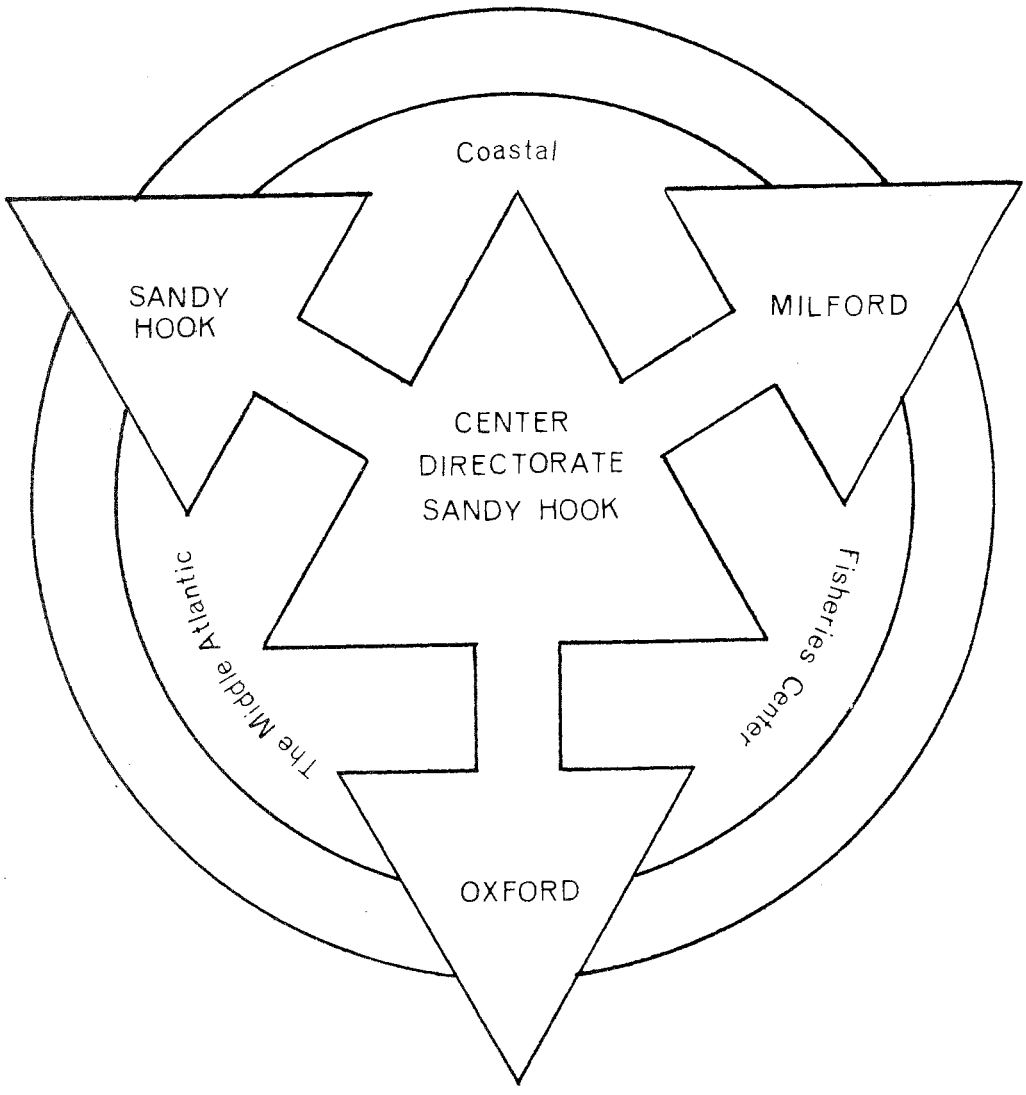
BIOLOGICAL BASELINES AND EFFECTS OF ENVIRONMENTAL CHANGE ON MARINE ORGANISMS
A PROPOSAL TO NOAA-MESA -- PART 1

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region

MIDDLE ATLANTIC COASTAL FISHERIES CENTER



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Biological Baselines and Effects

of Environmental Change on Marine Organisms

A Proposal to NOAA-MESA

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I. INTRODUCTION

It is now almost universally recognized that the nearshore waters of the oceans cannot be considered simultaneously as a stable source of living resources and as a waste disposal area. The ecosystems of the sea are resilient up to a point, but man's rapid encroachment into and degradation of inshore waters lead to genuine fear for the continued productivity of such waters.

Environmental degradation resulting from man's activities has readily observable effects on the inshore marine ecosystem, and on the living resources which are integral parts of that ecosystem. Such effects are usually negative, resulting in reduction in quantity and quality of products derived from the degraded environment. While we may feel, intuitively, that harmful changes result from environmental contamination, it is necessary to develop a body of demonstrated facts to support or refute any suppositions we may make. Vital to this development is establishment of a baseline of present information about distribution and abundance of living resources and waste materials; determination of rates of change, metabolism, and cycling of waste materials and organisms as derived from historical data, present surveys and future monitoring; and experimental verification of effects of environmental factors such as pollutants on living organisms.

The disposal of sewage sludge and dredging spoil in the ocean has been an accepted mode of waste disposal in the United States for over a century. Yet still not enough of the proper kind of information is available to adequately

determine the consequences, present and future, of disposal of wastes in the coastal ocean and in particular in the New York Bight. Buelow (1968) and Buelow, Pringle and Verber (1968) in a report concerned with ocean disposal of waste material stated that the extent and effects of the sludge blanket resulting from the disposal of approximately 12,600 yds^3/day of sludge were unknown. Buelow also referred to the previous studies concerned with hydrographic measurements in the New York Bight (Redfield and Walford, 1951; Miller, 1952; Howe, 1962; and Bumpus, 1965) as well as the study by Redfield and Walford (1951) concerned with the effects of ocean disposal of acid industrial wastes.

Burd (1968) has thoroughly reviewed the general problems associated with sludge handling and disposal. A report by the Tyneside Joint Sewerage Board (1969) considered the disposal of sludge from a specific treatment plant in the United Kingdom. Their report included sections devoted to barging and piping sludge to sea as well as the use of seabed drifters to determine possible movements of suspended solids by water movement. Grigg and Kiwala (1970) recently presented information concerned with the effects on marine life of sewage waste discharged from pipes terminating a short distance offshore.

Recently, MacKay and Topping (1970) and Shelton (1970) have reported on the effects of sewage sludge dumping in the Firth of Clyde and Thames Estuary, respectively. In their preliminary report, MacKay and Topping indicate that the disposal of 1,000,000 tons of sludge per year in the Firth of Clyde has resulted in "little obvious harm to the environment". They did, however, report a build-up of organic material and heavy metal residues on the sea bed

as well as some indication of qualitative changes in the fauna. It should be considered, however, that the wastes reportedon by these authors are deposited in 300 feet of water and amount to only one-fifth the tonnage of sludge and less than one-tenth of the combined amount of sludge and spoils currently being disposed of in the New York Bight.

The paper by Shelton (1970) is of interest even though it is based on data taken during only one month (April 1970). The author investigated a disposal area at the mouth of the Thames where five million tons of sludge are dumped annually in water 60-70 feet in depth. This is an amount equal to that disposed of in the New York Bight.

Saila et al. (1968) investigated the effects of dredging spoils resulting from the Providence River and Harbor Improvement Project, which were discharged at a designated site in Long Island Sound. An interim report prepared by the Chesapeake Biological Laboratory (1967) considered the gross physical and biological effects of overboard spoils disposal in the Upper Chesapeake Bay.

Very recently, Horne et al. (1971) have reviewed the problems associated with the disposal of sewage sludge and dredging spoils in the waters of the New York Bight. Brown and Shenton (1971) have reviewed and evaluated the general problems associated with waste disposal at sea. Based on findings of the BSWM study and Council on Environmental Quality's report they concluded that, "...it is no exaggeration to state that the environmental effects of past and present dumping operations are, with the exception of those dumped in the New York Bight

(sewage sludge, waste acid, dredging spoils) and off Cape May, Delaware (waste acid, sewage sludge) not even qualitatively known, much less measured accurately".

Most recently the NMFS, Sandy Hook Laboratory (1972) reported on the effects of waste disposal in the New York Bight. Impetus for this study was obtained from the reports of Buelow (1968) and Buelow, Pringle, and Verber (1968) concerning waste disposal in the New York Bight. The authors of the Sandy Hook report concluded that disposal of dredging spoils and sewage sludges has had a demonstrable, and often deleterious effect on the living resources of the New York Bight. They demonstrated that heavy metals and coliform bacterial concentrations were elevated in the sewage sludge and dredging spoil disposal areas relative to surrounding areas. Species diversity and biomass of benthic communities were decreased within the sludge and spoil beds relative to surrounding areas. Diseased larger crustaceans (crabs and lobsters) were observed inside the disposal areas and diseased fish were found from the shallower waters of the New York Bight with as many as 80% of the individuals of some species affected. Artifacts from humans (cigarette filters, band aids, etc.) were found in the digestive tract of fish collected from the waste disposal area indicating that finfish do feed at least at the periphery of the waste disposal areas and hence are exposed to the toxic and pathogenic contents of these wastes.

The effects of waste disposal activities in the New York Bight demonstrated by the Sandy Hook Laboratory were sufficient to document that such activities do have a deleterious effect on the living resources of the New York Bight. However,

the Sandy Hook report did not attempt to show any statistical relationships between the living resources and the waste materials being disposed in the Bight. Consequently, a program is presented here to: 1) statistically demonstrate the effects of waste disposal activities in the New York Bight; 2) provide the type of information that can be used by policy makers directly for the optimal management or regulation of waste disposal, public health, commercial and sport fishing, and recreational activities in the New York Bight and other coastal ecosystems.

III. DESIGN AND DESCRIPTION OF THE PROGRAM

Although interrelated, the procedures and techniques required to meet the foregoing objectives are substantially different; correlations between data obtained by biologists and physical scientists must be made if we are to understand the dynamics of the Bight ecosystem and answer questions such as: "Are the sludge beds increasing, and if so, at what rate?" (See Appendix 1 for a list of questions).

Where the personnel or facilities of the MACFC are unable to pursue certain disciplines, contracts will be let to academic or research organizations possessing the requisite expertise (Table I). The various data from elements of MACFC, NOAA-AOML and contractees will be processed and correlated to provide ready data interpretation (Table II).

The information developed will be used to help predict the impact of specific environmental changes on marine ecosystems and living marine organisms, and to recommend measures to mitigate the impact of man-made environmental changes on vulnerable inshore ecosystems and especially on the component living resources and on man himself.

A. BIOLOGICAL BASELINE AND PROCESSES

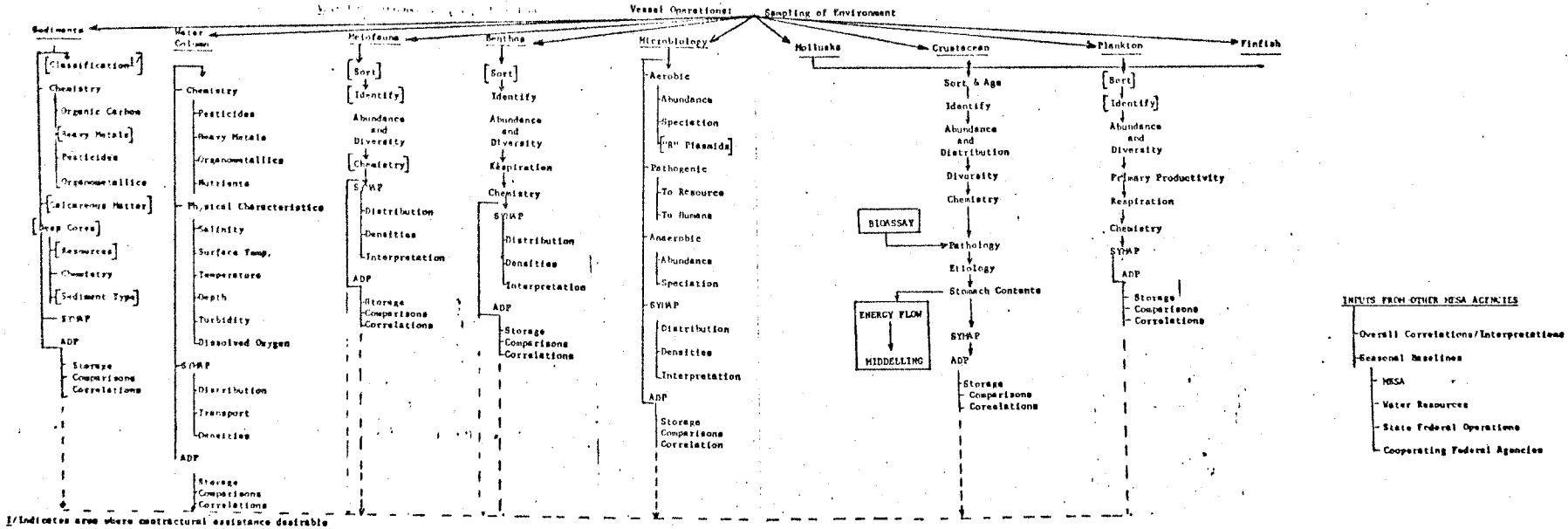
Detailed discussions and workshops (See Appendices 2 and 3) involving numerous marine and benthic ecologists have resulted in the conclusion that no sampling program can be established to ensure statistically valid results unless the area to be studied has previously been sampled to determine sample variance for each subarea. Numerous samples from the Bight already exist and these are

Table I. Research institutions and areas of competency which can be supported by MACFC and NOAA-MESA. Principal investigator in brackets.

MESA -- Possible Contract Research

Geological	Chemical	Microbiology	Benthos	Pathology	Productivity	Physiology
Adelphi (Koch) sediment types	W.H.O.I. hydrocarbons in fish	Montclair State (Kodischek) genetic transfer	CUNY (Tietjen) meiobenthos	Johns Hopkins (Bang) effects of temperature on immunity in invertebrates	CUNY (Malone) productivity and energy flow in lower Hudson	U. Tenn. (Vaughan) effects of h metals on salinity adaptation
Lehigh (Parks) sediment types	Rutgers (Sather) crude oil effects on clams	Rutgers (Atlas) oil degrading bacteria	U. Maryland (Small) ciliates as indicators			
	Syracuse (Sikka) pesticides	Rutgers (Litchfield) Vibrios				
	N.Y.Ocean Science Lab (Alexander) heavy metals					
	U. Michigan (Service Contract) heavy metals					

Table II. Ongoing and proposed research within MACFC and their relationship to NOAA-MESA. Research problems amenable to contract indicated in brackets.



1/Indicates areas where contractural assistance desirable

being examined to determine sample variance. Some subareas are not well represented and special sampling will be undertaken to determine sample variance for these areas. The results from the work-up of existing and acquired samples will be used to develop sampling strata for determining the placement and number of samples to be taken for statistically valid results (See Figure 1).

Benthic organisms are known to be excellent indicators of changing environmental characteristics, and the definition of benthic faunal communities within the New York Bight is necessary to assess the dynamic processes in the physical and chemical environment. In addition to their value as indicator organisms, the benthic fauna is an important, often sole, source of food for higher trophic levels. Therefore, the abundance, distribution and species composition of animals living on or in the bottom are often critical to the well-being and productivity of commercially important finfish, shellfish and marine game fish.

While surveys of communities are underway, the general biology of significant species will be investigated so that normal life history and population processes of the more important benthic species can be understood. Population dynamics including reproduction, recruitment, growth, and mortalities of selected fish and shellfish species will be included (Appendix 4 d, g, i, j,m, p, q, r, s and v).

It is of immediate concern to determine what selective effects man's activities may have on populations of microorganisms, the protista as well as bacteria and fungi. Man's activities in the aquatic environment may be related to disease processes affecting the abundance, distribution, and utilization of

the living marine resources. Certain microorganisms are involved in conversion mechanisms, i.e., methylation of mercury, hydrocarbon utilization, pesticide degradation, etc. The identification and understanding of the physiological activities of these groups of microorganisms will result in an understanding of those processes of microbial degradation which may lead to pollution increases or abatement (Appendix 4 a and b).

An ongoing program of importance involves the distribution patterns of fecal coliforms in order to assess the degree of microbial contamination in certain areas. In addition, other microorganisms are being isolated to determine their relationship to pollution factors (Appendix 4, a and u).

In conjunction with the biological sampling, the following physical/chemical data will be collected at each biological sampling station visited: temperature, salinity, conductivity, pH, turbidity, dissolved oxygen, chlorophyll, and nutrient data at selected depths. Additional hydrographic and chemical collections will be made in coordination with the chmical program to fulfill their objectives. These data will be stored in the ADP data storage system along with the biological data as it becomes available (Appendix 4, k, p, q, r, s, t, and u). Physical data and distributions and biomass of biota will be almost immediately available as SYMAP printouts (See Appendix 8).

The initial step (FY 73) towards establishment of biological baselines will be an intensive survey of the estuaries and nearshore waters of the New York Bight to inventory and map (three dimensionally and seasonally) the biological and chemical conditions of this highly polluted region (See Figure 1 and

Appendix 4 s,u). Within this area exist or are proposed examples of almost all types of man's activities that affect the Bight; i.e.: domestic sewage, industrial wastes, ocean outfall lines, ocean disposal of sewage sludge and dredging spoils, dredging and thermal additions. The sampling program for benthic, nektonic and planktonic organisms will be as follows:

1. An intensive sampling program with the Smith-McIntyre grab for benthic infauna will be initiated in FY 1973. Samples will be collected at stations positioned within a stratified sampling scheme (See Figure 1). During the remainder of FY 73 we will concentrate our sampling in the apex of the Bight, i.e., in and around the dredging spoils, sewage sludge and industrial waste disposal areas, and within the upper reaches of the Hudson Shelf Valley.

   Samples of benthic macrofauna will be processed and analyzed following procedures outlined in Holmes and McIntyre (1971) and Hulings and Gray (1971) and according to the additional suggestions prepared by participants in the Benthic Sampling Workshop held at Sandy Hook Laboratory, 20-21 November 1972 and the MTS Dredge Spoil Disposal Workshop held at Montauk, N. Y., 27-30 November 1972 (See Appendices 2 and 3).

   A study of the sublittoral meiofauna is proposed to accompany a study of the benthic macrofauna. Review of previous reports on ocean disposal in the Bight indicates that a greatly expanded study of the meiofauna is required to assess the impact of dredging spoils and

Figure 1 . Distribution map of sediment types in the New York Bight.

The strata designated by Roman numberals are based on sediment types defined by A. Cok (Adelphia U.) and D. Swift (NOAA-AOML). Where discontinuous, the strata subsets are indicated by a letter. Benthic fauna data collected at previously sampled stations within these strata are being analyzed to determine faunal homogeneity. Additional samples, usually in replicates of five, will be collected at stations within the strata to confirm homogeneity. Random stations within strata will be resampled quarterly during FY 73-74 to assess seasonal change and variations resulting from pollutant induced stress. Ambrose Light indicated by ⊙

Compiled by Dr. A. Cok, Adelphi University, and D. Swift, AOML - Miami, unpubl.

sewage sludge on the living resources of the Bight. A proposal for the first year of research on benthic meiofauna has been prepared by Dr. John Tietjen, City College of the City University of New York. The proposal entitled, "Sublittoral meiobenthos of the New York Metropolitan Region", is attached as Appendix 5.

The processing of the samples (which will begin in FY 1973 and extend into FY 1975) will result in species lists, species distribution maps, diversity indices, biomass estimates, comparative data from impacted and non-impacted areas, community phenomena associated with different impact areas, and specimens for heavy metals, pesticides and PCB analyses.

At each benthic station, sediment cores (10-15 cm in length) will also be taken and analyzed for heavy metals, pesticides, PCB's, organic content, redox potential, and grain size distribution. Because of the important relationship between sediment type and benthic communities we have proposed that a detailed study be made of the sediment types found throughout the apex of the New York Bight. Dr. James M. Parks, Director, Center for Marine and Environmental Studies, Lehigh University, has submitted to MACFC a letter proposal to investigate the properties of sediments collected within the New York Bight. This proposal is attached as Appendix 6. The Lehigh investigation would be coordinated with ongoing biological studies within MACFC and the physical and geological research proposed by NOAA-AOML. The collections will be accomplished in FY 1973-74, analyses completed in FY 1975, and data outputs provided in FY 1975 and 76.

2. An investigation of seabed oxygen consumption will be made to measure and map the present rates of in situ decomposition of organic wastes occurring as a result of biological and non-biological processes (Appendix 4 u). From this, and additional information concerning the extent of organic wastes in the Bight and the rates of input and export by physical means, the following can be determined: 1) the rate at which organic wastes are accumulating or disappearing in certain areas; 2) the quantity of organic input the various areas of the New York Bight can accommodate without deleterious effects to the living marine resources; and 3) the time required for the sediments to return to a homeostatic condition capable of accommodating predictable, but as yet unknown, quantities of organic matter. It is essential that baselines of decomposition rates be mapped to monitor the spread of pollutants in the future and to provide policy makers with usable information on quantities of organic matter that delineated areas of the Bight could accommodate temporally without deleterious effects. Sampling and determinations will be made according to Pamatmat (1971 a and b).

3. The commercially valuable surf clam is one of the principal target species selected by NMFS to determine levels of pollutants present in living resources at selected offshore areas. Extensive resource assessment surveys have been conducted by NMFS in the Middle Atlantic Bight, including much of the area of the NOAA-MESA New York Bight study

(Appendix 4 p, q & s). These surveys are being considered for their applicability to MESA. If some areas need to be surveyed because previous investigations were inadequate or outdated, such programs will be initiated. NMFS-MACFC is continuing surf clam resource assessment surveys, (Appendix 4 p) and data essential to MESA benthic program will be available.

Hydraulic and scallop dredge tows of five minutes duration will be made in areas bounded by Smith-McIntyre sampling sites. An odometer attached to the dredge will measure the distance traveled and surface area sampled. The resulting samples will be sorted for benthic macrofauna and used to develop semi-quantitative data for the larger and rarer organisms not sampled by the Smith-McIntyre quantitative grab. Other than using a minimum screen size of 10 mm^2 (instead of 1 mm^2 and 0.500 mm^2) the samples will be treated and analyzed as indicated in the "Handbook on Benthic Ecology" (Holmes and McIntyre, 1971).

4. Demersal finfish will be collected by use of an otter trawl. Fifteen and thirty-minute tows with a standard 30/60 trawl will be made monthly at 20 selected stations located in sampling strata within the Bight, principally in the strata inside the disposal areas but also at control stations (Appendix 4 p, q & s). Fish will be identified, measured, weighed, and examined for gross pathology on board ship. Selected species (particularly winter flounder, Pseudopleuronectes americanus; yellowtail flounder, Limanda ferruginea; silver hake, Marluccius

bilinearis; red hake, Urophycis chuss; white perch, Morone americanus; and striped bass, Morone saxatilis) will be saved for stomach content analysis and pollutant content. The otter trawl collections will result in information on species distribution, species diversity, community relationships, relationship of animal distribution to environmental phenomenon, food chains, and the distribution of pollutants in animals. Sampling was initiated in FY 1973 and will continue through FY 1974. Data analysis will be completed in FY 1975.

5. Collections of the larger malacostracean Crustacea will be made in conjunction with the otter trawl collections. A one-half meter and one-meter epibenthic sled fitted with a #0 mesh net will be mounted on the sweep of the otter trawl. The samples will be split and one-half frozen for contaminant analysis and one-half preserved for faunal enumeration and identification in the laboratory. The samples will be used for species distribution, community structure and relationships, relationship of animals present to fish stomach content, biomass estimates, food chain pathways, contaminant levels and incidence of disease. The schedule will be the same as the finfish program and the collections made simultaneously.

6. Preliminary plankton investigations have been done by NMFS-MACFC in the nearshore Bight region, Raritan Bay, Sandy Hook Bay, Hudson River Estuary and western Long Island Sound. The resulting data are being

reexamined for their information on species lists, community relations and diversity indices, seasonal patterns and standing crop estimates. In FY 1973, zooplankton collections will be made simultaneously with the finfish and malacostracan collections made with an otter trawl. "Bongo" nets fitted with #2 and #10 mesh net will be hauled obliquely during the otter trawl tow. The plankton samples will be split,with half frozen for contaminant analysis and half preserved for species enumeration. This will provide sufficient materials for identification and measurement of contaminant levels in the larger adult species (those collected in the #2 mesh net) and in the smaller planktonic species, including long chain diatoms and larger dinoflagellates taken in the #10 mesh net.

Inhouse research proposed and underway will be supplemented by a study proposed by City College of New York. This proposal, entitled "Phytoplankton productivity and energy flow in the Lower Hudson Estuary", is attached as Appendix 7. This research is directed towards measuring the effect of the Hudson River and its entrained pollutants on estuarine and coastal ecosystems. It will, in part, be oriented towards understanding the impact of Hudson River water on the Bight relative to the effects of ocean dumping.

7. Insofar as a microbiological baseline is concerned, there is an overriding need for immediate detection and identification of specific microbial types. To obtain baseline information on the distribution

of microbial types and numbers, the biological baseline sampling will be expedited through inhouse capabilities of MACFC (Environmental chemistry and microbiology investigation). (Appendix 4 a & m).

Long range task objectives are to establish baseline data, both qualitatively and quantitatively on microbial (aerobic and anaerobic) levels in the various elements of the ecosystem (animals, waters, sediments) and to examine the cycling of man-induced pollutants (microbial and chemical) through the biomass with emphasis on (1) concentrations of microorganisms and toxicants, (2) the influence of pollutants on microbial growth and types, (3) microbial conversion and degradation mechanisms of pollutants, (4) the synergistic effects of microorganisms and pollutants on marine animals, and (5) characterization of bacterial isolates by chemical, serological and animal assay methods, with emphasis on target species (predominant types isolated and Clostridia and Vibrio). The development of sensitive and specific methodology for the rapid and positive identification of marine microbes and chemical pollutants is a basic objective. This work is a continuation of studies now in progress in the New York Bight and Long Island Sound. (Appendix 4 a).

Studies on bacterial clearance and antibody response in finfish exposed to high levels of cadmium will be completed in FY 73. Bacterial clearance studies in an invertebrate exposed to industrial chemicals will be initiated in late FY 73.

Fin rot disease study of the New York Bight area will be directed to surveillance of prevalence as well as identification of the bacterial isolates obtained. Results of previous work will be published in late FY 73. An attempt will be made to verify if fin rot disease is restricted primarily to the heavily polluted marine waters of Raritan Bay and the inshore areas of the Bight. Research on the correlation between abundance of pathogenic bacteria and degree of pollution will be continued in FY 73 and 74 (Appendix 4 a).

Intensive surveillance and determination of nutritive requirements of phytoplankters involved in red tide problems of the New York Bight will continue. In addition, red tide blooms occurring in the New York Bight will be monitored for toxicity (Appendix 4 a).

Fenchel (1969), Fenchel and Riedl (1970) and Small (1972) have emphasized the importance of ciliates and other protozoans as components of the food web and as indicators of environmental change, including stress resulting from pollutants. MACFC has the inhouse capability to investigate the amoeboid protozoans commencing FY 73-74 (Appendix 4 n). Discussions are underway to negotiate a contract for the investigation of ciliate protozoans and their relationship to ocean disposal of sewage sludge and consequent reducing conditions. This investigation would start in late FY 73 or early FY 74 and continue through the first half of FY 76. The study would be closely

coordinated with the investigations concerned with reducing conditions and seabed oxygen consumption and benthic meiofauna. The ciliates and meiofauna are at the base of the food chains and are often the first organisms affected by environmental stress (Appendix 4 u).

FY 1974-75

a. Monitoring will continue at a reduced rate for fish, shellfish, benthic infauna and core samples. New or additional stations will be selected on the basis of their representation of a particular biocoenosis and ecotone; i.e., within an impact area, in a control area, or in a marginal area. These samples will provide data on seasonal and time variation in community structure and pollutant loads; seasonal sampling will begin in FY 1974 and will continue through FY 1975.

b. Investigations of the Hudson Shelf Valley will be instituted in FY 1974-75. The basic sampling program will be similar to the apex surveys in and around the disposal areas, except that sampling will be much less intensive in the offshore regions of the Canyon (Appendix 4 p, q, r, and u). Benthic sampling will be on a five-mile grid pattern in these areas. This sampling frequency was selected on the basis of inadequacies of a previous 10-mile survey and in consideration of the finite limits of MESA funds, manpower and

time. It is felt that the 5-mile grid can give gross changes in communities never before established in the New York Bight and the Hudson Shelf valley in particular. These samples will be taken seasonally and the material treated as outlined earlier. Plankton and population data will be drawn from the NMFS-MARMAP program. The benthic and malacostracan collections will be initiated in FY 1974 and sample analysis completed in FY 1975. (Appendix 4 k and u).

B. Contaminants Investigation

The objectives of the contaminants survey are to establish baseline data on the distribution of contaminants and to provide a program to monitor changes in levels of contaminants in the marine organisms and physical environment of the New York Bight. Representative organisms and water and sediment samples will be collected from cruises that will be initiated in the second half of FY 1973, as part of the Biological Baselines program and from ongoing NMFS activities such as MARMAP and NMFS-MACFC in-house investigations.

Research is now being conducted by NMFS-MACFC at sewage sludge disposal sites off New York Harbor and dredge spoil disposal sites in the New York Bight and Long Island Sound. We have found high levels of contaminants in sediments at these sites. Assays are being made by the Environmental Microbiology and Chemistry Investigation, MACFC, for contaminants in whole organisms and in specific organs or tissues. Identical materials are also being examined for pathogens and pathological conditions that might be associated with or result from contaminants. Exposure to chronic levels of specific toxic heavy metals have resulted in detectible tissue damage. (Appendix 4, a, m, u).

Specimens for heavy metal and pathological examination are routinely collected during NMFS-MARMAP groundfish surveys, including stations in the New York Bight. Port agents also obtain specimens of commercial fish landed at the major ports for heavy metal analysis. Many commercial catches of finfishes are made within the New York Bight region. Analyses of samples from these landings contribute

to our understanding of contaminant levels within the Bight. Catches from outside the Bight are being analyzed and used for comparative controls. (Appendix 4, a, m).

A more intensive survey to determine the levels of heavy metals; hydrocarbons, including petrochemicals and chlorinated hydrocarbons; and radionuclides in marine organisms and the surrounding environment will be undertaken in New York Bight, Long Island Sound, and ancillary embayments. In addition to the small number of selected target species currently being examined, the MESA contaminants survey must establish contaminant levels throughout the entire food web, i.e., the microflora and fauna, attached algae, benthic organisms, primary consumers, and carnivores at higher trophic levels, as well as in water and sediments of the area. (Appendix 4, a).

The initial phase of the survey will include the analysis of tissues and sediments collected in Long Island Sound, the New York Bight, and Raritan Bay during the second half of FY 73. These materials will be collected during cruises initiated by the NMFS-MACFC.

Sediment cores collected 10 to 12 years ago by Lamont Geological Library will be analyzed for heavy metals and organic contaminants; this will provide a historical baseline against which current and future values can be compared. This information may provide us with an additional estimate of the rate at which toxins are increasing in the Bight.

C. Experimental Studies of the Effects of Stress on Marine Organisms

The objective of experimental studies on the effects of pollution stresses is to determine the levels of contaminants which can directly or indirectly cause mortalities or affect growth or survival, and to identify differential responses of marine organisms to specific pollutants during various life stages. Assessment of contaminant levels that will affect or limit marine organisms must be conducted under carefully controlled laboratory conditions. Organisms must be challenged by acute dosages to show measurable mortalities within shorttime periods and by sublethal, long-term chronic exposures to indicate population limitations through modification of basic physiological mechanisms (see event diagram).

Acute challenges require mostly standard laboratory facilities, such as holding tanks and water supply, with the limiting factors being space for sufficient replicates for statistical validity and the availability of manpower. Since acute challenges are short-term (rarely more than 96 hours), sensitive life stages can be tested as they become available.

Chronic exposures, on the other hand, require sophisticated facilities to provide: pristine water, equipment for accurately metering contaminant dosages, and optimum facilities for maintaining test organisms for periods up to 2 years. Provisions must be made to decontaminate effluents before they are discharged to the environment. These facilities will not be available in FY 1973 but can be completed in FY 1974 if funds are available.

Challenged organisms,at various stages of their life history, will be examined by an array of biological disciplines to identify those features most

sensitive to contaminants. Capabilities exist within MACFC to culture bivalve mollusks and crustaceans, and experimental systems are available from academic studies for some crustaceans and finfish.

The studies will utilize physiological, enzymological, immunological, and histopathological techniques. (Appendix 4, a, m). Some of the research in future years can be carried out by contracts with educational institutions with particular competence in specialized areas. The specific approaches to these studies that can be most productive in the immediate future are detailed in the following:

a. Physiology: MACFC research in FY 1973 is designed to determine changes in osmoregulation of rock crabs, Cancer irroratus, and green crabs, Carcinus maenas, when exposed to heavy metals (copper and cadmium), and changes in oxygen consumption rates of gill tissues from these organisms after exposure. This, work will be continued, possibly including other metals, and will also assess changes in the osmoregulation of the cunner, Tautogolabrus adspersus. Experiments beginning in FY 1974 will determine changes in osmoregulation of other marine organisms. Experiments with stressed animals will be expanded to include polarographic measurements of large animals as well as an expansion of present micro-respirometry techniques. Respiration rates of crabs, fish, and mollusks will be determined "in vivo" during exposure to heavy metals. This capability should be expanded to include larval fish and crustaceans, when rearing techniques for pertinent species are developed. (Appendix 4, c, d, t).

b. Enzymology: This discipline provides the capability of short-term bioassay. The dynamic balance of enzyme systems is disrupted by chemical stress, therefore, early identification of enzyme changes can provide prediction of

organism viability. In FY 1973 selected tissues of target animals (crustaceans, finfish, and shellfish) are being examined, and normal patterns, both enzymographic and spectrokinetic, have been established for selected enzymes. In vitro and in vivo work with the pollutant metals, to determine their direct effect upon enzyme reactivities, will be initiated. In FY 1974, work will concentrate upon in vivo studies, beginning with acute exposure of the target animals to a range of concentrations of selected heavy metals and progressing to a study of synergistic effects of several metals. The main objects of scrutiny in FY 1974 will be the polymorphic enzymes, whose enzymographic profiles may alter as the animal adapts to its changing environment. (Appendix 4, a, t).

c. Immunology: Although marine fish, crustaceans, and shellfish have been found with high levels of chlorinated hydrocarbon and heavy metal contamination, there has been little direct evidence linking these levels with death of the animals. One important link can be through the immune system of the animal.

Current work in FY 1973 concerns antibody response in a finfish, the cunner, Tautogolabrus adspersus, exposed to cadmium, and projected work will include several other heavy metals. In FY 1974, immune responses in fish will be examined in the presence of other heavy metals (copper, mercury) and, if possible, two chlorinated hydrocarbons (one pesticide and one PCB). In later years immune mechanisms in selected crustaceans and mollusks will be examined, and effects of pollutants on such mechanisms will be determined. (Appendix 4,a).

d. Histopathology: Utilizing tissues from acute and chronic contaminant challenges, the resultant gross and microscopic pathology of marine organisms

will be examined. In FY 1973 examination of organs and tissues from selected invertebrate marine organisms from relatively uncontaminated areas of the New York Bight will be used to establish "normal" or baseline morphology and physiology. Animals can then be challenged with known toxic agents to determine sites or localization of pathology, types and severity of host response, micropathogen development, mechanisms of disease resistance, and disruption of tissue and cellular integrity. Also in FY 1973 tissues from fish exposed experimentally to cadium will be examined for histopathology. In FY 1974 tissues from fish exposed experimentally to metals other than cadmium will be examined, and a study of tumors and other lesions which may be associated with high pollutant levels will be initiated. (Appendix 4 d, m).

IV. OUTPUTS

The expected outputs of the biological program are described for each of the three major areas of investigation.

A. Biological Baselines and Processes

Analyses, beginning as early as FY 1974, will result in atlases, maps, and monographs of interest to a variety of Federal, State, and local agencies; private industries and organizations; and academic institutions. Outputs include such diverse items as distribution maps of representative pollutants, microorganisms, organisms, and sediment grain sizes; extent of the spread of a pollutant in relation to its sources; estimates of the accumulative phenomenon of pollutants in sediments and organisms; data for pollutant flow models and baseline information for comparative studies after pollution abatement or activity changes have occurred (i.e. termination of ocean disposal, relocation of disposal sites, new methods of disposal, changes in dredging activities, changes in water currents caused by various man-made structures or topographic alterations). Format and content of these outputs will be almost exclusively based upon continuing contacts with the area users.

Data will be analyzed along with inputs from other NOAA components to determine significance of total MESA output, and to prepare overall predictive models of the New York Bight.

Surveys will identify the origins of pollutants, and sources within the environment where animals assimilate contaminants. Survey results will provide outputs (between programs) on contaminant levels to which organisms are

exposed in the natural environment as a basis for selecting levels to be used in laboratory experiments.

B. Contaminants Investigation

After sufficient data have been acquired on the levels of contaminants in marine organisms 1) statistical analyses will be made available to interested groups (this information should start becoming available late in FY 1973) and 2) distribution atlases with isopleths for various contaminant levels will be prepared. In conjunction with IV A, this will result in data from which size of sludge and spoil beds and their rate of growth can be deduced as well as their possible effects on bottom dwelling and planktonic living resources.

C. Effects of Stress on Marine Organisms

The most important output of the stress work will be to make possible a comparison of experimental and field data, so that the precise effects of various levels of pollutants, singly or in unison, on various life history stages of selected organisms, may be related to environmental pollutant levels actually determined in baseline studies. Such a comparison will also be of great predictive significance in determining effects of anticipated or proposed environmental changes on populations of various organisms.

The output derived from acute and chronic exposure studies will be of value to enforcement agencies, such as the Environmental Protection Agency (EPA) for developing water quality criteria, which, in turn, will be used for developing water quality standards for our aquatic ecosystems. The studies will also provide an important informational base useful in coastal zone management and future

planning functions as well as to provide the data necessary to assess the environmental impact of proposed coastal zone developments.

Investigation of the effect of certain heavy metals on embryos and larvae of oysters and clams will be completed in FY 1973. The information will be made available to EPA and will also be disseminated through scientific journals. It is also expected that the research on the effect of cadmium, copper, and mercury on adult rock crabs, green crabs, and cunners will be completed in late FY 1973 and will be made available as above. By FY 1976, an appreciable body of information should have been accumulated and disseminated about the effects of heavy metals and other contaminants on a wide spectrum of organisms found in the New York Bight.

The results of research to determine the physiological and other biological effects of environmental stress will be made available to users in a variety of modes: as quarterly reports, as published manuscripts, through technical journals and, where possible, in the form requested by one or more interested users. This information can be used by EPA and state and local pollution abatement agencies toward reduction of specific contaminants by management and natural resource agencies to assist them in planning for the use and conservation of marine ecosystems and the associated resources.

D. Summary

Information will be of significant value to many user groups, including ocean industries of all kinds, sewage treatment districts and engineers, municipal and regional land and water use planners, state and federal legislators

and policy makers, Environmental Protection Agency (EPA), Food and Drug Administration (FDA), Corps of Engineers, River Basins Commissions, state fisheries and environmental management departments, citizen conservation groups, fishermen and fishery industries, and groups concerned with developing models of ocean systems. Information will be summarized, analyzed, and presented in as many forms as possible, to best meet the needs of diverse user groups.

The National Marine Fisheries Service, through its Middle Atlantic Coastal Fisheries Center (NMFS/MACFC) has substantial ongoing research in the New York Bight. Other federal agencies (EPA, FDA, Corps of Engineers, etc.) conducted specialized research. Through the NOAA/MESA program it should be possible to expand the work significantly -- both the in-house and that supported by contracts. The five-year MESA project provides the proper vehicle to bring broad capabilities -- governmental as well as academic -- to focus on the problem of the impact of man-induced environmental changes on marine ecosystems and on living marine resources.

V. REQUIREMENTS

The following list represents the equipment and support services required for the project.

A. Biological Baselines and Processes

1. Sampling in the estuaries and nearshore regions will require a 40-60 foot shallow draft vessel, capable of handling an otter trawl, plankton nets, Smith-McIntyre bottom grab, bathythermograph, XBT, water bottles, and electronic hydrographic measuring and recording instruments. The vessel will be needed for 40 sea days in FY 1973 and 60 sea days in FY 1974 and 1975. Time required for FY 1976 and FY 1977 is estimated to be about 24 sea days each. A navigation system, such as RAYDIST, will be required to permit precise station location and resampling. A RAYDIST system is available in NOS and may be available without purchase.

Field collections scheduled for later FY 73 and FY 74 and later in offshore areas will require a vessel (R/V Delaware II) capable of high seas work. It must be able to handle all of the previously mentioned gear and have room to accommodate additional researchers concerned with the physical and chemical components of the project. The vessel will be required for 50 sea days in FY 1974 with one-half of the days spread seasonally.

2. Where possible, standard MARMAP gear will be selected. The required field sampling gear listed below are standard off-the-shelf

items except for the Smith-McIntyre bottom grab, which can be ordered, if necessary, special from England or custom-made at local shops.

The following gear must be acquired: otter trawls, scallop and hydraulic dredges; plankton nets and epibenthic sleds; Tucker trawl; and Smith-McIntyre bottom grabs with attached photographic equipment..

3. The laboratory processing of the field collections will be started in FY 1973 and completed for all areas in FY 1976. This process will be handled by inhouse personnel and by contract to local universities and consulting groups. All samples generated by the New York Bight study can be stored at the NMFS facility at Sandy Hook, N. J. Funds will be directed for the processing, archiving, and maintenance of this storage system. Before the MESA program in the New York Bight is terminated in FY 1977, appropriate responsible users of this museum collection must be identified for long term maintenance.

4. Basic microbiological equipment is currently available inhouse through NMFS-MACFC. Emphasis will, however, be placed on the evaluation and development of equipment for the detection and characterization of microorganisms. Specialized instrumentation for identification of microbial types will be purchased in FY 1974.

5. Gear for sea bottom respiration studies must be fabricated or purchased by later FY 73.

B. Contaminants Investigation

Most of the facilities and equipment are available for analyses of the eleven metal ions that are to be initially considered. Contracts will cover any deficiencies. However, the following laboratory equipment will be needed: a gas chromatograph and detector for existing gas chromatographs.

Analyses of contaminants other than heavy metals may be done inhouse or by contract. Additional specialized equipment may be required beginning in FY 1973.

C. Effects of Stress on Marine Organisms

1. The equipment required for laboratory rearing of organisms would be mainly expendable items, such as plastic- and glassware. A major purchase of necessity would be a temperature control bath in which studies on the effect of temperature on the embryonic and larval forms of the organisms could be conducted.

2. To conduct chronic exposure studies, it will be necessary to purchase proper equipment and develop the test systems. Such systems will be made available in FY 1974. Setting up these systems will require the purchase of holding tanks, proportional diluters for dispensing pollutants and chemicals, and a disposal system for waste treating the effluent from the test tanks. The latter is required to meet new interagency requirements.

In order to initiate studies involving several species of marine organisms, some of these studies will be contracted to private organizations and universities in FY 1973 and 1974.

3. The following equipment will be required in FY 1973 and FY 1974 to conduct studies of physiological and biological changes in marine organisms: liquid scintillation counter, oxygraph, polygraph write-out accessories, specialized virological equipment, preparative ultra centrifuge, double-beam ratio recording spectrophotometer, pbt meter, analytical balance, electrophoretic apparatus, phase-contrast microscopic equipment, autoclavable closed system tanks and accessory equipment, and liquid scintillation spectrometer.

4. Histopathology investigations will require a preparative ultracentrifuge, a double beam recording spectrophotometer and certain miscellaneous apparatus for research to be initiated in FY 73. Certain research will be done by academic personnel under contract to MACFC and/or MESA.

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VII. SHIPTIME AND VESSEL COST

	FY 73	FY 74
Biological Baseline:	(In thousands $)	
R/V Delaware II (8 days/every two months.....	36.	72.
R/V Rorqual (one day/wk. in New York Bight).....	6.5	13.0
(6 wks./year in Long Island Sd.).....	-	-
(2 days/wk. in Raritan Bay).....	-	-
Subtotal.....	42.5	85.0
Contaminants Investigation:		
R/V Rorqual (5 days/month).....	7.5	15.0
Total Vessel Costs.....	50.0	100.0

VIII BUDGET

		FY 73 (In thousands $)
A. Biological Baselines:		
Contract Research (CCNY, Lehigh U., U. Maryland)	$88.	
Vessel operations	50.	
Equipment:		
Seabed oxygen consumption measurement apparatus	10	
Redox potential meter	0.8	
Liquid scintillation counter	12.	
Underwater photometer	0.7	
Expendable items	11.	$172.5
B. Contaminants Investigation:		
Contract Research (possible contract with Dr. G. L. Vaughan, U. of Tenn.)	32.	
Vessel operations	7.5	
Equipment:		
Ultracentrifuge	10.	
Microbalance	2.5	
Liquid Chromatograph	3.5	
Gas Chromatograph	3.5	
Expendable items	9.	68.0
C. Effects of Stress on Marine Organisms:		
Physiological Stress		
Contract Research	30.	
Rearing Techniques		
Temperature Control Bath	6.	
Bring Forward	36	240.5

Brought Forward	36.	240.5
Bioassay Investigation		
Chromic Exposure Laboratory	5.	
Waste Water Treatment Facility...	22.	
Physiological Investigation		
Oxygraph	3.5	
Scintillation Counter	12.	
Polygraph Accessories	1.5	
Microosmometer	3.	
Biochemistry Investigation		
Double Beam Recording Spectro-photometer	1.2	
Preparative Ultracentrifuge	13.	97.2
Histopathology Investigations		
Contract Research (U. Maryland)	12.	
Equipment:		
Preparative Ultracentrifuge	13.	
Double Beam Recording Spectro-photometer	1.2	
Misc. Equipment	5.	31.2
TOTAL MESA Related Research		$368.9

88.0
32.0
30.0
12.0
162.