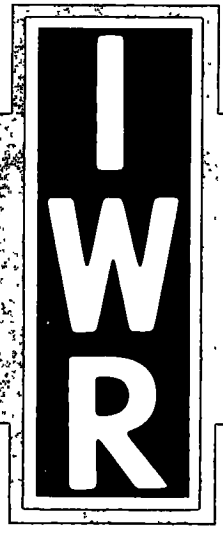
PRELIMINARY ANALYSIS OF THE ECOLOGICAL ASPECTS OF DEEP PORT CREATION AND SUPERSHIP OPERATION



INSTITUTE
FOR
WATER RESOURCES

DEPARTMENT OF THE ARMY
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IWR REPORT 71–10

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K. B. COOPER
Brigadier General, USA
Director

PRELIMINARY ANALYSIS OF THE ECOLOGICAL ASPECTS OF DEEP PORT CREATION AND SUPERSHIP OPERATION

A Report submitted to the

U. S. Army Engineer Institute for Water Resources
2461 Eisenhower Avenue
Alexandria, Virginia 22314

Study Administered and Coordinated
by the
Natural Resources Institute
University of Maryland
Eugene L. Cronin, Director

October 1971

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FOREWORD

This report represents the results of a short-term, intensive, preliminary state-of-the-art assessment by an interdisciplinary group of marine scientists. The objectives of the study were to identify on a preliminary basis:

--Key ecological impacts which should be assessed in conjunction with any plans to develop deepwater ports (ports of up to 100 feet in depth).

--Significant natural hazards and limitations to deepwater port development and supership operations.

--Existing deficiencies in relevant ecological information and analysis-evaluation techniques and short and long-term research needs and priorities.

The study represents one of a series of three studies being sponsored by the Institute for Water Resources, aimed at exploring in depth all aspects--engineering, economic, social and environmental--of deep port construction and supership operations. One of these which has been largely completed reviewed foreign experiences with superships and deep ports, including environmental considerations. The other, to be completed during the summer of 1972, seeks to illuminate the problems and issues related to establishment of deep ports in the United States. This study will deal with a broad range of environmental factors (including ecological) and will attempt to develop a framework and approach for environmental analysis and evaluation.

It should be noted, too, that a number of other agencies, including the President's Council on Environmental Quality and the U. S. Maritime Administration, are currently studying several facets of the problem, reflecting the current national interest in and

concern about superships and deep ports. In essence, all of these studies are aimed at providing information for those who must ultimately determine national policy and make investment decisions regarding supership facilities.

This study focuses strictly on ecological impacts, as opposed to the more comprehensive coverage of the other studies. In this regard, it was designed to serve as a necessary input to these other studies as they evolve. In a broader sense, however, the findings of the study represent a first step in the development of a systematic, comprehensive approach to the assessment of the marine and estuarine ecological impacts, not only of deepwater ports and supership operations, but of coastal development and operations in general. In this sense, the report should be of immediate value to those responsible for the assessment of the overall environmental impacts of such activities. Also of importance, the report points clearly to deficiencies in knowledge and information regarding ecological impact assessment and to surveys and research needed to correct them.

This report is not to be construed as necessarily representing the views of the Corps of Engineers. Any policy or procedural change which may result from this research will be implemented through directives by the Chief of Engineers.

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INTRODUCTION

Superships have entered world commerce and interest has rapidly expanded in the possibilities of developing U. S. ports which can receive such vessels and handle their cargos with efficiency and safety. Such vessels require at least 60 feet of water, and predictions anticipate need for 80-120 feet of depth within decades. Of the 100 principal U. S. ports, only those in Puget Sound and some parts of Alaska exceed 55 feet in depth.

Large ships and deep ports would, therefore, require creation of new facilities and the operation of such ships and ports will affect the environment. Because the Corps of Engineers must consider in advance the environmental aspects of such coastal construction and activities, the Corps' Institute for Water Resources contracted with the University of Maryland to convene a panel of selected experts to provide a preliminary analysis of the ecological aspects of deep port and supership operations. The Panel consisted of:

Dr. L. Eugene Cronin, Chairman
Director, Natural Resources Institute
University of Maryland

Dr. Edward W. Fager, Professor
Scripps Institution of Oceanography

Dr. M. Grant Gross
Senior Research Oceanographer
Marine Sciences Research Center
State University of New York - Stony Brook

Dr. Gordon Gunter, Director
Gulf Coast Research Laboratory
Ocean Springs, Mississippi

Dr. Donald Hood, Director
Institute of Marine Sciences
University of Alaska

Dr. Donald Pritchard, Director
Chesapeake Bay Institute
The Johns Hopkins University

Dr. Ernest Salo, Professor
Fisheries Research Institute
College of Fisheries
University of Washington

ASSUMPTIONS AND DEFINITIONS

As a basis for analysis of the ecological aspects of superships and deep ports, the Panel assumed:

1. That deepwater ports will be created on some of the coasts of the United States.

2. That superships will be brought into these ports to load or off-load oil, other liquids, and solid cargos, and that some of these cargos will be highly deleterious if they are released in coastal waters.

3. That deepwater ports will eventually handle all of these types of cargo.

4. That supership operations will involve spillages, leakages, discharges and, possibly, occasional large-scale accidents.

There are operational factors that can affect environmental impacts, including modification of ship structures to reduce accident and loss, improved clean-up techniques, traffic control, etc. This analysis does not deal directly with those factors, which we assume will be considered by others. Neither do we attempt to provide guidelines related to economic problems such as acquisition costs and alteration of the tax base or to other socio-economic aspects of deep port and supership operations.

We define superships as those of 150,000 or more dead weight tonnage, and recognize that they may reach 750,000 or 1,000,000 tons. They will require at least 60 feet of water and may need 80-120 feet. From information provided to us by the

Institute for Water Resources, we have adopted the following descriptions for purpose of discussion:

Table 1. Description of Superships

	Minimum	Estimated Maximum
Tonnage x 1000	150	750-1000
Depth required	60'	80-120'
Length	950'	1500'
Beam	150'	300'
Channel width		
Single vessel	450'	900'
Passing vessels	750'	1500'

For a vessel of 300,000 tons the following operating characteristics were given:

Operating speed	15-17 knots
Minimum for steerage	5-6 knots
Stopping distance	1 mile
Turning radius	4-5,000 feet

TYPES OF DEEP PORTS

Based upon the information provided through the Institute, we expect that three types of locations will be considered as sites

for deepwater facilities. These are off-shore, shoreline and inland.

A. Off-shore facilities.

1. Islands, natural or artificial

2. Towers

3. Moored devices

a. Floating docks

b. Buoys for positioning of ships for cargo transfer

4. Submerged pipe with a mechanism for ships to attach for loading or off-loading.

B. Shoreline landings. Where adequate depth exists or can be provided, deepwater piers or docks might be established along the present coastline of the country.

C. Inland ports.

1. Natural harbors, requiring that ships enter and pass through a natural waterway, usually an estuary, to reach a port facility.

2. Artificial (box) harbors, created along a coast where no natural harbor exists, and designed for exclusive or primary use as a harbor.

Each of these types involves different economic benefits, different costs, and different ecological considerations. In addition,

the U. S. coastline has exceptional environmental variety, ranging from near polar arctic to tropical, from rock to deltaic sediments, from areas of low biological production to rich and unique systems, from broad continental shelves to fjords, and from areas of low storm damage to hurricane tracks. Reasonable discussion and guidelines must therefore be directed toward general principles, and designed to assist in the thorough local analysis which must be made of each specific site which becomes a serious candidate for development as a deep port.

PRINCIPAL POSSIBLE ECOLOGICAL IMPACTS

Construction and Operation of Deepwater Ports

A. Offshore facilities. The construction activities will have ecological effects, usually temporary, which will be dependent upon the type of facility being built. The construction of floating devices (platforms) with submerged connections with shore-based facilities will have the least effect. Construction of piers, causeways or islands that have fixed connections or bases on the bottom will have greater and longer lasting influences on the ecology of the area.

The existence and operation of the facility will have influences that are dependent upon its type; however, some influences are

common to all of the types of off-shore ports, previously listed (page 5, A).

The effects on navigation will depend upon the extent of use of the local waters for traffic, commercial fishing and recreation. The size of the facility and the distance offshore will influence the effects on littoral drift and wave pattern. While possible pollutants are removed from the shoreline, thus affording greater dilution and flushing, the problems of containment of spills may be greater. The exposure of ships and ports to the weather and seas is greater, which may increase the probability of accidents. Fish populations may concentrate around these structures and hence be subjected to increased influence by pollutants.

These offshore facilities may become multiple-use facilities such as marinas, fishing fleet or aquaculture bases, recreation areas or even locations for nuclear power plants. If so, the effects of possible pollutants are likely to become more complex.

B. Open-coast shoreline landings. Although at the present time the number of existing open-coast sites of deep water close to shore is limited, these may be increased by deepening the approaches to the shore or by constructing them at the inner ends of submarine canyons. The construction of deep channels to shoreline ports has impacts that vary from site to site and the consequences

cannot be listed in any universal priority. The consequences are also dependent upon whether new ports are developed or existing ports are deepened.

The construction of new ports utilizes land and shoreline not used before for this purpose and the values for alternate uses need to be considered. This is particularly true for wetlands. Adjacent shoreline areas and nearby coastal waters will be affected by the construction and operation of the new port. The degree of influence will be determined in part by the coastal current patterns; by the extent of interception or change by jetties, groins, and breakwaters; and by the design of the harbor entrance.

C. Natural and artificial inland ports. An inland port, whether a natural harbor or constructed artificially, may be estuarine or non-estuarine and the degree of influence of construction and operation may be different between the two. The estuarine areas may serve as breeding and rearing areas for many different kinds of important fishes and, in general, may have a more complicated and fragile ecology than the strictly marine type.

As in the open-coast shoreline landing types, the consequences of construction will be dependent upon whether a new port is constructed or an existing port is deepened.

The deepening of existing ports will change the patterns of water circulation and flushing action and the consequences of these changes may be many and complicated. Existing ports operate under water quality standards that vary with the type of domestic and industrial use of their shorelines and with the degree of treatment that wastes from these uses receive prior to discharge into the waters of the port. Alteration of the circulation pattern and flushing action affect water quality. In estuaries, disturbances will cause changes in the extent of salt water intrusion and can in some circumstances affect the ground water supply of the region. Deepening of a partially mixed estuary will tend to increase the vertical density stratification. Consequently, any oxygen deficiency in the deeper layers will be increased. Deepening of a salt wedge type estuary will result in an upstream movement of the salt water-fresh water interface, and may change the intensity and upstream intrusion of any water layers having oxygen deficiency. Where wastes are discharged, the distribution of oxygen-demanding materials will change. Changes in salinity patterns will affect the distribution of marine fish populations and may affect the behavior of anadromous fishes. The distribution and degree of eutrophication and the distribution of fouling and boring organisms as well as the distribution of aquatic plants may change.

The creation of new inland ports whether estuarine, fresh water or marine, involves greater land-use problems than those encountered on the open coast. Dredging, blasting, filling and disposal of spoils are activities common to creation of new ports and the deepening of existing ones. If the inland waterway is already inhabited by aquatic populations, disturbances of these kinds may have temporary or long-lasting effects, depending upon the types and degree of sediment suspension and deposition. The assumption can be made that the deepening of existing ports will require periodic dredging so that some continuous consequences can be expected. If a new inland port is formed by excavation of land, aquatic animal and plant life will be introduced.

D. General Effects of operation of deepwater ports. The construction and operation of shore-based facilities such as docks, roads, railways and other auxiliary services associated with deep-water ports may affect the marine environment by making permanent changes in shorelines which affect drainage, runoff and vegetation. Deepwater ports will also change the location of refineries, granaries, warehouses and storage and dispensing facilities for liquids and bulk items. The overall effect will be toward concentration of large port facilities in a few areas. This may have a tendency to centralize accidental spillages, fires and other hazards,

and thus result in limited-use zones. Regulation of the activities and the setting and enforcement of standards may be accomplished more effectively in the centralized locations.

The operation of deepwater ports will change the use pattern of existing ports because the width of channels used for two-way traffic will need to be about five times the width of the beam of the largest vessels. Superships will create wakes and surges which may have serious effects on small boats and shorelines. Turning basins may be up to one-mile in diameter and the number and types of tug boats may be changed.

Operation of Superships

The use of superships will probably introduce few ecological problems that are qualitatively different from those involved in present ship operations. There are, however, likely to be considerable differences in degree. These arise mainly from two sources: the greater carrying capacity of single ships and the concentration of these ships at the few ports capable of handling them. If the projected economies of operation are realized, the total quantity of imports may further increase.

Some physical effects may arise from the sheer size of the ships and of their power plants. If concentration of vessels

in a relatively restricted port results in increased surface temperatures, these could change the reproductive patterns of organisms and the mortality rates of both young and adults. The latter effect can be aggrevated by interaction of raised temperatures with moderate chemical pollution. It is likely to impinge most heavily on the young, many of which at some stage in their life history spend time in surface waters.

In estuaries, very large propellors may have an effect on the salinity structure by increasing turbulent mixing in and through the halocline. If this occurs, it may seriously alter the relations between salinity changes, depth and bottom type which are important in determining the spawning grounds of some fish and invertebrates.

The surface waves created by the passage of such large ships through restricted waterways could lead to increased erosion of harbor margins composed of unconsolidated materials. This would clearly have a deleterious effect on animals and plants living on these margins. A secondary effect of putting sediment in suspension would be increased turbidity which reduces light penetration and thus primary productivity and precludes the establishment or survival of certain invertebrates whose filtering apparatus could be clogged.

The effects on the biota of chemical pollutants introduced by leakage during loading and unloading operations, by accidental spills or by collisions between ships or between ships and the bottom are likely to be more immediately serious and are almost certain to be longer lasting and more widespread than the physical effects. Chemical effects will be widespread and persistent. This is a consequence of the ability of many organisms to concentrate some pollutants (fat-soluble pesticides, heavy metals, etc.) in their tissues and to disperse them widely through the ecosystem by physical movement and by serving as links in the complex food web.

It seems unlikely that the types of potential pollutants will differ substantially from those presently being transported by sea. What will differ will be the quantities involved. These may involve some of the more dangerous ones because the liquid form in which they occur makes them especially suitable as cargo for supertankers. Examples are industrial organic solvents, monomers for manufacture of plastics, halogenated hydrocarbons, other petrochemicals, petroleum, industrial acids and herbicides and insecticides in liquid form or in solution. Most of the substances on this list will be highly destructive to marine organisms when present in high

concentrations, many are accumulated when available in low concentrations and some are known to be extremely persistent in the environment. Thus the effects of a major spill are likely to be immediate kill of substantially all animals and plants over a considerable area and slower spread of the effects outside the initial area of kill as organisms collect and concentrate the materials present in lower amounts in the surrounding waters. Some of the substances are also strongly adsorbed to sediment particles and thus retained for varying periods of time near the original discharge. In this form they are available to many deposit feeders. They also constitute a reservoir for continuing release to the adjacent waters. This retention could result in persistence of relatively abiotic conditions at the site of the spill for considerable periods of time.

If the use of superships produces larger accidental spills, the effects are likely to cover greater areas and affect larger numbers, and possibly more kinds, of animals and plants. This, therefore, puts a premium on both greater efforts toward prevention of spills and more rapid and effective cleanup procedures. If, as is assumed, the superships will be confined to a relatively few ports, the potential for serious damage or disaster in and

near these ports will be increased but so will the possibilities of more control of operations. The best way to reduce undesirable ecological consequences is to prevent accidents and reduce operational leakage to an absolute minimum. The next best is to develop methods that remove the spilled cargo from the water speedily and completely without introducing biological damage via the clean-up method.

INFORMATION REQUIRED FOR PREDICTION OF ECOLOGICAL EFFECTS OF DEVELOPING A PROPOSED DEEP PORT OR OPERATING SUPERSHIPS

Provided below is a comprehensive list of the types of information required in order to adequately assess the probable ecological impact of a proposed deep port development and associated supership operation. Some of the information included in this listing would normally be developed for other purposes associated with the planning and justification for the development of a deep port, and hence should be readily available. It should be obtained from the applicant. For a number of items included in this list the information would not normally be available, or would be incomplete, at the onset of planning for the port. The development of fully adequate information in these latter cases would then require field investigations by competent research personnel.

Several of the items listed below involve judgments which can only be made by experts familiar with the ecology of the region in question; for example, selections of the more significant and sensitive species for which toxicity information is required. Applicants for permits to construct and operate a deepwater port should be required to consult such experts in developing the information necessary to allow appropriate authorities to arrive at a judgment concerning the feasibility and desirability of the proposed port.

For some of the items of information, basic knowledge of pertinent processes is inadequate. For these items, research programs are required. These are described in a later section of this report.

Not all of the items included in the list are needed for all types of deepwater port development, and some items will be of higher priority in one type of environment than in another. Each of the items contained in the following list is expressed as a statement of the information required. From this list could be drawn a set of questions to be asked of any applicant proposing the development of a specific deepwater port.

Information Requirements

A. General description of port facilities and detailed plans and schedules for construction of new facilities or modification of existing ones. The plans should include pertinent details such as charts and appropriate drawings of waterways and approaches, docks, piers, breakwaters, jetties, dredged and filled areas, bridges, causeways, and material handling facilities.

The schedule of construction should indicate the time of initiation and completion of each phase of the construction project and should include the detailed schedule for conducting the required ecological studies.

B. Operational characteristics of cargos, ports, ships, and cargo-handling facilities, including:

1. Cargo and cargo-handling facilities

a. The volume and weight of each type of cargo should be specified both by the amount to be handled per ship and the total annual amount handled by the port. A ten-year projection should be provided.

b. Detailed chemical data should be provided on the constituents of each major type of cargo and for all dangerous, toxic and explosive materials handled in the port.

c. Detailed data on physical properties should be provided for each major type of cargo, including density, solubility in sea water, surface active properties, flammability, etc.

d. Data should be provided on toxic effects of materials handled on the normal metabolism of representative indigenous organisms.

e. Detailed data should be provided on the amounts and kinds of controlled discharge expected from ships and port facilities.

f. Estimates should be provided on the probability of accidental discharges and leakages of cargo and materials from harbor facilities and industrial installations.

g. The decomposition rate in the environment of major types of cargo, controlled discharges, industrial materials, and their degradation products should be provided to the extent deemed desirable by the regulatory agency.

h. Detailed plans should be provided of those features of the ship that limit the probability of accidental spillage of cargo.

i. Detailed plans should be provided of those features of port facilities that limit the probability of accidental spillage of cargo or industrial materials.

j. Detailed plans for equipment and techniques to be used for containment, recovery, and decontamination of spilled cargo or other materials should be provided.

2. Detailed data should be provided on physical changes to coastal areas and adjacent ocean bottoms to include the following;

a. Changes in submerged areas resulting from dredging and filling, spoil disposal, construction of breakwaters, pipelines, causeways, bridges, industrial sites, to include:

(1) Volume and types of materials involved

(2) Method of handling and disposal of spoil

(3) Frequency of maintenance dredging.

b. Changes in shorelines resulting from construction of breakwaters, jetties, docks, piers, bridges, causeways, pipelines, and dredging and fill operations.

3. Detailed data should be provided on generation and disposal of wastes, and on their physical and chemical characteristics, toxicity, half-life, and degradation products, in the environment.

The following waste sources must be considered:

a. Ship wastes, such as sewage, solids, ballast, and bilge.

b. Industrial wastes, including liquids, gases, and solids.

c. Municipal wastes, including liquids and solids.

C. Evaluation of the environment and prediction of probable ecological effects.

1. Evaluation of those physical properties and processes that affect the marine environment in and around the proposed port development. The evaluation will cover the initial conditions. Those prevailing after completion of the port will be predicted. The following items will be included:

a. Hydrography of the area, including temporal and spatial distribution of temperature, salinity, and density.

b. Flushing characteristics, including the rate of exchange of harbor waters with adjacent water bodies.

c. Evaluation of probable temporal and spatial distributions of any spilled cargo, controlled discharges, and of industrial and domestic wastes.

d. Surface wave characteristics and wave effects, including wind waves and swell, and those generated by ship operations.

e. Characteristics of natural surface films in the area of the harbor.

2. General assessment of the biological systems that are likely to be affected by the construction of the proposed harbor and its operations. This will be accomplished as follows:

a. General assessment of probable biological effects, based on existing information. This preliminary phase should be conducted in conjunction with experts who know the biology of the region, and should provide an assessment of the major impact of the project on known living resources.

b. Thorough studies of:

(1) Resident and transient marine biota including population size, and their spatial and temporal variability. The following groups should be included:

(a) Plankton, including primary productivity and the larval stages

(b) Attached plants

(c) Nekton

(d) Benthos

(e) Marine birds and mammals

(2) Distribution and abundance of rare species and others of special ecological significance.

(3) Probable effects on the most important and the most sensitive organisms and communities.

3. Provide an evaluation of those chemical properties and processes that affect the marine environment in and around the proposed port site. The evaluation will cover the initial conditions. Those conditions prevailing after completion of the project will be predicted. The following items will be included:

a. The temporal and spatial distribution of dissolved oxygen.

b. The temporal and spatial distribution of nutrients; i.e., phosphate, nitrogen compounds and silicate.

c. The temporal and spatial distribution of those trace elements which are deemed significant, based on the composition of cargo and expected waste materials.

d. The temporal and spatial distribution of those organic compounds which are deemed significant, based on the composition of cargo and expected waste materials.

e. Consideration of possible exchange of materials between water and sediment, such as nutrients, trace elements, and organic compounds, as they relate to the benthos or water quality.

4. Provide an evaluation of those geological processes that affect the marine environment in and around the proposed port site.

Those expected after completion of the port will be predicted. The following items will be included:

a. Geological conditions should be evaluated based on existing information, including sediment sources, distribution, and physical and chemical properties.

b. Shoreline stability should be evaluated, including probable effects of harbor construction and operation. This study should also include evaluation of historical records of shoreline changes, and examination of newly created shoreline features.

c. Evaluate sediment transport along the shore, to include resuspension by wave action and movement by long-shore currents and tidal currents.

d. Evaluate spatial and temporal distribution of suspended sediment concentrations, transport processes and deposition rates.

e. Survey of existing and potential non-living resources in the area, with emphasis on sand, gravel, shell, and minerals.

f. Evaluate effects of sediment transportation and deposition on benthic organisms and communities.

g. Evaluate effect of port construction on quantity and quality of ground water.

D. Predictions and Program of Survey and Research.

Two principal actions are required on the basis of the information requested in the first three parts of this section (A, B, C):

1. Prediction of changes that will take place when the port is completed and operation has commenced.

2. Development of a continuing program of survey and research.

The predictions should include both the expected average situation and the worst possible combination of events. Some estimate of the probability of this latter combination should be included. In addition, information should be supplied concerning the methods planned for dealing with both the average and extreme cases.

The continuing program of survey should be designed to emphasize the factors that have been predicted to be most influential in determining the ecological effects. The data required for the predictions will also supply estimates of variability that can be used to decide on the number, frequency and spatial distribution of samples required for a defined precision. The survey will ensure compliance with approved operating procedures and provide a basis for changes in these if the results are unfavorable. It will

also serve to test the predictions made. This should be used to improve the quality of future efforts to foresee and evaluate the changes associated with the development of deepwater ports.

Many types of information needed for the predictions will not be available. The process of collection and summarization of the information will certainly raise questions about priorities and new types of information and techniques needed. Research will be needed to supply the information required and to suggest answers to the questions. Some examples of research that the Panel considers of special importance are given in the next section of the report.

RESEARCH NEEDS

There is not now an adequate basis for preoperational prediction of all of the significant ecological changes that might result from the impacts of deepwater port creation or supership operation. Competent coastal ecologists can provide useful informed estimates of the probable effects at any selected site, if some information exists in regard to the ecology of the region and on the facility and operations to be considered. Such first estimates are of exceptional value, but they must not be allowed

to replace the much more precise and reliable predictions required before it will be possible to make rational decisions between possible alternatives.

There are no unique research aspects of deep ship operation and facilities. The problems which are or may be involved broadly overlap those encountered in controlling coastal waste disposal and pollution and those presented by physical modifications of the coastal area for various purposes. Some are related to the essentially non-ecological areas of marine accident prevention, shipping management, terrestrial transportation.

There are, however, several research needs whose urgency and importance are emphasized by the size of possible accidents associated with superships and the deepwater ports serving them and by the necessity for competent prediction of ecological effects from these activities. These, we suggest, merit identification, recognition, and special efforts toward research implementation. As they are conducted and completed, these programs will significantly improve the national ability to evaluate the probable ecological effects of supership operations and deep water ports, and should facilitate actions necessary to minimize those considered unfavorable. These needs are summarized as recommendations by the Panel.

Panel Recommendations on Research

I. That improved knowledge be obtained on the structure and dynamics of biological populations and communities at coastal sites and of the effects of probable perturbations.

COMMENT: This is a complex and exceptionally difficult task, and the answers would be useful in dealing with problems of coastal engineering, waste disposal, fisheries and other fields. It will require thorough surveys and long-term experimental studies in natural waters, examination of laboratory populations and communities, and new theoretical concepts. The field studies must continue for sufficient time to deal with the considerable inherent variability of the coastal zone. We recommend the selection in different regions of the coasts of types of habitat for possible offshore, coastal and inland ports and support or participation in supporting research to increase understanding of biological populations and communities in these habitats.

II. That the fate and ecological effects of principal supership cargos in the coastal environment, including all cargos of large volume or high potentials for environmental damage, be determined.

COMMENT: The most probable large vessel cargos can be identified, and it would be exceptionally useful to determine:

a) the physical behavior of each in coastal waters,

b) the chemical and biological sequence of degradation and its time schedule under realistic circumstances,

c) any geological association which occurs, and

d) the biological pathways and effects of each.

As the biological effects may be enhanced by interactions between the substances and the physical and chemical characteristics of the environment, it will be necessary to do some of the research using multifactorial design of the experiments. Such studies would require the identification of appropriate biological species, life history stages and communities at several different coastal sites, and representative of the habitat types identified under research recommendation I. Together, these would provide data on distribution, acute and chronic toxicity, biological concentration which may occur, movements through the food web and other data essential for establishing safety precautions.

III. That the environmental effects of suspension and deposition of sediments be determined.

COMMENT: The inland and shoreline locations will involve dredging, and disposal of spoil. The offshore locations may influence sediment transport along the shore. The sediments can

have a profound influence on the biology of an area. The kinds of organisms that live in and on sand are quite different from those that live on finer sediments; those that live in a region of high sedimentation rate differ from those in a low rate area; those in carbonate sands may differ from those in silica sands. Studies should be supported of the interactions between sediments and living organisms, under conditions like those at possible deepwater sites. The information obtained would permit separation of the short-term ephemeral effects of little significance from those which involve permanent or substantial consequences.

IV. <u>That the environmental effects of shoreline modification be determined</u>.

COMMENT: The biological production of estuaries and of some coastal areas is related to the nature of the shoreline. It provides an important habitat for many organisms, nutrients and sediments entering the water along the shore, and stands of plants frequently provide shelter and food for many useful species. Construction of inland deepwater ports is certain to involve the modification of the shoreline, which may be converted to long walls of timber, metal, concrete or other foreign material. As this reduces the habitat for species that live on the undisturbed shoreline, it provides new surfaces for sessile species. There is

a need for the design and conduct of research under conditions which are appropriate to the consideration of deep port problems in order to permit adequate prediction and evaluation of all of these changes.

V. That efficient environmental survey techniques for coastal areas be improved.

COMMENT: Survey designs based on statistical principles are urgently needed to provide, at the lowest cost of time and funds, measurement of physical, chemical and biological components of the environment with definable precision. The Corps' shares the need for these methods with many other agencies, and requires such data for many purposes in addition to deep port consideration and evaluations. As part of this program, development of more effective sampling and sensing devices should be supported.

VI. That a pilot design of a comprehensive and adequate approach to prediction and verification of the ecological effects of deep port construction and operation be completed.

COMMENT: The comments in this report are necessarily generalized so that they cannot provide the detailed focus necessary for consideration of a specific site. Considerable advantage could be gained by the development of a detailed pilot plan for predicting

and verifying the environmental effects at a designated site, or even for a well-described theoretical one. Future efficient evaluation of deep port proposals requires the experience gained from such research.

VII. That improvement be achieved in the physical and mathematical modeling of the physical, chemical and biological systems affected by construction of deepwater ports and operation of superships.

COMMENT: Although they involve considerable simplification, physical and, especially, mathematical models can quickly provide estimates of trends and reactions to perturbations. They also serve as guides to the type and precision of information needed.

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13. ABSTRACT

This report summarizes in a general, preliminary manner current knowledge regarding the probable ecological impacts of supership operations and deep port development. It describes briefly types and dimensions of port facilities(ship dimensions, key operating requirements and the probable ecological impacts of facilities and operations). It also outlines basic information required for prediction of ecological impacts. Seven major research problems are identified to meet current information deficiencies.

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