measurement systems and quality control practices should be developed.

Rationale

Economic considerations play a large part in decision-making processes concerning activities and facilities which introduce pollutants into the marine environment. Resource economics should also play a large and early role in such decisions, especially when major trade-offs are involved. Cost/benefit analyses should be used increasingly in marine pollution research, development and monitoring efforts.

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SECTION X

Hawaii and the Pacific Islands

I Introduction

The Hawaiian and Pacific Islands form a special environmental region because they are all oceanic islands. The Pacific Islands include Guam, American Somoa, Trust Territory of the Pacific Islands and the Commonwealth or Northern Mariana. These insular environments have unique environmental conditions and characteristics. Some of these characteristics are:

1. Each island is completely surrounded by the ocean with no continental shelf.
2. The waters surrounding the islands are relatively poor in nutrients.
3. The water surrounding the islands presents different circulation problems than the water off mainland coastal regions.
4. There is limited land in the islands.
5. There is a finite supply of fresh water on the islands.
6. Most of the polluting industries are food related. This creates very little toxic waste problems.
7. There is no fossil fuel resource for mining, but there is developable ocean thermal energy conversion and potential for deep seabed mining.
8. There are no land-based nuclear plants on any of the islands. The potential pollution problem would be the servicing of nuclear submarines in Pearl Harbor.
9. Coral and reef communities are the all-important organisms and are used as pollution indicators.

Because the marine environment around the islands is unique, the problems associated with the environment are different from those encountered on the mainland. This also means that the research development and monitoring needs must be developed to meet the conditions in the islands. Likewise, pollution abatement regulations and technologies must be made appropriate to meet the environmental conditions on the islands.

II Problems

1. Land Pollution from Nonpoint Sources--Land pollution from nonpoint sources is a serious problem to marine waters in the State of Hawaii and other Pacific Islands. Marine waters in estuaries and embayments are the most seriously affected. Islands in the Pacific, except for coral atolls, are affected by this problem. Soil losses from construction sites, agricultural fields and natural terrain in conservation areas are major contributors to the degradation of corals and other marine seabeds surrounding the islands.

Before solutions can be proposed, the magnitude of the problem has to be known. Not only must the amount of pollutant runoff to receiving waters from nonurban lands be examined, but comparisons with pollutants from urban runoff also require study. Sediment, pesticides and toxic metals are the dominant pollutants to be concerned with.

The quantity and quality characteristics of urban runoff have to be determined because there are no statewide data. Sampling of stormwaters from different types of urban developments (e.g., residential, industrial, etc.) should be intensified. Source control and street cleaning frequency are possible solutions. On the other hand, if soil loss is the major contributor and can be identified by sediment sampling in streams, there are no easy solutions.

Some of the solutions that have been proposed include land-use zoning, changes in subdivision rules and regulations and revision of the storm drainage standards to include nonstructural facilities, e.g., detention ponds. The retention of storm water on land, so that storm flow after development does not greatly exceed storm flow before development, is also being considered.

2. Water Quality Standards/Criteria--The Environmental Protection Agency (EPA) proposed marine water quality criteria may not be applicable for the waters around Hawaii and other Pacific Islands. The species of marine organisms used in the development of standards in the continental United States are not usually present in semitropical oceanic waters. Implementation of the criteria may require the introduction of undesirable biota into the Pacific Islands area. Baseline values of some water quality parameters may exceed the criteria in some locations. In defining a balanced indigenous population (BIP) within the zone of initial dilution (ZID), control sites must be selected far enough from an effluent discharge in order to compare temporal changes which may occur between communities within and outside the ZID. Natural fluctuations in indigenous populations can occur, and in some cases, with substantial magnitude. These natural fluctuations must be characterized so that differences between natural and induced changes can be distinguished.

Selection of appropriate organisms for toxicity bioassays in Hawaii also presents problems: There is no agreement at present on the marine organisms to be used, and there are questions about selection of animals which are readily available and live well in captivity in Hawaii and other Pacific Islands.

3. The Enhancement of Living Marine Resources by Municipal Waste Water Effluent--How feasible, economically and technologically, is the use of sewage effluent for the cultivation of fish? In various areas of the world, fishpond aquaculture utilizes efficiently raw sewage to enhance primary productivity upon which certain commercially valuable fish species can be grown.

The studies done on the effects of the construction of sewer outfalls and their subsequent discharge on the marine ecosystem have shown, that with proper design and consideration of oceanic mixing, the abundance of valuable fish species can be increased. Large aggregations of the blue lined snapper (taape) have been seen off the Mokapu Point outfall, Hawaii. This species was introduced in the mid 1950s as a potentially harvestable fish. In the future, should marine sewer outfalls be designed with potential harvesting in mind? If so, how should this exploitation be regulated?

In another study done off Hawaii Kai, Oahu, preliminary results show that nutrient enrichment from sewage discharge (3 mgd) may be coincident with observed increases in coral growth rates. In many cases, coral atoll environments may be ideal settings for enhancement research. Discharge of sewage in certain areas, especially lagoons, may cause an increase in locally utilizable resources. Research should be conducted to evaluate edible species raised under sewage-enhanced conditions for safe human consumption.

4. Human Virus and Related Microbial Pollution of the Marine Ecosystem: Fate, Distribution and Disease Potential--Accumulated evidence indicates that more than 100 human enteric viruses are known to be secreted in human feces. These viruses are present in raw sewage and are known to even

survive various sewage treatments. When discharged into the ocean,and because of their relative stability in the water environment, these agents can be widely disseminated. They therefore represent an important environmental health problem, particularly in marine waters (e.g., Hawaii) utilized for recreational activity, mariculture, aquaculture and shellfish industries. These agents may be transmitted to humans through direct person-to-person contact, via fecally contaminated water, or through the consumption of inadequately prepared or raw marine animals (e.g., oysters raised in sewage-contaminated ocean water).

An appreciable health risk from waterborne transmission of enteric viruses through sewage-contaminated ocean waters is not apparent for all human viruses. Documented waterborne outbreaks of viral diseases have largely been limited to the agent of infectious hepatitis (hepetitis A) and nonbacterial gastroenteritis (rotavirus, parvovirus) mainly because of the "explosive" nature of these outbreaks and their characteristic symptomatology. The consumption of shellfish grown in sewage-contaminated waters and the occurrence of hospitalized cases of hepatitis A is well established. However, the predominantly asymptomatic nature of infections by other waterborne human viruses has made it difficult to document their transmission; yet their occurrence in marine waters and in shellfishes is well documented and their potential for disease always exists. While there is rare documented outbreak of disease directly associated with exposure to sewage-contaminated ocean waters, the possible health hazards (for example, bathers and surfers in recreational beaches) from waterborne viral diseases must be considered. (In the 1960s, an outbreak of polio did occur in the Marshall Islands, caused primarily by fecal oral transmission.)

Although the etiological agents were not identified, recent epidemiological studies showed a correlation between swimming in sewage-polluted waters and disease incidence. Thus, the direct isolation and identification of these enteric viruses in sewage-contaminated ocean waters is needed. Furthermore, epidemiological approaches should be developed to determine the extent of endemic waterborne viral transmissions.

An important corollary problem relates to the use of bacteriological standards to reflect a viral disease hazard. Accumulated data (including this panel's) indicates that bacterial indicators such as fecal coliforms are inadequate for assessing the presence of human viruses in sewage-contaminated ocean waters. Human enteric viruses were recovered from seawaters which were essentially negative for the coliform indicator bacteria.

Consequently, there is probably no relationship between low coliform counts and viral contamination of marine water. Furthermore, the instability of the coliform bacteria in the seawater, which resulted in lower ratios (<4) of fecal coliforms/fecal streptococci obtained, invalidates the interpretation of the ratio to represent the absence of human fecal contamination of marine water. Thus, the direct monitoring for human enteric viruses in contaminated ocean waters is needed and new indicators or systems of virus contamination need to be developed for routine ocean water quality monitoring.

5. Toxic Substances and Biomagnification--There is increasing concern about the role and fate of toxic substances in the environment. Ocean discharge criteria and Section 301h requirements of Public Law 95-217 make it mandatory that baseline monitoring of contaminants in estuaries and coastal environments and their biota be undertaken. The major question is whether tissue levels of toxic substances present are directly attributable to biomagnification in organisms in the food chain. There are models for such studies. In Hawaii, the study of the transport of mercury through a food chain (Luoma, 1974) might serve as a model to answer questions such as:

   a. What are the control mechanisms and how do they determine the rate at which potentially toxic substances behave in sediment-water environments?
   b. What physiochemical factors influence the availability of toxic forms?
   c. What is the biological significance? Does it show evidence of increasing concentrations at higher trophic levels? Confirming studies on biomagnification and selection of candidate bio-indicators suitable for regulatory monitoring purposes are needed.

6. Problems Associated with OTEC Development--Ocean thermal energy conversion is of high interest to Hawaii as an energy alternative to oil. The OTEC deep water pipe will draw a substantial volume of water from up to 3,000 ft. deep. The nonconservative properties of this water, (i.e., those chemical properties that are changed by biological action), will be substantially different from both the surface water used in the heating portion of the generation cycle, and from the receiving water into which the combined effluent is released.

Concentration profiles show water from 3,000 ft. will be 50 times richer in nitrogen and phosphorus than surface water. Bacteria content of deep water is low. The deep water will be low in oxygen and low in pH, indicating elevated inorganic carbon concentrations. This will stimulate primary production in normally relatively low productivity surface waters, if there is sufficient time for substantial photosynthesis to occur before the effluent sinks. Present analysis indicates environmental effects are low.

Mariculture systems taking advantage of temperature and nutrient effects is one possible benefit from OTEC plant discharges. Stimulation of primary productivity has already been mentioned. Very large scale OTEC developments with surface discharges could conceivably affect air and water temperatures over extensive areas.

7. Manganese Nodule Processing Development--The possible impacts on the ocean environment from mining and processing of manganese nodules will depend upon the technologies used to mine and process the nodules. Further, if the ocean is used for disposal of the tailings, then the manner and site of disposal activities are important.

Seafloor mining will disturb sediments and cause their redistribution. A plume of sediment will follow each dredge. This sediment may blanket adjacent unmined areas, burying benthic life forms. The finer particles will be dispersed into the nepheloid layer and could be carried over wide areas. The mining systems that best avoid taking up sediment would obviously minimize the environmental effects. Until industry reveals the technologies contemplated, these impacts will remain speculative.

The processing technologies to be used and the effects these have on the state of metals (toxic elements) remaining in the tailings are of prime concern. A process not designed to recover manganese will leave almost 97 percent of the original nodule to be disposed of, either on land or at sea. The tailings may also include considerable quantities of toxic metals. If these metals occur in an inert form, then they may be judged as nonhazardous. When they are chemically active, environmental and legal problems will emerge.

The environmental consequence of ocean dumping is more complex than the question of toxicity; however, ocean dumping of tailings will create plumes. Since most marine life is near the surface, injection of tailings several hundred feet below the surface may avoid some environmental impact. Additionally, deep ocean dumping of tailings at various depths may have different effects than dumping adjacent to land masses.

Because there has been no commercial exploitation to date, the potential effects of manganese nodule mining and processing remain speculative. There is a need, therefore, to study baseline characteristics of proposed land and nearshore disposal sites in Hawaii. Preliminary studies should be undertaken to stimulate effects of ocean dumping. Preparations should be made to mount studies as soon as mining operations are initiated and actual tailings become available for study.

Ocean Minerals Co. (OMCO) has revealed plans to build a test facility on Oahu capable of producing 50 dry weight metric tons of nodules per day. OMCO has guaranteed that the processing technology will produce tailings of a nature to make meaningful environmental tests.

8. Transport Model for Oceanic Islands--The problem of predicting the fate of discharges to insular coastal waters has not been satisfactorily solved. Definitions of the interaction of open ocean currents, nearshore tide-related currents, wind induced circulation and island morphology are necessary to evaluate the siting of various wastewater discharges and the possibility of maximizing any beneficial effects. The relationship of the pollutant concentration, biological response and contact time is central to identifying the potential effects of discharges. The description of the transport around an island will require mathematical simulation backed up by physical models, where appropriate, and by field current and mixing measurements.

Models that have been developed for estuaries, lakes or rivers are not appropriate for islands because of very different boundary conditions. The definition of the boundary conditions for island transport is probably the central problem associated with such a model.

III Information Needs

A. High Priority

1. Applicability of Marine Water Quality Criteria to Hawaii and Pacific Islands--The marine water quality criteria were developed principally for the continental United States with evaluation using biota

indigenous to the continental temperature zone. The Pacific Islands are typified by a short coastal margin, relatively deep and nutrient-deficient surrounding waters, with semitropical biota. Thus, the existing criteria and the organisms selected for bioassay purposes are not appropriate to the Pacific Basin. The region should be allowed to modify the criteria using baseline data from completed field studies in control and ocean discharge areas.

2. Selection of Indicator Organisms for the Fish, Mollusk and Crustacean Categories for the Purpose of Toxicity Bioassays--Proposed EPA permit requirements include those of the static bioassay of three types of organisms subject to exposure to sewage effluent: a fish, a mollusk and a crustacean. Selection of the appropriate organisms in Hawaii poses a number of problems.

The animals must be euryhaline, able to live in fresh water as well as in the ocean water; they must be relatively hardy, unaffected by shock and transport and long-lived in the laboratory; and they must be readily available both in laboratory culture and the field (a minimum of 100 animals per month for each of four outfalls). Selection of the appropriate organism and the subsequent experimental work for assays requires time and focused research effort.

3. Natural Versus Induced Changes of a Balanced Indigenous Population (Community) within the Zone of Initial Dilution--EPA regulations require that biomonitoring of advanced primary treatment discharge be conducted in a zone of initial dilution (ZID) defined by the length of the diffuser and the depth of discharge. Within this zone the representative species of flora and fauna must be defined and monitored. In order to determine whether observed changes are due to effluent discharge, preliminary studies of the ecosystem must be conducted prior to discharge and construction of the outfall to determine the amplitude and duration of natural periodic fluctuations in the marine community. These studies may or may not be long term. If control sites well removed from the discharge site, but containing essentially the same indigenous biological community structure, are monitored coincidentally with that in the ZID, changes in important indicator species can be compared. Changes in relative abundances, species composition and species diversity of the balanced indigenous community can be used as parameters for comparison.

Quantitative similarity indices can be used both spatially and temporarily over a 5 to 10 year period to denote community changes. Once a biological indigenous population (community) is chosen, research on species specific population dynamics should be conducted. Seasonal, annual or long-term fluctuations of important species can then be determined. Once the population dynamics of important species are known, changes in the biological community can be better understood and the relationship to natural or induced changes can be ascertained.

4. Microbiological and Viral Research Problems--The following represent major areas for further research in order to more fully evaluate the possible health risk from human enteric viruses which might be present in sewage-contaminated ocean waters:

a. Present methods for isolation of human viruses from the ocean environment are complex, relatively inefficient, expensive, laborious and time consuming. There is an urgent need for the development of relatively simple, inexpensive and highly efficient methodologies which may provide accurate and quantitative information on the fate of the viral pollutants and their public health hazard to the various responsible governmental agencies.
b. Reassessment should be made of the current bacteriological standards used to reflect a viral disease hazard or contamination with human wastes in marine waters. Since bacterial indicators, such as fecal coliforms, are inadequate for assessing the presence of human viruses in sewage-contaminated ocean waters, new bacterial indicators or systems to indicate human and animal fecal contamination of marine waters is needed.
c. There is a need to develop or adapt highly quantitative and sensitive methods, such as the enzyme-linked immunosorbent assay or ELISA test, for the rapid detection or monitoring of viruses or viral components in marine food source animals.
d. The distribution and fate of human enteric viruses in the natural marine environment, not only in the water column, but also in the marine sediments should be reevaluated. Preliminary studies have shown that sediment-associated viruses survive for relatively longer periods of time than in the water column. Since a major portion of the natural viral population is particulates or sediment-associated, current recovery and monitoring of viruses must include examination of particulates and sediments. Just monitoring the water column may

yield false information in regard to the presence of viruses in the ocean environment. In addition, an evaluation should be made of the effect of natural factors (physical, biological and chemical) on the survival of human enteric viruses in the ocean environment.

e. Alternative sewage waste treatment technologies need to be evaluated. For example, practical disinfection treatments (chemical and physical), conducted under field conditions, should be made to eliminate or reduce the amount and kinds of microbial pathogens (including the significant types of pathogenic human enteric viruses) before they reach the ocean environment.

f. While a widely quoted study has shown that only one infectious unit of vaccine poliovirus would be required for successful infection of premature infants, these studies conducted under restricted experimental conditions may not reflect the true risk in nature. Thus, a reassessment of the risk to human health caused by human viruses, as a consequence of sewage disposal into the marine environment, is needed. An understanding of the minimum number of infectious units required to produce infection in a susceptible person is basic to finding the true risk of infection for ingested viruses. This has not been satisfactorily evaluated and, therefore, needs further work. In addition, there is need to develop epidemiological approaches to determine the extent of endemic waterborne viral transmissions.

5. Development of Low Energy Technologies for Treatment and Disposal of Waste Water--The small Pacific Islands are widely separated. Therefore, there is a limited resource base in the Pacific Basin to support the implementation of waste water treatment and disposal methods applied in urban situations. The problem is severe due to the lack of qualified operating personnel, difficulty of obtaining replacement parts and supplies, corrosion due to salt-laden air and high energy costs because of the need to import fuel oil.

Alternative (and innovative) means of treatment and disposal must be evaluated that would not be energy intensive but would be relatively simple to operate and maintain. Prospective alternatives would include:

a. sea water lagoons
b. rotating biological contractors
c. application of solar and wind energy (to conventional systems, as well) and
d. mariculture

6. Coral Protection from Silt by Coastal Land Zoning--Siltation due to construction is a major stress factor in areas where coral and algae reefs dominate the coastal environment. Siltation can smother corals outright, can reduce settlement of coral larva due to the elimination of hard substrate for attachment, and can cause a decrease in the light penetration so vital to hermatypic corals.

Research should be initiated to ascertain the feasibility of:

a. A buffer zone along the shoreline areas where development should be disallowed or kept to a minimum
b. Environmentally strict development and construction practices which emphasize maximum curtailment of silt runoff (e.g., developing land piecemeal to minimize runoff, settling ponds for silt catchment, etc.)
c. Validating the universal soil loss equation and erosion control guidelines

7. Toxic Substances and Their Biological Effects--There is increasing evidence that toxic substances may be widely distributed in nearshore marine environments. At the same time, it is well known that several such substances are involved in biomagnification among various organisms in the various food chains that comprise marine communities. Additionally, there is increasing speculation that toxic substances associated with fish poisoning (ciguatera) may be involved in food chain relationships. Except for one detailed study of mercury in a food chain, there is no experimental work on biomagnification of other toxic substances in food chains in Hawaii. Nor are there methodologies for assessing bioaccumulation of such substances in animal tissues from sediments. Such studies are essential for the establishment of baseline information on the distribution and role of toxic substances in indigenous marine organisms.

The occurrence of ciguatoxins in various seafoods organisms in the Pacific is well documented. However, little knowledge, if any, exists with regard to the control mechanisms or factors responsible for the presence of ciguatoxin in dinoflagellates, which has been a source strongly implicated with the problem.

The extent of the problem is considered extremely critical, both in terms of the extreme toxicity of ciguatoxins (which has caused death in humans) and the loss of

recreational and commercially important seafood species in the Pacific. Amberjack (kahala) prior to marketing must undergo extensive screening by the industry and health officials. The loss of a market for fish during seasons of suspected ciguatera incidence has been a major consequence to date.

8. Island Transport Model--Research needs for island transport models include the definition of boundary conditions, and integration of the various density gradients. Such a project would also require a certain amount of field data of current structures taken within a reasonable time frame for model tuning and verification.

The combination of an overall island transport model with a localized discharge plume model would be an effective application of the proposed research in defining the concentrations of pollutants, the biological community that would be affected, and the length of contact time between the various concentrations and the biological community.

9. Ocean Management Planning--Land-use management is a prerogative of state and local governments and is considered a regular function of these governments in Hawaii. Comprehensive ocean management planning, on the other hand, has never been done. Ocean management planning to accomodate potentially competing developments of marine resources surrounding oceanic islands is particularly needed in island communities. Competing uses include fishing, mariculture, recreation, waste disposal, ocean thermal energy conversion installation (OTEC) and U. S. Navy and shipping activities.

The major question is: Which ocean activities should take place and where? Guidelines and/or criteria should be established. A study should be initiated to develop guidelines/criteria and recommend management responsibilities.

B. Medium Priority

10. OTEC Associated Information Needs--Major OTEC developments are expected in Hawaiian waters in the next several decades. This includes a national experimental program and the development of OTEC plants to meet Hawaii's energy needs. Environmental effects will primarily arise from discharge of large volumes of OTEC effluent consisting of a mixture of cold deep-ocean water and warm surface water. The discharge may be at the surface or at some depth depending on the net benefits of the effluent.

The deep-ocean water is characterized by being cold, low in oxygen and pH, high in nitrogen and phosphorus and with low bacteria content. Possible negative impacts will be effects on warm water species of pelagic and other benthos in the vicinity of this discharge. Possible beneficial effects may be an increase in primary and related secondary productivity, creation of suitable environments for cold water mariculture and aggregation effects of OTEC facilities in pelagic fish populations. Research is needed to determine these effects of OTEC on mariculture.

The coldness of the water is a resource that offers tremendous flexibility and variety to potential mariculture activities. The nutrients in deep cold water may be sufficient for raising clams and oysters. Research is needed to determine species and systems to maximize possible benefits for the enormous volumes of cold water which will become available as OTEC develops.

The possible impacts of OTEC siting on pelagic fish populations include:

a. possible enhancement of primary productivity from increased nutrients (provided the sinking rate is sufficiently slow)
b. effects of fish populations gathering around OTEC facilities
c. possible damaging effects on fish larvae, juvenile and adult fishes and plankton of proposed OTEC sitings and follow-up studies as the development process proceeds

The presence of mini-OTEC and OTEC I test facilities in Hawaiian waters provides a unique opportunity to anticipate the effects of future large-scale developments.

11. Utilization of Increased Fish Populations Surrounding Ocean Outfalls--Increases in abundance of commercially valuable fish have been seen off some sewer outfalls and in areas of sugar mill waste discharge in the Hawaiian Islands. This increase may be due to:

a. the enrichment of the surrounding water and the subsequent growth of algae
b. the provision of new habitat space and settlement sites for sessile organisms, and
c. the increase of sediment-laden organisms utilized by bottom feeding species

Research should be directed to the feasibility of harvesting these large aggregations of fish by local fishermen. Changes in relative abundances of fish populations should be monitored periodically. This may indicate possible maximum sustainable yields so that

exploitation may be regulated. One item of concern is the public health acceptability of organisms grown under such conditions. Unless this important facet is addressed, the use of waste water in this fashion is moot.

12. Manganese Nodules Mining and Processing--Research is needed to determine the fate of the plumes associated with mining operations and their impacts on benthos, sediments, the nepheloid layer, etc. However, much of this work will probably need to be delayed until test mining operations are undertaken.

Potential impacts of disposal of nodules tailings is of concern. With up to 97 percent of the nodules as potential tailings, disposal becomes a critical question in determining the economics of processing. The magnitude of the ocean disposal problem depends on the extent to which processing leaves toxic metals chemically bound and the effects of the disposed sediments on life in the water column and settling areas.

Research is needed to determine the physical and biological characteristics of proposed sites adjacent to Hawaii, the rate of plume associated with dumping as test materials become available and the chemical qualities of processed tailings. If titanium and cobalt become sufficiently valuable to make mining of the shallower Hawaiian water manganese crusts economcially feasible, this mining process will become a candidate for priority study due to the relatively shallow occurrence of these crusts and their proximity to the Hawaiian Islands.

13. Lagoon Model--Research is needed to develop a generalized model that could be adapted to the various island lagoons found throughout the Pacific Islands. Such a lagoon model would include the exchange processes of tide, wind and waves, as well as the growth and toxic responses of the lagoon biological community to existing or proposed discharges.

Research needs involve the evaluation and adaptation of existing estuarian models to a lagoon morphology and boundary conditions and the definition of a growth response mathematical description for nutrient-poor central Pacific waters.

Application of such a model would aid in defining the most cost-effective solution to the questions of wastewater treatment requirements and disposal alternatives.

14. The Effects of Land Disposal of Solid Waste on Coastal Environments--There is limited land area on oceanic islands for suitable solid waste disposal sites. The problem is made critical because of needs for protecting ground water resources, recreational areas and critical marine and shoreline resource areas. Further, the island economy necessitates the importation of material resources resulting in large volumes of solid wastes in the form of shipping containers, cans, bottles, plastic and paper wrappers, etc.

Since ocean dumping of solid wastes is not an alternative, and interior areas are zoned for development and/or conservation, the coastal zone is a prime candidate for disposal sites. The effects of such disposal must be determined in terms of potential for leachate generation, toxicity, destruction of habitat categorically for types of waste (demolition, municipal) and waste handling methods.

C. Low Priority

15. Fishpond Aquaculture with Sewage Effluent--The farming of protein-rich fish species in protein-deficient areas of the world is well documented. The use of raw sewage to enhance primary and secondary productivity in small ponds (one to two acres) is being carried out in areas such as Africa, the Phillipines, Israel and Southeast Asia, among others.

Initial research should be implemented to study the feasibility of raising commercially valuable locally consumed fish, especially in technology and energy-poor areas, such as the Pacific Trust Territories. In other areas (Hawaii), fish aquaculture products may be marketable on a large scale.

Research should include:

a. cost feasibility
b. cost/benefit ratios in technologically poor areas
c. bioassay of fish to determine any bioaccumulation
d. growth and reproductive rates of target fish species and
e. hybridization experiments which may lead to better growth, reproduction and biomass yields per acre

The harvest of commercially preferred fish for immediate consumption could be augmented by trash fish aquaculture for fish protein concentration or other fish products.

16. Offshore Sand Mining--Research requirements to effectively exploit the sand resources in offshore areas of Hawaii and other Pacific Islands include the development of

appropriate mining technology and the selection of sites that would have minimal detrimental effects. This includes the definition of the rates of transport of sand among the offshore sand reservoirs and the rate of sand replenishment from sand production areas along the coastline and nearshore reefs.

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