MODIFICATION OF SECONDARY TREATMENT REQUIRE-
MENTS FOR DISCHARGES INTO MARINE WATERS

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TESTIMONY OF PROF. JOHN D. ISAACS, DIRECTOR, INSTITUTE OF MARINE RESOURCES, UNIVERSITY OF CALIFORNIA, SAN DIEGO

Dr. Isaacs. Thank you, Mr. Chairman. Another decrepit member of the faculty of the University of California rises to these hearings.

As I understand my role in these hearings, it was to lend a broad perspective to the nature of marine trophic systems, particularly contrasting with the commonly accepted view, that in rivers and lakes, and also particularly as the characteristics of them relate to waste water effects in the open sea.

Mr. Chairman, members of the Subcommittee on Water Resources, my name is John D. Isaacs. I am a professor of oceanography in the University of California, at Scripps Institution of Oceanography and the director of the statewide Institute of Marine Resources. In this capacity, I also administer the California Sea Grant College program, the Food Chain Research Group, and other components of the institute.

I continue to carry out personal research on a variety of marine oriented scientific and technical matters. These interests and research projects include those in the areas of physical oceanography, climatology, resources, marine biology, pollution, marine microbiology, trophic systems, marine engineering of various sorts, and a number of others, even social scientific, as are indicated by a representative list of publications which has been supplied to the subcommittee. In addition, I can make a complete list available should the subcommittee wish.

I am a graduate of the University of California at Berkeley, and have been a member of the staff and faculty of the university for about 34 years. I have been elected to membership in three academies-the National Academy of Science, the National Academy of Engineering and the American Academy of Arts and Sciences.

However, my beginning interest in marine matters stemmed from nonacademic experience. My early years as a merchant seaman, the owner and operator of a deep sea fishing vessel off the Pacific coast, and as an engineer in charge of naval base construction, have often guided me toward the applied.

I appear at the invitation of the subcommittee. My statement briefly sketches an overall perspective of the biological economy of the sea, contrasting it to the terrestrial and freshwater systems, pointing out from this contrast the serious ways in which the nature of the sea is commonly misunderstood, and commenting on the faulty perception of the system apparent in the regulations of the Environmental Protection Agency in their marine discharge policy and those misperceptions of the present proposed modification that is the subject of these hearings.

In a few minutes I will try to indicate the broader picture of how the forms and nature of the living systems of the sea have come to be, and particularly of the ways in which their sharp contrast with the living systems of the land have arisen and how these differences widely mislead us in our struggle to understand the impact of man's rapid emergence as a geophysical, geochemical, and biological force.

I will point out examples of these marine versus terrestrial contrasts and attempt to indicate some of the ways in which they often drive our research, our concerns, and our social and legal actions into irresponsible and unrewarding directions---directions that can be not only impressively expensive or even impoverishing but which may fail to profit from potential benefits of man's work.

The usual picture of the nature of the web of life of the sea is a more complex visualization of the trophic pyramid that is commonly thought to model the food pathways on land. In this imaginary text-book picture, plants initiate the cycle, and various herbivores, primary carnivores, secondary carnivores, are each born into their allotted niche in the pyramid, to constitute a vast, delicately balanced and tottering structure-a house of cards-ready to collapse into lifeless chaos with the slightest jiggling by the profane hand of man.

Regardless of the possible veracity of this picture in land, lake and perhaps other special delicate or limited systems, it is the misapplication of this idealization to the living systems of the open sea that has mislead us into an hysterical "the planet is dying and the sea is dead" syndrome and into irrational proposals and actions.

Actually, almost all of the creatures of the open sea are born into a highly variable and stochastic system, in which they have little assurance of the nature of their prey, predators, associates, or competitors during their span of existence. They find repast in anything grossly accessible to their mode of feeding, and are eaten by anything to which they are available. Individually and collectively as populations, they are opportunistic, unspecialized and resilient.

Yet the hypothesis of the ordered pyramid of life persists. To paraphrase Nicolli Machiavelli, "An hypothesis is always more believable than the truth, for it has been tailored to resemble our ideas of truth whereas the truth is just its own clumsy self. Ergo, never discover the truth when an hypothesis will do."

The terrestrial, marine, and freshwater systems have developed in adherence to the same great laws of physical, chemical, and biological evolution; in consequence of the same initial bequest of cosmic matter: and in response to the same broad episodes of solar and planetary evolution. Yet in the present stages of development, these systems usually dramatically differ, and seldom coincide in their responses and vulnerability to the activities of man. The creatures of the sea are born, live, breath, feed, excrete, move, grow, mate, reproduce, and die within a single interconnected medium. In land animals, however, many of these functions are largely separate between and within the three media of air, water and soil that land creatures utilize. It is not in the terrestrial experience continuously to inhale the young, eggs, sperm, food, and excreta of all of our fellow creatures, as do essentially all marine organisms. Although it may seem repulsive to us, it, nevertheless, is the way of marine life.

The cycle of life in the sea, like that of the land, is fueled by the sun's luminous energy acting on the pigments of green plants. Of every 10,000 photons of light reaching the Earth only some 5 enter into net production of basic organic material. Perhaps 3 of these 10,000 photons contribute to the growth of land plants and 2 to the growth of the single-celled green plants of the sea, the phytoplankton.

It is at this first stage that the fundamental differences between the terrestrial and the marine organisms and life systems are initiated. The primary production of organic material on land is mainly conducted by large multicellular plants immersed in a light gas and attached and concentrated on solid surfaces, whereas the marine food material is first elaborated by microscopic cells, singly or in loose aggregations, which are dispersed widely in a dense, circulating, and liquid medium. Only along some rocky coasts, where large marine plants are conspicuous does the sea produce some relatively large herbivores in a single trophic step.

At every subsequent step in the two living game plans these initial differences are further complicated. I will have time to point out and sketch only a few examples of these differences, but my emphasis, of course, is that these differences must be recognized if we are not to be tragically misled in our attempts to deal with mankind's needs from the sea and man's effects in the ofttimes painful process of his accommodation on this planet.

The initial input of food in the form of microscopic dispersed particles imposes restrictions that influence the nature of oceanic life throughout its entire development. This condition has not only encouraged such developments as eyes in near microscopic forms and filters of a bewildering variety, but it has urged all creatures excepting the terrestrial expatriates - marine mammals and birds (and some sharks) - to produce their young in immature larval forms so that they have access to the much more abundant fine particulate food at the commencement and terminus of the trophic web. Most of these larval forms pass through a number of complex and often grotesque stages and suffer almost total mortality before some few rejoin the adult stocks. The results of this ubiquitous tactic of marine organisms are many and I will mention a few. First, reproduction, which imposes an inescapable material burden on all adult organisms and which may expend 50 percent or more of their potential growth, is subtracted from the population biomass of almost all marine creatures. The remnants of the original material of the reproductive products which persist in the developing adult are infinitesimal. In the marine realm essentially all of this material is thrown downward through the food web to the more primitive particulate and detrital feeders, and is one of the strong homogenizing influences in the marine food web, one that drives marine systems even more strongly toward particulate and detrital feeding. In sharp contrast, in the macroscopic land food web large herbivores feed on large plants, reproductive products are added to the population biomass, and the young soon partake of the adult food and are early susceptible to the adult predators and parasites.

Parenthetically, would we not find it a peculiar world if each wolf produced 1 million tiny wolf eggs dispersed widely in the winds to hatch into virtually unrecognizable wolf larvae, metamorphosing and growing in innumerable stages, early preyed upon by the spiders, birds, and earthworms? And imagine the shepherd, dealing with a flock that not only produced 100 million barely visible young sheep larvae, but which also consumed young wolves in their grazing. It is just such almost unimaginable differences as these that sharply contrast the living system of the land and sea and that foster widespread misconception of the sea.

Implications of the difference in the two reproductive game plans are important, and some particularly so, in respect both to our employment of the oceans as a source of food and to our dealings with pollution in the marine environment.

For example, one class of worrisome contaminants is mutagens, those chemical agents that produce genetic changes. Since most mutations are undesirable, the creatures of the terrestrial system, with their limited number of progeny, are particularly vulnerable. However, for creatures that each produce a half million to one-half billion young as with most of the creatures of the sea, genetic defects appear to be naturally common. When marine fishes first were introduced into the Salton Sea of California, over 30 percent of their progeny were grossly defective with blind, even jawless adults being abundant. As soon as competition and predation developed in that sea, however, such defective adults disappeared. Similar conclusions can be drawn from an absence of genetic defects in the fishes of Bikini Atoll, subjected to millions of megacuries of highly mutagenic radioactive material in the mid-decade of this century. It is important to note that defective marine creatures can exist only where the environment is broadly out of balance, for example, where a selective fishery on a major predator has reduced predation. Otherwise, defective individuals are rapidly eliminated. This is a particularly instructive case, with their limited number of progeny, are particularly vulnerable, of some trace substances, as they are slower growing than the average. Thus the abnormal survival of a normal incidence of defective marine fish may be falsely interpreted as a problem of pollution, whereas in truth it may be the result of a selective fishery on quite a different species.

I will mention one more important case that ensues from the marine reproductive game plan. The organic pathways of the sea are largely conducted by immature and growing individuals who suffer immense mortality in this role. This is quite unlike the land, where young are a comparatively minor component of the biomass, mortality is low and adults dominate. This preponderance of growing individuals sets and important limit on the single step concentration factors for trace substances and contaminants that pass through the marine food web in ingested food. The effect, which is inadequately recognized, can be stated as follows : a trace substance in food that is taken up by an organism is "diluted" by the new tissue that a growing organisms is accumulating from the food. Thus, for example, if one quarter of the food is converted into new tissue, the upper limit of the single step concentration factor for such a trace substance in the organism is four. In nongrowing organisms such as adult land animals there exists no limit from this effect, the concentration factors can be tens or hundreds of thousands. It is this effect that undoubtedly has in part been responsible for the failure to demonstrate serious bioaccumulation of trace contaminants in marine creatures except in the nongrowing adult marine birds and mammals, such as gulls, seals and sea lions, which follow the terrestrial plan to a degree. This is not to say that these forms should not be protected, of course.

It is quite likely that this effect also has been responsible for the fact that fishes of the Mediterranean display somewhat higher levels of a number of trace substances than their Atlantic and Pacific counterparts, for the fishes of the Mediterranean are undoubtedly slower growing that the former, for the Mediterranean is a particularly unproductive and starving sea. It is also this effect that must be carefully considered in any interpretation of abnormalities in marine forms associated with elevated levels of trace substances in their tissue. The facts may be that the elevated levels are merely the result of slow growth due to undernourishment from impaired activity.

It is a fact that the seas of this planet hold only about one-tenth of the number of species of creatures that inhabit the land environment. Prima facie conclusions from this fact are that the sea holds fewer environmental niches, and that there are fewer specialists and more generalists and opportunities in the marine than in the land system. Another conclusion is that the trophic system of the sea cannot be the delicately balanced, structured trophic pyramid that is envisaged and idealized. Why should there be comparatively fewer species in the sea ? I have discussed two homogenizing effects, the microscopic input of food and the wide dispersal of reproductive products (and detritus) which make it difficult for specialists to develop, particularly in the early stages of the food web, and which also make most creatures similar as far as trace element composition is concerned.

As a measure of the comparative degrees of specialization possible in the two realms, we might contrast the 8,000 or so species of free-living copepods (a broad general link in the oceanic food web) with their terrestrial counterpart, the 800,000 or probably, 1 million species of land insects. As a result of these several effects, and as I said earlier, most creatures born into the sea have little assurance of the nature of their prey, predators, competitors, or associates. They are forced to be opportunistic.

I will have time to touch on only two other contrasts of the land and sea, the chemistry and the stability.

The sea has ever been a sink for the chemical materials leached from the land. Thus, it should be no surprise that the land and sea creatures differ sharply in their chemical needs, deficiencies, and susceptibilities. By definition, in a manner of speaking, if land animals find it necessary to concentrate some trace material from terrestrial sources, it is likely that sea creatures will find the material in abundance, for it has been leached from the land. Iodine, calcium, and salt are examples. On the other hand, those trace materials the sea creatures must concentrate, such as zinc, copper, iron, and silica, are likely abundant on land, for the materials have been precipitated from seawater and incorporated again into the landmasses. Thus both the chemical evolution of the sea and the biochemical evolution of its creatures cause almost totally opposed effects for most inorganic trace substances introduced into the sea.

It is from the action of these dual principles that the bones of sheep, remote from nuclear contamination by almost half the circumference of the planet, contain a higher concentration of radioactive strontium than do the bones of Bikini fish, where millions of megacuries of fission products have been injected over the last two decades!

The penultimate point that I must make concerns the circulation, the chemistry, and the stability of the oceans, and the distribution of the major plant nutrients, those materials - phosphate and nitrate - that are essential to all plant growth. On land these substances are taken up by plants and regenerated (or in some cases manufactured) from debris in the soil, where they are readily available for recycling into the food web. In humid jungles, for example, the free nutrients in the soil are almost nonexistent, so rapid is the uptake by the plants. In the sea, the same regenerative processes take place but much of it so far below lighted levels of the sea, that only extraordinary conditions or events, such as upwelling, can elevate or mix the essential nutrients into the near surface layers where they can again be employed by plants to reinitiate the cycle of life. It is the peculiar nutrient cycle of the sea, and the sea's circulation and stability, that restrict highly productive regions of the oceans to less than 20 percent of it's area. These factors condemn the oceans to a total organic production that is probably less than that of the land, despite their far greater expanse, for most of it is on a starvation diet. Blue, the color of oceanic deserts, dominates the sea, even in relatively productive regions such as the Pacific coast.

Many countries bordering on the deep blue sea are planning extremely expensive and highly advanced municipal waste treatment plants, ostensibly to avoid "polluting" the sea with organic material and nutrients. In my mind, such plans reflect the serious misunderstanding of science and the misguidance of social action by a lack of appreciation of the nature of marine biological systems. They neglect these facts: that a major part of the adaptation and activity of the creatures of the sea is directed to the conversion of waste particulates into new organisms; that most of the sea is starving and particularly deficient in just those sorts of materials that are introduced by domestic waste; that seawater is a toxic material to most land organisms and highly inimical to their survival (apparently including wastewater pathogens); that the many parts of the sea are now even denied the millions of tons of organic material that once annually flowed from rivers (for the natural flows of these materials are now stopped by dams); that there is no evidence that the marine discharge of secondary effluent improves anything, and reasons to believe that it may be more disturbing than any present practice; that the net changes engendered in the marine environment by primary discharge are an enrichment; that to expend vast sums of money for the construction of advanced treatment plants for domestic waste to prevent feeding a starving sea may well be a wholly irresponsible act. Witness that the doubling of fisheries production in the North Sea over the last two decades is reluctantly being attributed to the input of domestic waste into that system.

I must, of course, immediately modify this statement. There must be adequate source control of chemical pollutants. It is insanity to introduce into the sea such levels of organic mercury and DDT as have been discharged into Minimata Bay in Japan and Whites Point in California in the past. Also, removal of floatable materials and other advanced primary treatment must be exercised, and properly designed offshore discharges must be used. There also must be continuous alertness and monitoring for important pollutants such as PCB or mutagenic compounds and mitotic poisons, like dioxin. But to urge devotion of immense amounts of precious capital for sophisticated treatment at the secondary, tertiary or quaternary level, perhaps suitable for delicate lake or river environments, to avoid feeding the open sea, totally disregards, I believe, the true nature of the sea.

Indeed, to repeat, it is not clear that secondary treatment of domestic waste is a panacea for anything. In secondary effluent, trace metals and plant nutrients, are introduced in highly oxidized and highly available form. The toxicity of these metals is closely related to their valence state, and it makes no sense at all to reduce the metal contents of a discharge by 60 percent or so at great difficulty and expense, only to increase the toxicity of these metals by factors of thousands or more. Chromium and mercury are cases in point, where the usual valence states are essentially nontoxic but the more oxidized states are violent poisons. The same applies to the plant nutrients, which in primary treated sewage are partly tied up in organic food and only slowly available after passage through the food web. In secondary effluent, these nutrients are in the raw form and rapidly stimulatory to plant growth. On land, one pays a high premium for "natural" fertilizers where the trace metals and nutrients are in organic form and only slowly released to the plants after decay in the soil. However, the chemical fertilizers, ammonia phosphate, for example, are far cheaper but far more difficult and dangerous to employ. It seems a strange aberration of logic to contemplate expensive steps that take a premium grade natural fertilizer and food, and degrade it into brash and toxic chemicals before discharge into the sea.

I have spoken at length with planners in other countries on these matters. Their ultimate point seems to be that they want to copy us! They want the best technology regardless of whether it is the right technology. Like the March Hare, in Alice in Wonderland, who, after having buttered the works of his pocket watch, could think of nothing better to say than: "It was the best butter, you know."

More generally, I believe that it is the responsibility of scientists objectively and openmindedly to investigate and understand; and of public servants to weigh the total research, knowledge, and understanding and to act on it with insight and perspective without regard for the hysteria of the moment. We have yet to learn how to support scientific research dealing with man's accommodation to this planet, and to take social action without first generating a popular hysteria that clouds the vision of scientists and engenders acts and regulations that most often have no basis in research understanding nor even a basis in good judgment and probability.

There is a vast fund of important research results and understanding of the sea. This fund is a major resource. The responsible scientist and the responsible civil authority will act freshly on this knowledge, rather than blindly follow the "planet is dying and the oceans are dead" syndrome of hysterical actions.

Yet, in the United States, great sums of money have been expended in marine research, but to believe that the majority of regulatory actions of U.S. authorities on a wide range of marine problems are a rational result of the research findings, is a delusion.

This is truly a worldwide tragedy. No other country can conceivably duplicate the extensive research of the United States. A natural result is for other countries to conclude that our acts are the result of our understanding, and to copy them. Perhaps, we can afford this sort of irrational expenditure, but for some other countries it can only compound their bitter struggles.

With my conviction that the gulf that cleaves action and understanding is a most tragic syndrome of our times, it was with deepening sadness that I reviewed the EPA proposed modifications under consideration. Although the document does not reflect a bare suspicion that the open sea may have different characteristics than rivers and lakes, it directly or implicitly repeats the same old myths of the bioaccumulation of trace metals, the delicate balance of the marine environment, the all-healing properties of secondary sewage treatment, and many of the other cliches and misperceptions that already have led us to a serious estrangement from reality.

There is an abundance of similar cases, each somewhat different but each difficult or impossible to approach because the problem, if in fact there is one, has been defined too narrowly or erroneously or capriciously. Indeed, once these definitions have been recorded in the pristine and persistent tablets of law or policy, the enforcing or regulatory agency may specifically constrain any research that questions the validity of the supposed premises under which the law was established. The Marine Mammals Act, as administered, in effect eliminates the possibility of meaningful inquiries on the tuna-porpoise problem, just as the policy on domestic sewage effluent discharged to the open sea largely precludes research into its actual effects (for this also would question the presumptions of the law) despite the fact that these inputs appear mainly to be beneficial, contrary to the proclamations of Cousteau and Heyerdahl.

This is the most ominous cut of all, and many of the great regulatory and enforcement agencies in the United States are beginning to adopt the pose of the medieval churches, with regard not for what is true or right, but rather for what defends their notions of the intent of regulatory laws or their established policies and for what supports their own delusions of power, omniscience, and infallibility! The beleaguered scientist with evidence of the fallibility of these agencies, or the triviality of a program that they regulate, or of the underlying faults in their regulations can only recant his findings (if he wants any more research support) and content himself with the muttered aside: Eppur si muove ("nevertheless it moves")- as did Galileo, following his confrontation with the awesome forces of the hierarchy of his times.

One of the reasons for these excesses is that problems are our new frontier. We have come to value the problem more than the solutions. As Meg Greenfield recently pointed out, we tend to "colonize" them greeting each new problem, real or otherwise, as new and precious lands for settlement and a joyous, happy, and profitable existence. Shortly, such multitudes of research scientists, politicians, agencies, administrators and subsidized industries have joyously thronged to and colonized the problem that we daren't penetrate it very deeply lest it sink. In fact, much effort is spent in cultivation and refurbishment of the problem so that it continues to appear fresh, important and worthy.

I submit that humankind will encounter a sufficiency of problems on our stumbling path toward and adjustment with this planet. We cannot afford to do other than dismiss or solve those we can and move onto newer lands. What that requires is the vision to perceive the nature of these new continents across new seas so that the colonials can be moved on. As Whitehead has said:

Here we are with our finite beings and physical senses in the presence of a universe whose possibilities are infinite, and even though we may not apprehend them, those infinite possibilities are actualities.

With few exceptions - and the proposed policy modification before you is an exception - I truly see little that evokes joy whenever I approach the verge of that deep and unbridged gulf that now cleaves action from understanding.

It was mainly the challenge of the seas that lifted medieval European man out of the dark ages. His explorations of the oceans of this planet, his discoveries of the continents, his development of navigational instruments and ships led to new confidence that he could surpass the accomplishments of the ancients and overcame the inadequacies of his institutions and the darkness of his times.

The sea again challenges our sciences and our institutions and again possesses the potential of leading us into a new and future world.

Surely we must strive to perceive that new and future world within the infinite possibilities of which Whitehead is so confident, lest ultimately, like Stevenson's Villon, we be found still doctoring the toothache on the Judgment Day.

I have available to the subcommittee if you wish, a Scientific American offprint on "The Nature of Oceanic Life" that I published several years ago. I have used some extracts from this and others of my publications in the foregoing statement.

I thank you for your interest and for the privilege of presenting my thoughts to you on this important issue.

[The following was received for the record:]

(See Isaacs, J.D. 1967. The Nature of Oceanic Life. Scientific American).

Retyped from pages 36 through 44 of the hearings, verbatim including typeset and any editorial, grammatical and punctuation mistakes.
Alan J. Mearns, December 11, 1998