ENVIRONMENT IN COASTAL ENGINEERING: DEFINITIONS AND EXAMPLES**

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ABSTRACT

In current usage, environmental aspects of coastal engineering design include aspects of ecology and aesthetics, as well as environment. In practice, the aspect of environment is a limited one, considering man's surroundings, with the works of man left out. The increased consideration of environmental aspects over the past 15 years has brought real benefits to the coastal engineering profession, as well as obvious problems. One problem is a mythology of coastal processes that has become widely accepted. Priorities in coastal engineering design remain a structure that will last a useful lifetime and perform its intended function without creating new problems. After satisfying these fundamental requirements, the structure should minimize ecological change, and fit pleasingly in its setting.

INTRODUCTION

Design and THE Environment. A coastal structure must remain standing when hit by the most severe waves, currents, and winds that can reasonably be expected during its intended lifetime. Waves, currents, and winds are basic elements of the physical environment. In this structural sense, good coastal engineering is always sensitive to the environment.

But the designer who creates a structure that doesn't fall down has not necessarily solved a coastal problem. The structure must also perform a function, without creating significant new problems. It must reduce beach erosion, prevent flooding, maintain a channel, provide a quiet anchorage, convey liquids across the shore, or serve other functions. There are groins standing out at sea after the beach has eroded away; jetties exist that enclose a deposit of sand rather than a navigable waterway; some seawalls are regularly overtopped by moderate seas; water intakes are silted in.

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** This paper is an overview of the papers discussed in the poster session on Environmental Aspects in Coastal Engineering Design. The papers discussed are presented in Chapters 136-137.

These functional failures are no less costly than structural failures. To design a structure to function as intended requires a thorough knowledge of the coastal processes affecting the site. These coastal processes are basic elements of the environment. So in the functional sense also, good coastal engineering is always sensitive to the environment.

But physical factors of the environment (waves, currents, sediment transport, etc.) are not the principal factors of THE environment, as that word is now used in discussing environmental aspects of coastal engineering. "Protect the Environment" does not mean protect the design wave height. Rather, "Protect the Environment" means protect a complex of factors including fish and wildlife, wetlands, scenic views, water quality, odors and sounds, low population density, and even the subjective imaginings of people who will never see the sight.

Intent of this Paper. This paper is about the relation between coastal engineering and the environment in the above contemporary sense. The occasion of the paper was a poster session "Environmental Aspects in Coastal Engineering Design" held on 15 November 1982 in Cape Town as a part of the 18th International Conference on Coastal Engineering. A poster session provides for the individual authors to publish abstracts of their papers and to display key illustrations from their papers at the meeting hall during the conference. The chairman of the session discusses the authors' papers and the general subject, and puts his ideas in a paper. This is the chairman's paper for the poster session on "Environmental Aspects in Coastal Engineering Design."

Given the occasion of this paper, it should serve two functions: review the work of the individual authors taking part in the session, and comment on the subject matter in general. There are 4 papers eligible for review, that is, 4 papers whose abstracts were published in the conference abstract volume and whose authors displayed their results at the conference. These are the works of Perry (1982), Clark (1982), Hoffman, Mussalli, and Taft (1982), and Geldenhuys (1982).

The next section of this paper defines and distinguishes the meanings of environment as they apply to this paper. Following these definitions, four sections review each of the poster papers. The final section presents opinions of the writer on environmental considerations in coastal engineering design.

DEFINITIONS

To a large extent, words mean whatever their users think they mean. This has been especially the case in discussing environmental questions. Nevertheless, it is useful to review the accepted meanings of key words that are a part of the discussion. There are three words particularly relevant here: Environment, Ecology, and Aesthetics.

The authoritative sources of meanings are dictionaries, and the most authoritative dictionary for the English language is the Oxford English Dictionary (OED), issued in corrected form in 1933 with later supplements. A more contemporary and concise dictionary is the Oxford American Dictionary (1980). These two dictionaries (the OED and the OAD) are the sources of the following definitions.

Environment. Environment, according to the 1933 OED, comes from a French word meaning to encircle. Two definitions are given, the first and most general being "the object or regions surrounding anything." The second definition is "the conditions under which any person or thing lives or is developed; the sum-total of influences which modify and determine the development of life or character." The 1980 OAD defines environment as "surroundings, especially those affecting people's lives."

The coastal engineer developing a design wave height for a structure considers the environment in the first sense of these dictionary definitions. Once it is built, the structure itself becomes part of the coastal environment in this sense. But the environment, as used in the phrase "Protect the Environment", implies a slightly different definition; environment in this usage corresponds roughly to animals, plants, and the natural landscape, with the works of man removed. As used in this environmental sense, the meaning approaches that of 'ecology'.

Ecology. The word, 'Ecology', as such, does not appear in the 1933 OED. At that time the accepted spelling was 'oecology', which is defined as "The science of the economy of animals and plants; that branch of biology which deals with the relations of living organisms to their surroundings, their habits and modes of life, etc." (The 1972 Supplement to the OED now accepts 'ecology' as the more usual spelling.)

The 1980 OAD shows the evolution in meaning of ecology that has accompanied recent usage. The first OAD definition of ecology is a concise restatement of the 1933 OED definition: "The scientific study of living things in relation to each other and to their environment". The second definition is simply "this relationship", i.e., the study of relationship among organisms which was the original meaning of ecology is now coming to be replaced by the relationship itself. The OAD editors also add a postscript to their definition: "Note that ecology does not mean environment."

Relationships among native species and their environment, i.e., the ecology, may be affected by coastal engineering works, and the works themselves may be affected by the ecology. As an example, improving an inlet to make it more navigable may also increase the tidal prism, and thus change the salinity of the bay waters. Changed salinity could increase or decrease the productivity of oyster beds in the bay, an effect of a structure on the ecology. It could also change the abundance of marine borers infesting timber piles and bulkheads in the bay, an effect of the ecology on those timber structures. Depending on the circumstances, the net effect of the changes may be beneficial or harmful, although the doubt is usually in favor of maintaining the status quo, since the individuals whose livelihood is most threatened by such changes often hold a potential veto over the approval of the project.

The practical effect of these considerations is the development of a new functional design requirement for a coastal structure: the structure should not cause any significant change in the existing ecology, except for changes (such as improved water quality) that are not strongly opposed by any element of the affected population.

Aesthetics. 'Environment' and 'ecology' are words that have become commonplace. Their meaning may be vague, and one is often confused with the other, but these two words undoubtedly connote good things that people are in favor of. It has been the writer's experience, however, that regulatory decisions made in the name of the environment or ecology are often based, not on ecological principles, but on the personal philosophy of the regulator about what is right, i.e., what contributes to beauty in the situation. Often, in fact, the regulator has relatively little ecological data to base a decision on.

In these decisions, personal aesthetics and not the environment or ecology, determines the outcome. Aesthetics is defined (1933 OED) as "The philosophy or theory of taste, or of the perception of the beautiful in nature and art." The 1980 OAD defines aesthetics as "a branch of philosopohy dealing with the principles of beauty in art."

Few people, of course, formally sit down and write out their personal theory of what is pleasing and beautiful in nature, and then make decisions consciously following this formulation. It is more intuitive than that. Some things fit and others do not. Given the choice, wilderness is more appealing than development; clear water is preferred to turbid water; dunes are more natural than seawalls; and so on. Often it seems that these aesthetic judgements, with which almost everyone would agree, are made first and the ecological reasons to support the decision are brought up later. The net benefit of the structure to society runs a distant second in consideration.

Thus, while protecting the environment or the ecology may be the slogan, the practical application is often based on personal aesthetics. Aesthetic judgements are important and must be given weight. They are often intuitively correct. As an example, the selection of the site for the Field Research Facility of the Coastal Engineering Research Center located at Duck, North Carolina, was determined by a regulatory decision based on aesthetics. The site originally favored for that facility was Assateague Island, part of a National Seashore. The principal cogent objection to the facility at Assateague was the visual incompatibility of the pier superstructure with the setting. As a result of this objection, plans for the Assateague site were abandoned and the present site at Duck, North Carolina, was selected, a fortunate selection in the writer's view.

Sometimes, the basis for aesthetic decisions appears to automatically assume greater attractiveness of natural conditions. But the natural condition is not necessarily the most pleasing one, despite a strong predilection to assume so. The writer has had black California beach sand pointed out to him as evidence of oil spills. The sands in question were indeed visually unpleasing, but the blackness was entirely natural, due to naturally occurring dark minerals of the region.

In previous paragraphs, this section of the paper attempts to define and distinguish three terms applicable to what is called the environmental aspect of coastal engineering. The next sections get down to four concrete cases that were included in the poster session on Environmental Aspects of Coastal Engineering Design. These four cases are, in effect, a random sample of current coastal studies bearing on environmental aspects of design.

CLASSIFICATION OF NATAL ESTUARIES

Reference. The Estuaries of Natal: A Method of Classification, J.E. Perry, Abstracts volume, 18th International Conference on Coastal Engineering, Paper No. 17, pp. 33-34. (This abstract has been supplemented by selected data reports supplied by Mrs. Perry.)

Natal Estuaries. This report concerns the classification of 72 estuaries in Natal, South Africa. Classification is based on 6 sets of air photos covering the period from 1937 to 1980. Most of these photos were taken during the southern hemisphere winter. The photos are converted to a common 1:10,000 scale and landmarks used to locate changing features. A large number of measurements are made, most of which describe the geometry of the river and adjacent areas. Perhaps only 20% of these measurements concern coastal features directly, these being features associated with the river mouth. Table 1 identifies only the river mouth features measured in the classification.

The mouths of these estuaries often have spits from one or both sides, which frequently seal off the river mouth entirely. Rocks commonly occur in the vicinity of the mouth, and roads or rail bridges are also common. Data from the work of G.W. Begg (1978) and additional data supplied by J.E. Perry (received Dec 1982), show the following: The estuaries can be conveniently divided into north and south sets, with Natal Bay as the approximate dividing line (approximately 29°53' south latitude). The majority of Natal estuaries are south of Natal Bay and most of these are usually closed. Spits commonly grow north to south in the south and south to north in the north. In the south about 43 of 53 estuary mouths have noticeable rocks in the vicinity, but in the north only 8 of 21 show rocks in the vicinity. The estuaries in the south commonly are crossed by road and/or rail bridges near the mouth, but in the north this is the case at only 4 estuaries.

In their present state, these data are still being tabulated and interpreted, but as indicated in the previous paragraph, they offer interesting information, for example, on longshore transport directions. Mrs. Perry reports that particularly for the coast north of the river Tugela (29°13' south latitude), there are long northward-directed spits. Some of these shores show prominent accretion, as shown by the shoreline changes in Figure 1, reduced from a supplement to the report by Selby and Perry (1982).

Table 1. RIVER MOUTH DATA, NATAL ESTUARIES

Characteristics*	Measurements*
open/closed	right bank breakwater length
natural/ artificial	left bank breakwater length
canalized	rock sill level**
sandy	cliffs on right bank: height**
rocks on right bank	cliffs on left bank: height**
rocks on left bank	spit/bar: direction of growth in degrees
outer bar	length of spit/bar
silt plume (fluvial)	stabilized length
suspended sediment (marine)	width

*taken from data form "Classification of the Lower Reaches of Natal Rivers"
**measured from MSL

Opinion. This study illustrates a necessary fundamental step in any proper environmental study: the description of what actually exists in the field. The use of aerial photos is ideal for this purpose, since they provide a uniform source of morphologic data at identifiable times in the past. Once finished, the availability of such a set of data will put future analysis and policy decisions on a much surer basis. The wider possibilities of these data are illustrated by the shoreline change information of Figure 1.

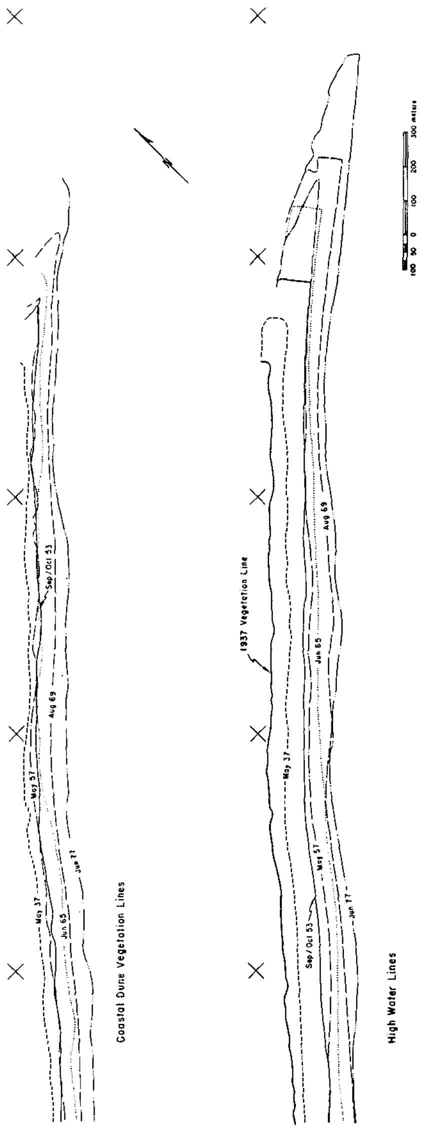

Figure 1. ACCRETION AT THE MOUTH OF SIALA RIVER, NATAL, SOUTH AFRICA (SELBY AND PERRY, 1982)

FLORIDA COASTAL CONSTRUCTION GUIDELINES

Reference. Coastal Construction Building Code Guidelines, Ralph R. Clark, P.E., editor, Florida Department of Natural Resources, Bureau of Beaches and Shores, Technical Report TR 80-1, Nov 1980, 52 pp.

Purpose. As explained in its introduction, this document is a product of the evolving state coastal management program in Florida. Since 1957, the Florida Department of Natural Resources (DNR) has held regulatory authority over building setback lines and coastal construction in the state. In recent years, Florida state legislation has encouraged delegation of this authority to the particular municipalities and counties, provided that the municipalities and counties have appropriate procedures to control coastal construction. The purpose of TR 80-1 is to provide local Florida governments with guidelines for a coastal construction building code.

(This delegation of regulatory authority to lower levels of government is an example of a nationwide trend. A similar effort in state coastal zone management is that taking place in California. Much of the permit jurisdiction formerly held by the California Coastal Commission is being assumed by the particular cities and counties within that state following completion of their local coastal programs.)

Building Code. This document (TR 80-1) consists of a one-page introduction, followed by two, nearly-identical modifications to existing building codes of approximately 24 pages each, and ending with 5 pages of references.

The body of the report (pages 1 thru 47) presents the building code guidelines recommended by DNR. These are in the form of supplements to the existing South Florida Building Code (pages 1 thru 23) and the existing Standard Building Code (pages 24 thru 47). The principal difference between the two supplements is the terminology used to subdivide and identify specific paragraphs.

As indicated by Clark (1982), three major concepts of coastal engineering design are incorporated into these building code guidelines:

a. Identification of a zone where major coastal construction is permitted, but where special coastal design criteria apply. The zone is three-dimensional, that is, it has both landward and seaward limits in plan, and vertical constraints in elevation.

b. Requirement that foundation design anticipate erosion occurring during the 100-year storm surge, or its cumulative equivalent.

c. Requirement that the structure be designed for loading expected during the 100-year storm surge.

Both supplements contain identical sections on definitions. The zone subject to these recommended building code supplements is defined as the Coastal Construction Building Zone. This zone is bounded on the seaward side by the Coastal Construction Conservation Zone, which is approximately the dunes and the beach as far as the mean high water line. Major structures cannot be constructed within the Conservation Zone. On the landward side, the Construction Zone is bounded by the Coastal Construction Control Line. This control line is defined by statute and plotted on official maps. It is intended to mark a landward limit to the effect of the storm surge with a 1% chance of occurrence in any year (the 100-year surge) or of a number of lesser storms which cumulatively have the same probability of occurrence. (The zoning is generalized for the purpose of this paper as Figure 2, drawn in part from the FEMA (1981) Coastal Construction Manual.)

Two types of erosion are distinguished under 'erosion' in the definitions: Horizontal Recession and Scour, based on whether or not the storm surge inundates the profile. This distinction appears unsatisfactory to the writer, because both horizontal recession and vertical scour can occur in the absence of storm surge, and because it appears to imply erosion due to onshore-offshore transport when much erosion is due to longshore transport. It would be better to define erosion within the concept of littoral sediment budget, erosion being the result when more sand is carried out of the area than is carried in by waves, currents, winds, and other processes.

The general load requirement is for all habitable buildings to be designed to withstand the forces accompanying the 100-year storm. These forces are defined to be "waves, hydrostatic, hydrodynamic, and wind loads". Wave loads are specified to be those required by appropriate Navy or Army Corps of Engineers Manuals (NAVFAC DM-26 or Shore Protection Manual, Volume II). Hydrostatic loads are given as the pressure resulting from the equivalent height of water. Hydrodynamic loads are given a lengthy discussion in the definitions section, but are discussed only briefly and in general terms under required loads. The wind load is

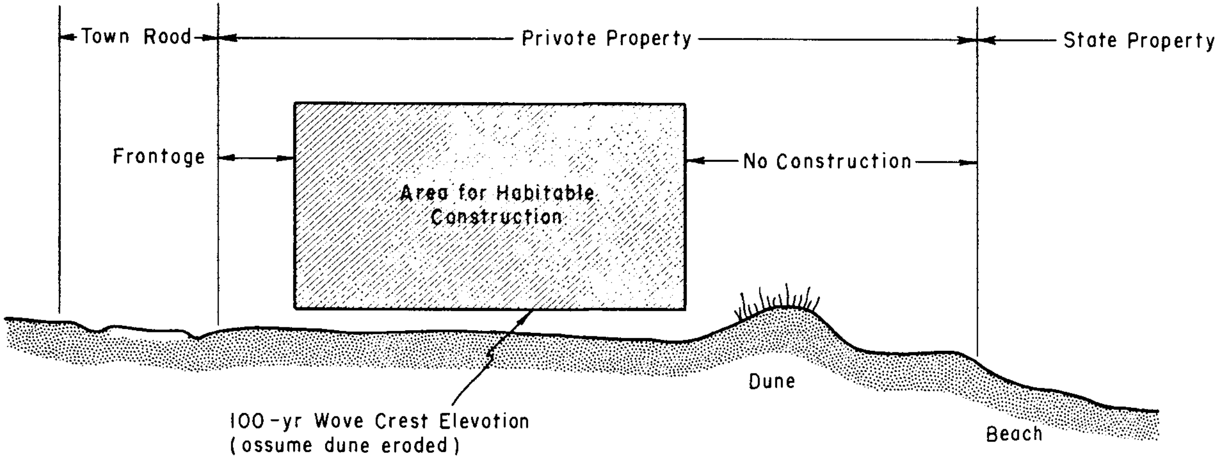

Figure 2. TYPICAL COASTAL CONSTRUCTION ZONE

specified by a table developed from the 2/7 power of elevation above grade, based on an assumed 140 mile per hour wind.

Although habitable structures must be designed for the 100-year storm, shore protection structures may have shorter design lifetimes, down to 10 years for bulkheads. Shore protection structures must be "designed for the minimum wave loads which are applicable for the design storm conditions which justify the structure."

Excavation in the Coastal Construction Building Zone is not recommended but is permitted, provided that excavated beach material is replaced or used elsewhere in the zone and provided that the excavation does not present potential danger during the 100-year storm design conditions.

The first floor must be above the expected wave crest elevation during the 100-year storm. This elevation is the higher of those determined by the DNR or the Federal Emergency Management Agency (FEMA), and is subject to revision.

A pile foundation is recommended for habitable structures, although soil-bearing foundations are permitted, if allowance is made for localized scour during the 100-year storm. The pile foundation is to have pile caps below the expected erosion surface during the 100-year storm. The pile foundation above grade is to have adequate spacing, defined as 8 feet or 8 times the pile diameter, which ever is greater.

Bibliography. The document contains a useful list of 65 references, almost all of which are not specifically listed in the building code guidelines. These 65 references identify about 13 national, county, and local building codes; 13 text books on a variety of subjects; 5 manuals; 6 reports related to FEMA's coastal flood insurance mapping; and at least 11 articles that might be called construction guidelines. The remaining 17 references deal mostly with coastal processes, sediment transport, and waves.

Opinion. Construction codes concern criteria based on the physical environment. The ecology of the environment is considered in the earlier steps defining the construction zone and granting the building permit. These Florida guidelines systematically reduce coastal engineering practice to terms applicable to the work of the building contractor, without overspecifying the criteria. The engineer still has to determine for the specific site the probable ground level during the 100-year surge and the forces exerted by this surge. Among the tougher questions to be determined is whether the dune, which is usually pictured seaward of the construction zone (Figure 2), will survive the 100 year surge. The 5-page bibliography is a most useful addendum to the guidelines.

EXCLUDING ORGANISMS FROM COASTAL WATER INTAKES

Reference. Environmental Considerations in Designing Coastal Water Intakes, P. Hofmann, Y.G. Mussalli, and E.P. Taft, unpublished draft report, Stone & Webster Engineering Corporation, 1982, 14 pp. including 7 figures.

Fish Transfer Systems. Cooling water intakes to power plants may entrain organisms, resulting in high mortality to the entrained organisms and possible damage to the cooling water system. The problem of excluding organisms from the water intake without killing them is a sophisticated extension of the problem of excluding trash, which has occupied engineers for a longer time (Linsley and Franzini, 1979, p. 233). Design of a water intake usually requires consideration of a trash rack; exclusion of organisms from coastal water intakes adds to this standard design requirement the effect of a living organism capable of independent reaction to the environment, and the complications imposed by coastal processes. The authors describe solutions to the problem of organism entrainment which they have studied. Additional related studies are found in Taft and Mussalli (1978).

Physical constraints of the site usually will determine the overall plan of the cooling water system. Modifications to that system are then made to minimize organism entrainment. The principal modification recommended by the authors, based on their studies, is the use of screens angled at about 25^{o} to the centerline of the upstream channel. Fish swept downstream sense these screens and in avoiding them, they are shunted into a bypass from which they are returned safely to open water. (The fish do not 'see' the screens, which are usually in the dark. Even if in a lighted conduit, the fish approach the screens tail first, so the sensing of the screens is presumably a reaction to the turbulent eddies shed by the screens.)

Louvers have been used for fish diversion in hydroelectric plant intakes, but the authors' studies show that the net efficiency, considering the cooling water system and fish mortality, makes screens the better choice. Mortality rates for fish vary considerably with the species tested. The 25^{o} angle of the screen is an empirical result of their tests with live fish.

The use of these screens is further modified to minimize pumping requirements for the fish bypass system. To reduce this cost it is desirable to minimize the flow in the bypass. This is accomplished by making each screen a vertical conveyor belt with fish buckets which lift fish to a smaller return trough (Figure 3). The conveyor belts are equipped with low pressure sprays to transfer the fish into the fish trough and a high pressure spray to remove trash.

There is a further complication in one Florida power plant imposed by the requirement to remove small organisms from the flow. This requires reducing the screen mesh from the normal 9.5 mm to 0.5 mm, which results in unique operational and reliability problems.

Opinion. These modified solutions to the problem of avoiding organism entrainment appear to be still in the development stage. It will be useful to see statistics on their operational reliability after several years. Statistics concerning the net effect of the cooling water system on the local ecology would be useful in justifying the cost of the traveling screens. Presumably, the heat discharge and turbulent energy accompanying the operation of the cooling system contribute benefits, as well as losses, to the local ecology.

RICHARDS BAY OUTFALL

Reference. Richards Bay Marine Effluent Pipeline - Environmental Aspects, N.D. Geldenhuys, Abstracts volume, 18th International Conference on Coastal Engineering, Paper No. 20, Nov. 1982, p. 39.

Discussion. This abstract identifies salient factors of the outfall at Richards Bay, South Africa, intended to handle effluent resulting from future industrial and population growth. The pipeline is a 1 meter diameter plastic pipe which is to extend 4 to 5 kilometers out to sea. Buoyant effluent will be discharged at a depth of 28 meters; dense effluent at a depth of 25 meters. The effluent consists of 3 principal substances: dense waste from a phosphoric acid factory, including gypsum, fluorides, and heavy metals; buoyant paper and pulp mill effluent; and buoyant municipal sewerage.

The volume of effluent is expected to rise from 64,000 m^3/day in 1984 to 176,000 m^3/day by 2013. The volume of dense waste will be a relatively low percentage of the total initial discharge and will remain relatively constant in

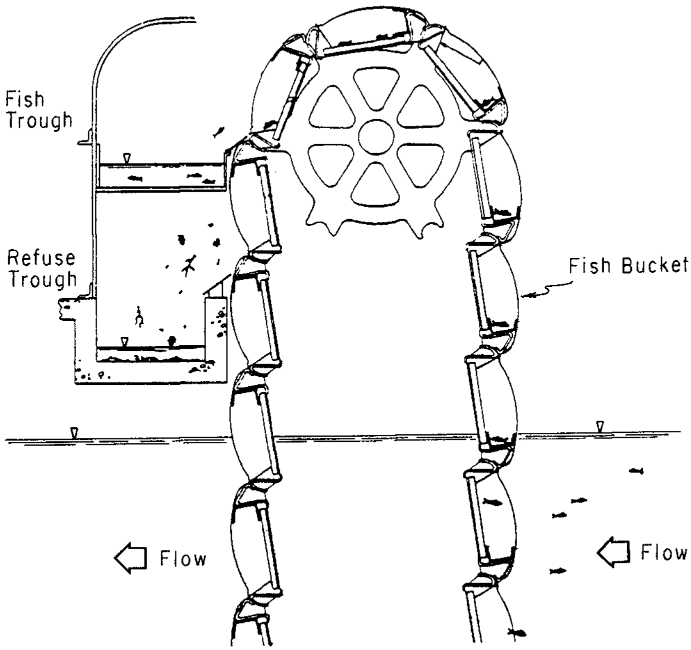

Figure 3. MODIFIED TRAVELING SCREEN WITH FISH BUCKETS
(HOFMANN, MUSSALLI, AND TAFT, 1982)

absolute terms. The volume of buoyant waste is a large percentage of the initial total, and is expected to grow in absolute terms.

Some environmental deterioration is expected in the vicinity of the diffuser, particularly from deposition of the gypsum slurry which will eventually cover 4 square kilometers of bottom. Adverse effects may be reduced by inplant treatment, by searching for alternative use of the material, and by monitoring.

Bottom currents are estimated to be slight with median values between 7 and 10 cm/sec. Wave action is moderately severe with 90% of all wave heights between 0.5 and 2.0 meters. The available information does not provide data on the design criteria leading to the selected pipeline lengths, discharge point, and diameter. The design of outfalls based on physical and ecological criteria is discussed in detail by Grace (1978).

SELECTED ASPECTS OF ENVIRONMENT IN DESIGN

The previous sections of this paper indicate the range of environmentally related studies that now occupy coastal engineers and scientists, from basic description of the environment (Table 1) to design and testing of highly specialized fish handling mechanisms (Figure 3). The environmental concern that led to these studies has had a number of effects on coastal engineering design, some of them for the good. In this final section of this paper, three effects on the profession are discussed:

a. Benefits to coastal engineering practice
b. Fostering of coastal myths
c. Design priorities

Benefits of Environmental Concern. The environmental movement is blamed for delay and cancellation of projects; perversion of technical data; exaggerated concern over improbable outcomes; and many other errors of commission and omission. Most practicing coastal engineers will have their share of stories to tell, so they will not be reviewed here. Despite these real difficulties, however, the environmental movement has benefited the coastal engineering profession in significant ways.

On an economic level, environmental requirements have generated a lot of work for coastal engineers. On a technical level, environmental studies have significantly improved the profession's capacity to design for new environments.

The work done in planning for the Atlantic Generating Station in New Jersey provided much work for the profession and advanced its technical understanding considerably. There have been many other projects of smaller scope.

Preliminary studies required to satisfy environmental regulations probably have reduced net project costs in many cases by eliminating some of the uncertainty that faces a contractor in making up his bid. An Engineering News Record article ("Outfall bid $10 million under estimate", 9 Apr 1981) credits the low bid on the Southwest Ocean Outfall in San Francisco to preliminary studies which reduced the size of contingency allowances added to the bids.

Environmental requirements have forced coastal engineers to recognize the costs of unwanted ecological change. Although engineers retain strong suspicions that the ecological data on which these costs are calculated are often questionable, the requirement to consider the question has widened the view of the engineers, to the benefit of the profession.

The activity of coastal engineers on these environmental questions has also partially educated the regulators. There is now grudging recognition among environmentalists that some coastal engineers know what they are doing.

Myths. The environmental movement has fostered a pervasive mythology about coastal processes. These myths include logical impossibilities, highly improbable assertions, and dubious hypotheses. These are reviewed in reports and editorials published in Shore and Beach (see Adams, 1982; O'Brien, 1982; O'Brien, 1980) and in Proceedings of Coastal Zone '80 (see O'Brien and Johnson, 1982, Olsen, 1982). The following paragraphs start off with a brief statement of a myth, followed by a statement believed to more accurately represent the facts.

a. *All structures cause erosion.* Well designed structures retard or prevent erosion. As pointed out by O'Brien and others, few people would go to the expense of building a structure if erosion did not already exist at the site. Since many structures are separated from the water by a sand beach when they are built, this supposed causal action implies that waves are equipped with some sort of remote-sensing ability to perceive the structure behind the berm. To really evaluate the effect of the structure, compare the condition after construction with what would have been the condition had no structure been built.

b. *Seawalls cause unacceptable scour.* It has not been demonstrated that wave action at a seawall results in worse conditions than no seawall at all. Well designed seawalls are effective structures in sites that require them.

c. *Sea level rise is the cause of erosion.* The net effect of even rapid sea level rise is small compared to the effects of other coastal processes contributing to erosion (Galvin, 1983).

d. *The world's beaches are eroding almost everywhere.* Erosion probably does dominate, but accretion is not negligible. The writer believes that this myth is partly an artifact of the reporting system. The beaches most justifying study (and thus being reported) are those that are eroding. Accretion, such as that shown in Figure 1, gets noticed and reported only by accident. It is also true that both environmentalists and engineers may stand to gain from reports of widespread erosion, and this can subconsciously affect the reported prevalence of erosion.

e. *Erosion is inevitable.* Erosion is preventable, often by modest engineering efforts. A large sand fill at Ocean Beach, San Francisco, was maintained on the Pacific Ocean for half a century prior to current construction. A sand dike at the entrance to Fire Island Inlet, New York, has remained exposed to the Atlantic Ocean for over 20 years.

f. *Barrier islands are fragile.* Barrier islands have evolved in a tough environment, and they persist there. Barrier islands pictured on 18th century charts of the U.S. Atlantic coast are still in place, along with most of the important inlets between them. The seawall at Galveston, on a low barrier island in an area of subsiding land levels, is now about 80 years old and still functioning. Lighthouses from the 19th century and earlier exist today on Atlantic coast barrier islands.

Priorities in Coastal Engineering Design. It is difficult to design a structure that will last a useful lifetime and perform its intended function without introducing new coastal problems. The pressure of environmental concern tends to displace these design priorities. The ecological and aesthetic requirements of the design must be subordinate to these primary requirements. A suggested list of priorities for the responsible engineer are as follows:

a. Know the environment of the structure under design. This must be personal knowledge, adequate to establish the physical design criteria with confidence. This is a first requirement, before design can begin.

b. Design the structure to last a useful lifetime under the expectable extremes of the environment. This is the primary requirement of the design.

c. Design the structure to perform its intended function without introducing significant new problems. If this functional requirement is not satisfied, the structure will still be a failure, even if it lasts its intended design life.

d. Design the structure to minimize environmental change, particularly those aspects of the environment which are critical to the existing ecology. As indicated above, approval of the project may depend on this.

e. Within the constraints of the preceding priorities, make the structure fit the landscape in a pleasing way. A structure that is both physically adequate and functional is usually aesthetically pleasing as well.

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