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Committee on Merchant Marine and Fisheries

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My name is Joseph M. O'Connor, and I reside in Warwick, New York. I am employed by the New York University Medical Center, Institute of Environmental Medicine where I currently hold the rank of Research Associate Professor of Environmental Health in the Department of Environmental Health Sciences. I am currently Principal Investigator or co-principal on five research projects, four of which deal exclusively with aspects of contamination in estuarine and marine environments and/or the impact of such contaminants on human health.

I received my Bachelor of Science degree in Biology in 1966 from the College of the Holy Cross, Worcester, Mass., and completed my Ph.D. at the State University of New York at Albany in 1971. My professional interest in the environmental impacts of dredging and dredge spoil disposal began in 1970 at the University of Maryland Natural Resources Institute where for three years I studied the effects of suspended and deposited sediments on estuarine and marine fishes. From mid-1973 through 1974, I was employed at Lawler, Matusky and Skelly Engineers, Tappan, N.Y. In January, 1975, I took my present position at the N.Y.U. Medical Center, specifically to develop a program within the Laboratory for Environmental Studies aimed at studying the interaction of contaminants in aquatic systems with human populations.

Introduction

My testimony will be limited to considerations of Environmental Health relative to estuarine and coastal marine systems. Environmental health, the study of environmental factors (living and non-living) which affect, or have the potential to affect, human health and well-being, must be differentiated from Public Health. Public health, which is the practice of disease prevention and control in human populations relates to environmental health insofar as branches of environmental health provide data which public health scientists use for disease prevention and control measures, and to ascertain origins of disease in human populations.

The physics, chemistry, and biology of trace contaminants in aquatic systems, especially estuarine and coastal marine systems, is first, not well know, and second, a new and expanding field of study. For these reasons, this testimony is presented on an empirical level. Our understanding of organic contaminants and metals in the urban-coastal ecosystem consists primarily of monitoring data and descriptive analyses of lethal effects on aquatic biota and bioaccumulation studies. Highly theoretical considerations, such as risk assessments remain based on external studies.

The specific topics for discussion by this panel relate strongly to risk assessment, i.e., to quantify the losses and uncertainties associated with undesirable events. Risk and hazard are both defined (1, 2) as the product of the extent of damage and the probability of an accident. In dealing with the Bight environment and the major contaminants of concern (perticides, PCBs, PAHs) we are faced with a task of evaluating risk in the context of an already existing source of contaminants. That is to say, it is understood, a priori, that the spoils of the New York region, as well as most dredge spoils from maintenance operations in major ports, contain toxic metals, pesticides, PCBs or PAHs. The presence of such contaminants in coastal systems is well documented (3, 4, 5).

Risk to Human Health from Ocean Dumping of Dredge Spoil

I. Procedures and Parameters Used to Evaluate and Predict Risk to Human Health

Risk or hazard analysis may proceed by a number of methods; "fault-tree" analysis (2), mathematical risk assessment (6, 7, 8), and the modified Delphi technique (9) for risk analysis being employed here. All procedures for risk or hazard assessment have several factors in common for predicting (i.e., foretelling) and evaluation (i.e., quantification) of health risk. The more important of these, in my opinion, are listed and described below, in relation to dredge spoil disposal problems in the New York Bight:

A. Prediction of risk - Procedures and Parameters

1. Identify hazardous compounds in the system - dredge spoils, sludges, sediments, etc.

2. Establish priorities for attention
   a. compounds requiring investigation
   b. compounds not requiring investigation at this time.
3. Demonstration that hazardous compounds occur in food chains leading to man.
4. Quantitation of hazardous compounds available to man

B. Evaluation of Risk - Procedures and Parameters
   1. Determine rate of consumption of contaminated food items in the human population
   2. Estimate the quantity and identity of contaminants ingested and assimilated
   3. Compare ingestion-assimilation estimate to levels previously identified as causative of human or animal disease.

Prediction of Risk

A large body of data is available documenting the presence of hazardous compounds in modern, technological society. The New York metropolitan area produces and discharges many hazardous compounds to nearby rivers, estuaries, and coastal waters. Studies conducted over the past 15 years. (5, 10, 11, 12) have documented the general classes of contaminants most prevalent in the Bight region. A panel of experts (13) evaluated contaminants in the Bight region, and suggested priorities for research based upon the potential for human health effects, the potential for ecological impact, and extent of distribution in the environment. Three classes of compounds given highest priority in the Panel report (13) were: 1) chlorinated pesticides; 2) polychlorinated biphenyls (PCBs); and 3) polynuclear aromatic hydrocarbons (PAHs). In subsequent environmental monitoring studies (14,15), concentrations of these three groups of compounds were determined in sediments and biota from New York Harbor waters, and from the New York Bight. Selected data from various monitoring studies (14,15,16,17,18) have been compiled (19) and will be published this year. These data make possible a prediction of risk to human health from ocean dumping of dredge spoils; i.e., they document the presence of potentially toxic compounds in the sediments and biota of the region.

This by no means estimates a specific risk to the human population. It is my opinion that a critical requirement, necessary for prediction of risk (quantitation of compounds), has not been fulfilled. Adequate information on the distribution of pesticides, PCBs and PAHs in the Bight region is only now being gathered. Only in the case of fishes from the Hudson River (12,15,16,19) do there occur instances of contamination (PCBs) which predictably fall above U.S. FDA action limits for PCBs in foods.

Prediction of Risk

Whereas a prediction of health risks associated with dredge spoil dumping in the Bight may be made, it is another matter to evaluate the potential risks. I have identified, above, the steps necessary for evaluation (or risk estimation).

Steps for risk assessment are outlined by IRLG (6) as follows:

a. definition and quantification of exposures

b. characterization of exposed populations in quantitative terms

c. chemical and physical properties of the substance, and its activity in relation to exposure

d. prudent...extrapolation of responses from observed to estimated exposure ranges...

e. qualification of the estimated risk in light of... differences that may be present in the exposed population.

It is impossible to make an empirical evaluation of human health risk for pesticides, PCBs, and PAHs in the Bight region, primarily because the data available are not adequate for full assessment. For example, although estimates of fish and shellfish consumption in the population exist, most are based on responses to mailings, market basket surveys, restaurant patronization, and the like. While the general population may be represented by such estimates, they do not characterize the exposed population. Research must be conducted to determine the extent and magnitude of finfish and shellfish consumption in "heavy user groups" (minorities; ardent fishermen; poachers; local villages). When these data are combined with expanded data on contaminants in finfish and shellfish, the beginnings of a reasonable risk assessment can be made. Under the circumstances of highly toxic, potentially carcinogenic chemicals, the personal survey will serve more to identify the populations at risk (20) than the highly sophisticated statistical approaches currently applied on a national basis (21). It should be noted that the local Health Systems Agencies have expressed a need for such data.

The most critical parameter in evaluation of risk is the identity of the compound(s) of concern (6). Within the broad range of compounds identified in the New York Bight studies (10,14,15), 21 chlorinated hydrocarbons (pesticides and PCBs) were encountered regularly, as were 15 PAHs (15). The distribution of these compounds was not regular; only PCBs and DDT (including metabolites) were found consistently in most, or all, of the sediment samples and biota (19). The occurrence of other compounds was sporadic. Laboratory studies show that PCBs and DDT behave somewhat similarly in the environment (see review in 22), but have important differences as to structure, toxicity, persistence and biodegradability. Most important is th fact that "PCB" represents a mixture of classes of compounds (210 possible isomers; see 22), whereas the DDTs represent only a handful of compounds.

A factor which has not been addressed in animal toxicity studies is that the PCBs in environmental samples are apparently not the same as those utilized in industry and lost to the environment (14-19,22,23). Environmental samples demonstrate a loss of the lower chlorinated classes, and enrichment of the classes representing tetrachloro, pentachloro, and hexachlorobiphenyls. Most analyses see these as, e.g., "Aroclor 1254", or "Aroclor 1260" (12,16-18,23,24), whereas newer techniques will see them as component PCB classes (14,15). This environmental transformation of PCBs becomes critical in risk assessment when one considers the following:

1. Different industrial preparations of PCBs (Aroclors) have different toxicities to plants, aquatic organisms and mammals (22).
2. Different PCB isomers have different toxicities (25).
3. Laboratory studies of toxicity and health effects (including invertebrates, fish mammals) have been carried out with industrial Aroclors, or with one of a few purified PCB isomers (22,25-27).
4. No studies have been carried out to determine if PCBs from environmental sources (fish, shellfish) show the same level of toxicity and physiological effect as the industrial preparations.

Since the question remains whether contaminants (e.g., polychlorinated dibenzofurans) may have contributed to Yusho and to occupational disease from PCBs (22,27-29), it seems incumbent upon us to resolve this question. The source of PCBs to humans, except for accidents, is primarily via seafood (22). Therefore, we must carry out the appropriate animal tests to determine the toxicity and potential health effects of the PCBs found in seafood.

II. Rationale Used for Determining the Level of Risk Which is Acceptable

Thirty-six organic compounds have been determined from samples of sediments, sewage sludge, and biota from the New

York Bight. Many of the compounds determined in food organisms represent known or suspected toxicants, mutagens, teratogens, co-carcinogens, and carcinogens. The more potent carcinogens determined in the fish and shellfish from the Bight region (dieldrin, benzo(a)pyrene, benzo(e)pyrene) are present at very low levels (15), and absent from most samples (14). PCBs and DDT (or metabolites) are present in most samples of sediment, fish, and shellfish (14,15). For most of these compounds, health risk assessments have not been performed using ingestion as the route of application. FDA has established action levels or criteria for very few. Proposed water quality criteria are being established by EPA (25,30).

The rationale behind acceptability of health risk depends upon: a) adequate data on demonstrable disease occurrence (via epidemiology, laboratory animal studies, etc.); b) consideration of appropriate "safety factors" for exposure (recognizing the non-threshold concept; 6,8); and c) recognition that health effects from accidents, occupational exposure, or laboratory data do not similate the low-level multiple compound exposures that occur in the environment.

An acceptable risk level can be established only after risk evaluation has been completed. Such an evaluation does not exist at present; essentially no data are available on the potential for health effects due to ingestion of low levels of pesticides, PCBs and PAHs in fish and shellfish. It appears ill-advised to establish acceptable risk levels prior to evaluating the risk for specific exposed populations.

Such populations are, in many ways, analogous to industrially exposed workers. Perhaps it's best to make the point with an example.

Foundry Cove, a backwater of the Hudson River, has been contaminated with cadmium (31). In evaluating the magnitude and extent of the contamination, it was noted that blue crabs in the Hudson were contaminated with cadmium at levels which may present a health risk to humans if they were eaten regularly (one meal per week, ten crabs per meal, 20 weeks per year). Based upon these findings, and armed with the results of a door-to-door survey of crab consumption in Cold Spring, N.Y. (32), an estimate was made of the population-at-risk for cadmium intoxication in that portion of the Hudson Valley which comprises New York's largest commercial and sport fishery for blue crabs (33).

The Cold Spring survey told us that 11% of the population eat crabs regularly. Some 4% consumed ∿ 200 crabs per year (fresh and stored frozen). If one assumed these values to represent the population residing between Yonkers and Newburgh, where crabs are most numerous, then a figure for a "population-at-risk" of ∿ 20,000 emerged (20). However, we can conclude that this estimate is wrong on two accounts. First, for the regional population, it overestimates exposure to cadmium in crabs. Second, for certain areas, like Buchanan, Verplanck, Haverstraw, Piermont and Cold Spring, it may underestimate exposure by a significant margin. In many small villages there exist enclaves of full-time and part-time fisherman which extract much of their meat protein, and some income, from the River. They fish for shad (and, formerly, striped bass) in the spring, and crabs, when available, through the summer. These individuals are exposed to cadmium to a greater extent than the rest of the population. Yet, their specific conditions fall outside the purview of regulatory agencies because they become lost in the statistics.

One can extrapolate to other localized populations throughout the Bight region where intake of potentially contaminated fish and shellfish is high. Professional fishermen, seafood workers, and poachers in closed areas may consume fish and shellfish at a rate far above the "average". Their exposure to contaminants, therefore, would be above the average. If adequate epidemiological work were performed on these populations, there may emergy a far better estimate of health risk associated with the consumption of fish and shellfish contaminated with the organic compounds found in the Bight.

III. Assumptions Involved in the Prediction of Risk

Whether the presence of the organic contaminants in food organisms can be assumed to be due to, or exacerbated by the dumping of dredge spoils is the subject of another panel. The evidence required to begin a health hazard evaluation according to the criteria of IRLG (6), exist for at least some of the contaminants (22,25,27-30). The prediction and evaluation of these health risks will depend on the validity of various assumptions. Some are readily proven, others are untested hypotheses. Some of these assumptions, and my estimation of their validity, are listed below. It is assumed that:

1. The levels of organic contaminants in the biota of the Bight region are due to, or exacerbated by ocean dumping of contaminated dredge spoils.
2. The toxicants present in food organisms are those which have been proved to impact health (i.e. using epidemiological studies, or extrapolating from animal data).
3. The route of exposure producing effects in animal studies, or in catastrophic events such as Yusho, is the same as that expected for exposure to contaminants in the Bight.
4. The same doses of contaminants occurs due to ingestion of contaminated foods as occurred in laboratory tests, or in catastrophic events.

Assumption 1. The validity of this assumption depends upon demonstrating a positive cause-effect relationship between contaminant concentrations in dumped sediments (or water affected by dumped sediments) and associated biota.

Studies of PCBs and chlorinated pesticides have shown:

1. the amount of dissolved material added to the water column was negligible at sediment-water ratios of 1:10 or less;
2. the amount of material dissolved from resuspended solids is negligible at sediment-water ratios of 1:10 or less;
3. materials are transferred to the water column by means of resuspended solids, which generally settled out within 5-24 hours (34).

This has been interpreted to mean that the quantities of contaminants in dredge spoil are dispersed over an area perhaps greater than the designated dumpsite, effectively diluting the quantities of contaminant at the spoil mound. Field data from the Bight region (14,15,19) show no correlation between sediment contaminant levels at the dumpsites and contaminant concentrations in biota. PCB concentrations in most of the fish from the Bight region (15,19,35) range from 0.1 ppm to $\sim$ 0.7 ppm. When compared with ambient water PCB levels ($\sim$ 0.04 ppb) one may calculate a bioaccumulation factor of $\sim 10^4$, very similar to that seen for most fish, shellfish, and invertebrates exposed to PCB only in water

(35-37). While it is possible to hypothesize that water uptake of PCBs in the Bight region is strongly affected by dredge spoil dumping, it is also true that the data to test that hypothesis do not exist. Specifically, information on the quantities of PCBs transported to the Bight region in the Hudson River plume are not available. Despite the suggestion made as early as 1972 (22; p.283), that we should "... determine water transport mechanisms...in solution <u>and in suspension in rivers and the shallow sea</u>..." (emphasis added). A few data points from up river stations are available (38) which show that fine suspended material may transport PCBs at concentrations of $> 15\ \mu g\ g^{-1}$. These data, from brackish and freshwater sectors of the river, cannot be freely extrapolated to the Harbor region.

Assumption 2. With the exception of the PCBs the toxicants present in the biota of the Bight region may be assumed to represent those used in animal studies and implicated in catastrophic incidents. For most of the available Bight data, the identity of organic contaminants was established using combined gas chromatography - mass spectrometry techniques.

For the PCBs, this assumption presents special problems in that

1. most animal studies have been conducted with industrial PCB preparations (25), and;

2. questions remain with regard to industrial exposures and Yusho, as to whether the effects were caused by, or contributed to by other contaminants (PCDFs in Yusho, 22,29; PCDFs, polychlorinated terphenyls, and polychlorinated naphthalenes in various industrial exposures, 22, 28).

Verification of PCB health effects should be performed in animal experiments using samples representative of, or extracted from, contaminated fish and shellfish.

Assumption 3. The potential for a compound to exert health effects may be specific for, or strongly biassed toward, a particular route of exposure. In the context of contamination by dredge spoil disposal in Bight region, it must be kept in mind that the primary route of exposure for humans will be ingestion (15,22). For many of the carcinogenic PAHs, the health risk from ingestion remains to be demonstrated. Their carcinogenic potential has been evaluated only through inhalation, or implantation.

Assumption 4. ingestion of PCB-contaminated striped bass from the Hudson River (at 15 ppm in the fish) at current recommended limits of one 100 g meal per week results in daily dose to an average man of 2.8 ug/kg/day of PCB. The Panel on Trace Hazardous Substances (22) reported that an ingestion rate of 1-3 ug/kg/day was an Acceptable Daily Intake. One ug/kg/day is 100 times less than the lowest "no effect level" reported from animal studies in 1972 (39).

Consumption of fish from the Bight region at the same rate (e.g., winter flounder at 0.7 ppm PCB, 100 g, once per week) results in a daily intake of 0.14 μg/kg/day. Seven meals per week yields a daily intake of $\sim$ 1 μg PCB/kg/day.

IV. Research Needs for Improving Reliability of Prediction Relating to Risk to Human Health

In my opinion, the following areas of environmental and health-related research should be undertaken to improve the reliability of present and future health risk assessments. Recommendations made previously in the testimony are listed; exhaustive explanations are not repeated.

Environmental Research

1. Establishment of a Comprehensive Bight Monitoring Program

Purpose: Anticipatory and Research Monitoring.
Monitoring for Regulatory Development.
Enforcement Monitoring.
Monitoring Success of Control Programs.

Adequately designed monitoring programs (40) for toxic contaminants in sediments, food organisms and "indicator species" (41) will provide information critical to the efforts of all scientists working the Bight region, especially those concerned with the dynamics of contaminants in the biotic and abiotic components of the system, and those attempting to perform human health risk assessments.

2. Comprehensive Survey for Identification of Point Sources of Organic Contaminants

   Purpose: Enable quantitative estimate of contaminant inputs.

   Identify sources requiring control.

An evaluation of sources, sinks and distribution of organic contaminants in the Bight (19) has concluded that major sourced of PCBs and PAHs to the Harbor sediments (and, subsequently to dredge spoil) occur in the metropolitan region. Such sources include combined sewer overflows, raw sewage discharges, treated sewage discharges, and stormwater runoff. Since nearly half the PCB, and a large portion of PAH input to the Lower River may derive from such sources, their identification and control (if possible) may benefit the entire system by reducing contaminant loads in sediments.

3. Generate a Specific Set of Environmental Transport Models for Pesticides, PCBs and PAHs in the Bight Ecosystem

   Purpose: Clarify interrelationships of the various contaminant classes.

   Identify regions susceptible to impacts.

   Evaluate actual health risks.

This recommendation dates from 1972 (22) in reference to PCBs. Our current situation (14,15,19) of contending with a large array of PAHs in addition ot PCBs gives even more force to the recommendation.

Toxicological Research

1. Define the toxicity of environmental contaminants, especially PCBs, in the context of animal studies performed with industrial preparations.

(Explanation provided in previous text.)

2. Develop, and Apply, a Method for PCDF Analysis in Large Numbers of Environmental Samples.

Since PCDFs may occur as contaminants with PCBs (28,29), their presence and action in the environment, and in human health is a possibility, and should be investigated.

3. Expand Studies of the Physiological Fate of Organic Contaminants in Aquatic Ecosystems.

To quote from the Panel on Hazardous Trace Substances (22, p.337) "...It is not possible to evaluate the significance of levels...in environmental samples without better knowledge of (their) biological fate in species of interest...".

Human Health Research

1. Identify Local Populations "at risk", and Estimate Health Hazard

(Explanation provided in previous text.)

2. Conduct Additional Studies of Organic Contaminants in Human Populations

Purpose: Determine distribution of contaminants in high-risk populations.
Establish rates of clearance of contaminants in human populations.

V. Adequacy of EPA-COE Ocean Dumping Criteria in Addressing Risk to Human Health

The greatest potential risk to human health in the Bight region derives from eating striped bass from the Hudson estuary (12,15,19,22). Some concern about pesticide concentrations in Hudson River blue crabs has been expressed (10,19), but subsequent studies of pesticides and PCBs in crabs (16) suggest that the risk is minimal.

Whether the EPA-COE criteria are adequate for minimizing risk to human health can be assessed in a preliminary manner from currently available data on pesticides, PCBs, and PAHs in food organisms (15-19,35,42). As stated above, the potential PCB dose to humans from eating such organisms may be estimated as 100 times lower than the lowest dose causing effects in laboratory animals (22,25, 27,28).

Environmental data and laboratory data lead me to the conclusion that dumping, as practiced under the present criteria and evaluated according to the present procedures (43,44) are adequate to protect human health insofar as we understand the health risk associated with consumption of fish and shellfish with low levels of organic contaminants.

The relationship of the existing criteria to ecological effects, however, is a matter for some discussion. The data now emerging from field studies in the Bight (review in U.S. Army Engineers "Matrix" report, 35) and from analysis of other aquatic systems (4) suggests strongly that uptake of organic contaminants conforms most closely in characteristic to direct water accumulation by equilibrium partitioning (19,23-25,35-37). It remains an important question whether uptake directly from sediments and from food is of significance to contaminant transport in marine ecosystems (35-37,42,45). Ecological impact considerations should receive prime consideration at this time. Given the absence of biomagnification of organic contaminants in marine food chains (14-17,19,22-25,30,34-36,42,45), criteria enforced to maintain the ecological integrity in the system should provide adequate protection for human health.

The transport of organic contaminants on suspended solids is a critical parameter necessary for understanding the sources and fates of these compounds (22,35). I wish to reiterate the need for a regular monitoring program for organics in the Bight-Harbor region, and the need to gather sufficient data to generate specific transport models (22). I endorse, in principle, the "matrix" approach to the problem of dredge spoils proposed by the Corps of Engineers. I suggest strongly that a significant research effort be maintained for defining the levels of organic contaminants which represent "trace" quantities of presently "prohibited constituents" (46) in dredge spoil.

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