INTEGRATION OF COASTAL WATER PARAMETERS

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ABSTRACT

Coastal water assessment is a problem in water quality management. The broader question on water quality management involves evaluation of the technical factors within the context of value judgments on socio-economics. By law, the ultimate objective is to serve the public interest in protecting water quality but in a way that promotes the optimum balance between economic development and environmental quality.

Decisions on management require that a cause and effect relationship be established. So far, none has been successfully established.

Therefore, there will always be uncertainties in the evaluation of the coastal water environment. Considering the limitations in sampling and analysis, the more meaningful approach is proposed to be one of managing environmental risks. While the precise nature of the coastal processes cannot be defined with confidence, the consequences and the likelihood of the consequences of an applied stress can be more meaningfully dealt with.

Decisions can best be guided within the framework of the risk-benefit equation.
INTEGRATION OF COASTAL WATER PARAMETERS

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INTRODUCTION

Coastal water assessment is a problem of water quality management. It is a means to an end, and that end involves a broader scope of evaluation than a scientific scrutiny of parameters and effects. It involves value judgments which are ultimately dictated by public policy.

Specifically, the legislative policy embodied in the Hawaii Statute on Environmental Quality [Section 342-6(c), Hawaii Revised Statutes] states that "... any determination of public interest shall promote the optimum balance between economic development and environmental quality." That policy presupposes that economic development and environmental quality are interrelated and that a quantitative relationship of cause and effect exists. But none has been satisfactorily established except in a few cases.

The determination of that balance is a fundamental objective in water quality management as expressed by law. Without the analytical bounds defined by cause-effect relationships, the optimum balance is almost completely a matter of subjective judgment on competing values evaluated in the different languages of science and law in the realm of the political process.
Considering the sampling and analytical difficulties, perhaps a different approach involving different concepts would prove to be useful in guiding decisions in water quality management.

Much of the work on coastal water assessments has been aimed at developing and monitoring wastewater management strategies with emphasis on sewage disposal. More attention must be given to non-point sources of discharges, to the apparent diffuse emissions of toxic substances that are finding their way in the food chain, and other effects that seem to be related to urbanization and urban growth.

History has shown that our institutions and laws have been reacting to problems in water quality management rather than anticipating problems and moving to prevent them from happening. For this reason, coastal water assessments and concepts on water quality management must change toward a broader scope and more initiative.

**Development of Wastewater Management Strategies**

The wastewater management strategies for Oahu evolved from an intensive study of water quality conditions in the coastal waters around the island.¹ The project identified and developed parameters which were not adequately dealt with in the then-existing water quality standards for the State of Hawaii. More emphasis was placed on parameters of floatables, settleables, toxicity, biostimulation, and other biological effects believed to be critical in

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attaining and maintaining relevant water quality standards and the beneficial uses of our coastal waters.

The County of Kauai also sponsored a water quality management study\textsuperscript{2} wherein the distribution of coral growth around the island was used as the principal parameter and the basis for corroborating hydrologic data, which indicated that storm runoff was the major emission from land to the nearshore coastal waters around the island. The annual average storm runoff from Kauai was estimated to be 2,000 mgd while sewage discharges amounted to less than 1 mgd at the time of the study.

It was concluded for Kauai that the coastal water ecosystems on a regional scale were influenced primarily by the non-point sources of discharges rather than sewage discharges. The effects of sewage discharges, if discernable, were localized around specific discharge sites.

The recommendation from studies by both counties was to dispose of sewage outside of the nearshore biologically active zone to the open coast, deep ocean regime where it would have the least effect on the aquatic environment by virtue of the dispersive characteristics and distance from biological communities deemed to be critical or potentially sensitive to sewage effluent discharges.

The more complete evaluation of alternatives for waste disposal actually involved an additional concept of acceptable risk which is often illustrated in the classic evaluation of tradeoffs

in engineering between two alternative systems: for the same price which is the more effective, secondary treatment with a short out-
fall in the nearshore waters, or primary treatment with a longer outfall in the deep ocean regime. The first alternative gives a higher level of treatment but there is no assurance that treatment is enough to control water quality effects in shallow waters. The difference between the two is the element risk—the risk of making the wrong decision and causing a damage or impairment which may be practically irreversible.

A similar evaluation was made of the alternative strategies for the Kaneohe Bay discharge. There were basically two alterna-
tives. One was tertiary treatment for those factors of biostimula-
tion and toxicity and continuing discharge into the Bay, and the other, diverting the discharge out of the Bay to the Mokapu out-
fall. The decision was ultimately to divert the discharge out of the bay. The major factor was the risk of damages despite the high degree of treatment given to the effluent.

Further Development of Water Quality Management Strategies

The wastewater management strategies involving discharges in coastal waters for the counties in the state have been developed and for the most part are being implemented. The problems with the major point sources of discharges are solved or are being solved. It is now a question of time and money.

Other problems require the same level of attention, if not more. Non-point sources of discharges including urban storm run-
off, the discharges of toxic substances that are entering the food
chain, and other sources that are not now defined, are examples where control measures are yet to be fully developed.

These are problems actually associated with urban growth. Urban activity generates emissions of waste products or energy in the form of waste heat: sewage, solid waste, air pollutants, sediment runoff, toxic chemicals, or thermal discharges. Emissions to the coastal waters cause stress on the aquatic environment. To preserve water quality, emissions must be controlled either by the application of technology as in the case of point sources of discharges or by management of the activity as in the case of non-point sources.

As the intensity and extent of urban activity increases, so will the emissions. Where the application of technology is the usual practice, the residual discharge from high density developments may even then exceed acceptable limits since technology is never one-hundred percent efficient. There will always be a residual discharge. Coupled with the trend for ever more stringency on emission control, the water quality management alternatives left are to curtail or eliminate the activity itself or to allow the activity and accept the risk of water quality impairment. This is a value judgment that is to be made by our political process. Present state law provides that the determination of the public interest promotes the optimum balance between economic development and environmental quality. It is a "given" in the realm of water quality management.

Yet there is no established relationship between development and environmental quality despite the efforts of our institutions
and professional organizations to do so.

Perhaps a different evaluation and analytical approach to
decision-making would be more useful.

Concept of Risks Management

Experience with environmental surveys and the history of dis-
covery of new effects previously unknown or unrecognized leads to
the following conclusions about sampling the environment:

(1) There is never enough data.
(2) There is never enough time.
(3) There is always uncertainty.

It follows that there is always a risk of making the wrong
decision in water quality management.

Considering the fact that abatement of pollution problems are
underway and our attention is directed to prevention of problems,
uncertainties of sampling are compounded by the inherent uncer-
tainties of making projections into the future. Within this con-
text the relevant questions that should be asked are these:

(1) If we're wrong, how wrong can we be? What is the proba-
bility of making the wrong decision? What are the conse-
quences; are they catastrophic; are they irreversible?
(2) If we're going to take chances, who should be the one to
make that decision? The scientists? The planners? The
public? The feds? counties? or state?
(3) If there is to be a decision, why should we take that
chance or assume that risk?

What is being proposed here is to proceed along the concepts
of the risk-benefit equation. It embodies almost all of the fac-
tors, technical and socio-economic, that must be considered in
evaluating that elusive notion of the optimum balance. The decision could be based on the notion of the minimum risk and maximum benefit.

It is the role of the scientific and professional community to define risks. Rather than attempting to define the actual response of the ecosystem to applied stresses considering the sampling and analytical limitations, it would be more meaningful to estimate consequences and the likelihood of their occurrences—or to define the risks.

It is then within the realm of public policy or of the political system to make the judgment on values and benefits in water quality management.

In reality, the evaluation of cause and effect relationships involving the environment points out the many interrelated technical and socio-economic factors that influence decisions on water quality management.

Perhaps the best way to sum up the present situation is to paraphrase Barry Commoner's laws of ecology:

(1) Everything is interconnected; and
(2) There is no such thing as a free lunch.

CONCLUSION

Environmental surveys and choice of parameters must be designed in view of the purpose and decision intended. Invariably the decision is one of water quality management involving the scientists, professionals, lawyers, lay-public, and politicians.

A meaningful approach is one defining the coastal water environment under consideration and evaluating the risks associated
with the uncertainties in the sampling and analytical scheme. Only then does it appear that there will be coherency in the ultimate decision-making process.

The Department of Health is heading in this direction and is approaching the entire problem of environmental quality control as one of risk management.
301(h) - A TESTING GROUND FOR WATER QUALITY CRITERIA AS A BASIS FOR REGULATING OCEAN OUTFALLS

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ABSTRACT

Section 301(h) of the Clean Water Act regarding modifications to the secondary treatment requirement for municipal ocean outfalls was enacted by the U.S. Congress in December 1977. This act provides for water quality criteria and maintenance of a balanced indigenous population as the key tests in granting a modification permit and allows for trade-offs in the quality of the effluents, the location of the outfall, and the varying sensitivity of the local environments where the outfall might be placed. This paper examines the techniques and scientific issues which are being studied by the Environmental Protection Agency with regard to the 67 applicants currently under consideration. Five of the 67 applicants represent claims from Hawaii and some issues unique to Hawaii's claims will be discussed.
"301(h) - A Testing Ground for Water Quality Criteria as a Basis for Regulating Ocean Outfalls", by D. J. Baumgartner*

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Thank you Mr. Chairman and Mr. O'Connell for those very kind words of introduction.

I. Introduction

Several months ago, when Roger Fujioka asked me to address this luncheon, he had in mind for me to present the position of the Environmental Protection Agency regarding modifications to the secondary treatment requirement for municipal ocean outfalls, a permit activity for which enabling legislation was enacted by Congress in December of 1977 (good lord, was it that long ago) as Section 301(h) of the Clean Waters Act. From my position in the Office of

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Research and Development, I am not able to provide a complete assessment of the Agency's position on this important issue. However, I believe I can provide some analysis of the technical and scientific issues which were addressed by our research staff and formed the basis for at least some of the criteria which will be used in making decisions about the modified permits for municipal discharges in the coastal zone. I would also like to address some of the technical issues which have not yet been resolved.

Ordinarily this would be a poor subject for an after luncheon speech because it is likely to be outrageously dull. I hope to avoid this, in part, by referring to remarks made by distinguished marine scientists who have spoken out on the subject of ocean outfalls and the proper treatment for municipal wastes. You might even sense a feeling of controversy existing between the viewpoints of Environmental Protection Agency spokesmen on one hand and the marine scientist I am quoting on the other. That would be good, of course, to aid in adrenaline production hoping that you would stay alert to see who lands the first, telling or final blow. But, of course, that would be wrong because there are certainly a variety of viewpoints that can exist regarding technical questions, the outcome of which is unknown. Nevertheless, I will take advantage of this opportunity to present some alternative interpretations.

Finally, I hope to be able to show how EPA is taking advantage of the opportunity offered within 301(h) to set the stage for a research effort over the next three to five (who knows how many) years, to provide the scientific information that ultimately will be needed to improve the basis for coastal water quality protection and the regulation of ocean outfalls. It is in this framework that I see the simultaneous promulgation of the 301(h) regulations
and a research effort as a testing ground for water quality criteria as opposed to a technology base for the regulation of outfalls and the establishment of appropriate effluent standards.

II. Development of the 301(h) Regulatory Criteria

There are a number of key technical issues that were involved in the gradual genesis of the criteria for granting a modified permit under Section 301(h). Many of these started generating advocates long before 301(h), long before the EPA administrators task force on secondary treatment of ocean outfalls was convened in 1974. The best place to start is probably before the 1972 Water Pollution Control Act was passed by Congress, when, during the course of hearings on the bill, it became obvious that the Congress was leaning very heavily toward a technology base for regulation of water pollution.

Scientists generally embraced the notion that a specific set of water quality criteria should be definable, which would protect one or more water uses of the coastal environment. But, they were not able to articulate them. Scientists generally recognized that around the coastal margin of our Nation there was a large number of coastal ecosystems of various configurations, different habitat, varying sensitivity and resiliency, and even without knowing the complex nature of municipal and industrial effluents, certainly recognized that a variety of treatment techniques might be called for in specific circumstances in order to protect that local environment. They undoubtedly recognized that a blanket prescription for treatment for all coastal discharges would be less than necessary in some cases and more than adequate in others. There were scientists, though, who were concerned about our inability to predict precisely what would happen in a number of marine ecosystems chal-
allenged by the unpredictable complex of pollutants relegated to municipal sewers by our industrialized society. I can imagine the frustration in Congress, and I am not surprised that a technology base was chosen in the light of possibly conflicting expert testimony and a general recognition that the scientific community did not have the basic information it needed to evaluate individual cases. I imagine the feeling was pretty much the same as expressed by Senator Muskie several years later in 1975, when he issued a call for more one-armed scientists. In a guest editorial in Science in 1975 Edward E. David of Chicago wrote that the occasion was a Senate hearing on the health effects of pollutants. Testimony from the National Academy of Sciences and other sources was not as definitive as the Senator desired. Witnesses insisted upon saying "on the one hand the evidence is so but on the other hand". Thus, the Senator's call for one-armed scientists.

I believe it was terribly significant for the marine science community that the 1977 act shows the first resurgence of water quality criteria and maintenance of a balanced indigenous population as the key test to be made in requiring a modified permit. This provides an opportunity which has not been possible for many years in the design of coastal water quality protection efforts. And, that is the possibility to consider trade-offs in the quality of the effluent, the location of the outfall and the varying sensitivity of the local environments where the outfall might be placed. It provides an opportunity for economic and engineering emphasis in pretreatment prior to the conventional systems usually employed at the terminal end of the municipal collection system. Although it has not been expressed in the legislation or the regulations promulgated by EPA, it ought to be evident to the marine science community that we now have an opportunity for considering ecological
tradeoffs in connection with design of ocean outfalls. There is an implicit recognition in the regulations that it may in fact turn out to be to the overall benefit of the environment to have less treatment for a certain quality of effluent and to discharge the partially treated wastewater much further from shore through a long ocean outfall into a component of the marine ecosystem that is less sensitive rather than nearshore disposal if a standard level of treatment alternatively had been prescribed.

The second key element of this regulation is that it provides for a zone of initial dilution. Some people would prefer to think of this as a mixing zone. But, for a variety of reasons which we needn't go into, we have chosen the term zone of initial dilution. By adopting this concept, EPA recognizes that there may be some adverse impacts near the point of discharge. This seems to be the only reasonable way to make the water quality criteria effective as a regulatory tool and is consistent with a scientific recognition that the effects in the environment from the long-term exposure of persistent pollutants at low levels of concentration are markedly different than the exposure conditions and the effects likely to be seen in the first several minutes after discharge when the wastewaters are undergoing a rapid rate of initial dilution due to the effects of buoyancy and momentum generated by the outfall device. How do we know that adverse impacts, if any, will be contained within the zone of initial dilution and how are these limited? Well, we believe that by some specific requirements related to, for example bioaccumulation and benthic deposits, plus a general requirement that a balanced indigenous population be maintained at and beyond the boundary of the zone of initial dilution, we feel confident that we will be able to recognize adverse conditions of ecological significance which are clearly unacceptable outside
the zone. Many marine scientists are rightly concerned about the size of the zone of initial dilution. Certainly we recognize that many people would take offense at large segments of the ocean dedicated to the purpose of dilution of wastes and even if the impacts are not too adverse from an ecological standpoint, we may be esthetically motivated to reject the idea. We feel that by defining the zone of initial dilution the way we have it will result in the smallest possible zone that is meaningfully consistent with the mechanics of wastewater discharge in the ocean and the relationship between exposure time and concentration of pollutants causing adverse impacts. To aid in this visualization, you might imagine the mixing zone as being only slightly larger than the length of the diffuser plus twice the depth of water and in width equal to the width of the diffuser plus twice the depth of water. Examples of this sort have generally served to demonstrate that EPA is not dedicating large segments of the continental shelf to the purpose of wastewater dilution with the ambient ocean water.

Within estuaries there are additional requirements on initial dilution zones and the impacts which can be considered acceptable within the zone. We recognize that the critical habitat within estuarine areas of the nation's coastline are a precious resource and must be guarded very carefully. This area is relatively small in comparison to the area of the continental shelf. Consequently, the size of the zone may be significantly more important in relation to the possible percentage depletion of available area. In addition to additional specific requirements for estuaries, the impact of the zone is taken into account, as it is on the continental shelf, in evaluating the overall impact of the balanced indigenous population at and beyond the boundary of the zone of initial dilution.
The third significant technical consideration in the regulation is that applicants may be able to acquire a modified permit even if their discharge is into waters that are stressed. By stressed I mean waters where the applicant cannot demonstrate there exists a balanced indigenous population outside a zone of initial dilution. This is not of direct local significance because none of the five applicants from Hawaii claim a stressed waters condition. However, it is generally significant because about one-fourth of the 67 applications we have received, involving 30% of the total volume of municipal sewage discharged, do claim a discharge to stressed waters. As you know, in all of the showings required for a 301(h) modification, the burden of proof is on the applicant. We feel that the burden of proof to demonstrate that an applicant'd discharge is neither contributing to nor impairing recovery at the discharge site will be very difficult showing for the applicant to make as it requires a prediction of biological responses to future pollution levels. It increases the complexity of the proofs and increases the time required and the effort required by EPA in reviewing and evaluating applications. The high priority we have assigned to applications in this category cannot but delay the final determination of all applications.

The fourth principal feature of this legislation is the opportunity for municipalities to receive a modified permit on the basis of a proposed improved treatment system or an improved outfall; for example, a relocated outfall. To do so they must show that any adverse impacts attributable to their existing discharge will be alleviated. This is important for the same reason as the stressed waters provision, in that it requires the applicant to make a substantial showing based in part if not entirely on projected conditions. For both the stressed waters and improved discharge provisions,
there were technical arguments both for and against their inclusion. In the end it was necessary to decide as a matter of Agency policy that both provisions should be included in the interests of allowing the applicant to make a showing. From the standpoint of the state-of-the-art of marine science, there is not a convincing body of knowledge to suggest that it will be possible for the applicants to do this. For this reason, EPA is not able to recommend any general methods that might be successful in making this showing.

The final provision I wish to note is the requirement for the successful applicant to conduct a field monitoring program to demonstrate that water quality criteria continue to be met and a balanced indigenous population continues to be maintained. The requirements for stressed waters and improved discharges are more elaborate. We have not specified a standard monitoring program recognizing that the nature and extent of observations must be tied to sensitivity of the local environment and the quality and quantity of the effluent. We have made some rather specific suggestions subject to the feasibility of employing those in each specific instance. However, our main idea is to try to work with the Regional Office Permit staff, the State and the applicant to develop a monitoring program which will provide the most sound scientific data that will be called upon by EPA and possibly the Congress in the next three to five years to determine whether this temporary modification to the Water Pollution Control Act was successful and should be continued, or whether it should be abandoned. From this standpoint, it behooves the communities to do their best to conduct monitoring programs of a substantial scientific nature. It may sound strange to say this, but I believe it also behooves the communities who do not get a modified permit to also conduct monitoring programs with the clear expectation that in the long run coastal water quality
and effluent discharges will be regulated on a case by case basis as soon as a sound scientific base is developed.

III. Some Unanswered Questions and Some Possible Explanations

It is hard to pick a point at which time it became obvious that widely divergent opinions were developing on the need for or utility of secondary treatment for marine waters. As I mentioned, it might well have started before the 1972 amendments to the Water Pollution Control Act were enacted. Certainly, by 1974 when Senator Muskie held his hearing in Honolulu on the impacts of secondary treatment on wastes discharged into the ocean, there were clear dissenting voices. Dr. Craven was one of them. He raised the possibility that noxious growth of algae in Kaneohe Bay resulted from the disposal of secondary effluent into the bay and suggested that it might be environmentally more desirable if the most untreated effluent were discharged into waters of low nutrient content. This was a very serious question. Is secondary treatment not only useless and costly but is it actually harmful to the marine environment?

Shortly after our draft 301(h) regulations were published, Dr. Craven was again asked to testify, this time before the House Subcommittee on Water Resources. In this testimony, in May, 1978, Dr. Craven presented more detail about the Kaneohe Bay situation suggesting that secondary effluent goes into the development of lower trophic forms of plant life before being incorporated into the food chain, whereas primary wastes are refractory to phytoplankton. Furthermore, in another part of Kaneohe Bay, four whales and a number of dolphins kept at a navy station produced over 800 pounds of fecal matter a day or the equivalent to that produced by more than 800 humans. And, of course,
their wastes were not treated and were discharged directly to the bay in raw form. Conditions at that site were satisfactory, if not desirable. Dr. Craven is also on record as recognizing as a matter of principle, that the amount of waste treatment ought to be adjusted on the basis of the quality of the receiving water and the flushing capability of the point of discharge. I suggest that an alternative explanation of the observations offered by Dr. Craven to the House Subcommittee might show that considering the rate of mass discharge of organics from the two sources in Kaneohe Bay taken together with the time period over which the wastes have been discharged and the time over which Kaneohe sewage reached the bay prior to secondary treatment, and considering the different flushing characteristics at each site, one might eventually establish an interpretation that secondary treatment for Kaneohe sewage at that location was not necessarily harmful but may will have been merely insufficient. This doesn't mean that the problem can be solved only by additional treatment and it certainly doesn't mean that the problem could have been solved by less treatment. It may be one of those situation where other options could be the best solution. For example, a longer outfall as now has been put into operation at Kaneohe Bay or some combination of a longer outfall and less treatment may or may not have been sufficient. At this point, the question is moot.

In the same House hearings, Dr. Issacs also states that there are reasons to believe secondary treatment may be more disturbing than any present practice in relation to ocean discharges. He cites two kinds of problems associated with secondary treatment. One with nutrients as was the point of Dr. Craven's position and one with respect to metals. In the case of nutrients, he makes the point that in primary treated sewage, plant nutrients are par-
tially tied up in organic food and are only slowly available after passage through the food web. A key point here is the notion of a rate process. In secondary effluent, he says, these nutrients are in the raw form and rapidly stimulatory to plant growth. By raw form, we understand him to mean the oxidized form. Focusing on primary effluent, let me suggest that primary effluent contains both soluble and particulate nutrients and the rate at which these materials are oxidized in the environment depends on a number of environmental factors as well as factors related to the character of the waste material. In some coastal locations, long-term disposal of primary sewage or raw sewage, which is presumably even more nutritious, has caused problems with algal growths as well as other problems. So, the rate of input as well as the capability of the coastal environment to accommodate these wastes either by biological, chemical or physical processes plays an important role in the overall impact. In secondary effluents, the mass of nutrients discharged is less because some have been removed in the treatment plant, but they generally are in a more oxidized form. Now, if these are rapidly stimulatory to plant growth, then they may or may not be a problem depending on the location of discharge and the area or volume of water over which this growth stimulation is distributed. What I am suggesting is that there may be an alternative interpretation based on the circumstances of discharge and the character and volume of waste rather than an unequivical statement that one type of treatment is either good or bad for the environment. Certainly, we ought to look into the possibility that in those cases where we think a secondary effluent has caused a problem, could not that problem have been alleviated or entirely prevented by another location for the outfall and/or a different design for the outfall so that the initial dilution zone would be either deeper or wider
or some other configuration. It seems that a full scale observation of this type of situation may be possible. Certainly, controlled experiments ought to be conducted before a definite conclusion is reached that secondary treatment is harmful for the environment.

The next question that Dr. Issacs raised was with respect to the toxic forms of metals. He cites chromium and mercury as cases in point where the usual valance states are essentially nontoxic but the more oxidized states are violent poisons. The essence of this concern is that chromium and mercury in various kinds of sewage may be in a reduced state but in activated sludge or other secondary treatment processes the metals are oxidized. To what degree or to what extent this takes place in the treatment plant is perhaps a good question for physical chemists to investigate in research activities relating to treatment plant performance. Perhaps processes might be improved to meet requirements of the marine environment. We should also look at what happens when the effluent is discharged to the environment. I suspect that the way in which metals leave the treatment plant may not have a lot to do with how they behave in the environment. Let me be more specific. If we are concerned about toxicity of metal forms, perhaps we should determine how the metals behave when they are mixed with seawater and shouldn't we do this for both particulate and soluble forms of the metal? And, shouldn't we do this for particulates which settle in the seabed and are subsequently influenced by a variety of geochemical sedimentary processes? I think we should attempt to find out if the ultimate fate of the metals, including their toxic forms, their distribution and their concentration isn't influenced more by the environmental processes and less by the form in which they left the treatment plant followed by rapid dilution in seawater within a few minutes to concentration
of 100 to 1 or less. If it turns out that the form of the metals is influenced very strongly by environmental factors which begin to exert dominating influence only a short distance from the outfall then the form leaving the outfall may make little difference. It may turn out that with respect to some metals it makes no difference whether the effluent is primary or secondary and it may also show that secondary treatment was not harmful to the environment.

John Ryther from Woods Hole also questions the utility of secondary treatment, implying that, if not directly stating, that secondary treatment provides an effluent which may cause harm in the environment. The harm that he describes follows from the growth of phytoplankton stimulated by oxidized forms of nitrogen and phosphorus in secondary effluents. Eventually the phytoplankton die and decompose removing dissolved oxygen from the water and in extreme cases create an anoxia and mass mortality of marine life. This secondary crop of organic matter represented by the phytoplankton may be as large as or even larger than the organic loading of the original untreated wastewater. This issue of secondary growth and its resulting impact associated with treated effluents warrants additional investigation. Increased knowledge about the long-term behavior of nutrients derived from domestic sewage as it is incorporated into one or more segments of the food web might provide some valuable insights into strategies for wastewater disposal in the coastal zone. For comparison, one might investigate the nature and extent of a similar situation resulting from primary effluents or raw effluents discharged to the environment. Isn't it likely that primary effluents which contain a greater mass of nutrients would eventually be oxidized or otherwise incorporated into secondary productivity and represent even a greater oxygen demand on the environment? Wouldn't raw domestic waste create even a still
greater impact? I think an alternative explanation might be that for the time and space scales involved, this secondary production, and the ensuing oxygen demand on its demise, need not be a problem unless the wastes are confined to coastal areas where replenishment with open ocean water is minimized. Under these circumstances it may turn out that secondary treatment would produce even less of an adverse impact than primary or no treatment.

The question of harm to the environment by secondary effluents is a most serious one for us to get to the bottom of because whether or not it is necessary or sufficient in any specific case, it is nevertheless one in our repertoire of treatment techniques that will be with us for a long time. More particularly, what we need to find with respect to our 301(h) situation is the right kind of treatment for ocean outfalls if a secondary treatment is not the right one. I call this "marine secondary", which in concept is not any specific set of waste treatment processes but may represent a variety of processes which are more effective than primary, and which are specifically selected to match the conditions of the environment, the economical alternatives for the outfall location and the character of the waste stream. I think one of the most promising approaches to this concept of marine secondary is the removal of particulate matter. By removing particulate matter we will be focusing, even if it is indirectly, on some of the pollutants of concern in the marine environment, i.e., some heavy metals and toxic, exotic, persistent, synthetic organics which are known to be associated with particulates. Also, we will be focusing on a problem of direct importance in that particulates frequently lead to sludge deposits or, more appropriately, altered sedimentary material which often is the most obvious impact in the region around the outfalls. In the history of the sanitary engineering profession in this country, I cannot
imagine a more unfortunate choice of words than "advanced primary", which in concept is very close, I believe, to what I propose and what my colleagues have proposed in attempting to achieve the opportunity that 301(h) has provided. I believe if we had stumbled upon this concept and chosen an appropriate instead of an inappropriate term several years ago, we would have been much further along in this effort. While some research is now being conducted to yield the specific parameters that will be needed to develop specific marine secondary processes, a great deal more research needs to be done that will relate observed environmental conditions to water quality criteria. That, together with outfall diffuser performance data can be used to define specific effluent requirements. The 301(h) program over the next several years provides the best opportunity to get this information and will provide a critical test of whether or not we can establish a rational scientific basis for the regulation of ocean outfalls.

IV. Improvements in Water Quality Criteria

As the last point in my talk I would like to develop a little further the idea that water quality criteria represent the central focus of a rational approach to regulations of ocean outfalls. If we can demonstrate after three to five years of effort in the 301(h) program, that we have been able to avoid environmental damage by employing a variety of treatment techniques under a variety of environmental situations, I believe we will be able to specify a set of water quality criteria applicable to the boundary of a mixing zone that will represent protection of the marine environment and control of the pollutants which are of concern to the marine environment. Presume for the moment that we are successful. If we have established water quality criteria that we
must meet at the end of a mixing zone, we know that can design ocean outfalls
to meet those criteria under average conditions and under specific rare condi-
tions depending on the sensitivity or frequency you might wish to prescribe.
From this we will compute specific effluent requirements that must be met.
And, from this we can realistically expect engineers to develop the appro-
priate processes to meet those requirements. It seems to be a promising blend
of both an environmental approach and a technology approach. I expect we will
find many common requirements throughout the country and we may find one, two,
or three (probably a small number in any event) of treatment processes which
will, perhaps with small modifications, do the job for a base level of treat-
ment. Most marine scientists today accept the idea that a technology base for
part of the control of pollution of the marine environment is admirable.
Toxics control at the source or in a pre-treatment mode is an example.

Again, assuming we are successful, looking at it from the far-field point
of view or the environmental perspective, we will be able to devote consider-
ably less of our resources to the variety and extent of monitoring programs we
will have to conduct to determine the absence of environmental impacts. I am
not saying that we can get away entirely from field monitoring. There will
probably be any number of reasons why we have to look for specific alterations
or very subtle changes in the marine environment. But, we should certainly
hope that we will come away from this experience with a dedication of con-
siderably less resources for every outfall in the country than we would be
facing under a continued program such as the next three years will require.
If we are successful this will represent, I believe, a system which allows for
case by case considerations and will also be manageable and appealing from the
standpoint of the publicly owned treatment works, the state, federal, local environmental protection organizations, and the Congress. And now the question is, "Can it be done?".

If water quality criteria are going to be useful in representing conditions necessary and desirable to protect a variety of marine uses, they by necessity must be variable themselves. The criteria to protect bathing water uses in tropical climates may be considerably different than what may be required in temperate climates. These differences may or may not be represented in terms of numerical concentrations but certainly would be a different in temporal distribution, perhaps seasonally. The specificity of many water quality parameters would need to be extended and improved considerably. For example, in relation to protection of kelp, we would need to have more detail relative to turbidity and suspended solids concentration that reflect, no pun intended, the amount of light reaching critical areas. These may or may not be the same as the parameters that would be used to protect a valuable resource relating to scuba diving in some coastal areas. To protect benthic environments we would need to extend water quality criteria to include interstitial waters and sediments and would expect to develop a new set of criteria analogous to water quality criteria relating to sediment quality. Criteria would have to take into account environmental factors, perhaps to a degree of complexity considerably greater than what is known today about the behavior of materials in the marine environment. Where transformations of chemical forms are important, as for example with nutrients and metals, we would need to know more about the mechanisms involved and the rates of reaction so that water quality criteria would accurately reflect the expected fate of the material. I believe this goal is achievable through a combined program of research and
monitoring associated with the behavior of materials discharged from ocean outfalls.

While this goal may be achievable it may be very expensive and it may not be achieved to everyone's complete satisfaction in the three to five years we now project as the timetable in front of us for 301(h). Our present research program relating to ocean outfalls anticipates that we will follow this approach. The mandatory monitoring program for successful 301(h) applicants will provide the opportunity for collection of some of the most important field data we need. We will, however, have to supplement this monitoring effort around outfalls where 301(h) permits have not been granted in order to provide the necessary comparisons. We may have to add on specific research objectives into the monitoring program at the 301(h) sites in order to obtain supplementary data for parameters we believe are important but which are not specifically regulated under 301(h). For example, one of the most serious unanswered questions is the health effects from consumption of finfish and shellfish caught around outfalls and containing certain levels of metals or organics in their tissues. Tissue concentrations for some of the materials we are concerned about may not be required under the 301(h) program, but in order to get at the question of exposure and risk assessment for those people who do consume fish from that environment, we will need to obtain additional data. We will have to make sure that we have comparable conditions for like environments but different diffuser systems, like environments and like diffuser systems but different waste characteristics, and adequate comparisons for large and small discharges. It is difficult to estimate how much this research effort will cost in order to provide results which will be useful in improved management schemes. We expect that the total program in addition to the
mandatory monitoring program will cost at least 2 million dollars per year. At the present time, EPA is devoting about $500,000 per year to the kinds of research projects that will need to be continued. Our present budgetary forecasts indicate that this is not likely to be increased significantly in the next year or two. Consequently, it seems that the municipalities and perhaps the states will have to contribute to this research effort if significant advances in the state-of-the-art are to be made.

This is the first opportunity I have had to discuss the major provisions of 301(h) and the associated research needs. I sincerely hope that this program will move along vigorously and will not be significantly redirected as a result of the two law suits that have been filed to impede the promulgation of the regulations. It was indeed an honor to be invited here to discuss this with you and it is a real pleasure to be in the land of unstressed waters.

Thank you very much.