United States
Environmental Protection
Agency

Office of Water Regulations
and Standards
Criteria and Standards Division
Washington, D.C. 20460

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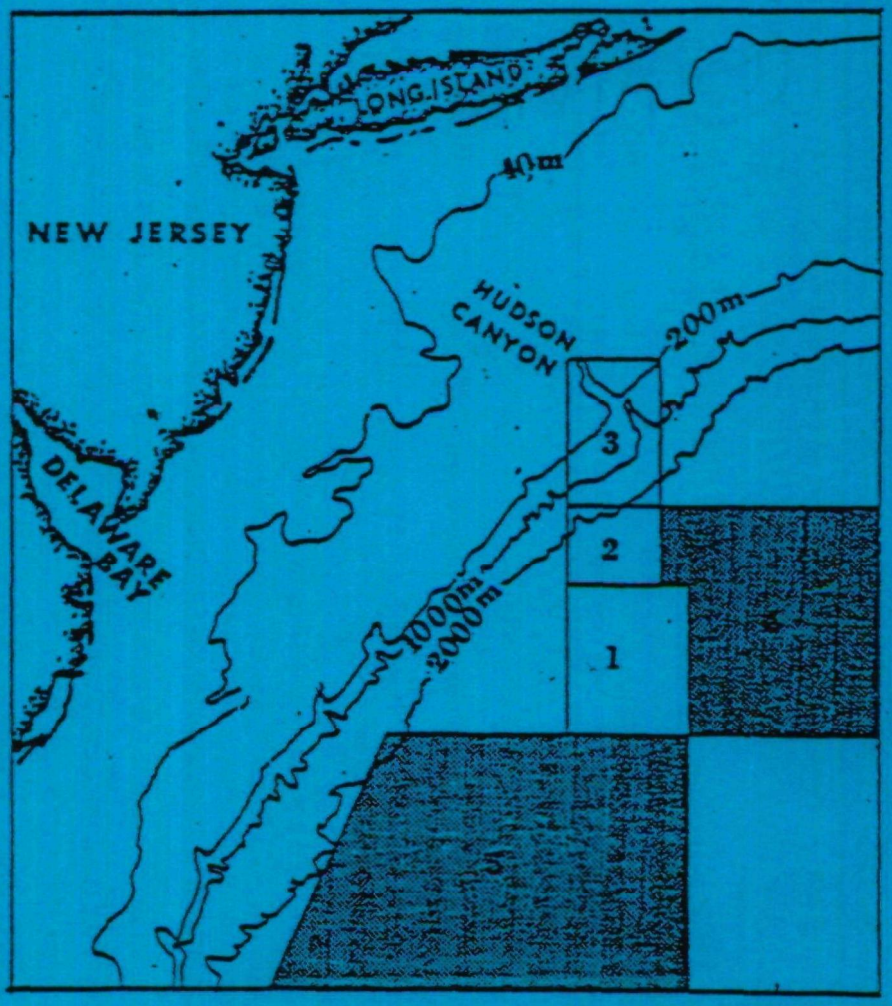
Water

EPA

Environmental Impact Statement (EIS) for North Atlantic Incineration Site Designation

FINAL



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FINAL

ENVIRONMENTAL IMPACT STATEMENT (EIS)

FOR

NORTH ATLANTIC INCINERATION

SITE DESIGNATION

Prepared by: U.S. Environmental Protection Agency
Criteria and Standards Division
Washington, DC 20460

APPROVED BY: William C. Shilling 11/25/81

William C. Shilling
Project Officer

Date

SUMMARY SHEET

ENVIRONMENTAL IMPACT STATEMENT FOR NORTH ATLANTIC INCINERATION SITE

( ) Draft
(X) Final
( ) Supplement to Draft

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER REGULATIONS AND STANDARDS
CRITERIA AND STANDARDS DIVISION

1. Type of Action

(X) Administrative/Regulatory action
( ) Legislative action

2. Brief background description of action and purpose.

The proposed action is the designation of a North Atlantic Incineration Site. The center of the site is approximately 140 nmi (260 km) east of Delaware Bay and 155 nmi (290 km) from Ambrose Light. The site will be used for the incineration of toxic organic wastes, principally organohalogens, generated in the mid-Atlantic states. The purpose of the action is to provide an environmentally acceptable area for the thermal destruction of the wastes, in compliance with EPA Ocean Dumping Regulations.

3. Summary of major beneficial and adverse environmental and other impacts.

The most important beneficial effect of this action is to provide the least hazardous location for destruction of toxic organic wastes. Previous incineration of such wastes in the Gulf of Mexico have proven

that short-term effects of the burned wastes are transitory and minor. Insufficient numbers of incineration operations have taken place to detect long-term changes in the environment; however, such changes are unlikely. Since before 1965 aqueous industrial wastes with toxic constituents have been dumped in the area without detectable long-term effects.

4. Major alternatives considered.

The alternatives considered in this EIS are (1) no action, which would require the use of land-based disposal methods, or the shutdown of the waste producing manufacturing processes, and (2) use of an alternative ocean site for the disposal of these wastes (e.g., the 106-Mile Ocean Waste Disposal Site, the areas north and east of the 106-Mile Site, the regions south and west of the proposed site, existing near-shore disposal sites over the Continental Shelf, a New England oceanic location, the South Atlantic Bight region, and the existing Gulf of Mexico Incineration Site).

5. Unresolved environmental issues.

At-sea incineration is an emerging disposal technology; therefore, certain specific environmental issues require further investigation to more fully establish the acceptability of this practice. Questions which remain unanswered, but can be resolved during monitoring efforts are:

(1) How do repeated exposures to toxic residues in the water affect the various biological communities?

(2) What are the effects on planktonic organisms due to prolonged adverse exposures when such organisms must drift with a polluted watermass that maintains its integrity for relatively long periods?

(3) What effects will stack emissions have on pelagic and migratory birds?

6. Comments were received from the following:

Federal Agencies and Offices

Department of Commerce
- National Oceanic and Atmospheric Administration (NOAA)
- Maritime Administration

Department of Defense
- Army Corps of Engineers
- Department of the Air Force

Department of Health and Human Services
- Public Health Service

Department of the Interior
- Office of the Secretary

Department of State

States and Municipalities

Delaware, Maryland, New Jersey, Rhode Island, and Commonwealth of Virginia

Private Organizations and Citizens

Ironbound, Newark, New Jersey
National Wildlife Federation, Washington, D.C.
Southeastern Waste Treatment, Inc., Dalton, Georgia
Waste Management, Inc., Oak Brook, Illinois

R. Elmbach, Brick, New Jersey
Robert F. Jambor, New Brunswick, New Jersey
George W. Liggett, Mays Landing, New Jersey

7. Comments are due on or about JAN 17 1982, but not later than 30 days from the date of EPA's publication of Notice of Availability in the Federal Register.

Comments should be addressed to:

William C. Shilling
Project Officer, Criteria and Standards Division (WH-585)
Environmental Protection Agency
Washington, D.C. 20460

Copies of the Final EIS may be obtained from:

Environmental Protection Agency
Criteria and Standards Division (WH-585)
Washington, D.C. 20460

Environmental Protection Agency
Region II (2SA-MWP)
Marine and Wetlands Protection Branch
26 Federal Plaza, Room 1642
New York, N.Y. 10278

The final statement may be reviewed at the following locations:

Environmental Protection Agency
Public Information Reference Unit, Room 2404 (Rear)
401 M Street, SW
Washington, D.C. 20460

Environmental Protection Agency
Region II
Library, Room 1002
26 Federal Plaza
New York, N.Y. 10278

Environmental Protection Agency
Region II, Library
Woodbridge, Ave.
GSA Raritan Depot
Edison, N.J. 08817

NOAA/RD/OMPA - North East Office
Old Biology Bldg.
State University of New York
Stony Brook, N.Y. 11794

APPROVED BY: William C. Shilling 11/25/81

William C. Shilling
Project Officer

Date

Chapter 1

PURPOSE OF AND NEED FOR ACTION

Incineration is currently the most environmentally sound means of ultimate disposal for some materials (e.g., toxic organic chemical wastes). Large volumes of industrial chemical wastes may become candidates for incineration at sea within this decade, thus the proposed North Atlantic Incineration Site may provide east coast industries with an effective area for disposal of chemical wastes. This chapter provides background information on the purpose of and need for the proposed site designation. It sets the stage for defining the action, the location of the proposed site, and the legal criteria which identify and establish viable options.

The oceans have been used for waste disposal for generations on an international scale. In the early 1970's U.S. legislation and international agreements were enacted to control waste disposal in the marine environment. This legislation, concurrent with the development of land-based alternatives, has led to a dramatic decrease in direct industrial and municipal ocean dumping. However, industries still produce toxic organic chemical wastes which require particularly safe and effective disposal procedures to prevent release of hazardous substances into the environment in appreciable quantities. High-temperature incineration is a technique which satisfies such disposal requirements.

Much organic chemical waste generation is centered around the heavily populated and industrialized east coast, and existing commercial land-based incineration facilities are located near populated areas. The incineration of some hazardous substances, such as polychlorinated biphenyls (PCB), has in the past created strong public opposition to incineration activities at commercial facilities on land. Community attitude is that the potential for environmental contamination from waste residues or accidents is too great a risk. If these wastes are environmentally unsuitable for land disposal then conventional methods of barging and dumping these types of wastes at sea are probably prohibited under §227.27 of the Ocean Dumping Regulations and Criteria. Alternative disposal methods have therefore been examined. Based on

results of research conducted in the Gulf of Mexico between 1974 and 1977 the Environmental Protection Agency (EPA) has established at-sea incineration as an acceptable alternative disposal method for hazardous organic wastes. Consequently, EPA has determined a need for designation of an at-sea Incineration Site in the northwest Atlantic Ocean to serve industries located on the U.S. east coast.

Final designation of the proposed site will create the second permanent U.S. at-sea Incineration Site for industrial chemical waste disposal. This action will fill the need for a suitable location off the middle Atlantic states for the incineration of certain industrial chemical wastes which do not comply with the criteria for direct ocean dumping under EPA Ocean Dumping Regulations, and where no environmentally sound land-based alternatives exist, but may be acceptable for disposal by incineration at-sea, as regulated under the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA) (PL 92-532; 86 Stat. 1052, 33 USCA§ 1401, et seq.).

At present, while alternative disposal methods are being developed, some industrial wastes, particularly liquid organohalogen wastes, can be safely and effectively disposed of by at-sea incineration.

Organohalogens encompass a broad category of synthetic organic chemical compounds consisting of carbon, hydrogen, and one or more elements of the halogen family: astatine, bromine, chlorine, fluorine, and iodine. Organochlorine compounds are a subcategory of organohalogens that contain the halogen chlorine, in addition to carbon, hydrogen, and possibly oxygen, nitrogen, phosphorus, or sulfur. Metals are often associated with the organic compounds in trace quantities. The majority of waste organohalogen chemicals are organochlorines. The percentage of chlorine in organochlorines is variable. Some wastes contain less than 10%, whereas others may contain up to 87% by weight. The average chlorine content of organochlorine wastes generated in 1975 was 60.6% (Paige et al., 1978).

The generalized combustion products of organochlorine are described by:

$$CHClCCl_2 + 2O_2 \longrightarrow 2CO_2 + HCl + Cl_2$$

Under optimal combustion conditions the major products are carbon dioxide (CO_2), hydrochloric acid (HCl), and water (H_2O); gaseous chlorine (Cl_2) is produced in negligible amounts.

The technical feasibility of destroying organic wastes at sea in high-temperature furnaces has been proven (Wastler et al., 1975; Clausen et al., 1977; and Ackerman et al., 1978). The low environmental hazard of atmospheric and marine pollution from incineration emissions has been demonstrated (TerEco, 1975 and unpublished), and the economic feasibility of such operations was examined and found to be justifiable (Halebsky, 1978). All factors indicate that at-sea incineration of certain wastes is a viable waste elimination alternative to landfill, land-incineration, or direct ocean dumping.

An Interagency Review Board (IRB) for the Chemical Waste Incineration Ship Program (CWISP) has been established, comprising representatives from nine Federal agencies. The primary agencies involved are EPA, U.S. Coast Guard, Maritime Administration, and National Bureau of Standards. The IRB will develop procedures for the coordination of permits for shore facilities, ship certification, and incineration of wastes. Additionally, IRB will evaluate alternatives to promote the construction of privately owned U.S. flag incinerator vessels.

At-sea incineration is viewed as a major element in an overall integrated hazardous waste management matrix. In addition to at-sea incineration, IRB will evaluate the full spectrum of alternative technologies, including recycling and land-based incineration, to achieve a balance of environmentally sound disposal procedures. This is particularly important when disposing of the most hazardous chemical wastes.

As part of the decisionmaking process for designation of the proposed North Atlantic Incineration Site, EPA investigated all reasonable alternatives to selection of the proposed site. Two broad categories of alternatives exist: (1) take no action, thereby requiring other means of disposal (e.g., landfill, storage, or land-incineration), transport of these wastes to the Gulf of Mexico Incineration Site, or if other acceptable disposal methods are unavailable, discontinue the waste-producing processes, and (2) consideration

of one or more alternate ocean locations for incineration of these wastes. After a careful review of the alternatives, EPA concludes that designation of the proposed North Atlantic Incineration Site is the most favorable course of action.

Based on the continued need for at-sea methods of waste disposal, the lack of significant adverse impact from at-sea incineration (as determined by research studies conducted in the Gulf of Mexico), and the lack of a better alternative site, the EPA proposes to designate the proposed North Atlantic Incineration Site for industrial chemical waste incineration. Use of the site will facilitate incineration of approved organohalogen wastes under appropriate ocean disposal permits and the disposal of other chemical wastes the EPA determines to be acceptable for at-sea incineration. The EPA Administrator or his designee will (1) manage the site and regulate the times, methods of disposal, rates, quantities, and types of materials to be incinerated, (2) develop and maintain effective monitoring programs for the site, (3) conduct disposal site evaluation studies, and (4) recommend modifications in site usage or designation, as required.

The center of the proposed site is approximately 155 nmi east-southeast of Ambrose Light, and 140 nmi east of the Delaware Bay entrance. Site coordinates are 38°00' to 38°40'N, and 71°50' to 72°30'W (Figure 1-1). The proposed Incineration Site is due south of the 106-Mile Ocean Waste Disposal Site, with a contiguous border.

INTERNATIONAL CONSIDERATIONS

The principal international agreement governing ocean dumping is the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention) (26 UST 2403; TIAS 8165), which became effective in August 1975 upon ratification by 15 contracting countries. The Convention is designed to control dumping of wastes in the oceans and specifies that contracting nations will regulate disposal in the marine environment within their jurisdiction, and prohibits disposal without

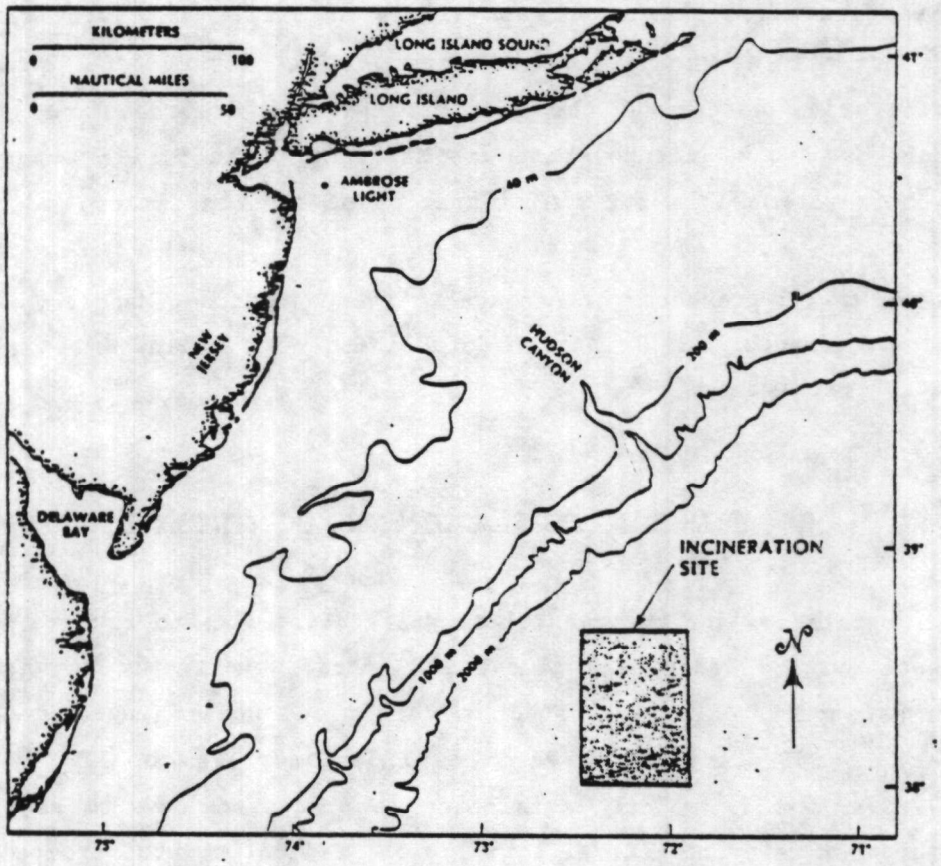


Figure 1-1. Location of Proposed North Atlantic Incineration Site Bounded by 38°00' to 38°40'N Latitudes and 71°50' to 72°30'W Longitudes. Distance from Ambrose Light to Center of Site is 155 nmi.

permits. Certain hazardous materials are prohibited (e.g., radiological, biological, and chemical warfare agents, and high-level radioactive matter). Certain other materials (e.g., cadmium, mercury, organohalogens and their compounds; oil; and persistent, synthetic or natural materials that float or remain in suspension) are also prohibited as other than trace contaminants. Other materials (e.g., arsenic, lead, copper, zinc, cyanides, fluorides, organosilicon, and pesticides) are not prohibited from ocean disposal, but require special care. Permits are required for ocean disposal of materials not specifically prohibited. Amendments to Annexes I and II of the London Dumping Convention adopted in 1978 establish requirements which allow organohalogens,

pesticides, and crude oil derivatives to be incinerated at-sea, provided the emission products of the substances entering the atmosphere and sea are rapidly rendered harmless by physical, chemical, or biological processes, or are present as trace contaminants. The nature and quantities of all incinerated wastes and the circumstances of disposal must be periodically reported to the Intergovernmental Maritime Consultative Organization (IMCO), which is responsible for administration of the Convention.

Appendix B presents the Annexes to the Convention, Mandatory Regulations with amendments, and Technical Guidelines to be followed by at-sea incineration permittees.

FEDERAL LEGISLATION AND CONTROL PROGRAMS

Legislation for the control of waste disposal into rivers, harbors, and coastal waters dates back almost 100 years; however, ocean waste disposal was not specifically regulated in the United States until the passage of the Marine Protection, Research, and Sanctuaries Act (MPRSA) in October 1972 (PL-92-532). This legislation is discussed here in detail together with other relevant Federal legislation, Federal control programs initiated by MPRSA, and EPA programs for ocean disposal site designation and issuance of ocean disposal permits. In 1974 EPA determined that the MPRSA also applied to at-sea incineration, thereby requiring a permit under the Act.

The Clean Water Act (CWA) of 1977 (PL 95-217) amended and replaced earlier legislation, established a comprehensive regulatory program to control outfall discharges of pollutants into navigable waters of the United States, including ocean waters. The primary objective of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. CWA regulates discharges by setting criteria to prevent degradation of the marine environment (Part 403), and to apply the criteria in the issuance of permits (Part 402). CWA and MPRSA are the primary Federal legislative means of controlling ocean waste disposal from ocean outfalls and offshore disposal sites.

MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT (MPRSA)

The MPRSA regulates the transportation and ultimate dumping of barged materials in ocean waters. The Act is divided into three parts: Title I—Ocean Dumping, Title II—Comprehensive Research on Ocean Dumping, and Title III—Marine Sanctuaries. This Environmental Impact Statement (EIS) responds to Title I, specifically Part 102(c), which charges EPA with the responsibility for designating sites or times for waste disposal.

Title I, the primary regulatory section of MPRSA, establishes the permit program for the disposal of dredged and nondredged materials, mandates determination of impacts and alternative disposal methods, and provides for enforcement of permit conditions. The purpose of Title I is to prevent or strictly limit the dumping of materials that would unreasonably affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities. Title I of the Act provides procedures for regulating the transportation and disposal of materials into ocean waters under the jurisdiction or control of the United States. Any person of any nationality wishing to transport waste material from a U.S. port, or from any port under a U.S. flag, to be dumped anywhere in the oceans of the world, is required to obtain a permit.

Title I prohibits the dumping into ocean waters of certain wastes, including radiological, biological, or chemical warfare agents, and all high-level radioactive wastes. Title I was amended in 1977 to include prohibition of dumping harmful sewage sludge after December 31, 1981 (PL 95-153). Alleged violations are referred to EPA for appropriate enforcement. The provisions of Title I include a maximum criminal fine of $50,000 and a jail sentence of up to one year for every unauthorized dump or violation of permit requirements, or a maximum civil fine of $50,000. Any individual may seek an injunction against an unauthorized dumper with possible recovery of all costs of litigation.

Title II of MPRSA provides for comprehensive research and monitoring of ocean disposal effects on the marine environment. Under Title II the National Oceanic and Atmospheric Administration (NOAA) monitoring program has conducted

extensive survey and laboratory investigations over the past several years at ocean disposal sites in the North Atlantic Ocean. This work aids EPA in site management by providing criteria for site use decisions.

Several Federal departments and agencies participate in the implementation of MPRSA requirements with the major responsibility mandated to the EPA to review, grant, and enforce disposal permits for all wastes, and to designate and manage all disposal sites (Table 1-1). In October 1973 EPA implemented its responsibility for regulating ocean dumping under MPRSA by issuing final Ocean Dumping Regulations and Criteria which were revised in January 1977 (40 CFR Parts 220 - 229). The Regulations established procedures and criteria for designating and managing ocean disposal sites (Part 228), evaluating permit applications for environmental impact (Part 227), and enforcing permit conditions (Part 226).

Under MPRSA the U.S. Coast Guard (USCG) is assigned responsibility to conduct surveillance of disposal operations, to ensure compliance with the permit conditions, and to discourage unauthorized disposal. Violations are referred to EPA for enforcement. Surveillance is accomplished by means of spot-checks of disposal vessels for valid permits, interception or escorting of disposal vessels, use of shipriders, aircraft overflights during dumping, and random surveillance missions at land facilities.

NOAA conducts comprehensive monitoring and research programs under Title II of MPRSA with respect to the effects of ocean dumping on the marine environment, including potential long-term effects of pollution, overfishing, and man-induced changes in oceanic ecosystems. Some of the responsibilities for conducting field investigations of ocean waste disposal effects have been shared with EPA. Title III of MPRSA authorizes NOAA to designate marine sanctuaries after consultation with other affected Federal agencies, and to regulate all activities within such sanctuaries.

At the request of EPA, the Department of Justice initiates relief actions in court in response to violations of the terms of MPRSA. When necessary, injunctions are issued to stop disposal. Civil and criminal fines, and jail sentences may be levied, based on the magnitude of the violation.

TABLE 1-1
RESPONSIBILITIES OF FEDERAL DEPARTMENTS AND AGENCIES
FOR REGULATING OCEAN WASTE DISPOSAL UNDER MPRSA

Department/Agency	Responsibility
U.S. Environmental Protection Agency	Issuance of waste disposal permits, other than for dredged material Establishment of criteria for regulating waste disposal Enforcement actions Site designation and management Overall ocean disposal program management Research on alternative ocean disposal techniques
U.S. Department of the Army Corps of Engineers	Issuance of permits for transportation of dredged material for disposal. Recommending disposal site locations
U.S. Department of Transportation Coast Guard	Surveillance Enforcement support Issuance of regulations for disposal vessels Review of permit applications
U.S. Department of Commerce National Oceanic and Atmospheric Administration	Long-term monitoring and research Comprehensive ocean dumping impact and short-term effect studies Marine sanctuary designation
U.S. Department of Justice	Court actions
U.S. Department of State	International agreements

The MPRSA was amended in March 1974 (PL 93-254) to bring the Act into full conformity with the Convention. The United States accepted amendments to Annexes I and II of the Convention dealing with international regulations for the incineration of wastes at sea. Requirements established by the U.S. regulations implemented both the Act and the Convention (Chapter 1, International Considerations). These amendments became effective in March 1979 as minimum national requirements in all oceanic incineration permits.

OCEAN DISPOSAL SITE DESIGNATION

Part 102(c) of the MPRSA authorizes the EPA Administrator to designate sites and times for ocean waste disposal, provided the waste does not contain prohibited materials and will not significantly degrade or endanger human health, welfare, and amenities, the marine environment and ecological systems, or economic potential.

Land-based methods of disposal as alternatives to ocean dumping are thoroughly evaluated during the permit application process. Through this evaluation the applicant must prove a need for ocean disposal and evaluate alternative disposal means before a permit for ocean dumping is granted. Since potential alternative disposal methods will vary, based on the type of waste, this issue is best resolved during the permit application stage.

Part 227 Subpart C of the Ocean Dumping Regulations specifies the factors considered and the basis for determining the need for ocean dumping. Even if a permit is granted, EPA may require the permittee to:

> "...terminate all ocean dumping by a specified date, to phase out all ocean dumping over a specified period or periods, to continue research and development of alternative methods of disposal and make periodic reports of such research and development in order to provide additional information for periodic review of the need for and alternatives to ocean dumping..."

The conditions apply even when the permittee has demonstrated compliance with the requirements of Part 227 Subparts B, D, and E; prevention of environmental impact (e.g., damage to aesthetic, recreational, or economic values, or interference with other uses of the ocean).

EPA has established criteria for designating sites in Part 228 of the Ocean Dumping Regulations. These include criteria for site selection and procedures for designating the sites for disposal. Through this and other EIS's, EPA is conducting in-depth studies of various disposal sites to determine their acceptability in keeping with the criteria.

General criteria for selection of sites, as provided in the Ocean Dumping Regulations are:

(a) The dumping of materials into the ocean will be permitted only at sites or in areas selected to minimize the interference of disposal activities with other activities in the marine environment, particularly avoiding areas of existing fisheries or shellfisheries, and regions of heavy commercial or recreational navigation.

(b) Locations and boundaries of disposal sites will be so chosen that temporary perturbations in water quality, or other environmental conditions, during initial mixing caused by disposal operations anywhere within the site, can be expected to be reduced to normal ambient seawater levels or to undetectable contaminant concentrations, or effects, before reaching any beach, shoreline, marine sanctuary, or known geographically limited fishery or shellfishery.

(c) If at any time during or after disposal site evaluation studies, it is determined that existing disposal sites presently approved on an interim basis do not meet the criteria for site selection set forth in [Section] 228.5 to 228.6 the use of such sites will be terminated as soon as suitable alternate disposal sites can be designated.

(d) The size of ocean disposal sites will be limited in order to localize for identification and control any immediate adverse impacts and permit the implementation of effective monitoring and surveillance programs to prevent adverse long-term impacts. The size, configuration, and location of any disposal site will be determined as a part of the disposal site evaluation or designation study.

(e) EPA will, wherever feasible, designate ocean dumping sites beyond the edge of the Continental Shelf, and other such sites that have been historically used. [§228.5]

In addition to the five general criteria established in the Ocean Dumping Regulations and listed above, the amendments to the London Dumping Convention include three general criteria specific to at sea incineration:

(a) The atmospheric dispersal characteristics of the area — including wind speed and direction, atmospheric stability, frequency of inversions and fog, precipitation types and amounts, and humidity — in order to determine the potential impact on the surrounding environment of pollutants released from the marine incineration facility, giving particular attention to the possibility of atmospheric transport of pollutants to coastal areas.

(b) Oceanic dispersal characteristics of the area, in order to evaluate the potential impact of plume interaction with the water surface.

(c) Availability of navigational aids.

Factors considered under the specific criteria for site selection treat the general criteria in additional detail. A proposed site which satisfies the specific criteria for site selection, will conform to the broader general criteria. Eleven factors are considered:

(1) Geographical position, depth of water, bottom topography and distance from coast;

(2) Location in relation to breeding, spawning, nursery, feeding, or passage areas of living resources in adult or juvenile phases;

(3) Location in relation to beaches and other amenity areas;

(4) Types and quantities of wastes proposed to be disposed of, and proposed methods of release, including methods of packing the waste, if any;

(5) Feasibility of surveillance and monitoring;

(6) Dispersal, horizontal transport and vertical mixing characteristics of the area, including prevailing current direction and velocity, if any;

(7) Existence and effects of current and previous discharges and dumping in the area (including cumulative effects);

(8) Interference with shipping, fishing, recreation, mineral extraction, desalination, fish and shellfish culture, areas of special scientific importance, and other legitimate uses of the ocean;

(9) The existing water quality and ecology of the site as determined by available data or by trend assessment or baseline surveys;

(10) Potentiality for the development or recruitment of nuisance species in the disposal site;

(11) Existence at or in close proximity to the site of any significant natural or cultural features of historical importance. [§228.6]

These factors are addressed in detail for the proposed Incineration Site in Chapter 2.

A designated site must be monitored for adverse disposal impacts. EPA requires that the following types of effects be monitored in order to determine the extent of marine environmental impacts occurring from material disposal at other sites:

(1) Movement of materials into estuaries or marine sanctuaries, or to oceanfront beaches, or shorelines;

(2) Movement of materials toward productive fishery or shellfishery areas;

(3) Absence from the disposal site of pollution-sensitive biota characteristic of the general area;

(4) Progressive, non-seasonal, changes in water quality or sediment composition at the disposal site, when these changes are attributable to materials disposed of at the site;

(5) Progressive, non-seasonal, changes in composition or numbers of pelagic, demersal, or benthic biota at or near the disposal site, when these changes can be attributed to the effects of materials disposed of at the site;

(6) Accumulation of material constituents (including without limitation, human pathogens) in marine biota at or near the site. [§228.10(b)]

AT-SEA INCINERATION PERMIT PROGRAM

EPA's Ocean Dumping Regulations establish a program for the application, evaluation, and issuance of at-sea incineration permits. When a site is selected and duly designated, permits for the use of the site will be issued by the EPA.

Ocean Dumping Regulations are specific about the procedures used to evaluate permit applications and the granting or denial of such applications. EPA evaluates permit applications principally to determine (1) whether there

is a demonstrated need for ocean waste disposal and that no other reasonable alternatives exist (40 CFR §227.14), and (2) compliance with the environmental impact criteria (Part 227 Subpart B), Mandatory Regulations and Technical Guidelines (Appendix B). As prescribed by §227.6(h) of the Ocean Dumping Regulations, the prohibitions and limitations of §227.6(a) do not apply to the granting of permits for the transport of listed substances for the purpose of incineration at sea if the applicant demonstrates that the stack emissions consist of substances which are rapidly rendered harmless by physical, chemical, or biological processes in the sea. Incineration operations shall comply with requirements established on a case-by-case basis.

Compliance with EPA marine environmental impact criteria ensures that the proposed waste disposal will not "unduly degrade or endanger the marine environment," and that disposal will not cause unacceptable adverse effects upon human health, the marine ecosystem, or other uses of the ocean. The relevant points of these lengthy criteria as they relate to incinerable wastes are briefly summarized below.

- Prohibited Materials - High-level radioactive wastes, materials produced for radiological, chemical, or biological warfare, insufficiently described materials, persistently buoyant materials which interfere with other uses of the ocean.

- Materials Present in Incinerable Wastes as Trace Contaminants Only - Mercury and mercury compounds, cadmium and cadmium compounds.

- Wastes Requiring Special Studies - Where there is doubt as to the thermal destructibility of the wastes or other matter proposed for incineration, pilot scale tests shall be undertaken.

  When proposing to permit incineration of wastes or other matter over which there are doubts as to the efficiency of combustion, the incineration system shall be subject to the intensive stack monitoring required for the initial incineration system survey. Consideration shall be given to the sampling of particulates, taking into account the solid content of the wastes. The minimum approved

flame temperature shall be 1,250°C, unless the results of tests on the marine incineration facility demonstrate that the required combustion and destruction efficiency can be achieved at a lower temperature.

Research permits will be issued during incinerator trial tests to certify equipment performance acceptability and establish the destruction efficiency for a specific type or mixture of organohalogen waste. Permittees incinerating wastes under research permits will be required to perform monitoring of short-term effects on air and water quality, similar to monitoring conducted in the Gulf of Mexico. Additionally, permittees will monitor incinerator stack emissions, as promulgated under Mandatory Regulations and Technical Guidelines of the Convention. Permits will specify an expiration date no longer than 18 months from the date of issue.

Special permits will be issued to allow incineration of approved wastes when an incinerator has been certified. Short-term monitoring of air and water quality impacts will not normally be required. However, monitoring of stack emissions will be required, as promulgated under Mandatory Regulations and Technical Guidelines of the Convention. Permits will specify an expiration date of no later than 3 years from the date of issue.

HISTORY OF THE U. S. AT-SEA INCINERATION PROGRAM

At-sea incineration of toxic wastes has been practiced in Europe since 1969. The practice did not begin in the United States until 1974, when permits were issued for incineration of Shell Chemical Company wastes in the Gulf of Mexico. Between October 1974 and January 1975 approximately 16,800 metric tons* (tonnes) of toxic organochlorine wastes from the Shell Chemical Company, Deer Park, Texas facility were incinerated aboard the incineration vessel M/T VULCANUS at a designated site in the Gulf of Mexico during four separate incineration operations. The first two "burns" (4,200 tonnes each)

* metric ton = tonne = 2,205 pounds (lb)

were conducted under research permits; the second two burns (4,200 tonnes each) were conducted under special permits. Wastes were composed of trichloropropane, trichloroethane, and dichloroethane. Monitoring results showed no detectable changes in the pH of the seawater where the incineration plume contacted the water surface (discussed in detail in Chapter 4). Similarly, no adverse effects were detected in plankton samples (TerEco, 1975).

The third series of incinerations occurred between March and April 1977. Approximately 16,800 tonnes of Shell Chemical Company wastes were incinerated aboard the M/T VULCANUS at the Gulf of Mexico Incineration Site during four incineration operations (Clausen, et al., 1977). These operations were permitted under special permit. Waste material was similar to that burned during the first incineration operation in 1974 and 1975. Monitoring results of these operations were comparable to the first burns, and no deleterious or subtle adverse impacts were detected. Field monitoring and laboratory studies were undertaken, exposing fish to various concentrations of Shell Chemical Company wastes. It was concluded that observed effects (Chapter 4) were temporary and presented no drawbacks to at-sea incineration (TerEco, unpublished; Clausen, et al., 1977).

The fourth and most recent at-sea incineration of organochlorine waste occurred in the Pacific Ocean near Johnston Atoll. Approximately 10,400 tonnes of Herbicide Orange were destroyed in three incineration operations aboard the M/T VULCANUS. The first burn occurred under a research permit and the other two under special permits. The primary toxic components of this waste were TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin), 2,4-D, and 2,4,5-T (Ackerman et al., 1978). In the case of Herbicide Orange, the incineration process appears to have been responsible for the production of new compounds absent in the original waste material. Plankton samples were collected from affected sea water to determine residue effects, but analysis results were inconclusive due to the low biological productivity at the site.

A recent paper (Kamlet, S.K. 1978) presents a detailed discussion of the events leading up to the use of at-sea incineration technology in the U.S. In addition, discussion therein of the development of Mandatory Regulations and Recommended Technical Guidelines of the Convention is informative.

Combustion efficiency (CE) and destruction efficiency (DE) are two measures of incinerator effectiveness in disposal of organic wastes. Combustion efficiency is an index of the completeness of combustion, based on the concentration ratio of carbon monoxide to carbon dioxide, usually expressed as:

$$CE\ (\%) = \frac{C_{co_2} - C_{co}}{C_{co_2}} \times 100$$

where C_{co_2} = measured concentration of carbon dioxide
C_{co} = measured concentration of carbon monoxide

Regulations require incinerator vessel operators to monitor and maintain a minimum CE of 99.9% during incineration operations. It has been found that a minimum CE of 99.9% produces a minimum DE of 99.99%.

Destruction efficiency (DE) in all Gulf of Mexico at-sea incineration operations were determined to be 99.96% or better. Destruction efficiency is computed from the difference between the amount of wastes fed into the incinerator and the amount of unburned residual wastes emitted from the stack. Several alternative methods are used to determine destruction efficiency. Table 1-2 lists four methods used in recent tests.

Aboard the M/T VULCANUS wastes are incinerated in two identical refractory lined furnaces at the stern. Each incinerator consists of two main sections, a combustion chamber and a stack, through which the combustion gases pass sequentially (Figure 1-2). Air is supplied by large fixed-speed blowers rated at 90,000 m^3/hr capacity for each incinerator. Liquid wastes are fed to the incinerator by means of electrically driven pumps. There are no air pollution control devices in the incinerators, but there is an emergency automatic waste shutoff system, which prohibits the flow of waste to the burners if the furnace temperature drops below a preselected level. Combustion temperatures are between 1,200 and 3,000°F (650°C to 1,650°C), but for maximal combustion efficiency the average is approximately 1,600°C. The average waste residence time is 1 second.

TABLE 1-2. DEFINITION OF DESTRUCTION EFFICIENCY TERMS

Destruction Efficiency Term	Method of Efficiency Calculation	Description of Method
DE_{THC}	$\frac{\text{THC fed} - \text{THC on-line monitor}}{\text{THC fed}} \times 100$	Total organic destruction efficiency based on total hydrocarbons (THC) measured by a continuous on-line monitor onboard the M/T VULCANUS.
DE_{GCHC}	$\frac{\text{THC fed} - \text{THC in grab gas sample}}{\text{THC fed}} \times 100$	Total organic destruction efficiency based on total hydrocarbons measured in the Tevlar bag grab gas samples by GC/FID.**
$DE_{SC_3Cl_3}$	$\frac{C_3Cl_3 \text{ fed} - C_3Cl_3 \text{ in SASS* samples}}{C_3Cl_3 \text{ fed}} \times 100$	Waste destruction efficiency based on trichloropropane (a major waste constituent) found in SASS* train samples. Trichloropropane was identified and quantified by GC/MS†.
$DE_{GCC_3Cl_3}$	$\frac{C_3Cl_3 \text{ fed} - C_3Cl_3 \text{ in grab gas samples}}{C_3Cl_3 \text{ fed}} \times 100$	Waste destruction efficiency based on trichloropropane (a major waste constituent) found in grab gas samples by GC after Tenax concentration.

* EPA Source Assessment Sampling System
** Gas chromatography/flame ionization detection (an analysis technique)
† Gas chromatography/mass spectrometry (an analysis technique)

Source: Clausen et al., 1977

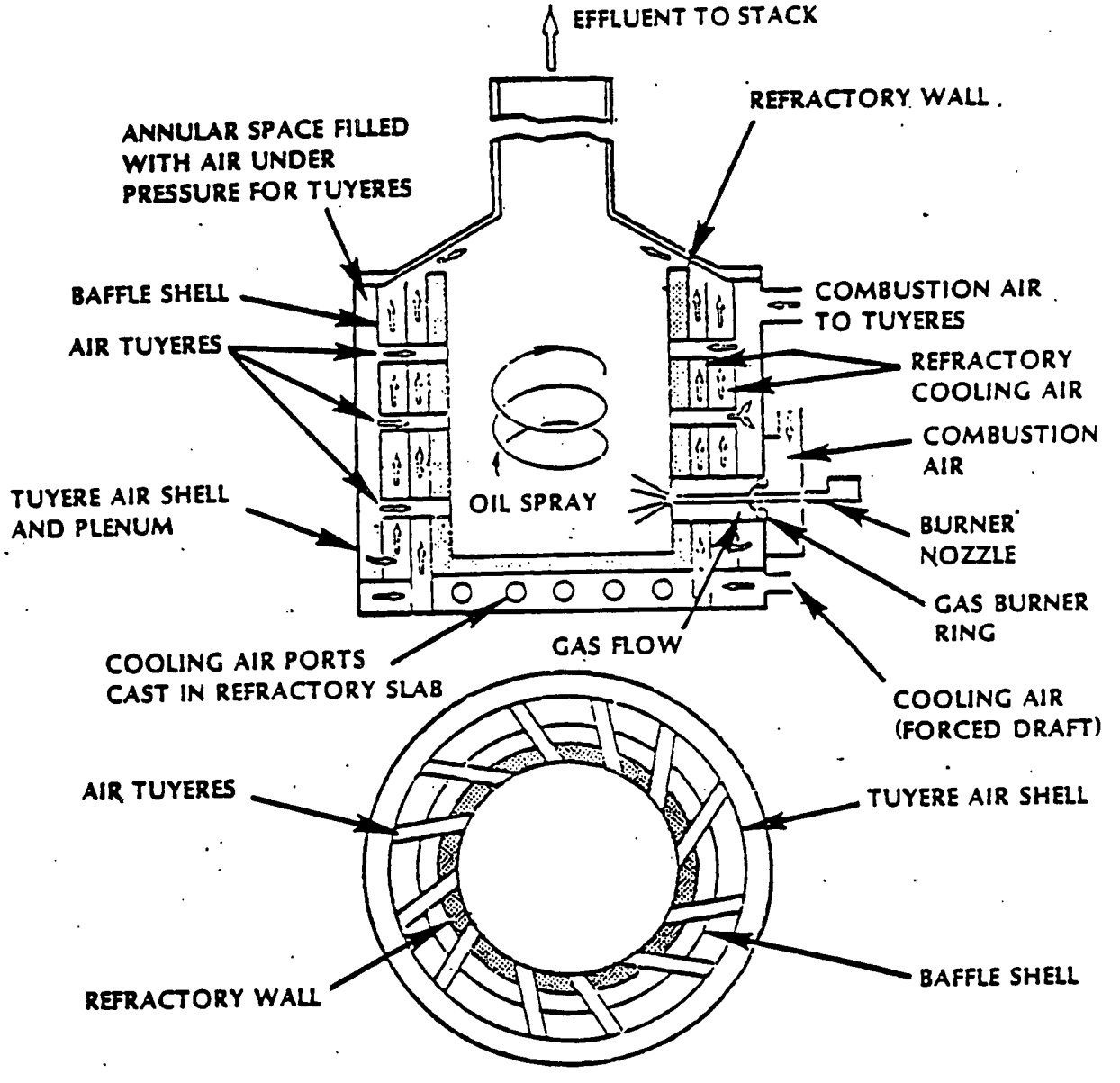


Figure 1-2. Vortex Liquid Waste Incinerators
Source: Paige et al., 1978

In organochlorine waste incineration three residues are produced which may adversely affect air and water quality: hydrochloric acid, unburned organochlorine waste, and trace metals in a gaseous phase. Residues are emitted from the incinerator stacks and rise into the atmosphere as a smoke plume which may or may not be visible, depending on atmospheric conditions. The plume is rapidly dispersed in all directions (Figure 1-3). Initial sea surface contact will occur within several hundred meters of the vessel's stern, and at such distances residue concentrations will be low. Research operations indicate (TerEco, 1975 and unpublished) that maximal sea-level concentrations occur at 1,000 to 2,000m downwind of the vessel. Sea surface concentrations will decrease with increased distance from the vessel. Mathematical modeling predicts that maximal sea surface concentrations will occur approximately 4,000m downwind of the vessel (Paige et al., 1978). Modeling indicates that within 14 km sea surface residue concentrations will be 50% of the maximum sea surface concentrations occurring at 4,000m.

PROJECTION OF QUANTITIES AND TYPES OF U.S. WASTES WHICH MIGHT BE INCINERATED AT SEA

Halebsky (1978) compiled data on U.S. manufacturing processes and estimated the potential U.S. industrial chemical waste quantities which may be available for at-sea incineration (Table 1-3). Wastes are grouped into four general categories depending on the character of the waste material. Organic chemicals, pesticides, and petroleum refinery wastes are considered acceptable incineration candidates because in most cases they will burn efficiently and produce residues which are environmentally acceptable (i.e., possess low metals content). Inorganic chemicals as a rule have a high metal content which prevent them from fulfilling the regulations for at-sea incineration under present technologies.

Surveys of U.S. industrial waste generators indicate 90% of the U.S. industrial chemical wastes are produced in Gulf coast states, or can be most economically transported to the Gulf coast for disposal. The remaining 10% of the industrial chemical wastes are generated primarily in four east coast

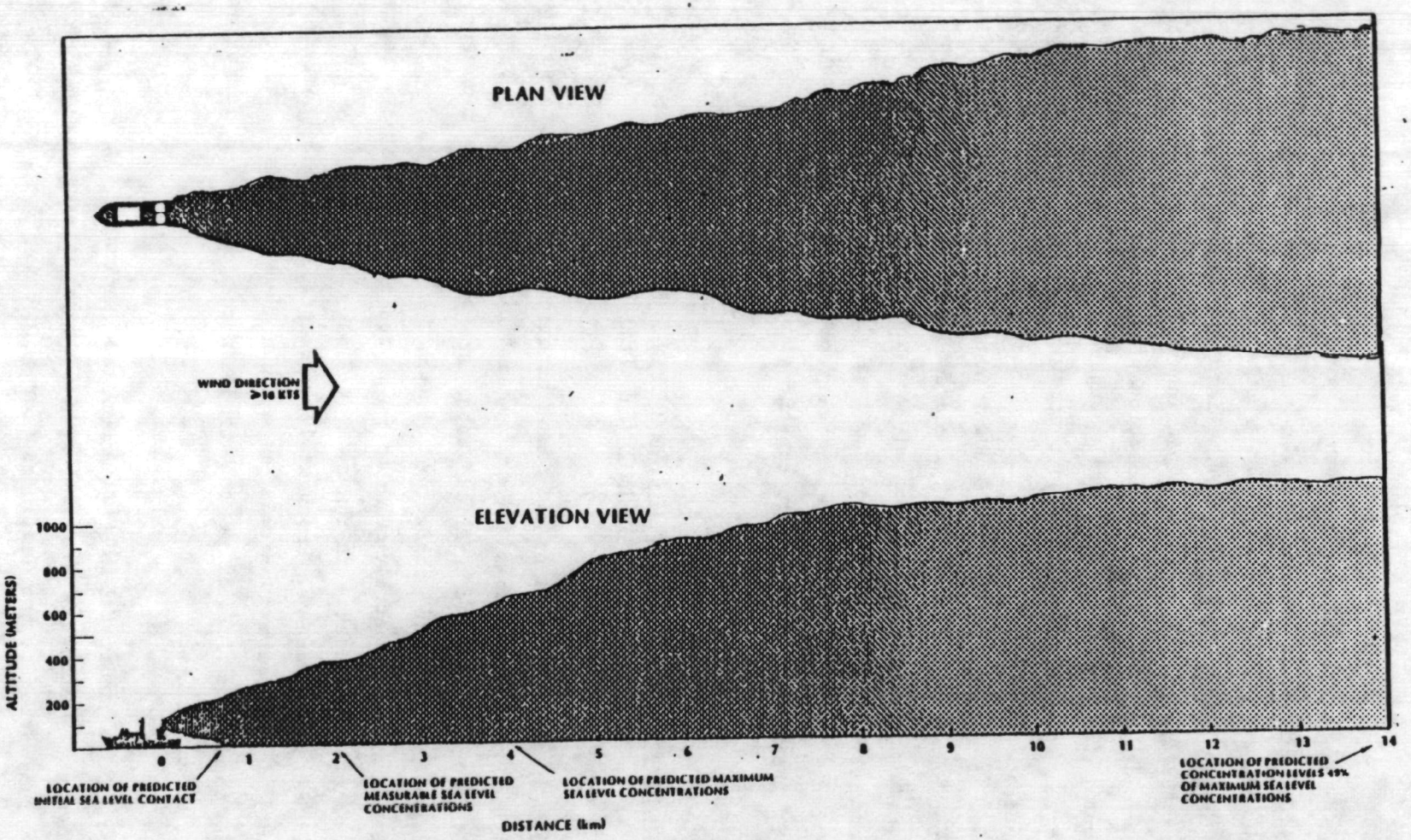


Figure 1-3. Plume Dispersal (M/T VULCANUS) Gulf of Mexico Research Incinerations, Research Burn II

NOTE: During actual incineration, the gaseous plume is virtually colorless and invisible

TABLE 1-3
POTENTIAL U.S. WASTE QUANTITIES AVAILABLE
FOR AT-SEA INCINERATION BY GEOGRAPHICAL LOCATION
(Thousands of Tonnes)

	1977			1983			1989		
	Total U.S.	Gulf Coast	East Coast	Total U.S.	Gulf Coast	East Coast	Total U.S.	Gulf Coast	East Coast
Organic Chemicals	645	586	59	1,496	1,358	138	2,237	2,031	206
Pesticides	33	29	4	78	69	9	113	100	13
Inorganic Chemicals	90	N/A	N/A	603	N/A	N/A	781	N/A	N/A
Petroleum Refining	167	149	18	392	350	42	480	428	52
TOTAL	935	764	81	2,569	1,777	189	3,611	2,559	271

Adapted from Halebsky, 1978
N/A = Not applicable to at-sea incineration under present technologies

states: Delaware, New Jersey, Pennsylvania, and West Virginia (Halebsky, 1978). Specifically, estimates show that only 9.2% of the potential total U.S. organic chemical wastes, 11.8% of the potential total U.S. pesticide wastes, and 10.8% of the potential total U.S. petroleum refinery wastes are considered to be available from the east coast for incineration at the North Atlantic Incineration Site.

Waste volumes are based on data limited to several large primary waste generating industries. Secondary waste producing industries are large in number and collectively generate a large volume of hazardous wastes. Therefore, substantially larger volumes of wastes may become candidates for at-sea incineration than indicated by Halebsky (1978).

In 1979 EPA recalled the pesticide, Silvex (2,4,5-TP), which is chemically similar to Herbicide Orange (2,4,5-T). The toxic compound Tetrachloro- dibenzo-p-dioxin (TCDD) is created in minute quantities during the manufacturing process of these compounds. Presently an estimated 700,000 gallons (approximately 2,400 tonnes) of 2,4,5-TP are stored for future disposal. When the recall program is complete an estimated total of 1.2 million gallons (4,100 tonnes), with an average TCDD content of 20 ppb, will require safe disposal.

The National Academy of Science (1979) reported that between 1930 and 1975 the total U.S. commercial sales and imports of PCB's was about 571,000 tonnes. Since 1975 approximately 340,000 tonnes were still in use, and about 25,000 tonnes had been destroyed in land-based incinerators or otherwise degraded. By 1978 an estimated 140,000 tonnes had been stored in landfills or equipment dumps. It is estimated that 68,000 tonnes have already been dispersed into the environment. The 340,000 tonnes still in use from 1975 will eventually have to be disposed of. Current Toxic Substances Control Act regulations require incineration of bulk liquid PCB and some solid mixtures. No estimates are available regarding the amount of PCB wastes that will ultimately become available for disposal on the east coast.

Marketing surveys indicate projected waste volumes exceed 1.1 million tonnes. Such quantities would require several incinerator vessels operating simultaneously, year-round, if at-sea incineration were used, and would require several incineration sites to ensure that two or more vessels did not occupy the same site simultaneously.

This EIS demonstrates the need for an at-sea Incineration Site off the east coast of the United States. Short-term monitoring of research burns in the Gulf of Mexico detected no measurable impacts during those operations (Wastler et al., 1975; TerEco, 1975 and unpublished) indicating the environmental acceptability of this alternative disposal method. The existing quantities and types of waste chemicals which require a safe disposal process, and the anticipation of annually increasing quantities (Table 1-3), indicate that in the future land-based disposal practices may be unacceptable or inadequate to accommodate the enormous amounts of accumulated wastes. In the past public sentiment has opposed incineration of hazardous wastes, such as PCB or 2,4,5-T, near populated areas where spills, equipment malfunctions, or residues may lead to contamination. Transport of wastes generated by east coast industries to a more distant site (e.g., Gulf of Mexico Incineration Site) is not a preferable alternative for several environmental and economic reasons discussed in Chapter 2.

Chapter 2

ALTERNATIVES INCLUDING THE PROPOSED ACTION

Industrial wastes unsuitable for landfill can either be stored on land or incinerated on land or at sea. Present-day land-based incineration is costly and for some substances public sentiment is strongly opposed to this method. The proposed North Atlantic Incineration Site offers a viable alternative to land-based incineration. In addition to the proposed site this chapter discusses several alternative ocean sites.

In accordance with the Council on Environmental Quality's (CEQ) recommended format, this chapter is the substance of the EIS. It is based upon the information and analyses presented in the other chapters and in the appendixes, particularly the chapters on the affected environment (Chapter 3) and the environmental consequences (Chapter 4).

This chapter specifically discusses the following alternatives:

- No action
  - Use of Gulf of Mexico Incineration Site
- Proposed site
- Alternative sites
  - 106-Mile Ocean Waste Disposal Site
  - Previously recommended northern Incineration Site
  - Other oceanic regions
    - Eastern mid-Atlantic Bight region
    - Southern mid-Atlantic Bight region
    - New England oceanic region
    - South Atlantic Bight region

Land-based disposal methods are thoroughly evaluated during the permit application process. Through this evaluation the applicant must prove a need for ocean waste disposal and evaluate alternative disposal means before a permit for at-sea incineration is granted. Land-based disposal methods are not discussed as alternatives to the proposed action, but introduced as considerations should the no action alternative be preferred.

The environmental impacts of the proposed action and the alternative sites have been thoroughly evaluated and are presented, thus defining the issues and providing a clear basis for choice among options by the decisionmakers and the public.

LAND-BASED DISPOSAL

Land-based disposal of liquid organic wastes has been practiced for many years. Numerous physical, chemical, and biological waste treatment processes have been evaluated. Several methods show promise for large-scale operations capable of handling commercial quantities of hazardous wastes, but most are impractical for projected future volumes. The EPA has published several reports in recent years dealing with these alternative methods of managing hazardous waste (e.g., Arthur D. Little (1977), TRW (1976), Versar, Inc. (1977), Process Research, Inc. (1977), and Wilkinson et al. (1978)).

LAND-BASED INCINERATION

Ten basic types of incineration techniques are presently being used or developed for disposal of hazardous wastes (Scurlock et al., 1975). This discussion concerns only liquid injection systems, the most frequently used technique for liquid organohalogen waste combustion, although a rotary kiln system has been used in an experimental procedure to reclaim chlorine from PCB's for cement production.

All commercial incinerator facilities now certified for incineration of organohalogen wastes are located near populated areas and are required to comply with stringent environmental standards. The proximity to populated areas is a result of the need for access to truck and rail transportation facilities, and the proximity to waste generators. Facilities must guard against accidental spill or leakage, and sabotage. Several facilities have been used for experimental incineration of PCB's, with destruction efficiencies greater than 99.99% when gas scrubbing equipment was used.

Land-based and at-sea incineration of organohalogen wastes are essentially the same. The primary difference is in the treatment of gaseous emissions. During at-sea incineration gaseous emissions are released without final treatment, carrying combustion products and residues into the marine atmosphere and oceanic environment. Land incineration methods remove many of the combustion products and residues by means of scrubber devices (e.g., water or alkaline solutions), which capture much of the undesirable effluents. Scrubber residue containing suspended particulates, dissolved (or neutralized) hydrochloric acid (HCl), small quantities of residual organic waste, and trace metals, must still be disposed of in some environmentally acceptable manner.

Incineration on land is a viable alternative to at-sea incineration; however, in the event of mechanical malfunction (flameout or inadequate combustion), the possibility of acute adverse effect upon the environment is greater at land-incinerator locations, due to nearby populated areas. Land incinerators cannot process wastes as rapidly as at-sea incinerators; only about 3 tonnes per hour can be burned on land, compared to about 20 to 25 tonnes per hour at sea.

Incineration on land is several times more expensive than at-sea incineration. Shih et al. (1978) reports that land-based incineration costs of organochlorine wastes ranges from $181 to $212 per tonne, or nearly two to three times the cost of at-sea incineration, which was quoted at $80 to $91 per tonne in 1978 (excluding monitoring costs).

In summary, the advantages and disadvantages of land-based incineration compared to at-sea incineration are:

- Advantages

  - Combustion residue is removed from stack gases by scrubbers, reducing atmospheric contaminant input and downwind land contamination.

  - Small spills may be better contained and are easier to clean up.

- Disadvantages

  - Incinerators are generally located near populated areas. Contaminants escaping the scrubbing process may increase human health risk due to repeated exposure.

  - Scrubber residue must still be disposed of; this usually involves burial in sanitary landfill or storage.

  - Equipment malfunctions (e.g., flameouts) have greater potential for adversely affecting public health and property through exposure to high atmospheric concentrations of waste.

  - Catastrophic spills (especially with fire) will have greater potential for affecting public health through exposure to high atmospheric or water concentrations of wastes.

  - Costs are higher per tonne of waste handled (excluding monitoring programs).

LANDFILLS

Land disposal of liquid organic wastes is widely practiced, and until recently required minimal handling and treatment, substantially reducing costs as compared to incineration. However, recent environmental concerns are resulting in more stringent regulation of hazardous waste disposal conducted in this manner. Requirements promulgated under the Resources Conservation and Recovery Act (RCRA) for improved landfill design, disposal procedures, and environmental monitoring are being implemented. Therefore, stringent regulations, environmental concerns, and social or economic factors relating to landfill may increase the attractiveness of incineration alternatives.

Certain materials (e.g., specific organochlorine compounds) are excluded from landfill disposal because of possible leaching and evaporative processes, thus restricting the method as a viable alternative. Burial in sanitary landfills is best-suited for relatively small quantities of wastes (e.g., domestic and agricultural wastes). Incineration has the advantage of

accommodating the increasingly large quantities of wastes industry is expected to produce, which would otherwise significantly shorten landfill lifespans.

CONVERSION OF WASTES

The RCRA requires industries to develop means of recovering useful resources from waste materials. Chemical conversion of organic wastes into products of economic value is presently in the developmental stages and shows great promise as an alternative disposal method.

The exhaustive chlorination process (chlorolysis) is useful on many organochlorine compounds. Using high pressure and temperature this process reduces wastes to carbon tetrachloride, phosgene, and HCl. However, certain limitations apply because compounds which contain sulfur, nitrogen, and phosphorus adversely affect the process and restrict the applicabilities (Wilkinson, 1978).

The catalytic hydrodechlorination process has potential as a waste elimination alternative. This process is still in the developmental stage and may be unavailable for large-scale use for several years. By using high-pressure hydrogen gas in the presence of a catalyst, chlorinated compounds can be dechlorinated. Consequently, the substance may be made less toxic and more readily biodegradable than the original highly chlorinated compound. Compounds which are capable of being completely dechlorinated may be useful as fuels, chemical intermediates, or solvents.

NO-ACTION ALTERNATIVE

The no-action alternative would cause postponement or cancellation of the site designation for at-sea incineration operations off the middle Atlantic states, thus requiring ultimate disposal of toxic and persistent organohalogen wastes by other means, or if land-based disposal methods are unavailable, it would require termination of the waste-producing process. This alternative would only be feasible under limited conditions: (1) existence of technologically, environmentally, and economically feasible land-based disposal

methods, or (2) evidence that at-sea incineration causes sufficiently adverse environmental consequences to preclude it from consideration.

The condition (1), listed above, has been met on a limited basis because land-based incineration is technologically feasible; however, several past attempts to obtain community approval for incineration of wastes, such as PCB's at commercial waste disposal facilities, have met with public resistance. The condition (2), listed above, has not been met; there is no evidence that controlled at-sea incineration would produce unacceptable environmental risks.

GULF OF MEXICO INCINERATION SITE ALTERNATIVE

As an alternative to no action or designation of a second U.S. Incineration Site, transport of wastes to an existing site in the Gulf of Mexico is considered in this section. The Gulf of Mexico Incineration Site was designated in 1976 (EPA, 1976b) primarily for incineration of organochlorine wastes, although other wastes may be considered acceptable pending documentation. The coordinates of this site are reported in the Federal Register (1978) as: 26°20'00"N to 27°00'00"N; 93°20'00"W to 94°00'00"W, occupying an area of 1,892 nmi^2 (6,489 km^2) (Figure 2-1). The original designation terminated on September 15, 1981; however, EPA has published a redesignation of the site for continuing use for an indefinite period of time.

Transport of east coast-generated industrial chemical wastes to the Gulf of Mexico Incineration Site is a potential environmental hazard and economically expensive. The overland distance from New York to New Orleans is about 1,300 miles (2,400 km). The waste materials that would be transported are hazardous. Accidents or spills along the national highways or rail lines would pose serious risks to public health and create new disposal problems if chemicals became mixed with soil or other solids during clean up. This material would then require disposal in a suitable landfill. Large quantities of wastes must be in transit at all times to facilitate the relocation of the volumes of wastes available for incineration. Waste shipments require additional expenses (e.g., manpower, fuel, and equipment maintenance) which would not occur if wastes were incinerated on the east coast.

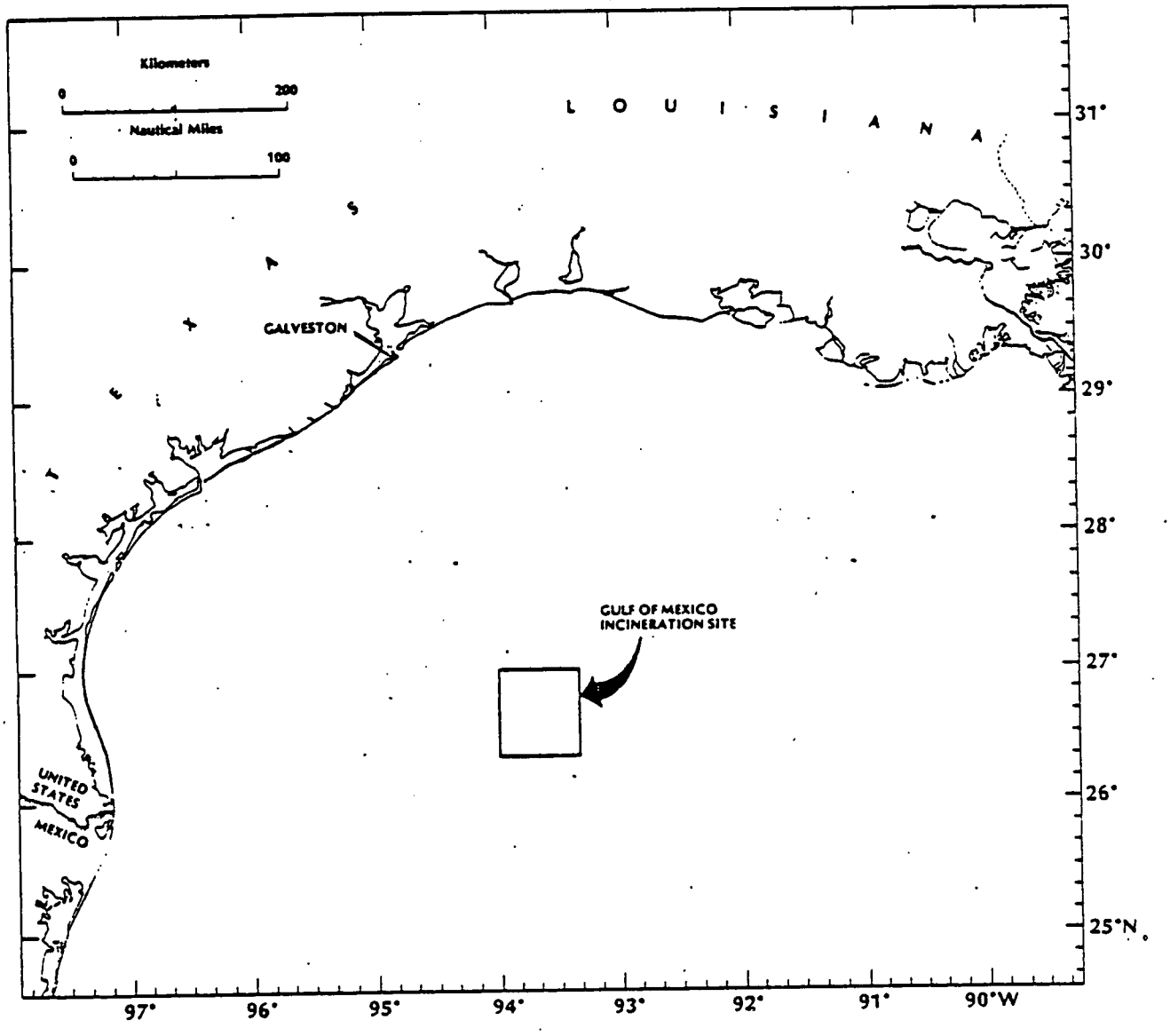


Figure 2-1. Gulf of Mexico Incineration Site

The alternative of shipping these wastes approximately 2,500 miles (4,600 km) by sea to the Gulf of Mexico requires significantly increased transit time. The incineration vessel would require 7 to 10 days to reach the Gulf of Mexico Incineration Site, but only several hours to reach the proposed North Atlantic Incineration Site. Incineration operations would require 7 to 8 days, and a return trip to New York would begin. Thus, a single shipload of wastes (approximately 4,000 tonnes) would require 21 to 28 days at sea for the disposal operation. This extended operational period would substantially increase the expense of at-sea incineration by increased ship time and fuel.

Currently the Gulf of Mexico Incineration Site is infrequently used. If at-sea incineration becomes more extensively used in the future, the capacity of the site to accommodate waste disposal may be rapidly saturated. More studies are necessary in order to determine the maximum rates and volumes of waste materials which can be incinerated without adversely affecting the marine environment. Waste residues will be widely dispersed and greatly diluted shortly after release (Chapter 4); however, to maintain water quality criteria (EPA, 1976a), rates and volumes will require management. Gulf Coast industries generate approximately 90% of the estimated total quantities of wastes available, thus the Gulf of Mexico Incineration Site may eventually achieve maximal use without any transport of east coast-generated wastes to the site. For the time being, notwithstanding the hazards and expense of long-distance transport of wastes, this site should be considered a viable alternative to the designation of a second Incineration Site.

In summary, the advantages and disadvantages to transport of waste chemicals to the Gulf of Mexico are:

- <u>Advantages</u>

  - Precludes the designation of another ocean disposal site and concomitant monitoring.

  - Wastes would be removed from the east coast, thus could not enter the environment unless spilled during transit to the Gulf of Mexico.

All wastes would be incinerated at one site; thus, resource requirements for monitoring and surveillance would be focused.

- Disadvantages

  - Wastes must be transported long distances (either over land or by ship) to reach the disposal site, which increases the potential for accidental spills during transit.

  - Increased future use of the Gulf Site by Gulf Coast waste generators will rapidly fill the maximum available use level (approximately 190,000 tonnes per year, c.f. page 2-36).

PROPOSED SITE

The proposed action is the designation of a North Atlantic Incineration Site for the purpose of at-sea incineration of hazardous industrial chemical wastes. This section summarizes anticipated impacts and forms the basis of comparison with other alternatives.

The western boundary of the proposed Incineration Site is 120 nmi east of Cape Henlopen, Delaware (Figure 2-2, No. 1). The site covers 1,240 nmi^2 (4,250 km^2) on the Continental Rise, bounded by latitudes 38°00'N to 38°40'N, and longitudes 71°50'W to 72°30'W. Water depths range from approximately 2,400m at the northwest corner of the site, to approximately 2,900m at the eastern edge. The 106-Mile Ocean Waste Disposal Site lies due north of the proposed Incineration Site, and an inactive radioactive waste disposal site exists inside the proposed Incineration Site, near the northern border, with center coordinates 38°30'N, 72°06'W (NOAA, 1975).

No baseline studies have been conducted within the proposed site for the explicit purpose of developing baseline data. NOAA, assisted by other governmental agencies and academic institutions, has been surveying the 106-Mile Ocean Waste Disposal Site and adjacent areas for several years (NOAA,

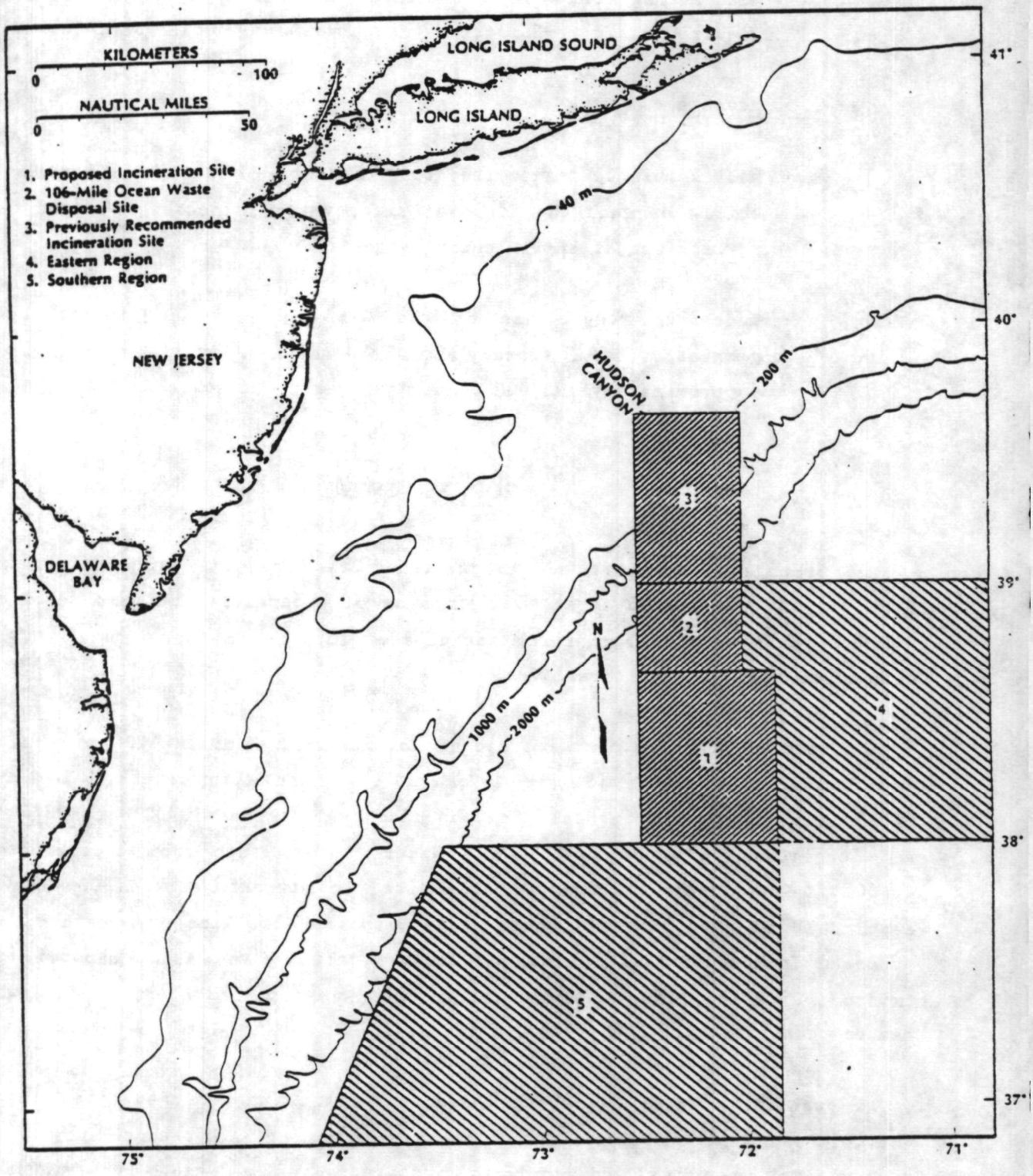


Figure 2-2. Alternative Sites in the Mid-Atlantic Bight Region

1975, 1977, and 1978). Permittees using the 106-Mile Ocean Waste Disposal Site have employed a private contractor to monitor that site, as one of the permit requirements. Physical, chemical, and biological data collected during these studies can be applied to the proposed Incineration Site. A Final EIS on the 106-Mile Ocean Waste Disposal Site has been completed (EPA, 1980a).

ENVIRONMENTAL ACCEPTABILITY

Previous EPA-permitted burns conducted in the Gulf of Mexico have demonstrated that no short-term adverse impacts are caused by incineration (Chapter 4). Materials considered for at-sea incineration must first meet MPRSA criteria; only those materials which burn efficiently and produce acceptable trace metal and organohalogen residual levels will be permitted. Incineration operations must then be conducted as required by the Mandatory Regulations and Recommended Technical Guidelines (Appendix B). The criteria are designed to avoid occurrence of undesirable short-term or long-term adverse impacts due to incineration.

Waste residues enter the marine environment as broadly dispersed atmospheric fallout; only the surface (to 20m) and near-surface (20 to 100m) waters are likely to be affected. Model simulation indicates that the most severe impact from atmosphere-to-water exchange occurs at approximately 4,000m downwind of the incineration vessel, and particulates are continually dispersed and diluted until removed by precipitation or settling (Paige et al., 1978). Atmospheric transport to coastal areas will be limited because the site is far from land and prevailing winds move west-to-east, carrying the waste plume seaward during periods of offshore flow. During these periods residues will be partially removed from the atmosphere and remaining residues will be diluted to background levels.

Waste residues are widely dispersed and diluted in the atmosphere and are already diluted on contact with the ocean surface. Acidity, the most pronounced short-term effect (resulting from hydrochloric acid), is rapidly neutralized in seawater and the residual chloride is easily absorbed by the water. Unburned organochlorine and trace metal constituents are quickly diluted to ambient levels and further dispersed by ocean currents and water turbulence.

Extreme water depths are expected to increase dispersion and dilution at the site, thereby limiting any adverse benthic impacts. This conclusion is supported by studies conducted at the 106-Mile Ocean Waste Disposal Site, which receives liquid wastes in quantities many orders of magnitude larger than the quantities which will enter waters at the proposed Incineration Site. No detectable adverse benthic impact has been observed at the 106-Mile Ocean Waste Disposal Site (EPA, 1980a).

Bird migration routes are broadly distributed across the mid-Atlantic region. During autumnal migration large numbers of birds leave the North American Continent for areas in the Caribbean and South America. The effects of incineration emissions on birds is unknown, but acid residue may provide adverse impacts on low-flying birds.

ENVIRONMENTAL MONITORING

The purpose of monitoring waste disposal sites is to ensure that long-term adverse effects do not develop unnoticed, especially irreversible effects. As NOAA has observed in its baseline report on effects of dumping at the nearby 106-Mile Ocean Waste Disposal Site, monitoring is more difficult at sites beyond the Continental Shelf because of the distance from shore, greater depths of water, and the general lack of background information on areas beyond the Shelf.

Another problem involves the subtle interaction of wastes with the surrounding water and marine life. Given the dynamic conditions of the site, long-term impacts will be difficult to measure. Affected organisms in the water will most likely move out of the area by swimming actively or being carried by currents. Monitoring will be difficult until new techniques and more precise measurements are available for detection of deleterious effects. Present monitoring activities will involve periodic physical, chemical, and

biological sampling of affected water within the disposal site and adjacent areas, in addition to atmospheric observations and sampling in the affected downwind environment.

Monitoring at the proposed Incineration Site may be complicated by the proximity of the 106-Mile Ocean Waste Disposal Site. Ocean currents in the region move predominantly to the southwest. Chemical wastes dumped at the 106-Mile Ocean Waste Disposal Site may be transported through some portions of the proposed Incineration Site, primarily in the northwest corner. Gulf Stream eddies (Figure 3-2) could transport 106-Mile Site wastes through large areas of the proposed Incineration Site, or incineration residues could be carried into the adjacent 106-Mile Ocean Waste Disposal Site. In the event of such mingling of waste plumes it would be difficult, if not impossible, to distinguish between chemically similar waste inputs, although waste indicator compounds could possibly be identified and monitored to eliminate mingling problems.

Expansion of the 106-Mile Ocean Waste Disposal Site monitoring program (to include the proposed Incineration Site) would serve to integrate and unify sampling procedures with the advantages of possibly reducing problems created by waste mingling, and by minimizing logistics problems and expenses.

SURVEILLANCE

Nearshore disposal sites facilitate surveillance by patrol vessels and helicopters; however, the proposed Incineration Site may require use of shipriders because it is beyond the range of other effective means of surveillance. In addition to, or in lieu of shipriders, electronic surveillance equipment can be installed on incineration vessels (as has been done in the past) to maintain accurate records of incinerator equipment operations, meteorological conditions, and navigational positions.

Satellite surveillance may have excellent potential in lieu of other techniques.

ECONOMICS

TRANSPORTATION COSTS

Halebsky (1978) prepared a detailed economic report of at-sea incineration based on uninflated dollars, projecting costs to 1989, and considered all aspects of the operation, including procurement and conversion of a U.S.-owned-and-operated east coast vessel. It was concluded that at-sea incineration will cost approximately $63 per tonne in 1983, decreasing to approximately $55 per tonne by 1989 (as volumes increase). Costs are based on transport from Delaware Bay to the existing 106-Mile Ocean Waste Disposal Site, due north of and contiguous with the proposed Incineration Site. However, estimates are based on burn rates and volumes which may not be environmentally acceptable, thus reducing operational efficiency and increasing costs (Chapter 4).

By comparison, the owners of the foreign-flag vessel M/T VULCANUS (as of March 1978) were charging $80 to $91 per tonne of waste for a minimum of two loads.

The proposed site will be located in a region convenient to the mid-Atlantic industries, where wastes are generated, and to port facilities.

MONITORING COSTS

The cost of monitoring the proposed Incineration Site will be high because of the complexity of the environment and distance from shore. NOAA has estimated an annual cost of $1 million to perform seasonal monitoring surveys of the 106-Mile Ocean Waste Disposal Site. The proposed Incineration Site is near the 106-Mile Ocean Waste Disposal Site, making it cost-effective to expand monitoring operations to include both sites. The costs to permittees for monitoring incineration activities will be high due to the distant location and depth of the site, as well as the high cost of measuring organic compound concentrations in the atmosphere and water column. Monitoring of deep offshore sites is feasible, but will be more expensive than monitoring shallow nearshore sites.

SURVEILLANCE COSTS

USCG surveillance activities include a shiprider aboard the incinerator vessel during disposal operations, random spot-checks before a waste vessel leaves port, and checking the ship log for departure and arrival times. The USCG presently assigns several full-time personnel to survey disposal activities in the New York Bight, including disposal operations at the 106-Mile Ocean Waste Disposal Site. Many other existing ocean dump sites are within the Bight Apex, and within the normal range of USCG vessels and helicopters (excluding the 106-Mile Ocean Waste Disposal Site). Surveillance of disposal activities at the proposed Incineration Site will consume a significant amount of time and money.

LOSS OF BIOTIC OR MINERAL RESOURCES

Almost all U.S. fishing activities are over the Continental Shelf and therefore should not be directly affected by the waste residues. Table 2-1 shows the most economically important finfish and shellfish taken in the mid-Atlantic. Along the edge of the Continental Shelf, fluke and lobster are the only organisms on this list which occur anywhere near the proposed Incineration Site, aside from the highly migratory tuna and billfish species. Waste residues would be extremely diluted when and if they reached the bottom, where these animals dwell, and since these animals are demersal and highly mobile, it is unlikely that stocks would remain in a single location to be adversely affected by incineration operations. Red crabs on the Continental Shelf/Slope break west of the proposed site represent a potentially valuable resource which may be further exploited in the future. However, no crabs of commercial size occur in the proposed site, and the adult crabs are taken sufficiently far from the proposed site so that waste residues released at the site are not likely to reach them. Foreign ships fish along the edge of the entire Continental Shelf from Georges Bank to Cape Hatteras, especially during late winter and early spring. However, the proposed site is not a unique location for foreign fishermen, nor does it obstruct migration routes of species valuable to foreign fishermen. Therefore, the likelihood of foreign fish stocks being affected by incineration operations at the proposed site is slight.

TABLE 2-1
1974 FINFISH AND SHELLFISH LANDINGS BY STATES
(Thousands of Pounds, Thousands of Dollars)

	New York		New Jersey		Delaware		Total	
	lb	$	lb	$	lb	$	lb	$
Finfish								
Fluke	2,487	846	3,499	1,153	-	-	5,986	1,999
Blue Fish	1,067	147	1,003	115	6	1	2,067	263
Atlantic Mackerel	322	39	774	109	2	1	11,098	149
Menhaden	576	18	107,307	2,735	13	0.5	107,896	2,753
Sea Bass	98	47	778	252	80	23	956	352
Sea Trout	1,427	341	2,686	312	281	64	4,394	717
Scup	3,635	852	6,040	880	-	-	9,675	1,732
Tilefish	49	23	838	263	-	-	887	286
Bluefin Tuna	10	4	872	232	-	-	892	236
Whiting	1,955	250	7,022	587	8	1	8,985	838
Swordfish	1	2	7	12	-	-	8	14
Shellfish								
Lobsters	731	1,396	1,191	1,916	26	55	1,948	3,367
Red Crab	-	-	25	2	-	-	25	2
Rock Crab	-	-	346	22	-	-	346	22
Surf Clams	3,951	719	22,657	2,948	5,817	770	32,425	4,437
Scallops	884	1,158	344	531	-	-	1,228	1,689
Other								
Squid	964	178	1,287	237	-	-	2,251	415

Note: Landings are shown in round (live) weight except for clams, lobsters (total meat), and scallops (edible meat).

Source: Adapted from NOAA-NMFS, 1977

During their migratory periods four endangered and one threatened species of sea turtles, and six endangered species of cetaceans, are known to use the offshore region occupied by the proposed Incineration Site, but are not unique to this region. Incineration operations are expected to have no unacceptable adverse impact on these organisms.

Waste incineration will not interfere with petroleum exploration or production activities on the Continental Shelf. Personnel manning the facilities will not be endangered because prevailing winds move west-to-east, and, in the event of temporary wind shifts, the nearest well platform will be 30 nmi (55 km) west (Figure 3-5), where residue concentrations will be diluted to undetectable levels. Although no mid-Atlantic oil exploration presently exists off the U.S. Outer Continental Shelf, the U.S. Geological Survey has indicated that future exploratory drilling beyond the Continental Shelf is possible (Figure 3-6). If off-Shelf drilling should occur within the site or in a downwind location, precautionary measures will be required to protect drillship and logistical support personnel from prolonged exposures. Normal precautions will be required to avoid navigational hazards presented by oil production platforms which may be erected in transit paths to the site.

SIZE AND CONFIGURATION OF THE PROPOSED INCINERATION SITE

The size and configuration of the proposed Incineration Site were chosen to accommodate the requirements of a continuously moving incinerator vessel. A shipload of waste requires many hours to burn, which necessitates numerous passes across the site. For example, with a burn rate of 25 tonne/hr, 5,000 tonnes of waste will require about 200 hours, or 8.3 days to burn; at a ship speed of 5 kn (9.3 km/hr), 1,000 nmi (1,850 km) must be traveled to complete the incineration operation. The proposed site is 31 nmi (57 km) by 40 nmi (74 km) square. Traveling the length of the site at 5 knots, a ship will require 25 passes along the length of the site to complete the incineration operation. Faster ship speeds will require more passes. Therefore, the site was given large dimensions for ease of ship-handling, and to aid in dispersing waste residues.

The location of the proposed Incineration Site was selected on the basis of several environmental and economic advantages; however, with this choice some disadvantages exist.

- Advantages

  - The proposed site complies with all regulations and site selection criteria as shown in this chapter.

  - The proposed site is as close as possible to waste material loading ports without infringing on other uses of the ocean.

  - Environmental studies have been performed at the nearby 106-Mile Ocean Waste Disposal Site and surrounding areas (including the proposed site), which can be readily applied to studies and monitoring efforts at the proposed Incineration Site.

- Disadvantages

  - Waste material from the 106-Mile Ocean Waste Disposal Site to the north may be transported into the Incineration Site by ocean currents moving southwesterly, which could create monitoring difficulties at the site.

  - The designation of a new disposal site will require expanded monitoring and surveillance efforts. These efforts will be costly.

ALTERNATIVE SITES

The Regulations and Criteria provide general and specific criteria by which disposal sites are evaluated for proposed designation (Chapter 1). In considering alternative incineration sites, the feasibility of using existing waste disposal sites was evaluated. Only one existing site, one previously

recommended site, and the areas east and south of the proposed site are viable alternative incineration sites in the mid-Atlantic Bight Region (Figure 2-2). The two primary alternative sites are the 106-Mile Ocean Waste Disposal Site (Figure 2-2, No. 2) and the site recommended by Paige et al. (1978) within 39°00'N to 39°40'N and 72°00'W to 72°30'W (Figure 2-2, No. 3).

Other sites between Long Island and Cape Henlopen over the Continental Shelf of the mid-Atlantic Bight (Figure 2-3) were eliminated from further consideration for several reasons. The proximity of these sites to shore and populated areas is of primary importance. Atmospheric transport of waste residues could cause direct impacts on coastal communities. Other considerations are the extensive commercial and recreational use of Shelf areas and resources and resultant heavy maritime traffic. These sites occupy areas which are rich fish and shellfish food production regions, and the hazardous nature of many wastes demands that the food chain bioaccumulation of residues be minimized.

106-MILE OCEAN WASTE DISPOSAL SITE

The 106-Mile Ocean Waste Disposal Site (Figure 2-2, No. 2) was established in 1961 for ocean disposal of industrial wastes unsuitable for land-based disposal. The site covers 470 nmi^2 (1,610 km^2) due north of the proposed Incineration Site. Physical, chemical, biological, and geological characteristics greatly resemble those of the proposed Incineration Site. However, plankton productivity appears to be slightly higher at the 106-Mile Site than at the proposed Incineration Site. This is apparently related to more frequent intrusions of Shelf water into the 106-Mile Site. The area has been monitored by NOAA for several years and disposal operations have also been monitored by permittees. EPA recently prepared a detailed Environmental Impact Statement (EIS) for the final designation of this site for continued use (EPA, 1980a).

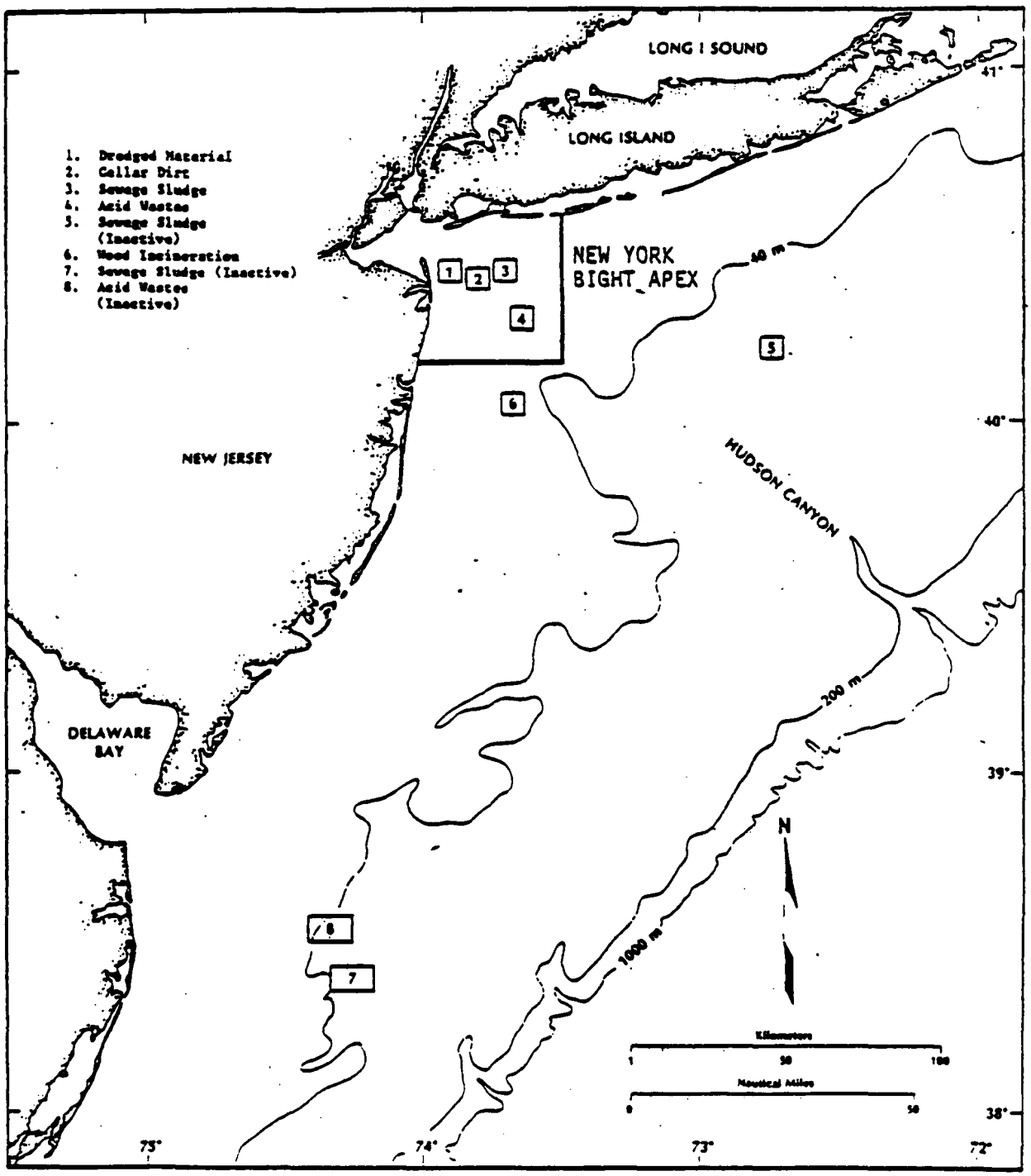


Figure 2-3. Existing Nearshore Disposal Sites in the Mid-Atlantic Bight Region

areas, and offshore oil and gas lease areas on the Continental Shelf (Chapter 3 and Appendix A). Furthermore, biological productivity increases substantially near the Continental Shelf.

The only other directions left to consider are further out to sea (eastward) or further south (Figure 2-2). Either choice has the advantage of diminishing (or eliminating) possible overlaps of contaminant loading from the 106-Mile Ocean Waste Disposal Site. Meteorological phenomena will not change to such an extent that they will decrease atmospheric impacts. Surface physical oceanographic phenomena will be similar at any site chosen; the primary differences will be a surface current-flow pattern shift to a more northeasterly direction and the proximity of the site to the Gulf Stream (Figure 3-2). Gulf Stream Water and Slope Water will alternate more frequently as occupants of an eastern or southern site due to Gulf Stream meanders. Biological characterization will not change significantly by moving the site location up to 60 nmi (110 km) east or south, since no major faunal breaks occur within the gyre.

To position an incineration site within an alternative region east or south, consideration should be given to the disadvantage of its possible physical separation from the 106-Mile Ocean Waste Disposal Site. Baseline information from studies conducted at the 106-Mile Site would be less applicable, additional site-specific baseline information would need to be collected, and new monitoring programs would be established to study more distant oceanic areas. The existing monitoring program at the 106-Mile Site may be expanded to include the latter Incineration Site with comparative ease, because many of the local characteristics of the proposed Incineration Site have already been established.

USE OF THE NEW ENGLAND OCEANIC REGION

The oceanic region southeast of New England beyond Georges Bank was examined as a candidate region for an alternative site location. Several environmental and political aspects diminish the viability of this alternative.

The region considered includes approximately 20,700 nmi^2 (71,000 km^2) in the northwest Atlantic Ocean beyond the 2,000m contour of Georges Bank (Figure 2-4a). The western boundary of the candidate region lies approximately 160 nmi (300 km) east of Cape Cod, Massachusetts. The distance from Cape Cod to the southeast corner of the region is approximately 330 nmi (610 km).

The entire area overlies the Continental Slope and Rise south of Georges Bank and is usually occupied by the Slope Water mass of the North Atlantic region. The southern area of the candidate region is frequently intruded by the eastward flowing Gulf Stream which meanders to the north and south of its historical axis (Figure 2-4b). East of the candidate region, 60 to 100 nmi (110 km to 185 km), the Gulf Stream is found to begin large meanders and is frequently highly diffuse, often appearing to split into several independent currents (Stommel, 1960; Fuglister, 1963). The northern portion of the candidate region is characterized by southwestward-flowing surface currents (U.S. Naval Oceanographic Office, 1965). Little is known about the subsurface currents.

Surface water temperatures range from an average low of 4°C during winter months to a high of 21°C during summer months (U.S. Naval Oceanographic Office, 1967). Surface salinities range from 33 ppt to 36 ppt annually. Average air temperatures range between lows of about 4°C to highs of about 22°C, although between October and March freezing temperatures (0°C or less) are often observed.

Ship operating conditions are rigorous during winter and spring months. Winds are reported above 17 kn (15 mph) more than 45% of the time between November and March (U.S. Naval Oceanographic Office, 1963). During this period the predominant wind direction is from the north to east quadrant. These winds result in heavy sea conditions, producing waves 3.7m (12 ft) or more 10% to 20% of the time. Seas greater than or equal to 2.4m (8 ft) have been observed 18% to 22% of the time. Between November and March successive gales have been reported, within 7 days of one another 84% to 95% of the time, and at a maximum of 23 days apart in a region southwest of the candidate region (U.S. Navy, 1955). However, gales were observed to pass within 1 day.

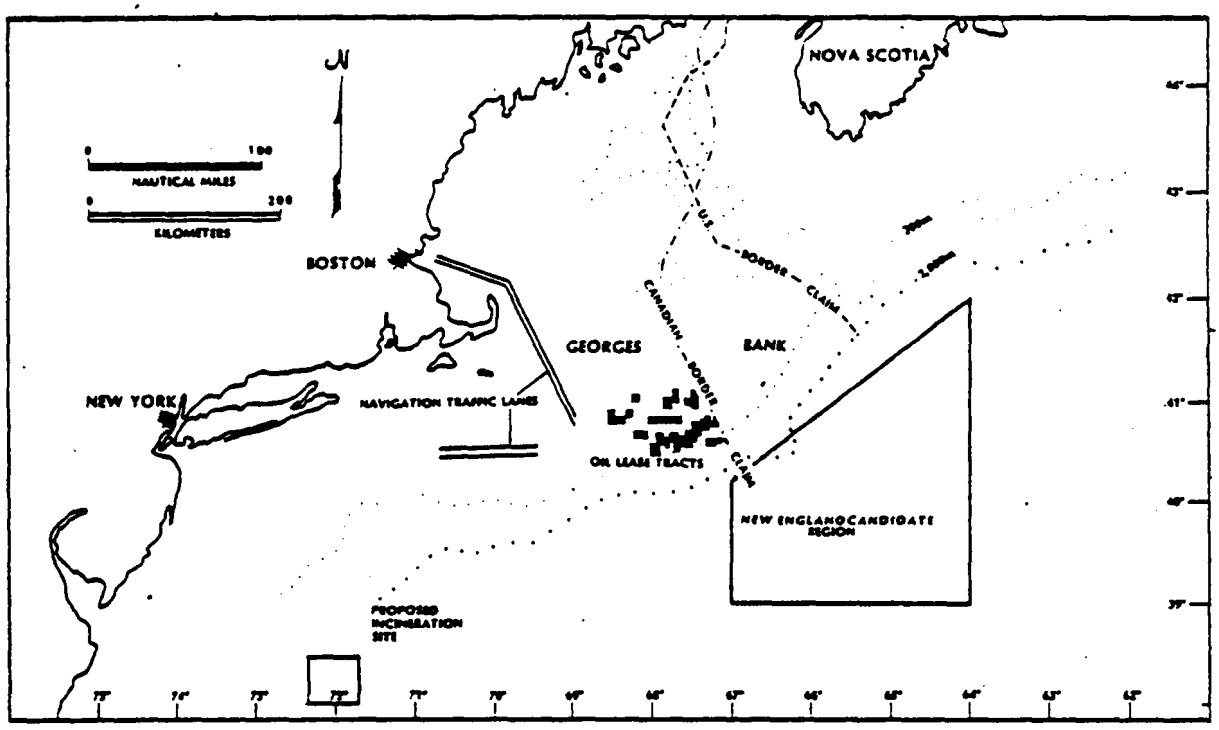


Figure 2-4a. Oil Lease Tracts and Territorial Claims
Source: Finn, 1980

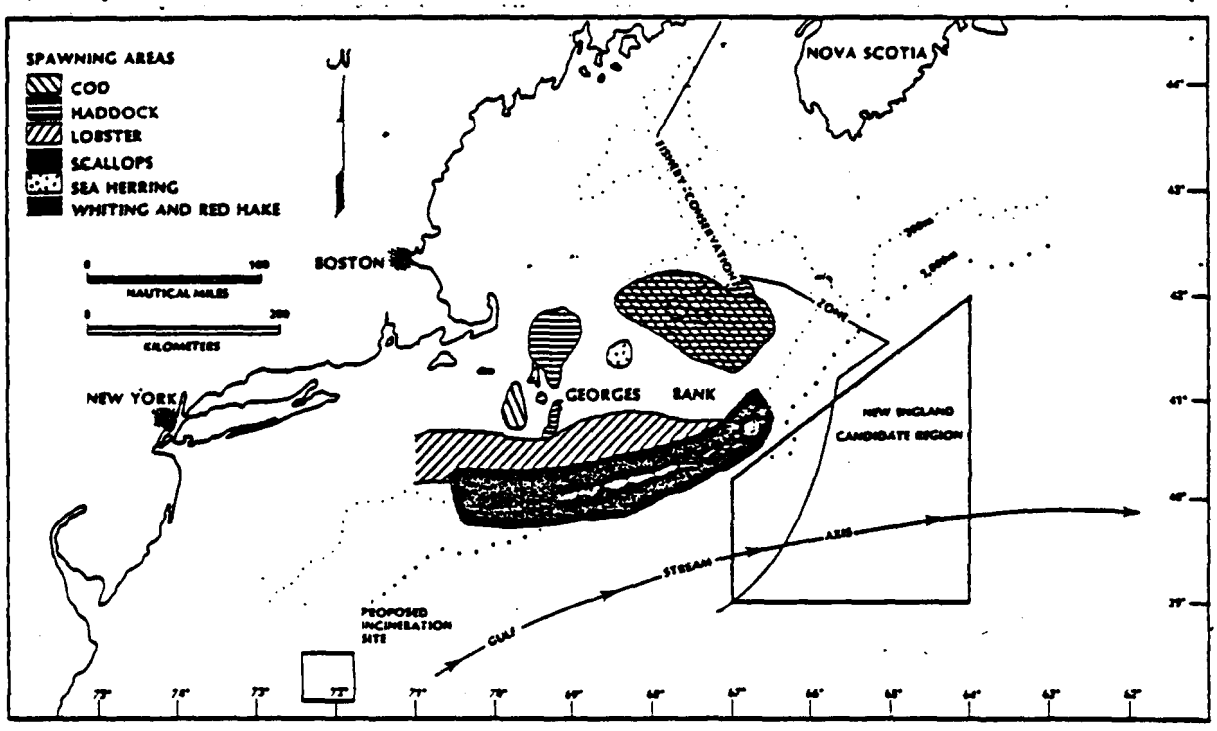


Figure 2-4b. Spawning Grounds on Georges Bank
Source: Finn, 1980

The most severe gale conditions occur from January to March, where storms may last up to 3 days. Extrapolating these conditions to the more northerly candidate region suggests that gale force storm conditions will be more frequent and perhaps more intense and long-lived in the candidate region.

Low visibility in the candidate region is most often associated with low cloud conditions producing rain or snow. As a result, visibility less than 5 nmi (9 km) occurs 10% to 20% of the year (U.S. Navy, 1955). The most severe low visibility conditions occur from January to March and May to July. Rain or snow accompanies winter weather patterns produced by westerly and northerly winds 30% of the time. During the warmer months of May through August southerly and easterly winds are accompanied by rain 5% to 25% of the time.

Transport of chemical wastes to a site southeast of New England would require shipment of wastes 300 to 400 nmi (560 km to 740 km) by sea. Weather conditions in this region of the northwest Atlantic are often severe during winter months. Heavy weather may hamper incineration operations or endanger the safety of the vessel and crew. Additionally, the frequency and suddenness of storms would limit the use of auxiliary monitoring vessels.

In addition to the distant location from waste generating industries and weather hazards of the candidate region, the enormously valuable commercial fisheries industry of Georges Bank must be considered. Annual landings of fish are valued at about $168 million, producing a net economic benefit of over $1 billion to the New England regional economy (Finn, 1980). Thus, other issues are currently focusing environmental and political concerns upon this region. In 1979 the Outer Continental Shelf Lease Sale 42 was conducted for tracts located on the southern edge of Georges Bank (Figure 2-4a), producing a furor among environmentalists and commercial fishery interests. Another issue is an ongoing border claim dispute between the U.S. and Canada (Figure 2-4a).

No advantages are known in selecting a New England region site over the proposed site for incineration. The disadvantages are the distance from the area of waste generation, increased weather hazards, and additional expense in the form of man-hour requirements, equipment maintenance, and fuel.

Phytoplankton sampling conducted from the Shelf to the Sargasso Sea shows a general decrease in numbers of individuals and numbers of species with increasing distance from shore; additionally, there is a change in dominance of phytoplanktonic species (Hulburt and MacKenzie, 1971). Diatoms are dominant in Shelf waters, dinophyceans and coccolithophores in Florida Current waters, and coccolithophores in the Sargasso Sea. Emery and Uchupi (1972) reported primary productivity in outer Shelf waters to be about 100 $mgC/m^2/day$ as compared with 500 $mgC/m^2/day$ in nearshore waters. Zooplankton have not been as thoroughly studied, but quantitative data show a decrease in standing crop in the outer Shelf region, as compared to nearshore waters (VIMS, 1974).

No navigational lanes have been established for this region, but several naval fleet operational areas and a National Aeronautics and Space Administration (NASA) operational area are located over much of the Continental Shelf. Several historical dump sites (all inactive) are located on and off the Continental Shelf. Beyond the Shelf a site formerly used for dumping chemicals and munitions is approximately 240 nmi (440 km) east of Daytona Beach, Florida, at latitude 29°20' N, longitude 76°05'W (Figure 2-5).

Halebsky (1978) reports that the majority of industrial chemical wastes produced on the east coast originate in the states of New Jersey, Delaware, Pennsylvania, and West Virginia. Therefore, wastes must be transported several hundred miles overland or by sea to reach a site in the candidate region. There are no known advantages in selecting this region over the proposed site for incineration. The disadvantage is the distance from the area of waste generation. Transport overland or by sea will increase incineration operation expenses in the form of manpower, equipment maintenance, and fuel, without providing any improved environmental quality in the operation. If future operations require an additional incineration disposal area, this region should be considered as a primary candidate. It is a large, environmentally complex region; therefore, a detailed EIS will be necessary.

SUMMARY

Several alternative locations and methods were considered relative to at-sea incineration (Table 2-2). In comparison to at-sea incineration

TABLE 2-2
SUMMARY EVALUATION OF ALTERNATIVE DISPOSAL SITES FOR AT-SEA INCINERATION

Location	Environmental Acceptability	Environmental Monitoring	Economics
Proposed North Atlantic Incineration Site	Removed from populated areas and from commercially important Shelf resources; located in a region of low biological productivity.	Monitoring is possible; expensive, requiring the use of auxiliary vessels.	Incineration operations will cost about $100 per tonne, plus monitoring expenses.
Gulf of Mexico Incineration Site	A site has been designated for at-sea incineration of hazardous waste chemicals; presently available for use, however, wastes must be transported about 1,300 mi by land, or 2,500 mi by sea, from an east coast port such as New York.	Short-term monitoring has been conducted during research incineration operation.	Shipment of east coast-generated wastes by truck or rail will cost as much as $150 per tonne, in addition to the incinerator vessel and monitoring, or shipment by sea will be about 17 times farther than the proposed incineration site.
106-Mile Ocean Waste Disposal Site	Concurrent waste chemical dumping activities and potential synergistic effects of wastes hinder the choice of this site as an alternative.	Monitoring has been conducted for several years. It has proven to be difficult and expensive due to the remote location. Use of the site for incineration operations will further compound monitoring difficulties.	Total costs will be similar to those incurred at the proposed site.
Existing Nearshore Sites	Proximity to populated areas; commercially and recreationally important Shelf resources hinder the choice of these sites as alternatives.	Monitoring is less difficult than at remote oceanic sites.	Incineration operations will cost about $100 per tonne plus monitoring; however, due to the relative nearness to shore and shallower water depths, monitoring expenses will be less than equivalent efforts at remote sites.
Previously Recommended Site	Proximity to commercially important Shelf resources, major shipping lanes, and oil and gas drilling operations hinder the choice of this site as an alternative.	Monitoring would be comparable to the proposed site or the 106-Mile Site.	Total costs will be similar to those incurred at the proposed site.
Other mid-Atlantic Oceanic Regions	The regions east and south of the proposed site appear to be environmentally acceptable. These regions possess the same basic features of the proposed site, but are less well-known due to the greater distances from the 106-Mile Site.	Monitoring will be comparable to the proposed site or the 106-Mile Site.	Total costs will be similar to those incurred at the proposed site; however, additional baseline data are necessary to better characterize these regions.
New England Oceanic Region	Hazardous winter weather conditions and the proximity to the highly productive and controversial Georges Bank hinder the choice.	Monitoring is possible but will often be hazardous or prevented due to severe winter weather conditions.	Shipment of wastes will involve a distance three to four times farther than the proposed site.
South Atlantic Bight	Preliminary examination indicates this region is environmentally acceptable as an alternative site location. However, wastes must be transported about 600 mi by land or sea to reach this region with no resultant improvement in environmental quality of the operations.	Monitoring would be comparable to the proposed site or the 106-Mile Site.	Shipment off east coast-generated wastes by truck or rail will cost as much as $50 per tonne, in addition to the incinerator vessel and monitoring, or shipment by sea will involve a distance about five times farther than the proposed incineration site.

operations, land-based operations are considered potentially more hazardous in the event of accidental spill or incinerator malfunction, due to proximity to populated areas, and are currently more expensive. A number of features make the proposed Incineration Site the best choice among the alternatives examined:

- It conforms to the legislative (MPRSA) directive for EPA to designate off-Shelf sites, whenever feasible.

- The proposed Incineration Site has great water depths; thus, dilution and dispersion of introduced materials are greatly enhanced, and the Gulf Stream ensures good mixing.

- The proposed Incineration Site is not in an area of significant commercial or recreational fishing or shellfish harvesting.

- The proposed Incineration Site is convenient to waste generating industries and major mid-Atlantic ports.

- Information already gathered in monitoring the nearby 106-Mile Ocean Waste Disposal Site can be applied to the proposed Incineration Site.

- As opposed to land-based incineration, mechanical malfunctions will not pose a threat to populated areas (excluding nearshore spill or leakage).

- The proposed Incineration Site can accommodate large quantities of wastes.

In considering all reasonable alternatives to the proposed action, the designation of the proposed Incineration Site as an organohalogen waste incineration location is the most favorable alternative. There are risks involved in the use of any site (Chapter 4), but the environmental risks of incinerating organohalogens at the proposed site are considered to be less environmentally and economically expensive than incineration on the

Continental Shelf or other Continental Slope locations. If subsequent monitoring at the site shows negative effects from residues to be greater than anticipated, EPA may discontinue or modify use of the site, according to 40 CFR §228.11.

DETAILED BASES FOR THE SELECTION OF THE PROPOSED SITE

Section 228.6 of the Ocean Dumping Regulations (Chapter 1) describes the 11 "general and specific criteria for selection of sites to be used for ocean-waste disposal." Each factor is briefly discussed here. More detailed information is presented in Chapters 3 and 4.

(1) Geographical position, depth of water, bottom topography, and distance from coast.

The proposed Incineration Site is beyond the mid-Atlantic Continental Shelf and over the Continental Rise (Chapter 1, Figure 1-1). Geographical coordinates are 38°00'N to 38°40'N, and 71°50'W to 72°30'W. Water depths range from 2,400m at the northwest corner to 2,900m along the eastern border. The bottom is generally a flat or gently sloping abyssal plain. The nearest point of land is at the Delaware-Maryland State boundary, approximately 120 nmi (220 km) from the northwest corner of the site.

(2) Location in relation to breeding, spawning, nursery, feeding, or passage areas of living resources in adult or juvenile phases.

All of these activities occur in some measure within the oceanic region along the Shelf Break near the proposed and alternative mid-Atlantic Bight Sites. Likewise, many noncommercially important marine organisms and migratory birds may periodically transit the site. No feature of the life history of these organisms are known to be unique to the proposed Incineration Site or its vicinity (Appendix A).

(3) Location in relation to beaches and other amenity areas.

The proposed site is approximately 120 nmi (220 km) from the nearest land (i.e., the coasts of Delaware and Maryland). Prevailing winds are from west-to-east (i.e., offshore); however, if wind directions reverse, the distance from land is adequate to provide for extensive dispersion and dilution of atmospheric waste residues before reaching shore. Therefore, use of the proposed site should not impinge on recreation, coastal development, or any other amenities along the shoreline. The same is true for alternative mid-Atlantic Bight sites except those located over the Continental Shelf.

(4) Types and quantities of wastes proposed to be disposed of and proposed methods of release, including methods of packing the waste, if any.

Wastes to be incinerated at the proposed site must meet EPA's marine environmental impact criteria outlined in 40 CFR Part 227 Subparts B,D, and E. The principal types of wastes anticipated to be incinerated are organochlorines, although other acceptable organohalogens may eventually be included. Previous burns have demonstrated the high destruction efficiency of incineration (+99.96%). Thus, 0.04%, or less, of the waste will be discharged into the environment. By 1989 approximately 271,000 tonnes of wastes requiring safe disposal may be accumulating on the U.S. east coast annually.

(5) Feasibility of surveillance and monitoring.

Although costly, both surveillance and monitoring are feasible at the proposed site and all alternative sites. Site characterization information obtained from the 106-Mile Ocean Waste Disposal Site will reduce the cost of monitoring at the proposed site over that for monitoring any site for which no baseline data exists.

(6) Dispersal, horizontal transport, and vertical mixing characteristics of the area, including prevailing current direction and velocity.

The prevailing winds and currents at the proposed site are sufficient to promote effective dispersion and dilution of incineration residues. Meteorological conditions will generally carry the plume seawards while initial dispersion is occurring. When fallout reaches the ocean surface currents of the mixed layer will further dilute and disperse the wastes. Prevailing winds move from west-to-east, with predominant velocities between 6 and 17 kn (5 to 15 mph). Surface currents move predominantly southwesterly at velocities of 0.2 to 0.5 kn (10 to 25 cm/s). Subsurface currents are largely unknown.

(7) Existence and effects of current and previous discharges and dumping in the area (including cumulative effects).

No incineration or recent ocean dumping of wastes has occurred at the proposed site. The proposed site does encompass an inactive radioactive waste disposal site, and the 106-Mile Ocean Waste Disposal Site (which has been used since 1961) is directly north of the proposed site. No adverse effects are known to have occurred from either of these waste-dumping activities. In view of the vast areas involved and the enormous dilution which occurs, the likelihood of detecting cumulative effects is remote.

(8) Interference with shipping, fishing, recreation, mineral extraction, desalination, fish and shellfish culture, areas of special scientific importance, and other legitimate uses of the ocean.

The proposed site (and most alternative sites) does not encroach upon commonly used shipping lanes or normal recreation, fishing, and fish and shellfish culture areas; the exception being the previously recommended site (Figure 2-2, No. 3) and existing nearshore disposal sites (Figure 2-3). Oil production may occur at the edge of the Continental Shelf, but incineration operations are not expected to interfere with these activities. The effects on future mineral extraction (deep-ocean mining

or drilling) is unknown, but it appears to be minimal, if any. No areas of special scientific importance are known to occur in the area. No desalination is practiced in the area, and no other legitimate uses of the site are being made.

During their migratory periods four endangered and one threatened species of sea turtles, six endangered species of cetaceans, and one threatened species of pelagic bird are known to use the offshore region occupied by the proposed Incineration Site, but are not unique to this region. Incineration operations are expected to have no adverse unacceptable impact on these organisms.

(9) The existing water quality and ecology of the site as determined by available data or by trend assessment or baseline surveys.

Data have been collected extensively at the nearby 106-Mile Ocean Waste Disposal Site for trend assessment involving aqueous waste disposal. Because of the proximity and similarity of the two sites, the existing data may be used as baseline data for the proposed site.

(10) Potentiality for the development or recruitment of nuisance species in the disposal site.

Incineration wastes are sterile, non-nutritive wastes.

(11) Existence at or in close proximity to the site of any significant natural or cultural features of historical importance.

No such features are known to exist at or near the proposed site.

ECONOMIC IMPACT

The economic impact of at-sea incineration was examined by Halebsky (1978). It was concluded that at-sea incineration is economically feasible, taking into consideration the outfitting of U.S.-owned-and-operated ships.

An EIS prepared by the U.S. Department of State and the EPA (1979) concluded that the economic impact of at-sea incineration would be minimal, using existing foreign-owned vessels and existing U.S. loading facilities.

Neither the incineration operation nor the use of the Incineration Site will have any detectable economic impact on commercial fishing since limited fishing activity exists east of the Continental Slope.

WASTE LOADING AT THE PROPOSED SITE

As a result of incineration operations, several toxic waste residues will affect the marine environment. The magnitudes of impacts will be directly related to the amounts and rates of residue inputs. Table 2-3 presents estimated toxic residue inputs for the next several years. These estimaces are based on data collected from research incinerations performed in the Gulf of Mexico, using Shell Chemical Company organochlorine wastes and potential waste quantities available for incineration (Table 1-3). The actual chemical compositions, volumes of future wastes, and incineration efficiency will affect these estimates. The figures are useful only for estimations of waste loading in the environment, and serve as bases of comparison with other environmental waste-loading activities (e.g., disposal at the 106-Mile Ocean Waste Disposal Site). No data on organohalogen substances have been reported (although some were dumped) as waste constituents at the 106-Mile Ocean Waste Disposal Site. The organohalogen residue volumes estimated (Table 2-3) are based on emission rates given in Paige et al. (1978) and potential waste volumes based on those reported in Halebsky (1978). Waste incineration volume estimates range as high as 193,000 tonnes if incineration operations could be conducted on a 24-hour basis 365 days a year, at an incineration rate of 22 tonnes per hour. The specific nature of such organohalogens is as yet undefined, but can be expected to vary greatly among manufacturers.

For comparative purposes, waste-loading data for the 106-Mile Ocean Waste Disposal Site are presented in Table 2-4. Monitoring of wastes for 6 years have shown no detectable adverse effects (EPA, 1980a). Due to the proximity

TABLE 2-3
ASSUMED WASTE LOADING AT THE PROPOSED INCINERATION SITE **

Year	1977	1983	1989
Total Available Waste (tonne/yr)*	81,000	189,000	193,000
Number of hours to burn @22 tonne/hr	3,682	8,591	8,773
Estimated Residue Loading as Fallout (tonne/yr)			
HCl	52,100	121,600	124,200
Unburned organohalogen (@99.96% DE†)	32.4	75.6	77.2
Total inorganics (maximum estimate)	268	619	632
Particulates Contained in Total Inorganics			
Fluoride	3.7	8.6	8.8
Chromium	14.9	34.4	35.1
Nickel	7.5	17.2	17.5
Lead	1.5	3.4	3.5
Copper	2.6	6.0	6.1
Zinc	2.6	6.0	6.1
Arsenic	0.4	0.9	0.9
Cobalt	0.4	0.9	0.9

** Based on data limited to several large waste generating industries (see p 1-24).

* 1.0 tonne = 2,205 lb

† DE = Destruction Efficiency, minimum observed during research burns

Sources: Paige et al., 1978; Halebsky, 1978

of the 106-Mile Ocean Waste Disposal Site, the potential for cumulative effects must be acknowledged. However, the total assimilative capacity of the marine environment has yet to be established. Thus, close monitoring of the region (within site boundaries and also down current) must be performed. Should evidence of adverse impacts begin to materialize, waste inputs must be reduced or terminated until further assessment is made.

TABLE 2-4
106-MILE OCEAN WASTE DISPOSAL SITE ESTIMATED TRACE METAL MASS LOADING
(tonne/yr)*

	1973	1974	1975	1976	1977	1978
Inorganics (as suspended solids)	1.2×10^3	0.4×10^3	2.3×10^3	10.4×10^3	2.5×10^3	3.1×10^3
Metals						
Cadmium	0.211	5.516	19.503	0.213	0.812	0.124
Chromium	0.677	0.696	0.705	0.215	73.845	83.917
Copper	1.011	0.603	0.826	0.535	3.695	1.407
Lead	0.251	0.933	1.085	0.928	15.336	10.316
Mercury	0.045	0.014	1.626	0.964	0.010	0.005
Nickel	0.420	0.355	0.785	0.571	8.009	9.352
Zinc	12.125	15.803	7.279	3.231	23.382	35.528

* Organohalogens are not reported

Source: EPA, 1980a

Metals contained in estimated waste inputs at the proposed Incineration Site, and in barged waste inputs at the 106-Mile Ocean Waste Disposal Site, are of comparable quantities (Tables 2-3 and 2-4). The EPA has prepared an EIS for designation of the 106-Mile Ocean Waste Disposal Site which demonstrates that no adverse impacts have been detected resulting from the disposal of approximately 3 million tonnes of wastes since 1973 (EPA, 1980a). Annual waste volume inputs at the 106-Mile Ocean Waste Disposal Site are decreasing, and this decrease will lessen the potential of adverse impacts from cumulative deposits at the 106-Mile Ocean Waste Disposal Site and the proposed Incineration Site.

CONCLUSIONS

After examining other possible site alternatives, designation of the proposed North Atlantic Incineration Site will best serve the requirements of at-sea incineration activities with minimal adverse environmental and economic consequences. To maintain the integrity of the affected environment, restrictions must be placed on the use of the proposed site. EPA and London

Dumping Convention Regulations have established guidelines for determining acceptability of wastes for at-sea incineration. The following restrictions and conditions will be applied to at-sea incineration operations, once the desirability for such operations has been established over alternative disposal methods.

TYPES OF WASTES

The environmental acceptability of incineration of some organochlorine wastes has been demonstrated (Wastler et al., 1975; TerEco, 1975; TerEco, unpublished). These wastes contain only trace amounts of other toxic substances (e.g., metals) and will burn efficiently with little or no supplementary fuel. Due to the enormous variety of chemical compounds which might be considered candidates for incineration, considerable testing will be necessary to establish the acceptability of specific wastes. All chemical wastes approved for at-sea incineration will:

- Contain no materials prohibited by Ocean Dumping Regulations or Annexes to the London Dumping Convention.
- Contain less than trace amounts of metals and uncombustibles.
- Have demonstrated thermal destructability.
- Have known combustion properties and products.

Presently wastes that may possess the characteristics necessary for consideration are:

- Organochlorine pesticides containing acceptable metal concentrations.
- Petroleum refinery wastes containing acceptable metal concentrations.
- PCB wastes with concentrations less than 500 ppm.

- Other organic chemical manufacturing wastes (e.g., wastes burned by Shell Chemical Company in previous burns).

Wastes not meeting incineration requirements are:

- Substances containing high metal concentrations, particularly inorganic compounds (e.g., chromium from chromium pigment manufacture), arsenic from boric acid manufacture, or nickel from nickel sulfate manufacture, and other heavy metals (Halebsky, 1978).

Other wastes may be approved for at-sea incineration, but only after appropriate testing and research has been completed.

WASTE LOADINGS

No incineration activities have occurred at the proposed Incineration Site, thus cumulative effects of waste loading cannot be demonstrated and no upper limit can presently be established with any certainty. By comparison, at the nearby 106-Mile Ocean Waste Disposal Site, disposal of about 750,000 tonnes (annual maximum, 1977) of industrial wastes and sewage sludge (containing metals) have shown no observable adverse effects. However, the critical element for evaluating the temporary effects of waste loading at the proposed site is not the total annual input, but rather the input of each individual incineration operation. The rate of input must not be greater than the ability of the atmosphere and ocean to recover from temporary harmful effects. Bioaccumulation and long-term (cumulative) effects must be minimized. The actuality of environmental recovery and the lack of significant bioaccumulation must each be determined by monitoring. The waste loading can be partially controlled during each burn by controlling the incineration flow rate and the combustion process, and by permitting only one incinerator vessel to operate at the Incineration Site at any given time.

The total assimilative capacity of the proposed site is unknown because the physical conditions (which cause waste dispersal) are still poorly understood. Therefore, it is impossible at this time to make acccurate predictions of

maximal permissible waste loading. Future research and monitoring at the site will further define the physical characteristics of the site and the environmental effects of the waste. Each waste considered for disposal at the site must be separately evaluated for inputs of toxic elements into the environment. Year-round use will permit the incineration of about 193,000 tonnes of chemical wastes (assuming a maximal burn-flow rate of 22 tonnes per hour) if no more than one vessel is permitted to operate at any given time.

DISPOSAL METHODS

Wastes will be transported to the site in specially constructed ships and oxidized matter will be discharged from incinerator stacks while the ship is safely underway within the site boundaries. Atmospheric turbulence created in the ship's wake will cause immediate dilution of the waste; final dilution occurs in the atmosphere and ocean.

Plume behavior is associated with the orientation of the ship with respect to the wind. Thus, the ship must be maneuvered in order to maximize waste dispersion in the atmosphere. Minimal adverse effects on localized water quality will occur when waste dispersion is maximized (Figure 4-1). This occurs when the ship moves at right angles to the wind, and to a lesser extent, when the ship moves directly into the wind (Paige et al., 1978).

The Resource Conservation and Recovery Act of 1976 (RCRA) establishes standards for control of hazardous waste from point of generation through storage, treatment, and ultimate disposal via transportation manifests and reporting. Owners and operators of facilities that treat, store, or dispose of hazardous waste must comply with the standards promulgated under section 3004 (40 CFR Parts 264 or 266). Section 3004 regulations, which set standards for hazardous waste facilities, establish proper treatment, storage, and disposal practices; provide States with minimum standards to receive EPA approval for this facet of their hazardous waste programs; and provide the technical basis for EPA - issued facility permits in States that do not operate a RCRA program.

Incineration operations will require shore-based support to receive, store, and blend wastes prior to shipboard loading and transport to the authorized Incineration Site. This facility will also serve as an off-loading location in the event the incinerator vessel is forced to return to port without completing incineration operations.

PERMIT CONDITIONS

Permit conditions are set forth in the Convention, Mandatory Regulations, and Technical Guidelines (Appendix B), and were adopted and incorporated in the MPRSA as minimum operating requirements for at-sea incineration practices.

All permittees will be required to conduct comprehensive monitoring of short-term effects, which will be performed by environmental contractors at the permittees' expense. All monitoring studies are subject to EPA approval. Short-term monitoring should include laboratory studies of the nature and toxicity of the waste, field studies of waste behavior upon discharge, and effects on local organisms. Monitoring will include the downstream region, in order to determine effects induced by transport of waste residues outside the disposal site.

INFORMATION REQUIREMENTS

To perform meaningful monitoring at the proposed Incineration Site, certain information must be developed to anticipate residue movement. This section discusses areas of existing information gaps.

Predicted environmental consequences due to incinerating organohalogen wastes at sea (considering worst-case situations) are presented in Chapter 4 and Appendix D. Several assumptions are made in the Chapter 4 model which may not occur in practice: (1) destruction efficiency is 99.96% rather than 99.99%, (2) all residues (HCl, metals and organohalogens) touch down within several kilometers of the vessel rather than remaining suspended in the atmosphere for longer periods, and (3) residues are dispersed to a 20m depth, rather than mixing to deeper depths.

Sampling procedures used during the Gulf of Mexico research operations are discussed in Appendix C. These procedures were designed to track the stack emission plume and measure short-term water quality impacts resulting from waste residuals.

The purpose of accurate long-term monitoring of the North Atlantic Incineration Site is to follow the transport and accumulation of residual materials in the marine environment, in order to eliminate long-term adverse impacts. Transport is accomplished by physical and biological means. Wind and water currents will move residue materials away from the site. Organisms (e.g., plankton) which may assimilate residues will act in a similar manner. Ultimately, persistent residues may begin to accumulate in sediments or in organisms of higher trophic levels, far from the Incineration Site.

Existing physical oceanographic processes near the site are poorly understood. In order to predict where accumulation may occur, and to monitor such an occurrence requires an understanding of the fate of wastes. For example, accumulations of waste residues in the benthic environment of the site are unlikely. However, accumulation could begin if transport occurs towards the Continental Shelf, where water depths are much shallower (50 to 100m). A quantitative estimate of such an occurrence will require development of a new model. The model will depend on comprehension of phenomena (e.g., vertical current structure and mixing) and the processes which contribute to dispersion and dilution; they are poorly known in the region, and available information is inadequate to support quantitative predictions of waste residue movements.

Intrinsically, the waste is an important factor. Accurate predictions of transport and accumulation of residues necessitate specific information describing the components of the waste material, the incineration decomposition products, and the amounts of waste residues available for transport and accumulation. In the case of organohalogen residues, the degradability potential of the original waste and partial decomposition products must be known as to atmospheric, water, and biochemical processes (specifically, whether the original waste or partial decomposition product is susceptible to photolytic, hydrolytic, or biochemical decomposition). In order to describe atmospheric transport, the distribution of particle sizes must be initially defined for organics and metals, to establish settling rates of residual constituents. Metals and HCl are expected to be removed rapidly; however, volatilized organics may remain suspended for longer periods.

During incineration of organochlorine wastes stack emissions will include CO, CO_2, H_2O, HCl, trace metals in a gaseous phase, and organic compounds. Organic compounds will appear as waste residue intact and partially as waste residue which has not oxidized completely. The discussion of environmental consequences of unburned organohalogens (Chapter 4) considers this category as intact organohalogen waste residue at waste volume of 0.04% or less. In practice this is not entirely accurate. Laboratory test burn studies under rigidly controlled incineration conditions reported by Duvall and Ruben (1976) showed that compounds (e.g., Kepone®, Mirex®, and DDT) achieve destruction efficiencies of 99.998% at temperatures of 900°C, with residence times of about 2 seconds, and produce hexachlorobenzene as a partial decomposition product. Similarly, laboratory test burns of biphenyl, several species of PCB's, hexachlorobenzene, dibenzofuran, and bibenzo-p-dioxin achieve destruction efficiencies of 99.9995% at a temperature of 1,000°C, with residence time of 2 seconds (Duvall and Ruben, 1977). In the case of PCB's and similar compounds (ibid.), partial decomposition products were produced, but no analyses were performed to identify the resultant compounds.

The disparity between destruction efficiencies of laboratory and field (vessel) incinerators can be explained as differences between their residence times and degrees of volatilization of waste material. Whereas the laboratory incineration tests are performed with a residence time of 2 seconds, residence time in the field incinerator is about 0.9 second. The field incineration is operated at temperatures of 1,250°C to 1,350°C, which are several hundred degrees higher than in laboratory tests. Laboratory samples are completely volatilized before injection into the incinerator chamber, which introduces single molecules of wastes to oxidation, but field incinerators simply inject waste materials as groups of molecules, thus offering a smaller surface area for oxidative reactions. Presumably, partial decomposition products of at-sea incineration will be comparable to partial decomposition products in laboratory tests. In order to track the transport and accumulation of residue materials released into the marine environment, laboratory studies must be performed to establish the destruction efficiency of specific wastes and the associated partial decomposition products; these factors will facilitate predictions of the types, quantities, and partical sizes of waste residues released.

The EPA Environmental Research Laboratory in Cincinnati, Ohio is currently developing the Thermal Decomposition Analytical System (TDAS) for laboratory use. The system will enhance development of baseline data on the basic decomposition products of wastes within a short period of time, thus eliminating problems associated with complex tests which could cause environmental risks (Carnes, 1978; Carnes et al., 1979). Another system being developed will include direct in-line sampling of waste residue products during incineration operations at various points of the incineration stream (Carnes and Whitmore, 1979). The latter system is being designed for more complex, land-based incineration, but the technology, once developed, can be applied to at-sea incineration.

Toxicological studies (bioassays) need to be performed to estimate potential environmental impacts or uptake of waste residues, including residue substances in marine organisms representative of the affected environment. This procedure would be an extention of the residue identification process discussed above.

Chapter 3

AFFECTED ENVIRONMENT

This chapter describes the environment of the proposed site and the general region of the mid-Atlantic. Topics discussed include the oceanographic environment and relevant related activities near the mid-Atlantic sites. EPA's recently produced EIS describing industrial waste disposal at the 106-Mile Ocean Waste Disposal Site (EPA, 1980a) is significant in this discussion, because of the similarities of metal content characteristics of the wastes, and the proximity of the affected environment to those of this site. The 106-Mile Ocean Waste Disposal Site EIS is further relevant to this EIS because the site occupies an oceanic region with characteristics similar to those of the proposed and alternative mid-Atlantic Bight incineration sites, and is itself an alternative site. Further details of the physical, chemical, and biological characteristics of the mid-Atlantic Bight region are provided in Appendix A.

This chapter describes the environmental setting of the northwestern mid-Atlantic oceanic region. The proposed site and all alternative mid-Atlantic Bight sites are examined simultaneously, because this region of the northwest Atlantic Ocean is considered to be environmentally homogeneous in many respects. It is recognized that the Continental Shelf break to the west provides for major environmental shifts in physical, chemical, and biological oceanographic phenomena; whereas the Gulf Stream to the east causes similar effects by serving as a buffer between the region and the Sargasso Sea. Furthermore, gradients of environmental factors begin to occur as distances from the Shelf increase. Environmental features of the greater region are known to exhibit wide variations common to all possible mid-Atlantic Bight sites selected as oceanic incineration alternatives. The most notable exception is the site previously recommended by Paige et al. (1978), in a region which is transitional between Shelf and Slope regimes, with numerous adverse characteristics, untenable in incineration site candidacy. (As explained in Chapter 2, the site was eliminated as an alternative site candidate.)

Detailed information on the proposed site and the 106-Mile Ocean Waste Disposal Site (Appendix A) is applicable to other mid-Atlantic geographic

areas, including the eastern and southern regions, which are candidates for Atlantic incineration sites. The following discussion is an excerpt from Appendix A.

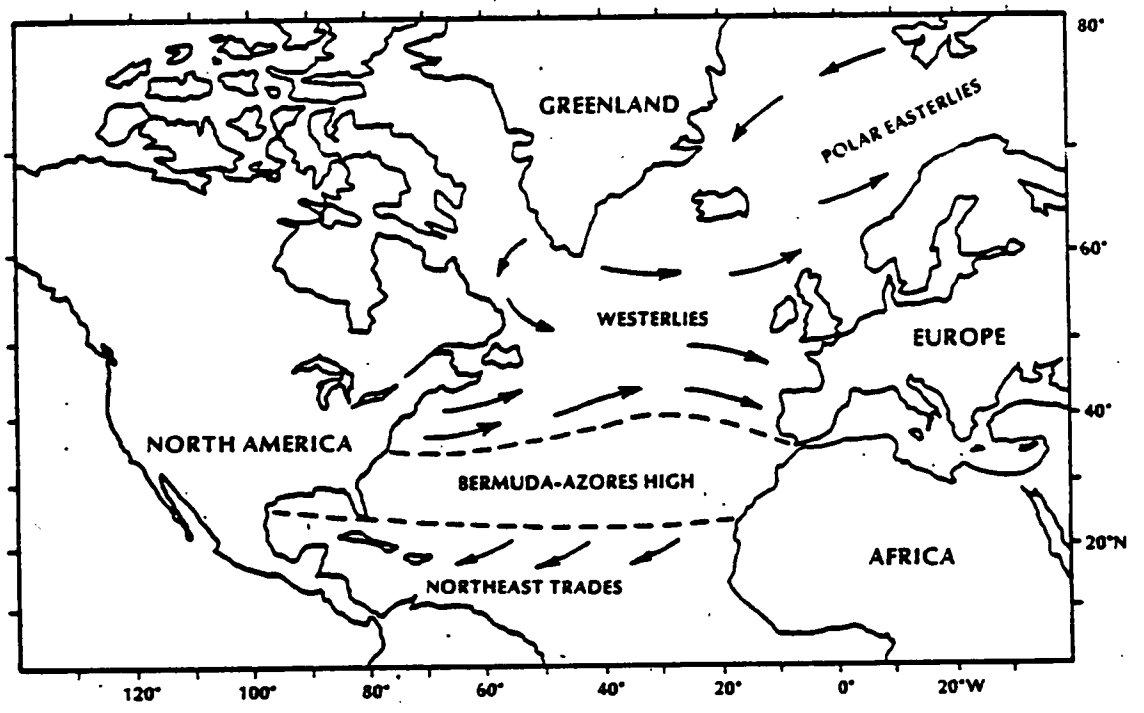
OCEANOGRAPHIC CHARACTERISTICS OF THE PROPOSED AND ALTERNATIVE MID-ATLANTIC BIGHTSITES

METEOROLOGY

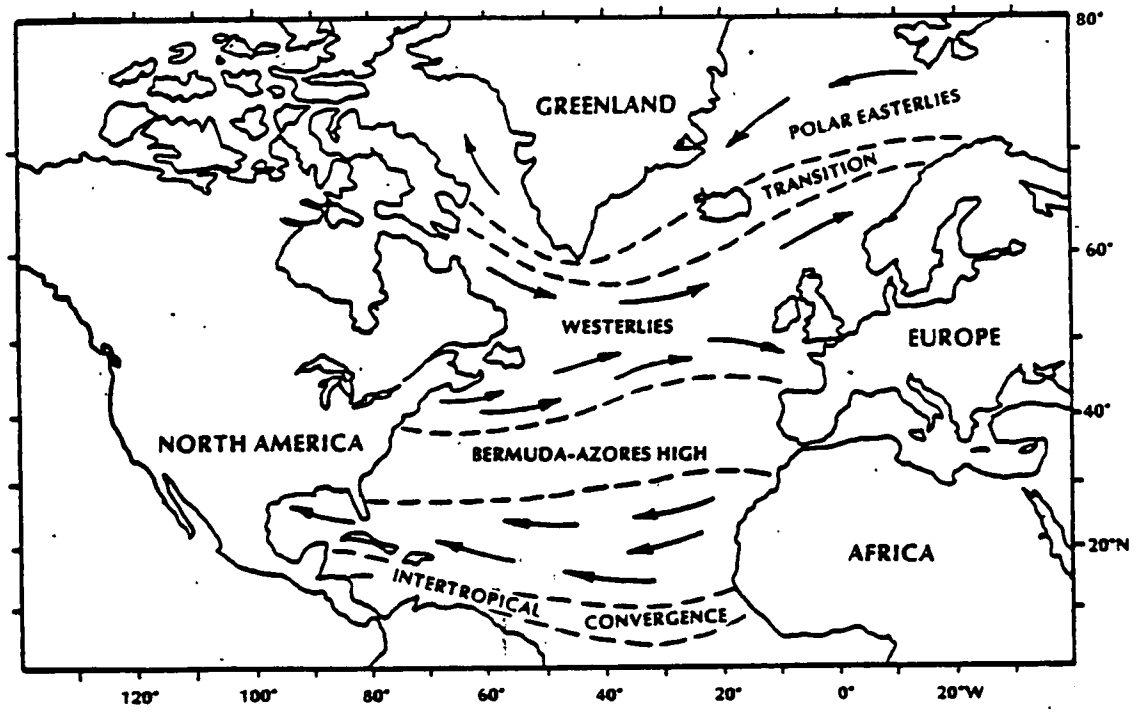
The proposed North Atlantic Incineration Site is seaward of the Continental Shelf, off the Delaware-Maryland coast (Figure 2-2, No. 1). The proposed and alternative sites lie within a mid-latitude zone of prevailing westerlies, where the daily wind flow generally moves from west to east (Figure 3-1). Polar air dominates the region about 2 months each year, whereas annual warmer tropical Atlantic air dominates during the other 10 months. In general, the climate of the region can best be described as modified continental, due to the greater influence of westward landmasses, as opposed to the eastward ocean (NOAA, 1977).

Marine air temperature is strongly influenced by the Atlantic Ocean. During winter months warm sea surface temperatures tend to increase air temperatures proportionately with distances from shore. Summer months are conversely affected, thus, temperatures decrease proportionately with distances from shore. Precipitation over the offshore regions is uncertain, due to the lack of data. Most rainfall occurs between November and March, generally associated with widespread storms, varying in intensity and coverage. Cloudiness is minimal during late summer and early autumn, at which times the Bermuda High dominates weather patterns, and is maximal during winter months when northeasterlies prevail. Visibility depends on the presence or absence of advection, fog, and haze. Visibility greater than 5 nmi (9.3 km) ranges from about 80% (late spring) to more than 90% (autumn and winter).

Meterological data (U.S. Navy, 1955) indicates that atmospheric temperature inversions are weak and infrequent occurrences in the region of the proposed



A - FEBRUARY SURFACE WINDS



B - AUGUST SURFACE WINDS

Figure 3-1 General Air Flow Pattern of the North Atlantic

site. Temperature inversions of 2°C, or greater, rarely occur below 1,000m, and are generally restricted to spring and summer. Above 1,000m, inversions of 2°C, or more, occur less than 3% of the time, year around.

Relative humidity is normally high. The annual average value is 81%; summer being slightly higher than winter due to persistent southerly winds.

PHYSICAL CONDITIONS

The proposed site, the 106-Mile Ocean Waste Disposal Site, and the eastern and southern regions are beyond the edge of the Continental Shelf, within the easterly influence of the Gulf Stream (Figure 3-2). Surface water may be derived from three different water masses, namely Shelf Water, Slope Water, and Gulf Stream Water; each with distinctive physical, chemical, and biological characteristics. Slope Water normally occupies the proposed site (Figure 2-2, No. 1) and 106-Mile Ocean Waste Disposal Site (Figure 2-2, No. 2), as well as the eastern (Figure 2-2, No. 4) and southern regions (Figure 2-2, No. 5). When the Shelf/Slope ocean front migrates eastward, Shelf Waters of equal or lower salinity and temperature mix with Slope Water, causing differing densities of water masses to form separate layers within the water; therefore, the mixing of waters at the site can be quite complex, influenced by predictable seasonal factors and other highly unpredictable factors (Warsh, 1975b).

Sometimes warm-core rings of water (eddies) break off from the Gulf Stream and migrate through the proposed site region, entraining Gulf Stream water or water in the Sargasso Sea (Figure 3-2). Such eddies do not pass through the proposed site on a seasonal basis, but have been observed to touch or completely occupy the 106-Mile Ocean Waste Disposal Site for about 70 days per year (Bisagni, 1976).

When surface waters of the region warm up in late spring, a phenomenon occurs causing the water to stratify within 10 to 50m of the surface and to form water layers having different temperatures, salinities, and densities. Stratification persists until mid- or late autumn, when cooling and storm activity destroy the layers. From autumn until winter and early spring, the

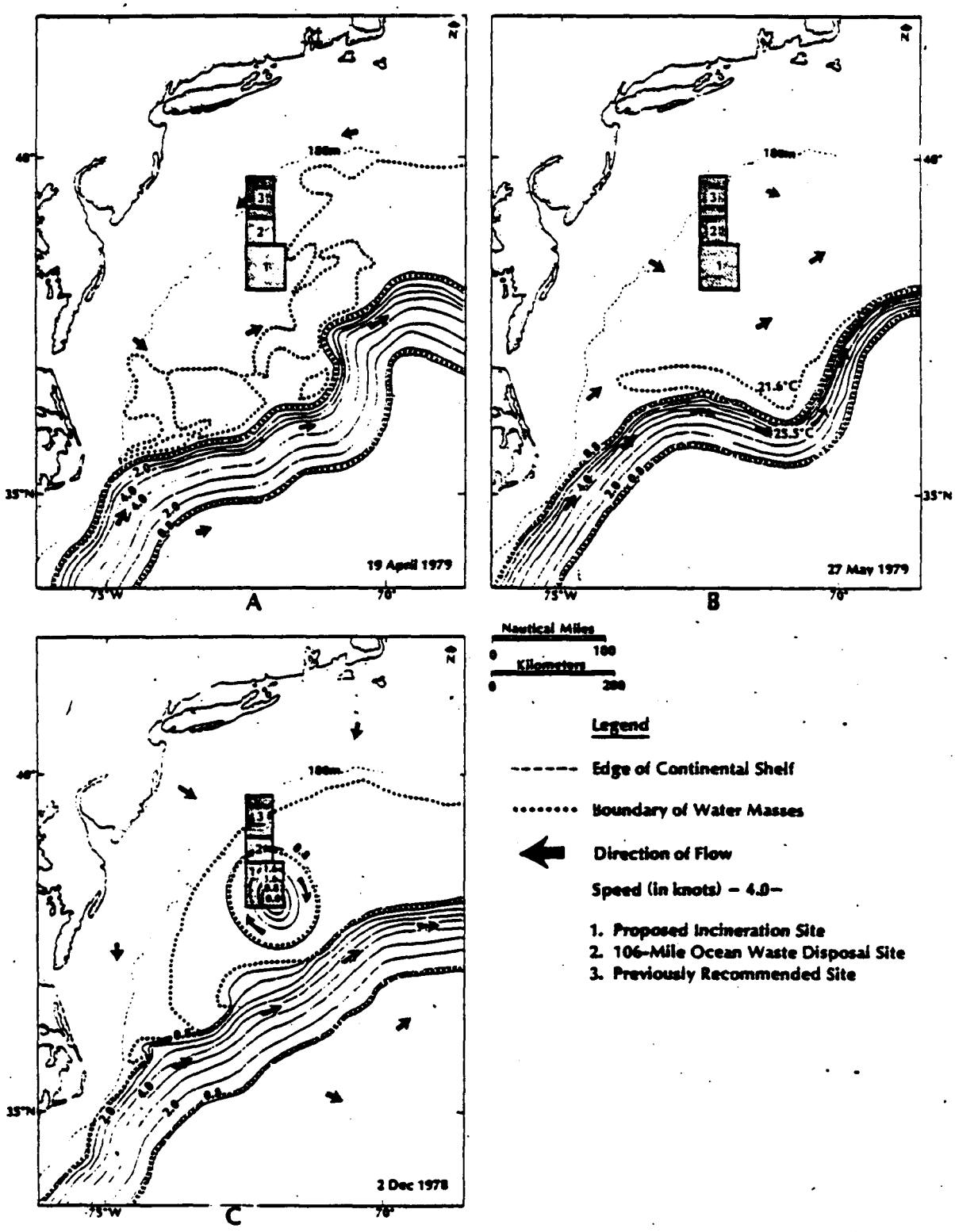


Figure 3-2. Water Masses and Current Flows of Northwest Atlantic Ocean Showing Gulf Stream Meanders and Anticyclonic Eddy (U.S. Coast Guard Weekly Current Charts)

temperature of the water is the same from the surface to a depth of approximately 200m. At 200m, however, a permanent stratification level exists. Below that level, waters are always of lower temperatures. Such physical characteristics are important because of their great influences on the ultimate fate of waste residues at the sites.

There is a paucity of current measurements for the site; however, the literature indicates that water at all depths in the area tends to flow southwest, generally following the boundary of the Continental Shelf and Continental Slope (Warsh, 1975b). Occasionally, water flow may change direction, especially when Gulf Stream eddies pass through the area. This effect has been observed in the deeper waters of the 106-Mile Ocean Waste Disposal Site.

Physical and chemical characteristics of all candidate sites cause biological complexities because each water mass possesses unique associations of flora and fauna.

GEOLOGICAL CONDITIONS

The Continental Slope within the proposed site area has a gentle (4%) grade, leveling to 1% in the region of the upper Continental Rise. Sediments within the 106-Mile Ocean Waste Disposal Site are principally sand and silt, with silts predominating (Pearce et al., 1975). Sediment composition is a major factor which determines the amounts and kinds of animals capable of colonizing the sea bottom at the site. Generally, greater diversities and abundances of fauna are associated with finer sediments (e.g., silt), although unusual physical conditions can play an important role. Thus, fine-grained sediments are more likely to contain higher concentrations of heavy metals. Sand, gravel, and rocky bottoms rarely contain metals in high concentrations.

Continental Slope sediments in various parts of the region are subject to different dynamic forces. The upper Continental Rise is in an area of tranquil deposition, whereas the lower Continental Rise is in an area of shifting deposition. Several erosional areas (caused by currents) occur between these two provinces. The different regimes will greatly determine the

ultimate fate of waste products reaching the bottom, which are anticipated to be quite small. In areas swept by currents, waste products would be carried out of the limits of the disposal site, dispersed, and greatly diluted. In erosional and shifting depositional areas similar conditions would exist, although the waste materials could be temporarily motionless before further transport. In areas of tranquil or slow deposition, waste products would be slowly buried.

CHEMICAL CONDITIONS

The amount of dissolved oxygen in seawater is generally an indicator of the life-supporting capacity of the waters. Dissolved oxygen levels below 4 mg/l cause stress in animals. Dissolved oxygen concentrations observed at the 106-Mile Ocean Waste Disposal Site are higher than 4 mg/l in surface water, and experience vertical gradients similar to the temperature gradients described above. Thus, the permanent stratification level at 100 to 200m divides the water column into upper and lower regimes. The different water densities and salinities prevent the two layers from mixing, and thus influence the distribution of dissolved oxygen concentrations. Dissolved oxygen levels are minimal at depths of 200 to 300m, and slowly increase with distance (up or down) from the stratification boundary.

Dissolved oxygen gradients during summer and winter at the proposed site and the 106-Mile Ocean Waste Disposal Site are similar; the main differences being higher surface concentrations during winter. Any waste material which undergoes oxidation in seawater will naturally consume oxygen, thereby lowering the concentration of dissolved oxygen in seawater.

Chemical baseline and monitoring surveys conducted at the 106-Mile Ocean Waste Disposal Site have examined trace metal levels in sediments, water, and selected organisms. Metals in the sediments and water are potentially available to site organisms. Within the fauna these contaminants could possibly be assimilated (bioaccumulated), and concentrated in toxic quantities.

Numerous metals are present as a natural occurrence in seawater; therefore, only concentrations of metals exceeding natural background levels that approach known or suspected toxicity levels would be possible threats to marine organisms and mankind. During the most recent studies of trace metal levels in the 106-Mile Ocean Waste Disposal Site waters, background levels typical of other uncontaminated Shelf-Slope regions occurred (Kester et al., 1977; Hausknecht and Kester, 1976).

Trace metals in sediments all along the Continental Slope and Continental Rise (including the proposed and 106-Mile Ocean Waste Disposal Site areas) are elevated in comparison to Continental Shelf values (Greig et al., 1976; Pearce et al., 1975). However, since such values vary widely, the elevated values are considered to be a natural occurrence and are not attributed to waste disposal activities at the 106-Mile Ocean Waste Disposal Site.

Analyses of trace metal concentrations in food chain organisms at the 106-Mile Ocean Waste Disposal Site and surrounding areas revealed high cadmium levels in three swordfish livers, mercury levels above the Food and Drug Administration action level ("unfit for human consumption") in most fish muscle samples, and low-to-moderate copper and manganese concentrations in finfish, similar to those in New York Bight finfish (Greig and Wenzloff, 1977; Greig et al., 1976). However, ocean waste disposal at the 106-Mile Ocean Waste Disposal Site could not be linked by investigators to the metal concentrations found in any of the analyzed benthic (bottom) or pelagic (open ocean) fishes as they were transient species with probably only a short period of residence in the site (Pearce et al., 1975).

BIOLOGICAL CONDITIONS

Plankton are microscopic flora and fauna drifting passively with currents or swimming weakly. Plankton are either plants (phytoplankton) or animals (zooplankton). Since the plankton are primary sources of all food in the ocean, their health and ability to reproduce are of crucial importance to all life in the ocean, including fish and shellfish of commercial importance.

Plankton at the 106-Mile Ocean Waste Disposal Site and surrounding region are highly diverse, due to the influences of Shelf, Slope, and Gulf Stream watermasses (see Physical Conditions section, above). The high-nutrient Shelf Waters primarily contribute diatoms to the region, and the lower nutrient Slope Waters contribute coccolithophorids, diatoms, dinoflagellates, and other mixed flagellates (Hulburt and Jones, 1977). Mixed assemblages of zooplankters common to the different watermasses have been found to occupy the 106-Mile Ocean Waste Disposal Site and surrounding areas during winter, spring, and summer (Sherman et al., 1977; Austin, 1975).

Fish have been surveyed at various depths within the 106-Mile Ocean Waste Disposal Site. The diversity and abundance of fish found only in surface waters are similar inside and outside the 106-Mile Ocean Waste Disposal Site limits (Haedrich, 1977). Fauna found primarily at middepths (mesopelagic fish) are predominately Slope water species. Also, Gulf Stream anticyclonic (clockwise) warm-core eddies contribute some north Sargasso Sea species (Krueger et al., 1975, 1977; Haedrich, 1977). Several migratory oceanic fish usually associated with the Gulf Stream often occur in midwater regions of the proposed site, 106-Mile Ocean Waste Disposal Site, and eastern region. Benthic (bottom) fish within the site are similar to assemblages in other Slope areas (Musick et al., 1975; Cohen and Pawson, 1977).

Numerous species of whales and dolphins (Table A-19) and five species of turtles (Table A-20) are believed to transit the Slope and nearshore waters of the mid-Atlantic Bight region, as migratory routes. The whales and dolphins use the Slope waters as a route between northern summering grounds and southern wintering grounds. The route used by turtles has not been determined exactly, but from July through October turtles follow their primary food (jellyfish) inshore. Six species of whales (right, blue, Sei, finback, humpback, and sperm) are classified as endangered throughout their range of habitat. Among the turtles, four species (hawksbill, leatherback, green, and Atlantic Ridley) are classified as endangered throughout their habitat. The loggerhead turtle is classified as threatened in its entire habitat.

Abundance and diversity of invertebrates at the 106-Mile Ocean Waste Disposal Site are similar to most other Slope localities of the mid-Atlantic

Bight. As in similar areas, the organisms on the bottom (the epifauna) of the proposed site and 106-Mile Ocean Waste Disposal Site are dominated by echinoderms (e.g., starfish), with segmented worms (polychaetes) as the dominant burrowing organisms.

Many species of birds are known to frequent the offshore and coastal waters of the mid-Atlantic Bight (Table A-21). Several pelagic species are regular inhabitants of the oceanic region containing the proposed and alternative sites. Other species are only occasionally observed. Summer months produce the greatest number of pelagic bird sightings.

Birds migrate through the entire region. During September and October many species of marine and terrestrial birds leave northeastern coastal areas for southern wintering grounds. The actual numbers of species using the routes are still uncertain, but a partial list and migratory route map are presented on Figure A-12 and Table A-22. No species of migratory birds listed by the Manomet Bird Observatory are considered endangered or threatened.

CONCURRENT AND FUTURE STUDIES

NOAA has been conducting surveys at the 106-Mile Ocean Waste Disposal Site for several years. Many sampling stations are within and near the proposed Incineration Site. The nearness of the proposed Incineration Site to the 106-Mile Ocean Waste Disposal Site minimizes logistical monitoring problems, and existing 106-Mile Ocean Waste Disposal Site data may be used from within the proposed site initially as baseline information, pending collection of additional data at the proposed site.

In addition to future Federal surveys, incineration permittees will be required to conduct short-term monitoring during incineration operations as required by permits.

OTHER ACTIVITIES IN THE SITE VICINITY

Few man-made marine activities occur near the proposed site. The 106-Mile Ocean Waste Disposal Site, immediately north of the proposed site, has been used for approximately 18 years as an industrial chemical waste dump and some municipal wastes (sewage sludges) have been dumped there since 1974. Foreign fishing fleets operate along the outer Shelf (Figure 3-3). Oil and gas lease tracts are west and north of the proposed site, along the outer Continental Shelf (Figures 3-5 and 3-6). The Hudson Canyon Navigational Lane crosses the Continental Slope to the north of the proposed site (Figure 3-7), but no major shipping lanes approach the proposed site boundaries.

U.S. COMMERCIAL FISHERIES

Limited fisheries resources exist at the proposed site and vicinity. Due to deep waters in and around the proposed site, no commercial shellfish species (commonly taken in the adjacent and shallower Continental Shelf/Slope regions) inhabit the bottom. Only limited finfishing occurs beyond the Continental Shelf. Bigeye, yellowfin, and longfin tuna are fished to the 2,000m contour. Swordfish may be taken at the 2,000m contour, but commercial gear is usually set within the 600m contour.

Most commercially important fishery resources in the New York Bight vicinity live and spawn in Continental Shelf waters, and along the crest of the Continental Shelf/Slope break (NOAA-MESA, 1975; BLM, 1978; Chenoweth, 1976). Consequently, most foreign and domestic fish trawling is conducted at depths shallower than 1,000m, much shallower than waters in the proposed Incineration Site. Pelagic waters have been used for commercial longline fishing of marlin, swordfish, and tuna (Casey and Hoenig, 1977). Catch statistics for Continental Slope areas are generally incomplete because fishing vessels wander from Shelf to Slope areas, mixing the catch of Slope species with Shelf species; landing records have failed to separate Shelf from Slope species. Table 3-1 presents catch statistics for specific types of fishing gear used to land fishery resources off New Jersey.

TABLE 3-1
QUANTITIES OF COMMERCIALLY IMPORTANT FISHERY RESOURCES TAKEN
BY SPECIFIC FISHING GEAR TYPES OFF NEW JERSEY IN 1974
(Thousands of Pounds)

	Purse Seine	Otter Trawl	Fish Pound Nets	Fish Pots and Traps	Lobster Pots and Traps	Gill Nets	Lines	Dredges
Finfish								
Fluke	-	3,487	11	-	0.5	-	0.5	-
Bluefish	7	362	72	-	-	549	14	-
Atlantic Mackerel	-	756	-	-	-	8	8	-
Menhaden	104,851	49	2,183	-	-	223	-	-
Sea Bass	-	138	0.1	-	-	3	1	-
Sea Trout	0.2	1,927	285	-	-	433	42	-
Scup	-	6,029	2	8	-	0.2	-	-
Tilefish	7	-	-	-	-	-	831	-
Bluefin Tuna	870	0.3	-	-	-	0.5	0.5	-
Whiting	-	7,021	0.2	-	-	1	-	-
Swordfish	-	0.1	-	-	-	-	7	-
Shellfish								
Lobster	-	551	-	7	633	-	-	-
Red Crab	-	23	-	-	2	-	-	-
Rock Crab	-	146	-	1	199	-	-	-
Surf Clams	-	-	-	-	-	-	-	22,657
Sea Scallops	-	7	-	-	-	-	-	321
Others								
Squid	-	1,287	-	-	-	-	-	-

Benthic invertebrate resources range in depth from shallow nearshore waters to the Shelf edge. Quahogs, surf clams, and scallops are caught on the Shelf; no areas of abundance are known to occur on the Slope. Cancer crabs are abundant on the Shelf from New Jersey to Nova Scotia, but have little value at present and are essentially unexploited. Two species of squid are also abundant and of immense economic potential to American fishermen. The winter squid (Loligo pealei) are caught on the bottom to depths of 91m, and summer squid (Illex illecebrosus) are found on the bottom to depths of approximately 481m. In 1979 foreign vessels caught 30,000 tonnes of squid from Cape Cod to Cape Hatteras, whereas domestic fishermen landed only 4,100 tonnes. The domestic effort was evenly divided between 0 to 3 nmi and 3 to 200 nmi offshore. Lobster, one of the most valuable shellfish resources, occur both on the Shelf and Slope, but generally not deeper than 500m. The red crab (a potential fishery resource) is most abundant at depths between 310 and 941m, with a maximum reported depth of 1,830m.

Important finfish (Table 2-1) of the Shelf area are generally not found in water deeper than 1,000m, or fished in water deeper than 200m. Atlantic mackerel (Scomber scombrus) occur in large schools that seasonally migrate from the Shelf edge to nearshore areas. Spawning grounds occur from 10 to 50 nmi offshore. Silver hake (Merluccius bilinearis) is an underexploited species, of great potential for American fishermen, which occurs to a maximum depth of 750m off New England. The foreign fishing industry has routinely taken silver hake in excess of 20 tonnes per tow along the 183m isobath.

Tilefish (Lopholatilus chameleonticeps) are found in abundance from Nantucket to Cape May, New Jersey between 91m and 145m. The species occurs within a narrow depth and temperature range, associated with the bottom, and dependent on temperature influences of the Gulf Stream. In 1882 an estimated 1.5 billion fish perished, presumably due to temperature variation when the Gulf stream shifted. A fish kill 170 miles long and 25 miles wide resulted (Gordon, 1977).

Tuna are highly migratory pelagic species; therefore, they are not included in the exclusive management authority of the 200-mile fishery conservation zone (Federal Register, 1978). Several species occur along the northwest

Atlantic Shelf, including blue fin, yellowfin, blackfin, bonita, bigeye, and albacore. In general, tunas prefer warm seas and occur in the northern part of their range in association with the Gulf Stream. The bluefin range extends to southeast Newfoundland; yellowfin are uncommon north of Virginia; both species have significant sport and commercial value.

Billfish are pelagic fish that are not dependent on the coast. Breeding areas for swordfish, white marlin, and blue marlin are near the Lesser Antilles, South America, and Puerto Rico, respectively. All three species are believed to migrate seasonally, occurring off the mid-Atlantic states during summer months. Saila and Pratt (1973) indicate that the summer distribution of swordfish is variable off of the mid-Atlantic coast, with larger and more stable population levels north of Hudson Canyon. White marlin are most abundant off Delaware Bay during the summer, and head offshore hundreds of miles during late fall. Blue marlin have major centers for sportfisheries off of North Carolina.

FOREIGN FISHERIES

Nearly all foreign fishing in the north and mid-Atlantic regions of the United States occurs on the Continental Shelf, at depths of 90m to 180m, within designated fishing areas (Figure 3-3). The exception to this rule is the tuna longline fishery (mainly Japanese), which follows the migration associated with the Gulf Stream. Peak foreign fishing activity occurs in late summer for short-finned squid, and in winter for long-finned squid, in accordance with gear and season restrictions (Figure 3-4). The foreign fleet is dominated by Japan, Spain, and Mexico, which send 80 to 90 vessels annually to fish along the Atlantic coast. The USSR (formerly the dominant foreign fleet) has been prohibited from fishing in the economic resource zone since late 1979. The major fisheries are directed toward squid and hake (silver and red), with butterfish and other finfish (including sea robins and flatfish) being of secondary importance. Herring and mackerel are minor components of the total incidental catch.

Pelagic tuna and billfish fishery efforts are widespread, including all warm-water areas of the North Atlantic Ocean from the equator to Nova Scotia,

although the more northern area is less frequently fished during winter than summer. Catch statistics (Tables A-23 and A-24) reveal that yellowfin tuna are the most frequently captured fish, followed by bigeye, albacore, and bluefin. Fishing effort expenditure varies from statistical area to statistical area, and from year to year.

From available data it can be concluded that the proposed Incineration Site occupies an oceanic area that may produce a portion of the annual foreign tuna landing. However, the site itself occupies less than 2% of the Japanese catch statistical area in which the site is located. Based on a comparison of Japanese statistics of the region occupied by the proposed site and the area to the east of the proposed site, it can be concluded that the area occupied

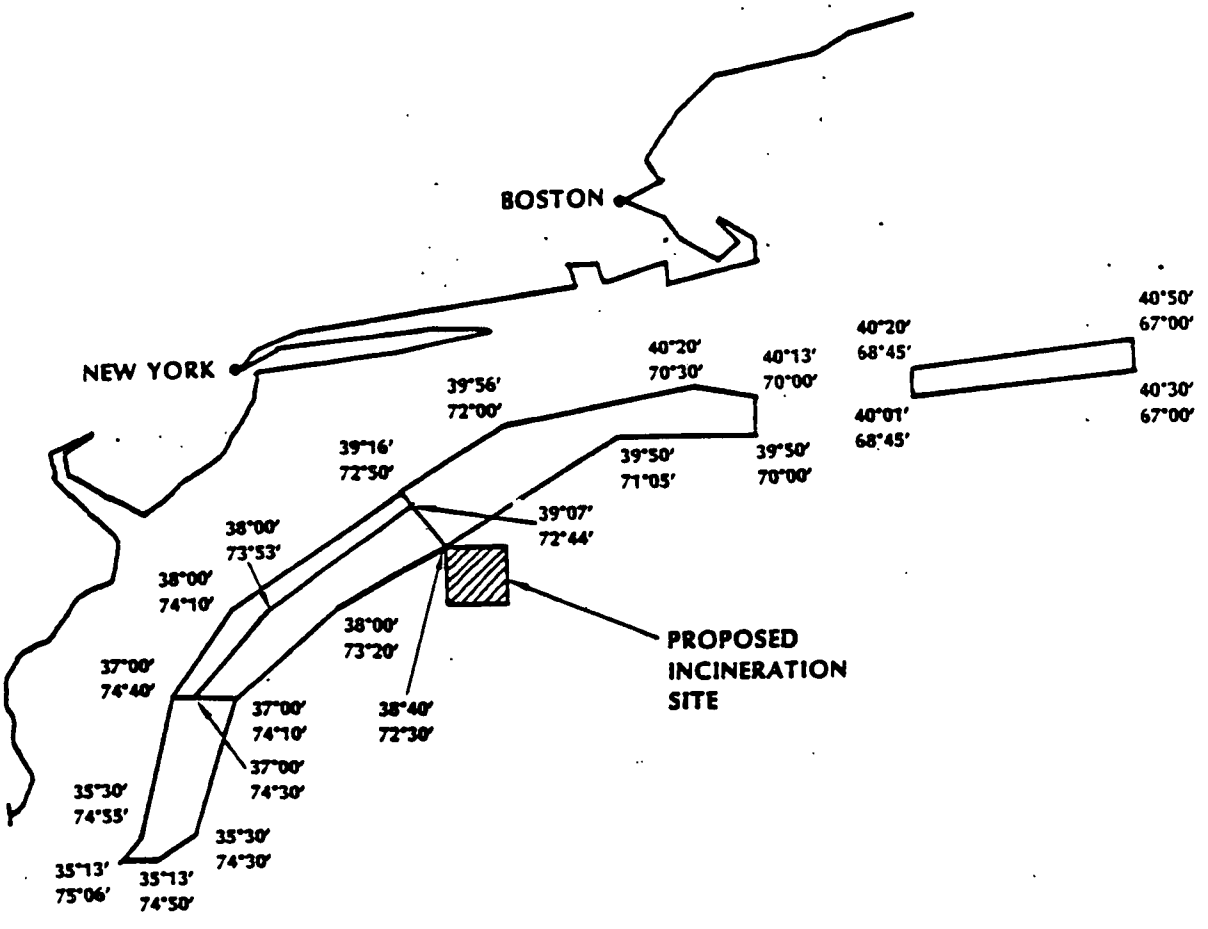


Figure 3-3. Fishing Areas in the Northwest Atlantic Ocean for Foreign Nations
Source: Federal Register, 43(244):59302

OFF-BOTTOM GEAR

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1										■	■	■
2	■	■	■			■	■	■	■*	■	■	■
3	■	■	■							■	■	■
4								■	■	■	■	■
5								■	■	■	■	■

BOTTOM GEAR AND OFF-BOTTOM GEAR

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1												
2												
3												
4	■	■	■									
5	■	■	■									

Unless otherwise noted, seasons open at 0001 hours local time on the last day of the month and terminate at 2400 hours local time on the last day of the month.

*Season begins at 0001 hours local time on June 15 and terminates at 2400 hours local time on September 15.

■ Denotes maximum open fishing seasons subject to possible earlier closure for some or all nations.

Figure 3-4. Fishing Gear and Season Restrictions by Fishing Area--Northwest Atlantic Ocean Fishery
Source: Federal Register, 43:59315

by the proposed site is not unique to fishing effort or catch results, and the site probably produces a catch proportional to its size—less than 2% of the statistical area.

RECREATIONAL FISHERIES

Most recreational fishing in the New York Bight vicinity is confined to inner Continental Shelf waters, which are most accessible to the public and where most sport species are found (Chenoweth, 1976). The important species are striped bass, weakfish, bluefish, and mackerel. The sport catch often equals or surpasses the commercial landings of certain species (e.g., striped bass) and has contributed significantly to the economics of several coastal areas. In 1970 1.7 million anglers caught 2.7 million pounds of fish in North Atlantic coastal waters. Recreational species taken further offshore are limited primarily to bluefin tuna, marlin, and swordfish. There are no accurate catch statistics for these species or amount of recreational fishing activity.

OIL AND GAS EXPLORATION AND DEVELOPMENT

Oil and gas lease tracts exist west and north of the proposed Incineration Site (Figures 3-5 and 3-6). The U.S. Bureau of Land Management (BLM) completed the first sale of oil and gas leases on the mid-Atlantic Outer Continental Shelf in August 1976 (Outer Continental Shelf [OCS] Sale No. 40). Exploratory drilling on tracts leased in OCS Sale No. 40 began in the spring of 1978 and continue to date (1981). In September 1978, BLM published a final EIS on the proposed OCS Sale No. 49, which includes 136 tracts totaling 313,344 hectares* (774,273 acres); sale No. 49 occurred February 1979. A third Sale (No. 59) is under consideration (Figure 3-5), tentatively scheduled for December 1981 (BLM, 1978). The Final EIS was issued in May 1981.

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*1 hectare = 1 km^2 = 2.47 acres

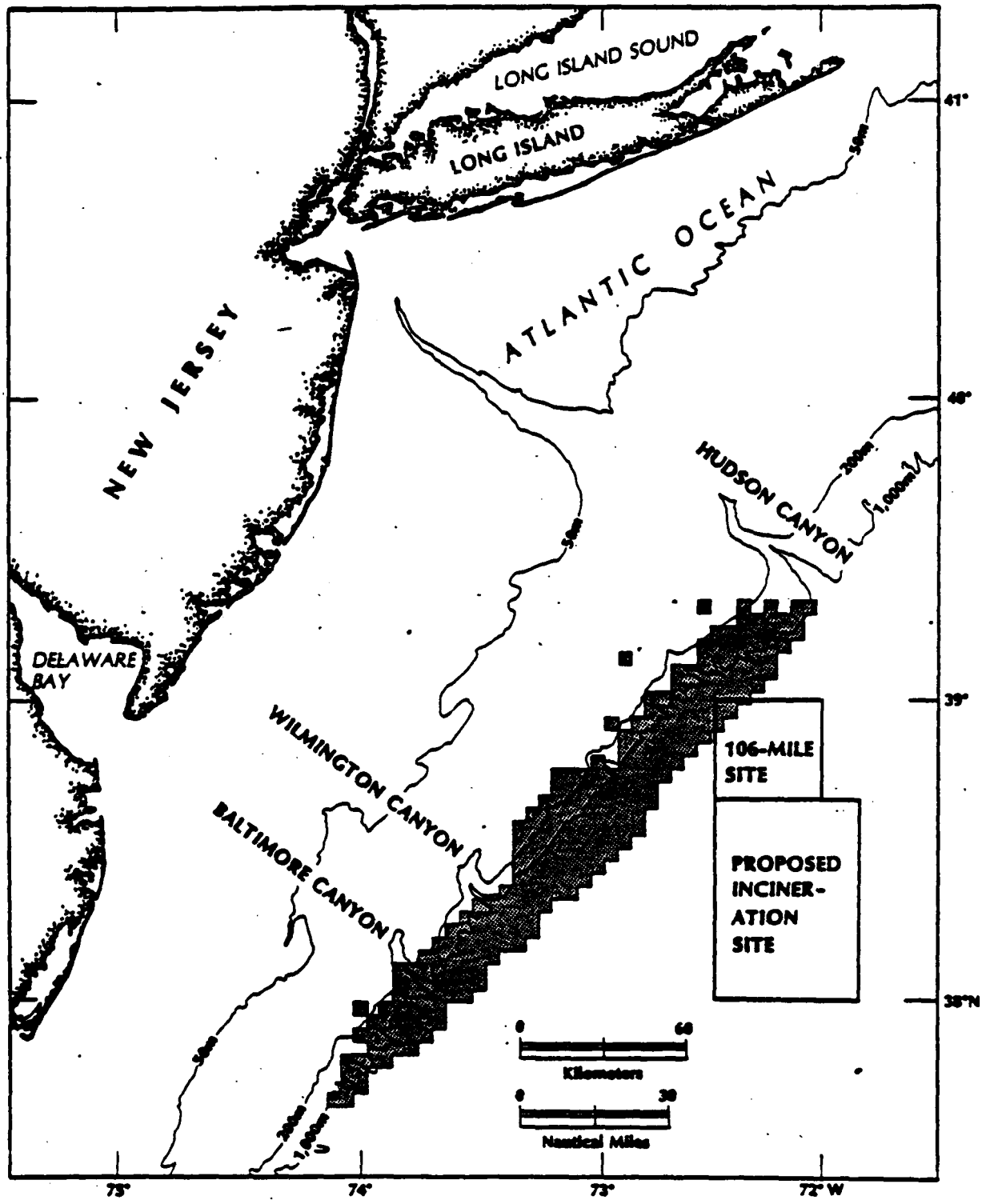

Figure 3-5. Proposed Oil and Gas Leases in the Mid-Atlantic Area--OCS Sale No. 59

Source: Date provided by New York BLM Office

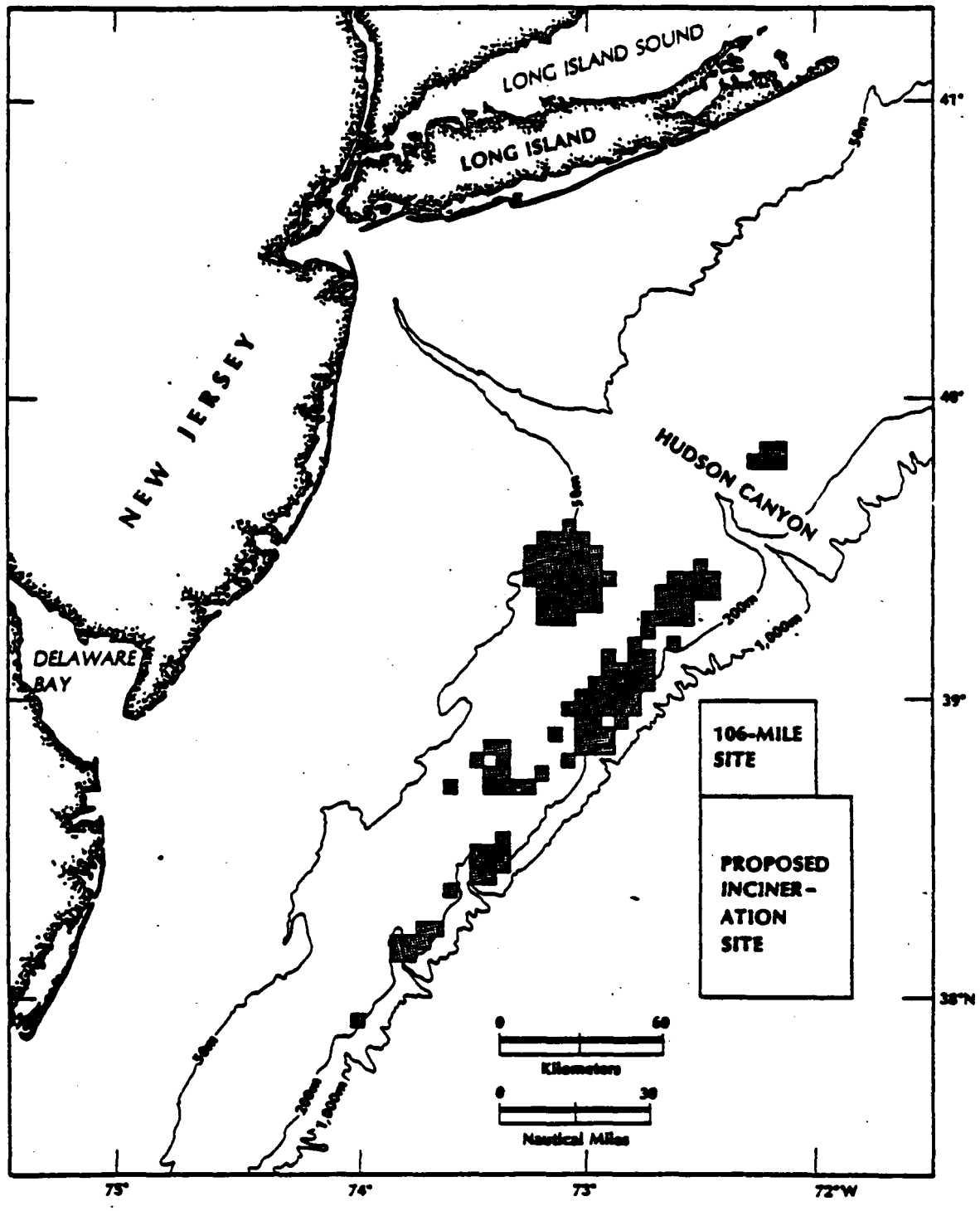

Figure 3-6. Active Oil and Gas Lease in the Mid-Atlantic Area--OCS Sale Nos. 40 and 49

Source: Adapted from EPA, 1978a

Recent disclosures by the U.S. Geological Survey indicate that exploratory drilling may be performed in Continental Rise waters between Maine and Florida within the next decade.

SHIPPING

The major trade routes charted by NOAA, which serve the New York-New Jersey areas, coincide with three major shipping lanes designated by USCG: the Nantucket, Hudson Canyon, and Barnegat Navigational Lanes (Figure 3-7). The trade routes which lie within the Navigational Lanes are usually the safest routes for shipping traffic, and USCG recommends that they be used by all major shipping traffic.

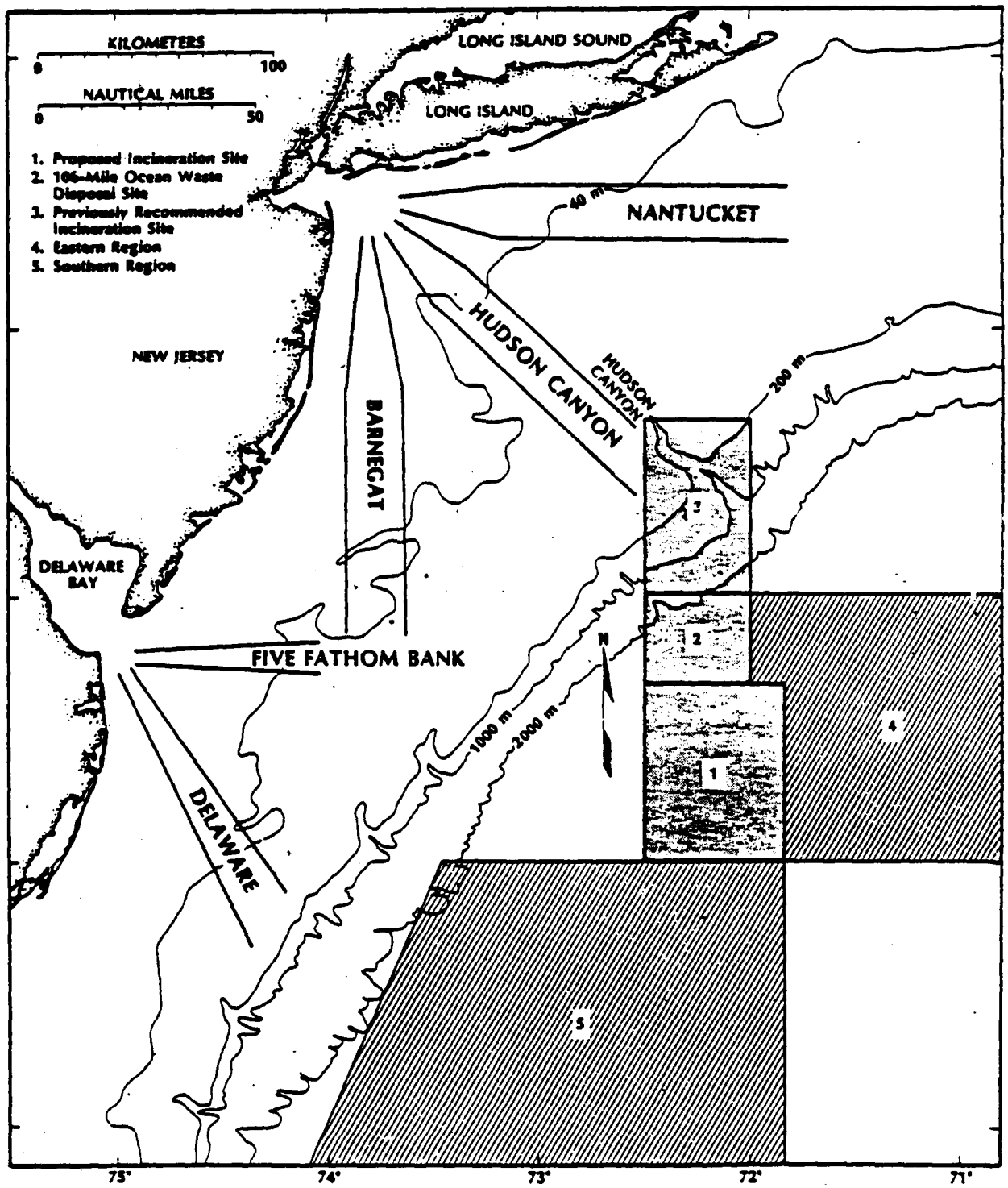

Figure 3-7. Ship Traffic Lanes in the Mid-Atlantic

Chapter 4

ENVIRONMENTAL CONSEQUENCES

Based on research burns conducted in the Gulf of Mexico, the projected environmental consequences of incinerating industrial chemical wastes at the proposed Incineration Site are environmentally acceptable. Waste residues are dispersed and diluted in air and water, reducing concentrations to undetectable or near-background levels within hours of emission. The consequences discussed here are valid for any location selected in the mid-Atlantic Bight region bounded by the Continental Shelf on the west and north, and the Gulf Stream on the east and south. Relocation of the site to the west (over the Continental Shelf) would create unacceptable potential environmental hazards.

This chapter details the environmental impact of waste disposal and the unavoidable adverse environmental consequences that will occur if the proposed action is implemented. The first sections include environmental changes directly affecting public health, commercial or recreational fisheries, and navigation; these are followed by environmental consequences of at-sea incineration. Waste residues at the site are assessed, and a discussion on the effects of waste residuals on air and water quality and marine organisms in the region is included. The chapter concludes with a discussion of unavoidable adverse effects and concomitant mitigating measures, relationships between short-term uses of the environment, the maintenance and enhancement of long-term productivity, and irreversible or irretrievable commitment of resources.

Industrial wastes previously incinerated at sea are discussed in this chapter; they were organochlorine chemicals produced by Shell Chemical Company at Deer Park, Texas. A vast assortment of other organic chemicals (organohalogens) may be considered as candidates for incineration in the future, but data do not presently exist to evaluate precisely any environmental effects which they might produce. Incineration of other chemical wastes using different incinerator vessels would be possible at the proposed site; however, burns would be subject to the prescribed testing and monitoring requirements of the MPRSA.

EFFECTS ON PUBLIC HEALTH AND SAFETY

Certain classes of organohalogen wastes (e.g., pesticides) have various properties that may be particularly hazardous to human and/or marine life. Wastes such as heptachlor or chlordecone (Kepone®) are known to have toxic properties that may lead to serious disorders in mammals (EPA, 1976a). Herbicide Orange and other chemicals contain trace amounts of toxic substances (e.g., dioxin), which produce birth defects in mammals. However, these examples represent extreme cases, and organohalogen wastes with such properties or constituents, even though combustible by incineration, require specialized handling and monitoring procedures. Organohalogen wastes may contain metals, but can be disposed of at sea if the metals are present only as trace contaminants (as defined by the MPRSA and the Convention).

It is important to note that although acceptable organohalogen wastes may have a relatively narrow range of elemental composition, a wide range of toxicities may occur. Therefore, Shell Chemical Company wastes may not be representative of residue toxicity, specifically the toxicity of unburned organohalogens.

Land-based incineration, especially in urban areas (Chapter 2), may be a greater direct threat to public health; consequently, remoteness of the proposed site further ensures reduction of all potential adverse impacts. While at-sea incineration does not decrease the toxicity of waste residues, the probability of short-term impacts or any direct threat to public health is lessened by the extreme dilutions which occur through this disposal method.

PUBLIC AND SHIPBOARD PERSONNEL

The MPRSA mandates that, when feasible, EPA should designate ocean disposal sites which are beyond the edge of the Continental Shelf. The proposed site is located more than 100 nmi (185 km) offshore, to provide protection against any direct public health hazards occurring in or near populated coastal areas. Shipboard personnel who conduct incineration operations are cognizant of safety procedures for the handling and transport of hazardous materials,

promulgated by the U.S. Coast Guard (USCG). Atmospheric concentrations of residual materials will be high near the vessel during incineration; thus, the incinerator vessel must be downwind of all known maritime traffic to prevent atmospheric contamination from drifting over other ships. Due to the extreme distance from shore, it is unlikely that any small recreational craft will be transiting the area.

COASTAL RECREATIONAL AREAS

The only known or estimable effects on the commercial and recreational value of coastal areas, or on people using such areas during or after incineration activities, would result from accidental discharges of wastes at loading times, or during transit to the disposal site. Any discharges or spills near coastal commercial and recreational areas would result in localized destruction of marine organisms and possible widespread contamination. The nature and magnitude of destruction of organisms and contamination would be dependent on the toxicity of each specific waste in the marine environment, modes of effect, the degradability (detoxication) of the waste, and the amount discharged. Consequently, the incinerator ship should be routed to avoid areas of high commercial and recreational value as much as practicable. All EPA and USCG precautions for the handling of wastes must be strictly observed.

COMMERCIAL AND RECREATIONAL FISH AND SHELLFISH

The most direct link between man and waste contaminants released into marine environment is through the food chain, by human consumption of contaminated seafood. Harmful effects caused by eating fish or shellfish which contain high levels of mercury, lead, or persistent synthetic organic substances, have been documented. However, comparative trace metal quantities known to be released at the nearby 106-Mile Ocean Waste Disposal Site (Table 2-2) have caused no detectable accumulation of metals in marine organisms (EPA, 1980a).

Waste disposal at the proposed Incineration Site will not directly endanger human health by contaminating edible organisms, because the site is not

located in any commercially or recreationally important fishing or shellfishing areas. Existing NOAA resource survey assessments do not extend beyond the Continental Shelf, but densities of fish eggs and larvae are known to be low beyond the edge of the Shelf (NOAA, 1977). Foreign fishermen in late winter operate along the Continental Shelf break, approximately 30 nmi (60 km) west of the proposed site (Figure 3-3), and usually catch highly migratory finfish. The probability of migratory fish accumulating toxic levels of contaminants from the waste is unknown, but assumed to be low. The waters are extremely deep, thus the likelihood of adverse effects on benthic organisms is remote. However, various physical and biological processes might eventually introduce minutely diluted contaminant concentrations in benthic organisms, which could increase with time to produce long-term sublethal effects.

NAVIGATIONAL HAZARDS

U.S. flag ships incinerating hazardous chemical wastes must obey all USCG regulations, which are designed to reduce the likelihood of sinking and to minimize the loss of hazardous cargos caused by collisions or strandings. The greatest risks exist in or near harbors and nearshore shipping lanes, where possible collisions are the most probable. On the high seas and in the vicinity of the proposed Incineration Site, collision risks are greatly reduced.

USCG casualty statistics for large vessels (1,000 gross tons or larger) during fiscal years 1974 through 1978 at four major east coast ports show that all collisions have occurred within inland waters. The four ports were: (1) New York Harbor, (2) Camden, New Jersey, (3) Wilmington, New Jersey, and (4) Wilmington, North Carolina. Of 350 reported accidents, 73% occurred in or near New York Harbor, 23% in the Delaware Bay region, and 3% in or near the Wilmington Harbor, North Carolina (USCG, 1979).

Comparatively, records indicate that only 44 vessels reported damages sustained in international waters of the northwest Atlantic Ocean (USCG code areas T-23 and T-30). Of the 44 vessels, none were involved in collisions and

none contained hazardous chemical cargos. Adverse weather conditions were major contributory factors in vessel damage in 34% of the reports. Mechanical malfunctions accounted for 41% of the primary causes of damage, 14% were due to personnel misjudgment, and the remaining 11% were due either to structural failure or unknown causes.

The potential economic and environmental hazards created by spillage, leakage due to collision, or grounding, greatly exceed the potential hazards of at-sea incineration. Therefore, in accordance with the permit condition requiring notification of regulatory agencies (e.g., USCG), shipments of hazardous waste materials will be protected against navigational hazards by regulation of sailing times, advantage taken of optimal traffic and weather conditions, and warning local shipping traffic of the movement of an incinerator vessel.

WASTE COMPONENTS

The major components of the organochlorine wastes produced by Shell Chemical Company are listed in Table 4-1. The wastes accumulate from the manufacture of allyl chloride, epichloride, dichloride, and vinyl chloride. According to Wastler et al. (1975) the organochlorine waste materials consisted primarily of chlorinated aliphatic hydrocarbons of low molecular weights, having a gross heat content of 3,860 Kcal/kg (6,950 Btu/lb). Analyses of the Shell Chemical Company wastes show that in addition to carbon, hydrogen, and chlorine, several metals exist in the waste in trace concentrations (Table 4-2).

Other waste production sources will generate different waste materials, but any organochlorine waste conforming to EPA regulations (Appendix B) will have similar elemental composition, and will produce similar waste residues. EPA will ensure elemental compositions are within acceptable concentration limits, although few specific limiting criteria have been established to regulate such concentrations. However, variations in elemental concentrations may be

TABLE 4-1
MAJOR COMPONENTS OF ORGANOCHLORINE WASTE MATERIAL
IN RESEARCH BURNS (Percent by Weight)

Chemical	Percent	
	Research Burn I	Research Burn II
1,2,3-Trichloropropane	27	28
Tetrachloropropyl ether	6	6
1,2-Dichloroethane	11	10
1,1,2-Trichloroethane	13	13
Dichlorobutanes, and heavier	11	10
Dichloropropenes, and lighter	20	22
Allyl chloride	3	3
Dichlorohydrins	9	8
Total	100	100
Specific gravity (25°F)	1.30	1.29

Source: Wastler et al., 1975

TABLE 4-2
ELEMENTAL ANALYSES OF WASTE
IN RESEARCH BURNS I and II, 1974

Waste Composition	Research Burn I	Research Burn II
	Nonmetals (percent by weight)	
Carbon	29.0	29.3
Hydrogen	4.0	4.1
Oxygen	4.0	3.7
Chlorine	63.0	63.5
	Metals (ppm)	
Copper	0.51	1.1
Chromium	0.33	0.1
Nickel	0.25	0.3
Zinc	0.14	0.3
Lead	0.05	0.06
Cadmium	0.0014	0.001
Arsenic	0.01	0.01
Mercury	0.001	0.002

Source: Wastler et al., 1975

significant. For example, analyses of Shell Chemical Company wastes incinerated during Research Burns I and II (Table 4-2) show that metals were found to be one to three orders of magnitude lower than comparable reported metals found in wastes incinerated during Research Burn III (Table 4-3).

Evidence exists indicating some wastes will produce organic residual compounds which were not present in the original waste. After incineration of Herbicide Orange waste in the Pacific Ocean, numerous (previously unidentified) compounds were found in analysis of stack emissions (Ackerman et al., 1978).

Based on research burn data of Shell Chemical Company's waste incineration in the Gulf of Mexico, Paige et al. (1978) estimated anticipated air and water quality effects (Table 4-4) using emission rates of Research Burn III. Stack gas emissions which may damage the marine environment are HCl (exhausted in large quantities), unburned organochlorides, and trace metals.

TABLE 4-3
ELEMENTAL ANALYSIS OF WASTE MATERIAL AND CALCULATED APPROXIMATE EMISSION RATES OF INORGANIC ELEMENTS DURING RESEARCH BURN III, 1977

Element	Concentration in Waste (ppm)	Calculated Emission Rate (kg/hr)	Element	Concentration in Waste (ppm)	Calculated Emission Rate (kg/hr)
Lead	5.0 - 20.0	0.1 - 0.4	Nickel	10.0 - 100.0	0.2 - 2.0
Barium	10.0 - 20.0	0.2 - 0.4	Cobalt	1.0 - 5.0	0.02 - 0.1
Iodine	2.0 - 4.0	0.04 - 0.09	Iron	30.0 - 400.0	0.7 - 9.0
Silver	1.0 - 8.0	0.02 - 0.2	Manganese	1.0 - 5.0	0.02 - 0.1
Molybdenum	10.0 - 20.0	0.2 - 0.4	Chromium	5.0 - 200.0	0.1 - 4.0
Zirconium	1.0 - 5.0	0.02 - 0.1	Titanium	10.0 - 20.0	0.2 - 0.4
Strontium	5.0 - 30.0	0.1 - 0.7	Scandium	0.1 - 1.0	0.002 - 0.02
Rubidium	0.5 - 1.0	0.01 - 0.02	Potassium	300.0	7.0
Bromine	5.0 - 10.0	0.1 - 0.2	Sulfur	30.0 - 60.0	0.7 - 1.0
Selenium	1.0 - 5.0	0.02 - 0.1	Silicon	90.0 - 100.0	2.0
Arsenic	1.0 - 5.0	0.02 - 0.1	Aluminum	10.0 - 50.0	0.2 - 1.0
Gallium	0.5 - 2.0	0.01 - 0.04	Fluorine	10.0 - 50.0	0.2 - 1.0
Zinc	10.0 - 30.0	0.2 - 0.7	Boron	1.0 - 10.0	0.02 - 0.2
Copper	10.0 - 30.0	0.2 - 0.7	Lithium	0.5 - 2.0	0.01 - 0.04

TABLE 4-4
SUMMARY OF MAJOR AIR AND WATER QUALITY EFFECTS ASSOCIATED WITH AT-SEA INCINERATION

Air Quality[a] ($\mu g/m^3$)			Water Quality (ppb)			
HCl	Inorganics[b]	Unburned Wastes[c]	Copper[d]	HCl	Unburned Wastes	Copper
4,422	22.49	2.75	0.22	197	0.09	0.04

a. Maxima for stipulated meteorological conditions: effective stack height = 125.5 m, wind speed = 4.0 m/s, stable atmosphere.

b. Based on summation of inorganic constituents in wastes; provides an estimate of particulate concentrations.

c. Based on lowest average observed destruction efficiencies (99.96%), determined by different analysis methods.

d. Copper and zinc are the metallic waste constituents with large emission rates (Table 4-3).

Source: Paige et al., 1978

EFFECTS ON THE ECOSYSTEM

Before substances are approved for incineration, the degradability and breakdown products of those substances must be determined, together with any combustion products. The uncertain degradabilities of many organic residue substances, which must be considered, cause possibilities of long-term accumulations. For example, substances such as PCB and DDT are known to persist in the environment for many years, thus posing the potential for direct threats to human health when accumulated in the food chain. PCB's may also be contaminated with highly toxic polychlorinated dibenzofuran (PCDF). Some substances degrade into more toxic material than the precursors, and others produce new compounds as a result of incineration. Therefore, each waste material must be considered for incineration on a case-by-case basis. A great deal of additional information is needed to make accurate predictions of the fate and effect of organic residues (Chapter 2).

In addition to organic residues, several inorganic residues will result from the incineration process. Other combustion products associated with

organochlorine wastes are carbon monoxide (CO), carbon dioxide (CO_2), water (H_2O), hydrochloric acid (HCl), and chlorine (Cl_2). Emissions from some wastes may contain sulfur dioxide (SO_2), phosphorus pentoxide (P_2O_5), and/or nitrogen oxides (NO_x) and trace metals in a gaseous phase.

Future incineration operations may result in the expansion of this alternative when increasing quantities of hazardous wastes become available. As a result, a more continuous (chronic) stream of residue may be introduced into the marine environment. This slow, continuous input may produce subtle environmental impacts, less noticeable than short-term, rapid (acute) inputs associated with individual operations.

By 1989 approximately 271,000 tonnes of organohalogen wastes may be available annually for at-sea incineration off the east coast of the United States (Table 1-3). Assuming a maximum delivery potential of 193,000 tonnes of wastes and a minimum 99.99% destruction efficiency, approximately 19 tonnes of organohalogens could possibly be introduced into the marine environment annually as atmospheric fallout from incineration. Research burns have shown destruction efficiencies to be as low as 99.96%, in which case annual organochlorine emissions of about 77 tonnes may occur by 1989 (Table 2-3).

Residues from incinerated chemical wastes will be dispersed throughout vast volumes of air and water. An assumed worst-case of 77 tonnes of organochlorine residuals, resulting from a 99.96% destruction efficiency (Table 2-3), will be distributed through about 32 x 10^{11} m^3 of water in the time period required to burn the waste (8,773 hr), assuming a 17 cm/s average surface current velocity and nonstop incineration operations for the entire 193,000 tonnes of waste material with mixing to 20m*; or with mixing to 100m, waste will be distributed through about 66 x 10^{11} m^3 of water.

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*Based on the Ekman Transport Model: $V = V_o W \frac{D}{\pi\sqrt{2}} \left(1-e^{\frac{-Z\pi}{D}}\right)$ (Ekman, 1963, and Von Arx, 1962)

AIR QUALITY

Air quality will be affected by gaseous emissions (primarily HCl, unburned organochlorines, and trace metals) produced during waste incineration. Dispersal of emission material is partially a function of wind speed. The emissions will rise into the atmosphere, forming a gaseous plume which will be transported by wind and dispersed by diffusion processes (Figure 1-3). Prevailing atmospheric conditions will affect plume behavior significantly. Under stable atmospheric conditions (as in dispersion modeling) the plume would expand in all directions above the ocean surface to a maximum of 32 nmi (59 km) from the point of origin (Paige et al., 1978). However, recorded burn observations reveal that the waste plumes behave erratically, contacting the water surface in a random manner (TerEco, 1975), with initial contact occurring as near as 0.2 nmi (0.4 km) downwind of the incinerator vessel (Wastler et al., 1975). Maximal altitude obtained by the plume during the 1974 Research Burn II was 850m, with maximal HCl concentrations occurring at altitudes of 100 to 240m between the ship, and 400m downwind. The plume fanned out horizontally to a width of 1,200m at a distance of 2,400m downwind from the vessel (Wastler et al., 1975).

HYDROCHLORIC ACID

Studies conducted during research burns of Shell Chemical Company wastes showed that approximately 16 tonne/hr of HCl are released into the atmosphere during a burn of 25 tonne/hr of waste, having approximately 63% chlorine content (EPA, 1976a). Monitoring during Gulf of Mexico Research Burns I and II showed that maximal air/sea surface concentrations of HCl occurred 400 to 500m downwind of the incineration vessel in winds of 10 kn, and as far as 2,780m in winds of 20 kn. Grasshoff (1974) calculated dispersal of HCl in moderate winds to be over an area of at least 250,000 m^2, which is a highly conservative estimate in comparison to the EPA (1976b) estimate of 22 x 10^6 m^2.

Paige et al. (1978) produced simulation models of the behavior of waste constituents, including HCl. The air quality simulation model predicts a maximal air/sea surface HCl concentration of 2.9 ppm, at 2.2 nmi (4 km)

downwind of the incinerator vessel. Maximal concentrations were observed to range from 0.01 to 7.0 ppm, at distances ranging from 0.25 to 0.5 nmi (463 to 925m) from the incinerator vessel several minutes after stack emission during the two 1974 research burns (Wastler et al., 1975). The predicted concentration is in close agreement with observed concentrations, indicating the usefulness of the predictive models.

The most severe atmospheric acid fallout will occur during periods of precipitation, but no calculated data are available to determine the effects. However, concentrated acid wastes released at the Acid Waste Disposal Site in the New York Bight dissipate rapidly (within hours), and have only transitory adverse impacts on marine organisms (EPA, 1980b).

UNBURNED ORGANOHALOGENS

Undestroyed (unburned) organohalogen wastes will be released with stack emissions at a rate of 0.04% (or less) of the waste-burn flow rate. For example, if the waste flow rate is 22 tonne/hr (for two incinerators), approximately 8.8 kg/hr of undestroyed waste will be released into the environment. These compounds do not condense as rapidly as HCl, and therefore require more time to reach the water surface, permitting greater atmospheric dispersion (Grasshoff, 1974). The simulation model presented by Paige et al. (1978) predicted a maximal atmospheric concentration of 2.75 $\mu g/m^3$ (0.51 ppb) at the sea surface 4,000m downwind of the ship. EPA (1976b) predicted a maximal sea surface concentration settling rate of 1 $mg/m^2/hr$, if all unburned waste residue settles within 1 hour after emission, based on a destruction efficiency only of 99.9%.

Duce and Kester (Appendix D) concluded that for residual compounds such as trichloroethane with emission rates of 8.8 kg/hr, one shipload of waste will contribute only about 10% of the quantity already existing within the atmosphere of the site. However, for compounds such as PCB or DDT, a more significant input is seen. The quantity of PCB released during incineration (assuming 99.96% DE) would be approximately 100 times greater than background levels observed over the site, and a few tenths of a percent of the total content of the northern hemisphere. For DDT the resulting emissions would be

over 1,000 times the background level observed over the Incineration Site, and about 10% of the estimated northern hemisphere level. Clearly, wastes which are to be considered for incineration must be assessed on a case-by-case basis.

With respect to the residence time of unburned chlorinated hydrocarbons in the gas phase, the unburned compounds must first be identified. If the waste material is Herbicide Orange, which was the case during burns aboard the M/T VULCANUS in the Pacific Ocean, it consists of a mixture of equal parts by volume of the n-butyl esters of 2,4-dichlorophenoxyacetic acid (2,4-D) and of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T). Other burns in the Gulf of Mexico have been primarily of such substances as 1,2,3-trichloropropane, dichloropropane, dichloropropene, trichloroethane, dichloroethane, and other chlorinated hydrocarbons of low molecular weights (Paige et al., 1978). There is currently little information available on the atmospheric residence time for most of the compounds listed above. However, estimates have been made for other somewhat similar chlorinated hydrocarbons. Some general estimates of possible residence times for the substances can be obtained by reviewing the known residence times for the other chlorinated hydrocarbons and making some simple comparisons with the chemical structure of the unknown compounds.

As pointed out by the National Academy of Sciences (1978), the chemical and physical properties of low molecular-weight chlorinated hydrocarbons (C_1 - C_3) are greatly different from the high molecular-weight chlorinated hydrocarbon herbicides, pesticides, and industrial chemicals such as PCB's. Any low molecular-weight chlorinated hydrocarbon containing unsaturated carbon-carbon bonds (e.g., $CHCl = CCl_2$) will have brief residence times generally on the order of hours in the atmosphere, due to their high reactivity (NAS, 1978) and involvement in photochemical smog-type reactions (e.g., NO_x, O_3, OH, etc.). Low molecular-weight chlorinated hydrocarbons with saturated C-C bonds (i.e., no double or triple bonds) will have much longer residence times, as they are quite resistant to most chemical reactions. These substances are fairly insoluble in seawater. It is generally believed that they are ultimately destroyed in the atmosphere via reactions with the OH (hydroxyl) radical, which is photochemically produced.

Table 4-5 presents estimates for the atmospheric residence times of trichloroethane and several chlorinated methane compounds. While there are considerable variations in the estimates for any individual substance, all of the residence times are long in terms of atmospheric transport processes, ranging from 3 months to more than 10 years. For trichloroethane, one of the substances which have been burned on M/T VULCANUS in the past, residence time has been estimated at 1 to 11 years, with the higher estimates obtained more recently. Thus, it would be expected that many saturated low molecular-weight chlorinated hydrocarbons injected unchanged into the atmosphere might have atmospheric residence times on the order of months to years, and could be subject to at least hemispheric, and perhaps global-scale transport.

There are no data available on the atmospheric residence time of compounds similar in structure to the n-butyl esters of 2,4-D and 2,4,5-T. It is expected that the compounds would be subjected to fairly rapid hydrolysis in the atmosphere.

TABLE 4-5
LITERATURE VALUES FOR THE ESTIMATED
ATMOSPHERIC RESIDENCE TIMES FOR CHLORINATED HYDROCARBONS

Formula	Name	Estimated Residence Time	Reference
CCH_3-CCl_3	Trichloroethane or methyl chloroform	8-10 years	Singh et al., 1979
		~6 years	Derwent and Eggleton, 1978
		1.1 years	Cox et al., 1976
		11 years	Chang and Penner, 1978
CH_3Cl	Methyl chloride	~3 months	Atkinson et al., 1976
		2-3 years	Singh et al., 1979
		2-3 years	Derwent and Eggleton, 1978
		~5 months	Cox et al., 1976
$CHCl_3$	Chloroform	~1 year	Derwent and Eggleton, 1978
		~3 months	Cox et al., 1976
CH_2Cl_2	Methylene dichloride	~1 year	Derwent and Eggleton, 1978
		~4 months	Cox et al., 1976
$C_{12}Cl_X$	PCB	1-3 months	Bidleman et al., 1976
-	DDT	1-3 months	Bidleman et al., 1976

The atmospheric residence time for PCB's has been estimated at 1 to 3 months. Similar residence times have been estimated for DDT. The unburned components of Herbicide Orange (2,4-D and 2,4,5-T) would be expected to have residence times considerably less than this, perhaps on the order of days. It must be emphasized, however, that no data are available on these compounds (Duce and Kester, Appendix D).

Junge (1977) has pointed out that non-urban air compounds having vapor pressures greater than 10^6 to 10^7 mm Hg under ambient conditions will generally be found primarily in the gas phase, rather than attached to particles. The saturated vapor pressure of the n-butyl ester of 2,4-D at 27°C is 4×10^3 mm Hg (Que Hee et al., 1975). This material, and all the low molecular-weight chlorinated hydrocarbons discussed previously, should be found almost entirely in the vapor phase in the atmosphere, rather than attached to particles. Actual measurements have shown this to be the case of PCB's and DDT over the North Atlantic as well (Bidleman et al., 1976).

TRACE METALS

Metals in stack emissions are generally in the form of inorganic particulates, such as salts or oxides. The quantity of metal salts or oxides in the plume is independent of combustion or destruction efficiency, and is directly proportional to the original metal content of the waste. Worst-case calculations indicate that for wastes with metal concentrations similar to Shell Chemical Company wastes (Table 4-3), the maximal sea surface concentration of inorganic particulates will be approximately 26 ug/m^3, or 10 times lower than EPA primary health standards for particulates (U.S. Department of State and EPA, 1979). Metals will exist in inorganic particulates in much lower concentrations. For example, chromium is a pronounced constituent (Table 4-3), and is predicted to occur at sea level concentrations of 1,200 ng/m^3 (0.6 ppb) 4,000m downwind of the vessel. This concentration is found to be 25 to 12,000 times higher than the expected background concentrations (Table 4-6). All metals are found to exceed background level at the sea surface location of highest atmospheric concentration, 4,000m downwind.

TABLE 4-6
PREDICTED ATMOSPHERIC CONCENTRATIONS OF SELECTED HEAVY METALS

Metal	Expected Background Concentration (ng/m^3 at STP)	Model Predicted Maximum Sea Level Concentration (ng/m^3 at STP)
Cu	0.5 - 20.0	220
Zn	2.0 - 100.0	220
Pb	10.0 - 200.0	120
As	0.05 - 5.0	30
Co	0.01 - 0.5	30
Cr	0.1 - 50.0	1,200
Ni	0.05 - 50.0	620

STP = Standard Temperature and Pressure
Source: Paige et al., 1978

Duce and Kester (Appendix D) estimated order of magnitude inputs of these heavy metals by assuming that the major mass of these metals resides on atmospheric particles less than 1 μm in diameter, which probably have dry deposition velocities of 0.05 to 1.0 cm/s. The resulting estimated areal fluxes are given in Table 4-7.

WATER QUALITY

After introduction into and subsequent dispersion by the atmosphere, the waste products are subject to removal from the atmosphere by two processes: (1) precipitation (e.g., rain or snowfall), and (2) gravitational settling and turbulent and diffusive transfer (e.g., dry deposition). As a result of these processes, the residual materials will undergo tremendous dilution and will descend and contact the water surface downwind of the incinerator vessel. The previous discussion of air quality provides estimates of maximal concentrations expected to affect the water surface. Theoretical and observed values are in close agreement.

Paige et al. (1978) emphasize their model is conservative and assume 100% of the emitted plume constituents are dissolved in a specified volume of water. Under actual conditions, some of the plume constituents remain

TABLE 4-7
PREDICTED FLUXES OF CHLORINATED HYDROCARBONS TO THE OCEAN

Compound	Total Mass Released at Burn Site	*Model Predicted Maximum Concentration	Maximum Gas Flux to the Ocean	Total Flux into the Ocean
	(g/hr)	($10^6 g/m^3$ STP)	($g/cm^2/s$)	(g/hr)
Trichloroethane	8,800	2.5	4×10^{-15}	0.2
PCB	8,800	2.5	4×10^{-13}	20
DDT	8,800	2.5	4×10^{-13}	20

Sources: Duce and Kester, Appendix D; *Paige et al. (1978)

airborne for a substantial distance downwind, preventing interaction of wastes with seawater in the vicinity of the vessel. If interaction of plume constituents and seawater does take place farther downwind, constituent concentrations will be lower than predicted. Comparatively, a water quality impact estimation is presented for organohalogens, based on a waste loading model which assumes dispersion of all residual wastes over the entire surface area of the site to a depth of 20m during the incineration of a shipload of wastes. However, the model does not account for the transport of water or "flushing effect" during the same period.

Duce and Kester (Appendix D) present a worst-case estimate of residual organohalogen loading in the water at the site, using a conservative model which restricts residue dispersion and dilution within a small area of the site, to a depth of 20m. This estimation predicts seawater waste residue concentrations resulting during the 4-hour initial mixing period. Using this model waste loading, estimates produce values several factors above EPA water quality criteria (EPA, 1976a).

Should an eddy persist in the region for a prolonged period, several successive incineration operations could allow residue input to be trapped within a relatively small water mass, permitting cumulative loading within the eddy.

HYDROCHLORIC ACID (HCl) AND CHLORINE (Cl_2)

Grasshoff (1974) presents anticipated HCl emission concentrations for burned wastes, and estimates the acid fallout per square meter of water surface per hour. By modifying the estimates to fit previous Shell Chemical Company waste quantities of 25 tonne/hr of waste burned, containing approximately 63% chlorine, HCl emissions would be approximately 16 tonne/hr. The estimate is comparable to the calculated value of 17 tonne/hr reported by EPA (1976b). Moderate wind speeds will disperse the waste plume over a sea surface area of at least 250,000 m^2 before HCl condenses and falls to the water surface. The estimates indicate that for a worst case approximately 65 g $HCl/m^2/hr$ will fall on the affected sea surface.

One cubic meter of seawater is capable of neutralizing 80 g HCl (80 ppm). Paige et al. (1978) predicted that with a 20m mixed layer depth the resultant HCl concentration would be 0.197 ppm (neglecting neutralization). The neutralization reaction results in carbon dioxide, boric acid, and chloride ions through the following general reactions (Grasshoff, 1974):

$$HCO_3^- + HCl \longrightarrow CO_2 + H_2O + Cl^-$$

$$CO_3^{=} + 2\,HCl \longrightarrow CO_2 + H_2O + 2\,Cl^-$$

$$B(OH)_4^- + HCl \longrightarrow B(OH)_3 + H_2O + Cl^-$$

Seawater pH normally ranges between 7.8 and 8.4. Samples of seawater collected at Research Burn I and II control stations showed ambient surface pH values of 8.20 to 8.39. To determine the effect of waste plume acid on ambient pH, water samples were collected at locations affected by the plume. The pH values ranged from 8.28 to 8.39. Results of approximately 100 samples showed no significant difference between affected areas and control station area samples. The greatest change observed was 0.15 pH unit, which is well within the acceptable water quality pH range of 6.5 to 8.5, or maximal change from ambient value of 0.2 pH unit (EPA, 1976a).

The maximal atmospheric concentration of HCl detected during all monitoring surveys was 7 ppm, which corresponded to a 1.9×10^{4} molar HCl solution with a pH of 3.7. If equal volumes of atmospheric HCl and seawater at pH 8.2 and alkalinity of 2.57 meq/l are combined, the resultant solution will have a pH of 7.4 and alkalinity of 2.34 meq/l. This example illustrates the resultant pH in the top several micrometers of sea surface, with no subsequent mixing or dilution. This is clearly not the case. Turbulent motion will immediately mix microdroplets of HCl into a volume of water with orders of magnitude greater than a 1:1 ratio. Thus, no detectable pH shift is expected to occur, and in the field only slight shifts were observed in a small number of samples.

North Atlantic water contains an average of 20g chloride ions (Cl^{-}) per liter, or 20 kg/m^3. The 65 g/m^2 of chloride ions due to acid fallout will increase the chloride ion content of 1.0 m^3 of seawater by a factor of 0.3%, which is insignificant in terms of the ambient chloride content (Grasshoff, 1974).

Turbulence in the ocean produces vertical mixing even in deep water, which greatly enhances the ability of seawater to absorb the HCl flux rapidly. During summer, when the mixed layer is shallowest, mixing may be limited to the upper 20m; during winter, mixing may occur to a +100m depth. Additionally, horizontal currents increase mixing, consequently, the quantity of HCl falling hourly on the sea surface may be anticipated to disperse through a volume of water many times greater than its surface area (Grasshoff, 1974). The decrease in pH will be insignificant and well within acceptable limits. Research burn studies show maximal decreases of 0.15 pH units below ambient values, which is less than the EPA limit of 0.2 units.

Chlorine gas (Cl_2) is produced during the incineration of organochlorine wastes. Measurements in the Gulf of Mexico showed Cl_2 emissions ranging from less than 10 ppm to 360 ppm, with an average concentrations below 200 ppm (Wastler et al., 1975). At an incineration rate of 22 tonne/hr, less than 4.4 kg/hr Cl_2 is anticipated to be emitted with other residues.

After release, Cl_2 will be rapidly dispersed by atmospheric turbulence and photochemically decomposed during daylight hours. Atmospheric turbulence will promote the atmospheric suspension of Cl_2, reducing the exchange rate at the water surface. Under conditions of extreme calm (such as during a windless night) only, will the relatively dense Cl_2 concentrate near the water surface.

Zafiriou (1974) examined the photochemistry of diatomic halogens in the marine atmosphere. He reported a calculated mean lifetime for Cl_2 of about 365 seconds (6 minutes), assuming there is overhead sun and unabsorbing atmosphere. Under actual atmospheric conditions, photolytic dissociation rates may be more conservatively estimated as 10% of dissociation rates under ideal conditions, and predominant over absorption into aerosols. Conversely, at night molecule-aerosol interactions become the dominant removal process. Under nighttime conditions Cl_2 molecules may survive 1,000 to 2,000 seconds before diffusion to a particle in a typical marine aerosol.

Dilution resulting from water circulation must be added to atmospheric dispersion and dilution. Eddy diffusion and turbulence created by ocean currents will continually cause the Cl_2 to be diluted. Although Cl_2 has a high solubility in seawater (50 g/l), it probably would enter the water column slowly, either by diffusion across the air/sea interface, or as precipitation with water droplets. The neuston and other near-surface organisms are the most likely to be affected by the addition of Cl_2 to the water.

Toxicity of Cl_2 to organisms is a function of concentration and exposure time. Exposure of marine organisms to Cl_2 concentrations of 10 mg/l or less for prolonged periods will not present an adverse environmental condition (EPA, 1976a). However, many planktonic organisms (such as fish eggs and larvae) may be susceptible to concentrations lower than the EPA water quality criteria. A survey of Cl_2 toxicity studies (NOAA, 1981) indicates that the most sensitive planktonic organisms will exhibit severe and irreversible damage when exposed to Cl_2 concentrations of 5 mg/l after 48 hours. In studies of short-term (1 hour) exposures, lethal Cl_2 concentrations occurred at 100 to 2,500 mg/l for fish larval stages.

A simple model can be constructed to approximate a worst-case example of water column Cl_2 loading. In this model it is assumed that 100% of the Cl_2 generated (4.4 kg) during 1 hour of incineration (22 tonnes) is mixed in the upper 10 cm of the water column within an elliptically shaped plume area of 2×10^{10} cm^2. This worst-case scenario indicates that the Cl_2 concentration within the neuston layer would be 22 mg/l. The resulting concentration is 220% greater than the concentration permitted by the EPA water quality criteria. However, in reality this concentration would never be obtained, and would probably be several orders of magnitude lower, due to atmospheric dispersion, photochemical dissociation, and water column dilution.

UNBURNED ORGANOHALOGENS

Unburned organohalogens (including organochlorides) will reach the sea surface in relatively high concentrations, but will then be diluted in the seawater. Paige et al. (1978) predict a maximal air/sea surface concentration of 2.75 ug/m^3 (0.53 ppb) to occur 4,000m downwind of the vessel. On settling in the water, Paige et al. (1978) calculate the residue will be diluted to 0.092 mg/m^3 (0.092 ppb) if mixing is restricted to the surface area affected during 1 hour of operations (3.6×10^6 m^3) and a mixed layer depth of 20m. Comparatively, if it is assumed that 100% of the unburned waste residue generated in 191 hours of incineration operations (1,680 kg @ 99.96% DE) is diluted within the upper 20m of the entire site (84.4×10^9 m^3) after release, a maximal concentration of 0.02 mg/m^3 (0.02 ppb) will result from a single shipload of waste, negating water transport during this period. Improving destruction efficiency to 99.99% results in a maximal concentration of 0.005 mg/m^3 (0.005 ppb). Results of research burn analyses show that organochloride residue concentrations of surface water samples were always below the minimum detection limit of 25 ppb.

By means of the plume model of Paige et al. (1978) and assuming: (1) a 99.96% destruction efficiency, (2) a chlorinated hydrocarbon emission rate of 8.8 kg/hr, and (3) an elliptically shaped plume (area = 2×10^{10} cm^2) of high concentration atmospheric chlorinated hydrocarbon residue over the ocean as a result of incineration, Duce and Kester (Appendix D) predicted the maximum areal and hourly flux of three chlorinated hydrocarbons into the ocean. These fluxes are given in Table 4-7.

Flux estimates indicate that airborne residues will require a substantial period of time before the total mass released will actually settle into the water column. Comparison with Table 4-5 suggests that 100% of the residual materials will not settle out of the atmosphere for months or years, further reducing water quality impacts.

Water quality criteria established for several toxic organohalogens range from 100 mg/m^3 (2,4-D) to 0.001 mg/m^3 PCB, DDT, Heptachlor, and others (EPA, 1976a). The maximal permissible concentrations can be maintained during incineration operations by regulating waste concentrations taken aboard the vessel and/or regulating waste burn-flow to rates permitting destruction efficiencies of 99.99% or more.

TRACE METALS

Quantities of trace metals contained in wastes (considered passable for ocean incineration) are closely scrutinized and no permit is issued for waste which does not satisfy all criteria adopted by EPA.

Using the model results of Paige et al. (1978) and assuming: (1) an elliptically shaped plume (area = $2 \times 10^{10} cm^2$) of high atmospheric heavy metal concentration forms over the ocean as a result of incineration, and (2) heavy metals concentrations in the elliptical region are approximately 80% of the maximum predicted by Paige et al. (1978) (Table 4-6), Duce and Kester (Appendix D) predicted areal and hourly flux rates of heavy metals from atmosphere to ocean. The total masses of each heavy metal deposited in this area by dry deposition and by rainfall in 1 hour are given in Table 4-8.

During Research Burn II copper was reported as the most highly concentrated metal present in the waste material, reaching 1.1 ppm. Seawater samples collected in control areas showed copper concentrations ranging from 0.0046 to 0.0067 ppm, whereas samples collected in affected areas 3,340m to 4,080m from the incineration vessel ranged from 0.0022 to 0.0067 ppm. Results from Research Burns I and II showed no statistically significant differences between control and affected areas (TerEco, 1975).

TABLE 4-8
PREDICTED AREAL AND HOURLY FLUXES OF SELECTED HEAVY METALS

Metal	Areal Fluxes		Hourly Fluxes		
	Flux to Sea Surface by Dry Deposition ($ng/cm^2/s$)	Flux to Sea Surface by Rainfall ($ng/cm^2/s$)	Flux into Atmosphere† from Burn Site (g/hr)	Flux into Ocean* by Dry Deposition (g/hr)	Flux into Ocean* by Rainfall (g/hr)
Cu	1.0 to 20	500 to 5,000	700	0.6 to 12	300 to 3,000
Zn	1.0 to 20	500 to 5,000	700	0.6 to 12	300 to 3,000
Pb	0.6 to 12	300 to 3,000	400	0.3 to 6	200 to 2,000
As	0.15 to 3	60 to 600	100	0.09 to 2	40 to 400
Co	0.15 to 3	60 to 600	100	0.09 to 2	40 to 400
Cr	6.0 to 120	3,000 to 30,000	4,000	3.5 to 70	2,000 to 20,000
Ni	3.0 to 60	1,000 to 10,000	2,000	1.7 to 35	1,000 to 10,000

†Adapted from Table 4-3
*Within a specified area of 2×10^{10} cm^2

Source: Duce and Kester, Appendix D

EFFECTS ON BIOTA

Air and water quality are predicted to show no measurable adverse effects; however, three waste residue constituents (HCl, unburned organohalogens, and metals) may have immediate (short-term), or delayed (long-term) adverse impacts on organisms in the affected water.

Chlorinity, pH, organochlorines, and trace metals were monitored during Research Burns I and II to evaluate both short-term and long-term effects on organisms. Additionally, chlorophyll *a* and adenosine triphosphate (ATP) concentrations were used to assess long-term effects. During Research Burn III the enzymes catalase, ATPase, and Cytochrome P-450 were monitored to evaluate short-term and long-term effects. The results of these analyses are discussed below.

PLANKTON

Plankton consist of plants (phytoplankton) and animals (zooplankton) which spend all or part of their lives floating or swimming weakly. Since incineration effluents primarily affect the water, plankton represent the first levels of the ecosystem where the biological effects might be observed. Accordingly, studies of the effects of waste residues on planktonic organisms have been conducted (TerEco, 1975).

Among the affected planktonic organisms, the neuston or near-surface organisms are expected to be the most severely affected. Initial acid neutralization and residue dilution will occur in the top few centimeters of seawater; as mixing proceeds, dilution will increase. When mixing has developed to approximately 20m deep, residues will be at or below detection limits and concentrations of residual constituents will be orders of magnitude below permissible potential short-term effect levels.

During Research Burns I and II short-term impacts on planktonic organisms were inferred from changes observed in water quality parameters. TerEco (1975) reported that no statistically significant differences were found between control and affected water samples. It can be concluded that

incineration will have no significant short-term adverse effects on planktonic organisms. This conclusion is supported by results of tests used to deduce the long-term effects.

To determine long-term effects, the concentrations of copper, zinc, and organochlorines were measured in phytoplanktonic samples collected in the affected area of waste residue fallout (Table 4-9, Test 3). These were then compared to the concentrations of the same parameters in phytoplanktonic samples from a control area (Table 4-9, Control 2). No significant differences were observed between the affected area samples and the controls (TerEco, 1975).

Chlorophyll *a* and ATP levels in phytoplankton were examined to augment long-term impact studies. Chlorophyll *a* is a measurement of the phytoplanktonic biomass; ATP is a biochemical substance essential to life processes and is an indicator of the effect of pollutants. Phytoplanktonic samples collected during Research Burns I and II showed no change in chlorophyll *a* or in ATP activity which could be interpreted as deleterious long-term effects produced by incineration activities (Wastler et al., 1975). However, these conclusions are based on samples with relatively low numbers of organisms (500 to 1,140 organisms per liter). Effects may be observable in samples with

TABLE 4-9
ANALYSIS OF TRACE METALS AND ORGANOCHLORINES IN PHYTOPLANKTON, GULF OF MEXICO RESEARCH BURN II, 1974

Phyto-planktonic Sample	Whole Sample (g)	Total Copper (mg/l)	Total Zinc (mg/l)	Total Whole Sample Organochlorines (ppm)
Test 3	276	0.036	0.09	<3
Control 2	281	0.030	0.08	<3

Source: Wastler et al., 1975

higher organism counts (Wastler et al., 1975). Zooplankton were also analyzed for copper, zinc, and organochlorines during Research Burn II to determine long-term effects of wastes. Organisms collected from affected water were compared to organisms from unaffected (control) areas (Table 4-10). No significant differences were observed between samples.

NEKTON

The nekton include animals such as fish and mammals capable of strong swimming and migrating considerable distances. Included in this section are pelagic organisms which inhabit oceanic waters beyond the Continental Shelf.

Short-term adverse impacts on nekton will be induced by sudden extreme pH changes of seawater, acutely toxic levels of unburned organochlorines, or trace metals. As discussed in the section on water quality impacts, such extreme fluctuations have never been observed; hence, short-term adverse biological impacts in all analyses were not observed. HCl was neutralized.

TABLE 4-10
ANALYSIS OF TRACE METALS AND ORGANOCHLORINES
IN ZOOPLANKTON, GULF OF MEXICO RESEARCH BURN II, 1974

Zooplankton Sample	Whole Sample (g)	Total Cu (ppm)	Total Zn (ppm)	Total Organochlorines (ppm)
Tow 1 Test 1	454	85	19	<3
Tow 2 Control 1	716	16	18	<3
Tow 3 Test 4	2,162	6	13	<3
Tow 4 Control 3	904	11	28	<3

Source: Wastler et al., 1975

rapidly upon contact with seawater and did not cause detectable pH changes in the environment. Trace metals and unburned organochlorines were dispersed and diluted in the atmosphere to nontoxic levels before contacting the water surface, then further dispersed and diluted by the water.

During Research Burn III in March 1977, a series of laboratory bioassays were performed on fish, using various concentrations of Shell Chemical Company waste (TerEco, unpublished). Fish were also exposed to plume-affected water in the site. In the laboratory and field experiments, catalase, ATPase, and liver P-450 enzyme activities were measured to determine effects of waste material. Only catalase and P-450 showed significant responses.

Laboratory experiments showed 50% mortality within 41 hours in fish exposed to a concentration of 74 ppm raw organochlorine waste, whereas no mortality was observed among fish exposed to a concentration of 7.4 ppm. Fish exposed to a 1 ppm waste concentration showed marked responses in catalase and P-450 enzyme activities during exposure periods of 2 to 9 days. The changes in enzyme activity indicated physiological stresses which could lead to deterioration of the metabolic system should such stress continue for a long period of time.

The field experiment revealed increased P-450 enzyme activity in test organisms, which indicated a stress response to environmental conditions. However, when returned to the laboratory and placed in clean water for several days, enzyme activity returned to levels exhibited in control organisms. It was concluded that observed effects were local and temporary, presenting no unacceptable threat to the nekton (TerEco, unpublished).

BENTHOS

Water depths encountered at the proposed Incineration Site minimize potential adverse impacts on benthic organisms at the site, due to water stratification and high dilution factors which dissipate contaminant levels. However, potential downstream accumulation should be studied in shallow-water organisms of the Continental Shelf during monitoring programs.

BIRDS

The welfare of marine bird life must be considered because emissions into the atmosphere may produce avian physiological responses, or otherwise affect migratory patterns adversely.

The designation of a North Atlantic Incineration Site will create the greatest potential effects on two groups of birds: seasonally migratory and pelagic (open-ocean) birds. All birds can be directly affected by short-term atmospheric contamination, primarily by HCl, or be indirectly affected by consumption of organisms which have assimilated waste residues, thus affecting the food chain adversely.

Broad migratory routes exist throughout this region of the north Atlantic Ocean (Williams and Williams, 1978a; Williams et al., 1977; and McClintock and Williams, 1978). As many as 100 million birds may leave North America during autumnal migrations (September and October) for the Caribbean Islands or South America (Figure A-12). Migrations may cover extremely long distances (up to 3,000 km) sometimes including 4 days of nonstop flight, and appear to be associated with the passage of northwesterlies. A return migration over the Gulf of Mexico occurs during spring (April and May).

Migration altitudes of 2,000m are frequently observed over oceanic regions and occasional 5,000m altitudes have been detected by radar observations near the Bahamas (Williams and Williams, 1978b). Radar observations indicate that birds migrating to South America slowly gain altitude after leaving the coastal U.S., reach maximal altitudes over the Bahama and Caribbean Islands, and then begin to descend during approaches to South America. Migration altitudes near the proposed site are known to be less than 2,000m and the greatest numbers of birds appear in the first 1,000m of altitude (T. Williams, personal communication)*.

*Dr. Timothy Williams, Professor of Ornithology, Swarthmore College, Swarthmore, Pennsylvania.

During migration through the area, birds may be affected by short-term atmospheric contamination near the vessel when the emission plume diffuses into the atmosphere. The problem will be most pronounced during periods of intense autumnal migration. Migrating birds have been observed to seek refuge on any available platform, including ships, during periods of adverse flying conditions, at times congregating by the thousands (T. Williams, personal communication). Under such conditions great numbers of birds may fly around or land on the vessel numerous times, repeatedly passing through the emission plume. The birds breathe at the same rate as a man running a 4-minute mile. They may be sensitive to the heavy HCl emissions; consequently, any respiratory injuries suffered from fumes may prove fatal sometime during the remainder of the migratory flight.

No studies have yet been performed to determine the effects of incinerated waste plume constituents on migrating birds, thus no conclusion can be made with respect to possible adverse effects. However, an estimate of the cross-sectional distance of migration flyway affected by the incineration exhaust plume is possible. This estimate demonstrates the small likelihood of affecting birds during migration. Figure A-12 shows the overall area utilized by migrating birds, which includes the area between Wallops Island, New Jersey and Cape Cod, Massachusetts, a distance of about 1,065 km.

The diagonal distance across the proposed Incineration Site is 50 nmi (95 km), or about 9% of the total flyway cross-section. The plume dispersion distance necessary to produce a 50% reduction in the predicted plume concentration at sea level is about 8 nmi (14 km), or 1.3% of the flyway width. A group of migrating birds departing the continent must therefore fly through a very narrow window of affected atmosphere to encounter atmospheric HCl concentrations between 2.9 and 1.5 ppm. It is anticipated that atmospheric concentrations will diminish with altitude, further reducing the potential effect of HCl.

Direct adverse effects may result in pelagic birds that follow the vessel. During incineration operations these birds may be exposed to high concentrations of HCl near the vessel, which could injure respiratory tracts, exposed soft tissues such as eyes, or feathers. It is not known if affected birds would exhibit an avoidance response.

A study reported by Shain and Lieder (1974) determined that HCl concentrations of about 4,000 ppm for 30 minutes result in death to pigeons, rabbits, and guinea pigs. Whereas exposure to concentrations of 100 ppm for 6 hours per day for 50 days produced only slight unrest and irritation to soft tissues such as eyes and nose. Comparatively, the concentration of HCl emitted from the incinerator stack will decrease from approximately 60,000 ppm at the stack, to approximately 2,000 ppm within 15 to 30m from the stack (Shain and Lieder, 1974). These values suggest that birds would only be adversely affected in very close proximity to the stack, and at such close distance both heat and acid could be detrimental.

Indirect effects of incineration on pelagic birds may be possible, but due to the scarcity of related information, the magnitude of this problem is presently unknown. Organisms may assimilate residual materials, subsequently transferred to avifauna, which consume such organisms, and impacts can only be resolved by monitoring surveys.

MARINE MAMMALS AND TURTLES

No data are available to determine effects of incineration residual materials on marine mammals or turtles. However, because these organisms are large (relative to fish and plankton) and generally do not linger in a single location, the likelihood of impacts from residues is remote.

SUMMARY

Information obtained during Gulf of Mexico research burns, representing the best information presently available, indicates that at-sea incineration for some industrial chemical wastes causes no unacceptable threats to marine organisms, either on a short-term or long-term basis. To provide environmental acceptability of incineration, the amount of particular waste constituents (primarily metals) must be regulated and incineration operations must be closely controlled and monitored. Residual input rates to the marine environment must be maintained at levels that will ensure the environment can assimilate residues without stresses on endemic organisms for sustained

periods. Water quality at the site must be maintained, taking into consideration the initial mixing period permitted by EPA's regulations. The criteria can be maintained by regulating shipboard waste substance concentrations, which will in turn limit quantities of waste residues introduced to the environment and/or regulate waste burn-flow rates to increase incinerator residence time and ensure minimum combustion efficiencies of 99.9%.

At-sea incineration is an emerging disposal technology; therefore, certain specific potential impacts must be further examined to establish fully the acceptability of this practice. Questions which remain unanswered but can be resolved during monitoring efforts are:

1. How do repeated exposures to toxic residues in the water affect the various biological communities?

2. What are the effects on planktonic organisms due to prolonged adverse exposures when such organisms must drift with a polluted water mass which maintains its integrity for relatively long periods (e.g., anticyclonic eddies)?

3. What effects will stack emissions have on pelagic and migratory birds?

ACCIDENTIAL SPILL OR LEAKAGE

The most significant potential hazard is an accidental spill or leakage of raw waste. Such occurrences, dependent on quantity and location, cause considerable adverse economic and environmental consequences. If an accident occurred near coastal recreational or commercial activities, a serious public health hazard could result. In the immediate vicinity of any future accident in the site or elsewhere, considerable biomass would probably be destroyed. Clean-up would be difficult and expensive, if possible at all. Effects of contamination could be widespread and possibly long-lasting.

Acute toxic responses were observed in 50% of fish exposed to Shell Chemical Company organochlorine waste in 41 hours, using concentrations of 74 ppm during laboratory studies (TerEco, unpublished). A concentration of 1.0 ppm produced a marked decrease in P-450 enzyme activity, indicating physiological stress. Heavy concentrations of organochlorine wastes would affect wide areas or volumes if a large spill occurred in shallow nearshore water, and sediments would also be affected. It should be noted that waste compounds, other than those described but acceptable for incineration, could present more or less of an environmental hazard, dependent on the constituents of the load.

An accidental spill in the vicinity of the designated site could have severe environmental effects; however, dilution afforded by deep water and lower productivities of flora and fauna in the region would reduce the effects of the short-term acute impacts. The remoteness of the proposed site from commercial fishing would reduce potential hazards to fisheries, but some temporary effect could be anticipated downstream. Sublethal effects may be more widespread, but possibly less severe than near shore, due to increased dispersion and dilution which would occur in the deepwater gyre. Cleanup would be either impractical, impossible, or both.

A National Oil and Hazardous Substances Pollution Contingency Plan (National Plan), 40 CFR 1510, as amended, has been prepared and implemented for coordination for Federal cleanup efforts in order to minimize environmental damage from oil and hazardous substances discharges. The National Plan is designed to protect all navigable waters of the United States and adjoining shorelines.

IMPACTS ON LAND USE AND LAND-USE TRENDS

No significant adverse impacts on existing land use or future trends will occur as a result of incineration activities. No additional land will be required for the project, since existing port facilities are adequate for storage and loading operations.

ECONOMIC IMPACT

The economic consequences of at-sea incineration were analyzed by Halebsky (1978). It was concluded that incineration is economically feasible, taking into consideration the outfitting of U.S.-owned-and-operated ships. However, the estimates are based on larger tonnages of wastes handled per shipload (12,000 tonnes), and burned at 3 to 4 times the M/T VULCANUS burn rate of 20 to 25 tonne/hr. Environmental consequences are based on a burn rate of 22 tonne/hr. Water quality criteria for organohalogen residues are obtainable at a maximal burn rate of 20 to 25 tonne/hr. Increasing these inputs by a factor of 4 must be considered environmentally unacceptable at present (1980). Future monitoring may show residue input rates can be increased without endangering the marine environment but evidence is not presently available. Thus, costs may be at least 4 times greater than Halebsky (1978) estimated for a U.S.-owned-and-operated incinerator vessel.

A study prepared by the U.S. Department of State and EPA (1979) concluded that the economic consequences of at-sea incineration would be minimal if existing foreign-owned vessels and existing U.S. loading facilities were used.

Neither the incineration operation nor use of the proposed Incineration Site will have any detectable economic impacts on any commercial activities (e.g., fishing or oil and gas production) over the Continental Shelf, because the nearest of these activities are 30 nmi (55 km) west of the proposed site. However, foreign fishing may occur in the outer portions of fishing areas 2 and 4 (Figure 3-3). Future oil exploration and development may occur in lease tract areas within 11 miles of the northwest corner of the proposed site.

UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS AND MITIGATING MEASURES

DETERIORATION OF AIR QUALITY

Local adverse impacts on air quality, as a result of the incineration process, are unavoidable when no stack emission scrubbing devices are used.

Affects will thus exist due to HCl, trace metals, unburned organochlorines, CO, CO_2, and Cl_2.

At 99.9% combustion efficiency and 99.99% destruction efficiency, organochlorine emissions (2.2 kg/hr) are insignificant in relation to the amount destroyed. Trace metal emissions are dependent on initial concentrations in the wastes. Other emissions (HCl, CO_2, H_2O) will approach maximal obtainable concentrations (e.g., HCl 16,000 kg/hr).

Research burns demonstrate that potential hazards of atmospheric acid (HCl) are rapidly diminished by atmospheric diffusion, and the acid is rapidly neutralized in seawater. Monitoring has shown that beyond 2 to 4 nmi (3.7 to 7.4 km) downwind of the emission source, any HCl remaining in the air disperses rapidly to ambient concentrations. The atmosphere is not the ultimate sink of emitted contaminants; therefore, adverse atmospheric effects will be short term.

To mitigate adverse atmospheric impacts on ship personnel caused by HCl, trace metals, and organochlorines, residues must be reduced at the source (requiring expensive stack emission scrubbing equipment); otherwise, effects and benefits of atmospheric dispersion must be maximized. Studies show that orientation of the incinerator vessel relative to prevailing winds is an important factor; therefore, requirements must be established through permit conditions to make optimal use of the atmospheric dispersion phenomena created by vessel orientation. During studies in the Gulf of Mexico a minimum wind velocity of 10 kn was required over the exhaust stacks. This requirement ensured exhaust gases did not cause impingement of the vessel when ambient wind conditions were insufficient to transport gases away from the vessel and operating personnel.

Paige et al. (1978) present results of ship orientation studies in order to determine the best vessel headings affording the least plume impingement on the vessel. It was found that a heading closer than 50° to the wind causes the plume to envelop the vessel. However, taking the wind more directly abeam (from port or starboard) causes the plume to move away from the vessel and over the sea surface. Figure 4-1 illustrates the relative headings would minimize atmospheric impacts due to plume impingement on the vessel.

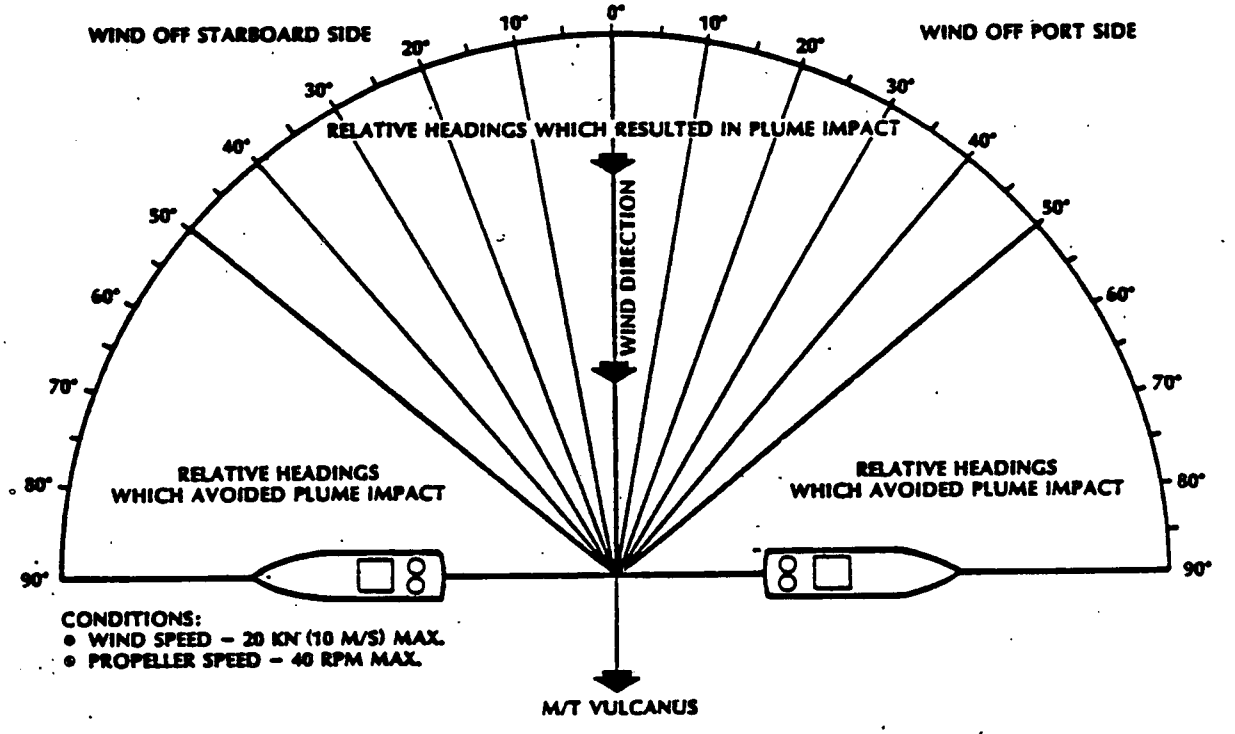

Figure 4-1. Ship Headings Relative to Wind Direction Which Avoid Plume Impact on Ship

DETERIORATION OF WATER QUALITY

After initial mixing in the atmosphere, substances will begin to settle on the water surface. Acid residue will be neutralized rapidly by the natural buffering capacity of seawater. Organochlorine and trace metal residues will be further diluted and dispersed by ocean currents. Chloride, a major constituent of seawater, will be assimilated readily by seawater.

In order to reduce contaminant inputs, emissions can be minimized at the source. Again, this would require stack emission scrubbing devices. As an alternative to scrubbing, dispersion phenomena can be used effectively to mitigate short-term adverse effects.

Air quality impact will affect water quality impact. Thus, short-term water quality impacts can be minimized by vessel orientation. Paige et al.

(1978) concluded that the following orientations of the vessel's heading relative to the wind help to reduce water quality impacts. Plume touchdowns near the vessel increase severity of water quality impacts in the following order:

(1) Moving at 90° to wind
(2) Steering directly into wind
(3) Drifting broadside

Plume touchdowns far from the vessel increase water quality impacts in the same order as above.

The present uncertainty of long-term adverse impacts requires that close monitoring be maintained to determine such effects.

EFFECTS ON MARINE ORGANISMS

Research burns reported in documents by TerEco (1975; unpublished) and Wastler et al. (1975) have demonstrated no observable significant short-term or predictable long-term adverse impacts on marine organisms. However, it is conceivable that some long-term effects may be observed when more effective field monitoring techniques are developed, and when better data are collected.

ACCIDENTAL SPILLAGE OR LEAKAGE

Immediate mitigating measures can best be directed towards prevention of accidental spills or emergency discharges. The possibility of severe environmental and economic damage exists as a consequence of such occurrences. The incinerator vessel might be involved in a collision with another vessel, or encounter adverse weather conditions which could jeopardize the safety of ship personnel or the vessel itself. Records maintained by the USCG during fiscal years 1974 through 1978 show that collisions are most likely to occur in harbor areas, and fewer collisions are likely to occur at sea. At sea 34% of all ship damage was due to adverse weather.

Weather conditions in the vicinity of the proposed Incineration Site may occasionally hinder vessel operations. The most severe weather conditions normally occur from November until March. Tropical storms and hurricanes can be anticipated occasionally in the vicinity of the proposed Incineration Site during summer months; however, hurricanes are predictable and measures can be taken to secure the safety of the vessel.

USCG regulations for vessel construction and operation will ensure maximal protection against loss of ship or cargo due to collision or other mishap. In addition, EPA will require a "Notice to Mariners" to be published as a radio warning to other vessels when the Incineration Site is in use. Augmentation of recent Vessel Traffic System policies, authorized under the Ports and Waterways Safety Act, will further enhance transportation and safety of hazardous material.

INTERFERENCE WITH OTHER ACTIVITIES AT THE PROPOSED INCINERATION SITE

SHIPPING

The northern boundary of the proposed Incineration Site is 40 nmi (74 km) south of the nearest shipping lane (Ambrose-Hudson Canyon Traffic Lane). New York Harbor experiences heavy shipping traffic, but the proposed site is in an area where no extraordinary traffic transits.

All waste disposal activities at the 106-Mile Ocean Waste Disposal Site must be within prescribed areas, thereby causing no danger to incineration activities.

COMMERCIAL FISHING

The proposed site is seaward of the Continental Shelf and contiguous fishing activities. It is highly unlikely that incineration will interfere with commercial fishing activities over the Continental Shelf.

RECREATIONAL ACTIVITIES

Due to the extreme distance from shore, it is improbable that small craft or recreational boats will visit the proposed site. However, during summer months small boat operators are known to transit deep water in search of game fish. Should any craft approach, the incinerator vessel must be reoriented downwind of any passing vessel.

OIL AND GAS EXPLORATION AND DEVELOPMENT

Exploration for oil and gas is continuing to progress along the Continental Slope in the mid-Atlantic Bight region. Areas of new lease may soon become available for exploration and possible production. The nearest single (future) lease tract is approximately 13 nmi west of the proposed site's northwestern corner, indicating that any plume will originate at a greater distance than 13 nmi. It can be assumed that the plume will never originate this close to lease areas because a vessel will be operated more internally to the site. For tracts farther south the distance to the western boundry increases progressively, so that the southwestern corner is approximately 60 nmi away.

The distance provided by the separation of lease tracts and the proposed site will allow extensive atmospheric dilution of incineration residues, which would be transported to the west during periods of onshore winds. It is possible that in the northern area of the site a plume could originate as far as 50 nmi east of the nearest potential lease tract, and in the southern region as far as 80 nmi.

Using the dispersion model of Paige et al. (1978), potential sea level concentrations of residues can be predicted. Assuming that the maximum sea level concentrations (100%) occurs 4,000m (2.2 nmi) downwind from the incineration vessel, from a centerline point of the site, the plume must travel 34 nmi before contact with the nearest lease tract. In the distance traveled the plume concentration will be diluted to 3% of the original 100% maximum concentration at 4,000m downwind from the vessel. The equivalent

atmospheric residue concentrations would be: HCl, 133 $\mu g/m^3$ (0.09 ppm); unburned wastes, 0.08 $\mu g/m^3$ (0.014 ppb as trichloroethane); copper 0.007 $\mu g/m^3$ (0.001 ppb).

RELATIONSHIP BETWEEN SHORT-TERM USES OF THE SITE AND LONG-TERM PRODUCTIVITY

During the limited use of the Gulf of Mexico Incineration Site, studies showed that no significant short-term (acute) damage was caused by incineration activity. However, the long-term (chronic) effects require a better understanding of ecological processes which operate under any induced stresses. Therefore, monitoring programs designed to detect subtle environmental changes before unacceptable environmental imbalances occur, must be devised and performed.

It should be noted that the 106-Mile Ocean Waste Disposal Site, immediately north of the proposed Incineration Site, receives great volumes of barged wastes containing metals, yet, after 18 years of use, still shows no evidence of having affected the long-term productivity of the area.

IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

Several resources will be committed irreversibly or irretrievably when the proposed action takes place:

- Energy will be lost in the form of fuel required to transport wastes to and from the site and used to raise the incinerator temperature to operating levels.

- Constituents in the waste (e.g., trace metals and organic chemicals) will be lost because present technology is not capable of recovery or reuse in an economical manner.

Chapter 5

COORDINATION

PREPARERS OF THE DRAFT EIS

Preparation of this EIS was a joint effort employing many members of the Interstate Electronics Corporation scientific and technical staff. This chapter summarizes the background and qualifications of the primary contributors to the document (see Table 5-1).

The principal author wishes to thank other people who assembled background information and wrote or critiqued sections of the EIS. The document has benefited greatly from their assistance.

TABLE 5-1. LIST OF PREPARERS

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COMMENTERS ON THE DRAFT EIS

The following persons submitted written comments on the DEIS. The letters and responses are in Appendix F.

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1	Boyd T. Duffie, III, Lt Col, USAF Director of Environmental Planning Department of the Air Force Headquarters Air Force Engineering and Services Center Tyndall Air Force Base, Florida 32403 (29 January 1981)
2	Neil Stuart Acting Chief, Planning Division Department of the Army North Atlantic Division Corps of Engineers 90 Church Street New York, New York 10007 (13 February 1981)
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4	Charles A. Burroughs United States Department of Commerce National Oceanic and Atmospheric Administration Environmental Data and Information Service Center for Environmental Assessment Services Washington, DC 20235 (29 January 1981)
5	Robert B. Rollins United States Department of Commerce National Oceanic and Atmospheric Administration National Ocean Survey Rockville, Maryland 20852 (27 January 1981)

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7	Cecil S. Hoffmann Special Assistant to Assistant Secretary United States Department of the Interior Office of the Secretary Washington, DC 20240 (23 February 1981)
8	Donald R. King Director Office of Environment and Health Department of State Washington, DC 20520 (9 February 1981)
9	David S. Hugg, III Acting Director State of Delaware Executive Department Office of Management Budget and Planning Dover, Delaware 19901 (4 March 1981)
10	James W. McConnaughhay Director, State Clearinghouse Maryland Department of State Planning 301 West Preston Street Baltimore, Maryland 21201 (2 March 1981)
11	Lawrence Schmidt, Chief Office of Environmental Review State of New Jersey Department of Environmental Protection Office of the Commissioner Post Office Box 990 Trenton, New Jersey 08625 (25 March 1981)

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14	D.C. Le Van Chief Geologist Commonwealth of Virginia Department of Conservation and Economic Development Division of Mineral Resources Natural Resources Building Box 3667, McCormick Road Charlottesville, Virginia 22903 (27 January 1981)
15	Edward F. Wilson Commonwealth of Virginia Office of the Secretary of Commerce and Resources Outer Continental Shelf Activities 509 Ninth Street Office Building Richmond, Virginia 23219 (20 January 1981)
16	Raymond E. Bowles, P.E. Director Bureau of Surveillance and Field Studies Commonwealth of Virginia State Water Control Board Post Office Box 11143 2111 Hamilton Street Richmond, Virginia 23230 (5 February 1981)
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Michael S. Moyer
Christopher S. Zarba

Chapter 6

GLOSSARY AND REFERENCES

ABUNDANCE — The number of individuals of a species inhabiting a given area. Normally, a community of several component species will inhabit an area. Measuring the abundance of each species is one way of estimating the comparative importance of each component species.

ABYSSAL PLAINS — Flat areas of the ocean floor extending from the base of the Continental Rise seaward to the abyssal hills.

ACUTE EFFECT — The death or incapacitation of an organism caused by a substance within a short time (normally 96 hours).

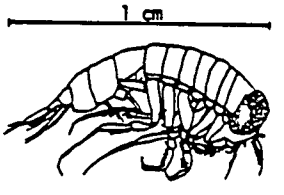
ADSORB — To adhere in an extremely thin layer of molecules to the surface of a solid or liquid.

ALIPHATIC HYDROCARBON — An organic compound composed of carbon and hydrogen, and characterized by a straight chain of carbon atoms.

ALKALINITY — The number of milliequivalents of hydrogen ions neutralized by one liter of seawater at 20°C. Alkalinity of water is often taken as an indicator of its carbonate, bicarbonate, and hydroxide content.

AMBIENT — Pertaining to the undisturbed or unaffected conditions of an environment.

AMPHIPODA — An order of crustaceans (primarily marine) with laterally compressed bodies, which generally appear similar to shrimp. The order consists primarily of three groups: hyperiideans, which inhabit open ocean areas; gammarideans, which are primarily bottom dwellers; and caprellideans, common fouling organisms.



ANTICYCLONIC EDDIES — Approximately circular oceanic current patterns, having relatively less dense (warmer) water in the centers. Rotation around these centers is clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere. Examples of these formations are Gulf Stream meanders.

APEX — See New York Bight Apex.

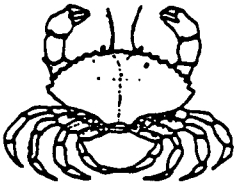
APPROPRIATE SENSITIVE MARINE ORGANISMS	Pertaining to bioassay samples required for ocean dumping permits, "at least one species each representative of phytoplankton or zooplankton, crustacean or mollusk, and fish species chosen from among the most sensitive species documented in the scientific literature or accepted by EPA as being reliable test organisms to determine the anticipated impact of the wastes on the ecosystem at the disposal site" (CFR 40 §227.27).
ASSEMBLAGE	A group of organisms sharing a common habitat.
ATP	Adenosine triphosphate; an organic compound having three phosphate groups which are bound by high-energy linkages. Enzymatic breaking of these bonds releases the energy for metabolic processes in living cells.
ATPase	An enzyme which catalyzes the hydrolysis (breakdown) of ATP, releasing bound energy.
BACKGROUND LEVEL	The naturally occurring concentration of a substance within an environment which has not been affected by unnatural additions of that substance.
BASELINE CONDITIONS	The characteristics of an environment before the onset of an action which can alter that environment; any data serving as a basis for measurement of other data.
BASELINE SURVEYS AND BASELINE DATA	Surveys and the data collected prior to the initiation of actions which may alter an existing environment.
BENTHOS	All marine organisms (plant or animal) living on or in the bottom of the sea.
BIGHT	A gentle bend in a coast forming a large open bay; a bay formed by such a bend.
BIOACCUMULATION	The uptake and assimilation of materials (e.g., heavy metals) leading to elevated concentrations of the substances within organic tissue, blood, or body fluid.
BIOASSAY	A method for determining the toxicity of a substance by the effect of varying concentrations on growth or survival of suitable plants, animals or micro-organisms; the concentration which is lethal to 50% of the test organisms or causes a defined effect in 50% of the test organisms, often expressed in terms of lethal concentration (LC_{50}) or effective concentration (EC_{50}), respectively.
BIOMASS	The quantity (wet weight) of living organisms inhabiting a given area or volume at any time; often used as a means of measuring the productivity of an ecosystem.
BIOTA	Animals and plants inhabiting a given region.

BIOTIC GROUPS — Assemblages of organisms which are ecologically, structurally, or taxonomically similar.

BLOOM — A relatively high concentration of phytoplankton in a body of water resulting from rapid proliferation during a time of favorable growing conditions generated by nutrient and sunlight availability.

BOREAL — Pertaining to the northern geographic regions.

BRACHYURAN CRABS — The "true" crabs, characteristically possessing short abdomens and pinching claws (chelipeds). Most edible species, including Dungeness crabs, are of this type.



BRITISH THERMAL UNIT (BTU) — A unit of heat energy equal to 0.252 calories; the heat needed to raise the temperature of 1 pound of air-free water one Fahrenheit degree at a constant pressure of 1 standard atmosphere, at or near the point of maximal density (39.2°F).

CALCAREOUS OOZE — A fine-grained pelagic sediment containing calcium carbonate ($CaCO_3$), derived from the skeletal remains of various marine organisms, mixed with clay-sized amorphous material.

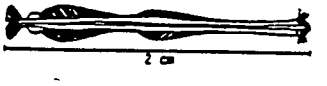
CARBON TETRACHLORIDE (CCl_4) — A widely used commercial organic solvent produced by the exhaustive chlorination of carbon disulfide or aliphatic hydrocarbons; also a by-product of a chlorinated hydrocarbon reclamation process.

CARCINOGEN — A substance or agent producing a cancer or other type of malignancy.

CATALASE — An enzyme which catalyzes the decomposition of hydrogen peroxide into oxygen and water.

CEPHALOPODS — Exclusively marine animals constituting the most highly evolved class of the phylum Mollusca (e.g., squid, octopus, and Nautilus).

CHAETOGNATHA — A phylum of small planktonic, transparent, wormlike invertebrates known as arrow-worms; they are often used as water mass tracers.



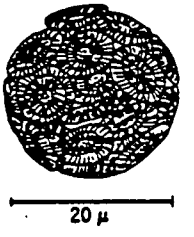
CHLORINITY — The quantity of chlorine equivalent to the quantity of halogens contained in 1 kg of seawater; may be used to determine seawater salinity and density.

CHLOROPHYLL *a* — A specific chlorophyll pigment characteristic of higher plants and algae; frequently used as a measure of phytoplankton biomass.

CHLOROPHYLLS — A group of oil-soluble, green plant pigments which function as photoreceptors of light energy for photosynthesis and primary productivity.

CHRONIC EFFECT — A sublethal effect of a substance on an organism which reduces the survivorship of that organism over a long period of time.

COCCOLITHOPHORIDS — Microscopic, planktonic unicellular, golden-brown algae characterized by an envelope of interlocking calcareous plates.



COELENTERATA — A large diverse phylum of primarily marine animals, members possessing two cell layers and an incomplete digestive system, the opening of which is usually surrounded by tentacles. This group includes hydroids, jellyfish, corals and anemones.

COMBUSTION EFFICIENCY — The ratio of heat actually developed in a combustion process to the heat that would be released if combustion were perfect; a parameter used to describe the efficiency of organic waste destruction using measurements of CO and CO_2 concentration in the hot gases leaving the combustion chamber; expressed as:

$$CE\ (\%) = \frac{[CO_2] - [CO]}{[CO_2]} \times 100$$

COMPENSATION DEPTH — The depth at which photosynthetic oxygen production equals oxygen consumed by plant respiration; the lower part of the photic zone.

CONTINENTAL MARGIN — A zone separating the emergent continents from the deep-sea bottom; generally consists of the Continental Slope, Continental Shelf and Continental Rise (see ABYSSAL HILLS illustration).

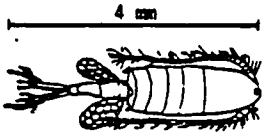
CONTINENTAL RISE A gentle slope with a generally smooth surface between the Continental Slope and the deep ocean floor.

CONTINENTAL SHELF That part of the Continental Margin adjacent to a continent extending from the low water line to a depth, generally 200m, where the Continental Shelf and the Continental Slope join.

CONTINENTAL SLOPE That part of the Continental Margin consisting of the declivity from the edge of the Continental Shelf down to the Continental Rise.

CONTOUR LINE A line on a chart connecting points of equal elevation above or below a reference plane, usually mean sea level.

COPEPODS A large diverse group of small planktonic crustaceans representing an important link in oceanic food chains.



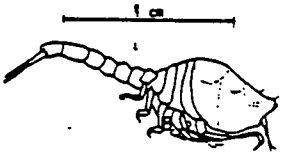
CORIOLIS FORCE An apparent force of the earth, acting on a body in motion and, due to rotation, causing circular deflection to the right in the northern hemisphere and to the left in the southern hemisphere.

CRETACEOUS The last period of the Mesozoic Era or the corresponding system of rocks; between 136 and 65 million years ago.

CRUSTACEA A class of arthropods consisting of animals with jointed appendages and segmented exoskeletons composed of chitin. This class includes barnacles, crabs, shrimps and lobsters.

CTENOPHORA An animal phylum, superficially resembling jellyfish, ranging in size from less than 2 cm to about 1m in length. Commonly known as "sea walnuts" or "comb jellies", these animals prey heavily on planktonic organisms, particularly crustaceans and fish larvae.

CUMACEANS Small motile crustaceans which usually inhabit the surface layers of sediment, although some species exhibit diurnal vertical migrations in the water column; their presence is often indicative of unstable sediment conditions.



CURRENT DROGUE A surficial current measuring assembly consisting of a weighted current cross, underwater sail or parachute and an attached surface buoy; it moves with the current so that average current velocity and direction can be obtained.

CURRENT METER An instrument for measuring the speed of a current, and often the direction of flow.

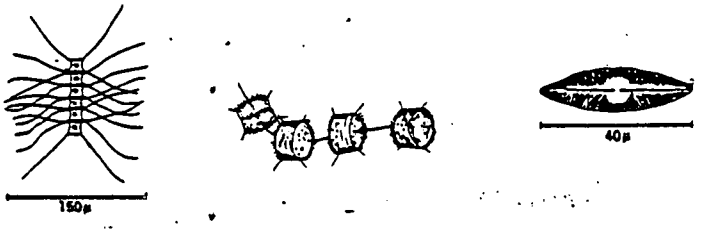
DECAPODA The largest order of crustaceans; members have five sets of locomotor appendages, each joined to a segment of the thorax; includes crabs, lobsters, and shrimps.

DEMERSAL Living at or near the bottom of the sea.

DENSITY The mass per unit volume of a substance, usually expressed in grams per cubic centimeter (1g water in reference to a volume of 1 cc @ 4°C).

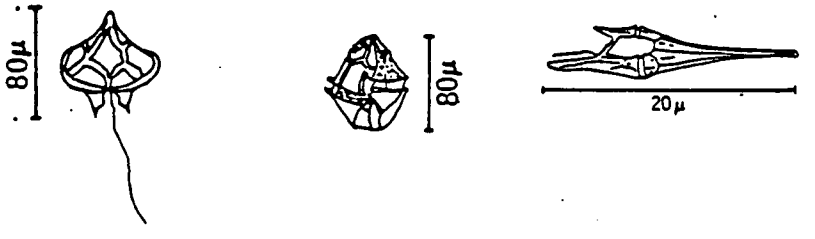
DETRITUS Product of decomposition or disintegration; dead organisms and fecal material.

DIATOMS Microscopic phytoplankton characterized by a cell wall of overlapping silica plates. Sediment and water column populations vary widely in response to changes in environmental conditions.



DIFFUSION Transfer of material (e.g., salt) or a property (e.g., temperature) under the influence of a concentration gradient; the net movement is from an area of higher concentration to an area of lower concentration.

DINOFLAGELLATES A large diverse group of flagellated phytoplankton with or without a rigid outer shell, some of which feed on particulate matter. Some members of this group are responsible for toxic red-tides.



DISCHARGE PLUME	The region of water affected by a discharge of waste which can be distinguished from the surrounding water.
DISPERSION	The dissemination of discharged matter over large areas by natural processes, e.g., currents.
DISSOLVED OXYGEN	The quantity of oxygen (expressed in mg/liter, ml/liter or parts per million) dissolved in a unit volume of water. Dissolved oxygen (DO) is a key parameter in the assessment of water quality.
DIVERSITY (Species)	A statistical concept which generally combines the measure of the total number of species in a given environment and the number of individuals of each species. Species diversity is high when it is difficult to predict the species or the importance of a randomly chosen individual organism, and low when an accurate prediction can be made.
DOMINANT SPECIES	A species or group of species which, because of their abundance, size, or control of the energy flow, strongly affect a community.
DRY WEIGHT	The weight of a sample of material or organisms after all water has been removed; a measure of biomass, when applied to organisms.
EC_{50}	Effective Concentration -50; Pertaining to bioassay studies, the concentration of a substance which causes a defined effect in 50% of the test organisms (usually phytoplankton) within a given period of time (often 96 hours).
ECHINODERMS	Exclusively marine animals which are distinguished by radial symmetry, internal skeletons of calcareous plates, and water-vascular systems which serve the needs of locomotion, respiration, nutrition, or perception; includes starfishes, sea urchins, sea cucumbers and sand dollars.
ECOSYSTEM	The organisms in a community together with their physical and chemical environments.
EDDY	A circular mass of water within a larger water mass which is usually formed where currents pass obstructions, either between two adjacent currents flowing counter to each other, or along the edge of a permanent current. An eddy has a certain integrity and life history, circulating and drawing energy from a flow of larger scale.
E_h	Redox potential or oxidation-reduction potential; measurement of the state of oxidation of a system by a voltage difference at an inert electrode immersed in a reversible oxidation-reduction system. Positive values

reflect an oxidizing environment and a surplus of oxygen, whereas negative values represent a reducing environment; often indicated by the presence of hydrogen sulfide.

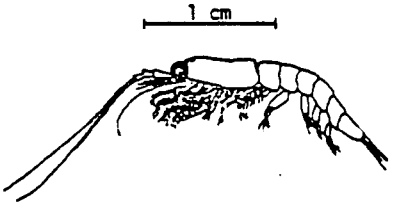
ENDEMIC — Restricted or peculiar to a locality or region.

EPIFAUNA — Animals which live on or near the bottom of the sea.

EPIPELAGIC — Of, or pertaining to, that portion of the oceanic zone into which enough light penetrates to allow photosynthesis; generally extends from the surface to about 200m.

ESTUARY — A semienclosed coastal body of water which has a free connection to the sea, commonly the lower end of a river, and within which the mixing of saline and fresh water occurs.

EUPHAUSIIDS — Shrimp-like, planktonic crustaceans which are widely distributed in oceanic and coastal waters, especially in cold waters. These organisms, also known as krill, are an important link in the oceanic food chain.

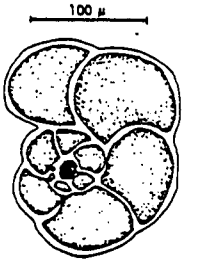


FAUNA — The animal life of any location, region, or period.

FINFISH — Term used to distinguish "normal" fish (e.g., with fins and capable of swimming) from shellfish. Usually in reference to the commercially important species.

FLORA — The plant life of any location, region, or period.

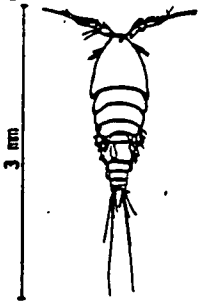
FORAMINIFERA — Benthic or planktonic single-celled marine organisms possessing a shell (usually of calcium carbonate) enclosing an ameboid body.



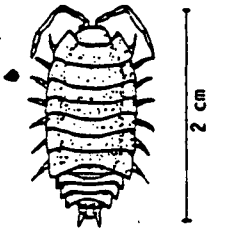
GASTROPODS — Molluscs which possess a distinct head (generally with eyes and tentacles), a broad, flat foot, and usually a spiral shell (e.g., snails).

GEOSTROPHIC CURRENT — A current resulting from the balance between gravitational forces and the Coriolis force.

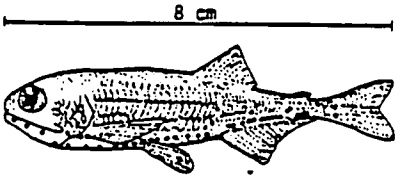
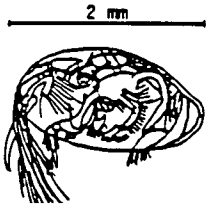
GULF STREAM	The relatively warm, swift, well-defined northward-moving ocean current, which flows up the North American East Coast. It originates where the Florida current and the Antilles current begin to curve eastward from the Continental Slope off Cape Hatteras, NC.
GYRE	A closed circulation system, usually larger than an eddy.
HARPACTICOIDS	Relatively small copepods of variable form, characterized by short antennules, with few segments and no conspicuous division of the body and tail sections; common constituents of meiofauna.
HEAVY METALS OR ELEMENTS	Metals with specific gravities of 5.0 or greater (e.g., 5 times the density of water).
HERBIVORES	Animals which feed chiefly on plants.
HISTOPATHOLOGY	The study of tissue changes characteristic of a disease.
HOLOTHURIAN	An echinoderm of the class Holothuroidea, characterized by a cylindrical body, smooth, leathery skin and feeding tentacles; includes the sea cucumbers.
HYDROCHLORIC ACID (HCl)	A solution of hydrogen chloride gas in water; primary by-product of the incineration of organochlorine compounds.
ICHTHYOPLANKTON	That portion of the planktonic mass composed of fish eggs and weakly motile fish larvae.
INDICATOR SPECIES	An organism so strictly associated with particular environmental conditions that its presence is indicative of the existence of such conditions.
INDIGENOUS	Having originated in, being produced, growing, or living naturally in a particular region or environment; native.
INFAUNA	Aquatic animals which live in the bottom sediment.
IN SITU	(Latin) in the original or natural setting (in the environment).
INVERTEBRATES	Animals lacking a backbone or internal skeleton.
ISOBATH	A line on a chart connecting points of equal depth below mean sea level.



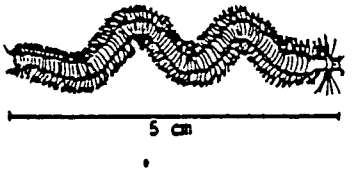
ISOPODS	Small crustaceans with flattened bodies, and reduced heads and abdomens. They are an important intermediate link in marine food chains.



ISOTHERMAL	Approximate equality of temperature throughout a geographical area.
LARVA	A young and immature form of an organism which must usually undergo one or more form and size changes before assuming characteristic features of the adult.
LC_{50}	Lethal Concentration -50; In bioassay studies, the concentration of a contaminant which causes 50 percent mortality in the population of test organisms during a unit time (usually 96 hours).
LIMITING PERMISSIBLE CONCENTRATION (LPC)	A concentration of a waste material which, after initial mixing, does not exceed marine water quality criteria, or cause acute or chronic toxicity, or other sublethal effects.
LITTORAL	Of or pertaining to the seashore, especially the regions between tide lines.
MACROZOOPLANKTON	Planktonic animals which can be recognized by the unaided eye.
MESOPELAGIC	Pertaining to depths of 200 to 1,000m below the ocean surface.
MID-ATLANTIC BIGHT	The Continental Shelf waters extending from Cape Cod, MA to Cape Hatteras, NC.
MIOCENE	A geologic epoch of the Tertiary period, extending from the end of the Oligocene to the beginning of the Pliocene; 7 to 26 million years ago.
MIXED LAYER	The upper layer of the ocean which is well mixed by wind and wave activity.
MODEL	A mathematical or physical system, obeying certain specified conditions, whose behavior is used to understand an analogous physical, biological or social system.
MOLLUSCA	A phylum of unsegmented animals most of which possess a calcareous shell; includes snails, mussels, clams, and oysters.
MONITORING	As used herein, observation of environmental effects of disposal operations through biological and chemical data collection and analyses.

MUTAGEN	A substance which increases the frequency or extent of mutations (changes in hereditary material).
MYCTOPHIDS	A group of small mesopelagic fish which possess light-emitting organs and undergo daily large-scale vertical (deep to near surface) migrations; also called lanternfish. 
NANNOPLANKTON	Minute planktonic plants and animals which are 50 u or less in size. Individuals of this size pass through most plankton nets and are, therefore, most easily collected by centrifuging water samples.
NEKTON	Free-swimming aquatic animals that move independently of water currents.
NEMATODA	A phylum of free-living and parasitic unsegmented worms; found in a wide variety of habitats.
NERITIC	Pertaining to the region of shallow water adjoining the seacoast, and extending from the low-tide mark to a depth of about 200m.
NEUSTON	Organisms that are associated with the upper 5 to 20 cm of water; mainly composed of copepods and ichthyoplankton.
NEUTRALIZE (NEUTRALIZATION)	To make a solution neutral (neither acidic nor alkaline) from an acidic or to an alkaline condition.
NEW YORK BIGHT	The Continental Shelf and overlying waters which extend from Montauk Point, Long Island, NY, to Cape May, NJ.
NEW YORK BIGHT APEX	A portion of the New York Bight bounded at the south by latitude 40°10' and at the east by longitude 73°30'.
NUISANCE SPECIES	Organisms of no commercial value, which, because of predation or competition, may be harmful to commercially important organisms.
ORGANOHALOGENS	Organic substances whose chemical constitution includes the elements carbon and hydrogen, plus a common element of the halogen family: astatine bromine, chlorine, fluorine, or iodine.
OSTRACODA	A subclass of the class Crustacea inclusive of small benthic forms with bodies completely enclosed within a round bivalve carapace; also called "seed shrimps." 

OXIDE	A binary chemical compound in which oxygen is combined with another element, metal, nonmetal, gas, or radical.
OXYGEN MINIMUM LAYER	A subsurface layer in the water column in which the concentration of dissolved oxygen is lower than in the layers above or below.
PARAMETER	Values or physical properties which describe the characteristics or behavior of a set of variables.
PCB(s)	Polychlorinated biphenyl(s); any of several chlorinated compounds having various industrial applications. PCBs are toxic pollutants which tend to accumulate in the environment.
PELAGIC	Pertaining to water of the open ocean beyond the Continental Shelf and above the abyssal zone.
PERCENT DRY WEIGHT	An expression of the concentration of a constituent in relation to its contribution (in percent) to the total weight of dried sample material.
PERTURBATION	A disturbance of a natural or regular system; any departures from an assumed steady state of a system.
pH	The acidity or alkalinity of a solution, determined by the negative logarithm of the hydrogen ion concentration (in gram-atoms per liter), ranging from 0 to 14 (lower than 7 is acid, higher than 7 is alkaline).
PHOSGENE ($COCl_2$)	A highly toxic, colorless gas which condenses to a fuming liquid at 0°C; used in the manufacture of organic compounds; also a by-product of the exhaustive chlorination reclamation process.
PHOTIC ZONE	The layer of a body of water which receives sufficient sunlight for photosynthesis.
PHYTOPLANKTON	Minute passively floating plant life in a body of water; the base of the food chain in the sea.
PLANKTON	The passively floating or weakly swimming, usually minute animal and plant life in a body of water.
PLUME	A patch of turbid water, caused by the suspension of fine particles following a disposal operation.
POLYCHAETA	The largest class of the phylum Annelida (segmented worms); benthic marine worms distinguished by paired, lateral, fleshy appendages provided with bristles (setae) on most segments.



UPWELLING	The rising of water toward the surface from subsurface layers of a body of water. Upwelled water is cooler and rich in nutrients; regions of upwelling are generally areas of rich fisheries.
VECTOR	A straight or curved line representing both direction and magnitude.
WATER MASS	A body of water, identified by its temperature-salinity values, or chemical composition, consisting of a mixture of two or more water types.
WATER TYPE	Ocean water of a specified temperature and salinity; defined as a single point on a temperature-salinity diagram.
ZOOPLANKTON	Weakly swimming animals whose distribution in the ocean is ultimately determined by current movements.

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Appendix A
ENVIRONMENTAL CHARACTERISTICS OF THE PROPOSED NORTH ATLANTIC INCINERATION SITE

CONTENTS

ILLUSTRATIONS

TABLES

Appendix A
ENVIRONMENTAL CHARACTERISTICS OF THE PROPOSED NORTH ATLANTIC INCINERATION SITE

METEOROLOGICAL CHARACTERISTICS

WINDS AND STORMS

General wind patterns of the Atlantic Coast are predominantly controlled by the position and intensity of the Bermuda-Azores High Pressure System (Figure A-1). During winter the system is centered distantly to the southeast, exerting little influence on the Bight. During this period low-pressure storm systems moving towards the south-southeast bring strong winds, with average velocities of 17 kn, and heavy rain or snow (Table A-1). In summer the influence of the high-pressure circulation creates predominantly south-southwesterly winds averaging 11 kn. This weather is characterized by warm, moist air from the Gulf of Mexico, producing showers, thunderstorms, low wind velocities, and uniformly high temperatures.

Brower (1977)* reported 45 tropical cyclones between 1899 and 1976 are recorded in the vicinity of the proposed site. These were characterized as: (a) 3 depressions, (b) 10 extratropical storms, (c) 11 tropical storms, and (d) 21 hurricanes, occurring between June and December, but mostly in late summer to early autumn, with the maximal frequencies in August.

PRECIPITATION

The amount of precipitation falling over the offshore region is uncertain, although coastal precipitation averages 100 cm/yr, and is well distributed

*See Chapter 6 for references cited in this Appendix

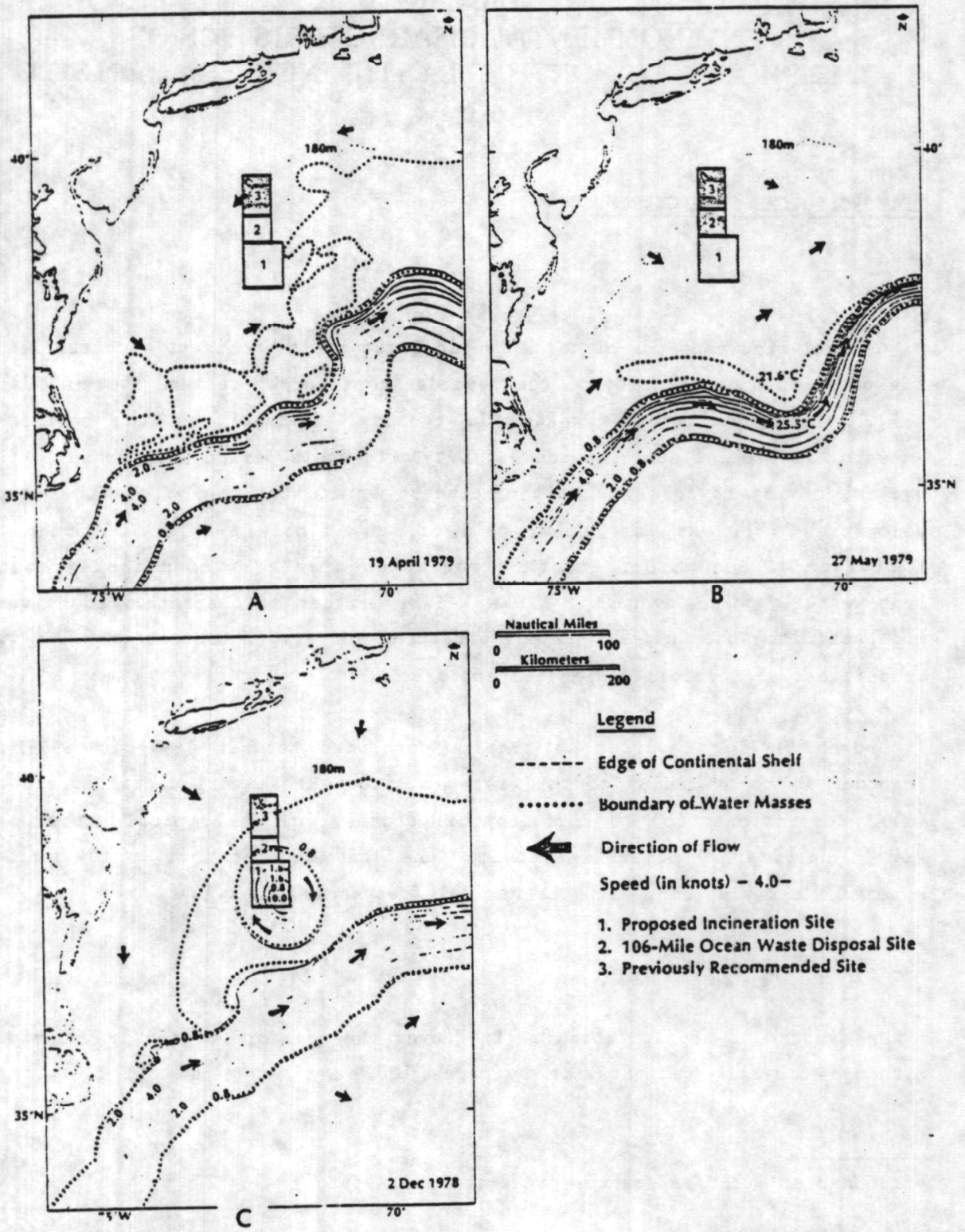

Figure A-1. Water Masses and Current Flows of Northwest Atlantic Ocean Showing Gulf Stream Meanders and Anticyclonic Eddy
Source: U.S. Coast Guard Weekly Current Charts

TABLE A-1
METEOROLOGICAL DATA FOR PROPOSED INCINERATION SITE

Month	Wind Direction (% of Time Occurring)									Mean Wind Speed	
	N	NW	W	SW	S	SE	E	NE	Calm	kn	m/s
January	18	23	17	12	10	4	4	8	4	18	9.0
February	23	22	16	10	9	3	4	8	5	19	9.5
March	17	19	15	12	13	6	4	9	5	18	9.0
April	15	12	14	14	17	5	6	10	7	15	8.5
May	13	8	10	16	17	7	8	10	11	13	6.5
June	9	6	10	19	18	8	8	10	12	12	6.0
July	7	5	9	23	21	5	6	10	14	11	5.5
August	11	6	8	18	19	7	8	12	11	11	5.5
September	16	8	7	10	11	7	12	19	10	12	6.0
October	18	16	10	9	11	6	8	14	8	15	7.5
November	18	20	16	10	10	5	5	10	6	17	8.5
December	19	23	19	11	9	3	4	7	5	18	9.0

Note: Data reported is the percent of total observations with snow or rain.

Sources: Wind direction data from NOAA (1973) for the area 35° to 40°N, 70° to 75°; all other data from Brower (1977) for 38°24' to 39°12'N, 71°48' to 72°36'W.

throughout the year (Brower, 1977). Most rainfall occurs between November and March (Table A-2) and is generally associated with widespread storms. Brief rainshowers associated with localized thunderstorm activity produce maximal rainfall with minimal frequencies in summer. Winter snowstorms produce an average of 38 to 100 cm/yr precipitation. Table A-2 presents percent frequencies of precipitation, reported by maritime vessels during passage through offshore areas.

TABLE A-2
ANNUAL PRECIPITATION

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of Observations	439	304	402	512	425	521	408	421	522	422	524	440
Percent of Precipitation	15.3	18.1	13.7	11.1	6.9	5.4	4.9	4.7	5.9	6.4	11.6	14.8
Percent of Snow	4.3	4.9	2.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.7
Percent of Precipitation with Snow	27.8	27.2	15.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	2.5	18.2

Coordinates: 38°24'N to 39°12'N, 71°48'W to 72°36'W

Source: Brower, 1977

AIR TEMPERATURE AND INVERSIONS

The proposed North Atlantic Incineration Site will be outside the mid-Atlantic Bight, seaward of the Continental Shelf, and off the Delaware-Maryland coast. The proposed and alternative sites lie within a mid-latitude zone of prevailing westerlies where the daily wind flow moves generally from west to east. Polar air dominates the region about 2 months out of the year, whereas warmer tropical Atlantic air dominates the other 10 months of the year. In general, the climate of the region can best be described as modified continental, due to the greater influence of the westward landmass, as opposed to the eastward ocean (U.S. Department of Commerce, 1977).

The marine air temperature is strongly influenced by the Atlantic Ocean. During winter months (October to March) the mean air temperature over the Bight gradually increases (from northwest to southeast) when cold northwesterly winds prevail. The warm sea surface rapidly modifies the cold continental air as much as 8°C. During summer the reverse phenomenon occurs, and air temperatures decrease from northwest to southeast.

Brower (1977) presents a detailed discussion of annual air temperatures in the vicinity of the proposed Incineration Site (Table A-3a).

TABLE A-3a
AIR TEMPERATURES, MONTHLY MEAN
(°C)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
I	5.5	3.7	5.5	7.9	12.2	18.5	22.6	23.5	20.7	16.4	11.8	7.6	13.4
II	7.0	6.4	7.5	10.5	14.1	19.6	23.5	24.0	21.6	18.3	13.5	9.2	12.4

Sources: I - Brower (1977); Southeastern Marine Area: 39°N to 40°N, 71°W to 73°W

II - Brower (1977); 106-Mile Ocean Waste Disposal Site: 38°24'N to 39°12'N, 71°48'W to 72°36'W

INVERSIONS

Atmospheric temperature inversions of marine air are generally weak and infrequent in the oceanic region of the mid-Atlantic Bight. The most frequent occurrences are observed above 1,500m (Table A-3b). Between 1,500m and 1,000m inversions of 2°C+ generally occur only during spring and summer. Below 1,000m inversions of 2°C+ occur only rarely.

Inversions can be disrupted by daily atmospheric temperature increases and wind turbulence. During daytime heating inversions less intense than maximum daily temperature increases will be broken. For this reason, only inversions of the 2°C+ category are considered significant in the region of the proposed site.

CLOUDINESS

Cloudiness over the Bight is minimal in late summer and early autumn when weather is dominated by the Bermuda High, and maximal in winter when northeasterly storms prevail. From October to March there is generally a seaward decrease of clear skies, with maximum overcasts occurring in December and January. Brower (1977) reports cloudy skies (equal to or greater than 5/8 coverage) reach a maximum of slightly more than 60% frequency of occurrence during the winter over the region of the proposed and alternative Incineration Sites (Table A-4).

TABLE A-3b
INVERSIONS

Altitude	Dec, Jan, and Feb		Mar, Apr, and May		Jun, Jul, and Aug		Sep, Oct, and Nov	
	Intensity	Frequency	Intensity	Frequency	Intensity	Frequency	Intensity	Frequency
1,500m	1	11%	1	11%	1	8%	1	11%
	2	7%	2	7%	2	3%	2	3%
	3	2%	3	3%	3	1%	3	3%
1,000m	1	4%	1	11%	1	9%	1	9%
	2	3%	2	3%	2	1%	2	1%
	3	0.5%	3	2%	3	2%		
500m	1	3%	1	4%	1	4%	1	2%
		2	1%	2	2%			
				3	1%			
50m	1	2%	1	1%	1	0.5%		0

Altitude represents the lower limit of observations

Intensity

1 = 0.0 to 0.9°C
2 = 1.0 to 1.9°C
3 = +2.0°C

Source: U.S. Navy, 1955

TABLE A-4
CLOUDINESS, MONTHLY MEAN
(% Frequency Cloud Cover ≥5/8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
I	58.5	60.7	43.8	40.5	46.6	38.4	36.2	28.2	35.1	37.8	49.7	56.6	45.2
II	61.2	63.5	50.2	44.5	39.9	35.0	32.9	29.7	34.0	39.1	51.8	60.0	45.2

Sources: I - Brower, 1977; Southeastern Marine Area: 39°N to 40°N, 72°W to 73°W

II - Brower, 1977; 106-Mile Ocean Waste Disposal Site: 38°29'N to 39°12'N, 71°48'W to 72°36'W

VISIBILITY

Reduced visibility in the vicinity of the proposed site is due mainly to advection fog and haze. Marked variation during the year is noted in the frequency of visibility of less than 2 nmi (Table A-5), with greatest values usually occurring during late spring and early summer. Dense fogs may occur during two or three consecutive mornings, but usually dissipate before noon (Brower, 1977). Reduced visibilities over Bight waters are generally infrequent.

The frequency of visibilities equal to or greater than 5 nmi range from about 80% frequency of occurrence (in late spring), to more than 90% (in autumn and winter).

TABLE A-5
VISIBILITY, MONTHLY MEAN
(Frequency Percentage <2 nmi)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
I	3.3	6.0	7.1	7.4	11.1	11.2	4.6	2.2	3.5	3.0	2.0	3.4	5.4
II	3.1	4.5	5.6	6.4	12.5	7.1	4.9	3.1	2.9	1.4	1.9	2.0	4.6

Sources: I - Brower, 1977; Southeastern Marine Area: 39°N to 40°N, 72°W to 73°W

II - Brower, 1977; 106-Mile Ocean Waste Disposal Site: 35°24'N to 39°12'N, 71°48'W to 72°36'W

RELATIVE HUMIDITY

Due to the marine influence relative humidity in the region is usually high (Table A-6). The annual mean value exceeds 81%. Summer months average slightly higher than winter months, due to the persistent southerly winds.

GEOLOGICAL CHARACTERISTICS

The proposed Incineration Site is over the Continental Rise (Figure 1-1), where water depths range from 2,400m in the northwest corner of the proposed site, to 2,900m along the east side of the site. The Continental Slope dips easterly at a grade of 4%, whereas the Continental Rise experiences an easterly dip grade of 1% (Bisagni, 1977).

Four submarine canyons incise the Continental Slope near the proposed site: Mey, Hendrickson, Toms, and Toms Middle Canyon. In addition, numerous smaller canyons exist in the Slope region west of the proposed site. The massive Hudson Canyon system (55 nmi north of the proposed site) extends from the New York Bight Apex to the edge of the Continental Slope.

The Recent Age sediments deposited on the Continental Slope and Rise are primarily silt and clay (Milliman, 1973). Most of the sand in this region is biogenic in origin, although patches of terrigenous sand occur in the axes of some canyons (Hathaway, 1971; Keller et al., 1973). The sediments on the

TABLE A-6
RELATIVE HUMIDITY, MONTHLY MEAN
(%)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
I	78.5	79.5	79.0	83.0	85.5	86.5	85.4	82.4	80.9	78.4	76.6	77.6	81.2
II	78.5	79.4	79.3	83.5	85.5	86.5	85.4	83.0	80.9	78.5	76.6	77.7	81.3

Sources: I - Brower, 1977; Southeastern Marine Area: 39°N to 40°N, 72°W to 73°W

II - Brower, 1977; 106-Mile Ocean Waste Disposal Site: 38°24'N to 39°12°N, 71°48'W to 72°36'W

tend to be olive or brown in color (Milliman, 1973), which may be caused by the high oxygen content of the Slope Water and iron staining. Calcium carbonate ($CaCO_3$) is a major component of Slope sediments, making up as much as 75% of the sediments in some areas. The carbonate grains are chiefly the tests of planktonic foraminifera, benthonic foraminifera, and echinoid plates. Coccoliths are often common components, but are seldom abundant (Milliman, 1973).

The lower Continental Slope and Rise, lying below 3,500m, have numerous current-induced features, formed by the southwestward-flowing Western Atlantic Undercurrent (Heezen, 1975). The lower Continental Slope and Rise may be thick prisms of deep-sea turbidities, clays, and slump deposits (Drake et al., 1968).

PHYSICAL CHARACTERISTICS

WATER MASSES

A water mass may be defined as a large seawater parcel having unique properties (temperature, salinity, and oxygen content) or a unique relationship between these properties. Each water mass, thus defined, is given a name qualitatively describing its location or place of origin. Water masses are produced in their source areas by either or both of two methods: (1) alteration of their temperature and/or salinity through air-sea interchange, and (2) mixing of two or more water types. After formation the water masses spread at a depth determined by their density, relative to the vertical density gradient of the surrounding water.

NOAA has characterized the physical oceanographic environment in the region of the proposed Incineration Site as being extremely complex and variable in all but the near-bottom waters (NOAA, 1977). Normally the surface layer of the site is Slope Water, which lies between fresher Shelf Water to the west and more saline Gulf Stream Water to the east. However, conditions often change periodically, allowing Shelf Water to enter the site from the west, or permitting Gulf Stream Water (in the form of southerly moving Gulf Stream eddies) to be present about 20% of the time (Figure A-1).

Shelf Waters

The waters overlying the Continental Shelf of the mid-Atlantic Bight are of three general types: Hudson River Plume Water, surface Shelf Water, and bottom Shelf water (Hollman, 1971; Bowman and Wunderlich, 1977). Hudson River Plume Water results from the combined discharge of the Hudson, Raritan, and various other rivers into the northwest corner of the Bight Apex. This low-density water floats over Shelf Waters as it moves into the Bight. During periods of high runoff, the plume may spread over large areas of the Bight, and produces large vertical and horizontal gradients of salinity. This water type persists throughout the year, but its extent and depth are highly dependent on Hudson and Raritan Rivers flows (McLaughlin et al., 1975). Generally, the plume flows southward between the New Jersey coastline and the axis of Hudson Canyon. Bowman and Wunderlich (1976) found the plume direction to be sensitive to wind stress and reversals in the residual flow. Consequently, the plume may flow eastward between the New Jersey coastline and the axis of the Hudson Canyon, or it may occasionally split and flow both eastward and southward.

With the onset of heavy river discharges in the spring, surface salinities in the Bight decrease and initially a moderate, haline-maintained (i.e., maintained by salinity differences) stratification occurs, separating the coastal waters into upper and lower layers. These two layers are the surface Shelf Water and the bottom Shelf Water. Decreasing winds and increasing insolation (solar radiation) increase the strength of the stratification and cause it to undergo a rapid transition (usually within a month) from a haline-maintained to a thermal-maintained (i.e., maintained by temperature differences) condition (Charnell and Hansen, 1974). This two-layer system becomes fully developed and reaches maximum strength by August.

Surface Shelf water is characterized by moderate salinity and high temperature. During winter water is essentially vertically homogeneous over most of the Bight Shelf. With the rapid formation of the surface Shelf Water layer during the spring, bottom waters become isolated until sufficient mixing takes place the following winter. Bigelow (1933) reported the "cool cell" (having a

temperature typically less than 10°C) of the bottom Shelf Water layer extended from south of Long Island to the opening of Chesapeake Bay, then seaward, nearly to the Shelf edge. This cold water persists even after the surface layers have reached the summer temperature maximum. Bigelow (1933) found the cool cell was surrounded on all sides by warmer water.

The upper layer of the bottom Shelf water is usually between 30 and 100m deep in the summer (Bowman and Wunderlich, 1977). Seaward near the Shelf edge strong temperature/salinity/density gradients occur, limiting large-scale mixing between the Shelf Water and the waters over the Continental Slope. The mechanism by which bottom Shelf Water is replenished is presently under study.

Slope Waters

Slope Water is a highly complex, dynamic body of water representing an area of mixing between Shelf Waters, which bound it on the north and west, and the Gulf Stream, which forms the southern boundary (Figure A-1). These boundaries (frontal zones) are not stationary, but migrate seawards and landwards when the Gulf Stream shifts its axis during meanderings.

The Gulf Stream frequently meanders in such a way that anticyclonic (clockwise) loops of current are formed. Occasionally, these loops detach and form separate entities, known as eddies (Figure A-1c). The eddies are rings of Gulf Stream Water surrounding a core of warm Sargasso Sea Water (which originates to the east of the Gulf Stream), or trapped Gulf Stream Water. Great amounts of this water may be advected to depths as great as 800 to 1,000m (NOAA, 1977). After detachment the eddies may migrate into the Slope Water region, usually in a southwesterly direction. In addition, the eddies may interact with Shelf Water, causing considerable disturbances in the water within the proposed site region. While there appears to be no seasonal pattern in the occurrence of these eddies, Bisagni (1976) found, based on the trajectories of 13 eddies between 1975 and 1976, the region of the proposed Incineration Site contained an eddy 20% of the time, which was either quasi-stationary or migrating, and capable of occupying the entire site. The eddies dissipate or are reabsorbed by the Gulf Stream, usually in the region of Cape Hatteras.

Like many deepwater oceanic regions, the water of Slope Water can be divided into three general layers: the upper or surface layer (where variability is great), the near-surface thermocline region (where temperature changes rapidly with depth), and the deep water (where seasonal variability is slight).

For Slope water in general, stratification forms in the upper water layers early in May and persists until mid or late autumn, when cooling and storm activities destroy it. A permanent thermocline is usually at a depth of 100 to 200m. During the period when the upper layers are stratified, a second, seasonal thermocline forms in the upper water layers and reduces the mixed-layer thickness from the surface to merely 30 to 40m deep. From autumn until early spring water is isothermal to the depth of the permanent thermocline.

Gulf Stream Water and Eddies

To the east of the Slope water is the Gulf Stream (Figure A-1), a moving current with core velocities 200 cm/s (3.9 kn) or greater (Von Arx, 1962). The Gulf Stream is a continuation of the Florida Current (a northward-flowing current extending from Florida to Cape Hatteras), flowing northeastward from the Continental Slope off Cape Hatteras to east of the Grand Banks. The Gulf Stream meanders throughout this region over great horizontal distances north of Cape Hatteras. Occasionally, the Gulf Stream cuts through a meander neck, much like river meander cutoffs. When the fast-moving Gulf Stream abandons its previous route, after cutting through a meander neck, it isolates a large mass of Sargasso Sea Water, which is distinctly warmer than surrounding Shelf Water and Slope Water. These warm-core eddies, or Gulf Stream rings, contain enormous energy imparted from the Gulf Stream. They continue to rotate clockwise (anticylonic) as they migrate in a southwestward direction through the Slope Water, until they either dissipate or join the Gulf Stream in the vicinity of Cape Hatteras (Fisher, 1973; Saunders, 1971). The Gulf Stream may also form cold-core (cyclonic) eddies by trapping cold water located to the north of the Gulf Stream; however, this type of eddy occurs only to the south or east of the Gulf Stream and is not to be found at the proposed Incineration

Site. It should be noted that warm-core eddies are not simply near-surface phenomena. The thermal and rotational characteristics are often manifested near the sea bottom, in water depths of thousands of meters.

CURRENT REGIMES

Well-defined circulation patterns are unknown in the surface layers of the Slope water region in which the proposed and alternative sites are located (Wright, 1976). Paucity of long-term current records, in addition to large natural variabilities, limit the usefulness of estimates of mean currents for this region. The westward-flowing Labrador Current loses its distinctiveness somewhat west of the Grand Banks. Current measurements have been made by several researchers, using neutrally-buoyant floats, parachute drogues, and moored current meters in the region of the Shelf Break and Slope, south of New England (Webster, 1969; Voorhis et al., 1976; Beardsley and Flagg, 1976). The mean currents in this area are generally of the order of 10 to 20 cm/s westward, following the bottom bathymetry. This direction is similar to the direction taken by currents over the Continental Shelf.

Wright (1976) indicated that along the northern boundary of the Slope, Slope Waters flow slowly to the southwest, following the bathymetry to Cape Hatteras, where the water mass turns and flows seaward, joining the Gulf Stream. Evidence of a slow northeastward flow along the Gulf Stream in the southern part of the Slope Water region was also found. Wright (1976) suggests the Gulf Stream and Shelf Water form a cul-de-sac near Cape Hatteras, and while some interchange of water occurs across these boundaries, most of the water entering the Slope Water region from the east probably exists along the same path.

Csanady (1979) demonstrated the presence of a deepwater counterclockwise (cyclonic) gyre system located between the Continental Shelf and Gulf Stream. This system transports as much as 10^7 m^3/s of water through the region of the proposed Incineration Site (equivalent to the volume of 500 Mississippi Rivers).

The Oceanographer of the Navy (1972) reported a mean surface current speed of 25 cm/s near the proposed Incineration Site. The direction of the flow was either east-northeast or south-southwest. No other current measurements for the region of the proposed Incineration Site have been reported.

WAVES

Brower (1977) compiled wave information for the New York Bight coastal region, the 106-Mile Ocean Waste Disposal Site, and adjacent waters. The data are taken from the MESA New York Bight Atlas Monograph 7, "Marine Climatology" (December 1976), and from other published and unpublished sources for the New York Bight and mid-Atlantic Bight. Observations for the period between 1949 and 1974 are discussed below.

In general, wave heights increase with distance from shore throughout the year and the differences in heights are smaller in summer. The average frequency of observations of hazardous waves (wave heights greater than or equal to 3.5m) is 5% to 6% from December until March. While the frequency of hazardous waves at two light stations near the New Jersey coast varies from less than 0.5% in summer to approximately 1% to 2% in winter, the frequency seaward at the proposed Incineration Site and surrounding area varies from about 1% in summer to more than 10% from November until March, with a peak of 13% in January and February (Table A-7). The frequencies tend to increase northwest to southeast across the Bight throughout the year.

The frequency of waves less than 1.5m in height follows the same pattern. Nearshore the frequency ranges from 70% in winter to 90% in summer. Offshore near the proposed Incineration Site the frequency of occurrences ranges from 35% to 40% in winter, to nearly 80% in early summer.

TEMPERATURE STRUCTURE

The waters in and around the proposed site are subject to sudden changes in temperature occurring between Shelf Water and Slope Water. Shelf water is always much colder than Slope water during winter but during the warmer months of the year peak surface temperatures of Shelf Water exceed those of Slope

TABLE A-7
MONTHLY WAVE HEIGHT FREQUENCY
FOR THE PROPOSED INCINERATION SITE REGION

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of Observations	355	243	329	392	314	382	274	290	401	337	409	377
WH 1.5m % Frequency	33.5	36.2	38.8	48.7	68.2	75.9	78.6	66.3	60.0	50.2	39.8	38.5
WH 2.5m % Frequency	70.7	68.1	75.3	82.7	90.1	95.3	95.0	97.6	89.5	80.2	79.2	78.5
WH ≥3.5m % Frequency	12.7	13.1	11.0	6.6	1.9	1.0	0.9	0.7	3.5	5.3	10.1	10.3

WH = Wave height

Source: Brower, 1977

Water. The horizontal temperature gradients between the two water masses become less marked only during periods of warming and cooling. The water masses are then best distinguished by salinity differences (Warsh, 1975a).

Warsh (1975b) summarized hydrographic information collected by USCG and the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) program. These data were taken during all seasons over an area encompassing the mid-Atlantic Bight and the Continental Slope, including a portion of the proposed Incineration Site. Monthly summaries from Marsden Square 116, subsquares 81 and 82 (Figure A-2), are discussed below. Table A-8 gives the ranges of temperatures for each subsquare. These areas, while differing in the month of minimum temperature, had the same month of maximum temperature. Surface temperatures ranged between 5.2°C (February-subsquare 82) and 25.0°C (August-subsquare 82). Figure A-3 illustrates the average monthly sea surface temperatures for each subsquare.

In the upper 50m a seasonal thermocline develops in late spring (May) and is usually present through mid-autumn (October); however, remnants of the thermocline may be present as late as November. By December the water is

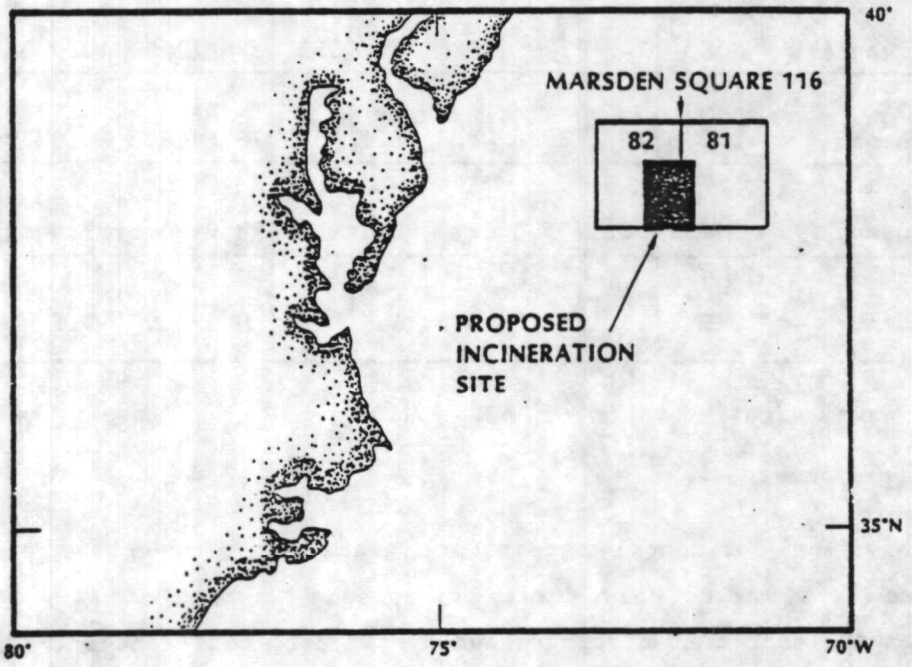

Figure A-2. Marsden Square 116; Subsquares 81 and 82 and the Proposed Incineration Site
Source: Warsh, 1975b

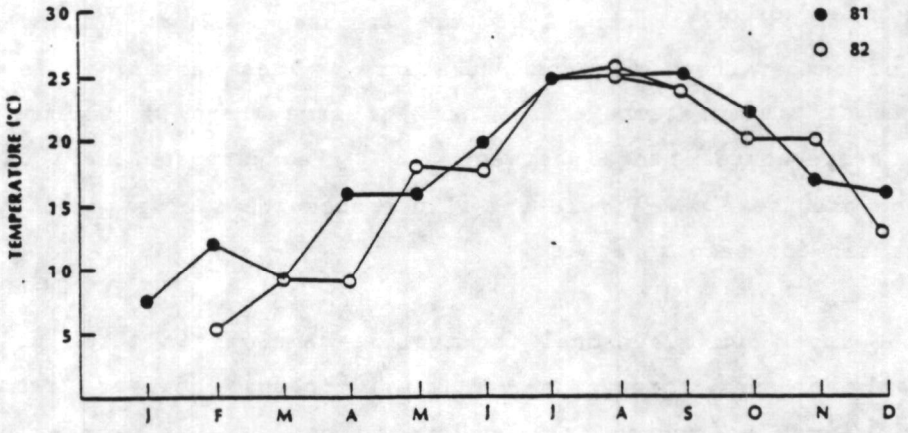

Figure A-3. Average Monthly Sea-Surface Temperatures for Subsquares 81 and 82 in Marsden Square 116
Source: Warsh, 1975b

TABLE A-8
AVERAGE SURFACE TEMPERATURE RANGES AND MONTHS OF MINIMUM AND MAXIMUM TEMPERATURES FOR SUBSQUARES 81 AND 82 IN MARSDEN SQUARE 116

Subsquare	Month of Temperature Minimum	Average Surface Temperature Range (°C)	Month of Temperature Maximum
81	January	7.8 to 24.9	August
82	February	5.2 to 25.0	August

Source: Warsh, 1975b

essentially isothermal to a depth of 100m, but temperature inversions have been observed near depths of 30m. These inversions may persist until April or May. The permanent thermocline usually occurs between 100 and 500m depths. From 500 to 1,000m depths the temperature decreases to between 4°C and 6°C, and below 1,000m depths the temperature ranges from 2°C to 4°C.

SALINITY STRUCTURE

The waters in and surrounding the proposed Incineration Site are subject to sudden changes in salinity occurring between Shelf and Slope Waters. Shelf Water is always fresher than Slope Water during winter. During the warmer months, the two water masses are best distinguished by temperature differences, but during periods of warming and cooling the water masses are best distinguished by salinity differences (Warsh, 1975b).

Warsh (1975b) found the range of surface salinity was quite variable and was dependent on the water mass present (Shelf, Slope, or Gulf Stream) within each square (Table A-9). The values ranged from 32.70 ppt in June (subsquare 82) to 35.75 ppt in April (subsquare 81). Figure A-4 illustrates the range and average monthly sea-surface salinities for each area.

Salinity generally increases to depths of 100 to 150m, where maximal salinities are encountered. Values at these depths average approximately 35.75 ppt. Salinity then decreases with depth to about 400m, where the minimum average salinity of 34.95 ppt exists. Below 400m, the water is nearly isohaline, and salinity may range between 34.90 ppt and 35.05 ppt.

TABLE A-9
AVERAGE SEA-SURFACE SALINITIES
FOR SUBSQUARES 81 AND 82 IN MARSDEN SQUARE 116

Subsquare	Month of Salinity Minimum	Average Surface Salinity Range (% or ppt)	Month of Salinity Maximum
81	January	33.05 - 35.75	April
82	June	32.70 - 35.45	November

Source: Warsh, 1975b

CHEMICAL CHARACTERISTICS

WATER CHEMISTRY

Dissolved Oxygen

Oxygen is a fundamental requirement for marine life. It is produced during photosynthesis in the photic (sunlit) zone, usually less than 100m in depth, and is used by animals, plants, and some bacteria in respiration and in the decomposition of organic matter.

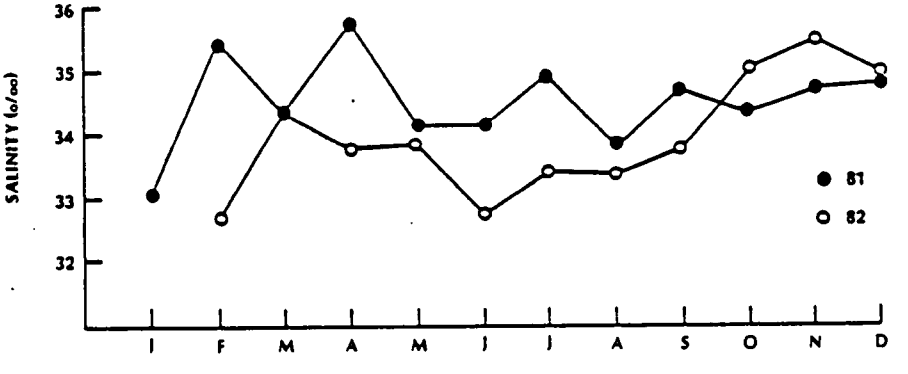

Figure A-4. Average Monthly Sea-Surface Salinities for Subsquares 81 and 82 in Marsden Square 116
Source: Warsh, 1975b

Warsh (1975b) summarized historical data for the water within and adjacent to the 106-Mile Ocean Waste Disposal Site. Within the site monthly average oxygen values at the surface range from 4.9 ml/l (approximately 104% saturation) in August to 7.5 ml/l (approximately 113% saturation) in April. The oxygen minimum zone is between 200 and 300m and the oxygen concentrations range between 2.8 ml/l (approximately 43% saturation in February) and 3.5 ml/l (approximately 57% saturation) in September. The historical data for the site show the development of a subsurface oxygen maximum zone during several months. Values varied from 7.0 ml/l at 30m during August to 8.2 ml/l at 10m during February.

Monthly average oxygen values for surface waters in the region surrounding 106-Mile Ocean Waste Disposal Site and within the proposed Incineration Site range from 4.5 ml/l (approximately 92% saturation) in October to 7.5 ml/l (approximately 106% saturation) in March. The oxygen minimum zone in waters north of the proposed Incineration Site occurs between 200 and 300m.

A baseline investigation of the 106-Mile Ocean Waste Disposal Site during May 1974 (NOAA, 1975) showed dissolved oxygen concentrations at the surface ranging from 6.94 to 4.36 ml/l. The highest values occurred in areas over the Continental Shelf and generally decreased seaward. An oxygen minimum layer occurred between 200 and 400m. Most of the values recorded for this layer were about 3.2 ml/l. The lowest value recorded for the oxygen minimum layer was 3.12 ml/l at approximately 300m. At depths below the oxygen minimum, values increased to slightly more than 6 ml/l. From 1,200m to the bottom, dissolved oxygen concentration fluctuated between 6.2 and 5.3 ml/l.

pH and Alkalinity

The pH parameter is a measure of the acidity and/or alkalinity of a solution; the pH ranges from 0 to 14, with a neutral solution having a pH of 7. Acidic solutions have pH values lower than 7, whereas basic solutions have pH values higher than 7. Surface seawater pH ranges from 7.8 to 8.6, averaging 8.2. This small range is maintained in seawater by buffering from chemical systems, such as the carbon dioxide-bicarbonate-carbonate complex.

Buffering is the ability of a substance in solution to neutralize either acids or bases while maintaining the original alkalinity of the solution. The buffering capacity or alkalinity of seawater results from the presence of acid-neutralizing bicarbonate (HCO_3^-) and carbonate ($CO_3^=$) ions. Alkalinity is important for fish and other aquatic life because it buffers pH changes occurring naturally as a result of photosynthetic activity. Components of alkalinity (carbonate and bicarbonate) have been shown to complex some toxic heavy metals and reduce their toxicity. Alkalinity is increased by the dissolution of calcium carbonate already present in seawater and that which enters by runoff. Decomposition of organic matter in seawater comsumes oxygen and produces carbon dioxide, reacting with water to form carbonic acid and lower the pH. Thus, pH and oxygen profiles in the sea generally parallel one another since the pH is lowered as the oxygen concentration decreases.

Hausknecht and Kester (1976) reported pH values for samples taken during the summer at the nearby 106-Mile Ocean Waste Disposal Site. At the surface the average pH was 7.9, while below 300m the pH decreased to an average of 7.6.

EXISTING METAL AND ORGANOHALOGEN CONCENTRATIONS

Several metals were measured in water samples taken in and around the 106-Mile Ocean Waste Disposal Site in May 1974 (Brezenski, 1975) and in February 1976 (Hausknecht, 1977). These metal concentrations are summarized in Table A-10. Compared to the range of metal concentrations reported in the literature (Table A-11), the values in the vicinity of the 106-Mile Ocean Waste Disposal Site appear to be high. Hausknecht (1977) examined these data in detail and found the distribution patterns indicated possible enrichment of heavy metals within the site relative to surrounding waters; however, the magnitude of enrichment was too great to be attributed to dumping. Moreover, observed concentration gradients did not support the hypothesis of possible enrichment from inshore waters. These incongruities, and the fact that the values were 2 to 100 times higher than those in the literature, tend to diminish the significance of the metal distributions reported therein.

TABLE A-10
SUMMARY OF SEAWATER METAL
CONCENTRATIONS AT THE 106-MILE OCEAN WASTE DISPOSAL SITE
(μg/l)

	Sample Range	Sample Average (100m)	Sample Average (100m)	Sample Average
May 1974				
Cadmium	0.05 to 0.60	0.30 ± 0.14 (40)	0.30 ± 0.14 (56)	0.30 ± 0.14 (99)
Zinc	1.60 to 21.40	7.30 ± 3.40 (40)	6.50 ± 2.70 (56)	6.80 ± 3.00 (99)
Copper	0.20 to 1.70	0.70 ± 0.40 (40)	0.70 ± 0.30 (56)	0.70 ± 0.30 (99)
Manganese	0.50 to 4.50	1.60 ± 0.40 (40)	1.30 ± 0.60 (56)	1.40 ± 0.60 (99)
Lead	0.80 to 6.10	3.30 ± 0.90 (40)	3.00 ± 1.2 (56)	3.10 ± 1.10 (99)
Mercury	0.04 to 4.00	0.71 ± 0.54 (75)	0.56 ± 0.46 (87)	0.63 ± 0.50 (163)
February 1976				
Cadmium	0.40 to 2.80	0.39 ± 0.46 (90)	0.50 ± 0.59 (56)	0.46 ± 0.54 (151)
Zinc	<0.20 to 38.00	6.60 ± 6.80 (89)	7.50 ± 8.70 (55)	6.90 ± 7.50 (148)
Copper	<0.10 to 7.00	0.30 ± 0.40 (92)	0.60 ± 1.10 (56)	0.40 ± 0.80 (148)
Manganese	<0.10 to 6.60	0.30 ± 0.30 (90)	0.40 ± 1.10 (56)	0.50 ± 1.00 (148)
Lead	<0.20 to 14.00	0.60 ± 1.60 (88)	0.60 ± 1.00 (55)	0.70 ± 1.40 (148)
Mercury	<0.09 to 0.71	0.18 ± 0.10 (91)	0.17 ± 0.16 (59)	0.17 ± 0.09 (152)

(Values given are range + standard deviation; number of samples is given in parentheses)

Sources: Brezenski, 1975; Hausknecht, 1977

TABLE A-11
RANGE OF METAL CONCENTRATIONS IN SEAWATER

Local	(µg/l) Cd	Zn	Cu
Eastern U.S. Continental Shelf	0.02-0.190 (a)	1.20-08.00 (a)	
Slope Water		3.90-10.90 (b)	2.30-2.80 (b)
Sargasso Sea	0.010 (c)	1.20-2.70 (b)	
		1.03-6.55 (d)	0.48-7.90 (d)
			0.12 (c)
Surface Waters of World Oceans			
Nearshore	0.04-0.300 (e)	0.60-12.60 (e)	0.30-3.80 (c)
Open Ocean	0.02-0.180 (e)	0.40-3.00 (e)	0.10-3.90 (e)
N.W. Atlantic	0.150 (f)		
	0.004-0.012 (g)		
Surface Water	0.008 (h)	0.002-0.011 (i)	
Subtropical North Atlantic	0.010-0.054 (j)		
Sargasso Sea		0.01 (k)	
Atlantic Near Bermuda			0.07 (l)
Nova Scotia Shelf	0.068-0.098 (m)		
Surface Waters of World Oceans			
Open Ocean	ND-0.127 (n)		

Sources:

(a) Windom and Smith (1972)
(b) Spencer and Brewer (1969)
(c) Bender and Gagner (1976)
(d) Brewer et al. (1972)
(e) Chester and Stoner (1974)
(f) Fitzgerald et al. (1974)
(g) Fitzgerald (1975)
(h) Fitzgerald and Lyons (1975)
(i) Fitzgerald and Hunt (1974)
(j) Gardner (1975)
(k) Bender et al. (1977)
(l) Chow and Patterson (1966)
(m) Cranston and Buckley (1972)
(n) Chester et al. (1973)

Hausknecht (1977) has suggested that contamination or alteration of the samples during collection, storage, or analysis may be the most logical explanation for the high concentrations and scatter observed in the metal values.

As a check against possible contamination, three stations were revisited later in 1976 (Kester et al., 1977). Special precautions were taken to minimize contamination and to separate the particulate and dissolved fractions from the total metal concentrations. The revised estimates for selected metal concentrations representing background values (i.e., not in the immediate influence of a waste dump) are shown in Table A-12. The cadmium concentrations are one order of magnitude less than those reported in the 1974 and February 1976 studies. Lead concentrations are lower than the previously reported values by a factor of 20, and copper concentrations are approximately half as high as those from the previous studies. This study by Kester et al. (1977) shows background metal concentrations at the 106-Mile Ocean Waste Disposal Site to be similar to those observed in other oceanic regions.

Metal concentrations in sediments were reported by Pearce et al. (1975) and Greig and Wenzloff (1977). These metal values are presented in Table A-13 and the approximate locations of sampling sites are depicted in Figure A-5. Metal concentrations reported for 1976 are consistent with those for 1974. Sediment metal concentrations show little variation in samples from depths greater than 180m. Although the heavy metal contents of sediments taken beyond the Continental Shelf appear to be elevated (relative to sediments on the Shelf), it is unlikely that the metal concentrations can be attributed to present disposal practices at the 106-Mile Ocean Waste Disposal Site. Pearce et al. (1975) conjectured that stations south of the Hudson Canyon could possibly be contaminated from inshore sources since contaminants could be transported down the Canyon. However, samples collected considerable distances to the north and south of the 106-Mile Ocean Waste Disposal Site exhibited metal concentrations similar to those in the dump site (Figure A-5 and Table A-13). At present there is no evidence to suggest the wastes disposed at the 106-Mile Ocean Waste Disposal Site have in any way impinged on the sediments or benthic fauna collected at sampling sites in the vicinity (Pearce et al., 1975).

TABLE A-12
MEAN CONCENTRATIONS OF SELECTED METALS IN SEAWATER SAMPLES
FROM THREE AREAS NORTH OF THE PROPOSED INCINERATION SITE (SEPTEMBER 1976)

Station No. Location	Depth Range (m)	Copper x µg/liter			Lead x µg/liter			Cadmium x µg/liter		
		Particulate	Dissolved	Total	Particulate	Dissolved	Total	Particulate	Dissolved	Total
03	100	0.041	0.28	0.321	0.018	0.09	0.108	0.0022	0.022	0.0242
38°57'N	150-200	0.032	0.22	0.252	0.023	0.09	0.113	0.0003	0.031	0.0313
71°25'W	300-800	0.033	0.15	0.183	0.017	0.05	0.067	0.0003	0.034	0.0343
06	<100	--	0.29	--	--	0.09	--	--	0.023	--
37°58'N	150-300	--	--	--	--	--	--	--	--	--
71°26'W	500-800	--	0.16	--	--	0.06	--	--	0.032	--
09	<100	0.019	0.19	0.209	0.008	0.05	0.058	0.0004	0.024*	0.034*
38°57'N	200	0.015	0.23	0.245	0.004	0.05	0.054	0.0002	0.051	0.0512
72°24'W	300-600	0.016	0.13	0.146	0.006	0.02	0.026	0.0003	0.024	0.0243

* Value questionable

Source: Kester et al., 1977

TABLE A-13
HEAVY METAL CONCENTRATIONS IN THE UPPER 4 CM OF SEDIMENTS, COLLECTED IN THE VICINITY OF THE PROPOSED INCINERATION SITE (MAY 1974 AND FEBRUARY 1976)

	Metal Concentrations, Mean ± Standard Deviation (ppm dry wt)					
	Cadmium	Chromium	Copper	Nickel	Lead	Zinc
106-Mile Ocean Waste Site						
1974	--	25.3 ± 1.9	26.8 ± 3.6	24.0 ± 3.9	27.2 ± 3.9	58.3 ± 3.8
1976	1.2 ± 0.1	23.5 ± 6.7	23.0 ± 9.9	25.5 ± 10.2	9.8 ± 3.8	46.0 ± 13.6
Proposed Incineration Site						
1974	--	26.5 ± 1.7	33.8 ± 2.6	29.8 ± 2.5	27.3 ± 2.1	56.4 ± 4.0
1976	1.4 ± 0.3	24.4 ± 3.2	25.6 ± 5.1	34.7 ± 5.5	17.8 ± 2.6	47.6 ± 9.0

* Positions of sample locations used for averaged values are shown in Figure A-5

Sources: Pearce et al., 1975; Greig and Wenzloff, 1977

Similarly, metal concentrations in marine biota were examined during the 1974 and 1976 investigations at the 106-Mile Ocean Waste Disposal Site. The concentrations of silver, cadmium, and chromium showed little variation among fish and invertebrates, compared to offshore areas in the New York Bight (Pearce et al., 1975). Copper, zinc, and lead concentrations among these same organisms showed detectable variations. Liver tissue from the deep-sea slickhead Alepocephalus agassizi had the highest concentrations of silver, cadmium, copper, and zinc. These metal concentrations are several orders of magnitude greater than metals in windowpane flounder (Scophthalmus aguosus), tissues taken from the sewage sludge and dredged material disposal sites in the Bight Apex. Liver tissues from the deep-sea grenadier Nematonurus armatus, rattail Nezumia bairdii, whiting Merluccius bilinearis, and Halosaupsis saurus macrochir exhibited metal concentrations similar to those from windowpane flounder taken in coastal waters (Pearce et al., 1975).

Greig and Wenzloff (1977) found metal concentrations in midwater fish fairly consistent in 1974, 1975, and 1976 studies. Copper concentrations were slightly higher in pelagic fish during 1976. One species, Gonostoma elongatum, had copper concentrations of 3.95 and 3.35 ppm, approximately

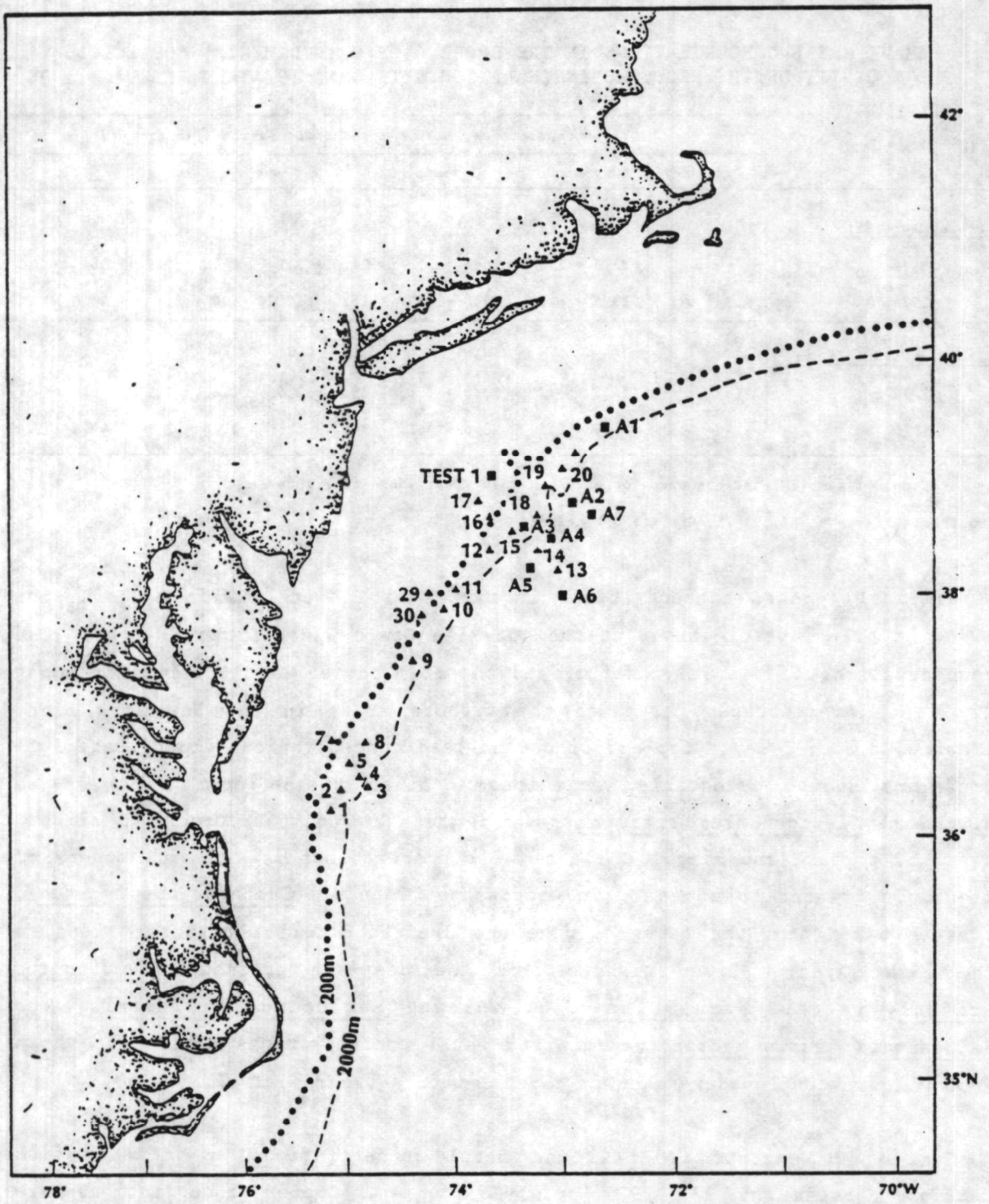

Figure A-5. Locations of Sediments Sampled for Heavy Metals in 1974 (■) and 1976 (▲) (also see Table A-13)

three times greater than in 1975. Sharks were the only species sampled in sufficient numbers for statistical comparisons between locations. No geographic differences in metal concentrations among sharks were detected. Cadmium concentrations in shark muscles were less than 0.12 ppm, and 0.28 to 7.2 ppm for the livers. Metal concentrations in muscle tissue of sharks and other fish were generally less than 1.5 ppm, and 0.5 ppm for copper and manganese, respectively. Lead was usually below the detection limit of 0.6 to 0.8 ppm. Zinc in fish muscles at 1.0 to 6.9 ppm were several orders of magnitude higher than the other metals. Mercury in fish muscles almost always exceeded the FDA limit of 0.5 ppm, except in the lancetfish, where concentrations were less than 0.23 ppm. Swordfish livers contained an unusually high concentration of cadmium, 16.1 to 26.9 ppm. Results of the extensive metal analyses on individual fish are presented in Greig and Wenzloff (1977), and are not reproduced herein.

Greig et al. (1976) determined the concentration of nine metals in four demersal fish species in three epipelagic species, and in the red crab from the vicinity of the 106-Mile Ocean Waste Disposal Site in water depths of 1,550 to 2,750m (Table A-14). The values reported were considered representative of normal ambient metal concentrations in deepwater fish. Mercury concentrations in deepwater fish muscles averaged 0.30 ppm, compared to an average of 0.154 ppm previously reported by Greig et al. (1975) in muscles of offshore Continental Shelf finfish.

At the 106-Mile Ocean Waste Disposal Site, Antimora rostrata were found to have an average mercury concentration of 0.62 ppm (Greig et al., 1976). Barber et al. (1973) found mercury concentrations in the same species ranging between 0.24 and 0.76 ppm, increasing proportionately with the length of the fish. These samples were taken southeast of Cape Hatteras, well outside the influence of any ocean disposal activities.

In the same study an A. rostrata collected in 1883 was found to contain 0.5 ppm mercury. Thus, fish collected within the 106-Mile Ocean Waste Disposal Site, well away from dumping and before dumping exhibited no apparent significance as to the variations in mercury concentrations.

TABLE A-14
METAL CONCENTRATIONS IN FISH AND CRABS COLLECTED
IN THE VICINITY OF THE 106-MILE OCEAN WASTE DISPOSAL SITE

Species	No. of Animals	ppm, Wet Weight								
		Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
1. **Antimora rostrata*	10	<0.09	21.1	<0.09	<0.52	<0.50	0.62	<0.51	<1.00	2.40
	10	0.13	4.8	0.32	<0.52	3.34	--	<0.48	<1.00	43.00
	5	0.15	--	<0.12	<0.61	<0.51	0.49	<0.51	<0.80	2.84
	5	0.12	--	<0.12	<0.61	<0.51	0.32	<0.51	<0.80	3.15
	5	0.11	--	0.36	0.59	1.96	--	<0.45	0.70	12.20
	5	0.11	--	0.33	0.57	1.86	--	<0.47	1.20	11.10
2. **Nematonurus armatus*	10	<0.10	20.0	<0.10	<0.52	<0.50	0.28	<0.60	1.00	2.90
	10	--	10.4	1.33	0.52	0.70	0.31	<0.50	<1.00	50.00
	7	<0.10	10.0	<0.10	<0.52	<0.50	<0.10	<0.50	<1.00	1.40
	7	--	--	1.21	<0.86	4.80	--	<0.82	<1.60	16.20
	4	0.11	--	<0.11	<0.53	<0.44	0.30	<0.44	<0.70	3.13
	4	0.14	--	0.14	<0.68	<0.57	0.44	<0.57	0.90	3.19
3. **Halosauropsis macrochir*	3	<0.12	--	<0.12	0.98	1.49	0.09	<0.48	<0.70	2.45
	3	0.12	--	<0.12	1.17	1.65	0.10	<0.50	0.80	2.37
4. **Synaphobranchus kaupi*	10	<0.09	8.0	0.12	<0.42	1.62	<0.15	<0.49	<1.00	6.80
5. **Geryon quinquedens*	7	<0.13	1.6	<0.10	<0.51	8.30	0.23	<0.48	<1.00	69.00
		0.43	9.1	0.81	<0.52	31.3	<0.16	<0.50	<1.00	20.20
6. *+Seriola*	6	<0.10	1.2	<0.10	<0.52	<0.63	<0.10	<0.50	<1.00	3.70
	6	0.24	--	0.24	<1.26	1.96	--	<1.20	<2.40	15.50
7. *+Hygophum hygomi*	10	<0.09	--	<0.11	<0.49	<0.47	--	<0.47	<0.95	7.40
	15	0.08	--	0.11	<0.35	0.64	--	0.74	1.00	8.50
	15	<0.07	--	0.09	<0.31	0.57	--	0.37	<0.60	7.70
	15	<0.10	--	<0.07	<0.37	0.73	--	0.53	<0.75	6.90
8. *+Stephanolepsis hispidus*	6	<0.07	--	0.14	<0.36	<0.90	--	0.48	1.00	--
	5	<0.09	1.5	<0.13	<0.52	0.89	<0.11	<0.49	<1.07	10.30

*Species regarded as bottom dwellers
+Species considered epipelagic

Source: Greig et al., 1976

Mercury concentrations were determined in muscles and livers of 41 species of fish, some plankton, invertebrates, and sediments collected from North Atlantic offshore waters in 1971 (Greig et al., 1975). The average mercury concentration for fish muscle was 0.154 ppm, while invertebrate concentrations were generally less than 0.1 ppm. Plankton and sediment samples all contained less than 0.05 ppm mercury. The highest mercury levels in fish muscles were found in cusk, spiny dogfish, northern searobin, and striped searobin. Fish livers with highest mercury contents were from blackbelly rosefish, cusk, northern searobin, and American shad. Average mercury content of livers was 0.01 ppm greater than for muscles; however, in most species examined, mercury concentrations in livers and muscles were similar.

The distribution of other contaminants has not received the attention given to metals. Greig and Wenzloff (1977) found the concentration of C_{15} and heavier hydrocarbons in sediments at the 106-Mile Ocean Waste Disposal Site to be similar to presumed uncontaminated areas on the Shelf, and much less than C_{15+} hydrocarbon levels at dump sites in shallow waters (Table A-15). The C_{15+} hydrocarbon concentrations in sediments from the Sewage Sludge Disposal Site and Dredged Material Disposal Site in the New York Bight Apex were 1,568 to 3,588 μg/g, and 6,530 μg/g respectively.

PCB production was halted in 1977 by the sole manufacturer, Monsanto, but between 1930 and 1975 total U.S. commercial sale of the substance was about 571,000 tonnes. Since 1975 approximately 340,000 tonnes of PCB were still in use; studies indicated approximately 68,000 tonnes have already been dispersed into the environment. Another 130,000 tonnes are estimated to be stored in landfills and equipment dumps, with an anticipated increase to 140,000 tonnes by 1978. An estimated 25,000 tonnes have been incinerated since 1975, or otherwise degraded. The 340,000 tonnes still in use from 1975 will eventually have to be disposed.

Total U.S. atmospheric PCB burden is conservatively estimated to be 18 tonnes, within a volume of 32.5 million km^3 over U.S. continental and oceanic areas. Atmospheric PCB concentrations for North Atlantic oceanic areas range from less than 0.05 to 1.6 ng/m^3. A value of 0.05 ng/m^3 is considered to be the average atmospheric burden (NAS, 1979).

TABLE A-15
C15+ HYDROCARBON CONTENT OF SEDIMENT
SAMPLES FROM THE 106-MILE OCEAN WASTE DISPOSAL SITE

Location	Water Depth (m)	Organic Carbon Weight (%)	Hydrocarbon (µg/g)	
			C_{15+} Saturated	C_{15+} Aromatic
38°34.9'N, 72°13.4'W	2,786	0.64	24	20
38°31.9'N, 72°10.5'W	2,812	0.64	20	22
38°31.2'N, 72°12.1'W	2,818	0.52	26	22
38°46.0'N, 72°30.7'W	2,318	0.86	14	18
38°49.9'N, 72°34.1'W	2,027	1.06	18	20
38°56.5'N, 72°25.1'W	1,688	0.94	10	14
38°55.0'N, 72°05.0'W	2,477	0.64	10	18
39°09.9'N, 72°54.8'W	1,959	0.42	20	54

Source: Greig and Wenzloff, 1977

In the marine environment PCB's have been most extensively studied in north Atlantic waters. Data collected in the north Atlantic by various researchers indicate that PCB levels are subject to inexplicable variations, prohibiting accurate predictions of persistence times and ultimate fates of the substance (NAS, 1979).

Harvey et al. (1973) measured PCB's in north Atlantic waters between 26°N and 63°N. PCB's averaged about 20 parts per trillion (ng/kg), amounting to 200,000 tonnes of PCB's in the upper 200m of water. The range of concentration was found to be wide (less than 1.0 to 150 ng/kg), with extreme concentrations occurring several kilometers distant. No apparent relationship between PCB concentration and proximity to land was observed, and it was suggested that the high variation may be due to localized slicks, rainfall, or ship discharges.

The atmosphere appears to be the predominant mode of transport of PCB's, thus accounting for the widespread distribution. PCB concentration decreased with depth, averaging 35 ng/kg at the surface and 10 ng/kg at 200m. Measurable concentrations were found at depths to 3,000m, suggesting that animal migration and detritus sinkings transport the PCB's out of the mixed layer, thereby preventing permanent accumulation in surface waters.

More conservative estimates suggest that the waters of the north Atlantic Ocean contain an upper limit of 66,000 tonnes of PCB's. However, it has been further suggested that all measurements of PCB's in oceans have been biased upwards, due to sampling contamination, and that reported measurements may be too high by at least one order of magnitude, thus resulting in a lower limit estimate of 6,000 tonnes.

Chlorinated hydrocarbon concentrations (PCB and DDT) in organisms were investigated by Harvey et al. (1974). Most significant among their results is that no support was found for food chain magnification among the gilled organisms, and no discernible horizontal concentration gradients existed among plankton or mesopelagic organisms, although North America is presumed to be the major source of chlorinated hydrocarbons in Atlantic waters. The researchers did not observe any evidence of effects on marine life, nor any decline in abundance of the various populations. Plankton exhibited the highest PCB concentrations, ranging up to hundreds of parts per billion.

BIOLOGICAL CHARACTERISTICS

PHYTOPLANKTON

Phytoplankton are free-floating algae which produce some of the organic matter upon which the rest of the marine food chain is built. Phytoplankton consist of autotrophic algae which have representatives from six taxonomic groups: Bacillariophyta, Pyrrophyta, Cyanophyta, Coccolithophorida, Chlorophyta, and Euglenophyta. The algal cells are commonly found in combinations of single filamentous or colonial units of varying sizes in the euphotic zone (upper 100m) and require sunlight, nutrients, and certain

conditions of temperature and salinity to synthesize organic matter. The various combinations of these factors in the euphotic zone dictate the floral characteristics of the waters at any particular time or place.

Few phytoplankton investigations have been performed in the region of the proposed and alternative sites, and the available data indicate summer was the only season in which sampling was performed. Hulburt and Jones (1977) found the phytoplankton abundance at the 106-Mile Ocean Waste Disposal Site to vary with depth from 100 to 100,000 cells/liter, with the phytoplankton much more abundant in the upper 20m than at 25 to 50m depth. Abundance was greatly reduced at greater depths. The dominant species of phytoplankton was a group of unidentifiable naked cells. Phytoplankton populations at the 106-Mile Ocean Waste Disposal Site were found to be composed of a mixture of coastal and oceanic species, due to the site's location in a transitional area between coastal and oceanic waters and in the path of Gulf Stream eddies.

Data from Hopkins et al. (1973) indicate the summer chlorophyll values at the 106-Mile Ocean Waste Disposal Site are highest at or near the surface, decreasing to very low levels at 100m depth, and then slowly rise to a second maximum (much smaller than the first) at depths greater than 1,000m. Steele and Yentsch (1960) observed these chlorophyll concentrations at great depths and attributed the higher concentrations to the sinking of phytoplankton until their density equals that of the surrounding water. The subsurface accumulation of chlorophyll occurs at depths where water is dense, which is inversely related to temperature down to 4°C, is increasing most rapidly. This phenomenon becomes more apparent as the summer progresses and is most distinct in Slope waters. This midwater accumulation of chlorophyll disappears with the destruction of stratification of the water in autumn.

More data exist on phytoplankton in the mid-Atlantic Continental Shelf and Slope waters than in waters of the Continental Rise. The locations of the stations from which phytoplankton samples have been taken are depicted in Figure A-6. Available information indicates the phytoplankton population in the mid-Atlantic are comprised mainly of diatoms during most of the year. Hulburt (1963, 1966, 1970) described 33 abundant phytoplankton species, of which 27 were diatoms, 4 were dinoflagellates, and 2 were nannoflagellates.

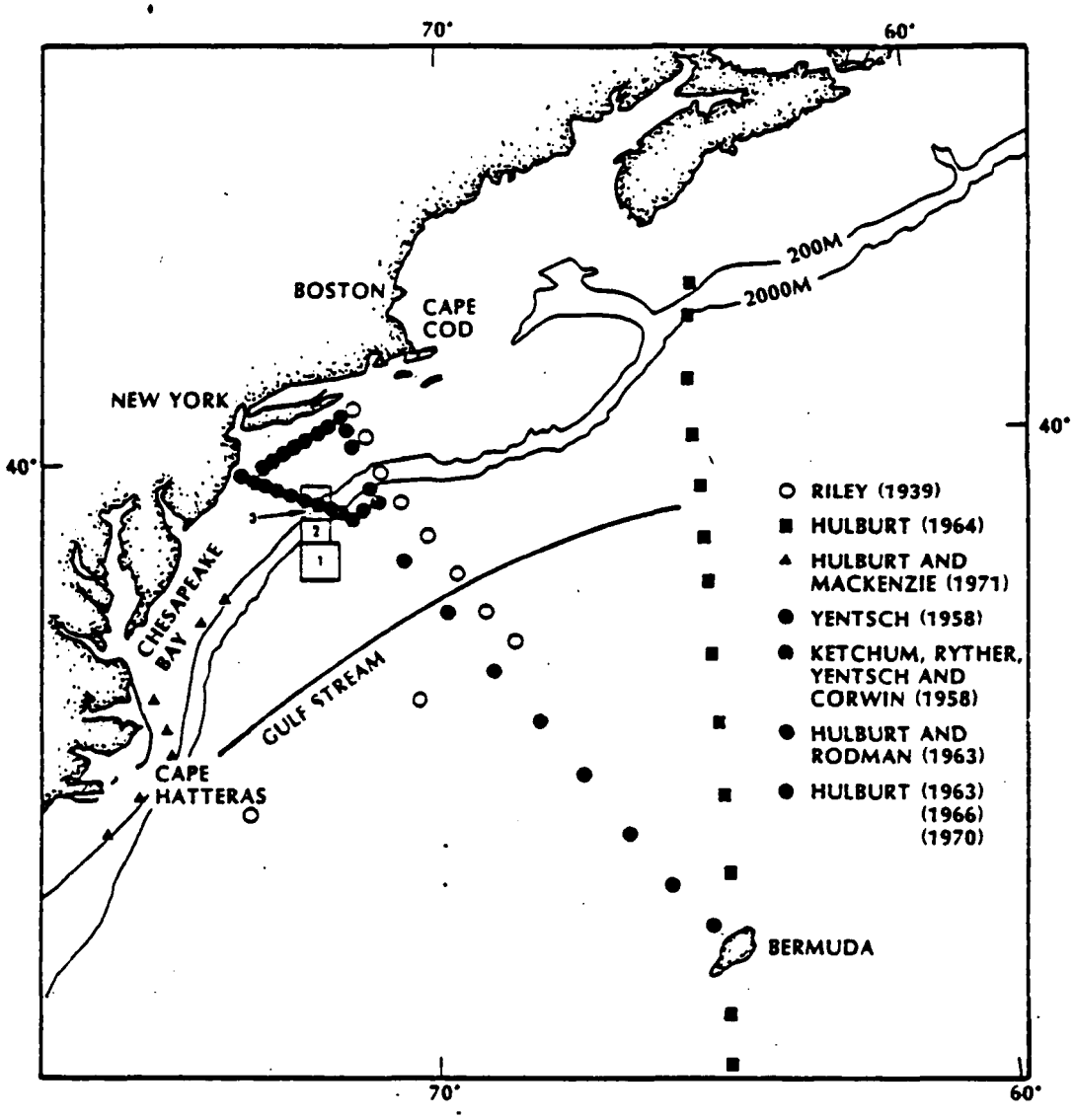

Figure A-6. Station Locations of Major Phytoplankton Studies in the Northeastern Atlantic
Source: Chenoweth, 1976

Hulburt (1963, 1966, 1970) and Hulburt and Rodman (1963) found Rhizosolena alata dominates during summer and Thalassionema nitzschioides, Skeletonema costatum, Asterionella japonica, and Chaetoceros socialis dominate during winter. Spring dominants include Chaetoceros spp. and Nitzschia seriata. Thalassionema nitzschioides dominates in autumn.

In several studies phytoplankton densities ranged between 10^3 and 10^6 cells/liter, generally decreasing with distance from land (Hulburt, 1963, 1966, 1970). Major pulses in phytoplankton abundances were due to four

neritic diatom species: Skeletonema costatum, Asterionella japonica, Chaetoceros socialis, and Leptocylindrus danicus (Hulburt, 1963, 1966, 1970; Malone, 1977). Uniform distributions were exhibited by Rhizosolena alata in summer and Thalassionema nitzschioides in winter. The flagellates Chilomonas marina, C. gracilis, Ceratium lineatum, Katodinium rotundatum, Oxytoxum variabile, and Prorocentrum micans were locally abundant, but rarely dominant during summer. Maximum cell densities were observed in December and minimum densities in July (Malone, 1977).

Major changes in species composition occur inshore to offshore. Dominant coastal species are primarily chain-forming centric diatoms (Smayda, 1973), which require relatively high nutrients to sustain high bloom populations, and are subject to wide seasonal variations in abundance and diversity. Of secondary importance in coastal waters are the dinoflagellates and other flagellated groups. In contrast, oceanic waters under some influence of the Gulf Stream carry a phytoplankton community characterized by dominance of coccolilthophorids, diatoms, dinoflagellates, and other mixed flagellates (Hulburt et al., 1960; Hulburt, 1963), all of which require somewhat lower nutrients and are subject to reduced or dampened seasonal variations in abundance.

Riley (1939) showed the vertical distribution of phytoplankton from a Slope Water station adjacent to the Continental Shelf and from a station near the outer boundary (Figure A-7). The inner station is characteristic of Shelf Waters having higher surface abundance (2.5 µg chlorophyll a per m^3) with the phytoplankton disappearing at about 100m. The outer Slope station has fewer surface phytoplankton (0.9 µg chlorophyll a per m^3) but cells are found at greater depths (200m). This illustrates the transition in terms of vertical abundance between coastal and open ocean characteristics within Slope Water (Chenoweth, 1976).

Mid-Atlantic Bight waters are well-mixed during winter and strongly stratified during summer. This sharp seasonal distinction is reflected in the seasonal changes in phytoplankton abundance. During summer diversity is high, while at other times, when growth conditions are more favorable, diversity is lower. In Slope Water the seasonal cycle is characterized by two equally

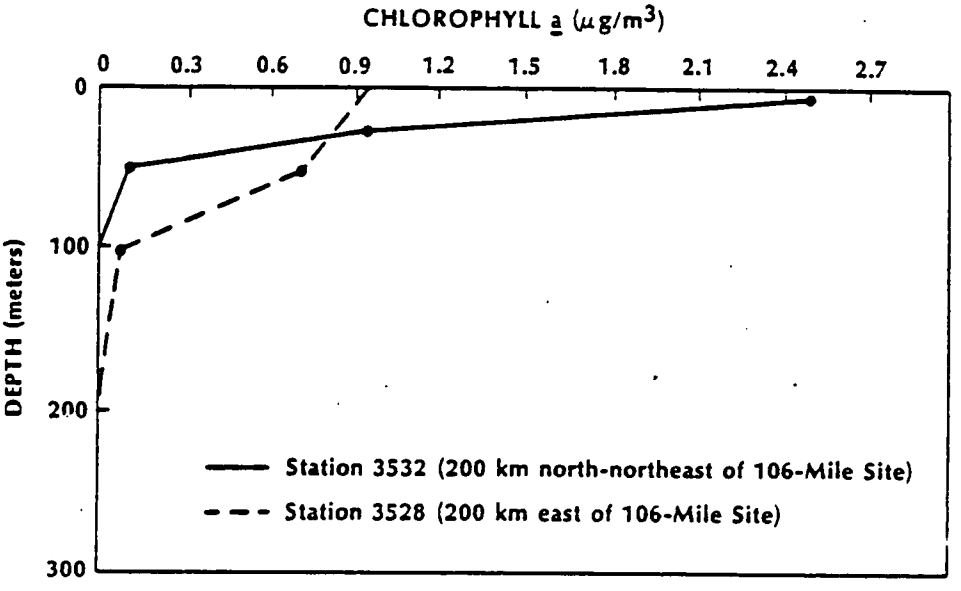

Figure A-7. Vertical Distribution of Chlorophyll a
Source: Riley, 1939

intense pulses of chlorophyll: the spring and autumn blooms (Yentsch, 1977). In Shelf Water the autumnal bloom is the most intense feature of the seasonal cycle. Chlorophyll concentrations vary regionally and seasonally from less than 0.5 mg/l to about 6 mg/l (Smayda, 1973). The seasonal variations in mean chlorophyll content for the inshore (less than 50m) and offshore (greater than 1,000m) stations are given in Figure A-8a. The annual range in primary production (Figure A-8b) does not differ appreciably between inshore (0.20 to 0.85 g C/m^2/day) and offshore (0.10 to 1.10 g C/m^2/day [Ryther and Yentsch, 1958]). However, the total annual production differs over the Shelf and Slope, with an annual production of 160 g C/m^2 at the inshore stations (less than 50m) decreasing progressively seaward to 135 g C/m^2 at the intermediate locations (100 to 200m), and 100 g C/m^2 at the offshore stations (greater than 1,000m). Ketchum et al. (1958) indicated the nutrient-impoverished offshore areas (Slope Water) cause physiological differences between inshore and offshore phytoplankton. Results of their light and dark bottle experiments (Figure A-9) show differences in the ratio of net to gross photosynthesis.

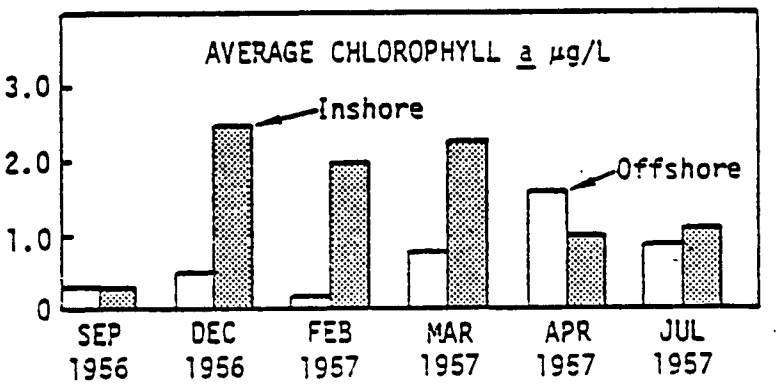

Figure A-8a. Summary of the Average Chlorophyll a Content at Inshore (less than 50m) and Offshore (greater than 1,000m) Sites in the Mid-Atlantic Bight
Sources: Ryther and Yentsch, 1958; Yentsch, 1963

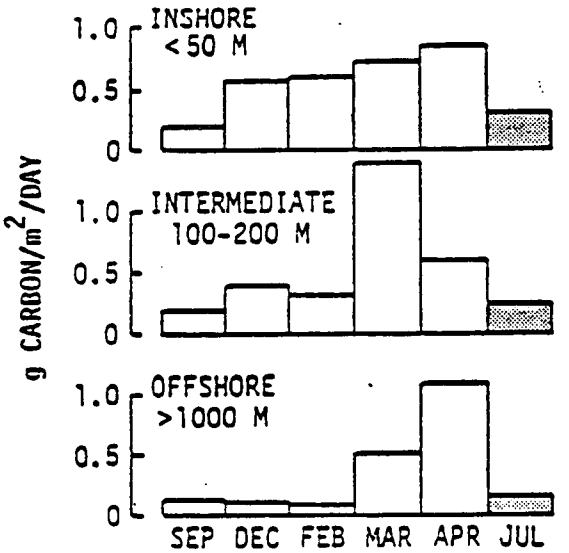

Figure A-8b. Summary of Mean Daily Primary Production per Square Meter of Sea Surface at Inshore (less than 50m), Intermediate (100 to 200m), and Offshore (greater than 1,000m) Sites in the Mid-Atlantic Bight
Sources: Ryther and Yentsch, 1958; Yentsch, 1963

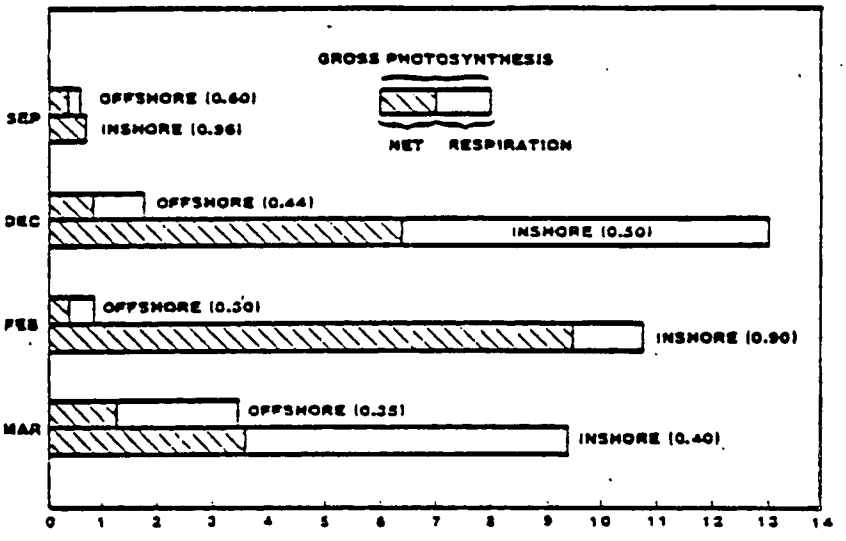

Figure A-9. Comparison of Gross and Net Photosynthesis Between Inshore and Offshore Stations
Source: Chenoweth, 1976

High ratios in September and February indicated healthy, growing populations; while lower ratios in December and March indicated less healthy populations. Geographically the low ratio of offshore populations indicated poorer physiological conditions. Ketchum et al. (1958) suggested this variation of net gross photosynthesis ratios may be the result of nutrient deficiencies, particularly in the offshore waters.

The critical depth (the depth to which plants can be mixed and at which the total photosynthesis for the water is equal to the total respiration of primary producers) accounts for the low total annual production in offshore waters. Although compensation depth and the critical depth for mid-Atlantic Bight waters are not precisely known, Yentsch (1977) estimates them to be between 25 and 40m and at 150m, respectively. If this estimate is at all accurate, it means that critical depths are not encountered on the Shelf, since the average water depth is about 50m. Beginning in autumn extensive vertical mixing occurs with the cooling of surface waters and an increase in wind velocity. Shelf Waters are mixed to the bottom during autumn and winter,

thus the average plant cell within the water receives adequate light for production. Plants have access to the nutrients dissolved within the entire water column, and since production is limited by light only, production can proceed at a moderately high level.

Concentrations of chlorophyll decrease during autumn and winter, moving from the Shelf to the Slope (Yentsch, 1977). As winter conditions intensify, Slope chlorophyll concentrations become much lower than Shelf Water concentrations. This is due to Slope Water being deep enough for critical depth conditions to occur, since these waters are mixed to a depth of 200m or more. Therefore, although daily photosynthesis may equal or exceed that of Shelf Water (Ryther and Yentsch, 1958), the average plant cell within the Slope Water column does not receive sufficient light to grow, thus production proceeds at a low level.

In the spring vertical mixing is impaired first in shallow waters and then progessively seaward into deeper waters (Yentsch, 1977). Following the development of the thermocline, there is a brief period of high production, since the average cell above the thermocline is then exposed to much greater radiation. Therefore, the spring bloom begins and then is impaired, first on the Shelf and then progressively seaward to the Slope. The spring bloom is of greater magnitude in the Slope Water mass than in Shelf Water, since the nutrients have not been depleted by growth during the winter. Oligotrophic conditions prevail in Shelf and Slope Water masses during the summer until the cooling and mixing processes of autumn destroy the thermocline. The autumnal bloom occurs during the transition from a stratified to a mixed water column.

ZOOPLANKTON

Zooplankton are the passively swimming animals of the water column and contain members of nearly every phylum. Zooplankton represent the second trophic level of the food chain, since the group is dominated by herbivorous crustacea (copepods, euphausiids, amphipods, and decapods) which graze on the phytoplankton. The zooplankton studies performed at the 106-Mile Ocean Waste Disposal Site (Austin, 1975; Sherman et al., 1977; Harbison et al., 1977) have confirmed the variable and transient nature of water masses in the area of the

proposed and alternative sites. The composition of the zooplankton population was found to be the result of mixing of the Shelf, Slope, and Gulf Stream Water masses. Even within areas for which the water mass could be identified, Sherman et al. (1977) could not differentiate species characteristics for the area. However, the contour of diversity indices was such that a differentiation could be made between Shelf, Slope, and Rise Waters (Chenoweth, 1976). Copepod populations in Shelf Waters were dominated by boreal assemblages characterized by high abundance and few species, while the Slope and Rise Water masses contained a mixture of subtropical and boreal assemblages resulting in lower abundance of individuals and a greater number of species.

The seasonal zooplankton biomass range was 7.7 to 1780 ml/1000 m^3 in summer, and 5.5 to 550 ml/1000 m^3 in winter. The displacement volumes are comparable with literature values for Shelf and Slope Water masses. The dominant zooplankton species found at or near the 106-Mile Ocean Waste Disposal Site during various seasons of the year are listed in Table A-16. The most common copepod genera were Centropages, Calanus, Oithona, Euaugaptilus, Rhincalanus, and Pleuromamma. Centropages and Calanus predominated in the Shelf Water and in areas where Shelf Water mass intrusions occurred in the Slope water. Calanus was least abundant in the offshore areas where water stability suggested an oceanic origin. Mixing of waters was demonstrated by the presence of Gulf Stream water in the center of the disposal site study area, as indicated by the abundance of Rhincalanus, Euaugaptilus, Oithona, and Pleuromamma. Copepods common to deep waters of the northwestern Atlantic, Euchirella rostrata, were found at all the stations.

The chaetognaths were dominated by Sagitta species and were most abundant over the Shelf (greater than 23/m^3) and least abundant beyond the Shelf Break (less then 10/m^3). The euphausiids found at the 106-Mile Ocean Waste Disposal Site were a mixture of boreal-arctic and subtropical species, which were dominated by Nyctiphanes couchii, a cold-water form. However, warm-water species of the Euphausia and Stylocheiron genera were also dominant. Pteropods were dominated by species of Limacina.

Neuston organisms associated with the air-sea interface were sampled at the 106-Mile Ocean Waste Disposal Site during various seasons. The results are summarized in Table A-17.

TABLE A-16
DOMINANT ZOOPLANKTON SPECIES IN THE
VICINITY OF THE 106-MILE OCEAN WASTE DISPOSAL SITE

Group	Species	Summer 1972	Winter 1973	Spring 1974	Winter 1976
Copepods	Centropages spp.			3/22	
	C. typicus	3/18			2/22
	Clausocalanus arcuicornis	2/18			
	Oithona similis				1/22
	O. spinirostris	4/18			
	Pleuromamma borealis			1/22	
	P. gracilis	5/18	4/16		10/22
	Pseudocalanus minutus		5/16		1/22
	Rhincalanus cornutus			1/22	
	Temora longicornis	1/18			
Euphausiids	Euphausia americana			2/21	
	Meganyctiphanes norvegica	1/16			
	Nyctiphane couchii			7/21	
	Stylocheiron elongatum			4/21	
	Thysanoessa gregaria				2/21
Chaetognaths	Sagitta enflata	4/16			
	S. serratodentata		1/17	—	
	S. spp.	2/16			2/21
Pteropods	Limacina helicina			1/21	3/21
	L. retroversa				3/21
	L. trochiformis		4/17		
	L. sp. (Juveniles)	1/16	4/17		

Note: Number of samples in which the species comprised 50% or more of the individuals of that group/number of stations sampled

Source: Austin, 1975

The zooplankton from Cape Cod to Hatteras have been studied more or less continuously for the past 50 years. The station locations of these studies are shown in Figure A-10. However, many of these studies do not compare well with one another due to the use of different techniques for sampling and the

TABLE A-17
DOMINANT NEUSTON SPECIES IN THE
VICINITY OF THE 106-MILE OCEAN WASTE DISPOSAL SITE

Group	Species	Summer 1972	Winter 1973	Spring 1974	Winter 1976
Copepods	Anomalocera patersoni	3/18	3/15		
	Calanus finmarchicus		3/15		
	Candacia armata	1/18			
	Centropages typicus	5/18			1/18
	Clausocalanus arcuicornis	1/18			1/18
	Labidocera acutifrons	4/18			
	Metridia lucens		1/15		
	Oithona similis		1/15		
	Pleuromamma gracilis		2/15		12/18
	P. robusta				1/18
	Rhincalanus nasutus		1/15		
Euphausiids	Eukrohnia hamata				1/14
	Euphausia brevis	1/13			
	E. krohnii		1/15		
	E. spp.				1/14
	Meganyctiphanes norvegica				2/14
	Nematoscelis megalops		1/15		
	Nyctiphanes couchii			4/12	
	Stylocheiron robustum			5/12	
Chaetognaths	Sagitta enflata	7/13			
	S. serratodentata	1/13	1/15		2/14
	S. spp.	1/13	1/15		3/14
Pteropods	Cavolina uncinata			1/12	
	Creseis virgula conica			1/12	
	Limacina helicina		2/15		
	L. retroversa		1/15		
	L. sp. (Juveniles)	1/13	4/15		

Note: Number of samples in which the species comprised 50% or more of the individuals of that group/number of stations sampled

Source: Austin, 1975

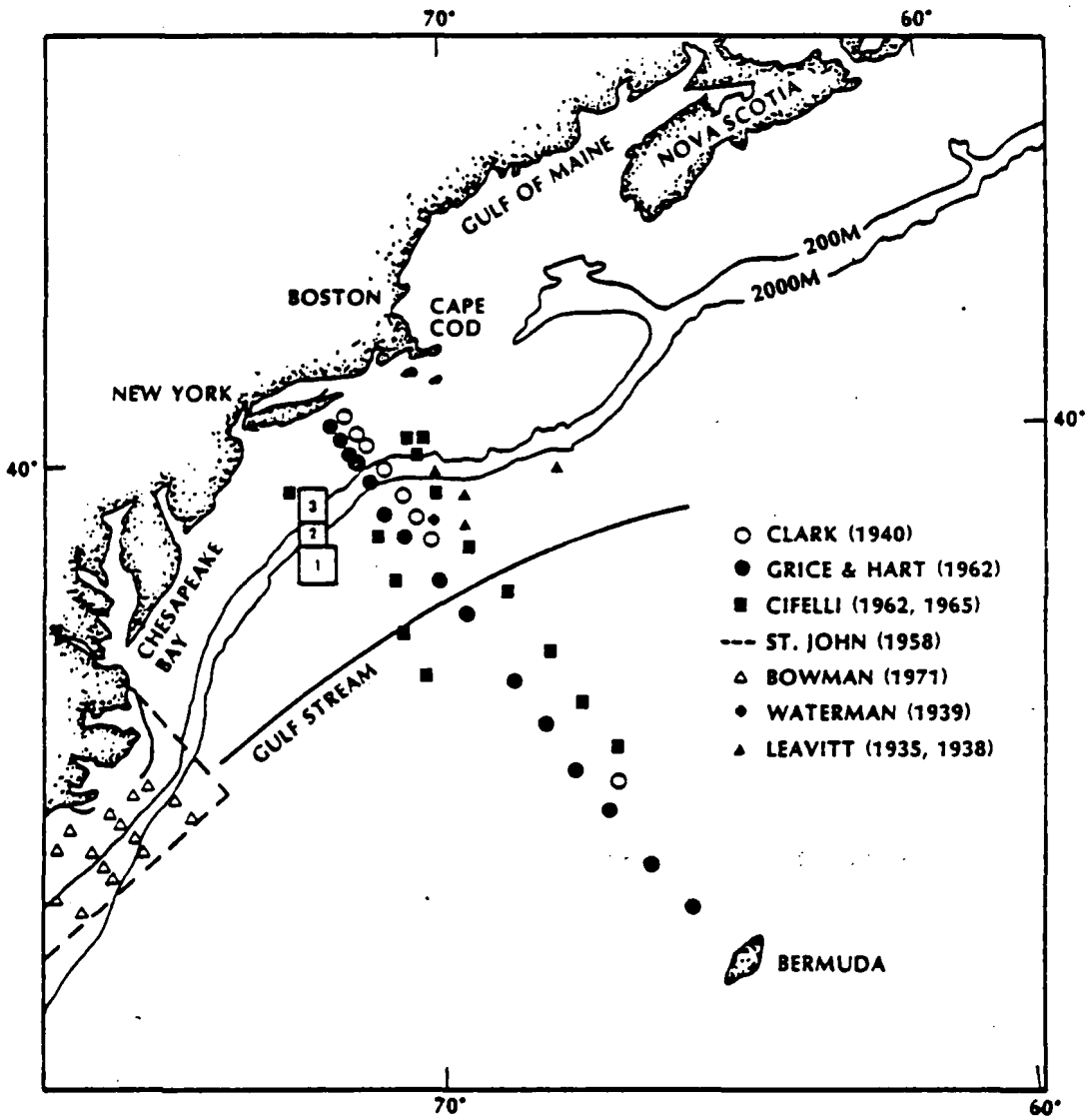

Figure A-10. Station Locations of Major Zooplankton Studies in the Northeastern Atlantic
Source: Chenoweth, 1976

varied ways of expressing such parameters as abundance and biomass. Jeffries and Johnson (1973) point out that most of the studies were, at best, of only a few years' duration. Therefore, since few of them overlapped, the literature is not cohesive. The data clearly show, however, that fluctuations occur not only in the total mass of zooplankton, but in the abundance of some of the more common species.

The most striking feature of the mid-Atlantic Bight zooplankton is the near-complete dominance of calanoid copepods, numerically and volumetrically (Grice and Hart, 1962; Falk et al., 1974). Copepods tend to show greater diversity than any of the other zooplankton groups (Falk et al., 1974). Nine species of copepods have been found to dominate the zooplankton at various times. These include Centropages typicus, Metridia lucens, Paracalanus parvus, Pseudocalanus minutus, Oithona similis, Acartia tonsa, Temora longicornis, Clausocalanus furcatus, and Calanus finmarchicus. The ctenophore Pleurobrachia pileus and the pelagic tunicate Salpa fusiformis dominate occasionally.

Early investigators found certain species of zooplankton were indicative of the continental region from which the samples were collected (Bigelow and Sears, 1939; Clarke, 1940). Grant (1977), using cluster analysis, examined these indicator species and found that three distinct communities are present throughout much of the year: a coastal community, a central Shelf community, and a Slope boundary (oceanic) community. Grant found that the coastal community is identified in all seasons, except spring, by the great abundance of the copepod, Acartia tonsa. During spring the coastal community is characterized by the simultaneous occurrence of Centropages hamatus and Tortanus discaudatus. Typical inhabitants of the central Shelf community include Centropages typicus, Calanus finmarchicus, Sagitta elegans, S. tasmanica, Nannocalanus minor, and Parathemisto gaudichaudii. C. typicus is the dominant organism, and with C. finmarchicus and S. elegans, is an indicator of this central Shelf community. A distinct faunal boundary exists at the Shelf break (200m contour), with the organisms occurring offshore of this boundary being oceanic in nature. Useful indicators of this offshore water type include Metridia lucens, Pleuromamma gracilis, Euphausia krohnii, Meganyctiphanes norvegica, and Sagitta hexaptera. M. lucens has an extended distribution over the Shelf during winter and spring, and M. norvegica is found in spring (Grant, 1977); however, other oceanic species are seldom found more than 9 to 13 nmi inside the 200m contour (Sears and Clarke, 1940). Occasionally, Shelf water becomes temporarily overridden with an oceanic

species (e.g., Salpa fusiformis) which reproduces rapidly, but this is due to local propagation, and is not an indication of an unusually large mixture of Slope Water with Shelf Water, since other oceanic species occur only as traces (Sears and Clarke, 1940).

Although information is lacking, a preliminary description of the zooplankton seasonal cycle can be given. Grice and Hart (1962) noted maximum displacement volume occurred in July (0.76 ml/m^3) and a minimum displacement in December (0.04 ml/m^3), a 20-fold difference. Clarke (1940) reported a 10-fold seasonal difference; however, Grice and Hart (1962) considered their December values low because of a missing station and believed that it should be closer to 10 ml/m^3, which would be comparable to Clarke's value. Shelf Water exhibited a much greater seasonal fluctuation (20-fold to 40-fold), whereas the Sargasso Sea volumes showed little seasonal variations. Similarly, the numerical abundance of zooplankton varied seasonally in the Slope water but with lesser magnitude than neritic areas. Maximum average values ($571/m^3$) occurred in September and minimum values ($36/m^3$) in July. The March average ($504/m^3$) was similar to that of the Shelf waters ($585/m^3$).

The available biomass data for the mid-Atlantic Bight is summarized in Table A-18. Grice and Hart (1962) determined the mean zooplankton standing crop in Shelf Waters was about three times greater than in the Slope Waters, and in the Slope Water it was three to four times greater than those of the more oceanic Gulf Stream and Sargasso Sea areas. If salps were included in the measurements, Slope Water zooplankton were four times less abundant than those of Shelf Waters, and nine to ten times more abundant than the zooplankton of the oceanic areas. This compares with Clarke's (1940) estimates (salps included) of Slope Water zooplankton, four times less abundant than the Shelf water zooplankton, and four times more than the more oceanic areas. Examination of the numerical abundance, as well as the displacement volumes of each taxonomic group, indicates this difference between Shelf and Slope Waters is not due to the disappearance or decline of any one group of organisms but apparently to the general reduction of zooplankton in Slope Water (Grice and Hart, 1962).

TABLE A-18
ZOOPLANKTON BIOMASS IN THE MID-ATLANTIC BIGHT

Region	Displaced Volume ($ml/1,000m^3$)	Wet Weight (mg/m^3)	Net Mesh (mm)	Depth Range (m)	Source
Western North Atlantic					
Coastal	8,100		0.158	0 to 25	Riley (1939)
Slope water (spring)	4,300		0.158	0 to 50	Riley (1939)
Slope water (summer)		430 to 1,600	0.158	0 to 400	Riley & Gorgy (1948)
Coastal (yearly mean)	540		10 strands/cm	0 to 85	Clarke (1940)
Offshore (yearly mean)	400		10 strands/cm	0 to 85	Clarke (1940
Cape Cod-Chesapeake Bay					
Coastal					
(summer)	700 to 800			Variable	Bigelow & Sears (1939)
(winter)	400			Variable	Bigelow & Sears (1939)
Continental Slope 38° to 41°N (fall)	328		0.170	0 to 200	Yashnov (1961)
New York-Bermuda					
Coastal waters (yearly mean)	1,070		0.230	0 to 200	Grice & Hart (1962)
Slope water (yearly mean)	270		0.230	0 to 200	Grice & Hart (1962)

Several authors have noted that the most productive area for zooplankton seems to be near the edge of the Continental Shelf. Grice and Hart's (1962) data show the most consistent peaks of either biomass or numbers to be at the outer Shelf or inner Slope stations. During March quantities for the inner Slope exceeded (in biomass and abundance) those of all other areas. Riley et al. (1949) noted from their summary of existing data the water at the edge of the Shelf was unusually rich in zooplankton.

The published biomass and abundance relationships from coastal to oceanic areas apply only to the surface zone, since most surveys had a maximum sampling depth of less than 275m. Examination of the vertical distribution and diurnal migration of zooplankton in Slope Waters indicates a significant number of organisms reside below the surface zone (Leavitt, 1935, 1938; Waterman et al., 1939). Leavitt's data (Figure A-11) show a series of peaks

down to 2,000m, the highest occurring at 600 to 800m. It was determined that between 40% and 90% of the animals were in depths less than 800m; however, only 20% to 50% of the total volume occurred above 200m. Waterman et al. (1939) determined that the malacostracan crustacea of the Slope water migrated 200 to 600m vertically, in response to light stimulus. This implies there is a large number of zooplankton unaccounted for by the surface surveys. Leavitt (1938) concluded that the deepwater zooplankton maximum was not due to the occurrence of a well-developed bathypelagic fauna, but comprises species such as Calanus finmarchicus and Metridia longa, which are abundant in boreal surface waters. He suggested that the deepest maximum resulted from the intrusion of water masses which originated in shallow waters of higher latitudes.

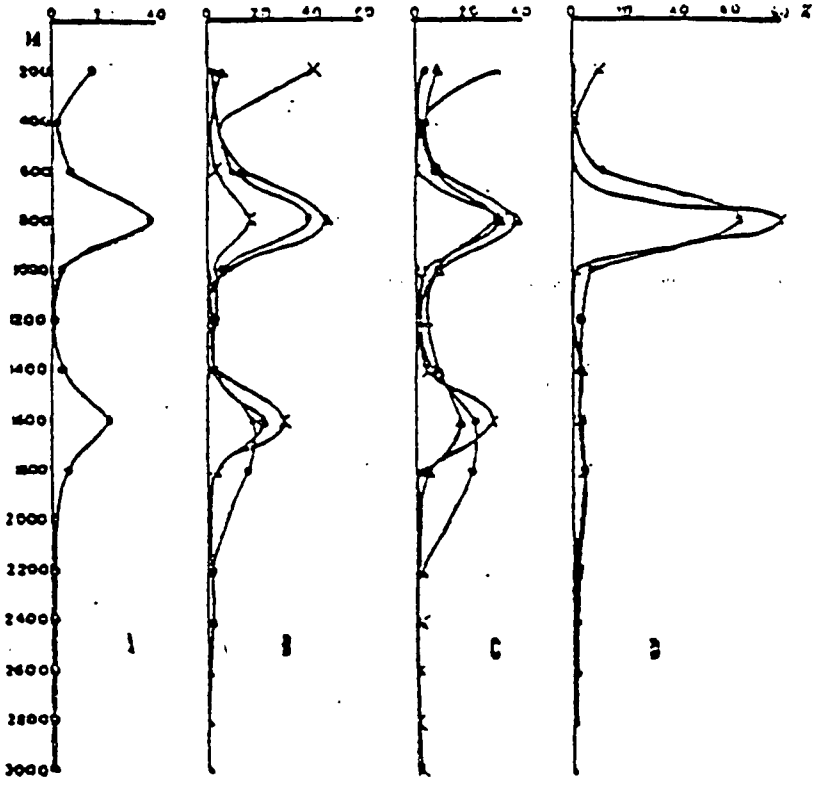

Figure A-11. Vertical Distribution of Zooplankton in Slope Water
Source: Leavitt, 1938

The neuston (organisms associated with the air-sea interface) of the mid-Atlantic compose a unique faunal assemblage quite different from subsurface populations. The neuston is dominated during the day by the early life stages of fish, joined at night by the zoea and megalopae stages of decapod crustacea, primarily Cancer sp., which migrate vertically into the neuston (Grant, 1977). The euneuston (organisms which spend their entire life cycle in the surface layer) are usually less abundant than the "facultative" neuston (organisms which spend only part of their life cycle in the surface layer). The euneuston are dominated by pontellid copepods and the isopod Idotea metallica.

NEKTON

Nekton are marine organisms (e.g., fish, cephalopods, and marine mammals) which have sufficiently strong swimming capabilities, maintaining position but move against local currents. Nekton can be subdivided into three groups: micronekton, demersal nekton, and pelagic nekton. Micronekton consist of weakly swimming nekton (e.g., mesopelagic fish and squid) which are commonly collected in Isaac-Kidd Midwater Trawls. Demersal nekton are the extremely motile members of the nekton associated with the bottom, whereas pelagic nekton inhabit the overlying waters. Since nekton schools are highly mobile, migrate over long distances, and have unknown depth ranges, data on these organisms are limited and qualitative.

Investigations of midwater nekton at the 106-Mile Ocean Waste Disposal Site by Krueger et al., (1975, 1977) have shown the community to be dominated by micronekton, gonostomatid, and myctophid fishes. During the day most fishes are found at considerable depths (greater than 200m), but at night large numbers of the population migrate to the upper layers of the water column. During the day between 50% and 80% of the catch in the upper 800m were composed of Cyclothone species (family Gonostomatidae), while lanternfish (family Myctophidae) made up 14% to 35%. Cyclothone species remain at depths greater than 200m, day and night, while lanternfish migrate upwards at night, at which time they account for 95% of the catch in the upper 200m. Above 800m at night the proportion of the population made up of Cyclothone species decreases, with a concomitant increase in the lanternfish portion, probably as

a result of lanternfish migration from below 800m and becoming more easy to catch at night. An estimated 20% of the population of lanternfish migrate from below 400m during the day, to the upper 200m at night; one-third to two-thirds of which reach the upper 100m (Krueger et al., 1977).

Most of the Cyclothone catch at the 106-Mile Ocean Waste Disposal Site was attributable to C. microdon and C. braueri, the first and third most abundant species for all areas and seasons. C. microdon is most abundant below 500m, while C. braueri predominates above 600m. Both species appear to occur in generally shallower waters in winter rather than in summer. Of the 50 species of lanternfish captured, only four were abundant. Krueger et al. (1977) reported Ceratoscopelus maderensis as the second most abundant species overall, but only by virtue of a single extremely large sample. Otherwise, this species was only moderately abundant during winter and rare or entirely absent during summer. Hygophum hygomi and Lobianchia dofleini were moderately abundant during summer but were virtually absent during winter. Adult Benthosema glaciale were abundant during winter, but during summer the species was only moderately abundant, and composed primarily of juveniles. Cyclothone and lanternfish contributed between 25% and 70% of the total biomass in the upper 800m, dependent on area and diel period. Therefore, small numbers of larger species contribute greatly to the total fish biomass. Krueger et al. (1977) found that larger fish inhabit depths greater than 300m and speculated that these fish concentrate toxic materials as a result of feeding on smaller fishes and larger zooplankton. Only five species, Benthosema glaciale, Lepidophanes guentheri, Cyclothone pallida, C. braueri, and C. microdon were taken in all areas and seasons.

Krueger et al. (1977) concluded that the 106-Mile Ocean Waste Disposal Site in summer and winter was characterized by Slope Water fish fauna, upon which Northern Sargasso Sea fauna (presumably transported to the site by warm-core eddies) were superimposed. The Sargasso Sea species, present in summer, were less abundant in winter, suggesting that their presence and abundance are dependent on eddy size, age, and/or core temperatures.

The most common pelagic nekton in the 106-Mile Ocean Waste Disposal Site include the tunas, bluefin (Thunnus thynnus), yellowfin (T. albacares), bigeye

(T. obesus), albacore (T. alalunga), swordfish (Xiphias gladius), lancetfish (Alepisaurus spp.), blue shark (Prionace glauca), mako shark (Isurus oxyrinchus), and dusky shark (Carcharhinus obscurus). All of these species are seasonal migrants north of Cape Hatteras and feed on a variety of prey (Casey and Hoenig, 1977). Approximately 50% and 30% of the tuna diet consist of fish and cephalopods, respectively. Crustaceans and miscellaneous organisms comprise the remainder of the diet. Swordfish feed on surface fish (e.g., menhaden, mackerel, and herring) and a variety of deepwater fish and cephalopods. Lancetfish feed on small fish and zooplankton. The blue and mako sharks feed mostly on small fish and cephalopods, while other sharks feed mainly on teleosts.

The cetaceans (whales and dolphins) are wide-ranging marine mammals which use the Slope Water of the mid-Atlantic Bight. There are, however, very little data on which species are found in the Slope Water and the role this region takes in their life history. The species of cetaceans found in the mid-Atlantic, their range, distribution, and estimated abundances are summarized in Table A-19. From the available data on cetaceans in offshore waters, it appears that the Slope Waters serve as a migratory route between northern summering grounds and southern wintering grounds (Chenoweth et al., 1976). The proximity of rich feeding grounds along a north-south migration route would make the Slope Waters an extremely attractive region to the cetaceans. The 200m isobath appears to be the inshore boundary for the distribution of some of the larger species.

Five species of sea turtles are known to be associated with mid-Atlantic coastal and Slope Waters (Table A-20). Four of the species (hawksbill, leatherback, green, and Atlantic ridley) are endangered, and the loggerhead is threatened. Leatherbacks (Dermochelys coriacea), loggerheads (Caretta caretta), ridleys (Lepidochelys kempi), and green turtles (Chelonia mydas) are regular migrants in East Coast waters, usually most numerous from July to October, at which time the turtles follow their primary food (jellyfish) inshore. The exact migration route used by these organisms is not known.

TABLE A-19
SPECIES SUMMARY OF CETACEANS

Family	Common Name	Species Name	Western Atlantic Range and Distribution	Habitat	Estimated Abundance in Western North Atlantic
Balaenidae*	Right whale	Eubalaena glacialis	New England to Gulf of St. Lawrence; possibly found as far south as Florida	Pelagic and coastal; not normally inshore	100 to 1,000
Balaenopteridae*	Blue whale	Balaenoptera musculus	Gulf of St. Lawrence to Davis Strait; routinely sighted on banks fringing outer Gulf of Maine; population much reduced from original number of about 1,100 in western North Atlantic	Pelagic, deep-ocean; however, occasionally approaches land in deepwater regions (e.g., the Laurentian Channel of the St. Lawrence River)	Generally not common; some sightings expected in offshore regions; no estimates
Balaenopteridae*	Sei whale	Balaenoptera borealis	New England to Arctic Ocean	Pelagic; does not usually approach coast	1,570 (off Nova Scotia)
Balaenopteridae*	Finback whale	Balaenoptera physalus	Population centered between 41°21'N and 57°00'N, and from coast to 2,000m contour	Pelagic, but enters bays and inshore waters in late summer	7,200
Balaenopteridae	Minke whale	Balaenoptera acutorostrata	Chesapeake Bay to Baffin Island in summer; eastern Gulf of Mexico, northeast Florida, and Bahamas in winter	Pelagic, but may stay nearer to shore than other rorquals (except humpback)	No estimates
Balaenopteridae*	Humpback whale	Megaptera novaeangliae	Common near land, but can be found in deep ocean	Approaches land more closely and commonly than other large whales; also found in deep ocean	800 to 1,500
Delphinidae	Killer whale	Orcinus orca	Tropics to Greenland, Spitzbergen, Baffin Bay	Mainly pelagic and oceanic; however, they do commonly approach coast	No estimates; apparently not seen as commonly as in more northerly areas

TABLE A-19. (continued)

Family	Common Name	Species Name	Western Atlantic Range and Distribution	Habitat	Estimated Abundance in Western North Atlantic
Delphinidae	Saddleback dolphin	Delphinus delphis	Caribbean Sea to Newfoundland; very wide ranging; may be most widespread and abundant delphinid in the world	Seldom found inside 100m contour, but does frequent seamounts, escarpments, and other offshore features	Poorly known; probably more common than available records indicate; may be more common in Massachusetts Bay; no estimates
Delphinidae	Atlantic pilot whale	Globicephala melaena	New York to Greenland; especially common in Newfoundland	Pelagic (winter) and coastal (summer)	Most common whale seen in Cape Cod Bay; Schools of up to 300 on Georges Bank; no estimates
Delphinidae	Bottle-nosed dolphin	Tursiops truncatus	Argentina to Greenland, but most common from Florida, West Indies, and Caribbean to New England	Usually close to shore and near islands; enters bays, lagoons, and rivers	Rare, especially in inshore regions; no estimates
Delphinidae	Grampus; Grey grampus, Risso's dolphin	Grampus griseus	Ranges south from Massachusetts	Coastal waters; habitat poorly known	Uncommon, but possibly not rare; no estimates
Physeteridae*	Sperm whale whale	Physeter catadon	Equator to 50°N (females and juveniles) or Davis Strait (males)	Pelagic, deep-ocean	Estimated 22,000 inhabit North Atlantic Ocean
Physeteridae	Pygmy sperm whale	Kogia breviceps	Tropics to Nova Scotia	Pelagic in warm ocean waters	Very rare; only one record
Ziphiidae	Bottle-nosed whale	Hyperoodon ampullatus	Rhode Island to Davis Strait	Pelagic; cold temperature and subarctic waters	Poorly known; between 260 to 700 taken annually in North Atlantic Ocean between 1968 and 1970
Ziphiidae	True's beaked whale	Mesoplodon mirus	Northern Florida to Nova Scotia	Nothing is known	Extremely rare; poorly known
Ziphiidae	Dense-beaked whale	Mesoplodon densirostris	Tropics to Nova Scotia	Probably pelagic in tropical and warm waters	Extremely rare; stray visitor

*Endangered Species

Source: Chenoweth et al., 1976

TABLE A-20
THREATENED AND ENDANGERED TURTLES FOUND IN MID-ATLANTIC SLOPE WATERS

Common Name	Species Name	Geographic-Bathymetric Range	Habitat	Reason for Decline
*Hawksbill turtle	Eretmochelys imbricata	Tropical waters; rare in New England waters; nests on Carribean shores and along Atlantic coast to Brazil on undisturbed beaches	Deep ocean	Heavily exploited for shell
*Leatherback turtle	Dermochelys coriacea	New England waters summer-autumn; closely associated with Slope waters during	Highly pelagic; feeds on pelagic jellyfish	Some slaughter by fishermen; eggs collection on breeding grounds
†Loggerhead turtle	Caretta caretta	New England waters summer-autumn; migrate Atlantic coast to/from Sargasso Sea	Frequently sighted in coastal waters; more littoral than leather-bill	Predation by raccoons and people; egg destruction of breeding beaches due to coastal development
*Green turtle	Chelonia mydas	Occasionally seen in New England waters in summer; tropical oceans; rare north of Cape Cod	Deep Slope waters between Gulf Stream and littoral feeding grounds	Reduction of breeding grounds and commercial exploitation
†Atlantic ridley	Lepidochelys kempii	New England waters during summer months; breeds on more tropical beaches	More littoral than leather-back or hawks-bill	Eggs plundered on breeding beaches

*Endangered species
†Threatened species

BENTHOS

The benthos of the proposed and alternative sites lie at abyssal depths in the lower mid-Atlantic Continental Slope and in the Continental Rise. Research on the faunal assemblages of the Continental Slope commenced only recently and centered around the contributions of comparatively few workers. This accounts for the sparse amount of data concerning Continental Slope benthic populations. There is substantial evidence, however, that the major components of faunal assemblages at various Slope depths do not change significantly throughout the mid-Atlantic and neighboring areas (Larsen and Chenoweth, 1976; Rowe et al., 1977; Pearce et al., 1977).

Variations in sediment types are generally recognized as the primary factors influencing benthic faunal distributions in the mid-Atlantic Shelf. These factors, however, are of doubtful importance in influencing benthic faunal distributions in the proposed alternative site areas, due only to slight sediment variations within similar areas (Rowe and Menzies, 1969). Temperature can be discounted as an important factor since no seasonal changes or variations with depth occur below 1,000m (Larsen and Chenoweth, 1976; Rowe and Menzies, 1969). It has not been determined to what extent species-interaction within any chosen site determines the faunal composition and zoning regime, but competitive exclusion may be a critical factor (Sanders and Hessler, 1969).

Deep-sea nutrition is one of the most important factors influencing benthic faunal distributions in the site regions. Larsen and Chenoweth (1976) believe the lower levels of available organic carbon at greater depths are key factors determining faunal biomass and densities in the deep benthos. The importance of competitive exclusion mentioned above relates directly to the abundance and distribution of nutrients.

The food materials of the benthic fauna in the proposed and alternative sites, the associated food sources, and transport mechanisms are not completely known. Several dominant species of fish in the 106-Mile Ocean Waste Disposal Site are known to feed strictly on the epibenthic and infaunal invertebrates, but other fish feed primarily on pelagic items (Cohen and

Pawson, 1977; Musick et al., 1975). Most of these pelagic species were diurnal migrants correlating with the views of Sanders and Hessler (1969) regarding the importance of these migrants in efficient transport of food from the euphotic zone to deeper layers. The majority of fish at the site are probably generalized feeders, since this is characteristic of the fish at deeper depths (Haedrich et al., 1975) and many generalized feeding fish have been found at the site (Musick et al., 1975).

Based on studies at the 106-Mile Ocean Waste Disposal Site by Jones and Haedrich (1977) and Pearce (1974) the dominant epibenthic and infaunal invertebrates of the proposed and alternative sites are believed to be deposit feeders whose abundance and distribution would depend on the availability of detrital food items. It is generally recognized that the food supply of the benthos originates from shallower areas, particularly the euphotic zone, (Sanders and Hessler, 1969) but the primary method by which the food is transported to the deeper layers is uncertain. The most important transportation of detritus (to the benthos of the site) is probably the passive sinking of potential food items. Turbidity currents may also play some minor part, but their role has been discounted (Sanders and Hessler, 1969).

Many authors have recognized distinct quantitative and qualitative zones of distribution for the benthic fauna in Continental Slope areas of the mid-Atlantic. The number and demarcation of zones may vary between authors, but all authors center the zones on one axis, horizontal or vertical, to the Slope. Cohen and Pawson (1977) mention a horizontal distribution pattern of benthic fish and invertebrates at the site. They observed great variance in the abundance of the four most commonly seen epibenthic invertebrates from one site area to the next, but were hesitant to label this distribution as patchy.

Surveys of the benthos in the 106-Mile Ocean Waste Disposal Site have found no species of present commercial importance, and only a few of potential importance. The shellfish commonly harvested on the adjacent shelf, including the surf clam, sea scallop, and southern quahog, do not extend their ranges to the Continental Slope. The lobster, Homarus americanus, is presently fished in Canyon and Shelf areas to the north and west (Pratt, 1973). The red crab,

Geryon quinquidens, is a potential commercial species of the mid-Atlantic but is found only in Slope areas to the north and west (Musick et al., 1975; Pratt, 1973).

No demersal fishes of commercial importance are presently being harvested from the vicinity of the proposed site, and only a few potential species have been found in the region. Two dominant site species, Coryphaenoides rupestris and Alepocephalus agassizii, have been experimentally harvested by the Russian and British fishing industries from areas west of the 106-Mile Ocean Waste Disposal Site. The 106-Mile Ocean Waste Disposal Site is known to serve as a nursing ground for Glyptocephalus cynoglossus, the adults of which support a fishery elsewhere (Musick et al., 1975). The previously recommended site (Paige et al., 1978) encompasses Shelf areas popular among foreign fishing industries.

BIRDS

Thirty-nine species of marine birds (Table A-21) are known to frequent the offshore and coastal waters of the mid-Atlantic Bight (Gusey, 1976; Heppner and Gould, 1973; Murphy, 1967). The abundances range from occasional to common, and most often exhibit migratory or seasonal variability. A few species are thought to be rare or endangered in some parts of their range; however, none are considered endangered species in the region of the mid-Atlantic Bight.

Wilson (1967) lists nine pelagic birds as regular (year-round) inhabitants in the vicinity of the proposed Incineration Site: the North Atlantic shearwater, greater shearwater, sooty shearwater, Leach's storm petrel, Wilson's storm petrel, gannet, red phalarope, northern phalarope, and parasitic jager. Moore (1951) presents observational information for several of these birds. For all reported species winter observations show that few birds frequent the proposed site region between November and March. The summer months between April and October produce the greatest number of bird sightings. May and June sightings generally produce the highest average counts.

TABLE A-21
MARINE BIRDS AND MIGRATORY WATERFOWL OF THE
MID-ATLANTIC BIGHT AREA WHICH USE WATERS MORE THAN 5 MILES OFFSHORE

Common Name	Scientific Name	Frequency In Area*	Status	Distribution	
				Pelagic	Littoral
Black-capped petrel	Pterodroma hasitata	O		X	
Gannet	Morus bassanus	C, AM		X	X
Red phalarope	Phaloropus fulicarius	CM		X	X
Northern phalerope	Lobipes lobatus	O		X	X
Pomerine jaeger	Stercorarius pomarinus	O		X	X
Parasitic jaeger	Stercorarius parasiticus	RM		X	X
Long-tailed jaeger	Stercorarius logicaudus	O		X	
Black-legged kittiwake	Rissa tridactyla	CW		X	X
Arctic tern	Sterna paradisaea	O		X	
Skua	Catharacta skua	O		X	X
Razorbill auk	Alca torda	O		X	X
Common murre	Uria aalge	O		X	X
Thick-billed murre	Uria lomvia	O		X	X
Dovekie	Plautus alle	O		X	X
White-tailed tropic bird	Phaethon lepturus	O		X	
Blue-faced booby	Sula dactylatra	C (in south)	Peripheral	X	
Frigate bird	Fregata magnificens	O (in south)		X	
Common loon	Gavia immer	C, SA		X	
Red-throated loon	Gavia stellata	C, SA		X	
Red-necked grebe	Podiceps grisegena	U, SC		X	
Horned grebe	Podiceps auritus	C, SA		X	
Common goldeneye	Bucephala clangula	CW		X	
Bufflehead	Bucephala albeola	C, AW		X	
Oldsquaw	Clangula hyemalis		C		X
Common eider	Somateria mollissima	C, AW		X	
White-winged scoter	Melanitta deglandi	AM		X	
Surf scoter	Melanitta perspicillata	C, AM		X	
Common scoter	Oidemia nigra	C, AM		X	
Fulmar	Fulmarus glacialis	O		X	X
Cory's shearwater	Puffinus diomedea	C, AM		X	X
Greater shearwater	Puffinus gravis	O		X	X
Sooty shearwater	Puffinus griseus	O		X	X
Audubon's shearwater	Puffinus puffinus	O		X	X
Manx shearwater	Puffinus puffinus	O	Threatened (Hawaii)	X	
Leach's storm petrel	Oceanodroma leucorhoa	O	Declining	X	X
Wilson's storm petrel	Oceanites oceanicus	C	Declining	X	X
Frigate storm petrel	Pelagodroma marina	O		X	
Harcourt's storm petrel	Oceanodroma castro	O		X	
Bermuda petrel	Pterodroma cahow	O		X	

*O = Occasional
C = Common
AM = Abundant migrant
CM = Common migrant
RM = Regular migrant;
CW = Common in winter
SA = Seasonally abundant
SC = Seasonally common
AW = Abundant in winter

Sources: Compiled from Gusey, 1976; Heppner and Gould, 1973; Murphy, 1967

Several bird migration routes occur over the western north Atlantic Ocean and are used by numerous species of terrestrial and marine birds (Williams and Williams, 1978b), as shown in Figure A-12. During annual autumnal migration perhaps 100 million birds leave northeastern coastal areas for the Caribbean Islands or South America.

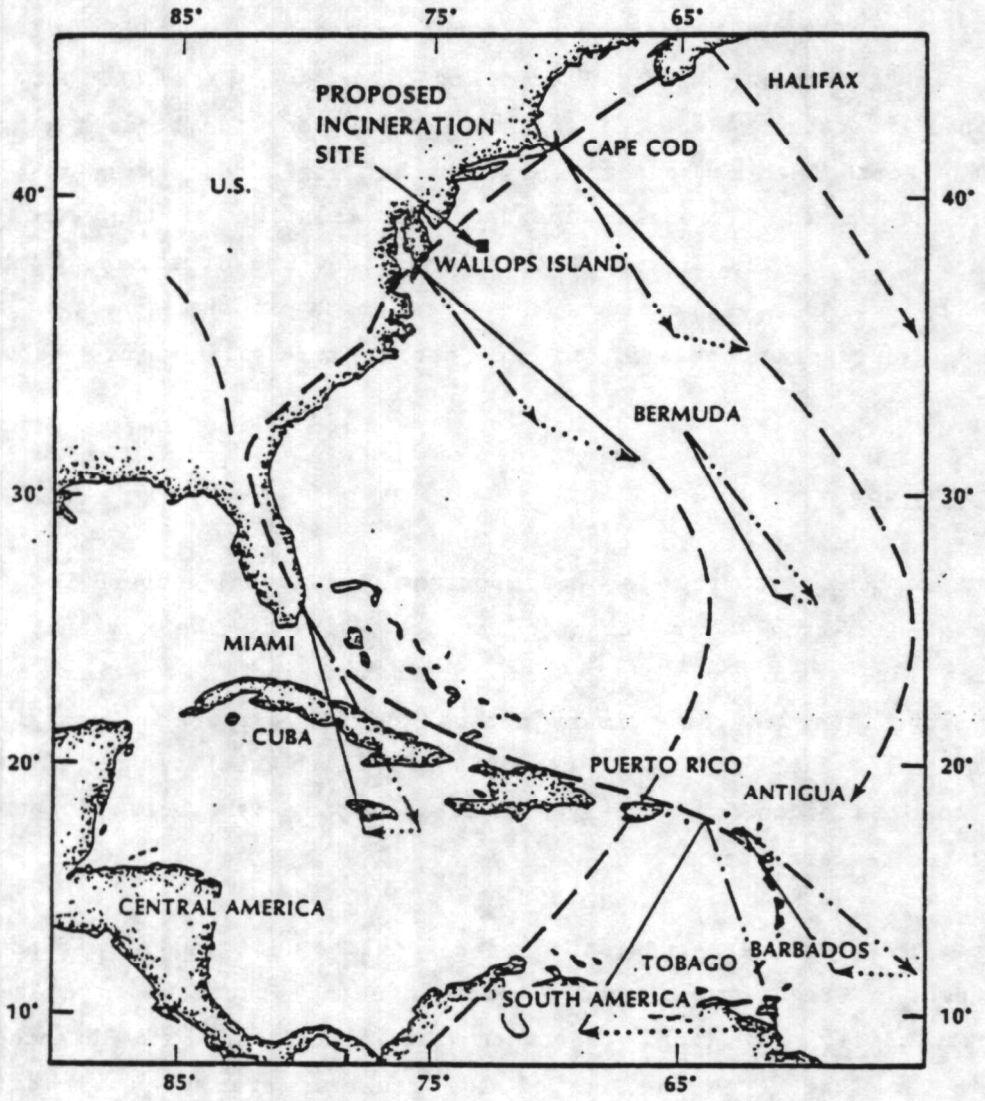

Figure A-12. Bird Migration Routes
Source: Adapted from "An Oceanic Mass Migration of Land Birds," T.C. Williams and J.M. Williams

The actual numbers of species using the routes are still uncertain, but the Manomet Bird Observatory located at Manomet, Massachusetts, maintains a list of birds known to use the routes (Table A-22). This list includes terrestrial and marine birds observed in the western North Atlantic.

Bird migration routes from North America to the Caribbean Islands and South America (Figure A-12) are based on radar observations from Halifax, Cape Cod, Wallops Island, Bermuda, Miami, Puerto Rico, Antigua, Barbados, and Tobago. Broken lines indicate two sets of possible routes, one for birds flying along or near the North American coast, and the other for birds making most of the trip over the ocean. Triangles indicate the relation of the wind to the heading and track of the birds. Dotted lines show the direction of the wind (with relative wind speed indicated by the length of the line). Dash-dot lines show the average heading of the birds, and solid lines show their average track.

FOREIGN FISHERIES

Foreign fishing activity is an important commercial enterprise in the oceanic region of the North Atlantic Ocean. Japan is the dominant country maintaining fleets fishing in the open ocean off the U.S. Atlantic coast, utilizing longlining as the primary method for the capture of pelagic fish. Taiwan and Korea fish the area intermittently with similar gear. Fishing ships follow the migratory pathways of tuna, paying particular attention to surface water temperatures.

Sets are made with gear consisting of a longline (100 km) with floats, and radio beacons or light buoys spaced every 368m and connected by a length of line approximately 20m long. Between the floats are six branch lines (gangions) 23m long. At the end of the gangions are hooks (of differing sizes, depending on fish to be captured) that are baited with squid, mackerel, or saury. A set usually consists of 2,160 hooks, which are deployed and retrieved within a 24-hour period. When giant bluefin are sought a shorter longline with fewer hooks is used because the vessel must stop to land each fish.

TABLE A-22
COMMON TO ABUNDANT BIRD SPECIES MIGRATING ANNUALLY
FROM NORTH AMERICA TO THE CARIBBEAN ISLANDS AND SOUTH AMERICA

Pied-billed Grebe	Ring-billed Gull
White-tailed Tropic-Bird	Common Tern
Great Blue Heron	Arctic Tern
Little Blue Heron	Yellow-billed Cuckoo
Black Duck	Common Nighthawk
Green-winged Teal	Belted Kingfisher
Blue-winged Teal	Yellow-bellied Sapsucker
American Widgeon	Barn Swallow
Merlin (Pigeon Hawk)	Hermit Thrush
Sora Rail	Cedar Waxwing
Common Gallinule	Red-eyed Vireo
American Coot	Black-and-White Warbler
Semipalmated Plover	Prothonotary Warbler
Killdeer	Parula Warbler
American Golden Plover	Yellow Warbler
Black-bellied Plover	Magnolia Warbler
Ruddy Turnstone	Cape May Warbler
Common Snipe	Myrtle Warbler
Spotted Sandpiper	Black-throated Green Warbler
Solitary Sandpiper	Blackpoll Warbler
Greater Yellowlegs	Western Palm Warbler
Lesser Yellowlegs	Ovenbird
Pectoral Sandpiper	Northern Waterthrush
White-rumped Sandpiper	Yellowthroat
Least Sandpiper	Hooded Warbler
Short-billed Dowitcher	American Redstart
Stilt Sandpiper	Bobolink
Semipalmated Sandpiper	Baltimore Oriole
Sanderling	Indigo Bunting
Red Phalarope	Common Redpoll
Pomarine Jaeger	Pine Siskin
Great Black-backed Gull	Savannah Sparrow
Herring Gull	Snow Bunting

Source: Manomet Bird Observatory, Manomet, Massachusetts

In order to evaluate the fishery of the middle Atlantic area, including the proposed Incineration Site, information from the National Marine Fisheries Service (NMFS), Foreign Fisheries Observer Program, Southeast Region (Table A-23) and the Japanese Far Seas Laboratory (Table A-24) are utilized.

The U.S. Observer Program maintains a 20% coverage of foreign fishing effort in U.S. waters; thus, the overall effort and catch is estimated by applying a factor of 5 to the observations of U.S. fisheries personnel. U.S. Observer statistics utilized in this discussion are taken from NMFS statistics for the oceanic region between 71°00'W to 74°00'W and 37°00'N to 39°00'N. The Japanese statistics are reported for two 5-degree-square areas. A western area, bounded by 75°00'W to 70°00'W and 35°00'N to 40°00'N, contains the proposed site. An eastern area, bounded by 70°00'W to 65°00'W and 35°00'N to 40°00'N, lies in the Sargasso Sea. U.S. Observer data have been obtained for an area 15 times larger than the proposed Incineration Site, whereas Japanese statistics are from areas 57 times larger than the proposed site. The object of the following comparison is to determine, on the basis of available information, if the proposed site area produced greater catch per unit effort than the larger area along the migratory pathway of tunas. Of secondary importance is quantity and fish species caught.

U.S. Observer data report fishing efforts that occurred in January, July, and November 1979, and August through December 1980. The greatest number of sets in a single month (November 1979) was 14, with 11 in September 1980. The only year that may be directly compared is 1979, based on U.S. Observer data and Japanese catch reports. This comparison is reported as 1979 extrapolation of 100% coverage for 75° to 70°W, 35° to 40°N (Table A-23).

To compensate for the disparity between the smaller U.S. Observer surface area and the larger Japanese statistical area, a factor of 4.17 has been applied to the U.S. Observer data. Similarly, the 1979 extrapolation of 100% coverage also includes a factor of 5 to account for the 20% coverage by U.S. Observer Program. These data indicate that the U.S. Observer area had proportionately the same number of sets as the larger Japanese statistical

TABLE A-23
NUMBERS OF FISH CAUGHT PER YEAR BY GEOGRAPHICAL LOCATION

	Sets	Bluefin	Bigeye	Yellowfin	Skipjack	Albacore	Blackfin	Little Tuna	Atlantic Bonito	Tuna*	Blue Marlin	White Marlin	Sailfish	Swordfish	Sharks	Other Fish
20% Coverage U.S. Observer Data 71° to 74°W; 37° to 39°N (1979)	19	-	201	182	3	309	-	-	-	1	1	17	-	27	612	615
Extrapolation of 100% Coverage 75° to 70°W; 35° to 40°N (A x 4.17 x 5) (1979)	396	-	4,191	3,795	63	6,443	-	-	-	21	21	354	-	563	12,760	12,813
20% Coverage U.S. Observer Data 71° to 74°W; 37° to 39°N (1980)	23	-	336	17	-	91	-	-	-	1	1	30	-	15	732	599
U.S. Observer Data 71° to 74°W; 37° to 34°N Total (1979 and 1980) (A + C)	42	-	537	199	3	400	-	-	-	2	2	47	-	42	1,344	1,214
U.S. Observer Data 71° to 74°W; 37° to 39°N Average per year (A + C ÷ 2)	21	-	269	100	2	200	-	-	-	1	1	24	-	21	672	607
100% Coverage per year Estimate for 71° to 74°W; 37° to 39°N (E x 5)	105	-	1,345	500	10	1,000	-	-	-	5	5	120	-	105	3,360	3,035
100% Coverage per year Estimate for 70° to 75°W; 35° to 40°N (F x 4.17)	438	-	5,609	2,085	42	4,170	-	-	-	21	21	500	-	438	14,011	12,656
Estimate of % Species Composition 35° to 40°N; 70° to 75°W (1979 and 1980)	-	-	16%	5%	0.1%	11%	-	-	-	0.1%	0.1%	1.3%	-	1.1%	35.6%	32%

*Unidentified

Sources: NMFS, Southwest Region 1974-1979; Japanese Far Seas Laboratory, 1974-1979

TABLE A-24
JAPANESE CATCH STATISTICS BY YEAR FOR TWO NORTH ATLANTIC STATISTICAL AREAS
(Numbers of Fish)

	Sets	Hooks	Bluefin	Albacore	Bigeye	Yellowfin
			35° to 40°N; 70° to 75°W			
1974	565	1,191,816	17	2,865	2,561	22,136
1975	436	925,107	5	4,500	11,679	12,531
1976	695	1,520,737	2,194	7,025	8,568	13,194
1977	307	644,740	839	3,897	4,223	7,398
1978	684	1,443,783	4,955	5,126	13,243	13,827
1979	393	894,093	7	2,959	3,033	13,851
Total (6 years)	3,080	6,620,276	8,017	26,372	43,307	83,437
Average per year	513	1,109,379	1,336	4,395	7,218	13,906
			35° to 40°N; 65° to 70°W			
1974	221	465,377	1,770	3,857	1,307	6,873
1975	61	131,697	9	583	809	1,365
1976	649	1,404,465	4,528	10,149	7,451	16,556
1977	651	1,311,276	13,921	17,379	8,400	1,381
1978	554	1,186,302	1,297	7,164	9,398	7,534
1979	776	1,618,680	2,361	15,607	9,174	13,631
Total (6 years)	2,912	6,117,797	23,886	54,739	36,544	47,340
Average per year	485	1,019,633	3,981	9,123	6,091	7,890

Source: Japanese Far Seas Laboratory, 1974-1979

area, with a prediction of 396 sets, based on U.S. observer coverage (Table A-23), and 393 sets reported by the Japanese fleet in 1979 (Table A-24). The data also indicate that effort was directed at catching yellowfin tuna (and other smaller tunas) from 1974 to 1980, using an average of 2,160 hooks per set.

Numbers of tuna caught (as reported by the Japanese) are highly reliable; whereas numbers of other fish caught are less useful. This is true because all other fish are prohibited by the 200-mile limit (Federal Register, 1978), and a directed fishery must (by definition) produce greater than 50% of the fish being sought. U.S. observer data are the best information on incidental catch (fish other than tunas).

A comparison of estimated catch of tunas with the reported catch indicates that bigeye are sometimes caught more frequently in the U.S. Observer area than in the Japanese statistical area; yellowfin, however, appear to be caught more often (by a factor of 5) somewhere other than in the U.S. observer area. The albacore catch is evenly distributed. Incidental catches appear to be composed of roughly equal numbers of sharks and other pelagic fish, including lancetfish, wahoo, king mackerel, and dolphin. Sharks are mako, blue, and thresher, with blue sharks probably being the most numerous. Billfish are mostly white marlin and swordfish.

To determine if the western Japanese statistical area (75° to 70°W and 35° to 40°N) produces more fish than the eastern Japanese statistical area (70° to 65°W and 35° to 40°), Japanese catch statistics for 1974 through 1979 were examined. Over that 6-year period 51% of combined effort was expended in the western area, whereas 49% was expended in the eastern area. Catch of each species (per unit effort) was varied during each year within each area, but over the entire 6-year period it can be concluded that albacore and giant bluefin are produced more from the eastern area, whereas yellowfin are caught more frequently in the western area. Bigeye are only slightly more abundant in the western area than the eastern.

Appendix B

AT-SEA INCINERATION REGULATIONS AND GUIDELINES

CONTENTS

ANNEXES TO THE INTERNATIONAL CONVENTION ON THE PREVENTION OF MARINE POLLUTION BY DUMPING OF WASTES AND OTHER MATTER

ANNEXES

ARTICLE IV

1. In accordance with the provisions of this Convention Contracting Parties shall prohibit the dumping of any wastes or other matter in whatever form or condition except as otherwise specified below:

(*a*) the dumping of wastes or other matter listed in Annex I is prohibited;

(*b*) the dumping of wastes or other matter listed in Annex II requires a prior special permit;

(*c*) the dumping of all other wastes or matter requires a prior general permit.

2. Any permit shall be issued only after careful consideration of all the factors set forth in Annex III, including prior studies of the characteristics of the dumping site, as set forth in Sections B and C of that Annex.

3. No provision of this Convention is to be interpreted as preventing a Contracting Party from prohibiting, insofar as that Party is concerned, the dumping of wastes or other matter not mentioned in Annex I. That Party shall notify such measures to the Organisation.

ANNEX I

1. Organohalogen compounds.
2. Mercury and mercury compounds.
3. Cadmium and cadmium compounds.
4. Persistent plastics and other persistent synthetic materials, for example, netting and ropes, which may float or may remain in suspension in the sea in such a manner as to interfere materially with fishing, navigation or other legitimate uses of the sea.
5. Crude oil, fuel oil, heavy diesel oil, and lubricating oils, hydraulic fluids, and any mixtures containing any of these, taken on board for the purpose of dumping.
6. High-level radio-active wastes or other high-level radio-active matter, defined on public health, biological or other grounds, by the competent international body in this field, at present the International Atomic Energy Agency, as unsuitable for dumping at sea.
7. Materials in whatever form (e.g. solids, liquids, semi-liquids, gases or in a living state) produced for biological and chemical warfare.
8. The preceding paragraphs of this Annex do not apply to substances which are rapidly rendered harmless by physical, chemical or biological processes in the sea provided they do not:
   (i) make edible marine organisms unpalatable. or
   (ii) endanger human health or that of domestic animals.

The consultative procedure provided for under Article XIV should be followed by a Party if there is doubt about the harmlessness of the substance.

9. This Annex does not apply to wastes or other materials (e.g. sewage sludges and dredged spoils) containing the matters referred to in paragraphs 1-5 above as trace contaminants. Such wastes shall be subject to the provisions of Annexes II and III as appropriate.

ANNEX II

The following substances and materials requiring special care are listed for the purposes of Article VI(1)(a).

A. Wastes containing significant amounts of the matters listed below:

arsenic, lead, copper, zinc } and their compounds

organosilicon compounds
cyanides
fluorides
pesticides and their by-products not covered in Annex I.

B. In the issue of permits for the dumping of large quantities of acids and alkalis, consideration shall be given to the possible presence in such wastes of the substances listed in paragraph A and to the following additional substances:

beryllium
chromium
nickel
vanadium
} and their compounds

C. Containers, scrap metal and other bulky wastes liable to sink to the sea bottom which may present a serious obstacle to fishing or navigation.

D. Radio-active wastes or other radio-active matter not included in Annex I. In the issue of permits for the dumping of this matter, the Contracting Parties should take full account of the recommendations of the competent international body in this field, at present the International Atomic Energy Agency.

ANNEX III

Provisions to be considered in establishing criteria governing the issue of permits for the dumping of matter at sea, taking into account Article IV(2), include:

A. Characteristics and composition of the matter

1. Total amount and average composition of matter dumped (e.g. per year).
2. Form, e.g. solid, sludge, liquid, or gaseous.
3. Properties: physical (e.g. solubility and density), chemical and biochemical (e.g. oxygen demand, nutrients) and biological (e.g. presence of viruses, bacteria, yeasts, parasites).
4. Toxicity.
5. Persistence: physical, chemical and biological.
6. Accumulation and biotransformation in biological materials or sediments.
7. Susceptibility to physical, chemical and biochemical changes and interaction in the aquatic environment with other dissolved organic and inorganic materials.
8. Probability of production of taints or other changes reducing marketability of resources (fish, shellfish, etc.).

B. Characteristics of dumping site and method of deposit

1. Location (e.g. co-ordinates of the dumping area, depth and distance from the coast), location in relation to other areas (e.g. amenity areas, spawning, nursery and fishing areas and exploitable resources).
2. Rate of disposal per specific period (e.g. quantity per day, per week, per month).

3. Methods of packaging and containment, if any.

4. Initial dilution achieved by proposed method of release.

5. Dispersal characteristics (e.g. effects of currents, tides and wind on horizontal transport and vertical mixing).

6. Water characteristics (e.g. temperature, pH, salinity, stratification, oxygen indices of pollution—dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD)—nitrogen present in organic and mineral form including ammonia, suspended matter, other nutrients and productivity).

7. Bottom characteristics (e.g. topography, geochemical and geological characteristics and biological productivity).

8. Existence and effects of other dumpings which have been made in the dumping area (e.g. heavy metal background reading and organic carbon content).

9. In issuing a permit for dumping, contracting Parties should consider whether an adequate scientific basis exists for assessing the consequences of such dumping, as outlined in this Annex, taking into account seasonal variations.

C. General considerations and conditions

1. Possible effects on amenities (e.g. presence of floating or stranded material, turbidity, objectionable odour, discolouration and foaming).

2. Possible effects on marine life, fish and shellfish culture, fish stocks and fisheries, seaweed harvesting and culture.

3. Possible effects on other uses of the sea (e.g. impairment of water quality for industrial use, underwater corrosion of structures, interference with ship operations from floating materials, interference with fishing or navigation through deposit of waste or solid objects on the sea floor and protection of areas of special importance for scientific or conservation purposes).

4. The practical availability of alternative land-based methods of treatment, disposal or elimination, or of treatment to render the matter less harmful for dumping at sea.

MANDATORY REGULATIONS WITH AMENDMENTS TO ANNEXES TO THE CONVENTION

THE THIRD CONSULTATIVE MEETING,

RECALLING Article I of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, which provides that Contracting Parties shall individually and collectively promote the effective control of all sources of pollution of the marine environment,

HAVING NOTED the use of incineration at sea as a means of disposal of wastes containing highly toxic substances and the consequent risks of marine and atmospheric pollution which may result from this process,

DESIRING to prevent such pollution and to minimize the risk of hazards to other vessels or interference with other legitimate uses of the sea which could arise from incineration operations at sea,

RECOGNIZING present methods of incineration at sea as being an interim method of disposal of wastes pending the development of environmentally better solutions, considering at all times the best available technology,

AFFIRMING that the intention of the adoption of mandatory provisions for the control of incineration at sea is not to increase the amounts and kinds of wastes or other matter incinerated at sea for which there are available practical alternative land-based methods of treatment, disposal or elimination,

REAFFIRMING that, in accordance with Article IV(3) of the Convention, Contracting Parties can apply additional regulations for incineration at sea on a national basis,

NOTING that Article VIII of the Convention encourages Contracting Parties, within the framework of regional conventions, to develop further agreements reflecting the conditions of the geographical area concerned,

RECALLING the decision of the Second Consultative Meeting that provisions for the control of incineration at sea should be implemented by Contracting Parties on a mandatory basis in the form of a legal instrument adopted within the framework of the Convention (LDC II/11, Annex II),

HAVING CONSIDERED the proposed amendments to the Annexes of the Convention for the control of incineration at sea contained in the Report of the Ad Hoc Group of Legal Experts on Dumping,

ADOPTS the following amendments to the Annexes to the Convention in accordance with Articles XIV(4)(a) and XV(2) thereof:

(a) addition of a paragraph 10 to Annex I;

(b) addition of a paragraph E to Annex II; and

(c) addition of an Addendum to Annex I, containing Regulations for the Control of Incineration of Wastes and Other Matter at Sea,

the texts of which are set out in Attachment to this Resolution,

ENTRUSTS the Inter-Governmental Maritime Consultative Organization with the task of ensuring, in collaboration with the Governments of France, Spain, the Union of Soviet Socialist Republics and the United Kingdom, that the texts of the above Amendments are drawn up by 1 December 1978 in all official languages of the Convention with the linguistic consistency in each text, which would then become the authentic text of the Annexes to the Convention in the English, French, Russian and Spanish languages,

RESOLVES that for the purposes of Articles XIV(4)(a) and XV(2) of the Convention, 1 December 1978 shall be treated as the date of the adoption of the amendments,

REQUESTS the Secretary-General of the Organization to inform Contracting Parties of the above-mentioned amendments,

REQUESTS the Ad Hoc Group on Incineration at Sea to prepare draft Technical Guidelines for the Control of Incineration of Wastes and Other Matter at Sea with a view to adoption by the Fourth Consultative Meeting,

INVITES Contracting Parties to implement, as an interim measure, the existing Technical Guidelines (LDC II/II, Annex II, with amendments (IAS/9, Annex IV)) and the notification procedure set out in Annex 2 to LDC III/12.

Attachment

AMENDMENTS TO ANNEXES TO THE CONVENTION ON THE PREVENTION OF MARINE POLLUTION BY DUMPING OF WASTES AND OTHER MATTER CONCERNING INCINERATION AT SEA

The following paragraph shall be added to Annex I:

10. Paragraphs 1 and 5 of this Annex do not apply to the disposal of wastes or other matter referred to in these paragraphs by means of incineration at sea. Incineration of such wastes or other matter at sea requires a prior special permit. In the issue of special permits for incineration the Contracting Parties shall apply the Regulations for the Control of Incineration of Wastes and Other Matter at Sea set forth in the Addendum to this Annex (which shall constitute an integral part of this Annex) and take full account of the Technical Guidelines on the Control of Incineration of Wastes and Other Matter at Sea adopted by the Contracting Parties in consultation.

The following paragrpah shall be added to Annex II:

E. In the issue of special permits for the incineration of substances and materials listed in this Annex, the Contracting Parties shall apply the Regulations for the Control of Incineration of Wastes and Other Matter at Sea set forth in the Addendum to Annex I and take full account of the Technical Guidelines on the Control of Incineration of Wastes and Other Matter at Sea adopted by the Contracting Parties in consultation, to the extent specified in these Regulations and Guidelines.

ADDENDUM

REGULATIONS FOR THE CONTROL OF INCINERATION OF WASTES AND OTHER MATTER AT SEA

PART I

REGULATION 1

Definitions

For the purposes of this Addendum:

(1) "Marine incineration facility" means a vessel, platform, or other man-made structure operating for the purpose of incineration at sea.

(2) "Incineration at sea" means the deliberate combustion of wastes or other matter on marine incineration facilities for the purpose of their thermal destruction. Activities incidental to the normal operation of vessels, platforms or other man-made structures are excluded from the scope of this definition.

REGULATION 2

Application

(1) Part II of these Regulations shall apply to the following wastes or other matter:

(a) those referred to in paragraph 1 of Annex I;

(b) pesticides and their by-products not covered in Annex I.

(2) Contracting Parties shall first consider the practical availability of alternative land-based methods of treatment, disposal or elimination, or of treatment to render the wastes or other matter less harmful, before issuing a permit for incineration at sea in accordance with these Regulations. Incineration at sea shall in no way be interpreted as discouraging progress towards environmentally better solutions including the development of new techniques.

(3) Incineration at sea of wastes or other matter referred to in paragraph 10 of Annex I and paragraph E of Annex II, other than those referred to in paragraph (1) of this Regulation, shall be controlled to the satisfaction of the Contracting Party issuing the special permit.

(4) Incineration at sea of wastes or other matter not referred to in paragraphs (1) and (3) of this Regulation shall be subject to a general permit.

(5) In the issue of permits referred to in paragraphs (3) and (4) of this Regulation, the Contracting Parties shall take full account of all applicable provisions of these Regulations and the Technical Guidelines on the Control of Incineration of Waste and Other Matter at Sea for the waste in question.

PART II

REGULATION 3

Approval and Surveys of the Incineration System

(1) The incineration system for every proposed marine incineration facility shall be subject to the surveys specified below. In accordance with Article VII(1) of the Convention, the Contracting Party which proposes to issue an incineration permit shall ensure that the surveys of the marine incineration facility to be used have been completed and the incineration system complies with the provisions of these Regulations. If the initial survey is carried out under the direction of a Contracting Party a special permit, which specifies the testing requirements, shall be issued by the Party. The results of each survey shall be recorded in a survey report.

(a) An initial survey shall be carried out in order to ensure that during the incineration of waste and other matter combustion and destruction efficiencies are in excess of 99.9 per cent.

(b) As a part of the initial survey the State under whose direction the survey is being carried out shall:

(i) approve the siting, type and manner of use of temperature measuring devices;

(ii) approve the gas sampling system including probe locations, analytical devices, and the manner of recording;

(iii) ensure that approved devices have been installed to automatically shut off the feed of waste to the incinerator if the temperature drops below approved minimum temperatures;

(iv) ensure that there are no means of disposing of wastes or other matter from the marine incineration facility except by means of the incinerator during normal operations;

(v) approve the devices by which feed rates of waste and fuel are controlled and recorded;

(vi) confirm the performance of the incineration system by testing under intensive stack monitoring, including the measurements O_2, CO, CO_2, halogenated organic content, and total hydrocarbon content using wastes typical of those expected to be incinerated

(c) The incineration system shall be surveyed at least every two years to ensure that the incinerator continues to comply with these Regulations. The scope of the biennial survey shall be based upon an evaluation of operating data and maintenance records for the previous two years.

(2) Following the satisfactory completion of a survey, a form of approval shall be issued by a Contracting Party if the incineration system is found to

be in compliance with these Regulations. A copy of the survey report shall be attached to the form of approval. A form of approval issued by a Contracting Party shall be recognized by other Contracting Parties unless there are clear grounds for believing that the incineration system is not in compliance with these Regulations. A copy of each form of approval and survey report shall be submitted to the Organization.

(3) After any survey has been completed, no significant changes which could affect the performance of the incineration system shall be made without approval of the Contracting Party which has issued the form of approval.

REGULATION 4

Wastes Requiring Special Studies

(1) Where a Contracting Party has doubts as to the thermal destructibility of the wastes and other matter proposed for incineration, pilot scale tests shall be undertaken.

(2) Where a Contracting Party proposes to permit incineration of wastes or other matter over which doubts as to the efficiency of combustion exist, the incineration system shall be subject to the same intensive stack monitoring as required for the initial incineration system survey. Consideration shall be given to the sampling of particulates, taking into account the solid content of the wastes.

(3) The minimum approved flame temperature shall be that specified in Regulation 5 unless the results of tests on the marine incineration facility demonstrate that the required combustion and destruction efficiency can be achieved at a lower temperature.

(4) The results of special studies referred to in paragraphs (1) (2) and (3)

of this Regulation shall be recorded and attached to the survey report. A copy shall be sent to the Organization.

REGULATION 5

Operational Requirements

(1) The operation of the incineration system shall be controlled so as to ensure that the incineration of wastes or other matter does not take place at a flame temperature less than 1250 degrees centigrade, except as provided for in Regulation 4.

(2) The combustion efficiency shall be at least 99.95± 0.05% based on:

$$\text{Combustion efficiency} = \frac{C_{CO_2} - C_{CO}}{C_{CO_2}} \times 100$$

where C_{CO_2} = concentration of carbon dioxide in the combustion gases

C_{CO} = concentration of carbon monoxide in the combustion gases.

(3) There shall be no black smoke nor flame extension above the plane of the stack.

(4) The marine incineration facility shall reply promptly to radio calls at all times during the incineration.

REGULATION 6

Recording Devices and Records

(1) Marine incineration facilities shall utilize recording devices or methods as approved under Regulation 3. As a minimum, the following data shall be recorded during each incineration operation and retained for inspection by the Contracting Party who has issued the permit:

(a) continuous temperature measurements by approved temperature measuring devices;

(b) date and time during incineration and record of waste being incinerated;

(c) vessel position by appropriate navigational means;

(d) feed rates of waste and fuel - for liquid wastes and fuel the flow rate shall be continuously recorded; the latter requirement does not apply to vessels operating on or before 1 January 1979;

(e) CO and CO_2 concentration in combustion gases;

(f) vessel's course and speed.

(2) Approval forms issued, copies of survey reports prepared in accordance with Regulation 3 and copies of incineration permits issued for the wastes or other matter to be incinerated on the facility by a Contracting Party shall be kept at the marine incineration facility.

REGULATION 7

Control over the Nature of Wastes Incinerated

A permit application for the incineration of wastes or other matter at sea shall include information on the characteristics of wastes or other matter sufficient to comply with the requirements of Regulation 9.

REGULATION 8

Incineration Sites

(1) Provisions to be considered in establishing criteria governing the selection of incineration sites shall include, in addition to those listed in Annex III to the Convention, the following:

(a) the atmospheric disperal characteristics of the area - including

wind speed and direction, atmospheric stability, frequency of inversions and fog, precipitation types and amounts, humidity - in order to determine the potential impact on the surrounding environment of pollutants released from the marine incineration facility, giving particular attention to the possibility of atmospheric transport of pollutants to coastal areas;

(b) oceanic dispersal characteristics of the area in order to evaluate the potential impact of plume interaction with the water surface;

(c) availability of navigational aids.

(2) The coordinates of permanently designated incineration zones shall be widely disseminated and communicated to the Organization.

REGULATION 9

Notification

Contracting Parties shall comply with notification procedures adopted by the Parties in consultation.

TECHNICAL GUIDELINES ON THE CONTROL OF INCINERATION OF WASTES AND OTHER MATTER AT SEA

1. INTRODUCTION

1.1 In 1978 the Third Consultative Meeting of Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter adopted Resolution LDC Resolution 5(III) by which it approved the following amendments to the Annexes to the Convention concerning the prevention and control of pollution by incineration of wastes and other matter at sea:

.1 the addition of a paragraph 10 to Annex I;

.2 the addition of a paragraph E to Annex II; and

.3 the addition of an Addendum to Annex I, containing Regulations for the Control of Incineration of Wastes and Other Matter at Sea.

1.2 Under these amendments, the Contracting Parties shall, in the issue of permits for incineration, apply the Regulations for the Control of Incineration of Wastes and Other Matter at Sea and take full account of the Technical Guidelines on the Control of Incineration of Wastes and Other Matter at Sea adopted by the Contracting Parties in consultation. The requirements for the issue of permits for different types of wastes are summarized in the following table:

Substances	Permit	Regulations	Technical Guidelines
1. Organohalogen compounds; Pesticides and by-products	Special	All provisions of the Regulations in Parts I and II to be applied	All provisions of the Technical Guidelines to be taken into full account
2. Crude oil, fuel oil, etc. taken on board for purpose of disposa;; Annex II substances (without pesticides)	Special	Control to the satisfaction of Contracting Parties taking into account: all applicable provisions of Regulations in Parts I and II	all applicable provisions of the Technical Guidelines
3. Substances not mentioned under 1 and 2 above	General	as under 2 above	

1.3 The present Guidelines have been developed on the basis of existing scientific knowledge of the incineration process and on a knowledge of current technology. Although the state of knowledge on the incineration of liquid organochlorine wastes in existing vessels has enabled specific guidelines to be drawn up covering the incineration of these wastes, there remain types of wastes where knowledge is insufficient at present. Scientific work and technical development is, however, proceeding and consequently these Guidelines should be kept under review as the results of further research and investigations become available.

1.4 These Technical Guidelines apply to wastes or other matter loaded or kept on board marine incineration facilities which are defined in Regulation 1(1) and include vessels, platforms or other man-made structures which might at some future date carry out factory operations and generate wastes which could be incinerated at sea. Incineration at

sea is defined in Regulation 1(2) and exclude activities incidential to the normal operation of ships (e.g. combustion of ship-generated garbage) or platforms (e.g. flaming of gas from oil production or exploration).

1.5 The incineration of a waste at sea must be controlled to safeguard a number of uses of the marine environment as laid down in Annex III to the Convention. Additionally the Resolution of the First Consultative Meeting of Contracting Parties to the London Dumping Convention (1976) recognized that the risks of atmospheric pollution should be taken into account.

1.6 Where the word "Convention as amended in 1978" is used, this is to be understood as reference to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, with amendments to the Annexes to the Convention adopted in 1978 as listed under 1.1. above. Where the word "Regulation" is used, this is to be understood as reference to the corresponding regulation of the Addendum to Annex I to the Convention as mentioned in 1.1.3 above.

1A.1 Responsibility of Contracting Parties

1A.1.1. The initial survey of the marine incineration facility referred to in Regulation 3 should be the responsibility of a Contracting Party. Subsequent surveys of the marine incineration facilities should be the responsibility of the Contracting Party which conducted the initial survey or of a Contracting Party responsible for issuing a permit for current operations in consultation with that Contracting Party.

2 INCINERATION OPERATIONS

2.1 Waste type and feed rates of waste to the incinerator

2.1.1 Continuous flow-measuring devices for recording liquid waste flow rate should be installed on existing marine incinerator facilities by 1 June 1980. Interim methods of control should be based on a continuous display of the waste fuel pump status supplemented by manual checks of the

type and amount of waste burned every hour, weather and sea state permitting, to be recorded in the log.

2.1.2 Where solid wastes are burned, the waste type and rate of input should be recorded in the log.

2.1.3 The feeding of wastes in containers to the incinerator will necessitate special design and operational requirements in order to comply with Regulation 5. These should include but not be limited to:

.1 the waste should be feed to the incinerator at such a rate that the oxygen demand is well within the capability of the combustion air fan; and

.2 the waste should be fed to the incinerator via an air lock chamber.

2.2 Air feed to the incinerator

2.2.1 The amount of air entering the incinerator should be sufficient to ensure that a minimum of 3 per cent oxygen is present in the combustion gases near the incinerator stack exit. This requirement should be monitored by an automatic oxygen analyser to routinely record oxygen concentrations.

2.2.2 Although existing incinerator vessels employ a fixed air input rate, marine incineration facilities may in the future use a variable air feed in which case this rate should be recorded.

2.3 Temperature controls

2.3.1 Temperature controls and records should be based on the measurement of wall temperature. Unless otherwise determined by the Contracting Party there should be three or more temperature measurement devices for each incinerator.

2.3.2 In order to comply with Regulation 5 the Contracting Party should define the operating wall temperature and the temperature below which the flow of waste to the incinerator should be automatically shut off by approved equipment.

2.3.3 The minimum wall temperature should be 1200°C unless the results of tests on the marine incineration facility demonstrate that the required combustion and destruction efficiencies specified in Regulations 3 and 5 can be achieved at a lower temperature.

2.4 Destruction efficiency

2.4.1 For the purpose of applying Regulation 3 the destruction efficiency should be determined not only for the total organic components of the wastes but additionally for particular substances such as those listed in 4.1.2.

2.5 Residence time

2.5.1 The mean residence time of the incinerator should be of the order of one second or longer at a flame temperature of 1250°C (e.g. as measured by an optical pyrometer) during normal operating conditions.

2.6 Automatic shut-off systems

2.6.1 Devices to shut off the waste feed to the incinerator in accordance with Regulation 3 should include the following:

.1 flame sensors with each burner to stop waste flow to that burner in the event of a flame-out; and

.2 automatic equipment to stop waste flow in the event of wall temperatures falling below 1200°C or the temperature determined in 2.3.3.

2.7 Positioning of measuring devices

2.7.1 In applying Regulation 3(1)(b)(i) and (ii) to approve the siting of temperature measuring devices and gas sampling probes the Contracting Party should take into account that in certain cases flames can be non-homogeneous (e.g. through vortex formation in the incinerator or during incineration of solid or containerized wastes).

3 GENERAL CONTROL OF THE MARINE INCINERATION FACILITY AND ITS OPERATION

3.1 Loading and stowage of wastes

3.1.1 Due to the risk of spillages wastes should not be transferred from barges or other vessels to marine incineration facilities outside harbour limits except where special arrangements have been made for the prevention of spillages to the satisfaction of the Contracting Party.

3.1.2 Wastes in damaged containers should not be taken on board marine incineration facilities.

3.1.3 Containers loaded on board should be adequately labelled.

3.1.4 Containerized wastes should be stowed in accordance with the regulations of the IMCO International Maritime Dangerous Goods Code (IMDG Code).

3.2 Disposal of residues

3.2.1 Tank washings and pump-room bilges contaminated with wastes should be incinerated at sea in accordance with the Regulations for the Control of Incineration of Wastes and Other Matter at Sea and with these Technical Guidelines, or discharged to port facilities.

3.2.2 Residues remaining in the incinerator should not be dumped at sea except in accordance with the provisions of the Convention.

3.3 Prevention of hazards to other vessels

3.3.1 In licensing the incineration of wastes and other matter on board approved marine incineration facilities, the Contracting Party should have regard to the need to avoid hazards to other vessels by appropriate location of the incineration sites or incineration zones concerned and by ensuring that the relevant maritime authorities are notified of the date

of sailing and/or intended schedule, as well as the intended movements of the marine incineration facility (whether underway, at anchor, etc.).

3.3.2 Regular radio warning should be broadcast during the period of incineration.

3.3.3 Contracting Parties in a given geographical area should endeavour to designate common incineration sites in the area.

3.4 Construction of marine incineration facilities

3.4.1 For the carriage of liquid wastes an incineration ship shall carry a valid "Certificate of Fitness" as required under the IMCO Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk.

3.4.2 The compotent national authorities of the country concerned should designate suitable conditions for the construction and equipment of marine incineration facilities not mentioned under 3.4.1 above, based on the principles of the IMCO Bulk Chemical Code. Such conditions should be notified to the Organization.

3.5 Data recording

3.5.1 In addition to the records required by Regulation 6 of the Addendum to Annex I, marine incineration facilities should also record:

.1 the oxygen concentration in the combustion gases as monitored in accordance with 2.2.1 of these Guidelines;

.2 the air feed rate in accordance with 2.2.2;

.3 the tank(s) from which waste is taken; and

.4 the meteorological conditions, e.g. wind speed and direction.

3.5.2 Parameters which may require recording in the future, subject to satisfactory technical development, include routine measurement of destruction efficiency and total particulate matter in the combustion gases.

3.5.3 The result of the recording devices under Regulation 6 and the data recording described in paragraphs 3.5.1 and 3.5.2 above should be provided to the Contracting Party which had issued the incineration permit. Where more than one Contracting Party had issued a permit for one incineration operation, arrangements for review of the data should be made among the Contracting Parties involved.

4 NATURE OF WASTES OR OTHER MATTER AND NOTIFICATION PROCEDURES

4.1 Characteristics of wastes

4.1.1 Information on the characteristics of wastes or other matter to be provided in connexion with a permit application in accordance with Regulation 7 should include in addition to that in the Appendix hereto, if possible, information on the chemical and physical transformation of the waste after incineration, in particular, subsequent formation of new compounds, composition of ashes or unburned residues.

4.1.2 For the purpose of Regulation 4, examples of wastes or other matter over which doubts exist as to the thermal destruction and efficiency of combustion are lised as follows:

.1 Polychlorinated biphenyls (PCB's)

.2 Polychlorinated triphenyls (PCT's)

.3 Tetrachloro-dibenzo-p-dioxin (TCDD)

.4 Benzene hexachloride (BHC)

.5 Dichlorodiphenyl trichloroethane (DDT)

4.2 Compliance with paragraphs 8 and 9 of Annex I of the Convention

4.2.1 The Contracting Party must ensure through the application of procedures adopted by Contracting Parties in consultation that the incineration of a waste containing Annex I substances should not result in the introduction of Annex I substances into the marine environment unless these are rapidly rendered harmless or are present as trace contaminants.

Based on current scientific knowledge on the environmental effects of incinerating liquid organochlorine compounds, this requirement is considered to be met if the Regulations and Technical Guidelines are observed.

4.2.2 Where it is proposed to incinerate wastes at sea containing other Annex I substances or organochlorine compounds referred to in 4.1.2, it will be necessary to determine that the residues entering the marine environment after incineration are rapidly rendered harmless or present as trace contaminants through procedures adopted by the Contracting Parties in consultation.

4.3 Notification of permits issued for incineration at sea

4.3.1 Each Contracting Party should immediately notify the Organization of a Special Permit issued for incineration of wastes or other matter at sea in accordance with Regulation 2(3). A record of the General Permits issued for incineration in the previous calendar year in accordance with Regulation 2(4) should be sent directly or through a Secretariat established under a regional agreement to the Organization by 31 March in each year.

4.3.2 The notifications should contain for each permit the kind of information set out in Appendix hereto.

4.3.3 The Organization should treat notifications of incineration permits in the same way as permits issued for dumping.

Appendix C

MONITORING

Appendix C

MONITORING

The Final EPA Ocean Dumping Regulations and Criteria (40 CFR Parts 220 to 229) discusses monitoring requirements (§228.9):

(a) The monitoring program, if deemed necessary by the Regional Administrator or the District Engineer, as appropriate, may include baseline or trend assessment surveys by EPA, NOAA, other Federal agencies, or contractors, special studies by permittees, and the analysis and interpretation of data from remote or automatic sampling and/or sensing devices. The primary purpose of the monitoring program is to evaluate the impact of disposal on the marine environment by referencing the monitoring results to a set of baseline conditions. When disposal sites are being used on a continuing basis, such programs may consist of the following components;

(1) Trend assessment surveys conducted at intervals frequent enough to assess the extent and trends of environmental impact. Until survey data or other information are adequate to show that changes in frequency or scope are necessary or desirable, trend assessment and baseline surveys should generally conform to the applicable requirements of Section 228.13. These surveys shall be the responsibility of the Federal government.

(2) Special studies conducted by the permittee to identify immediate and short-term impacts of disposal operations.

(b) These surveys may be supplemented, where feasible and useful, by data collected from the use of automatic sampling buoys, satellites or in situ platforms, and from experimental programs.

(c) EPA will require the full participation of other Federal and State and local agencies in the development and implementation of disposal site monitoring programs. The monitoring and research programs presently supported by permittees may be incorporated into the overall monitoring program insofar as feasible.

Further, in §228.10, the Ocean Dumping Regulations delineate specific types of effects upon which monitoring programs must be built:

(a) Movement of materials into estuaries or marine sanctuaries, or into oceanfront beaches, or shorelines.

(b) Movement of materials toward productive fishery or shellfishery areas.

(c) Absence from the disposal site of pollution-sensitive biota characteristic of the general area.

(d) Progressive, nonseasonal, changes in water quality or sediment composition at the disposal site, when these changes are attributable to materials disposed of at the site.

(e) Progressive, nonseasonal, changes in composition or numbers of pelagic, demersal, or benthic biota at or near the disposal site, when these changes can be attributed to the effects of materials disposed of at the site.

(f) Accumulation of material constituents (including without limitation, human pathogens) in marine biota at or near the site.

Thus, the regulations identify two broad areas that must be taken into account in monitoring:

(a) Short-term or acute effects immediately observable and monitored at the time of disposal, and before disposal of the waste itself.

(b) Long-term or progressive effects measurable only over a period of years and indicated by subtle changes in selected characteristics over a gradual period of time.

There is a paucity of data on incineration at sea with respect to the fate and effects of incineration residues. Research burns conducted in the Gulf of Mexico support the contention that short-term adverse effects are unlikely. The extreme set of conditions imposed on the estimation of impact in Chapter 4 will never, in practice, occur. These assumptions are:

(1) Destruction efficiency 99.96% rather than +99.99%.

(2) All residual materials (HCl, metals, and organochlorines) will settle out of the atmosphere within several kilometers of the vessel, rather than remaining suspended in the atmosphere for longer periods.

(3) Residues are dispersed in a volume of water at a depth of 20m, rather than mixing to deeper depths.

Short-term impacts may be waste-specific. Therefore, wastes must be approved for at-sea incineration on a case-by-case basis and incineration operations closely monitored while environmental impacts are more precisely determined. Short-term monitoring conducted in the past has included measurements of pH, chlorinity, alkalinity, chlorinated hydrocarbons, selected metals, phytoplankton, zooplankton, and in situ biochemical analyses of surface waters in exposed and control areas. Future short-term monitoring should consist of similar parameters and should be conducted as a routine adjunct of incineration operations during further development of this disposal technique.

During research incineration operations in the Gulf of Mexico, TerEco Corporation of College Station, Texas performed monitoring studies to determine the environmental acceptability of this disposal process (TerEco, 1975 and unpublished)*. The sampling procedure consisted of three operational plans: (1) plume identification and tracking, utilizing pH sensing equipment to monitor HCl; (2) once the plume was identified, surface water samples were collected to measure short-term impacts, as determined by pH, chlorides, organohalogens, and trace metals. Plankton tows were conducted in the center of the affected area and these samples examined for organohalogens and trace metals; (3) long-term impacts were estimated by measuring catalase, ATP, and P-450 enzyme activities in test organisms exposed to affected water, in situ. In situ bilogical sampling was accomplished using specially designed drift nets or Pelagic Biotal Ocean Monitors (P-BOM), which permit test organisms to be placed in affected water and allowed to drift, then retrieved when desired.

Atmospheric monitoring was augmented with aircraft equipped to sample HCl and condensation nuclei, and collect grab bag samples for analysis of residual wastes.

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*See Chapter 6 for references cited in this Appendix

Data should be collected over a broad spectrum of conditions, which will occur during incineration operations. Data does not need to be collected during the entire operation, but should be collected at least in duplicate, preferably under both day and night conditions (TerEco, 1975).

Control stations should be occupied several miles upwind of the incinerator vessel. These stations should be sampled for each set of impacted area samples and treated in the same manner. Data should be collected over a broad spectrum of conditions during incineration operations. Data need not be collected during all operations, but should be collected during variable climatic conditions during day and night.

Monitoring conducted on the site (for long-term and larger spatial scale) must be aimed at recognizing unpredicted accumulation of residue materials or compounds produced by interaction of residue materials with other materials present in the water or air mass in the site region.

Evidence of such accumulation should be sought through a field sampling design, including observations of chemical components of waste residue falling into the following categories:

(1) Tracers - Compounds which are easily analyzed and may be uniquely associated with the waste incineration.

(2) Potentially Toxic Agents - Compounds presenting the most potent danger to man through the environment or through food sources.

(3) Food Chain Accumulation - Observations of residue compound accumulations in animal tissues, and of changes to population relationships in the site region.

The monitoring plan is designed to cover the areal extent of the site; dilution mixing of the waste to ambient levels should proceed to a concentration below the measurable level by the time the residue has reached the site boundaries.

Appendix D

MODEL ESTIMATIONS OF WASTE RESIDUE LOADING

Atmospheric and Oceanic Behavior of Combustion Products Released at a Proposed Incineration Site in the New York Bight

by

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IEC

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This Appendix presents results of an independent study of potential waste residue loading within the proposed site environment. Drs. Robert Duce and Dana Kester prepared this report as a worst-case study for comparative purposes in response to specific questions from Interstate Electronics Corporation.

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I. BACKGROUND INFORMATION

A. Atmospheric Residence Times

1. General Considerations

The length of time any substance, X, remains in the atmosphere, its residence time, is a function of a number of parameters, including the physical form of the substance, i.e., whether it is present in the gas phase or on atmospheric particles or aerosols.

If the material is present in the aerosol phase, its residence time will be dependent upon:

a. The particle size

b. The chemical properties of the aerosol, which are related to cloud droplet formation and precipitation scavenging

c. The extent to which the pollution aerosol is vertically mixed in the atmosphere

If the material is present in the gas phase, its residence time will be dependent upon:

a. Its chemical and photochemical reactivity

b. Its scavengeability by rain and snow

c. Its direct gas exchange properties with the ocean and terrestrial biosphere.

In addition to the chemical and physical properties of substance X, the atmospheric residence time is dependent upon a number of environmental factors, including intensity of solar radiation, concentration of other chemical species which may interact with X, temperature, relative humidity, and amount, duration, frequency, intensity, and type (rain, snow, etc.) of precipitation. Because all of these factors are quite variable in the atmosphere, and in fact are often unknown, the results of calculations leading to estimates of atmospheric residence times must be viewed cautiously. With an understanding of the inherent

uncertainties in such estimates, however, a knowledge of approximate residence times is extremely useful in attempting to evaluate the extent of transport of atmospheric pollutant substances and the rate of their removal from the atmosphere.

The simplest approach used to estimate the atmospheric residence times of a substance is simply to divide the total mass of that substance in any particular compartment of the atmosphere by the rate of addition or removal of that substance from the compartment. This is given by:

$$\tau_1 = \frac{M}{dM/dt} \qquad (1)$$

Where τ_1 = atmospheric residence time, e.g., in days

M = total mass of substance in the compartment, in grams

dM/dt = rate of input of substance to or removal from compartment, in grams/day

This approach assumes that the rate of removal (or input) of a substance is dependent on the quantity of that substance already in the reservoir. This is rarely the case for removal processes although somewhat more common for source functions. However, until more is known about the factors controlling the fluxes of substances in and out of atmospheric reservoirs, this approach may continue to be most commonly used for determining atmospheric residence times.

A second approach to residence time calculations assumes that the rate of removal, dM/dt, is dependent on the concentration of M, i.e.,

$$M = M_o e^{-\lambda t} \qquad (2)$$

Where M_o is an initial mass of substance in the compartment, in grams

M is the mass, in grams, present at some later time, t, in days, and

λ is the removal constant in day^{-1}.

For this first order removal process the residence time, τ_2, is defined as the mean or average atmospheric lifetime of a particle or molecule of the substance, and is given by:

$$\tau_2 = 1/\lambda \qquad (3)$$

Where τ_2 is the time required for the concentration or mass of substance X to drop to 1/e or 0.37 times its initial value. For our consideration of atmospheric removal in this report τ_2 is the appropriate term to use. However, the measurement or estimation of actual atmospheric residence times is so uncertain that the distinction between the two definitions above has little meaning in practice.

2. Particles in the Atmosphere

The residence time of atmospheric particles or aerosols is closely related to particle size. Unfortunately no information is available on the size distribution of particles produced by the proposed burning process. Figure 1 (derived from Jaenicke, 1979) presents an idealized general relationship between aerosol size, as indicated by the particle radius, and residence time, in days. The residence time of the largest particles, with radii greater than approximately 10 μm, is controlled primarily by gravitational settling and dry deposition of the particles to the earth's surface. Residence times range from a few seconds up to perhaps 1 day for particles with r > 10 μm, decreasing with increasing size.

The residence time for particles with radii ranging from 0.1 to 10 μm is controlled primarily by wet removal, i.e., rain, fog, snow, etc. The atmospheric residence time for particles in this size range is in the range of a few days to perhaps a maximum of 2 to 3 weeks, dependent upon the amount, duration, intensity, and type of precipitation and the chemical properties of the aerosol. There is evidence, for example, that hygroscopic salt particles are more efficiently

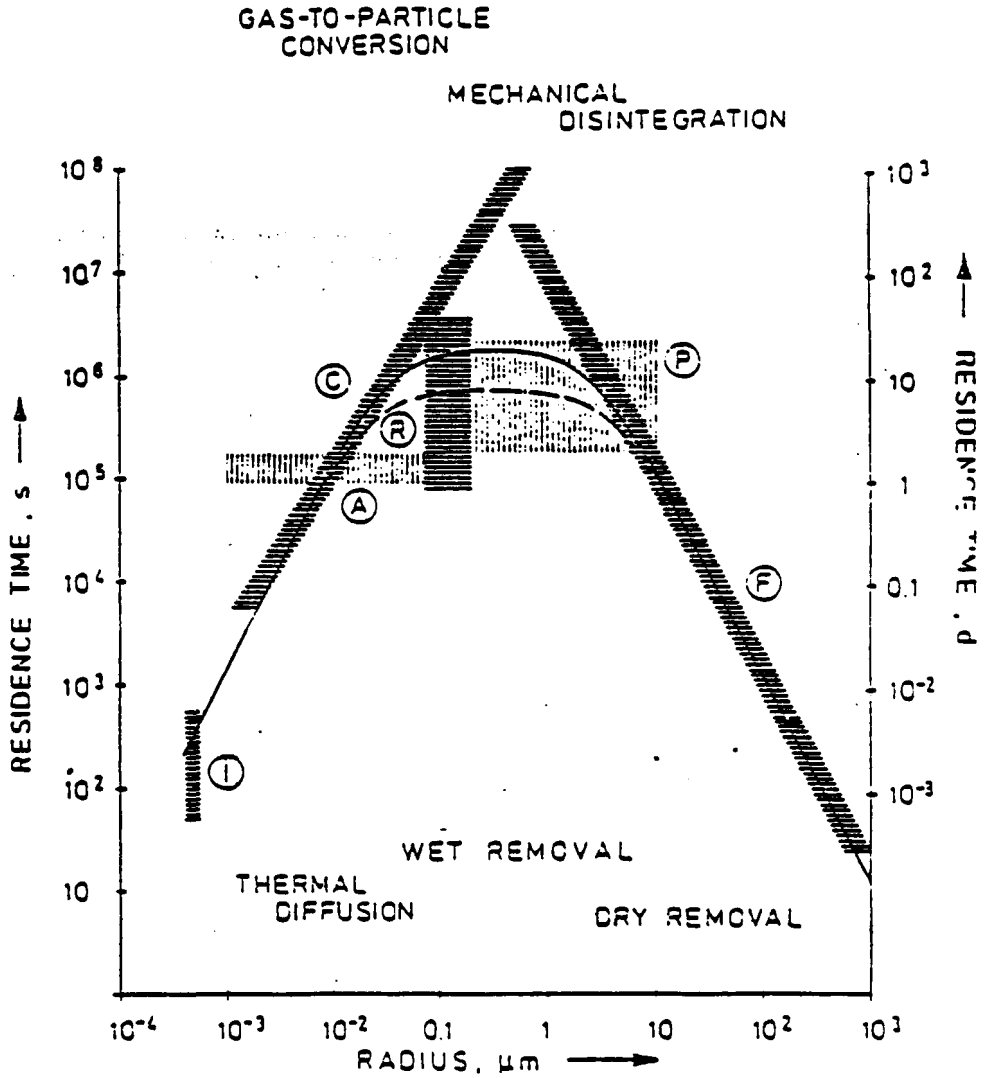


Figure 1. Residence time of aerosol particles as individuals, as a function of particle size. The shaded areas are published residence times derived for various properties of the atmospheric aerosol. F = falling time in a homogeneous aerosol layer of 1.5 km scale height; P = precipitation estimates; R = radioactivity data; A = Aitken particle residence time; C = thermal coagulation; I = small ions residence time. An empirical function with two different parameters is fitted. (After Jaenicke, 197

removed from the atmosphere by rain than soil-derived, relatively non-hygroscopic alumino-silicate particles. The size range of 0.1 to 10 μm is definitely the most stable size range in the atmosphere and it is aerosols in this size range, particularly the lower end of this size range, which are subject to long range transport from their source region. Aerosols in this size range can easily be transported hundreds to thousands of kilometers in the atmosphere over ocean or land areas before being removed.

As the radius drops below 0.1 μm the residence time begins to decrease rapidly again. This decrease is misleading, however, as it only refers to the time before removal from a particular size range, not time before removal from the atmosphere. These smaller size particles grow rather rapidly due to coagulation with each other. This process is important up to a radius of $\sim$ 0.1 μm, after which precipitation removal becomes the primary controlling factor for the particle residence time, as indicated previously.

In summary, relative to removal from the atmosphere, particles from the smallest size, with radii on the order of 10^{-3} μm, up to particles with radii of a few μm can be expected to have atmospheric residence times on the order of days to perhaps a week or two. Only particles with radii $\gtrsim$ 10-50 μm would be expected to be deposited in the vicinity of the source area, in this case the proposed burn site, unless there is rather intense precipitation occurring during the burn. Obviously information on the particle sizes produced by this burning process is required before any accurate estimate can be made of the removal rate of the particles. It should be pointed out that in urban areas most submicrometer size aerosols are produced by high temperature processes such as fossil fuel burning and/or incineration (Rahn, 1971; Friedlander, 1973; Gordon et al., 1974; Natusch et al., 1974; Whitby et al., 1972). It is expected that the ship-based

burning process considered here will also produce large quantities of submicrometer particles. Thus it is very possible that many of these particles will remain in the atmosphere for a number of days.

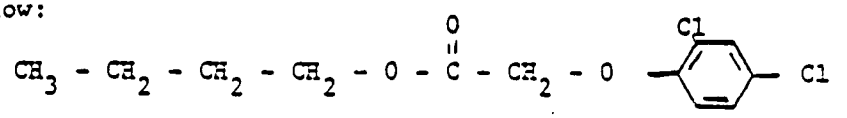
3. Trace Gases

The atmospheric residence time for trace gases is extremely variable and may range from a few minutes for extremely reactive species to decades for non-reactive species such as the freons. The primary concern, with substances released from the proposed burn site, rests with unburned chlorinated hydrocarbons, and heavy metals. While some of the more volatile heavy metals and their oxides or other salts, e.g., As, Hg, Se, will probably be released to the atmosphere in the vapor phase, most will condense rapidly on pre-existing particle surfaces. One exception is Hg, which is known to exist primarly in the atmosphere in a vapor phase (Fitzgerald, 1979). The atmospheric residence time of vapor phase Hg is unknown.

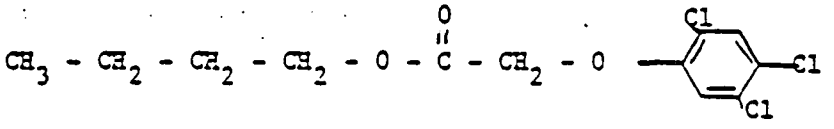
Hydrogen chloride (HCl) is very soluble in water and will be rapidly scavenged by cloud, fog, rain droplets and the slightly alkaline surface of the ocean. There are relatively little data available on background HCl concentrations in near surface air over the ocean. Values for total inorganic gases containing chlorine, most of which are probably present as HCl, are generally $\sim$ 1-2 $\mu g/m^3$ (Junge et al., 1957; Duce et al., 1965; Chesselet et al., 1972; Rahn et al., 1976). The residence time of background HCl is unknown but is probably rather short, on the order of a few days at most, due to its reactivity.

With respect to the residence time of unburned chlorinated hydrocarbons (CHC) in the gas phase, the unburned compounds must first be identified. If the primary burn material is Herbicide Orange, as has been the case in some M/T Vulcanus burns in the Pacific Ocean, it consists of a mixture of equal parts by volume of the

n-butyle esters of 2, 4-dichlorophenoxyacetic acid (2, 4-D) and of 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5-T). The structures of these two compounds are indicated below:



and



Other burns, in the Gulf of Mexico, have been primarily of such substances as 1,2,3 trichloropropane, dichloropropane, dichloropropene, trichloroethane, dichloroethane, and other chlorinated hydrocarbons of low molecular weights (Paige et al., 1978). Apparently PCB's and DDT and other pesticide residues have also been burned.

There is currently little information available on the atmospheric residence time for most of the compounds above. Estimates have been made for other, somewhat similar chlorinated hydrocarbons, however, and some general idea of the residence times of the substances above can be obtained by looking at the residence times for these other CHC, and making some simple comparisons with the chemical structure of the compounds from the burn site.

As pointed out by NAS (1978), the chemical and physical properties of low molecular weight CHC (C_1 - C_3) are very different from the high molecular weight clorinated hydrocarbon herbicides, pesticides, and industrial chemicals such as PCB's. Any low molecular weight CHC containing unsaturated carbon-carbon bonds (e.g., $CHCl = CCl_2$) will have very short residence times, on the order of hours in general, in the atmosphere due to their high reactivity (NAS, 1978) and involvement in photochemical smog-type reactions (e.g., NO_x, O_3, OH, etc.). Low molecular weight CHC with saturated C-C bonds (i.e., no double or triple bonds) will have much longer residence times as they are quite resistant to most chemical

Table 1

Literature Values for the Estimated Atmospheric Residence Times for Chlorinated Hydrocarbons

Formula	Name	Estimated Residence Time	Reference
CH_3-CCl_3	Trichloroethane or Methyl Chloroform	8-10 years	Singh et al., 1979
		∿6 years	Derwent and Eggleton, 1978
		1.1 years	Cox et al., 1976
		11 years	Chang and Penner, 1978
CH_3Cl	Methyl Chloride	∿3 months	Atkinson et al., 1976
		2-3 years	Singh et al., 1979
		2-3 years	Derwent and Eggleton, 1979
		∿5 months	Cox et al., 1976
$CHCl_3$	Chloroform	∿1 year	Derwent and Eggleton, 1979
		∿3 months	Cox et al., 1976
CH_2Cl_2	Methylene Dichloride	∿1 year	Derwent and Eggleton, 1979
		∿4 months	Cox et al., 1976
$C_{12}Cl_x$	Polychlorinated Biphenyls (PCB)	1-3 months	Bidleman et al., 1976
-	DDT	1-3 months	Bidleman et al., 1976

reactions. These substances are rather insoluble in seawater. It is generally believed that they are utilmately destroyed in the atmosphere via reactions with the OH (hydroxyl) radical, which is photochemically produced.

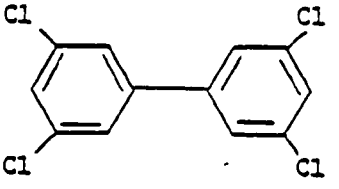
Table 1 presents estimates for the atmospheric residence times of trichloroethane and several chlorinated methane compounds. While there are considerable variations in the estimates for any individual substance, all of the residence times are long in terms of atmospheric transport processes, ranging from 3 months to more than 10 years. For trichloroethane, one of the substances which have been burned on M/T vulcanus in the past, τ has been estimated at 1-11 years, with the higher estimates obtained more recently. It would thus be expected that many saturated low molecular weight CHCS injected unchanged into the atmosphere

might have atmospheric residence times on the order of months to years and could be subject to at least hemispheric and perhaps global scale transport.

There are no data available on the atmospheric residence time of compounds similar in structure to the n-butyl esters of 2, 4-D and 2, 4, 5-T. It is expected that these compounds, with their ester linkage, would be subject to fairly rapid hydrolysis in the atmosphere. The polar character of the esters and their hydrolysis products would result in rapid scavenging by precipitation processes.

Estimates have been made of the atmospheric residence time of polychlorinated biphenyls, a group of chlorinated organic compounds with a molecular weight range similar to the components of Herbicide Orange.

These compounds have the following structure:



, etc.

are marketed and used as mixtures of compounds with varying numbers of chlorine atoms attached to the basic biphenyl structure.

As shown in Table 1, the atmospheric residence time for PCB's has been estimated at 1-3 months. Similar residence times have been estimated for DDT. The unburned components of Herbicide Orange would be expected to have residence times considerably less than this, perhaps on the order of days. It must be emphasized, however, that no data are available on these compounds.

Junge (1977) has pointed out that non-urban air compounds which have vapor pressures greater than 10^{-6} to 10^{-7} mm Hg under ambient conditions will generally be found primarily in the gas phase rather than attached to particles. The saturated vapor pressure of the n-butyl ester of 2, 4, -D at 27°C is 4×10^{-3} mm Hg (Que Kee et al., 1975). Thus this material, and all the low molecular weight

CHC's discussed previously, should be found almost entirely in the vapor phase in the atmosphere rather than attached to particles. Actual measurements have shown this to be the case of PCB's and DDT over the North Atlantic as well (Bodleman et al., 1976).

B. Atmospheric Removal Processes

1. Precipitation

Particles and trace gases are removed from the atmosphere via rain and snow. In the case of rain removal, material can be removed within the rain forming cloud as part of the droplet nucleation and growth process (rain-out) and beneath the cloud by scavenging action as the droplet falls to the land or water surface (washout). Very little is known about trace substance removal by snow.

The scavenging ratio or washout factor, W, is a useful empirical tool often utilized to relate atmospheric concentrations of substances to their concentrations in rain. Washout factor, W, is defined as follows:

$$W = \frac{C_{rain}}{C_{air}} \qquad (4)$$

Where C_{rain} is the concentration of any substance in rain in, for example, ug/Kg rain.

C_{air} is the concentration of any substance in air, in ug/Kg air.

For most reactive trace gases (e.g., SO_2, NH_3) and aerosols W generally ranges from 300 to 3000. For aerosols it is related to aerosol size. This is shown in Figure 2, which is a plot of calculated values of W determined from analyses of rain and air samples collected in the marine atmosphere in the Florida Keys vs the mass median diameter of trace elements found on particles in the marine atmosphere (Duce et al., 1979). Note that W increases with increasing particle

size. This has been observed in urban areas by Gatz (1977) and in rural areas by Lindberg et al., (1979) and Peirson et al., (1973).

For a substance present on particles in the atmosphere, a crude order of magnitude estimate can be made of its concentration in rain if its atmospheric particulate concentration is known or can be predicted. As mentioned above, values of W will generally range from 300 to 3000 for particulate substances. If the particle size distribution of the substance is known this crude estimate can be refined somewhat, as W will generally be on the high end of the range for particles with r >1um and on the low end of the range for particles with r <1um. If an estimate can be made of the concentration of any substance in rain, this can be combined with local climatological data on daily, monthly, etc., rainfall to determine a rainfall flux of that substance into the ocean. For atmospheric particles it has been estimated that, on a global scale, rainfall removes perhaps 50-90% of the total particle mass while dry deposition is responsible for the remaining 10-50%. The actual distribution at any location is of course, a function of particle size, wind speed, and rainfall frequency, intensity, and duration, among other factors.

For relatively non-reactive trace gases, such as many of the CHC's, values for W are much lower. Atkins and Eggleton (1971) reported values for W ranging from 2 to 65 for the CHC's benzene hexachloride, dieldrin, and DDT in London. The value of 65 was for DDT and was about 30 times higher than laboratory experiment values calculated for the vapor phase of this compound, suggesting that much of the DDT in London was present on particles. Thus the true value of W for scavenging heavy vapor phase CHC is probably quite low. W for the low molecular weight saturated CHC would probably even lower.

2. Particle Dry Deposition

Particles can be deposited directly onto water (and land) surfaces via gravitational settling and turbulent and diffusive transfer. If the atmospheric

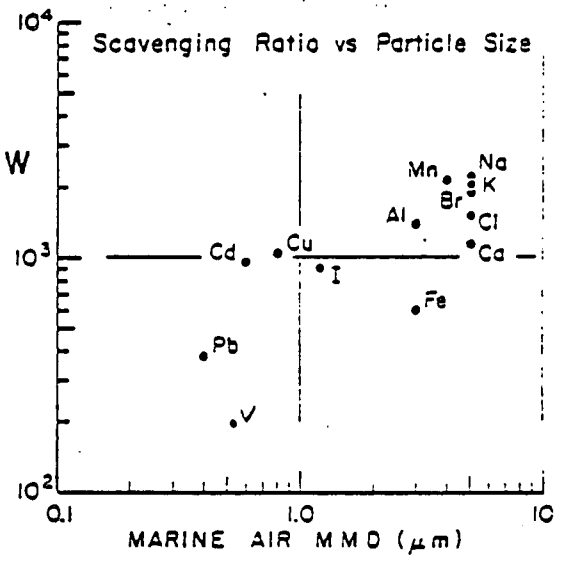


Figure 2. Variations of washout factor, W, with heavy metal particle size (After Duce et al., 1979).

concentration and particle size distribution for a particular substance of interest is known, for example a certain heavy metal, it is possible to predict crudely the flux of this substance to the earth's surface via dry deposition.

A useful concept in evaluating dry deposition of atmospheric particles to land or water surfaces is the deposition velocity, v_d, where:

$$v_d = \frac{F}{C} \tag{5}$$

Where C = the concentration or mass of particles or material present on particles per unit volume of air (e.g., g/cm^3), and F = the mass flux of particles or material present on particles deposited on the surface (e.g., g/cm^2 sec). Effective deposition velocities for particles in the stable aerosol size range close to the ground are often near 1 cm/sec, but this varies considerably with particle size, wind speed, and surface roughness. In a laboratory wind tunnel experiment Schmel and Sutter (1974) investigated the particle size and wind speed. A summary of the results is presented in Figure 3. There is a general decrease in deposition velocity with decreasing particle size at a given wind speed, with a dramatic drop between 10 and 1 μm diameter. For a given particle size greater than 1 μm diameter, the deposition velocity increases with increasing wind speed. Below approximately 1 μm diameter there appears to be no clear relation between deposition velocity and wind speed.

Unfortunately, field measurements of aerosol deposition velocity do not always agree with these wind tunnel studies. This is particularly true for submicrometer particles. For example, Young and Silker (1979) recently investigated aerosol deposition velocity to the ocean surface using ^7Be. They found 88% of the ^7Be to be on particles with $r < 0.5$ μm with only 1% on particles with $r > 3.5$ μm. Thus ^7Be is primarily on submicrometer particles. The aerosol

deposition velocity determined from the ^{7}Be measurements was $\sim$ 0.8 cm/sec, considerably higher than would be expected from Figure 3.

In a study of the atmospheric input of heavy metals to the North Sea, Cambray et al., (1975) determined atmospheric concentrations and dry deposition rates to a dry filter paper for a variety of trace metals. From this data deposition velocities can be calculated using Equation (5). Rahn (1976) has compiled mean values of mass median diameters for atmospheric particulate heavy metals using all the atmospheric data available up to mid-1976. A plot of Rahn's mass median diameter vs the deposition velocities calculated from Cambray et al., (1975) for a number of heavy metals is presented in Figure 4. The trend of deposition velocity vs particle size, i.e., increasing v_d with increasing particle size, is apparent in both figures. Note that agreement between the figures is reasonable for particles with radii $\gtrsim$ 1 μm. Agreement is poor for submicrometer particles. It must be remembered, however, that the data of Cambray et al, (1975) are for deposition to a dry filter paper, not a water surface. At the present-day level of understanding it can be stated that the deposition velocity for aerosols with $0.1 < r > 1.0$ μm is probably in the range of 0.05 to 1.0 cm/sec, while that for particles from $\sim$ 1 to 5 μm radius is probabl in the range of 0.5 to 3 cm/sec, noting that v_d is a function of wind velocity and that this function is not well characterized at present. Using the values above, information on the particle mass median diameter for a particular substance of interest, and the atmospheric concentration of that substance, crude order of magnitude estimates of dry deposition flux to the ocean surface can be made by use of Equation (5).

3. Direct Gas Exchange

Liss (1973) and Liss and Slater (1974) have reviewed the process of gas exchange across the air/sea interface. In the model described by these

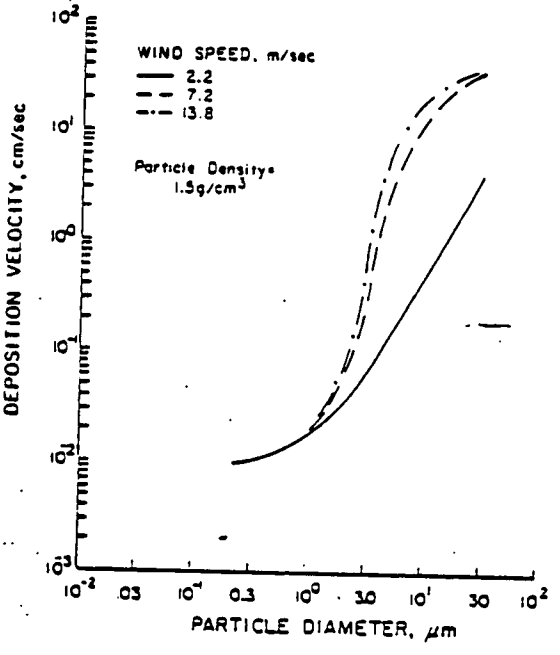


Figure 3. Laboratory studies of particle deposition velocity as a function of wind speed and particle size. (After Schmel and Sutter, 1974)

papers, the interface between air and sea is considered as a two-layer film system. Away from the interface each reservoir is assumed to be well-mixed. The primary resistance to gas transport comes from the gas and liquid phase laminar film, or interfacial, layers. It is assumed that gases cross these interfacial layers by molecular diffusion. (See Figure 5).

In such a two layer boundary system at an air/water interface, the flux, F, of any gas through the boundary layer is given by:

$$F = k\Delta_c \tag{6}$$

where F is the flux in, e.g., g/cm^2 sec.

Δ_c is the concentration difference across the particular layer in g/cm

and k is the corresponding exchange coefficient or transfer velocity in cm/sec.

As Liss (1973) points out, k depends on many factors, including the degree of mixing of the water and air and the chemical reactivity of the gas. The reciprocal of k is often called the resistance, r, and is a measure of the "resistance" of the gas to transfer. It has units of sec/cm. The total resistance to the exchange of any gas will be the sum of the resistance in the gas and liquid phase laminar layers.

In the free atmosphere above the ocean the concentration of the trace gas of interest is c_g. As the air/sea interface is approached the concentration changes and at the water surface the atmospheric concentration is c_{sg}. A similar condition occurs in the liquid phase, with the bulk water concentration of the dissolved gas being c_l and the concentration of the interface being c_{sl}. Assuming the gas transport to be a steady state process and using Equation (6),

$$F = k_g (c_g - c_{sg}) = k_l (c_{sl} - c_l) \tag{7}$$

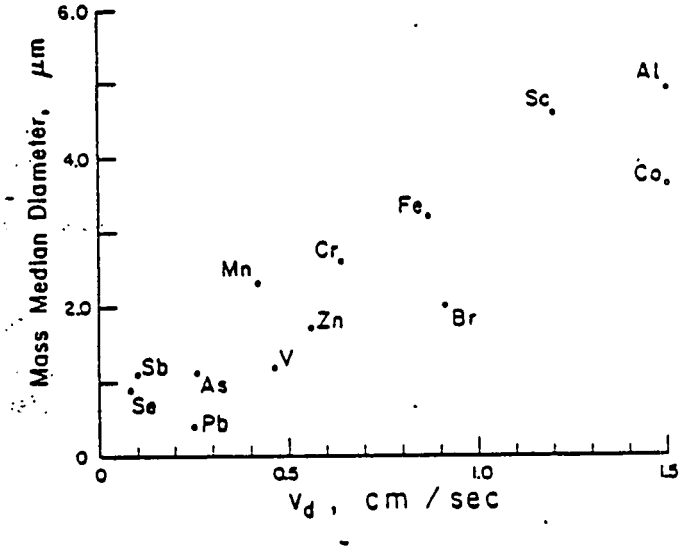


Figure 4. Trace metal mass median diameters (Rahn, 1976) vs deposition velocity (Canbray et al., 1975)

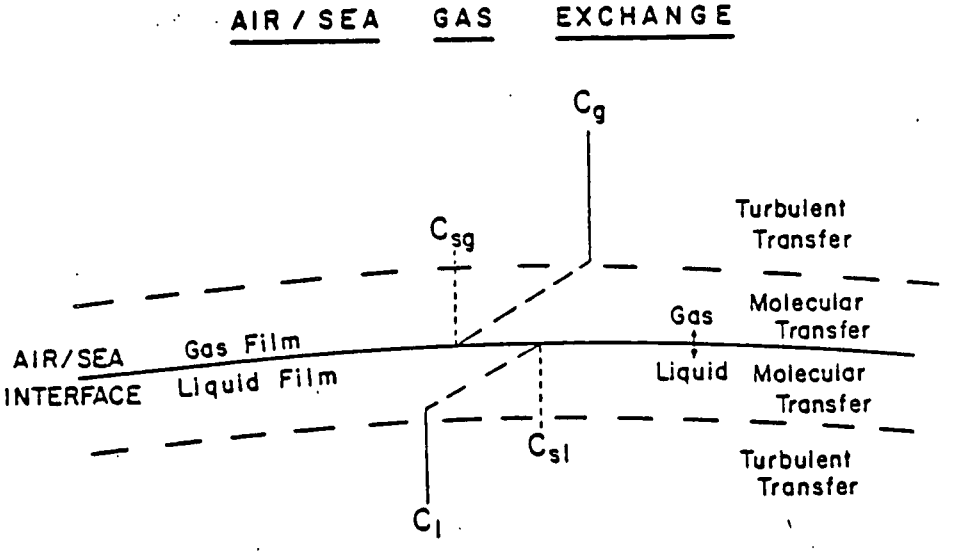


Figure 5. The two film model of air/sea gas exchange (After Liss and Slater, 1974)

The first expression represents exchange across the gas phase laminar layer and the second represents exchange across the liquid phase laminar layer. Obviously the two must be equal. If the exchanging gas obeys Henry's Law, then

$$c_{sg} = Hc_{sl} \tag{8}$$

Where H, Henry's Law constant, is given by:

$$H = \frac{\text{Equilibrium concentration in gas phase (g/cm}^3 \text{ air)}}{\text{Equilibrium concentration of unionized dissolved gas in liquid phase (g/cm}^3 \text{ water)}} \tag{9}$$

c_{sg} and c_{sl} are not measurable in the field but can be eliminated between Equation (7) and (8) to obtain:

$$F = \underbrace{K_g (c_g - Hc_l)}_{\text{(gas layer exchange)}} = \underbrace{K_l (c_g/H - c_l)}_{\text{(liquid layer exchange)}} \tag{10}$$

Where $1/K_g = 1/k_g + H/k_l = R_t$ (gas phase basis) (11)

and $1/K_l = 1/k_l + 1/Hk_g = R_t$ (liquid phase basis) (12)

The total resistance to transfer of any particular gas, R_t, expressed either on a gas phase basis ($1/K_g$) or a liquid phase basis ($1/K_l$) is a function of both the individual exchange constants for that gas for each phase (k_g and k_l) and the Henry's Law constant, H, for that gas.

Thus, in order to calculate the flux of any gas across the air/sea interface the concentration of the gas in the atmosphere and dissolved in the ocean must be known, as well as its Henry's Law constant and its gas and liquid phase exchange coefficients.

For the unburned wastes expected to be injected into the atmosphere from M/T Vulcanus, the atmospheric concentration of each substance must be modelled, as was done by Paige et al., (1978), for total unburned gaseous wastes. The

seawater concentration of each waste would have to be measured. Henry's Law constants for most of these substances are currently unavailable and need to be measured in the laboratory under near-expected ambient concentration conditions.

According to Liss and Slater (1974), k_g and k_l for any gas of interest can be determined from the corresponding values for water exchange. Liss and Slater (1974) use the following values for H_2O:

$$k_g(H_2O) = 0.83 \text{ cm/sec.}$$

$$k_l(H_2O) = 5.6 \times 10^{-3} \text{ cm/sec.}$$

To obtain k_g values for gases other than water, the value for $k_g(H_2O)$ should be multiplied by the ratio of the square roots of the molecular weights of H_2O and the other gas.

As pointed out by Liss and Slater (1974) the value for $k_l(H_2O)$ is based primarily on measurements of CO_2 exchange and is reasonably accurate for gases with molecular weights of 40 ± 25. For heavier gases $k_l(H_2O)$ should be multiplied by the ratio of the square roots of the molecular weights of CO_2 and the other gas. For a chemically reactive gas the situation is more complex and the paper of Liss and Slater (1974) should be consulted.

C. Atmospheric Concentrations in the Proposed Burn Area

All of the substances which would be introduced into the atmosphere by the waste burning at the proposed burn site are probably already present at some concentration in the ambient atmosphere at that location. While there are virtually no data for that area for any of the substances of interest, there are data for a number of these substances at coastal sites along the northeastern United States and from Bermuda and ships in the western North Atlantic.

Table 2 presents data on the mean concentration of a number of trace metals measured in the atmosphere in the general area of interest. Most of

the data for "Urban Regions" were obtained at an altitude of 600 meters at sites 32 to 48 Km downwind of major urban centers in the northeastern United States (Young et al., 1975). These concentrations may be representative of coastal areas in the vicinity of large cities on the east coast. Data are also presented for Bermuda, approximately 750 miles southeast of the proposed burn site (Duce, 1976a and b). These three data sets are also given in NAS (1978). A very limited data set was obtained from atmospheric samples collected over the New York Bight from a ship in May, 1974. The New York Bight data (Duce et al., 1976c) are compared with New York City data (Kneip and Eisenbud, 1974) in Table 3. Note the higher trace metal concentrations over the New York Bight when the winds are from the "northwest" sector, reflecting the strong source regions in the United States.

From the data in Tables 2 and 3 we can determine an expected range of trace metal "background" concentrations which might be expected under normal conditions in the proposed burn area. These expected concentration ranges are presented in Table 4.

Atmospheric concentration data are presented in Table 5 for five representative CHC - PCB, $CH_3 - CCl_3$, $CHCl = CCl_2$, DDT, and CH_3Cl. CH_3Cl is primarily from natural sources, with the ocean being the major source. The others are all primarily from anthropogenic sources. Note that $CHCl = CCl_2$ has much higher concentrations in U.S. coastal sites than in open ocean areas, which supports the concept of a short atmospheric residence time for this unsaturated CHC. Concentrations of this compound in the urban atmosphere around New York City are reported to be over 5000 ng/m^3 STP (Lillian et al., 1976). Concentrations of CH_3CCl_3 are rather uniform in all areas, supporting a long residence time for this saturated low molecular weight CHC.

Table 2

Atmospheric Trace Metal Concentrations, Urban Regions and Bermuda

	Urban Regions, Northeastern U.S.[÷]			Bermuda[!]		
	Geometric Mean ng/m^{3}STP	GSD*	Range ng/m^{3}STP	Geometric Mean ng/m^{3}STP	GSD*	Range ng/m^{3}STP
Na	510	3	130-2300	1600	3	200-8000
Mg	730	3	150-2030	200	2	30-900
Al	1600	2	340-3800	140	6	3-3000
Ca	1200	3	410-6100	140	3	6-1100
K	400	-	-	120	3	17-1000
Fe	1700	3	380-4800	90	5	4-1900
Pb	170	3	48-1000	3	4	0.10-20
Zn	120	3	29-740	3	3	0.2-20
Mn	32	3	8-110	1.2	4	0.03-30
V	16	3	9-170	0.8	3	0.2-6
Cu	50	-	-	0.9	4	<0.08-15
Hg	0.22	3	0.9-1.3	-	-	-
Cr	14	4	2.6-153	0.3	3	<0.04-3
Ni	20	-	-	0.08	-	<0.02-1.5
Ce	3	-	-	0.2	5	0.005-3
Cd	3	-	-	0.2	4	<0.01-1.6
Se	1.7	2.7	0.5-5.7	0.13	3	<0.02-0.6
As	16	2.0	7.5-50	0.07	3	0.012-0.5
Co	0.97	2.0	0.42-2.8	0.03	5	<0.005-0.5
Sb	3.0	2.9	0.81-12	0.014	5	<0.001-0.3
Sc	0.39	2.3	0.11-1.3	0.02	5	0.002-0.4
Th	0.3	-	-	0.02	5	0.002-0.2
Ag	0.6	-	-	0.003	3	<0.002-0.08
Eu	0.056	2.8	0.016-0.21	0.003	5	<0.0002-0.05

* Geometric Standard Deviation

÷ Young et al., 1975 and Zoller (personal communications)

! Duce et al., 1976a & b; Duce and Hoffman, 1976

Table 3

Mean Atmospheric Trace Metal Concentrations,
New York Bight[+] and New York City[!]

Wind Direction	Fe ng/m^3STP	Al ng/m^3STP	Zn ng/m^3STP	Cd ng/m^3STP	Pb ng/m^3STP
New York Bight					
SW through NW to NE	240±140	260±160	57±51	1.4±0.9	200±60
NE through SE to SW	80±40	110±70	32±5	0.52±0.19	44±18
New York City*					
-	1400	-	310	5.8	1400

* Geometric mean of monthly values, 1972-73

[+] Duce et al., 1975

[!] Kneip and Eisenbud, 1974

Table 4

"Background" Concentrations of Trace Metals on Particles Expected near Sea Level in the Proposed Burn Area

Metal	Expected Concentration Range (ng/m^3 STP)
Na	500-2000
Mg	200-500
Al	50-500
Ca	100-500
K	100-400
Fe	50-500
Pb	10-200
Zn	2-100
Mn	0.5-5
V	0.5-10
Cu	0.5-20
Hg	0.01-0.1
Cr	0.1-50
Ni	0.05-50
Ce	<0.05-0.5
Cd	0.05-2
Se	0.01-1
As	0.05-5
Co	0.01-0.5
Sb	0.01-1
Sc	0.01-0.1
Th	0.01-0.1
Ag	0.005-0.2
Eu	<0.001-0.01

Table 5

Atmospheric Concentrations of Chlorinated Hydrocarbons at Selected Locations

Substance	Location	Concentration ng/m^3 STP	Reference
PCB	Bermuda	0.15-0.5	Harvey and Steinhauer, 1974
	Bermuda	0.08-0.66	Bidleman et al., 1976
	Chesapeake Bay	1.0-2.0	Bidleman et al., 1976
	Grand Banks	0.05-0.16	Harvey and Steinhauer, 1974
CH_3-CCl_3	Numerous sites, North Atlantic and North Pacific	∿700	Singh et al., 1979
	Numerous sites, northern hemisphere	∿600	Rasmussen, 1977 Reported in Chang and Penner, 1978.
	Irish Coast	∿400	Cox et al., 1976
	Sandy Hook, N.J.	∿900	Lillian et al., 1975
	U.S. Pacific northwest	∿600	Cronn et al., 1977
$CHCl=CCl_2$	Numerous sites, North Atlantic and North Pacific	∿90	Singh et al., 1979
	Irish Coast	∿90	Cox et al., 1976
	U.S. Pacific Northwest	∿120	Cronn et al., 1977
	Sandy Hook, N.J.	∿2000	Lillian et al., 1975
	Marine air mass, Maryland coast	∿300	Lillian et al., 1975
CH_3Cl	Numerous sites, North Atlantic and North Pacific	∿1500	Singh et al., 1979
	U.S. Pacific Northwest	∿1400	Cronn et al., 1977
	Irish Coast	∿1700	Cox et al., 1976
DDT	Chesapeake Bay	0.014-0.37	Bidleman et al., 1976
	Bermuda	<0.003-0.058	Bidleman et al., 1976

D. Climatological Conditions in the Proposed Burn Area

A detailed description of the general climatological conditions in the area of the New York Bight is given by Brower (1977). Information on this region is also available in NOAA (1973). Of particular concern (relative to the atmospheric transport and deposition of residues from the proposed burn site) are wind speed and direction, precipitation frequency, intensity, duration and type, and fog. Information on these parameters is presented in Table 6.

1. Wind Direction and Speed

Percentage frequency of wind direction from eight points of the compass and calm as well as mean wind speed in Knots and meters/sec are given in Table 6. From a map of the east coast of North America it can be seen that if a line were drawn roughly southwest to northeast through the proposed burn site location, winds blowing from the southeast side of this line would generally carry any atmospheric substances toward the North American coastline, while winds from the northwest side of the line would carry material out to the open ocean. Table 7 presents data on the monthly variation of the fraction of the time the wind direction is from these "northwest" and southeast" sectors. For the purpose of this table calm conditions were split evenly, assuming that the general flow was "northwesterly" half the time and "southeasterly" half the time. Note that the wind flow is primarily from the northwest sector during autumn. winter, and early spring and from the southeast sector during the late spring and summer. Wind speed is much stronger in the winter, with a mean of 18-19 kts, but drops to a minimum of 11 kts in the middle of summer. Calm conditions are 3 to 4 times more prevalent in summer than winter.

2. Precipitation

The percentage frequencies of total observations reporting rain and show in the proposed burn area are presented in Table 6. There is, of course,

Table 6

Meteorological Data for Proposed Burn Site[1]

Month	Wind Direction (% of Time occurring)									Mean Wind Speed		Precipitation* Snow	Precipitation* Rain	Visibility
	N	NW	W	SW	S	SE	E	NE	CALM	KTS	M/SEC	%	%	% < 2 Miles
January	18	23	17	12	10	4	4	8	4	18	9.0	4.3	11.0	3.1
February	23	22	16	10	9	3	4	8	5	19	9.5	4.9	13.2	4.5
March	17	19	15	12	13	6	4	9	5	18	9.0	2.1	11.6	5.6
April	15	12	14	14	17	5	6	10	7	15	8.5	0.3	10.8	6.4
May	13	8	10	16	17	7	8	10	11	13	6.5	0.0	6.9	12.5
June	9	6	10	19	18	8	8	10	12	12	6.0	0.0	5.4	7.1
July	7	5	9	23	21	5	6	10	14	11	5.5	0.0	4.9	4.9
August	11	6	8	18	19	7	8	12	11	11	5.5	0.0	4.7	3.1
September	16	8	7	10	11	7	12	19	10	12	6.0	0.0	5.9	2.9
October	18	16	10	9	11	6	8	14	8	15	7.5	0.0	6.4	1.4
November	18	20	16	10	10	5	5	10	6	17	8.5	0.3	11.3	1.9
December	19	23	19	11	9	3	4	7	5	18	9.0	2.7	12.1	2.0

[1] Wind direction data from NOAA (1973) for the area 35^{o}-40^{o}N, 70^{o}-75^{o}W, all other data from Brower (1977) for 38.4^{o}-39.2^{o}N, 71.8^{o}-72.6^{o}W.

* Data reported are the percent of total observations with snow or rain.

Table 7

Wind Direction Frequency from "Northwest" and "Southeast" Sectors

	SW - NW - NE (%)	NE - SE - SW (%)
January	70	30
February	73	27
March	64	36
April	57	43
May	50	50
June	46	54
July	44	56
August	45	55
September	50	50
October	60	40
November	67	33
December	72	28

no snow in late spring, summer, or early autumn, with a maximum of snow being reported about 5% of the time in February.

Rainfall frequency is also much higher in the winter than in the summer. The annual accumulation of precipitation is about 100 cm in coastal areas west of the burn site, and range from 5-8 cm in June to 10-13 cm in August, being fairly uniformly distributed, in amount, throughout the year. Most rainfall from May through October is from thunderstorms. These rains are generally brief but of high intensity. The November through April precipitation is more often associated with widespread storms. Duration of rain and snow is often one or two days, but the intensity is not as great as during the summer.

3. Fog and Visibility

The percentage frequencies of reports of visibility less than two miles are reported in Table 6 and are indications of the frequencies of dense fog. The most common fog in this area is advection fog. It occurs most frequently in late spring and early summer when warm humid air from the south is carried over the cooler water surface.

II. RESPONSE TO QUESTIONS CONCERNING ATMOSPHERIC BEHAVIOR OF COMBUSTION PRODUCTS

A. 1. How Long Will These Substances (Unburned Chlorinated Hydrocarbons and Heavy Metals) Remain Suspended in the Atmosphere?

A general range of expected atmospheric residence times for several classes of substances expected to be released from the proposed burn site are given in Table 8. For substances present as particles, the atmospheric residence time is a function of a number of parameters, as described in paragraph I.A.2, above. Based on currently available data, submicrometer size particles, the size on which much if not most of the waste residues in the particulate phase should be found, will have atmospheric residence times on the order of a few days to a week or so. Most of the residual trace metals will be present on particles, but most of the residual CHC will be present in the vapor phase.

In the vapor phase, saturated low molecular weight unburned CHC can be expected to have atmospheric residence times on the order of months to years. Unsaturated low molecular weight CHC will have much shorter residence times, on the order of hours to days. High molecular weight chlorinated hydrocarbons which are polar in nature and easily hydrolyzable, such as the major components of Herbicide Orange, would be expected to have relatively short atmospheric residence times, probably on the order of a few days or less. High molecular weight CHC which are aromatic and non polar, such as PCB's, are expected to have atmospheric residence times of weeks to a few months.

2. What is the Fate of the Unburned Chlorinated Hydrocarbon and Heavy Metals Emitted to the Atmosphere?

Residual material present on atmospheric particles will be removed by dry deposition and precipitation to the earth's surface, either ocean or land.

While some fraction of the low molecular weight vapor phase CHC are removed directly by rain, most are destroyed in the atmosphere primarily via attack by

Table 8

Estimated Atmospheric Residence Time Ranges
for Various Classes of Substances Released at the Proposed Burn Site

Substance	Estimated Residence Time Range
Submicrometer Particles (e.g., containing heavy metals)	Days to a week or two
Saturated Low Molecular Weight CHC (e.g., CH_3-CCl_3)	Months to years
Unsaturated Low Molecular Weight CHC (e.g., CHCl = CCl_2)	Hours to days
Polar and Hydrolyzable High Molecular Weight CHC (e.g., n-butyl ester of 2,4-D)	Hours to days
Aromatic, Non Polar High Molecular Weight CHC (e.g., PCB's)	Weeks to months

the OH radical and, in the case of unsaturated perchloro-compounds, ozone. The detailed atmospheric reaction pathways and products of the photochemical reactions of these chlorinated compounds as well as the reaction rates are still poorly known. It appears, however, that such reaction products as formyl chloride, phosgene, chloroacetatdehyde, and di- and tri-chloroacetyl chloride as well as HCl and ClO may be formed. The oxygenated chlorinated hydrocarbon reaction products should have a short atmospheric residence time, on the order of days at most.

3. What Percentage Reaches the Ocean and Where Does the Rest Go?

This question cannot be answered accurately, as it is a function of a variety of atmospheric conditions and chemical and physical properties of the atmospheric residue. (See Question D for some crude model calculations).

With the winds in a generally westerly direction, away from North America, atmospheric submicrometer particulate residues, with their roughly 4-10 day residence times, should be largely deposited in the North Atlantic. With easterly winds, depending on the detailed air mass trajectory, much of the submicrometer particulate material could be deposited over North America. A similar analysis would apply for the polar and hydrolyzable heavier CHC and the unsaturated low molecular weight CHC with their relatively short residence times. Note in these latter cases, however, that a fraction of the material will have undergone reactions, and/or degradations either in solution or in the vapor phase, while in the atmosphere. There is presently insufficient information on reaction rates, scavengeability, etc., to predict the relative quantities of these substances destroyed in the atmosphere and returned to the ocean or land surface intact.

The low molecular weight saturated CHC have atmospheric residence times of months to years and thus can be distributed around the northern hemisphere and even globally, mixing into the southern hemisphere. They are largely destroyed in the atmosphere but do undergo slow exchange with the ocean as described below.

B. How Far Will Particles or Trace Gases be Transported in the Atmosphere?

For particles, residence time is related to particle size, as discussed in paragraph I.A.2, above. A residence time of a few days to a week or so for submicrometer size particles is probably reasonable. The mean surface wind speed in the proposed burn site ranges from 5.5 meters/sec in the summer months to 9.5 meters/sec in the winter (see Table 6). Winds will be stronger at higher altitudes. The distances a particle or gas molecule would travel, over time periods ranging from 1-30 days assuming the 5.5 and 9.5 meters/sec summer and winter mean wind speeds, are indicated in Table 9. The trajectory followed by the particles or molecules

Table 9

Atmospheric Transport Distances Under Various Conditions

Mean Wind Speed (m/sec)	Atmospheric Residence Times			
	1 Day	4 Days	10 Days	30 Days
	Transport Distance (Km)			
4	350	1400	3500	10,400
5	430	1700	4300	13,000
6	520	2100	5200	15,500
7	600	2400	6000	18,100
8	690	2800	6900	20,700
9	780	3100	7800	23,300
10	860	3500	8600	25,900

would not be linear, of course, but would be highly complex and variable, depending on the particular synoptic meteorological patterns present during and after the burn. It is apparent, however, that for submicrometer particles, and unburned CHC's which have atmospheric residence times in the range of days to weeks, transport on the order of thousands of kilometers is possible. This has been corroborated by many atmospheric investigations of continentally derived aerosols found over the ocean thousands of Kilometers from their source.

In summary, particles and trace gases with atmospheric residence times of more than one to two days can be transported over a thousand kilometers from their source area. While the concentration of these substances will have been diluted to the extent that they may not be distinguishable from the background concentrations of these substances, these distances are considerable.

Note in Table 7 that the percentages of the times the wind is out of the southeast sector (i.e., 045° through 135° to 225°) range from a low of 27% in the winter to a high of 56% during the summer. Winds within this sector would

transport the substances of interest back towards North America, which is only some 200 Km from the burn site. Thus, while they would considerably dilute the particle and gas concentrations, winds from this sector could easily transport submicrometer particles and trace gases back across the coastline of the United States.

C. Can any Particles be Expected to Remain Suspended for an Indefinite Period?

"Indefinite" is quite vague. As discussed in paragraph I.A.2, the atmospheric residence times of particles smaller than a few micrometers in radii generally range from a few days to a few weeks. The maximum residence time for submicrometer particles is probably in the upper troposphere in geographical regions with little precipitation. In these areas particulate residence times of a month are possible. It is assumed that none, or an extremely small fraction, of these particles enter the stratosphere, where longer residence times do occur.

D. What Will be the Air/Sea Surface Concentrations Observed at Various Distances Downwind of the Emission Source, and What is the Flux of These Substances from the Atmosphere to the Ocean?

1. Chlorinated Hydrocarbons

Model calculations of the atmospheric concentrations of certain substances downwind of an at-sea incineration have been presented by Paige et al., (1978). Their calculations will be utilized in this section in an attempt to relate atmospheric concentrations to potential air/sea exchange of some of the substances of interest. Considered here will be rates of input into the ocean, comparison of total quantities of emitted substances with background concentrations of these substances in the atmosphere, fraction of the total quantities emitted per unit time which reach the ocean in that same time interval, etc.

To evaluate the potential importance of the direct gas phase uptake of low molecular weight CHC by the ocean, we will use CH_3-CCl_3 (methyl chloroform or trichloroethane) as an example, along with a number of simplifying assumptions. To calculate the gas phase flux of CH_3-CCl_3 into the ocean the values of c_g, c_l, H, k_l, and k_g for this compound must be known (see paragraph I.B.3.). On the basis of H values for freon 11 and CCl_4 (5 and 1 g/cm^3 air per g/cm^3 water respectively) a Henry's Law constant of 2 will be assumed for CH_3-CCl_3. As a first approximation, $c_l = 0$ will be assumed, i.e., that there is initially no CH_3-CCl_3 dissolved in the ocean around the burn site.

For expected atmospheric concentrations we utilize the results reported from the Gaussian plume model of Paige et al., (1978), Appendix B. Assuming a 99.96% destruction efficiency, they utilized an emission rate of 8.8 Kg/hr for unburned CHC waste from the ship. We will assume this is all CH_3-CCl_3 for this exercize. With an effective stack height of 125 meters and a wind speed of 4.0 m/sec for an at-sea burn, they calculated a maximum ground level concentration of unburned waste of $\sim$ 2.5 μg/m^3 (or 2.5 x 10^{-12} g/cm^3), which we here assume is all CH_3-CCl_3. Thus $c_g = 2.5 \times 10^{-12}$ g/cm^3.

From paragraph I.B.3. we know that k_l for CH_3 CCl_3 is given by:

$$k_l = 5.6 \times 10^{-3} \text{ cm/sec} \times \sqrt{\frac{\text{Mol. Wt. } CO_2}{\text{Mol. Wt. } CH_3\text{-}CCl_3}} = 3.4 \times 10^{-3} \text{ cm/sec}$$

and k_g is given by:

$$k_g = 0.83 \text{ cm/sec} \times \sqrt{\frac{\text{Mol. Wt. } H_2O}{\text{Mol. Wt. } CH_3\text{-}CCl_3}} = 0.30 \text{ cm/sec}$$

On a liquid phase basis:

$$R_t = 1/K_l = 1/k_l + 1/Hk_g = \frac{1}{3.4 \times 10^{-3}} + \frac{1}{2 \times 0.30} = 296 \text{ sec/cm}$$

or $K_1 = 3.4 \times 10^{-3}$ cm/sec.

Now the flux, F, from the atmosphere to the ocean is given by:

$$F = K_1 (c_g/H - c_1)$$

and, since we assume $c_1 = 0$

$$F = \frac{K_1 c_g}{H} \qquad (13)$$

$$F = \frac{3.4 \times 10^{-3} \text{ cm/sec} \times 2.5 \times 10^{-12} \text{ g/cm}^3 \text{ air}}{2 \frac{\text{g/cm}^3 \text{ air}}{\text{g/cm}^3 \text{ water}}} = 4.3 \times 10^{-15} \text{ g/cm}^2\text{sec}$$

If the atmospheric concentration of 2.5×10^{-12} g/cm^3 were maintained indefinitely, CH_3-CCl_3 would continue to enter the ocean until the water concentration, in g/cm^3 water, was half the atmospheric concentration, in g/cm^3 air (since we assumed H was $2 \frac{\text{g/cm}^3 \text{ air}}{\text{g/cm}^3 \text{ water}}$). Thus the equilibrium water concentration would be $\sim 1.25 \times 10^{-12}$ g/cm^3. If the net input flux remained constant at its initial value of 4.3×10^{-15} g/cm^2 sec (which it would not, of course, because of the initiation of a return flux to the atmosphere as soon as $c_1 > 0$) it would take about 8 hours to saturate the ocean to a depth of 1 meter and about one month to saturate the ocean to a depth of 100 meters, assuming complete material mixing and assuming the atmospheric concentration remained constant at 2.5×10^{-12} g/cm^3. Of course these high concentrations persist over an area of the ocean for only a few hours at most, as the plume and ship move across the ocean and the plume continues to disperse in the atmosphere.

Looking at the problem a different way, we can estimate what fraction of the emitted CH_3-CCl_3 might be removed in an hour. The emission rate is 8.8×10^3 g/hour. Utilizing the model results of Paige et al., (1978), Appendix B, we will assume that an elliptical shaped plume of high concentration is found over the ocean as a result

of the incineration. In this region we assume the surface level atmospheric concentrations are ∿ 80% of the predicted maximum concentration of Paige et al. (1978), or ∿ 2×10^{-12} g/cm^3. This elliptical area has a maximum length of ∿ 10,000 meters and maximum width of ∿ 250 meters and thus has an area of ∿ 2×10^{10} cm^2. The total mass of CH_3-CCl_3 deposited in this area in one hour is given by:

$$\text{Total Mass} = \frac{K_1 c_g}{H} \times 2 \times 10^{10} \text{ cm}^2 \times 3600 \text{ sec}$$

$$= \frac{3.4 \times 10^{-3} \text{ cm/sec} \times 2.0 \times 10^{-12} \text{ g/cm}^3 \text{ air} \times 2 \times 10^{10} \text{ cm}^2 \times 3600 \text{ sec}}{2 \frac{\text{g/cm}^3 \text{ air}}{\text{g/cm}^3 \text{ water}}}$$

$$= \sim 0.2 \text{ grams.}$$

This can be compared to the total mass of CH_3-CCl_3 released per hour, 8.8 Kg. All these values are presented in Table 10. Thus removal to the ocean by direct gas exchange is very slow for this compound and most of the low molecular weight saturated CHC's will be carried far from the burn area, as discussed previously.

Table 10

Predicted Fluxes of Chlorinated Hydrocarbons to the Ocean

Compound	Total Mass Released at Burn Site g/hr	Paige et al. (1978) Model Predicted Maximum Concentration 10^{-6} g/m^3 STP	Maximum Gas Flux to the Ocean g/cm^2/sec	Total Flux into the Ocean* g/hr
CH_3-CCl_3	8800	2.5	4×10^{-15}	0.2
PCB	8800	2.5	4×10^{-13}	20
DDT	8800	2.5	4×10^{-13}	20

* Within a specified area of 2×10^{10} cm^2, see text for details and assumptions used.

or $K_1 = 3.4 \times 10^{-3}$ cm/sec.

Now the flux, F, from the atmosphere to the ocean is given by:

$$F = K_1 (c_g/H - c_1)$$

and, since we assume $c_1 = 0$

$$F = \frac{K_1 c_g}{H} \qquad (13)$$

$$F = \frac{3.4 \times 10^{-3} \text{ cm/sec} \times 2.5 \times 10^{-12} \text{ g/cm}^3 \text{ air}}{2 \frac{\text{g/cm}^3 \text{ air}}{\text{g/cm}^3 \text{ water}}} = 4.3 \times 10^{-15} \text{ g/cm}^2\text{sec}$$

If the atmospheric concentration of 2.5×10^{-12} g/cm^3 were maintained indefinitely, CH_3-CCl_3 would continue to enter the ocean until the water concentration, in g/cm^3 water, was half the atmospheric concentration, in g/cm^3 air (since we assumed H was $2 \frac{\text{g/cm}^3 \text{ air}}{\text{g/cm}^3 \text{ water}}$). Thus the equilibrium water concentration would be $\sim 1.25 \times 10^{-12}$ g/cm^3. If the net input flux remained constant at its initial value of 4.3×10^{-15} g/cm^2 sec (which it would not, of course, because of the initiation of a return flux to the atmosphere as soon as $c_1 > 0$) it would take about 8 hours to saturate the ocean to a depth of 1 meter and about one month to saturate the ocean to a depth of 100 meters, assuming complete material mixing and assuming the atmospheric concentration remained constant at 2.5×10^{-12} g/cm^3. Of course these high concentrations persist over an area of the ocean for only a few hours at most, as the plume and ship move across the ocean and the plume continues to disperse in the atmosphere.

Looking at the problem a different way, we can estimate what fraction of the emitted CH_3-CCl_3 might be removed in an hour. The emission rate is 8.8×10^3 g/hour. Utilizing the model results of Paige et al., (1978), Appendix B, we will assume that an elliptical shaped plume of high concentration is found over the ocean as a result

of the incineration. In this region we assume the surface level atmospheric concentrations are ∿ 80% of the predicted maximum concentration of Paige et al. (1978), or ∿ 2×10^{-12} g/cm^3. This elliptical area has a maximum length of ∿ 10,000 meters and maximum width of ∿ 250 meters and thus has an area of ∿ 2×10^{10} cm^2. The total mass of CH_3-CCl_3 deposited in this area in one hour is given by:

$$\text{Total Mass} = \frac{K_1 c_g}{H} \times 2 \times 10^{10} \text{ cm}^2 \times 3600 \text{ sec}$$

$$= \frac{3.4 \times 10^{-3} \text{ cm/sec} \times 2.0 \times 10^{-12} \text{ g/cm}^3 \text{ air} \times 2 \times 10^{10} \text{ cm}^2 \times 3600 \text{ sec}}{2 \frac{\text{g/cm}^3 \text{ air}}{\text{g/cm}^3 \text{ water}}}$$

$$= \sim 0.2 \text{ grams.}$$

This can be compared to the total mass of CH_3-CCl_3 released per hour, 8.8 Kg. All these values are presented in Table 10. Thus removal to the ocean by direct gas exchange is very slow for this compound and most of the low molecular weight saturated CHC's will be carried far from the burn area, as discussed previously.

Table 10

Predicted Fluxes of Chlorinated Hydrocarbons to the Ocean

Compound	Total Mass Released at Burn Site g/hr	Paige et al. (1978) Model Predicted Maximum Concentration 10^{-6} g/m^3 STP	Maximum Gas Flux to the Ocean g/cm^2/sec	Total Flux into the Ocean* g/hr
CH_3-CCl_3	8800	2.5	4×10^{-15}	0.2
PCB	8800	2.5	4×10^{-13}	20
DDT	8800	2.5	4×10^{-13}	20

* Within a specified area of 2×10^{10} cm^2, see text for details and assumptions used.

We can make a similar estimation of the gas phase flux of PCB and DDT from the atmosphere to the ocean. According to Bidleman et al., (1976), H for PCB (and DDT) is on the order of $1 \times 10^{-3} \frac{g/cm^3 \text{ air}}{g/cm^3 \text{ water}}$ and thus K_1 is $\sim 1.7 \times 10^{-4}$ cm/sec. Assuming c_g is again 2.5×10^{-12} g/cm^3, i.e., all the unburned organic residue is PCB or DDT, and assuming $c_1 = 0$, the flux of PCB (or DDT if the unburned residue is DDT) is on the order of 4×10^{-13} g/cm^2 sec. Assuming the flux is 80% of this value over an elliptical area of 2×10^{10} cm^2 for 1 hour, the total flux into the ocean is $\sim$ 20g, as shown in Table 10. This compares to the total of $\sim$ 8800 g released by the burning process. While this is a factor of $\sim$ 100 greater than the mass of CH_3-CCl_3 entering the ocean, it is still a small fraction of the total PCB or DDT released.

Assuming the entire 8.8 Kg/hr unburned waste released is CH_3-CCl_3, we can also compare the quantity of CH_3-CCl_3 released in a typical 185 hour burn with the ambient quantity of this material present in the atmosphere over (a) the entire 4500 Km^2 designated incineration site area and, since the residence time of this compound is long, (b) the entire northern hemisphere. We assume the background concentration is uniform vertically at $\sim$ 600 ng/m^3 STP (see Table 5) and that the atmosphere has a scale height of 6.5 Km. The resulting quantities are compared in Table 11. A similar comparison can be made for PCB and DDT and the results of the calculations are given in Table 11. A PCB background concentration of 0.5 ng/m^3 STP and a DDT background concentration of 0.02 ng/m^3 STP was assumed. Note that for CH_3-CCl_3, the total mass released is only $\sim$ 10% of the mass of this compound which already exists in the atmosphere over the designated burn area, and is extremely small relative to the total northern hemisphere quantity. For PCB, the situation is somewhat different. In this case the quantity of PCB released would be $\sim$ 100 times the amount normally present within

Table 11

Comparison of Masses of Material Released from a Typical Burn with the Mass Already Present in Several Atmospheric Reservoirs

Substance	Quantity Released* in 185 Hour Burn (g)	Quantity Already Present Over Designated Incineration Site (g)	Quantity Already Present in Northern Hemisphere Atmosphere (g)
CH_3-CCl_3	2×10^6	2×10^7	1×10^{12}
PCB	2×10^6	1.5×10^4	1×10^9
DDT	2×10^6	6×10^2	4×10^7
Cu	1.3×10^5	$1.5 \times 10^4 - 6 \times 10^5$	-
Zn	1.3×10^5	$6 \times 10^4 - 3 \times 10^6$	-
Pb	7×10^4	$3 \times 10^5 - 6 \times 10^6$	-
As	2×10^4	$1.5 \times 10^3 - 1.5 \times 10^5$	-
Co	2×10^4	$3 \times 10^2 - 1.5 \times 10^4$	-
Cr	7×10^5	$3 \times 10^3 - 1.5 \times 10^6$	-
Ni	4×10^5	$1.5 \times 10^3 - 1.5 \times 10^6$	-

* See text for assumptions concerning burn residues.

the atmosphere over the 4500 Km^2 area of the designated burn region. It is a few tenths of one percent of the total PCB content of the northern hemisphere atmosphere. For DDT the quantity released is over 1000 times the background quantity over the designated burn region and almost 10% of that expected in the entire northern hemisphere background atmosphere, which would be quite significant.

These crude calculations show that the impact of the burn on the atmospheric concentration of the substance released and its subsequent concentrations in the ocean varies greatly from compound to compound, and each has to be assessed separately.

2. Heavy Metals

It is useful to estimate the input of heavy metals to the ocean from the atmosphere, both via dry deposition and rain removal. The heavy metal emission rates from incineration used by Paige et al. (1978) in their Gaussian plume model are given in Table 12.

With a mean wind speed of 4 m/sec and an effective stack height of 125.5 m, the Paige et al., (1978) model predicts the maximum atmospheric concentrations would occur 4000 meters from the burn site. (See their Appendix B). Their predicted maximum concentrations are given in Table 13 along with the ranges of expected background concentration over the ocean in that area (from Table 4).

From Table 13 it appears that the Pb concentration predicted by the model is within the expected background range. The maximum Cu, Zn, and As concentrations predicted from the model burn are about 2 to 10 times the upper end of the expected background concentration ranges, while the predicted Ni, Cu, and Cr concentrations are 10 to 60 times the upper end of the background range.

To obtain order of magnitude estimates of the input of these heavy metals to the ocean under dry conditions, we can assume the major mass of these metals is on submicrometer particles, which probably have dry deposition velocities of 0.05 to 1.0 cm/sec (paragraph I.B.2.). Using the relationship:

$$F = Cv_d \qquad (14)$$

Where F = trace metal flux, in g/cm^2 sec

C = atmospheric concentration in g/cm^3

v_d = deposition velocity, in cm/sec (0.05 to 1.0 cm/sec)

Table 12

Predicted Hourly Fluxes of Heavy Metals

Metal	Flux into the Atmosphere from the Burn Site g/hr	Flux into the * Ocean by Dry Deposition g/hr	Flux into the * Ocean by Rainfall g/hr
Cu	700	0.6 - 12	300 - 3000
Zn	700	0.6 - 12	300 - 3000
Pb	400	0.3 - 6	200 - 2000
As	100	0.09 - 2	40 - 400
Co	100	0.09 - 2	40 - 400
Cr	4000	3.5 - 70	2000 - 20,000
Ni	2000	1.7 - 35	1000 - 10,000

* Within a specified area of 2×10^{10} cm^2 - see text for details and assumptions used.

the predicted range of fluxes for these metals can be calculated. The results of this crude calculation are given in Table 13.

We assume, as in the discussion of CH_3-CCl_3 above, that an elliptically shaped region of high atmospheric heavy metal concentration is found over the ocean. Trace metal concentrations in this region are $\sim$ 80% of the maximum predicted by the model of Paige et al., (1978). The elliptical region has an area of $\sim 2 \times 10^{10}$ cm^2. The total mass of each heavy metal deposited in this area by dry deposition in one hour is given in Table 12.

Under the conditions of this crude dry deposition removal model, it appears that from a few tenths of one percent to a few percent of the mass of the trace metals released each hour is deposited in the ocean during the first hour.

Table 13

Predicted Atmospheric Concentrations and Fluxes to the Ocean of Selected Heavy Metals

Metal	Expected Background Concentration 10^{-9} g/m^3 STP	Paige et al., (1978). Model Predicted Maximum Concentration 10^{-9} g/m^3 STP	Predicted Dry Deposition Flux to the Ocean Surface 10^{-14} g/cm^2 sec	Predicted Rainfall Flux to the Ocean Surface 10^{-14} g/cm^2 sec
Cu	0.5 - 20	220	1 - 20	500 - 5000
Zn	2 - 100	220	1 - 20	500 - 5000
Pb	10 - 200	120	0.6 - 12	300 - 3000
As	0.05 - 5	30	0.15 - 3	60 - 600
Co	0.01 - 0.5	30	0.15 - 3	60 - 600
Cr	0.1 - 50	1200	6 - 120	3000 - 30,000
Ni	0.05 - 50	620	3 - 60	1000 - 10,000

Subsequent vertical dispersion of the material in the plume would result in lesser percentages being deposited from a one hour burn in subsequent hours. Note that the entire quantity of each heavy metal released by burning per hour is not delivered to the ocean each hour, as was assumed for HCl in the model of Paige et al., (1978) - see their Appendix D. In fact, a rather small percentage is removed, at least under dry conditions.

The numerous limitations of the Gaussian plume model relative to the problems associated with the proposed incineration site have been discussed by Paige et al., 1978. The deposition calculations made, using data derived from the plume model, are highly uncertain and serve only as order of magnitude estimates which apply only under the specific conditions of the model.

To obtain order of magnitude estimates of the rainfall removal of these trace metals from the atmosphere, we can use the washout factor discussed in paragraph I.B.1. We will assume that the atmospheric concentrations of the particulate heavy metals in the 2×10^{10} cm^2 elliptical deposition area are about 80% of the maximum values given in Table 13, as was assumed in the crude dry deposition model. We will also assume that this atmospheric concentration is maintained throughout an hour's rainfall, which will clearly not be the case, and will result in the calculation of anomalously high input values to the ocean. We will assume that the particles are submicrometer in size and, from Figure 2, will assume that W, the washout factor, is $\sim$ 1000. As shown in Section I.B.1.

$$C_{rain} = C_{air} W \qquad (15)$$

In Equation (15) the units for C_{air} are ng/Kg air. To convert the model predicted concentrations given in Table 11, which are in ng/m^3 STP, to ng/Kg air, we multiply the ng/m^3 STP values by 0.78. With this information we can predict the heavy metal concentrations in the rain.

The concentrations in the rain are a function of rainfall intensity, duration, etc., but this cannot be accurately modelled at this time. If we assume a continuous average rainfall rate from 1 to 10 mm/hr, a reasonable range, then the total quantity of each heavy metal removed, in $g/cm^2 sec$, can be calculated and is given in Table 13 for these rainfall rates. Note that the ranges of rain removal fluxes predicted for each metal are much greater than the ranges of fluxes predicted by dry deposition. Thus rain, when it occurs, is an efficient mechanism for the removal of atmospheric particles. Applying these rainfall removal rates, over a one-hour period and an area of 2×10^{10} cm^2, results in the ranges of values reported in Table 12 for rainfall removal in the elliptical deposition area.

The lower end of these ranges is approximately the same as the total emission rates of these metals from the burning process. The higher, unrealistic, end of the range results, of course, from the assumption that the area of high atmospheric concentration can be maintained over a one-hour period. As these results show it obviously cannot, i.e., the rainfall removal is very efficient. This rapid scavenging of particles in the lower atmosphere is well-documented in the literature. It appears that most of the particulate output from a burn could be removed in roughly an hour or so, under conditions of continuous rain at rates of 1 - 10 mm/hr.

E. What Effects do Variable Atmospheric Conditions Have on the Fate of Emissions (e.g., Fog, Precipitation, Increased Wind Velocity, etc.)?

The atmospheric residence times and removal rates for substances are related to a number of atmospheric conditions. Increasing wind speed increases the effective deposition velocity for a given size particle, as shown for laboratory studies in Figure 3, presumably due to increased turbulence in the near boundary layer. Direct gas exchange is also enhanced with increasing

wind speed. Unfortunately there are not sufficient field data available to quantify these effects well or to utilize them in a predictive mode. Increasing wind speed accelerates the dispersion of the pollution plume. As described by Paige et al., (1978), in a conventional Gaussian plume model, concentration is inversely proportional to wind speed. Thus a doubling of the wind speed results in halving the predicted concentration at any point downwind from the source, all other parameters remaining constant.

Precipitation and fog will both enhance the removal of all the substances, but particularly HCl, particles, and the polar and hydrolyzable organic constituents. Low molecular weight saturated CHC will not be affected significantly by fog or precipitation.

Assuming that the primary objective relative to the atmospheric emissions is rapid dispersal and rapid removal to the ocean surface, the optimum meteorological conditions include relatively strong winds from the "northwest" sector coupled with periods of precipitation. Periods of fog are not desirable as they affect general ship operations. In addition, fog only occurs during light wind conditions. With these meteorological conditions in mind, and reference to Table 6 (the monthly climatological information for the proposed burn site), it is apparent that the best time of year to obtain the general conditions above is in autumn, winter, and early spring.

III. RESPONSE TO QUESTIONS CONCERNING OCEANIC BEHAVIOR OF COMBUSTION PRODUCTS

A. Transport of Combustion Products Entering the Ocean from the Proposed North Atlantic Incineration Site

The proposed North Atlantic Incineration Site is located in a region of the northwest Atlantic Ocean known as the Slope Water region. The transport of residues by oceanic processes will depend on the specific location of the plume in the atmosphere and on the prevailing hydrographic conditions. Figure 6 illustrates the location of the site relative to the major oceanographic features. Typically, the Shelf Water resides north and west of the 200 m contour to depths of 100-200 m along the continental shelf. This water is distinguished by its relatively low salinity (less than 34.5°/$_{oo}$), and its temperature which varies seasonally from about 2-4°C in the winter to about 22°C in the summer (Beardsley and Flagg, 1976). A distinct surface front separates the Shelf Water from the Slope Water at approximately the 200 m isobath. The upper 50 m of the Slope Water is generally more saline (34.5 - 35.5°/$_{oo}$) and warmer (10°C winter, 24°C summer) than the Shelf Water. The Slope Water is bounded on the south and east by the Gulf Stream.

The nominal circulation of waters through this region is a southwesterly flow along the shelf and inner slope and a northeasterly flow of the Gulf Stream (Beardsley et al., 1976) with a possible northeasterly flow in the outer Slope Water. This pattern gives rise to an oblong counterclockwise gyre circulation in the Slope Water region (Figure 7).

There can be large variations in the Slope Water region from the normal location and flow of Shelf, Slope, and Gulf Stream Waters due

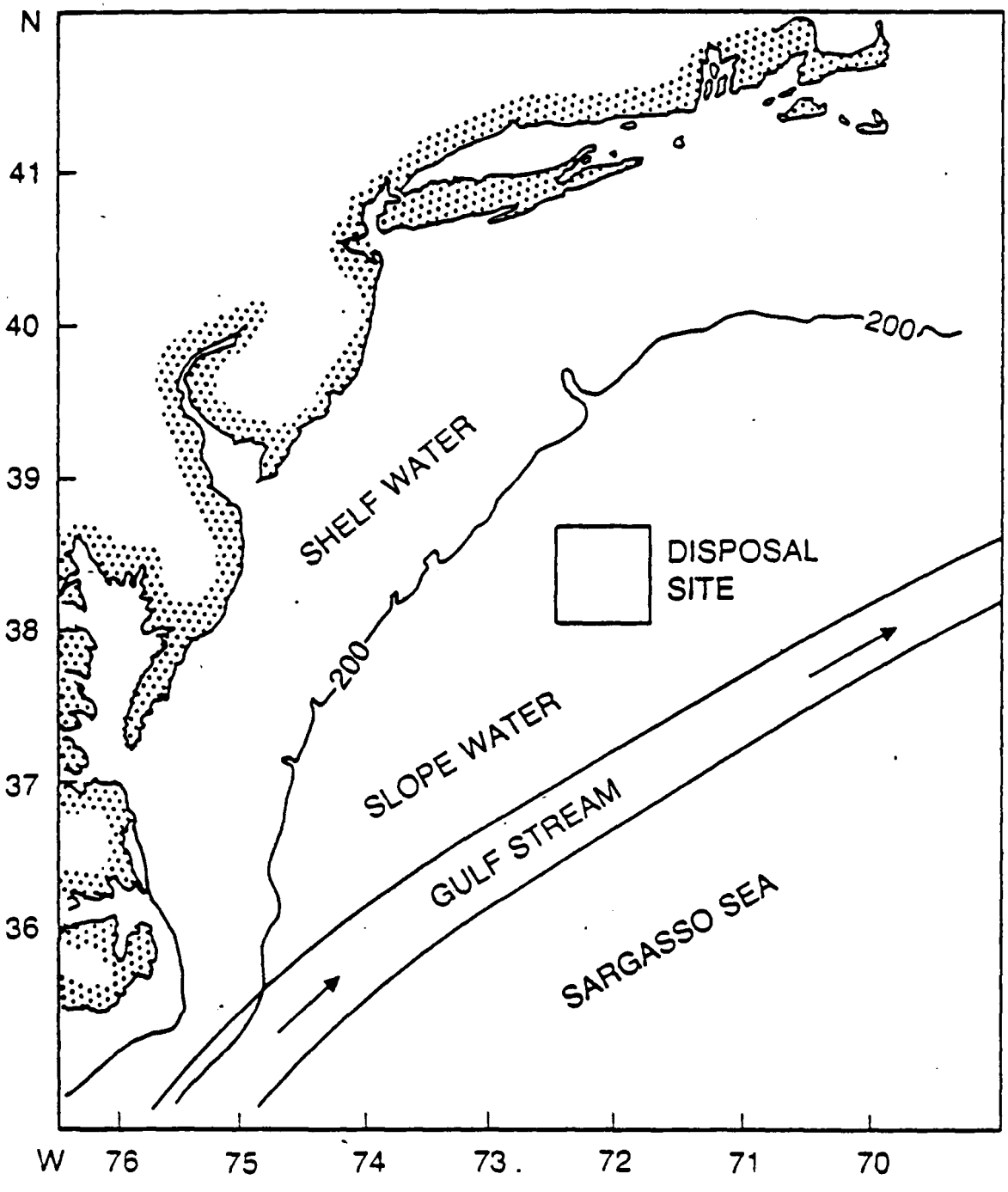


Figure 6. Major water mass regimes and the proposed incineration site.

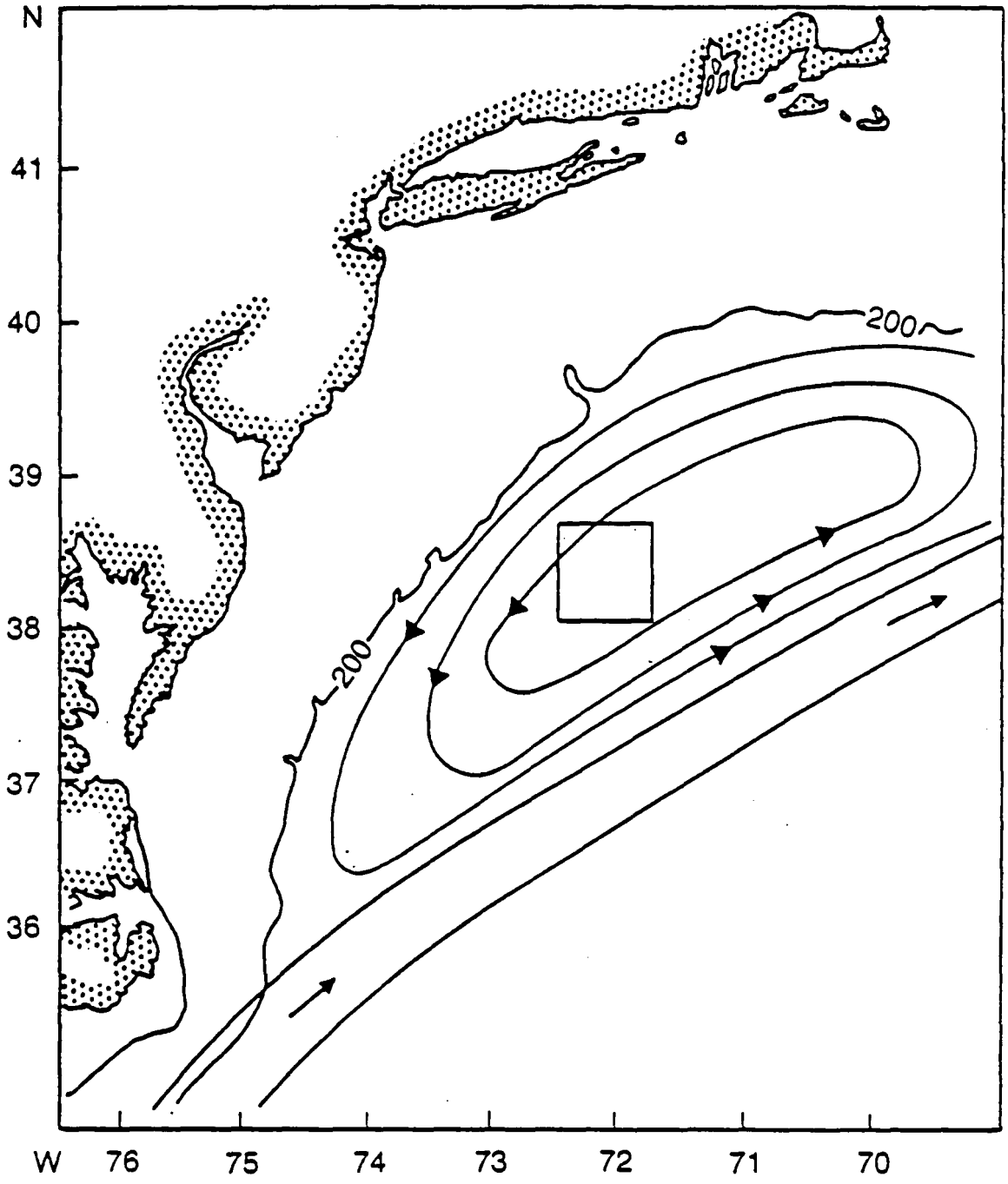


Figure 7. Schematic illustration of the proposed Slope Water gyre (after Csanady, 1979).

to three phenomena: Shelf Water intrusions, Gulf Stream meanders, and Warm Core Rings. Occasionally tongues of Shelf Water can be seen in infrared satellite images penetrating into, and apparently mixing with the Slope Water. The Gulf Stream often develops meanders which displace and modify the outer Slope Water. Warm Core Rings are bodies of Gulf Stream and Sargasso Sea Water which are imbedded in the Slope Water. These features are 80-150 km in diameter; they rotate in a clockwise direction with surface currents of about 1-3 knots; they have a lifetime of about 6-14 months during which they migrate southeasterly through the Slope Water region. The transport of incineration residues will be determined by the water masses and near-surface currents beneath the atmospheric plume.

For an initial consideration of residue transport we will assume that the atmospheric plume results in deposition of wastes within 10 km of the incineration ship. This assumption is based on observations during burns in the Gulf of Mexico in which the plume was detected at sea-level within 0.5-3.5 nautical miles of the M/T VULCANUS. Thus, we will consider deposition of residues within the Incineration Disposal Site when the "average" hydrographic conditions prevail. Under these circumstances the residues will be deposited in the Slope Water. It is likely that they will be trapped in the Slope Water circulation which has a physical residence time on the order of 2-4 years. The following projection can be suggested for the transport of residues deposited in the Slope Water. They will tend to be transported with the surface waters to the southwest at a rate of about 3-5 km/day (based on speeds up to 10 cm/sec; Beardsley et al., 1976). Within 50-80 days the residue

will reach the southern portion of the Slope Water region and begin to drift northeastward along the outer portion of the Slope Water gyre. If we consider the waste to be trapped in the Slope Water gyre it will take about 3 years to travel once around the gyre. These waters are not trapped indefinitely; they exchange with waters at the Slope Water boundaries, and we could assume a residence time for waters in the Slope Water region to be on the order of 5 years. This residence time is not very well known from direct data, but it is unlikely that it is as short as 1 year or as long as 10 years.

Next we can consider the advective fate of residues if they are deposited into water masses other than the Slope Water during those occasions when other waters penetrate the Disposal Site. Shelf Water intrusions may extend into this region and then withdraw back onto the continental shelf. This is the most likely mechanism for transporting residues onto the shelf and possibly into coastal regions within the surface waters. This transport is of special importance because residues could enter the continental shelf ecosystem, to be taken up by human food fisheries or to accumulate in the benthic organisms and sediments. While this transport is likely, its contribution to the flux of contaminants to the continental shelf system is probably very small.

Residues will occasionally be deposited in Warm Core Rings passing through the Slope Water region. This event is important because the residues can be hydrographically trapped within a relatively small portion of the ocean and successive burns within a 30 day period could deposit cumulative loads of residue within a Ring. The potential impact of residues in a Ring may be different from those in the Slope Water,

because of differences in their biological communities. Rings have been observed impinging on the continental shelf break and they are suspected of affecting the local fisheries environment. Residues deposited in a Ring or in a meander of the Gulf Stream are likely to enter the large North Atlantic gyre.

A consideration of the transport of residues by physical processes requires an assessment of the fate of these residues in the ocean. In the preceding discussion we assumed that the residues are merely carried along by the waters. This is a useful starting point because it serves to define the time scales which must be considered. For example, we identified a 50-80 day time scale for transport to the vicinity of Cape Hatteras by the Slope Water. A 2-4 year time scale was suggested by circulation within the Slope Water gyre and a 5 year time scale was estimated for the Slope Water residence time. A time scale of decades would be applicable for transport by waters of the North Atlantic gyre. Shelf Water intrusions are likely to have time scales on the order of tens of days. As the time scale increases, processes other than physical transport will become important in determining the fate of contaminants. Horizontal and vertical mixing will decrease the concentration of residues and increase the volume of ocean in which they are dispersed. Contaminants that become associated with particles or biota may be removed from the surface waters by the vertical particle flux. These processes will be considered in the next three sections.

B. Differential Transport Due to the Vertical Gradient in Current Velocity

The physical structure and detailed dynamics of the near-surface ocean waters will influence the transport of combustion products

entering the sea. Two extreme conditions may be identified: in the winter vertical mixing extends downward to the permanent thermocline at 100-150 m, whereas during the summer the seasonal thermocline inhibits vertical mixing to above about 30 m. More rapid penetration and greater dilution of wastes will occur in winter than in summer. This effect has been observed by Kester and coworkers (1979, unpublished results) in studies of acid-iron waste dispersion at DWD-106. Typically, there is a decrease in current speed with depth, and there may also be a change in current direction with depth. This feature of surface ocean currents is commonly kown as the Ekman spiral in which the current vectors decrease in speed and rotate clockwise in direction with increasing depth. This behavior is expected from theoretical considerations of surface currents driven by the frictional stress of wind on the sea surface and this general behavior can be observed in some instances such as iceberg drift patterns. The detailed current structure in the Slope Water region is not well known or understood. Under some conditions the currents may result primarily from local wind stress, but there may be other factors such as long-shore pressure gradients that can drive the surface currents with different degrees of vertical shear.

There may be at least two sources of recent information that can provide examples of vertical shear in this region of the ocean under specific conditions. E.G.& G. has been conducting an investigation of the physical oceanography of the Georges Banks region (under contract to BLM) in which several different approaches have been taken to defining near surface currents on the continental shelf and upper slope. An experiment to measure vertical shear at DWD-106 was conducted by

investigators for the NOAA Ocean Dumping Division in April 1979. These studies are recent and the results may not be fully interpreted, but they provide direct sets of observations of vertical current structure in this region.

In general vertical shear along with vertical mixing may enhance dispersion of wastes in the upper ocean. The magnitude of this dispersion will vary seasonally, and with the local conditions prevailing at the time combustion products enter the ocean. The depth and vertical stability of the seasonal thermocline will influence the extent of vertical mixing. The present understanding of these processes is not adequate to permit quantitative predictions in the absence of observations.

C. Times Required for Dilution of Combustion Products

Our experience with the dilution of wastes that are ocean dumped at 106-Mile Ocean Waste Disposal Site suggests three main events in the dilution process. When wastes enter the ocean from a moving barge the turbulence created by the wake of the barge leads to a rapid initial dilution, on the order of 10^4 to 1, within 1-2 hours. Subsequent dilution due to oceanic mixing from values of 10^5 to greater than 10^6 occurs in time scales of 8-20 hours; it has been inferred that dilutions of 10^6 may persist for days or weeks in the absence of a major perturbation in ocean mixing, such as may be caused by the passage of a storm through the region. The basis for these generalizations is contained in a series of research reports to be published in early 1980 in the book "Ocean Dumping of Industrial Wastes." In waste plumes created by barge dumping we encounter distributions with mixing scales of 30 m vertically during summer stratification (100 m during winter mixing) by 10^3 m in width and by 40-50 km in length. It is likely that these general

scales of mixing are applicable to combustion products entering the ocean near an incineration ship. In that case the dispersion in the atmospheric plume provides an initial dilution of wastes analogous to the turbulence behind a barge, and the oceanic dilution process will commence with the relatively slow lateral mixing processes, the thermocline-controlled vertical mixing, and the periodic enhanced mixing due to storms.

In considering the oceanic concentrations of combustion products we will distinguish three classes of chemical constituents. The light weight hydrocarbon and related organic substances with long atmospheric residence times will enter the geochemical cycle with length scales of 10^3 to 10^4 km and their fate will not be relatable to their origin as an at-sea incineration combustion product. They will contribute to the total burden of contaminants in the North Atlantic and northern hemisphere. The inorganic elements will be expected to have a short atmospheric residence time and will enter the ocean with the rates characteristic of dry particulate deposition and of rainout. Uncombusted high molecular weight organic substances, such as PCB's and pesticides, the aromatic hydrocarbon solvents and degradation/combustion products, can enter the ocean in particulate phases similar to the inorganic elements, or by gas phase exchange, thereby having a somewhat greater atmospheric residence time.

For those constituents with natural chemical cycles in the ocean the ambient concentration provides a reference from which the anthropogenic impact can be assessed. Table 14 lists the inorganic elements for which emission rates have been calculated associated with at-sea incineration of organic wastes. The elements have been placed in four groups based on the extent and reliability of existing knowledge

Table 14. Summary of inorganic elements associated with at-sea incineration disposal or organic substances.

Group A Elements: Generally good knowledge of oceanic concentrations and chemical cycles.

Element	Surface Ocean Water Concentration	Calculated Emission Rate mole/hr	Emission Rate / Ocean Water Concentration x 10^6
Pb	0.6 nmol/kg	1.9	3200
Cu	1.9 nmol/kg	11.0	5800
As	5 nmol/kg	1.3	2600
Ni	5 nmol/kg	34	6800
Zn	0.5 nmol/kg	10.7	21,000
Fe	3.5 nmol/kg	161	46,000
Co	0.5 nmol/kg	1.7	3400
Mn	16 nmol/kg	1.8	110
I	0.35 µmol/kg	0.7	2
F	68 µmol/kg	53	0.8
Ba	73 nmol/kg	3.1	42
Sr	90 µmol/kg	8.0	0.08
Si	20 µmol/kg	71	3.6
Br	0.84 mmol/kg	2.5	0.003
B	0.43 mmol/kg	18.5	0.04
S	29.1 mmol/kg	31	0.001
K	10.2 mmol/kg	179	0.017

Group B Elements: Some data available on oceanic concentrations, but marine geochemical cycles poorly known.

Element	Surface Ocean Water Concentration	Calculated Emission Rate mole/hr	Emission Rate / Ocean Water Concentration x 10^6
Cr	1 nmol/kg	77	7700
Se	2.5 nmol/kg	1.2	480
Ga	0.4 nmol/kg	0.6	1500
Al	74 nmol/kg	37	500
Rb	1.4 µmol/kg	0.2	0.1
Li	27 µmol/kg	5.8	0.2

Group C Elements: Little or no information available on ocean distribution and chemistry

Element	Surface Ocean Water Concentration	Calculated Emission Rate mole/hr	Emission Rate / Ocean Water Concentration x 10^6
Ag	0.4 nmol/kg	1.8	4500
Mo	10 nmol/kg	4.2	420
Ti	0.2 nmol/kg	8.3	4100
Zr	--	1.1	--
Sc	0.02 nmol/kg	0.4	20,000

Group D Elements: Information was not provided on their emission from at-sea incineration and they could be important.

Element	Surface Ocean Water Concentration
Hg	0.02 nmol/kg
V	49 nmol/kg
Cd	0.02 nmol/kg

of their marine chemistry. Within each group the elements have been qualitatively ranked, based on the magnitude of their emission rate relative to oceanic concentrations and their potential for environmental impact (e.g., their biological toxicity or perturbation in seawater composition). Based on this approach attention should be focused on Group A elements for Pb through Co, on Cr and Se in Group B and Mo, and Ag in Group C. Group D identifies those elements that were not included in the calculated emission rate analysis, but that could be important.

In order to estimate the elevation of oceanic concentrations one must have a model for the flux from the atmosphere and the mixing within the ocean. Paige et al., (1978) presented a model for the instantaneous plume from an incineration ship with the following characteristics: ship

speed 9.7 knots (5 m/sec) into a wind of equal speed, and an elliptical plume 270 x 5000 m with an area of 10^6 m^2. A number of research burns have been conducted of 4000 metric tons of waste at a burn rate of 25 metric tons per hour for a duration of about 7 days (U.S. Dept. of State and EPA, 1979). The proposed incineration site is approximately 45 x 30 nautical miles in size. We previously assumed an instantaneous deposition area on the order of 2 x 10^{10} cm^2 or 0.2 x 10 km (Tables 10 and 12), thus a simple scenario for the burn of a load of waste would be a series of lines within the dumpsite 45 nautical miles in length at the western boundary of the dumpsite, assuming a wind from a western quadrant. A burn for 160 hours while steaming at 9.7 knots will require a ship track 1,550 nautical miles in length, which corresponds to about 35 north-south runs through the incineration site. It is evident from this calculation that considerations based on an instantaneous plume are inadequate; there will be cumulative deposition of wastes on the sea surface from multiple transects of the incineration ship.

As pointed out in Table 12 the flux of inorganic elements from the atmosphere to the ocean will vary greatly, depending on whether it occurs by dry deposition or by rainfall. We will first examine a worst-case situation to determine if the deposition on the ocean represents a significant flux. We will assume that the entire emission flux enters the 2 x 10^6 m^2 area of the ocean beneath the plume, which could occur during rainfall. Thus, for Pb the flux to the ocean surface would be 5.5 x 10^{-12} $g/cm^2/sec$. For a ship moving at 5 m/sec trailing a 10 Km plume each square cm under the plume will be exposed to the preceding flux for 2000 sec per transect. This corresponds to 11 ng/cm^2 for Pb. We will assume this Pb is mixed to a depth of 20 m (Paige et al., 1978),

thereby producing an elevation in the ambient concentration of 5.5 ng/kg or 0.027 nmol/kg. The cumulative effect of 35 transects to complete a burn would be 0.9 nmol/kg which is about equal to the ambient concentration. Under conditions of efficient rainout for all inorganic elements the effect on the ambient ocean water concentration will be proportional to the emission rate/concentration ratio in Table 14. A ratio of 3×10^9 corresponds to a doubling of the ambient concentration; a 3×10^{10} ratio corresponds to a 10 fold increase above ambient concentrations. We conclude that measurable increases in surface concentrations could be seen for Pb, Cu, As, Ni, Zn, Fe, Co, Cr, Ag, Ti, and Sc during rainout.

In the preceding analysis we have taken an upper limit for the atmospheric flux by considering rainfall conditions. During dry deposition the flux to the ocean would be about 1% of the total and the total deposition would occur over a larger area. Under these conditions none of the inorganic element concentrations would be elevated beyond natural variations.

In applying this consideration to organohalogen compounds we will use PCB as an example of the possible elevation of oceanic concentrations. The maximum gas flux to the ocean beneath a plume 0.2 x 10 km was calculated to be 4×10^{-13} g/cm^2/sec in Table 10. The incineration ship is assumed to steam with a speed of 5 m/sec (about 9.8 kts) and we will assume that the 10 km plume travels above the sea surface with this effective speed. Actually the duration of the plume over a fixed part of the ocean is controlled by dispersion and advection rather than movement of the ship, but the preceding approach will provide an estimate of the duration of the 4×10^{-13} g/cm^2/sec flux from the plume produced by the moving ship. The time during which a square cm

of ocean surface will be under a 10 km long plume produced by a ship moving at 5 m/sec is 2000 sec. Thus, the total input of PCB to this square cm is 8×10^{-10} g/cm^2. We will assume that this amount of PCB mixes to a depth of 20 m which will result in a concentration increase of 0.4 ng/kg for each transit of the ship. A total burn of 35 transits could lead to a cumulative concentration increase of 14 ng/kg. Bidleman et al., (1976) summarized PCB concentrations in surface ocean waters based on a number of investigations from 1971-1975. Values for the Sargasso Sea to New York Bight and the New England continental shelf were 0.8 ng/kg. Thus, the gas phase flux of PCB to the upper 20 m of the ocean during a 160 hour burn of waste could elevate the ocean PCB concentration 17 fold. The EPA quality criterion for PCB in fresh and marine waters is 1 ng/l, thus the effect of at-sea incineration of wastes in the proposed dumpsite could exceed the EPA criterion by more than 10 fold.

An additional point should be considered in the behavior of contaminants transferred to the ocean by gas phase exchange when compared to the inorganic elements which may be transferred at a maximum rate by rainfall. Table 10 implies that (20/8800) x 100 = 0.2% of the PCB is absorbed by the ocean beneath the 2×10^{10} cm^2 plume. If all the non-combusted PCB is eventually absorbed by the ocean the area of impact will be much greater than that in the preceding analysis which considered only the region beneath the plume. The available model is inadequate to estimate the total impact on ocean concentrations, but it should be realized that our estimate of 14 ng/kg in a volume of the ocean 200 m x 83 km x 20 m has accounted for only 0.2% of the PCB released.

The duration over which elevated concentrations may persist depends on the rates of dispersion and removal from the surface waters. Our observations of wastes at 106-Mile Ocean Waste Disposal Site as well as physical models of dispersion suggest that elevated concentrations can persist for days under non-storm conditions. An analysis of the frequency of storms in the region could provide a basis for the duration of elevated concentrations assuming they are eliminated by the enhanced mixing produced by a storm. In addition to physical dispersion one may expect removal of inorganic and organic substances from the water by adsorption onto particles suspended in the water, and by incorporation into the biota. These processes can provide a means of contaminant removal from the surface waters and transfer to deep ocean by the gravitational flux of large particles. The rates of these processes are not known wich much precision, and they will vary with the type and intensity of biological activity.

D. Waste Accumulation on the Bottom

There is no basis for expecting that the combustion products would reach the seafloor in an identifiable manner in the Slope Water region with water depths in excess of 2000 m. The most likely way that combustion products could enter the benthic environment are for the plume or the waters in which it is deposited to pass over the continental shelf where the water depth is 50-100 m. There is considerable evidence for chemically stable waste substances such as PCB and kepone being able to accumulate in continental shelf sediments. The maximum concentrations attainable are a function of the duration of the input and the sedimentation rate. A quantitative estimate would require the development of a model which is not available at the present time.

E. The Maximum Fallout Rate to Maintain Water Quality Criteria

In estimating the maximum fallout rate, which will not produce a concentration increase greater than the Water Quality Criteria (Table 15) after four hours, we will make the following consideration. Four hours will be sufficient time to mix the contaminants to a depth of 20 m, but there will not be appreciable horizontal dispersion away from the initial plume. Chemical and biological removal will not be significant in a 4 hour time period. If we take PCB as an example of a gas phase contaminant that could set the maximum permissible fallout, we calculate that 1 ng/l to a depth of 20 m represents 2 ng/cm^2 deposition. If this deposition occurs over a 2000 sec period corresponding to a 10 km plume extending behind a ship moving 5 m/sec, the maximum permissible flux of PCB is 1×10^{-12} $g/cm^2/sec$. If there is a possibility of cumulative deposition due to multiple transits within the incineration site the maximum permissible flux will be $[(1 \times 10^{-12}) \div n]$ $g/cm^2/sec$ where n is the number of multiple transits.

The calculation of maximum permissible fallout based on inorganic elements can not be done meaningfully, because only three elements have specific concentration criteria. The amount of Hg and Cd were not specified in the emission rates provided (Appendix 1) and Mn does not represent a major component of the waste. The other elements' criteria are given relative to "sensitive organisms" for which we have no specific data. In the absence of suitable criteria for inorganic elements we might consider it acceptable to double the ambient concentrations of elements such as Cu, Ni, Cr, or Ag. On this basis the limiting condition will occur during rainfall deposition of all the inorganic material in the plume. Let C be the acceptable concentration increment of the

Table 15.. Summary of 1976 U.S. EPA Water Quality Criteria.

1. Elements for which specific marine concentrations are given.

Element	Acceptable Concentration
Hg	0.1 µg/l
Cd	5.0 µg/l
Mn	100 µg/l

2. Elements for which the criteria are specified as 0.01 times the LC_{50} based on a sensitive marine organism.

Element
Ni
Ag
Se

3. Elements for which the criteria are specified as 0.01 times the LC_{50} based on a sensitive fresh water organism.

Element
Pb
Zn

4. Element for which the criteria are 0.1 times the LC_{50} for a sensitive marine species.

Element
Cu

5. Organic substances for which specific marine concentrations are given.

Substance	Acceptable Concentration
PCB	1 ng/l
DDT	1 ng/l
Parathion	40 ng/l
Malathion	100 ng/l

deposited element in nmole/kg or nmole/l. Then 2C will be the nmole/cm^2 that can be deposited, assuming that mixing distributes the element to 20 m depth. If this deposition is generated by a 2000 sec flux (the time required for the ship to travel the 10 km length of the plume at 5 m/sec) the flux will be C/1000 nmole/cm^2/sec. This flux extends over an area that is 2×10^{10} cm^2 so that maximum emission rate is 2×10^7 C nmole/sec or 7.2×10^{10} C nmole/hr. If we take

into account the possible accumulation of contaminants due to n transects through the region, the maximum emission rate becomes [7.2 x 10^{10} C/n] nmole/hr. If we take n = 35, the rate becomes 2 x 10^{9} C nmole/hr. For Pb we would take C = 0.6 and the maximum emission rate (MER) would be 1.2 mol/hr; for Cu C = 1.9 and MER = 3.8 mole/hr; for Cr C = 1 and MER = 2 mole/hr. It is evident that with these criteria and considerations of deposition from the plume, the emission rates for some elements listed in Table 15 exceed the maximum permissible.

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TABLE 4-7. CALCULATED APPROXIMATE EMISSION RATES OF INORGANIC ELEMENTS

Element	Concentration in Waste (ppm)	Calculated Emission Rate (kg/hr)	Element	Concentration in Waste (ppm)	Calculated Emission Rate (kg/hr)
Lead	5-20	0.1-0.4	Nickel	10-100	0.2-2
Barium	10-20	0.2-0.4	Cobalt	1-5	0.02-0.1
Iodine	2-4	0.04-0.09	Iron	30-400	0.7-9
Silver	1-8	0.02-0.2	Manganese	1-5	0.02-0.1
Molybdenum	10-20	0.2-0.4	Chromium	5-200	0.1-4
Zirconium	1-5	0.02-0.1	Titanium	10-20	0.2-0.4
Strontium	5-30	0.1-0.7	Scandium	0.1-1	0.002-0.02
Rubidium	0.5-1	0.01-0.02	Potassium	~300	~7
Bromine	5-10	0.1-0.2	Sulfur	30-60	0.7-1
Selenium	1-5	0.02-0.1	Silicon	90-100	~2
Arsenic	1-5	0.02-0.1	Aluminum	10-50	0.2-1
Gallium	0.5-2	0.01-0.04	Fluorine	10-50	0.2-1
Zinc	10-30	0.2-0.7	Boron	1-10	0.02-0.2
Copper	10-30	0.2-0.7	Lithium	0.5-2	0.01-0.04

Appendix E

SAFETY PLAN FOR THE INCINERATION OF HAZARDOUS WASTES ABOARD THE M/T VULCANUS

CONTENTS

Appendix E
SAFETY PLAN FOR THE INCINERATION OF HAZARDOUS WASTES ABOARD THE M/T VULCANUS

This appendix presents a general safety plan for the incineration of hazardous wastes aboard the M/T VULCANUS. Prior to the incineration of Herbicide Orange in the Pacific Ocean in 1977, a detailed safety plan was prepared. The plan was demonstrated to work effectively, and will be closely adhered to during future incineration operations.

The scope of the plan is limited to shipboard operations. Specifically excluded are the safety requirements for ship loading operations, which are covered by USCG and OCS standard procedures.

POTENTIAL HAZARDS AND TERMINATION OF A BURN

Specific wastes destined for at-sea incineration must be scrutinized for potential health hazards of the primary waste(s) and associated contaminants. For example, in the case of Herbicide Orange, the trace contaminant TCDD was of particular concern because of its high toxicity. The primary wastes, 2,4-D and 2,4,5-T, were relatively less hazardous. For a substance such as PCB, highly toxic PCDF contamination must be considered, in addition to exposure to PCB.

Threshold limit values (TLV) for specific waste components are used to determine maximum prolonged exposures to atmospheric concentrations of toxic substances. The TLV is a time-weighted safe air concentration value or index for an 8-hour work day or 40-hour work week. Based on the TLV a range of time-limited personnel breathing zone concentrations, considered safe, are determined. In the event that the TLV of any monitored substance is exceeded, corrective measures must be undertaken immediately, or incineration of wastes terminated.

Incineration may be terminated if at any time the plume is observed to remain in contact with the vessel, even after corrective measures have been taken. Similarly, incineration will be terminated if spills occur onboard the vessel and cannot be readily contained or cleaned.

Incineration will also be terminated if stack gas concentrations of waste compounds are obsserved to fall below the prescribed minimum combustion efficiency of 99.9%.

PERSONNEL PROTECTIVE EQUIPMENT

Due to the potential health hazard relating to the incineration of wastes aboard the M/T VULCANUS, special safety requirements have been established for all personnel to ensure that no hazards exist. To ensure adequate protection, issued coveralls shall be worn, as appropriate, as well as protective gloves, shoes, and masks. In addition to the normal equipment used in this type of activity, the following items will be provided.

(1) An approved pesticide gas respirator
(2) Fire extinguishers
(3) Firefighter entry suits
(4) Scott Air Pak
(5) Portable emergency eye baths; at least two of these must be present continuously in the pump room, as well as in the burner room.

All personnel that will be onboard the M/T VULCANUS and may enter a potentially contaminated area will be duly trained on the proper use and operation of the above equipment.

Other general safety requirements that will be adhered to are the following:

(1) All personnel within the incinerator area and/or sampling area during the incineration of wastes will have an approved gas mask available for immediate use.

(2) If an emergency condition is detected, all personnel will be notified to don masks and to evacuate a given area if necessary.

(3) Personnel exposed to high temperatures and/or direct thermal radiation will wear entry suits.

(4) Confirmed or suspected spills will be reported to the shipmaster and the safety officer for proper cleanup.

PERSONNEL HYGIENE

Methods of personnel hygiene concur with the concepts of personal cleanliness, isolation of contaminated areas, and preservation of "clean" areas which are described herein. Most procedures designed to protect personnel from hazards are a compromise between the ideal condition of complete avoidance of exposure, and the reality of providing safe conditions in areas in which work can be performed.

Proper personal hygiene practices are of primary importance in preventing exposure of personnel to hazardous materials. Of equal importance is the establishment of "clean" areas, in which personnel can coexist normally; the isolation of the hazard in areas where contamination is expected and can be dealt with; and the maintenance of an interface between the two areas which can be crossed, while maintaining the integrity of the clean area and the safety of personnel therein.

It is anticipated that the first opportunity for exposure would come from spills and leaks in the system. The exposed liquids will evaporate only partially, especially from hot decks and tankage areas below decks, and the very hot combustion room.

Liquids may be tracked over the decks and passageways and may find their way into the eating and living quarters, unless an inviolate interface is established between the two areas. The basic requirements for effective personnel hygiene against hazardous materials are:

(1) Protection of personnel from vapor and liquid contact in the contaminated areas by source control and protective gear.

(2) Provision of disposable clothing and food covers.

(3) Provision of disposal facilities at the interface region between the contaminated and clean areas.

(4) Provisions or a shower, hand, face, and eyewashing facilities at the interface region.

(5) Provision of clean clothing and foot covering at the boundary of the clean area upon return to working areas.

(6) Instruction in the use of the cleaning and protective equipment, and in methods of personal cleansing.

(7) Mandatory and enforced use of the above facilities and concepts.

Smoking, eating, or drinking from containers or cups should be avoided in potentially contaminated areas. This also applies to personnel who have not showered or otherwise cleansed themselves after being in potentially contaminated areas. The living quarters must be cleaned daily and thoroughly.

The pump room and the burner room are to be considered as contaminated areas. The number of people entering these rooms must be restricted. There must be interface regions between these two rooms and the rest of the ship. When leaving these rooms clothes and shoes must be changed and a shower must be taken before entering other areas of the ship. Hot and cold drinks, disposable cups, emergency eye baths, and the opportunity for hand washing

must be present at all times in the burner room. Flashlights must be also present at all times in the burner room and in the pump room. They are only to be removed from these rooms for destruction by incineration.

Whenever possible the routes taken by personnel should be planned so that the entrance to the working area and exits from the working area are separate. Disposable shoe covers must be provided at entrances and they must be incinerated after use. The hourly watch rounds must be made in the following manner and in no other: from the burner room to the generator room to the pump room, and back again to the burner room. The indoor floor on this route must be covered with heavy, disposal paper, and it must be renewed regularly. The floor and the deck on this route must be cleaned daily. One shall never go directly from the pump room and the burner room to the living quarters, mess room, galley, bridge, toilets, or passageways.

There must be a monitoring system based on wipe sampling and analysis onboard to ensure that clean areas remain so.

Finally, all working personnel should be made aware of the need for good personal hygiene, and of the consequences to themselves and others if poor personal cleanliness and poor housekeeping are occurring. A training program should be developed and personnel should be instructed in personal hygiene practices. The effectiveness of the program will depend on the degree to which personnel accept the training, willingly put the principles to use, and cooperate in preventing exposure. Personnel who are unwilling or unable to accept and apply the personal hygiene procedures should be excluded from contact with and entry to the working area by direction of the shipmaster.

SAFETY PROCEDURES AND MONITORING

The safety of all shipboard personnel will have top priority during the incineration of wastes onboard the incineration vessel. As a minimum the following safety precautions are required, as they apply before, during, and after burn operations. These safety precautions are grouped by participating organizations to define and emphasize areas of responsibility.

(1) The tank system will be maintained to minimize the escape of vapors into the atmosphere.

(2) Any waste spills, leaks, or residuals detected shall be immediately contained, and the area restricted until decontamination is completed.

(3) Whenever the piping system has to be opened for repairs or replacements, the part of the system to be repaired shall be flushed for at least 3 minutes with gas oil whenever possible.

(4) Fugitive waste emissions from the waste pumping room or any other source shall be minimized.

(5) An automatic shutoff device shall be in operation on both furnaces, set to turn off the flow of wastes if the temperature reading indicates the flame temperature drops below 1,250°C.

(6) The furnace may be brought up to operating temperature at a rate consistent with ship's practice and experience, using fuel oil. When the furnace flame temperature has reached 1,280°C (using correlated thermocouple or optical pyrometer measurements), the feed stock may be switched over to wastes. The practice of converting to waste feed by setting furnaces on successive stream should be followed. The flame temperature of the furnace must be restored to at least the original level of 1,280°C before the next burner is changed over to waste.

(7) During tank changeover, prior to each subsequent tank depletion, and any time prior to the time when any water or uncombustible liquid will be injected into the incinerator, the ship shall be underway, and oriented in such a direction as to minimize plume impingement,

should incinerator flame be extinguished. At least 15 minutes before tank depletion pumping will be switched so that two burners of each incinerator will be fed from a full tank, with the remaining burner used to deplete the material in the emptied tank.

(8) Temperature and combustion monitoring of the furnaces will be in effect during the changeover. The continuous record of temperature shall also be maintained during this time.

(9) The operational controls and monitoring panels shall be manned at all times by a responsible individual to ensure the incinerators are operating within desired combustion parameters.

(10) A device for the addition of ammonia to produce a visible plume will be installed and made operable.

(11) The speed and direction of the M/T VULCANUS during waste incineration will be controlled in such a manner as to prevent incinerator plume contact with any part of the ship.

(12) The M/T VULCANUS should demonstrate the ability to maintain 24-hour communication by voice and by code, using frequencies and channel appropriate to the area, and to the conditions of transmission and reception. This requirement supplements, but is not intended to supersede or replace the existing communication equipment. Daily communication will be required to report test progress and conditions. Emergency conditions will be reported as soon as possible.

(13) Personnel of the M/T VULCANUS will give a briefing on ship safety procedures and regulations. This shall include, but not be limited to, the assignment of lifeboat seats and at least one lifeboat drill.

(14) The M/T VULCANUS will comply with all applicable U.S. Coast Guard (USCG) rules and regulations governing a ship of this class and specification.

(15) Appropriate first aid supplies shall be available onboard the M/T VULCANUS for emergency situations.

EPA/USCG

(1) Appropriate first aid and medical supplies and trained medical personnel will be available onshore to respond to emergency situations onboard the M/T VULCANUS.

(2) A plan will be developed and in readiness to cover emergency rescue or medical requirements of shipboard personnel during operations at sea. An EPA representative will brief all EPA and vessel personnel, as well as key personnel (as determined by the ship's captain), regarding the provisions of this plan.

(3) Monitoring of the incinerator stack gases for CO and CO_2 will be carried out by the sampling/monitoring crew. The CO and CO_2 determinations will be used to ensure that the desired degree of combustion efficiency (99.9%) is achieved during incineration.

(4) Sampling of the stack gases for organohalogen waste residues, if any, shall be carried out by the sampling/ monitoring crew. The levels of the stack gases will, preferably, be determined onboard the M/T VULCANUS.

(5) If possible, an onboard air monitoring system for waste will be operated.

(6) If possible, an onboard monitoring system for the detection of spills and leaks of waste, based on the analysis of wipe samples, will be operated.

(7) A sampling system for locating the plume shall be established, using HCl in the air on the ship as a tracer indicator. If levels of HCl reach 0.1 to 0.5 ppm, immediate corrective actions will be taken. Immediate withdrawal of personnel from areas with HCl concentrations equal to or in excess of 5 ppm is mandatory. Any location with positive results shall be recorded, together with wind direction, wind speed, vessel heading, and vessel speed.

(8) Reports of significant incidents of equipment malfunction, plume impingement, personnel injury, or exposure will be prepared and reported immediately by radio communications to shore for subsequent relay to other concerned units. In the event of serious injury or exposure to personnel, EPA representative will consult with the shipmaster and the safety officer to ensure compliance with evacuation procedures. On return of the M/T VULCANUS to the shore, a complete report of the incident will be submitted, and copies transmitted to all concerned authorities.

SAFETY OFFICER

(1) The M/T VULCANUS crew and any other shipboard personnel boarding the incineration vessel will be briefed by medical personnel and the safety officer.

(2) The safety officer will in close cooperation with the shipmaster, survey all safety measures and precautions onboard the M/T VULCANUS.

Appendix F

COMMENTS AND RESPONSES TO COMMENTS ON THE DRAFT EIS

The Draft EIS (DEIS) was issued in October 1980. The public was encouraged to submit written comments. This Appendix contains copies of written comments received by EPA on the DEIS. There was a great variety of comments received; thus, EPA presents two levels of response:

- Comments correcting facts presented in the EIS, or providing additional information, which have been incorporated into the text and noted in this section.

- Specific comments, which were not appropriately treated as text changes, have been numbered in the margins of the letters, and responses have been prepared for each numbered item.

Some written comments were received after the end of the comment period. In order to give every consideration to public concerns, the Agency took under advisement all comments received up to the date of Final EIS production.

The EPA sincerely thanks all those who commented on the DEIS, especially those who submitted detailed criticisms which reflected a thorough analysis of the EIS. A list of the commenters by name and agency is presented in Chapter 5.

COMMENT

RESPONSE

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE ENGINEERING AND SERVICES CENTER
TYNDALL AIR FORCE BASE, FLORIDA 32403

28 JAN 1981

DEV

Draft Environmental Impact Statement (EIS) for Proposed North Atlantic Incineration Site Designation

EPA (Mr T. A. Wastler)

1-1 1. The Assistant Secretary of the Air Force for Environment and Safety (SAF/MIQ) forwarded the subject statement to us for review and comment. Our technical staff has reviewed the document and find no conflict with Air Force mission, plans, or policies.

2. We appreciate the opportunity to comment on this proposed action. Our project officer is Mr Myron Anderson, (904)283-6165.

FOR THE COMMANDER

BOYD T. DUFFEE, III, Lt Col, USAF
Director of Environmental Planning

Cy to: HQ USAF/LEEV
HQ USAF/LE
CVAE
SAF/MIQ

1-1 Thank you for your review and comments.

2

DEPARTMENT OF THE ARMY
NORTH ATLANTIC DIVISION. CORPS OF ENGINEERS
90 CHURCH STREET
NEW YORK, N. Y. 10007

NADPL-R

13 February 1981

Mr. T. A. Wastler
Chief, Marine Protection Branch (WH-548)
U. S. Environmental Protection Agency
Washington, D. C. 20460

Dear Mr. Wastler:

As requested, the Draft Environmental Impact Statement for the Proposed North Atlantic Incineration Site Designation has been reviewed and our consolidated comments are attached.

Thank you for the opportunity to review this document.

Sincerely,

NEIL STUART
Acting Chief, Planning Division

1 Incl
Draft EIS comments

F-4

CORPS OF ENGINEERS NAD COMMENTS ON
DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR THE
PROPOSED NORTH ATLANTIC INCINERATION SITE DESIGNATION USEPA

2-1 1. A Public Involvement section to indicate what has been done in the past and what is to be done in the future in this regard would be more appropriate than the inclusion of listings now located in the "Summary Sheet' section.

2-2 2. The regulations/guidelines indicate that PCB concentrations up to 500 ppm can be incinerated. Is the solvent other wastes? If so, it would be possible to dilute using other wastes and bring an excluded level of PCB waste to within permissible limits. The net effect would be to have the same insult to the ecosystem (i.e. the total amount of PCB) in a larger volume of solvent which probably would have been disposed of by incineration anyway.

2-3 3. The importance of identifying the decomposition products, quantifying their toxicity, and evaluating their resistance to incineration should be stressed if post-incineration scrubbing is not to be done.

2-4 4. A more detailed description of the monitoring program envisioned by NOAA (page 2-14) would be informative.

2-5 5. Residence times and furnace temperatures which would produce the greatest percent combustion/decomposition should be utilized to reduce the impact on the ecosystem. This as opposed to cost should be the primary criteria used in determining the conditions for incineration.

2-6 6. Concentration is one indicator of the rate at which contamination occurs; however, the analysis of the effects on the ecosystem should equally emphasize total net input of individual components (similar to what was done on page 2-37) and also account for processes such as bioaccumulation of these materials.

2-7 7. Are there contingency plans for accidental or compelled discharge/spillage of untreated waste?

2-8 8. No significant impacts are anticipated regarding Corps' areas of concern.

2-9 9. Cover page as per NEPA (S1502-11) is missing.

2-10 10. The summary section does not include information on any controversy or lack thereof, or if any unresolved issues remain.

2-11 11. Page 2-1 lists alternatives to be discussed. The subsequent four pages discuss alternatives not listed on page 2-1. Please clarify.

2-1 Comment noted.

2-2 This approach will, in all likelihood, be the preferred method for the blending of wastes. As accurately pointed out, certain wastes can be further diluted in the environment. Advantage can also be taken of the BTU content of wastes, minimizing the need for supplementary fuels.

2-3 EPA concurs. This process would be done as part of the permit application.

2-4 The National Oceanic and Atmospheric Administration (NOAA) is currently conducting monitoring at the 106 Mile Ocean Waste Disposal Site to detect adverse environmental impacts. A detailed monitoring plan has not yet been developed for the proposed incineration site; however, expansion of the 106 Mile Ocean Waste Disposal Site monitoring program to include the proposed incineration site would integrate sampling procedures and limit expenses. Appendix C provides a discussion of several parameters that will be considered in future monitoring operations of the proposed site. See also response 7-1.

2-5 EPA concurs.

2-6 Presently, it is impossible to establish the total net input of individual waste components because of the wide spectrum of wastes that may, or could be incinerated. However, in evaluating potential water quality and related biological impacts, the Final EIS (Chapter 4) assumes the worst case for the proposed site. Should at-sea incineration become an active waste disposal practice, the Environmental Protection Agency (EPA) can evaluate the volumes of specific waste types and regulate rates of disposal. Long-term monitoring will provide information regarding the bioaccumulation of contaminants.

2-7 Contingency planning to cover incinerator flameout, accidental spillage or discharge aboard ship, or vessel collision would be required as conditions to an incineration permit. Additionally, the National Oil and Hazardous Substances Pollution Contingency Plan is in effect for accidents occurring in the navigable waters of the United States, adjoining shorelines and waters within the 200 mile management authority under the Fishery Conservation and Management Act of 1976. The U.S. Coast Guard is the Federal agency responsible for response actions under the National Plan.

2-8 Comment noted.

2-9 The "Summary Sheet" serves as the required cover page. (40 CFR § 6.201).

2-10 This information has been added in the Summary of the Final EIS.

2-11 The proposed action is to designate a suitable site for at-sea incineration. Land-based disposal methods are not discussed as alternatives to the proposed action, but introduced as considerations [redacted]

3

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Policy
Washington D.C. 20230

FEB 12 1981

Mr. T. A. Wastler
Chief, Marine Protection Branch
(WH-548)
Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Wastler:

This is in reference to your draft environmental impact statement entitled, "Proposed North Atlantic Incineration Site Designation." The enclosed comments from the Maritime Administration and the National Oceanic and Atmospheric Administration (NOAA) are forwarded for your consideration.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving six (6) copies of the final statement.

Sincerely,

Robert T. Miki
Deputy Assistant Secretary for
Regulatory Policy (Acting)

Enclosure Memos from: Kenneth W. Forbes
Office of Shipbuilding Costs
Maritime Administration

Charles A. Burroughs
Environmental Data and Information Service
NOAA

Mr. Robert B. Rollins
National Ocean Survey
NOAA

F-7

UNITED STATES DEPARTMENT OF COMMERCE
Maritime Administration
Washington DC 20230

January 29, 1981

MEMORANDUM FOR: Bruce Barrett
Environmental and Technical Evaluation Division
Office of Regulatory Policy

Subject: Environmental Protection Agency - Draft Environmental Impact Statement (DEIS) for the Proposed North Atlantic Incineration Site Designation

The subject document has been reviewed as requested. Our comments are as follows:

3-1 1. Interagency Review Board for the Chemical Waste Incinerator Ship Program (IRB/CWISP)

The DEIS should record the formation of an Interagency Review Board (IRB) consisting of representatives from appropriate Federal agencies to coordinate and expedite all Federal Government activities related to legislation, funding, further environmental evaluation, design, construction, permitting, and operation of U.S. flag chemical waste incinerator ships. In addition, the IRB will develop procedures for the coordination of permits required for waterfront facilities, ship certification, and incineration of wastes and will evaluate additional alternatives to promote the construction of privately owned U.S. flag incinerator ships. (See the "Report of the Interagency Ad Hoc Work Group for the Chemical Waste Incinerator Ship Program.")

The IRB views incineration at sea as a major element in an overall integrated hazardous waste management matrix. Therefore, although the Board's main purpose is to pursue incineration at sea, the Board is also interested in the complete spectrum of technologies for treatment, recycling, and incineration on land so that every viable process may be developed to achieve an ultimate disposal program which utilizes each technology in its most appropriate role. High temperature incineration, whether on land or at sea, is the most effective method available today for the destruction of combustible hazardous wastes, destroying 99.99 percent of the wastes. Incineration that occurs at sea removes the destruction site from populated areas, which is of special value when incinerating the most toxic wastes.

3-1 Text modified, Chapter 1, under section "Purpose of and Need for Action."

F-8

2. Waste Quantities Available for At-Sea Incineration, pages xii, 1-22, 2-14, and 2-36

The Maritime Administration (MarAd) supported investigation: "A Study of the Economics and Environmental Viability of a U.S. Flag Toxic Chemical Incinerator Ship" is used in the DEIS as the source for the potential U.S. waste quantities available for at-sea incineration. It should be recognized and duly noted in the statement that the waste volumes predicted in this report are based on an EPA data base limited to several large primary waste generating industries. The secondary waste generating industries and organizations, e.g., the users of chemicals, are large in number and collectively generate substantial waste volumes. In addition, governments - Federal, State, and local - generate hazardous wastes. Therefore, substantially larger volumes of wastes for incineration, both at sea and on land, will very likely be available on the East Coast in 1983 and beyond if the hazardous waste management regulations are stringently enforced.

3-2

3. Environmental Consequences and Gaseous Emissions, pages xii, xviii, xx, 2-3, 2-12, and Chapter IV

The evaluation of environmental consequences is based on the use of technology which is 5-10 years old. Technological improvements have been made and will continue to be made in the field of incineration at sea. Under the auspices of the Interagency Review Board, EPA plans to conduct research and development aboard U.S. flag ships to advance the state-of-the-art of at-sea incineration. Areas addressed would include solid waste incineration (e.g., rotary kiln incinerators) and emission control devices (e.g., once-through seawater scrubbers). However, in order to understand more fully the characteristics of the gaseous emissions and their potential environmental impacts, the at-sea incineration projects conducted by EPA should have a well planned monitoring program as an integral part of the operations.

3-3

4. Disposal Operations, page xxi

The following additions are recommended to the requirements listed:

> "The U.S. Coast Guard will be notified of planned incineration operations to facilitate surveillance of loading, transport, and disposal activities and for notification of other marine traffic."

3-4

5. Federal Responsibilities, pages 1-8 and 1-9

In response to the requirements of the MPRSA, the Maritime Administration (MarAd), U.S. Department of Commerce, initiated its Chemical Waste Incinerator Ship Project. With the assistance of EPA, MarAd issued a Final Environmental Impact Statement (FEIS)

3-5

3-2 Text modified, Chapter 1, under section "Projection of Quantities and Types of U.S. Wastes Which Might be Incinerated At-Sea."

3-3 See comment and response 2-4.

3-4 The FEIS has been modified to include the statement.

3-5 EPA greatly appreciates the efforts that MarAd has expended in the development of at-sea incineration as an alternative hazardous waste disposal technology.

concerning this Project in July 1976. Subsequently, the Maritime Administration/Maritime Subsidy Board approved the FEIS and concluded that the Project should be pursued with Federal assistance. The MarAd aid plan, as currently described, involves several elements: (a) loan guarantees to aid in the construction of incinerator ships, (b) sale of National Defense Reserve Fleet vessels for conversion to incinerator ships, and (c) financial support for an incinerator ship system safety analysis. MarAd is endeavoring to expand this assistance program as part of its participation in the Interagency Chemical Waste Incinerator Ship Program.

3-6 6. Plume Dispersal, page 1-21

Figure 1-3 implies that the plume from an incinerator ship is highly visible and black in color. To the contrary, the naturally occurring plume ranges from white in color to being practically invisible, depending on meteorological conditions. It is strongly recommended that Figure 1-3 be redrafted to properly configure the true nature of the incineration plume.

7. Economics, page 2-14

3-7 The cost estimates listed under Halebsky (1978) are based on uninflated 1977 dollars.

8. Organohalogen Wastes, page 2-43

3-8 The first sentence of the second paragraph should be rewritten:

"During incineration of organochlorine wastes. . ."

9. Air Quality, page 4-9

3-9 The development of seawater scrubber technology will greatly decrease any impacts on air quality due to incineration operations.

We would appreciate receiving two copies of the FEIS.

Kenneth W. Forbes

KENNETH W. FORBES
Chief, Division of Environmental Activities
Office of Shipbuilding Costs

3-6 Figure 1-3 is a diagrammatic representation of the gaseous plume and should not be interpreted as a representation of a literal image of the operation. However, this fact is now noted in the title of Figure 1-3.

3-7 Text modified for clarification.

3-8 Correction made.

3-9 EPA concurs that scrubber technology for at-sea incineration should be investigated to reduce air impacts. For additional information, refer to comment and response 7-13.

4

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Center for Environmental Assessment Services

January 29, 1981 OA/D23/CAB

TO: PP/EC - Joyce Wood

FROM: OA/D23 - Charles A. Burroughs

SUBJECT: DEIS 8012.28 - North Atlantic Incineration Site Designation

The subject draft report was forwarded to this office for review by Dr. Kenneth Hadeen. Dr. Stephen W. Fehler, staff chemical oceanographer, has been the principal reviewer of the report. Comments below are for your consideration.

(1) General Introduction

The at-sea incineration of organic wastes is, in principle, an attractive means of eliminating industrial wastes and byproducts. In the DEIS, several alternatives to the proposed disposal site are suggested. The DEIS, however, does not fully address all the scientific and technical issues to be considered as pertinent. Deficiencies are noted in the discussions of chlorine gas, HCl, unburned organohalogens, and the sea surface microlayer.

(2) Trace Concentrations of Chlorine Gas

4-1 The potential production of chlorine gas (Cl_2) by the incineration process is suggested on page 1-2, and is regarded as "minimal", "under optimal combustion conditions." To the contrary, the potential for release of Cl_2 is probably quite

4-2 high. Note, that Table 4-3 gave concentrations for all halogens except Cl_2. Why? Some halogens, e.g. Fluorine had quite high concentrations (up to 50 ppm), and Fluorine was only a small proportion in the unburned material relative to chlorine. Does this table refer to elemental or atomic fluorine? The section on HCl & Cl_2 (pg. 4-16) also fails to deal with Cl_2. From an environmental and human health standpoint, Cl_2 is extremely important. Long term human exposure to Cl_2 should not exceed 1 ppm (CRC Handbook). It is strongly suspected that several hundred to several thousand ppm will be produced by the burning process. Furthermore, the environmental chemistry of chlorine gas is quite different from HCl. Cl_2 is very soluble in water (3 volumes Cl_2 in 1 volume of distilled water at 10^0C). Has the solubility of Cl_2 in seawater been studied? It should be a part of the DEIS. Unlike HCl, Cl_2 will not hydrolyze or react with seawater, but will selectively react with biological materials (particularly with sulfhydryl groups, amino groups and carbon-carbon double bonds). The reaction of Cl_2 with biological materials accounts for its use as a disinfectant, and as a poison gas in World War I. The potential that Cl_2 would damage the biological community, particularly the important neuston layer, is high. No incineration should be considered until

4-3 this is resolved. The incinerator design might need modification to lower Cl_2 emissions. The preliminary studies done in the Gulf of Mexico (page 1-15) on

4-4 phytoplankton, etc. are not sufficient to resolve this issue because the short-term burn of 4 or 16 tons of material is in no way comparable to 200,000-500,000 tons per year on a continuous burn basis.

Finally, in view of the level of Cl_2 emitted (and Fluorine, at 50 ppm), a

4-5 copy of this DEIS should be submitted to OSHA for review regarding crew safety and working conditions.

4-1 The FEIS has been expanded to include a discussion of chlorine gas in Chapter 4, under the section "Effects on the Ecosystem."

4-2 Table 4-3 represents an elemental analysis of waste material with subsequent emission rates. Chlorine is shown to be present as a major component of the organochlorine waste material (Table 4-2). Chlorine gas will appear as a relatively minor constituent of emissions.

4-3 Chlorine emissions resulting from present incinerator designs are not considered a significantly adverse input. However, as stated, this is an emerging technology and future designs may well reduce residue inputs of unburned organochlorines and Cl_2.

4-4 The monitoring effort conducted in the Gulf of Mexico is considered to be reasonable for determining that this type of waste elimination alternative is safe. Short- and long-term monitoring will be conducted to ensure that no significant adverse impacts result. Detection of any adverse effects will result in site use modification. It should be emphasized that alternative disposal methods will continue to be pursued; future developments in this area may reduce the need for at-sea incineration and amount of use this site may receive, if designated. See also comment and response 11-14.

4-5 Comment noted. Refer to comment and response 6-3.

(3) Dispersion of HCl

4-6 The dispersion modeling of HCl has not been adequately addressed from two viewpoints. First, the potential for transport of HCl into the upper atmosphere has not been adequately studied. The transport of HCl into the upper atmosphere could be an extremely important consideration. An examination of oxidation-reduction half reactions shows that HCl should react with ozone, particularly in the presence of ultraviolet light.

Note: O_3 (g) + $2Cl^-$ + $2H^+$ $\rightleftharpoons$ O_2 (g) + Cl_2(g) + H_2O

E^o = 0.71.

4-7 The second point regarding the HCl plume from the incinerator is that the upper navigable airspace HCl concentrations were not determined. Aircraft aluminum is quite reactive to HCl. In this region, planes coming from the south are often offshore in their approach to New York, as are planes coming from Bermuda and trans-Atlantic. The position of the air traffic routes are unknown to the reviewer, but they may be near the plume at a time when the aircraft are descending to lower altitudes. Since HCl attacks Al so readily, repeated passes through this area could significantly increase aircraft maintenance schedules and cost, and potentially put human lives at risk. This proposal should also be submitted to the FAA for an analysis of air traffic patterns in the region, and for an analysis of the effect of vapors of several ppm HCl on aircraft structures.

4-8 Note that the assumption in the Monitoring Section (pg. C-2) that all residual materials will settle out within "several" kilometers may be a false assumption, since the HCl droplet sizes are unknown. Furthermore, in the Regulations Section, Part II, reg. 3 (1)(b)(vi) (page B-11) is not adequate for the current DEIS since HCl and Cl_2 should be added to the list of compounds
4-9 to be monitored.

(4) Unburned Organohalogens

4-10 It is noted that the unburned levels of PCB's and DDT emitted are quite high (pg. 4-11), with PCB's at 100 times background levels and DDT at 1000 times background level. These compounds should not be incinerated until the burner design is improved. This is particularly important since these compounds will accumulate in the sea-surface interfacial microlayer which is discussed below. Note also that data do not exist on the atmospheric residence time of the esters of 2, 4-D and 2, 4, 5-T (Agent Orange).

4-6 Studies conducted in the Gulf of Mexico revealed that residues were not detected above 1,000m, and HCl monitored downwind of the vessel showed that background levels were attained within 3,000m.

4-7 In light of response 4-6, and the fact that commercial aircraft will not normally be found at 1,000m altitudes 130 miles from the coast, no such impact is anticipated.

4-8 As noted in the DEIS (p. 2-43 and C-2), the assumption that residual materials settle out within several kilometers of the vessel will, in practice, never occur. This example was utilized to demonstrate an extreme case for water column residue loading.

4-9 Regulations listed in Appendix B are mandated by the London Dumping Convention (LDC). Future modifications of the regulations may include the suggested parameters. As a Contracting Party to the LDC the U.S. is bound by these regulations; however, the U.S. will publish domestic regulations for at-sea incineration, which may extend the existing regulations or the permitting authority may impose such monitoring as a permit condition.

4-10 As indicated in the DEIS (pp. 4-11 through 4-13), wastes considered for incineration will be assessed on a case-by-case basis. Also stated in the DEIS (p. 4-13), no current data are available on the atmospheric residence times of Herbicide Orange (2,4-D and 2,4,5-T).

4-11 (5) Sea-Surface Interface Microlayer

The microlayer consists of lipid and oil-like compounds usually of biological origin floating on the sea surface in many areas. The chemistry of the microlayer is quite complex. Because much of the unburned residues of the incinerator are lipophilic compounds such as halo-organics, they will tend to concentrate highly in the microlayer. In particular, the mixing of the organics will not resemble the dilution of acid-iron for site 106 given on page D-52. The assertion made on pg D-52 of the similarity in the dilution factors for acid-iron and organic residues is not well founded. The acid-iron is highly hydrophilic; whereas, the organic residues will be hydrophobic. The organic residues will thus float at the surface in the microlayer if they are less dense than seawater, or sink in micellar form if they are more dense. Early studies of the effect of petroleum oils on phytoplankton showed that micellar droplets of oil were far more toxic than the water soluble fraction. The effect was probably the result of the surface chemistry interaction between the oil and the organism. A similar effect probably thus exists for the organohalogens. This should be studied before incineration begins.

The sea-surface microlayer is potentially extremely important, particularly if it should become contaminated by organohalogens. This is because the microlayer can coat the neuston organisms. Since the neuston contains larval fish stages (se the "facultative" neuston, pg A-39, and Table A17), and the zoea and megalopae crustacea, these larval forms are of enormous biological and economic importance to the fisheries. Note that the region is very rich in zooplankton (pg. A-44). The discussion of "fisheries" activities on page 3-11 is somewhat misleading, because the biological events leading up to a fishable adult population may be remote in time and distance. The neuston is particularly important for many larval fish stages, and it is these stages that would be most easily damaged by a contaminated microlayer. The discussion of the movement of water masses in this region is particularly relevant here, since the residence time of slope water may be five years, and it may travel hundreds of kilometers during that time (pg. D-49). A monitoring scheme should be devised to collect both neuston, and the sea-surface microlayer. Surface water samples have been collected (page C-3), but contaminants in the microlayer may be 100-1000 times more concentrated than in the immediately adjacent seawater. Again, it is the lipid/larval surface interactions that are probably most important here. Reliable and simple microlayer collection techniques are well known.

4-11 At present, the character of the organohalogen compounds, or the quantities that will eventually be incinerated, are unknown. Therefore, it is not possible to state that "most" compounds will be lipophilic, although no doubt some will be. The dilution of residues will differ from acid waste dilution because incineration residues will undergo significant atmospheric dilution prior to entering the water. Atmospheric dilution will present opportunity for volatilized organic residue to combine with particulate matter, which will promote settling and transport through the microlayer. The minute quantities that will contact the surface layer will not resemble an oil slick.

Laboratory studies of the exact interaction of residues with the sea surface layer and its associated flora and fauna can only approximate the interactions that will occur in the highly dynamic oceanic environment. Numerous physical, chemical, and biological variables will affect the ultimate fate of waste residues. These effects are best determined through in situ testing.

This region of the northwest Atlantic is known to be less biologically productive than Shelf and Slope Waters; consequently, there will be fewer impacts associated with use of the proposed site than alternatives on or near the Shelf.

5

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
[illegible]

JAN 27 1981

OA/C52x6:JVZ

TO: PP/EC - Thomas K. Bick

FROM: OA/C5 - Robert B. Rollins

SUBJECT: DEIS #8012.28 - Proposed North Atlantic Incineration Site Designation

5-1 The subject statement has been reviewed within the areas of the National Ocean Survey's (NOS) responsibility and expertise, and in terms of the impact of the proposed action on NOS activities and projects.

Although NOS does not possess specific oceanographic data for the area, the evaluation and analysis of the data presented in the "Physical Conditions" section of chapter 3, appear adequate for the intended purposes of the study.

5-1 Thank you for your review and comments.

F-15

10TH ANNIVERSARY 1970-1980
National Oceanic and Atmospheric Administration

6

DEPARTMENT OF HEALTH & HUMAN SERVICES — Public Health Service

Centers for Disease Control
Atlanta, Georgia 30333
(404) 262-6649

January 29, 1981

Mr. T. A. Wastler
Chief, Marine Protection Branch (WH-548)
Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Wastler:

We have reviewed the Draft Environmental Impact Statement (EIS) for the Proposed North Atlantic Incineration Site Designation. We are responding on behalf of the U.S. Public Health Service.

This document appears to have adequately covered the possible consequences associated with the destruction of chemical wastes by at-sea incineration for the proposed site.

We are in favor of establishing sites that are environmentally safe for the destruction of chemical waste especially when this is an alternative to land disposal. The probable environmental consequences of at-sea incineration will pose less of a threat to human health than other alternatives.

6-1 One question we have with respect to the proposed site is on Page 4-9. It is stated that "approximately 19 tons of organohalogens could possibly be introduced into the marine environment annually as atmospheric fallout from incineration." What is the expected impact of this loading to the food chain and ocean water quality?

6-2 We realize that each burn for this site will be decided on a case-by-case basis and permitted accordingly by the Environmental Protection Agency. We assume the permit for each event will embody a strong provision to ensure that 99.9 percent destruction efficiency will be accomplished.

6-3 We also have concerns about the safety of the workers who will be directly associated with the handling and incineration of waste on the vessel. We would like to see the provisions and regulations for workers' safety relating to these jobs included as an appendix to the EIS.

We appreciate the opportunity to review this Draft EIS. Please send us one copy of the final document when it becomes available.

Sincerely yours,

Frank S. Linella, Ph.D.
Chief, Environmental Affairs Group
Environmental Health Services Division
Center for Environmental Health

F-16

6-1 The estimate of 19 tonnes of organohalogen residue introduced as a result of incineration activity is based on an assumption that incineration will be occurring 24 hours per day, 365 days per year, at 22 tonnes per hour, with a Destruction Efficiency (DE) of 99.99%. In practice, it is unlikely that such rates of incineration will occur. Weather and mechanical malfunctions may prove to be a significant factor in reducing actual site use. It is believed that the tremendous dilution of residues that will be afforded by at-sea incineration will mitigate potential impacts on water quality and the food web. Furthermore, short- and long-term monitoring will be conducted to ensure that no significant adverse impacts result. Detection of any adverse effects will result in site use modification to correct problems.

6-2 It has been determined that a Combustion Efficiency (CE) of 99.9% produces a DE of 99.99%. In accordance with the London Dumping Convention Regulations for Incineration At-Sea, CE must be 99.95± 0.05%. Permittees must comply with all regulations.

6-3 The issues enumerated are addressed as permit requirements, and all permittees must comply. Appendix E has been added in the FEIS to present an example of the provisions of a safety plan, which must be included with a permit application and, when issued, is made a specific condition under the permit.

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

ER 81/14

FEB 23 1981

Mr. T. A. Wastler
Chief, Marine Protection Branch (WH-548)
Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Wastler:

The Department of the Interior has reviewed the draft environmental statement for Proposed North Atlantic Incineration Site Designation. We have the following comments and recommendations.

General

The proposed action is the designation of a site in the North Atlantic Ocean for at-sea incineration of certain toxic organic wastes, principally organohalogens, generated in the mid-Atlantic States. As indicated in the draft statement, the most important beneficial effect of this action is to provide an option for the disposal of these materials at the least hazardous location. We believe that the characterization and discussion of short-term impacts related to the incineration of toxic wastes at the proposed site appears to be adequate. However, the characterization and discussion of long-term impacts is inadequate. We cannot accept the dismissal of the potential for long-term changes in the environment because pertinent information is lacking and no unusual or deleterious effects were detected during one series of incinerations using relatively insensitive monitoring methods. The conclusion that negative long-term impacts are unlikely is unsubstantiated in the draft statement.

Although not directly related to the proposed action for which the subject draft was prepared, reference to and comments regarding the impacts associated with the transportation of materials to the proposed incineration site were included in this document. These comments were in regard to the spill impacts following a collision of (or a grounding of) the incineration vessel. This discussion is pertinent to the proposed action and necessary, but is incomplete because collisions and groundings are not the only cause of spills. All causes should be covered and evaluated.

7-1

7-2

7-3

7-1 The potential for long-term adverse impacts on the environment are not dismissed, and it is repeatedly acknowledged that this potential does exist (See Chapter 2, under section "Proposed Site"). It is further stated that every effort will be made to detect and correct the cause of such effects.

NOAA has the responsibility under the Marine Protection, Research, and Sanctuaries Act (MPRSA) for long-term monitoring and is currently conducting monitoring at the 106 Mile Ocean Waste Disposal Site. It is anticipated that a monitoring plan will be developed to encompass the two sites, thus minimizing logistic problems and maximizing the continuity of efforts and results. A combined monitoring plan would improve chances of detecting any subtle environmental impacts at an early stage. See also response 2-4.

The monitoring effort conducted in the Gulf of Mexico is considered to be reasonable for determining that this type of waste elimination alternative is safe. Continued monitoring of incineration operations at any site will provide the necessary information to detect any long-term adverse impacts that may begin to develop. If effects are determined to be detrimental, site use will be modified.

7-2 The conclusion that negative long-term impacts are unlikely is based on the premise that incineration operations will be regulated and managed in an environmentally sound manner. Monitoring will be conducted to detect adverse impacts and, if necessary, corrective measures will be taken (see response 7-1).

7-3 The discussion of Navigation Hazards in the DEIS (p. 4-4) includes a summary of casualties reported to the U.S. Coast Guard at several major U.S. harbors, and international waters of the Mid-Atlantic Bight in and around the proposed site. In addition to collisions in harbors (which comprise the majority of accidents), casualty statistics revealed that several vessels reported damage sustained in international waters as a result of weather, mechanical malfunction, personnel misjudgment, and structural or unknown causes.

7-4 We also believe that the discussion regarding spills is inadequate. Other candidate incineration sites were eliminated from further consideration because the release of the reportedly innocuous incineration products posed an unacceptable threat to the sensitive and highly productive system and commercially valuable fishery resources associated with near-shore waters. Spills of incinerable materials into these near-shore waters, regardless of the cause, could be equally devastating.

These deficiencies do not permit us to fully evaluate all aspects of the effects the proposed action will have on fish and wildlife and other marine resources. However, the designation of the proposed site for at-sea incineration would be a logical next 7-5 step but should be taken only for the purpose of conducting experimental incinerations. These experimental incinerations should be undertaken with the intent to develop appropriate monitoring methods while simultaneously characterizing long-term impacts on these resources.

Specific

Pages xvi and xvii - Table S-1

For all but the no designation alternative, "detection of adverse impacts caused by incineration is difficult due to environmental complexity and low volumes of traceable waste residues," is mentioned as an unfavorable factor. The inability to detect residues in a complex environment because of insensitive monitoring methods (page 2-12) is more than an unfavorable factor. It is a fundamental deficiency. Thus, a more extensive discussion of the 7-6 efforts to be undertaken to characterize long-term impacts should be presented in the final environmental impact statement.

Additionally, citing the "low productivity" of oceanic areas as a favorable factor does not reflect an understanding of the basic ecological attributes of systems, communities and populations (e.g., structure, community and ecosystem dynamics, dominance, and diversity). Rather than comparing the productivity of two relatively dissimilar systems, characterizations of the kinds and 7-7 proportionate changes of the above mentioned attributes expected to occur in the impact area should be fully developed in the final statement.

Page xviii: Environmental Considerations

The several statements in the first paragraph under this heading regarding both short- and long-term impacts can easily be misconstrued. It is not satisfactory, even in the summary section, to merely reference Chapter 4. A reader must look elsewhere

7-4 The discussion of accidental spill and leakage in the DEIS (pp. 4-3, 4-28 and 4-29) does address this issue. However, a precise determination of the adverse environmental impacts cannot be made due to the numerous variables that surround such a possibility. Naturally, impacts will be related to the type and quantity of wastes that may be released under these circumstances.

7-5 Experimental (or research) incineration at-sea would be conducted under a permit issued for such purposes. The site designation process does not encompass the permit process except to identify the designated site where the research operations would be conducted.

7-6 Refer to comments and responses 2-4 and 7-1.

7-7 As indicated in the DEIS (p. xv) the proposed incineration site is not a highly productive biological area, and is limited in commercial or recreational fisheries. Consequently, the remoteness of the proposed site further ensures reduction of all potential adverse impacts.

The dynamics of the ocean is an important factor, which significantly reduces the probability of adverse impacts. The Ocean Dumping Regulations establish criteria for managing ocean disposal sites and assessing any impacts of ocean disposal and alternative disposal methods. The proposed sites must satisfy specific criteria for site selection before a permit can be issued.

For additional information on the environmental consequences of incineration on the ocean community, refer to Chapter 4.

(pages 1-15 and 1-16) to learn that the environmental assessments are based upon a series of four experimental incinerations and that the experimental determination of long-term impacts is based almost entirely upon one series of burns (i.e., Gulf of Mexico, 1977). This deficiency should be corrected.

7-8

Pages 1-15 and 1-16

The four previous incinerations were of limited volume and apparently did not involve PCBs. These incinerations also did not involve many of the other candidate organohalogens under consideration for incineration. Accordingly, the final statement should clearly reflect the uncertainty surrounding the environmental effects that may result from incinerating these other materials.

7-9

Page 1-22 (Table 1-3) and 1-23

At-sea incineration of the projected waste volumes would require "...several incinerator vessels operating simultaneously, year-round...and would require several incineration sites to ensure that two or more vessels did not occupy the same site simultaneously." The following concerns regarding this information should be addressed in the final statement:

7-10 1. Table 1-3 should be expanded to include estimates of the number of ships and the number of sites required for incineration of each of the three "target-years."

7-11 2. It should be clearly stated, rather than deduced, that the test burns constituted an acute input of incineration products, and that the environmental assessment is so oriented. However, as the frequency of incinerations at a given site increases, the input becomes progressively more chronic. To equate impacts related to acute and chronic inputs is untenable.

7-12 3. If other at-sea incineration sites are to be designated, their environmental acceptability must be less than that of the proposed site.

Pages 2-3 and 2-4

7-13 Provisions of the Marine Protection, Research and Sanctuaries Act of 1972 provide for the regulation of the ultimate disposal of waste materials in ocean waters. This act does not preclude the use of scrubbers for at-sea incinerations. By utilizing scrubbers during landbased incinerations, the load of suspended particulates, dissolved (or neutralized) hydrochloric acid, small quantities of residual organic waste, and trace metals in the gaseous emissions

7-8 Deficiency corrected in Summary, under section "Environmental Consequences."

7-9 These facts were pointed out on pages 1-2, 2-36, 2-39, 2-43, 2-44, 4-5, 4-7, and 4-8 of the DEIS.

7-10 Table 1-3 is presented only as an estimate of potential waste quantities that may become available during the defined period. While these estimates may vary, a distinct maximum quantity of wastes can be accommodated at the incineration site. Table 2-3 presents the resulting estimated quantity of wastes located in proximity to the east coast, which may ultimately be incinerated at the proposed site, and associated residues. Examination of Table 2-3 shows that until 1989 the maximum use level may not be attained. In 1989 the maximum utilization of 193,000 tonnes of wastes may be available for incineration. The differences (78,000 tonnes) between 271,000 tonnes (Table 1-3, East Coast total) and 193,000 tonnes (Table 2-3, 1989 use level) represent the estimated amount of wastes which must be handled by some land-based technology or at some other at-sea incineration site, unless improved incineration technology permits an environmentally acceptable increase in the rate of at-sea incineration at the proposed site. In the event of improved technology (i.e., increased DE or implementation of scrubbers) the upper limit of 193,000 tonnes may be significantly increased. At this time it would be unfeasible to expand Table 1-3 to include estimates of the number of ships and the number of incineration sites.

7-11 The text has been modified to reflect this fact (Chapter 4, "Effects on the Ecosystem"). However, future technological developments may reduce chronic inputs. The DEIS does not equate acute and chronic impacts, rather it uses evidence gathered during studies of acute (short-term) impacts to estimate some potential chronic (long-term) impacts.

7-12 Not necessarily. Relative to the needs for additional incineration sites, some locations would be more environmentally sensitive and controversial, and others may be less advantageous due to the economics and potential environmental hazards of transport from waste generators.

7-13 Land-based and at-sea incineration of organohalogen wastes are essentially the same except that at-sea incineration releases gaseous emissions without final treatment. Adequate control of air emissions from incineration can be achieved by using scrubber devices. However, scrubber residues must still be disposed in some environmentally safe and acceptable manner. Incineration on land and at-sea has been demonstrated to be a highly effective waste elimination procedure, although both are expensive. Presently, cost analysis on scrubber devices for at-sea incineration is not available. In addition, refer to Chapter 2, under section "Land Based Disposal."

is greatly reduced. Because reductions of these materials are great enough to consider incineration on land a viable alternative to at-sea incineration, the use of scrubbers during at-sea incinerations could greatly reduce the potential for negative, long-term environmental impacts. Accordingly, the use of scrubbers during at-sea incinerations may also reduce (or offset altogether) the costs incurred by the permittee and the government for monitoring, surveillance and enforcement actions. Thus, costs for at-sea incineration with scrubbers that are not significantly different from costs associated with land-based incinerations would be evidence of the economic and environmental feasibility of using scrubbers during at-sea incinerations. If this information is available elsewhere, it should be incorporated into the final statement.

Page 2-12

7-14 The statement, "The effects of incineration emissions upon birds is unknown, but acid residues may provide adverse impacts upon low-flying birds," reinforces our belief that there is a general lack of understanding of the primary and secondary impacts of at-sea incineration on the higher animals, trophic levels, and food web of the marine system.

Page 2-12

The statement, "Monitoring will be difficult until new techniques and more precise measurements are available for detection of deleterious effects," is disturbing because two questions are posed. The first is whether existing monitoring methods can detect changes in how accurate and precise are existing impact assessments, particularly long-term impact assessments. If

7-15 these questions are not answered directly, then a discussion of the consequences of proceeding with at-sea incineration without sufficiently sensitive monitoring methods should be included in the final statement.

Page 2-14

The discussion regarding the incidence of adversely affecting stocks of red crabs because, "...no crabs of commercial size occur in the proposed site and because the adult crabs are taken sufficiently far from the proposed site so that waste residues released at the site are not likely to reach them," does not reflect an awareness of the ecological concepts of "biomagnification," "mobility"

7-16 or "food web." The final statement should include an acknowledgement of the potential for juvenile crabs, that have accumulated materials as a result of spills or incineration, to move to another area and to attain commercial size. This acknowledgement should be expanded and extended to non-commercial species as well.

7-14 Very little data are available to determine the effects of incineration residual materials on higher animals of the marine community. Seasonally migratory and pelagic birds can be directly affected by short-term atmospheric contamination, primarily by HCl. For additional information on the effects of incineration emissions upon birds, refer to Chapter 4, under the expanded section "Effects on the Ecosystem."

7-15 EPA believes that existing monitoring methods will be capable of detecting any adverse short-term impacts. It is recognized that the detection of long-term effects presents a formidable task, and such an evaluation proves to be difficult under any set of environmental conditions, marine or otherwise. Undoubtedly scientific techniques will be an ongoing developmental process from its present state of the art.

The environment in which the proposed site would be located is highly dynamic, and wide ranges of natural variations can be anticipated during any future monitoring effort. It is this wide range of natural environmental variation that will result in the difficulty of detecting deleterious effects. As more knowledge of the environment is obtained, it is likely that more natural variations can be accounted for, and measurement techniques can be more accurate and precise in the detectability of subtle long-term impacts that may begin to develop. Hence, although this question cannot be answered directly here, it should not be construed that present technology is wholly inadequate to permit the continued development of this alternative disposal technology.

7-16 With regard to the referenced passage, because of the dilution afforded by the volume of water between the proposed site and the more productive Continental Shelf, the dissolved residues which may reach the Shelf will be extremely dilute. As stated in the DEIS (p. 2-15) red crabs are located on the Continental Shelf west of the proposed site. The proposed site is located in extremely deep waters (2,400 to 2,900m). Juvenile red crabs have been found from depths of 560 to 1,000m, and the commercial fishing effort for red crabs is concentrated at intermediate depths of 300 to 500m. However, some upslope migration of juvenile red crabs occurs with increased age (size). EPA maintains that incineration activities will occur at a sufficient distance from shore to prevent any contamination of resources taken along the Continental Shelf or Slope. EPA believes that the extremely low concentrations that will result will not pose an unacceptably adverse environmental hazard to the marine environment or human welfare.

The EIS is not attempting to convey the idea that animals may exhibit avoidance responses. It is unlikely that incineration residue concentrations will ever exceed one or two parts per billion (ppb), even within the incineration site after the initial mixing period. Extrapolating the low initial concentration to the vast dilution potential of the oceanic region, it is highly unlikely that even the most sensitive organism will experience a residue concentration sufficient to elicit an avoidance response; the exception to this being any birds that approach the incinerator stack during operations.

Further, the passage, "...and since these animals are demersal and highly mobile, it is unlikely that stocks would be adversely affected by incineration operations," could be interpreted to mean that because animals are mobile they will avoid the areas where waste residues occur. This can be misleading. Avoidance behavior is manifested when stimuli "strengths" are at or above detectable levels. Detection levels usually differ between species. Thus, some species are more "sensitive" to a specific stimulus than are other species. When the strength of a stimulus equals or exceeds a species detection level, the species may respond by avoiding the impacted area. This does not mean that the species remaining in an area are unaffected. More correctly, it may mean that the detection levels of the remaining species are higher, or that the species is unable to respond by avoiding the impacted area due to effects resulting from exposure to undetectable levels of deleterious materials or conditions. This deficiency should be corrected in the final statement.

Page 2-16

Regarding pelagic birds, "...one threatened species of pelagic bird..." near the off-shore region occupied by the proposed incineration site and "...no unacceptable adverse impact..." is expected. An inspection of Table A-21, pages A-55 and A-56, revealed that two species of pelagic birds are listed as threatened (i.e., the black-capped petrel and the Manx shearwater). Only the Hawaiian sub-species of the shearwater is federally designated as threatened, and the petrel is not a federally designated threatened species. These errors should be corrected in the final statement.

7-17

Further, it should be noted that Cory's, greater, and sooty shearwaters commonly follow ships. Thus, the potential for impacts resulting from these birds following the incineration vessel to the site and subsequently feeding upon marine organisms affected by the contents of the plume should be characterized in the final statement.

7-18

Pages 3-10 and 3-11

Our comments regarding Page 2-15 would also apply to the commercial fishing discussion on these pages.

7-19

Page 4-1

This passage does not constitute an adequate assessment of the damages that would result from accidental discharges of wastes during loading operations or during transit to the proposed

7-17 Corrections made.

7-18 A more detailed discussion of this issue has been included in the FEIS in Chapter 4, under section "Effects on the Ecosystem."

7-19 See response 7-16.

7-20 incineration site. Since this consideration was included in the draft statement, an expanded and more detailed assessment should be included in the final statement.

Pages 4-24 and 4-25

7-21 This discussion provides support to the contention that long-term impacts can be expected and that a great deal of study remains to be done before initiating incineration operations at the proposed site on anything but an experimental basis.

We hope these comments will be of assistance to you.

Sincerely,

CECIL S. [illegible]

Special Assistant to
Assistant SECRETARY

7-20 For a more detailed discussion of this issue, refer to Chapter 4 of the FEIS, under section "Accidental Spill or Leakage." See also comments and responses 2-7 and 7-4.

7-21 Comment noted. See response 7-5.

8

DEPARTMENT OF STATE

Washington D.C. 20520

BUREAU OF OCEANS AND INTERNATIONAL
ENVIRONMENTAL AND SCIENTIFIC AFFAIRS

February 9, 1981

Mr. T.A. Wastler
Chief, Marine Protection Branch
Environmental Protection Agency (WH-548)
Washington, D.C. 20460

Dear Mr. Wastler:

We have completed the Department of State's review of the Environmental Protection Agency's "Draft Environmental Impact Statement (EIS) for Proposed North Atlantic Incineration Site Designation" and would like to offer the following comments.

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention), in the Agenda to Annexes I and II, requires that "...Contracting Parties shall first consider the practical availability of alternative land-based methods of treatment, disposal or elimination, or of treatment to render the wastes or other matter less harmful..."

F-27

8-1 While the DEIS considers land-based incineration in some detail, its treatment of both elimination of the production of wastes as well as the conversion of wastes is cursory. In our view, those sections should be expanded.

8-2 In the "Technical Guidelines on the Control of Incineration of Wastes and Other Matter at Sea", Contracting Parties are called upon to designate common incineration sites in a given geographic area. Both Canada and Mexico are also Contracting Parties to the London Dumping Convention. The DEIS should discuss whether these countries are likely to use any of the alternative sites and how their decisions on incineration might affect the site selection process.

8-3 It would be helpful if the DEIS outlined, for each alternative site, the information which indicates that all the applicable criteria of the London Dumping Convention have been met. This has been done for the site selection criteria under the U.S. Ocean Dumping Regulations (pg. 2-32 - 2-35). A similar selection, perhaps in tabular form, could be applied to the "Regulations for the Control of Incineration of Wastes and Other Matter at Sea", the Technical Guidelines on the Control of Incineration of Wastes and Other Matter at Sea", and Annex III. As the DEIS is written, it is very difficult to assess quickly whether all international obligations have been met. For example, it does not appear that the frequency of atmospheric inversions (called for in Regulation 8) has been discussed for the sites.

8-1 Ocean Dumping Regulations establish a program for the application, evaluation, and issuance of at-sea incineration permits. The permitting process provides for an evaluation of alternative disposal methods, including land-based disposal options. The discussion of land-based disposal methods (Chapter 2) is provided for comparative purposes, rather than a critical review. The reviewer wishing more detailed information is referred to Scurlock et al. (1975); Shih, C.C. (1978); and Wilkinson et al. (1978).

8-2 To date, neither Canada nor Mexico have conducted at-sea incineration. Should either country wish to utilize the North Atlantic, Gulf of Mexico, or any alternative site, the request would be given serious consideration, providing all regulatory requirements are satisfied and human health and environmental concerns are not diminished.

8-3 Regulations and Technical Guidelines of the Convention must be observed, no matter where a site is designated. U.S. criteria regarding site selection are consistent with the requirements of the LDC.

The FEIS has been modified (Chapter 3 and Appendix A) to include a discussion of known atmospheric inversions in the mid-Atlantic Bight region occupied by the alternatives within the region.

8-4 The formula for combustion efficiency (pg. B-13) is in error. The minus sign in the numerator has been omitted.

We appreciate the opportunity to review the Draft EIS.

Sincerely,

Donald R. King
Director
Office of Environment
and Health

8-4 Thank you for pointing out the omission. It has been corrected.

9

[illegible]
[illegible]

[illegible]

[illegible] Environmental Protection Agency
[illegible] Special Materials Control Division
Marine Protection Branch
Washington, DC 20460

Dear Mr. Wastler:

RE: ENVIRONMENTAL IMPACT STATEMENT FOR PROPOSED NORTH ATLANTIC INCINERATION SITE DESIGNATION

9-1 The Office of Management, Budget and Planning, in its function as State Clearinghouse, has reviewed the above listed proposed EIS and has no negative comments to offer at this time.

Sincerely,

[illegible]

[illegible]

[illegible]

F-29

9-1 Thank you for your review and comments.

10

Harry Hughes
Governor

MARYLAND
DEPARTMENT OF STATE PLANNING
301 WEST PRESTON STREET
BALTIMORE, MARYLAND 21201
TELEPHONE 301 383 2451

Constance Lieder
Secretary of State Planning

January 7, 1981

Mr. T. A. Wastler
Chief, Marine Protection Branch (WH-548)
Environmental Protection Agency
Washington, D. C. 20460

RE: State Clearinghouse Project 81-1-540 Draft EIS
Proposed N. Atlantic Incineration Site

Dear Mr. Wastler:

The State Clearinghouse has received the above project. The review of this project has now been initiated and you may expect a reply from us by February 12, 1981. If you have any questions concerning this review, please contact Bryan Gatch (383-2499) of this Clearinghouse.

We are interested in your project and will make every effort to ensure prompt action. Thank you for your cooperation with the Clearinghouse program.

Sincerely,

James W. McConnaughhay
Director, State Clearinghouse

BG:mmk

F-30

MARYLAND
DEPARTMENT OF STATE PLANNING
301 W PRESTON STREET
BALTIMORE MARYLAND 21201

HARRY HUGHES
GOVERNOR

CONSTANCE LIDER
SECRETARY

March 2, 1981

Mr. T. A. Wastler
Chief, Marine Protection Branch (WH-548)
Environmental Protection Agency
Washington, D. C. 20460

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT (EIS) REVIEW

Applicant: U.S. Environmental Protection Agency

Project: Draft EIS - Proposed North Atlantic Incineration Site for Destruction of Toxic Organic Waste

State Clearinghouse Control Number: 81-1-540

State Clearinghouse Contact: James McConnaughhay (383-2467)

Dear Mr. Wastler:

The State Clearinghouse has reviewed the above project. In accordance with the procedures established by the Office of Management and Budget Circular A-95, the State Clearinghouse received comments from the following:

10-1 Dept. of Natural Resources, Dept. of Economic & Community Development, Including their Historical Trust section, Dept. of Transportation, University of Maryland Center for Environmental and Estuarine Studies, Town of Ocean City, and our staff, noted that the Statement appears to adequately cover those areas of interest to their agencies.

Maryland Office of Environmental Programs and Worcester County were provided the opportunity to comment, but have not responded as of this date. If subsequent comments are received, they will be forwarded.

The Clearinghouse appreciates your attention to the A-95 review process and looks forward to continued cooperation with your agency.

Sincerely,

James W. McConnaughhay
Director, State Clearinghouse

JWM:BG:nunk

cc: Mayor H. Kelley/Edward Pigo/D. Taylor/John Yankus/L. Frederick
Clyde Pyers/Herbert Sachs/Max Eisenberg

TELEPHONE 301 383-2467
OFFICE OF STATE CLEARINGHOUSE

F-31

10-1 Thank you for your review and comments.

11

State of New Jersey
DEPARTMENT OF COMMUNITY AFFAIRS

JOSEPH A. LEPANTE
COMMISSIONER

101 WEST STATE STREET
POST OFFICE BOX 3768
TRENTON, N.J. 08625

January 7, 1981

Mr. T.A. Wastler
Chief, Marine Protection Branch (WH-548)
Environmental Protection Agency
Washington, D.C. 20460

RE: State Identifier No. OSRC-EY-81-923 Environmental Impact Statement for Proposed North Atlantic Incineration Site Designation

Dear Mr. Wastler:

The New Jersey State Clearinghouse has received and is processing your Project Notification as required by the provisions of the U. S. Office of Management and Budget Circular A-95 Revised and Chapter 85, New Jersey Laws of 1944. This project has been designated OSRC-EY -81-923.

The State Clearinghouse has assigned a 30 day review period effective with the date of this letter. This review period is consistent with our internal procedures and federal regulations relevant to your program. The appropriate state agencies have been requested to comment on your application, while the State Clearinghouse will perform its own review. If comments are received and any conflicts or issues arise, the Clearinghouse will notify you. It may be necessary to request additional information and/or to schedule a conference in order to resolve the issues prior to clearance; otherwise you are cleared at the end of the review period to forward your final application to the federal funding agency, accompanied by a copy of this letter. It is the responsibility of the applicant to attach any comments to the application forwarded to the federal agency.

Please feel free to call upon the State Clearinghouse at any time to assist you with any problems or questions you may have with the A-95 review procedure.

Very truly yours,

Richard A. Gimman
State Review Coordinator

NOTE: Please place your State Identifier Number on all further correspondence and application forms (424) so that the Clearinghouse may more efficiently process this application.

F-32

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF THE COMMISSIONER
P.O. BOX [illegible]
TRENTON N.J. 08625
609-[illegible]

February 5, 1981

Mr. T.A. Wastler, Chief
Marine Protection Branch
Environmental Protection Agency
Washington, DC 20460

Re: Draft EIS - Proposed North Atlantic
Incineration Site

Dear Mr. Wastler:

I am herewith requesting a 30 day extension of the review period for the above noted Draft EIS. It seems that originally 3 copies were sent to the N.J. Department of Environmental Protection but subsequently became lost. My office had to request additional copies which has caused a delay in the review of this document.

In the future, the review of all EIS's could be expedited if 6 copies were sent directly to me. This would enable my staff to handle the distribution to the various Departmental agencies and keep tabs on the review process.

Sincerely,

Lawrence Schmidt

Lawrence Schmidt, Chief
Office of Environmental Review

2/11/81
Called to above re. request.
Explained official comment
period ends 2/23, not 2/12
as DEIS indicates. 30 day extension
not needed under [illegible]
circumstances but agreed to
2/27.
[illegible signature]

100% RECYCLED

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF THE COMMISSIONER
[illegible]

March 25, 1981

Mr. T.A. Wastler
Chief, Marine Fisheries Protection
Branch
(WH-548)
Environmental Protection Agency
Washington, DC 20460

Dear Mr. Wastler:

The Department of Environmental Protection has completed its review of the Draft EIS for the Proposed North Atlantic Incineration Site. As a result of the review we have had substantial comments from our Division of Fish, Game and Wildlife relative to potential impacts on the marine fisheries resources. The major concerns of the Division are summarized as follows:

11-1 1. After doing a limited amount of work in the Gulf of Mexico the EPA knows very little of the affects of incineration upon the ecosystem. Further, after admitting the Gulf burn was very limited and
11-2 constricted as to the chemicals that could be incinerated, they are proposing to let almost unrestricted burning of almost unlimited amounts of toxic and organic wastes to occur off our coast.

11-3 2. EPA admits there will be hazards associated with incineration at sea, but they do not know what they will be or what amounts of toxic wastes will occur.

3. Statements dealing with the proposed site and existing oceanographic conditions and existing productivity of the area in fisheries in the proposed
11-4 site were either untrue or conflicted with other statements made throughout the report. The sections dealing with the off shore fishery were grossly inadequate and failed to recognize the importance of several large commercial fisheries existing in this location.

In addition to the comments on the marine fisheries, we note that
11-5 the Draft EIS is weak with regard to analyzing the land based impacts of storage and transfer of hazardous waste. If an on-site facility were considered in the State of New Jersey, there would be a number of regulatory reviews necessary which would lead to the issuance of the following permits:

11-1 The limited research and monitoring conducted to date indicates that there is reasonable justification for proceeding with continued development of at-sea incineration technology. It should also be recognized that research and monitoring will be carried out during future operations at sea, particularly for new disposal sites and wastes that have not been previously incinerated at sea. Additionally, research on incineration of hazardous wastes is being conducted at EPA's research facility in Cincinnati, Ohio.

11-2 At-sea incineration will not be unrestricted or unlimited. Stringent technical requirements must be adhered to, and operations will be monitored to protect the receiving environment. For further information, refer to response 7-10.

II-3 Potential hazards associated with at-sea incineration were clearly identified in the DEIS. Unknowns were also identified. The quanti of residues will be directly related to the types and amounts of wastes incinerated. Although the level of use is unknown, 200,000 tonnes per year appears to be an upper level for the site (see response 7-10).

II-4 The DEIS has been carefully reviewed; all issues raised on fisheries have been reverified, and the text is expanded, as necessary, in response to specific comments. However, no substantial inaccuracies were identified as no substantial commercial (or recreational) fisheries occur in the site. As stated in the DEIS, most fishing activities occur on the Continental Shelf upper Slope, a minimum of 30 nmi west of the western border of the site.

II-5 In February 1980, EPA promulgated regulations for sections of the Resource Conservation and Recovery Act (RCRA). These regulations establish standards for control of hazardous waste from point of generation through storage, treatment, and ultimate disposal via transportation manifests and reporting. RCRA provides for cradle-to-grave tracking and safe handling of hazardous wastes up to the shipboard loading of wastes, whereby the MPRSA takes effect.

The EPA will not grant a permit for at-sea incineration unless RCRA and other federal, State and local requirements are satisfied. In addition, the permittee would be required to apply for any required State permits for land-based operations. For additional information, refer to Chapter 2 of the FEIS, under "Conclusions" section.

1) Waterfront Development Permit - a project would have to meet with the State's promulgated Coastal Waterfront Development Policies.

2) Registration Permit from the Solid Waste Administration - this will involve a complete engineering review of the facility to insure that hazardous wastes are properly managed.

3) Air Pollution Control Permits - this would involve storage and transfer points where there may be air emissions.

4) Spill Prevention and Containment Plan - this is a requirement of the Division of Hazard Management.

II-6 Finally we question whether the incineration equipment aboard the vessel should not have some sort of scrubbing device or other air pollution devices to remove chlorides, nitrites, and sulfur oxides. These products of incineration can only add to acidic atmospheric conditions which cause "acid rain".

In addition to the above general comments, the Division of Fish, Game and Wildlife has generated specific detailed comments which I have attached to this letter.

Sincerely,

Lawrence Schmidt

Lawrence Schmidt, Chief
Office of Environmental Review

Attachments

II-6 See comments and responses 3-9 and 7-13.

Specific Comments on DEIS for the Proposed North Atlantic Incineration Site

11-7 P. xii - The site designation for incineration of toxic organic waste at very least should authorize specific industrial chemicals to be incinerated at sea. The options of an environmental preferable method of destroying toxic and other hazardous chemical waste leaves the decision of disposal solely to the operator. We find this objectionable. We have seen time and time again, to the misfortune of our health and well being, that the operators often use the most expedient and profitable methods, not necessarily the safest and least destructive the environment.

11-8 P. xiii - It is stated in the DEIS that the Gulf of Mexico site was found unsatisfactory "...to assimilate the tremendous volume of wastes which are generated on the Gulf and east coast..." However, it further states that the volume in question is unknown. If this statement is true and the volume of chemical wastes are not known for the east coast, then this volume may be too large for any site and would require several ships operated simultaneously to "handle the projected potential volumes of wastes."

P. xiii - An oceanic site southeast of Georges Bank was evaluated for a site but rejected because: 1) the wastes must be transported several hundred miles to reach the site; 2) severe weather conditions that occur in the area, especially during winter and spring may interfer with the incineration process, 3) closeness to important fishing grounds. In regard to the proposed site in the middle Atlantic, the additional slight increase in the distance to a

11-9 suitable site should be the last concern to our well being, not the principal one. Second, the weather conditons on Georges Bank are very little, if at all different from those 150 miles south of there. Identical sea states, wind conditions and percipitation occur in these almost climatologically identical areas. Third, highly productive fishing areas occur off the middle Atlantic coast. Some two billion pounds (1 million MT) of fish are harvested annually from the middle Atlantic bite area. Indeed, the proposed incineration site

11-10 is located in about the center of one of the most productive tuna and swordfish areas in the western north Atlantic Ocean. The proposed site is situated along

11-7 The site designation does not include authorization of specific industrial chemicals. As noted in the DEIS, all waste materials considered for at-sea incineration are subject to EPA permitting process, which evaluates and determines those materials exceptable for incineration. Hence, the final decision to utilize the at-sea incineration alternative is not determined by the waste producers, but by the EPA site management authority. Also refer to comment and response 19-6.

11-8 As noted in the DEIS, (p. 1-20), approximately 90% of all wastes identified are generated in Gulf Coast states. Use of the Gulf of Mexico site for wastes generated on the east coast may present a problem if the site is used extensively in the future. As explained in Chapter 4, the upper limit of site use is estimated to be 200,000 tonnes of wastes per year, based on a single vessel operating in the site 24 hours per day, 365 days per year, at 22 tonnes per hour (see also Tables 1-3 and 2-3). It would not be possible to use the Gulf site for wastes generated on both coasts, as wastes from either coast can potentially satiate the use of a single site.

Another significant factor that should not be ignored is the potential environmental hazard and expense of transporting large quantities of hazardous wastes more than 1,000 miles by land or sea.

11-9 Georges Bank is considered an unacceptable location for the several reasons discussed in the DEIS, Chapter 2, under section "Alternative Sites."

11-10 As noted in Chapters 3 and 4 of the DEIS, the proposed incineration site is not located in any commercially or recreationally important fishing or shellfishing areas. Limited finfishing occurs beyond the Continental Shelf. Available catch statistics (see added Table 3-1) for the proposed site and vicinity and nearby alternatives indicate that there is some fishing activity for tuna and billfish species. Pelagic fishing also occurs to the east and south in warmer waters of the Sargasso Sea and Gulf Stream. Chapter 3, section "Other Activities in the Site Vicinity", has been expanded to provide more information on U.S. and foreign fisheries.

Numerous species of whales and dolphins (see Table A-19) transit the Continental Slope and nearshore waters of the mid-Atlantic bight region, as migratory routes. Presently, no data are available to determine effects of incineration of residual materials on marine organisms; however, the likelihood of impacts from residues is remote.

the migratory pathways of many of our important pelagic species, i.e. bluefin tuna, yellow eye, albacore, swordfish, blue marlin, as well as along the migratory pathways of important marine mammals such as the humpback whale, finback whale and sperm whale. Only cursory treatment was given to marine mammals in the DEIS.

11-11 P. xiv - The statement on this page that the area "...is not a highly productive biological area..." is a meaningless statement. When the area of the proposed site is compared to the Sargasso area or certain areas in the Carribean Sea or Pacific and Indian Oceans, it is indeed highly productive. Further, the statement made on page A-48 relative to the slope water where the proposed site is located indicates that the area would be extremely attractive to cetaceans because of the proximity of rich feeding grounds along a north-south migratory route. This statement appears to refute the statement that the area "...is not a highly productive biological area..."

11-12 P. xv - The statement on this page "The site (proposed) is not a highly productive biological area and does not support commercial or recreational fishes." is simply not true. As pointed out above, the proposed incineration site does center on a very substantial commercial fishery and may lie along an area with an important recreational fishery as well. While the recreational fishery has yet to be documented, New Jersey will be conducting a survey this year to determine whether or not an important recreational fishery takes place near the proposed site.

11-13 P. xviii - The statement in the first paragraph on this page that site No. 5 is closer to the Gulf Stream than site No. 1 does not bear true. The vagaries of the massive ocean currently called the Gulf Stream as it influences all of the proposed sites is not fully known. To indicate that site No. 1 would be easy to monitor based upon its position to the Gulf Stream is almost beyond belief. Certainly site No 5 may be more difficult to monitor than site No.1, but only because of the greatly enlarged area of site No. 5 relative to site No. 1. Why are the proposed sites of greatly different sizes?

11-14 P. xviii - The DEIS indicates the environmental consequences of incineration at sea within the middle Atlantic area was assessed by means of research conducted in the Gulf of Mexico. Because of the differences in oceanographic and climatological factors, it is questionable whether you can substitute one

11-11 Relative to the Continental Shelf and Slope, for which alternative site locations are examined, the proposed site has a lower primary productivity rate (160 g $C/m^2/yr$, Shelf versus 100 g $C/m^2/yr$, Slope), chlorophyll *a* concentrations (2.5 ug/m^3, Shelf versus 0.9 ug/m^3, Slope), and biomass (1,070 $ml/1000 m^3$, Shelf versus 270 $ml/1000m^3$, outer Slope), in addition to reduced abundance of many indigenous species. Thus, the area is not highly productive relative to food items taken for human consumption.

11-12 Refer to responses 7-7 and 11-10.

11-13 Response to these comments will be approached in somewhat reverse order.

The area identified as Number 5 is not a site, rather it is a "region" in which a site may be located, which explains the difference in size. The larger area is used to simplify the discussion of environmental conditions. It is acknowledged in the DEIS (Chapter 2) that numerous environmental factors confound the overall understanding of the proposed site, as well as the surrounding region.

The DEIS never asserts that monitoring will be easy; in fact, it is pointed out on several occasions that monitoring in the distant marine environment is no simple task. There is nothing unbelievable about the complexities produced by extreme environmental variation resulting from periodically monitoring inside, then outside, the Gulf Stream. In a literal sense monitoring will be no more difficult in either the proposed site or somewhere within the southern region alternative. The difficulty arises in the interpretation of monitoring results, and it is here that control (or reduction) of natural variation will reduce problems associated with interpretation of data.

11-14 The chemical characteristics of oceanic seawater vary only slightly in a global sense, temperature and salinity notwithstanding. Certainly the biological characteristics change substantially from the poles to the equator, and in relation to continental influences. No doubt one species will react differently than another to a specific stimuli, and the response will probably be associated with a given life history stage, age, size, and environmental acclimation. Applying an extrapolation of studies conducted in the Gulf of Mexico to the North Atlantic offers a reasonably predictive tool, and monitoring of incineration operations will provide verification.

area for the other. It is further stated that long term effects were not detectable as a result of the Gulf of Mexico research burn. However, this was with only limited volumes and types of waste incinerated at the Gulf site. Since EPA is using the Gulf site as the basis of assessment, extrapolates a limited burn in one geographically different area to a much larger and complicated burn in a different area. We do not agree that the "tremendous volume and water available for dilution and dispersion would therefore counter any adverse affects in the proposed site."

P. xix - The argument is used to support the proposed site that it lies 120 miles offshore and the prevailing winds are westerly. This would carry any contaminants away from land. However, no mention is made of the consequences of an easterly or northeasterly wind that often blows on shore at rates varying from 5 knots to 40 knots or more. What happens to residue both in the atmosphere
II-15 and in the water when the wind direction changes from west to east and continues in an easterly direction for three days or more?

Further, because of the circulation pattern common to the proposed site area,
II-16 toxic residue would very likely be carried northward and eastward towards Georges Bank. Once there they could very well be entrapped in a southward flow that often move along the continental margin or onto the edge of the continental shelf. Thus, residues could be carried onto the shelf when it would be concentrated in various marine organisms that act as food for larger organisms - crabs, lobsters, fish - eaten by man.

P. xix - A statement is made on this page concerning heavy metals and organic compounds that might accumulate in body tissues of marine organisms. It is stated that the potential for accumulation of these wastes appears to be minimal.
II-17 This is a gross misunderstatement of a problem which presently exists. Mercury levels found in pelagic oceanic fishes such as swordfish and tuna are now at or above minimal FDA levels. Any addition to these levels, even slight ones, may very well have serious biologic and economic consequences. It is further stated that the "dynamics" of the ocean is an important factor which significantly reduces the problem of adverse impact of off shore incineration. It further states that the dilution and dispersion of waste residues by ocean currents are the principal factors for this. Also, the fact that marine organisms con-

II-15 As noted in the DEIS, (Chapter 2, under section "Detailed Bases for the Selection of the Proposed Site") the offshore distance of the proposed site from the coastal shore is adequate to provide for extensive dispersion and dilution of atmospheric waste residues. It is unlikely that incineration of residues will cause any adverse environmental hazard to the atmosphere and marine environment.

II-16 Transport across a distance as great as described would require months, or possibly years and result in enormous dilution of any remaining residue.

II-17 Mercury and cadmium are two metals strictly regulated under the U.S. Ocean Dumping Regulations and the Annexes to the London Dumping Convention. Problems that do exist are invariably associated with large (typically industrial) sources of metal input, and are usually near shore. It is not anticipated that at-sea incineration will lead to unacceptable inputs of mercury, or other metals. Heavy metals are present in wastes only in trace amounts, and as noted in the DEIS (Chapter 4 and Appendix D), the potential for accumulation of these trace metals appears to be minimal.

Fifteen years of monitoring at the nearby 106-Mile Ocean Waste Disposal Site have not detected accumulation of metals that were contained in disposed industrial wastes.

For a very informative discussion of existing acceptable FDA mercury levels in seafoods, the reader is referred to C.B. Officer and J.H. Ryther, 1981. Swordfish and Mercury: A case history. Oceanus, vol. 24, no. 1, p. 34-41.

tinually move in and out and the affected area is used as an argument for decreased concentrations of waste residue in these organisms. While the chemical and physical properties of the area are briefly discussed, EPA has not considered the fact that many marine organisms concentrate various chemical residues, some 100,000 times or more. They do not address the problem that low levels of heavy metals presently found in marine fish are a serious question regarding the edibility of these species.

11-18 P. 2-15 - Table 2-1 shows the most important finfish and shellfish species taken in the middle Atlantic region. This table is deficient in the fact that it does not have the catch of tilefish which amounts to over 5,000,000 pounds worth some $1,000,000 to the fishermen. This species is a resident bottom dweller and found in close proximity to the proposed site. In addition, the catch and value of the foreign fishery off our coast - squid, mackerel, silver hake and tuna - are not addressed at all. These fisheries will probably be replaced by US fishermen in the near future.

11-19 P. 2-15 - A statement made on this page indicates that there are no crabs of commercial size that occur in the proposed site and that adult crabs are taken sufficiently far enough away from the site so that waste residues are not likely to reach them. This statement is without foundation. In addition to the red crab occurring along the slope area, several cancer crabs occur in the same area have a large potential for a commercial fishery. It is stated further on page 2-15 that species available to the foreign fishery will be be affected.

11-20 There is no foundation for this statement at all. In fact, the increase levels of heavy metals on these species may have severe biological and economical consequences as stated above.

11-21 P. 2-16 Table 2-1 does not have the tilefish, swordfish or tuna landings for the various middle Atlantic states.

11-22 P. 2-16 - The statement is made that the incineration operations are expected to have no unacceptable adverse impacts upon endangered or threatened marine animals. We would like to know what an acceptable adverse impact upon these marine organisms would be.

11-18 Table 2-1 has been expanded to include all fishery resources addressed within these comments.

11-19 EPA maintains that incineration activities will occur at a sufficient distance from shore to prevent any interference with, or contamination of, the fishery resources taken along the Continental Shelf or Slope. Foreign fishing activities are widely dispersed to the east and south of the proposed site. Any fishing activity that would have otherwise occurred in the area occupied by the proposed site would not represent a significant fishing effort. See also comment and response 7-16.

11-20 See response 11-17.

11-21 Table 2-1 has been modified to include these species.

11-22 As noted in the DEIS, (pp. 3-9 and 4-27), all endangered and threatened species that are known to occasion the area occupied by the proposed site are relatively large organisms (i.e., turtles and whales). Because all of these organisms are air breathing, the atmosphere represents the residue transport medium having the greatest potential for adverse impact. An unacceptable adverse effect can be viewed as one that would lead to chronic physiological malfunctioning or death. However, because the organisms are large and exposure is likely to be transitory, it is unlikely that any unacceptable adverse impact will occur.

P. 2-16-2-17 - On these pages you speak of the interference with petroleum exploration along the continental shelf. You argue that present oil exploration does not exist beyond the continental shelf. In fact, the federal government is deciding

11-23 upon proposed drilling sites in the slope area, particularly outer continental shelf site No. 59. This may bring well platforms within 20 miles of the incineration site. How will you protect human exposure?

P. 3-11 - A statement is made on this page concerning the lack of catch statistics for slope waters. In fact, there is a great deal of catch statistics for Japanese

11-24 vessels fishing in the area of the proposed site. These records can be found in the International Commission for the Conservation of Atlantic Tunas in their Data Record and Collected Volume of Scientific papers. These data indicate that the proposed site is a very important area for tuna and swordfish.

P. 3-15 - On this page a statement is made that recreational species taken offshore are limited to bluefin tuna, marlin and swordfish. This statement

11-25 is not so. Bluefin tuna are rarely taken by recreational fishermen offshore although they occur over the entire shelf and in the oceanic waters. The principal catch of recreational fishermen in the area includes yellowfin tuna, bigeye tuna and dolphin and to a lesser extent, skipjack tuna and blue marlin.

P. 3-15 - A statement is made on this page to the effect that foreign fishing

11-26 is dominated by the Soviet Union. This is not true. Also, the major foreign fishery no longer includes sea herring. It is increasingly dependent on various species of squid. Further the statement that tuna has recently become an important foreign catch is not true. Tuna have been taken by foreign fisheries off our coast in numbers exceeding 60 million pounds annually since 1964.

P. 3-15 - The statement concerning the fact that foreign fisheries are not required to report their annual harvest within the FCZ is not so. In fact,

11-27 they are required to keep detailed records of their catches by position and time and there is, in fact, a large and comprehensive collection of statistics for this fishery.

P. 4-3 - The statement made on this page that the only known effect on the

11-23 Oil exploration does not presently occur beyond the Continental Shelf; however, lease sale 59 is under consideration. A Final EIS was issued in May 1981 and the proposed lease sale is scheduled for December 1981.

In the event that production does occur west of the proposed site, the distance between the nearest lease tract and the proposed site is anticipated to provide for sufficient removal and dilution of residues. An expanded discussion of this issue is presented in Chapter 4, under section "Interference with Other Activities at the Proposed Incineration Site."

11-24 See revised text, Chapter 3, under section "Other Activities in the Site Vicinity" and Appendix A.

11-25 There are no accurate catch statistics for these species or amount of recreational fishing activity.

11-26 This information has been updated in Chapter 3, under section "Other Activities in the Site Vicinity."

11-27 This information has been updated in Chapter 3, under section "Other Activities in the Site Vicinity."

coastal recreational area from the incineration activities would result from accidental discharge of wastes during loading time or during transit to the proposed site is without foundation. Our contention is that residues may well be concentrated by various marine organisms and have sublethal affects upon

II-28 marine animals that man ultimately eats. Again, the statement that the waste disposal site will not harm human health by contaminating edible organisms because the site is not located in any commercial or recreational important shellfish area is not true. The fact remains that the proposed site is in an important commercial fishing area and in close proximity to important recreational areas.

II-28 No documentation exists to qualify the area of the proposed site as recreationally or commercially important, and no shellfish resources occur within the 30 nmi of the western boundary of the site. The great depths at the proposed site minimize potential adverse impacts on benthic organisms and migratory species due to high dilution and water stratification, which dissipate contaminant levels. Therefore, it is unlikely that incineration of residues will directly endanger human health by contaminating edible organisms. For additional information, refer to responses 7-16 and II-10, and Chapter 4.

12

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

Department of Administration
STATEWIDE PLANNING PROGRAM
265 Melrose Street
Providence, Rhode Island 02907

February 12, 1981

Mr. T.A. Wastler, Chief
Marine Protection Branch (WH-548)
Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Wastler:

This office, in its capacity as the clearinghouse designate under OMB Circular No. A-95, Part II, has reviewed the Draft Environmental Impact Statement for the Proposed North Atlantic Incineration Site Designation.

The Technical Committee of the Statewide Planning Program was presented the staff findings as a result of the review at its meeting of February 6, 1981. The Technical Committee recommendation is as follows:

12-1 1. Although impacts to the State's resources appear to be minimal, the EPA and/or DEM should monitor the State's air and water for impacts from this facility.

2. More information should be gathered for the final draft EIS about the following:

12-2 a. The projected amounts and geographical location of wastes from products which have been dispersed and sold throughout the U.S. which will eventually be discarded.

12-3 b. DEM would like information about the chemical content of the material to be burned and a thorough description of the incineration equipment and process.

12-4 c. A discussion of the incinerator vessel shore base support is conspicuously absent, except some economic costs from Delaware Bay. DEM would like analysis of proposed locations for such a facility, as well as the environmental impacts in the final EIS. These should consider the transportation of hazardous wastes to the facility, on-site waste storage and handling, and disposal alternatives for unburned wastes.

F-45

12-1 Because of the distance of the proposed site offshore, EPA does not anticipate onshore air and water quality to be affected from the operations at sea.

12-2 This EIS evaluates the most suitable location for at-sea incineration of hazardous wastes to serve industries of the U.S. east coast. Presently, conducting a study to the extent suggested is not feasible. However, as noted in Tables 1-3 and 2-3 and Chapter I of the FEIS, estimates are provided on potential waste quantities which may ultimately be incinerated at the proposed site.

12-3 With the exception of substances discussed in Chapters I and 4 of the FEIS, no specific data currently exist regarding the precise contents or quantities of wastes that may be candidates for at-sea incineration. Wastes that may be incinerated at sea will more than likely be a blend of various compounds selected for BTU content to minimize supplementary fuel requirements.

For a detailed description of the ship's incineration equipment and process, the reviewer is referred to Wastler et al. (1975); Ackerman et al. (1978); (see References, Chapter 6) Ackerman, D.A., R.J. Johnson, E.L. Moon, A.E. Samsonov, and K.H. Scheyer, 1979. At-sea incineration: Evaluation of waste flow and combustion gas monitoring instrumentation onboard the M/T VULCANUS - U.S. Environmental Protection Agency, Office of Research and Development, EPA-600/2-79-137. July 1979. 100 pp.

12-4 An at-sea incineration facility location has not yet been determined. When such a facility is established, compliance must be met with section 3004 of the RCRA. EPA will not grant a permit for at-sea incineration unless RCRA and other Federal, State and local requirements are satisfied. For further information, refer to Chapter 2 of the FEIS, under "Conclusions" section.

12-5

d. Because of the paucity of monitoring information because most can be collected only after incineration has begun, the program for monitoring and sampling of the ocean environment downwind should be more detailed in the Final EIS. Any program involving the mentioned search for new study techniques for this difficult environment should also be described.

We thank you for the opportunity to review this proposal.

Yours very truly,

René J. Fontaine

René J. Fontaine
A-95 Coordinator

RJF/KR/ajc

Reference File: EIS-81-02

12-5 The DEIS (Appendix C) identified certain minimum parameters which should be considered in the final development of a detailed monitoring plan, and has presented suggestions based on previous experience. However, a monitoring plan must be designed around the equipment and financial resources available. Thus, development of a detailed plan would be impractical at this time.

The Environmental Protection Agency, National Environmental Research Centers at Cincinnati, Ohio and Research Triangle Park, North Carolina are actively engaged in the development of incineration technology. In addition, an Interagency Review Board for the Chemical Waste Incineration Ship Program has been established to develop procedures for the coordination of permits and evaluation of alternatives (see comment letter 3).

13

COMMONWEALTH of VIRGINIA

Council on the Environment

February 20, 1981

Mr. T. A. Wastler
Chief, Marine Protection
Branch (WH-548)
Environmental Protection Agency
4th and M Streets, S.W.
Washington, D. C. 20460

Dear Mr. Wastler:

The Commonwealth of Virginia has completed its review of the Draft Environmental Impact Statement (Draft EIS) for the Proposed North Atlantic Incineration Site Designation. The Council on the Environment is responsible for coordinating the State's review of federal environmental impact statements and responding to appropriate federal officials on behalf of the Commonwealth. The following agencies and officials participated in this review:

Department of Health
Department of Conservation and Economic Development
State Water Control Board
Virginia Institute of Marine Science
Outer Continental Shelf Activities Coordinator.

13-1 The Commonwealth of Virginia is of the opinion that the preferred alternative is the most acceptable for the reasons given in Chapter 2 of the Draft EIS. The designation of an ocean incineration site will keep the materials and disposal operations away from populated land areas and thus make disposal safer for most people. It should be remembered, however, that the smoke from the incineration will be no less toxic at sea than it would be on land. Moreover, there will be effects from ocean incineration; people in boats (and on oil drilling facilities) will need to be protected from the burning material and its smoke.

13-2 Accordingly, we urge that a number of safeguards accompany any action pursuant to the site designation. A list of preventive measures and mitigation measures should be developed in order to help contain any environmental damage resulting from spills or leaks. Secondly, the rate at which the toxic substances are incinerated should

13-3 be carefully controlled so as to prevent undue pollution of the local atmosphere. Thirdly, monitoring should be complete and careful; the concept of ocean incineration is relatively unknown, as are the diversity and duration of its effects on the marine and atmospheric environments. Consequently, much information is needed. The Draft EIS mentions some of these items, and we urge your continued attention to them.

13-1 Comment noted. These factors will be considered in the permitting process. For additional information, refer to Chapter 4, under section "Effects on Public Health and Safety."

13-2 See response 2-7. Contigency planning will be addressed as special conditions of any permits issued to incinerate at-sea. Maximum allowable rates for incineration are also set as permit conditions.

13-3 Comment noted. Incineration rates and monitoring are subject to permit requirements. Refer to Appendix C and response 2-4.

13-4 In connection with the possible effects of the site designation on other facilities, it should be kept in mind that use of an incineration site may impede exploration, production, or shipment of any oil or gas that is found under the ocean; care should be taken to avoid this handicap and to prevent any hazards to oil facility personnel stemming from the proximity of incineration and oil operations. A second consideration in regard to facilities is that on-shore support will be needed to load wastes onto ships destined for the site. Careful handling of wastes at port facilities will be necessary for environmental safety, and the affected state or states should be involved extensively in devising appropriate restrictions.

Thank you for the opportunity to review this Draft EIS. We look forward to reviewing the Final EIS when it is published.

Sincerely,

J. B. Jackson, Jr.

JBJr:CHE:pw

CC: The Honorable Maurice B. Rowe, Secretary of Commerce and Resources
Mr. Raymond E. Bowles, State Water Control Board
Mr. Edward F. Wilson, Outer Continental Shelf Activities Coordinator
Mr. Bruce B. Meador, Department of Conservation and Economic Development

13-4 The nearest potential OCS lease tract is 13 nmi west of the northwest corner of the proposed site (updated figures are provided in Chapter 3). Incineration operations are anticipated to have no significant adverse impacts on personnel associated with oil and gas exploration and production. At-sea incineration is presently viewed as an environmentally safe procedure for the destruction of hazardous chemical wastes that may present unnecessary risks at land-based disposal locations near populated areas. Also see Chapter 4, "Interference with Other Activities at the Proposed Incineration Site," and refer to response 11-5.

14

CME

COMMONWEALTH of VIRGINIA

DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
1100 WASHINGTON BUILDING
CAPITOL SQUARE
RICHMOND, VIRGINIA 23219
(804) 786-2121

January 30, 1981

MEMORANDUM

TO: Mr. Charles Ellis

FROM: Bruce B. Meador

SUBJECT: EIS Project 439 - Incineration Bar

Attached are comments from our Division of Mineral Resources on the above. I understand our program OCS has sent you comments directly.

If we may further assist, please let me know.

ptc

Attachment

cc: Mr. Don LeVan - Mineral Resources
Mr. Ed Wilson - Outer Continental Shelf

F-50

14

COMMONWEALTH of VIRGINIA

DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT

DIVISION OF MINERAL RESOURCES
NATURAL RESOURCES BUILDING
McCORMICK ROAD
BOX 3667, CHARLOTTESVILLE VA 22903
(804) 293-5121
ROBERT C. MILLER, COMPASS ORDER AND STATE GEOL

DIST JAN29'81

DCED

January 27, 1981

Mr. Bruce B. Meador, DCED/EIS Coordinator
Dept. of Cons. & Econ. Development
1100 Washington Building
Capitol Square
Richmond, Virginia 23219

Dear Mr. Meador:

We have reviewed the Draft EIS for the Proposed North Atlantic Incineration Site Designation, transmitted with your memorandum of January 9. The proposed action is to establish an oceanic site for the destruction by incineration of toxic organic wastes. The site suggested is 140 miles seaward of Delaware Bay and overlies the Continental Rise. The available data are interpreted by the EPA to indicate that the process of incineration could be conducted at that site with minimal environmental consequences.

We believe that a major concern is to insure that the incineration process would not pose a hazard or act as a limiting factor to any future oil and gas operations. As exploration continues, drilling may extend seaward from the Continental Shelf as noted on page 2-17. The EIS states (p. 2-17) that if drilling were to take place within or downwind from the incineration site precautionary measures would be required to protect the drillship and support personnel. The U. S. Geological Survey should evaluate the likelihood of oil and gas activity ultimately extending into the proposed incineration site, and the optimum use for the site, as a part of the site-designation process.

14-1

On page xx it is noted that shore-based support will be necessary to receive, store and blend the toxic wastes for shipboard loading, and for possible off-loading in case of an incomplete incineration run. It is possible that such a facility could be established in a Virginia port area. This scenario would necessitate the development and

14-2

F-57

14-1 Refer to above comment and response 13-4.

14-2 The Interagency Review Board (note comment and response 3-1) will be involved in this process, and RCRA requires strict management of hazardous substances. See response 11-5 for additional information.

effective application of strict environmental controls to guarantee against such events as spillage or leakage, careless handling, etc. at the onshore site, and would likely involve State goverrment to a considerable degree.

Very truly yours,

DIVISION OF MINERAL RESOURCES

D. C. Le Van
Chief Geologist

DCL/lcl

15

COMMONWEALTH of VIRGINIA

Office of the Secretary of Commerce and Resources
Outer Continental Shelf Activities

EDWARD F. WILSON
COORDINATOR

608 NINTH STREET OFFICE BUILDING
RICHMOND, VIRGINIA 23219
(804) 786-6466

January 20, 1981

MEMORANDUM

TO: Charles H. Ellis, III

FROM: Edward F. Wilson

SUBJECT: Comments on Environmental Impact Statement for Proposed North Atlantic Incineration Site Designation

This office has two comments on the Environmental Statement for a proposed incineration site for toxic industrial wastes offshore the mid-Atlantic states. Both of them are based on the fact that this is not the proper way to dispose of these wastes. Both support the adoption of alternative number one, "the use of land-based disposal methods, or...shut down" those wastes which cannot properly be burned on land should not be burned at sea. If the products of incineration are toxic they should not be added to the atmosphere whether it is on land or at sea.

15-1 The first objection is to the location of the site, right in the general area where substantial interest is being expressed by the oil industry that a major petroleum resource (oil field) may be located somewhere in the 2,000 meters and deeper waters. Two federal lease sales are currently being planned for this year, representing literally billions of dollars worth of resources including this area. It does not make sense to cope with the environmental impacts of oil exploration, which are minimal, and at the same time, place a major source of toxic wastes in the area.

71-53

15-1 EPA believes that the safe elimination of toxic wastes in this manner will not place a major source of toxic wastes in the area. EPA evaluated all environmental consequences of the locations of the alternative sites and suggests that the proposed site will have minimal impacts on the environment. For additional information, refer to comment and response 13-4.

15-2 The second objection is that these wastes should not be burned. The individual components should be separated during the production phase and recycled or they should be stored on land until acceptable incineration or other land disposal methods are available. The fact that they cannot be acceptably incinerated on land leads to the inescapable conclusion that they should not be incinerated at sea either.

Therefore, this is a bad proposal and should not be pursued. Alternate one is the only reasonable alternate.

cc: Leon App

15-2 Some hazardous wastes (i.e., PCB's) are required to be destroyed by incineration. Other wastes (i.e., 2,4,5-T and 2,4,5-TP) can most effectively and safely be eliminated by incineration. Separation and recycling are sometimes economically unfeasible alternatives, and storage on land is presently a significant environmental problem.

EPA agrees that it would be most desirable if no hazardous wastes or incineration residues were ever released into the environment. However, the technological complexity of our world results in the production of wastes, and many will be hazardous. It should also be born in mind that although some organohalogen wastes will be resistant to degradation, none will be permanent features of our environment. EPA believes that at-sea incineration will offer a reasonably safe and rapid waste elimination procedure that will enable those responsible for the manufacture of these wastes to dispose of them in a timely and environmentally safe manner. It is hoped that this additional alternative will greatly reduce or eliminate the present need to store hazardous wastes for prolonged periods, often in an unsafe manner.

16

COMMONWEALTH of VIRGINIA

STATE WATER CONTROL BOARD
2111 Hamilton Street

R. V. Davis
Executive Secretary

Post Office Box 11143
Richmond, Virginia 23230
(804) 257-0056

February 5, 1981

Mr. Charles H. Ellis, III
Environmental Impact Statement Coordinator
Council on the Environment
903 Ninth Street Office Building
Richmond, Virginia 23219

Re: EPA-DEIS: North Atlantic Incineration Site

Dear Charlie:

We have reviewed the above-referenced DEIS and offer the following comments:

16-1 1. Figure 3-4 on Page 3-13 does not represent the total area which could be leased under OCS Sales 40, 49 and 59.

16-2 2. It is most important that there is a control over the amount of waste incinerated during an allocated time span to regulate the flow of the adverse end products into the environment. This amount that the environment can accept without quantifiable adverse effects has been predetermined by studies on the proposed site yielding guidelines to be adhered to.

16-3 3. Although the disastrous effect on the environment resulting from an accidental spill or leakage is recognized in the DEIS, there is a need for a list of preventative and mitigative measures that could be taken in the event of such an occurrence. If, as stated in the DEIS, clean-up measures are impossible or impractical there is more of a need to set up early guidelines to prevent an accident. Methods of containment, such as booms, should also be ready at hand.

16-4 4. Monitoring of the project and surrounding area must be of the highest possible quality. As the proposed site is adjacent to the 106-mile site, possibly a joint monitoring effort encompassing the two sites would reduce costs and increase efficiency. A complete monitoring program is essential for three main reasons. First, the results are needed as there is a lack of information due to the relative new nature of ocean incineration. Secondly, each site will affect the environment differently in accordance with the oceanographic characteristics of the area. Finally, this strict monitoring effort is necessary

16-1 Figures 3-5 and 3-6 have been revised in the FEIS.

16-2 Refer to comment and response 11-2.

16-3 See response 2-7.

16-4 EPA concurs. Shipboard (short-term) monitoring would be conducted by permittees under special conditions to the permit. This would be supplemented by EPA environmental impact monitoring for all research incineration operations, and on an as-needed basis for other incineration operations.

NOAA has responsibility under the MPRSA to perform long-term monitoring. NOAA is currently conducting monitoring at the 106-Mile Ocean Waste Disposal Site and EPA will request that they also include monitoring at the proposed incineration site in their activities.

to catch long term in addition to short term problems as the water quality of a body of water as vast as the Atlantic Ocean still has the potential of being degraded by man.

Thank you for the opportunity to comment on this document. If we may be of further assistance, please don't hesitate to call on us.

Sincerely yours,

Raymond J. Bowles, P.E.
Director
Bureau of Surveillance
and Field Studies

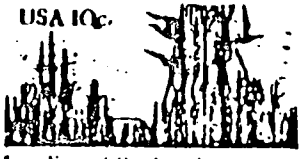
:scc

cc: B. Gail Todd-SWCB, Division of Ecological Studies
B. D. Harrison-SWCB, Bureau of Surveillance & Field Studies
EIS File

17

Robert F. Jambor
140 Sandford St.
New Brunswick, NJ
08901

USA 10c.



Landing of Rochambeau, 1780

T.A. Wastler
Chief, Marine Protection Branch
(WH-548)
USEPA
Washington, DC 20460

17-1 Dear Mr. Wastler: 07 February, 1981

Would it be possible to capture the combustion products from the North Atlantic Incineration Site and have them launched into the Sun? Could it be possible to forego the North Atlantic Incineration Site and just launch the materials proposed for incineration into the Sun?

Robert F. Jambor

17-1 The National Aeronautics and Space Administration (NASA) has been approached about this possibility regarding other hazardous substances (i.e., radioactive wastes). Although the idea may have technical merit, it is considered to be cost prohibitive. For example, the maximum payload of the new space shuttle system is 63,000 pounds (28.6 tonnes). The approximate cost of delivery of a single shuttle load (of wastes) would be $35 million. The calculation of cost to payload ratio must also consider the weight of a specialized container system, which would, of course, reduce the maximum deliverable payload of wastes. Hence, for estimation purposes, if it is assumed that a waste payload of 60,000 pounds (27.2 metric tonnes) can be transported by the shuttle, a single shipboard (4,200 tonnes) will cost approximately $5.4 billion to transport into space.

18

NOTE: This comment has been printed from a handwritten letter.

River Road, Box 13
Mays Landing, New Jersey
January 23, 1981

EPA
Region II, N.Y.

Dear Sirs:

My name is George M. Liggett. I am the water pollution chairman of the Atlantic County Citizens Council on Environmental (ACCCE) and a member of the Audubon Society.

I am concerned about your proposed plan to incorporate toxic chemicals at sea, off the coast of New Jersey.

As you know in your EPA Quarterly Report, July-September 1979, tests were made on the amount of Planar in fish in thirteen major U.S. water sheds. PCBs, PCDFs and PCDDs were found in the samples. As you know, Dioxin is the most deadly toxic known to man.

The brochure goes on to state that "PCDDs were recently found to be present in fly ash of municipal incinerators in Europe, which has led to the hypothesis that PCDDs in the environment were a result of combustion and not a result of industrial processes." Also, "PCDFs are known contaminants in PCBs and may also be formed from PCBs at high temperatures."

Now we also know that PBCs have been found in marine life on an extensive basis (Dr. Vaughn, Woods Hole, Mass). We also know that PCBs have a life (full) span of about 60 years the same as DDT and its derivatives, and has about the same effect on the cell as DDT.

18-1 So if you start incineration at sea in '85 the toxic effects from the ash and disposed gases will still be present in marine organisms in 2045.

18-2 Not only that, but what will the synergistic effect be from the union of the ash and other toxins at the "burn site", especially with radioactive isotopes now escaping from leaking drums in that general area? As you know, sunlight on the smog in Philadelphia causes new poisons to form from the photo effect on other poisons.

While burning at sea, as an emergency measure may be better than dumping toxics at Price's Landfill, it has long term consequences not known yet.

18-1 EPA acknowledges that residual wastes will be released with incineration emissions during at-sea incineration. However, these emissions will be on the order of 0.01% of the volume destroyed. It is entirely possible that with improved technology, emissions can be further reduced (e.g., scrubber devices). EPA believes that monitoring incineration activities at the site will provide the necessary insight to determine if unacceptable adverse impacts on marine organisms are resulting.

18-2 The phenomenon of synergism complicates the study of toxic effects of substances. It is difficult enough to determine the affect of a single substance on its surrounding environment. As for radioactive isotopes, the great depth and dilution afforded by the site will inhibit the interaction of residues and isotopes. Therefore, the synergistic effect of any isotopes leaked into the environment may be indistinguishable from natural background radiation.

18-3 I think the ultimate solution is to make industry find a chemical which will dissolve the molecular structure of the chemicals produced at the plant before disposing of them. If these reversing chemical neutralizers can't be found, new chemicals should not be made.

As I remember it; life was good back in the 20's and 30's before the advent of millions of industrial poisons. What do you think?

Please respond. Thanks for listening.

Sincerely,
George W. Liggett

18-4 P.S. Did Atlantic Electric Corporation get your permission to burn PCBs at Beesley's Point? Please answer.

18-3 EPA will continue to encourage the development of all types of promising waste disposal technologies. If chemicals such as these can be isolated, they too will be investigated.

18-4 This question was responded to in a separate letter by EPA Region II.

19

NATIONAL WILDLIFE FEDERATION
1412 Sixteenth Street, N.W., Washington, D.C. 20036 202—797-6800

January 29, 1981

Mr. T. A. Wastler
Chief, Marine Protection Branch (WH-548)
Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Re: NWF Comments on the Site Designation DEIS for the Proposed North Atlantic Incineration Site (Oct. 1980)

Dear Mr. Wastler:

We have carefully reviewed the subject DEIS and offer the accompanying comments for your consideration. We trust the Final EIS will adopt the recommendations we have made.

In our view, the present DEIS is the best of the sequence of site designation DEIS's to date. The analyses by Drs. Duce and Kester, contained in Appendix D, are particularly useful and informative in allowing readers to evaluate potential long-term incineration impacts. We hope future site designation EIS's will continue this approach.

We have little difficulty endorsing at-sea incineration for organochlorine wastes in individual cases, where this method of destruction seems to be the best available disposal or treatment alternative. However, we are concerned about the long-term cumulative impacts of at-sea incineration of organohalogens should this practice become widespread in the United States. While a destruction efficiency of 99.96% seems very high, the release of even 0.04% of unburned organohalogen residues from the combustion of large-volume wastes, can have significant environmental and health impacts--particularly where such highly toxic and persistent compounds as PCB's and DDT are involved. So, caution must be the watchword, and preference should always be accorded to the disposal option which maximizes the isolation or destruction of the candidate compound. At-sea incineration should be pursued only if it offers environmental--and not merely economic--advantages over other management options.

The opportunity to offer these views is appreciated.

Sincerely,

Kenneth S. Kamlet
Assistant Director for Pollution and Toxic Substances

F-60

KSK:sc

Attachment

cc: Russ Wyer, Acting Director
Edwin Johnson, Deputy Assistant Administrator
Robin D. Lewis, IEC
Noel Plutchak, IEC
Dana Kester, Professor of Oceanography
Ray Krueger, Chemist
Ralph Colleli, Attorney Advisor
Maureen Hinkle, Environmental Defense Fund

19

NATIONAL WILDLIFE FEDERATION
1412 Sixteenth Street, N.W., Washington, D.C. 20036 202—797-6800

COMMENTS OF THE NATIONAL WILDLIFE FEDERATION
ON THE DEIS FOR THE PROPOSED NORTH ATLANTIC
INCINERATION SITE DESIGNATION (October 1980)

1. Consideration of Alternative Ocean Disposal Sites

Based on the information contained in the DEIS--and despite the preference expressed for proposed incineration site #1--we believe a strong case could (and should) be made for choosing site #4 (to the east of the proposed site) instead. This conclusion flows from several considerations:

19-1a --Site #4 is further from shore than site #1, serving to further reduce potential impacts on shore-based and coastal resources. As noted in the DEIS (at 2-30), the cost of using this site is not expected to be greater than that for the proposed site.

19-1b --Site #4 would minimize the monitoring complications associated with site #1 (see, DEIS, at 2-13, 2-22, 2-36). The potential for mingling of waste plumes between the 106-Mile Site and the incineration site is greater for site #1 than for site #4. Also, because of past dumping of munitions and radioactive wastes at the proposed site (DEIS, at xv, xvii), interference with certain monitoring operations can be imagined if this site is chosen although the DEIS is silent on this point. The DEIS acknowledges the potential for sediment effects (at 2-42); monitoring of such effects could be hampered by the presence of munitions at site #1. Site #4 would not raise these problems.

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19-1a EPA believes that the distance provided by the proposed site will permit sufficient dilution of any residues which may, at any time, be transported toward coastal areas. Although it is acknowledged that costs at either location will be similar, it should not be concluded that they will be equal. The additional distance will add time, and, hence, expense to transportation of all vessels which must transit to the eastern region.

19-1b EPA does not believe that the potential for mingling of residues from incineration and wastes dumped at the 106-Mile Site poses a significant threat to monitoring efforts. Monitoring of the 106-Mile Site has not been hindered by the past practice of dumping munitions and low-level radioactive waste. Benthic sampling has occurred in these areas, but has not been affected by previously dumped materials. The only residues from incineration at-sea are the stack emissions which are rapidly dispersed in the air or onto the immediate surface waters.

19-1c --Although the DEIS asserts that monitoring costs would be greater at site #1 than at site #4 because of the assumed need for additional baseline surveys at the latter but not at the former (DEIS, at 2-23, 2-30, 3-10), the DEIS also notes elsewhere (at 3-1 and 4-1) that "information on the proposed site and the 106-Mile Ocean Waste Disposal Site... is applicable to other mid-Atlantic geographic areas, including the eastern... region (site #1)," and environmental consequences discussed for site #1 "are valid for any location selected in the mid-Atlantic Bight region bounded by the Continental Shelf on the west and north, and the Gulf Stream on the east and south." We believe it is safe to assume that, if

19-1d acquiring additional baseline data was not necessary for site #1, that it would be equally unnecessary for site #4.

19-1e --Given the dependence of safe at-sea incineration on dilution and dispersion, the larger size of site #4 relative to site #1, might also make the former a more suitable incineration site.

19-1f In short, we urge EPA to reconsider its tentative determination to choose site #1, and recommend that serious consideration be given to designating site #4 instead.

2. Consideration of Land-Based Alternatives and the No-Action Alternative.

The principal advantages given by the DEIS to incineration at sea rather than on land are: much lower costs (DEIS, at 2-3, 2-29); reduced potential for acute adverse effects on the environment due to mechnical malfunction or accidental spill (DEIS, at 2-3, 2-29, 2-31); and faster rate of processing wastes (DEIS, at 2-3).

F-103

19-1c To correct this comment, the DEIS stated that monitoring costs would be greater at site No. 4. Baseline studies will be necessary at alternative region No. 4, if it should be the designated site location. Alternative Site No. 1 is the proposed site, and the past monitoring at the 106-Mile Site has overlapped into the northern portion of the site. The information gathered there constitutes site-specific data. No comparable data exist for the eastern region (alternative No. 4), hence, site-specific data would need to be collected in this region.

19-1d It is possible, indeed necessary, to utilize existing data collected from the 106-Mile Site and proposed Incineration Site to characterize the general environmental settling of the greater region, because few other data exist. However, it would not be scientifically sound to utilize these same data for analytical comparison to any future data collected following incineration operations in the more distant eastern region.

19-1e Alternative No. 4 is not a site per se; rather, it is an area of consideration in which a site could be located.

19-1f Comment noted. EPA believes that the proposed site (No. 1) affords acceptable health and environmental safeguards to warrant its selection over the other alternatives in the greater region.

19-2 However, there is no adequate analysis of comparative environmental implications. For example, if it were true (as has been suggested to us by spokesmen for the Vulcanus) that the ability to construct ship-board incinerators without having to accommodate stack-scrubbers allowed such incinerators to maximize combustion efficiency relative to land-based incinerators, that would be a potent argument in favor of the at-sea alternative. Conversely, if it were possible, through the use of a large number of land-based incinerators located near waste sources, to reduce the concentrated release of unburned organohalogen and metal residues in a given geographic area, or by reducing required transport distances and transfer steps to reduce the potential for spills, that would argue in favor of a preference for land-based incineration. (For example, the DEIS at 4-11 indicates that at-sea incineration of PCB and DDT could increase local PCB and DDT concentrations by 100 times and 1,000 times over background levels, respectively. If the use of a larger number of slower burning land-based incinerators could significantly reduce such localized build-ups, that might be a very important factor to consider in terms of the potential for long-term health and environmental impacts.)

19-3 Furthermore, although the DEIS mentions the availability of chlorolysis and catalytic hydrodechlorination processes for destruction of many organochlorine wastes, nothing is said about destruction efficiencies for such processes in relation to those of incineration. Obviously, if there are chemical or other destruction techniques that are more efficient at destroying organochlorines than at-sea incineration, such techniques deserve emphasis and preference.

T-61

19-2 A distinct advantage of at-sea incineration is the elimination of bulk residue that must still be handled in an environmentally sound manner. Similarly, technological difficulties of the incinerator are substantially reduced. However, it is not a foregone conclusion that limited scrubbing will not be considered in future design technology.

Presently (1981) only two commercial land-based incinerator facilities have been approved by EPA. Therefore, it is unlikely that a large number of these lower-flow-rate capacity incinerators will be available to handle the anticipated volumes of wastes.

19-3 As pointed out in the DEIS (Chapter 2) these are developing technologies which are presently limited in their application. EPA will continue to encourage the development of all promising alternative disposal technologies.

The Final EIS should attempt to at least generally compare destruction efficiencies for the various applicable waste conversion processes to those associated with at-sea incineration.

19-4 Finally, as part of the alternatives discussion, something needs to be said about the feasibility or lack thereof of fitting shipboard incinerator stacks with scrubbing devices. We don't advocate such a step, but the discussion of alternatives should make clear why this would not be worth doing in the interest of reducing stack emissions, while retaining the advantage of remoteness. (See, DEIS at 4-32).

19-5 We object to the characterization of the "feasibility" of land-based alternatives on pp. 2-5 and 2-6. Land-based methods cannot automatically be deemed infeasible just because at-sea incineration has not been precluded from consideration because of excessively adverse environmental consequences.

3. Characteristics of Wastes Permitted for At-Sea Incineration.

The DEIS discussion in this regard is confusing.

In one place (at xx) it specifies only that permitted wastes may contain no substances prohibited by the Ocean Dumping Regulations, and must contain low concentrations of trace metals.

In another place (at 1-2) it says that "some industrial wastes, particularly liquid organohalogen wastes" are suitable for at-sea incineration.

Then (at 1-20) it says that organic chemicals, pesticides, and petroleum refinery wastes are considered acceptable incineration candidates.

Elsewhere (at 2-11) it is said that "only those materials which burn efficiently and produce acceptable trace metal residual levels will be permitted." And (at 2-33): "[t]he principal types of wastes

19-4 See comments and responses 3-9 and 7-13.

19-5 Considering that feasibility is defined as "capable of being accomplished or brought about," the statement referred to is intended to explain that land-based alternatives are justifiable if the probable and possible consequences are not determined to be unacceptable. As pointed out in the DEIS, for certain wastes, community disapproval in the past has prevented the utilization of land-based incineration.

F-65

anticipated to be incinerated are organochlorines, although other acceptable organohalogens may eventually be included."

While these various statements are not mutually exclusive, they represent differing nuances and imply differing preferences. We hope the Final EIS will develop one uniform formulation of the types of wastes deemed acceptable and unacceptable for at-sea incineration.

19-6

Specifically, we would like to see it made clear that wastes to be considered for at-sea incineration must have the following properties: (a) contain no "prohibited materials"; (b) contain less than "trace" amounts of heavy metals and other uncombustibles; (c) be subject to efficient and virtually complete thermal destruction; (d) have known combustion properties (including nature of breakdown products and destruction efficiencies); (e) be subject to prior pilot scale tests where there is doubt as to the thermal destructibility of the waste, and to intensive initial stack monitoring where there are doubts as to the efficiency of combustion (see, DEIS, at 1-14).

4. Conditions of Permitted At-Sea Incineration.

19-7

The use of the designated at-sea incineration site should be restricted to material which meet the conditions described in Comment 3 above. It should also be restricted to burn operations which are conducted subject to the following conditions:

--in-depth monitoring of short-term effects on air and water quality and of incinerator stack emissions, particularly for burns under "research" permits (DEIS, at 1-15).

--all of the requirements listed in the DEIS, at p.xxi.

--a long-term monitoring program must be devised and implemented to detect subtle environmental changes resulting from use of the proposed incineration site before unacceptable environmental

19-6 The suggestion is appreciated. The FEIS has been modified (Chapter 2) to incorporate this idea.

19-7 With the exception of a long-term monitoring plan, all points listed are subject to permit requirement, as deemed appropriate at the time of permit issuance. Long-term monitoring falls within the responsibility of NOAA under the MPRSA (see response 16-4).

imbalances occur (see, DEIS at 4-35).

--short-term monitoring should include in situ biochemical analyses of surface waters in exposed and control areas, including in situ bioassays (e.g., use of biotal ocean monitors and enzyme assays). (See, DEIS, at C-3).

19-8 --in view of variable meteorological conditions, consideration should be given to restricting or prohibiting at-sea incineration at the proposed site during the late spring and summer. This would optimize weather conditions which favor rapid dispersal and rapid removal to the ocean surface of incinerator ship emissions. (DEIS, at D-44).

The Final EIS should discuss these various mitigation measures and their environmental implications in one place in the EIS.

5. Prevailing Wind Conditions and Possible Landfall of Emission Plumes.

19-9 The DEIS (at 2-11) makes the assertion that [a]tmospheric transport [of incinerator ship emissions] to coastal areas is highly unlikely because the site is far from land and prevailing winds move west-to-east, carrying the waste plume seaward." This statement is contradicted in Appendix D which demonstrates (DEIS, at D-26, D-28, D-32, and D-44) that "the wind flow is primarily... from the southeast sector [i.e., from east to west] during the late spring and summer." Appendix D also indicates that, "[w]ith easterly winds... much of the submicrometer particulate material could be deposited over North America" (DEIS, at D-31) and that "low molecular weight saturated CHC [chlorinated hydrocarbons]" which have "atmospheric

19-8 Seasonal use restrictions can be imposed as a special condition of the permit issue to reflect developing information. However, EPA does not view this as a necessary precondition to site designation.

19-9 The DEIS recognizes the reality of wind shifts during summer months (Appendix A). The referenced passage has been revised in the FEIS. It should still be understood that the distance to shore will provide significant dilution of residues that may remain in the atmosphere. As pointed out on page D-32, these residues probably would be indistinguishable from background concentrations.

As with comment and response 19-8, EPA does not presently consider seasonal restrictions of use a necessary precondition to site designation. If future monitoring results indicate a need for use modification, this can be accomplished by revising the permit conditions.

residence times of months to years" can "be distributed around the northern hemisphere and even globally, mixing into the southern hemisphere" (Id.). See also, DEIS at D-32 - D-33: "Winds within [the southeast sector] would transport the substances of interest back towards North America, which is only some 200 Km from the burn site."

The Final EIS should be revised to address this reality. It should also discuss the feasibility of restricting at-sea incineration to the Fall, Winter, and early Spring--to minimize the potential for landward transport of emissions by the onshore winds prevailing during late Spring and Summer.

6. Shore-Based Support Facilities and Risks of Accidents.

The DEIS notes (at xx) that "shore-based support facilities will be necessary to receive, store, and blend wastes prior to shipboard loading and transportation to the site" and serve "as an offloading location in the event the incinerator vessel should be forced to return to port without completion of incineration." The DEIS also notes (at 4-3) that among the most significant risks to people or to coastal resources of at-sea incineration "would result from accidental discharges of wastes at loading times, or during transit to the disposal site."

19-10 However, despite this, the DEIS says nothing about what constitutes acceptable and unacceptable loading facilities and other shore support. It merely states tersely (at 4-3) that "[a]ll EPA and USCG precautions for the handling of wastes must be strictly observed."

F-68

19-10 Refer to comments and responses 11-5 and 12-4.

The Final EIS should provide information on the nature of potential northeast loading and spill handling facilities that may service at-sea incineration at the proposed site.

In addition, the DEIS (at 4-4 - 4-5) notes that adverse weather conditions and mechanical malfunctions accounted for 75% of the collision damage occuring at four major east coast ports between 1974 and 1978, and that "[t]he potential economic and environmental hazards created by spillage, leakage due to collision, or grounding, greatly exceed the potential hazards of at-sea incineration." In response to these concerns, the DEIS merely notes (at 4-5) that "shipments of hazardous waste materials will be protected against navigational hazards by regulation of sailing times, advantage taken of optimal traffic and weather conditons, and warning local shipping traffic of the movement of an incinerator vessel." The DEIS also states (at 4-33) that "[i]mmediate mitigating measures can best be directed towards prevention of accidental spills or emergency discharges."

However, it is left unclear how adverse wheather conditions can be guarded against for an incinerator ship engaged in active burning for 7-8 days at a stretch (in addition to transit time to and from the burn site). Since the most severe weather conditions normally occur from November until March (DEIS, at 4-34), the Final EIS should discuss the feasibility of restricting or prohibiting at-sea incineration during these months. This in turn must be balanced against the advantages (discussed in Comment 5, above)--in terms of maximizing dispersion--of encouraging at-sea incineration during this time period.

19-11

19-11 Modern weather forecasting and communications technologies greatly enhance the ability of operational planning and advance reaction to impending inclement weather. Thus, it would seem an unnecessary prohibition to limit the use of the site during a seasonal period that would most enhance the desired result of at-sea incineration, namely dispersion and dilution of residues. However, limitations on incineration operations may be considered during the permit process to limit use of the site during specific periods.

F-69

19-12 7. The section on "Projection of Quantities and Types of U.S. Wastes Which Might Be Incinerated At Sea" (DEIS, at 1-20 - 1-24) should be updated to reflect the latest available information on current at-sea incineration proposals involving PCB's, Silvex, and DDT. (DDT is not discussed in the current Draft at all).

This is especially important given EPA's apparent intention to permit or initiate the at-sea incineration of these three organochlorine compounds without the benefit of individual, project-specific EIS's.

8. Miscellaneous Comments.

a. The DEIS (at 2-37), provides a table (which is misnumbered) showing estimated residue loadings as fallout (in tonnes/yr.) for assumed waste loadings through 1989. It then provides a table (at 2-38) to "serve as [a] basis of comparison" showing estimated trace metal loadings (in kg./yr.) at Deepwater Dumpsite

19-13 106. If these tables are to be compared by the reader, the units of measurement employed should be comparable--either both tonnes/yr. or both kg./yr.

b. The DEIS states (at 1-16) that monitoring tests for the third Shell Chemical Company burn showed "no deleterious or subtle adverse impacts."

19-14 However, the DEIS itself later points out (at 4-24) that a field bioassay using "biotal ocean monitors" in connection with the third shell burns "revealed increased P-450 enzyme activity in test organisms, which indicated a stress response to environmental conditions."

19-12 EPA has since received, and is reviewing, two official applications to incinerate PCB and Silvex wastes. Final determination on issuance of the permits has not been made. The FEIS has been modified to present this new information.

The Department of Defense issued a DEIS on the collection, transport, and disposal of DDT. The FEIS was made public in January 1981. To date, EPA has not received a formal request to dispose of DDT by at-sea incineration.

An applicant wishing to dispose of wastes by at-sea incineration must provide specific information describing the wastes and associated hazards. On receipt of an application, a public notice is published and comments solicited prior to a final decision on an application.

19-13 Change made on Table 2-4 to reflect tonne/year.

19-14 It is also stated in the DEIS (p. 4-24 and 4-25) that following transfer to unaffected water for several days, organisms returned to a normal state. It was concluded that effects were local and temporary, presenting no unacceptable threat to the nekton.

c. The DEIS estimates (at 4-9) the quantity of incineration emissions that will mix with the upper 20 meters of the incineration

19-15 site. But it fails to estimate the resulting final residue concentrations in the water (after this mixing). The Final EIS should take the calculations through this extra step.

d. The DEIS indicates that maximal air/sea surface HCl concentrations would be 2-9 ppm (at 4-10), and that the maximal atmospheric concentration of unburned hydrocarbons at the sea surface would be 0.51 ppb (at 4-11). It fails, however, to consider the

19-16 potential biological significance of these levels--e.g., in relation to marine water quality criteria. The Final EIS should add such a discussion.

e. The DEIS (at 2-43) mentions that incineration of DDT and other pesticides (Kepone and Mirex) produced hexachlorobenzene as a partial decomposition product; in the case of PCB's partial decomposition products were produced, but the DEIS says that "no analyses were performed to identify the resultant compounds." The DEIS (at 4-7) also points out that incineration of Herbicide Orange waste (consisting of mixtures of 2,_4-D, 2,_4,_5-T, and TCDD) generated emissions containing "numerous (previously unidentified) compounds."

However, apart from appropriately stating that, "[b]efore substances are approved for incineration, the degradability and breakdown products of those substances must be determined, together with any combustion products" (DEIS, at 4-7), the Draft fails to point out that the partial degradation products of organochlorines

19-15 The 20m depth used in model calculations is assumed to represent a worst-case condition. Additional mixing, both horizontal and vertical, will represent continued dispersion and increased dilution, thereby reducing potential short-term impacts. Ultimately, residue levels will be veiled by background concentrations.

19-16 As stated in the DEIS, the HCl concentration predicted at the air-sea interface is 2.9 ppm, not 2-9 ppm. This, as well as predicted unburned hydrocarbons, is anticipated to produce no unacceptable adverse impact on the affected water column and associated marine organisms.

Because of the complexity of the physical processes which promote atmospheric dispersion, exchange across the air-sea interface, and dilution within the water column, it is not possible to predict with any degree of accuracy the resulting seawater concentrations which could then compare to water quality criteria. The models presented in an attempt to do this are simple and do not account for the exceedingly complex real-world physical and chemical processes affecting the short-term fate of residues. The most effective approaches presently available to estimate the potential biological significance of incineration residuals is short-term monitoring of the water column and in situ biological experiments using representative marine organisms. Studies conducted in the Gulf of Mexico have indicated that no unacceptable impacts will result.

can often be more toxic than the original material. They may also be more stable and have longer residence times in the atmosphere (see, e.g., DEIS at D-31).

19-17 These facts and their implications should be discussed in the Final EIS.

19-18 The Final EIS should also provide and discuss the recent evidence that PCB and DDT incineration can generate significant concentrations of highly toxic dioxins and furans.

19-19 f. In the discussion of atmospheric residence times of various organochlorines (DEIS at 4-11 - 4-14), the Draft notes that some compounds will "be subjected to fairly rapid hydrolysis in the atmosphere" (at 4-13). (Shouldn't the reference more properly be to "photolysis" rather than "hydrolysis"?)

19-20 The Final EIS should discuss the possibility that some of these hydrolysis (or photolysis) products in the atmosphere may still be toxic, with possibly negative environmental implications.

19-21 g. The discussion of "passage areas of living resources" (DEIS, at 2-32) should include reference to routes of passage of migratory birds (cf., p. 4-25). It should also encompass non-commercial fishery resources.

19-22 h. The DEIS states (at 2-12) that the "effects of incineration emissions upon birds is unknown." In fact, there are studies on respiratory effects of HCl gas on gallinaceous birds. (Discussed in reports on first set of Shell burns). This and other relevant information should be included in the Final EIS.

19-17 This was pointed out on page 4-8 of the DEIS.

19-18 Text modified, Chapter 4, under section "Effects on the Ecosystem."

19-19 Reactions are dependent on the chemical species involved.

19-20 This concept is considered at page 4-8 of the DEIS; although it is unknown to what extent this phenomenon will occur. However, it is important to note that such products will be highly diffuse.

19-21 Text modified as recommended within Chapter 2, under section "Detailed Bases for the Selection of the Proposed Site."

19-22 Additional information has been included in the FEIS, Chapter 4, under section "Effects on the Ecosystem."

19-23 i. The projections of HCl emissions from at-sea incineration at the proposed site through 1989 should compare levels of HCl generated by incineration with estimates of sulfuric acid mists falling on North America as "acid rain." How significant is the potential contribution of sea incineration HCl emissions to North American (or global) acid rain problems? The Final EIS should discuss this.

19-24 j. The DEIS states (at 2-12) that "[m]onitoring will be difficult until new techniques and more precise measurements are available for detection of deleterious effects." This possibly overstates the difficulty. As described elsewhere, "biotal ocean monitors" and sensitive enzyme assays have succeeded in measuring subtle effects of past incineration operations (DEIS, at 4-24).

19-25 k. Consideration should be given to expanding the section on "History of the United States At-Sea Incineration Program" (DEIS, at 1-15, et. seq.) to reflect the paper by Kamlet, K.S., "Ocean Disposal of Organochlorine Wastes by At-Sea Incineration," to be published very shortly by Plenum Press as part of a book entitled Ocean Dumping of Industrial Wastes. A copy of this paper is attached to these comments as an Appendix.

l. The DEIS (at 4-19) implies that the EPA criteria will ensure against at-sea incineration of a waste containing damaging levels of trace metals. (The DEIS also notes, at 4-5, that the metal levels in Shell wastes "were found to be one to three orders of magnitude lower [during Research Burns I and II] than comparable reported metals found in wastes incinerated during Research Burn III"). Since the EPA criteria define "trace contaminants" on the basis of

19-23 Any HCl that may be transported toward the continent will be diluted to background levels, and would not measurably increase the incidence or severity of acid rains. The prevailing winds in the general area move from West to East, thus the HCl would tend to move away from land. Any acid rain is likely to occur far out at sea, and the HCl would be rapidly neutralized in sea water.

19-24 Refer to comments and responses 2-4 and 7-15.

19-25 Reference to the paper has been included in the FEIS, Chapter 1.

19-26 non-contaminant-specific bioassay tests, it is difficult to imagine how one could evaluate a waste prior to incineration in terms of the acceptability of its heavy metal content. The Final EIS should discuss this issue more fully.

19-27 m. The Draft (at 4-14) compares the maximal sea surface concentration of inorganic particulates to EPA primary health standards for particulates--a comparison that doesn't seem terribly relevant at the sea surface over 100 miles out at sea. A more ecologically-oriented frame of reference should be provided.

19-28 n. The worst-case estimate discussed at p. 4-16, indicates that during the initial mixing period residual organohalogen loading in the water at the incineration site would exceed EPA water quality criteria by "several factors." The possible environmental implications of this--particularly if at-sea incineration becomes more widespread in the future--are not discussed, but should be. (See also, DEIS at 4-18 - 4-19, 4-30, 4-31, D-37 - D-38).

19-29 The flat assertion that "organochlorine emissions are insignificant" (DEIS, at 4-31) seems inappropriate and unjustified.

19-30 o. The DEIS, in its discussion of "Loss of Biotic or Mineral Resources" (at 2-15 - 2-17) and "Commercial and Recreational Fish and Shellfish" (at 4-3 - 4-4), fails to consider the likelihood that deep-sea marine organisms, far removed from the nearshore zone and being accustomed to a highly stable environment, may be particularly sensitive to stresses associated with at-sea incineration.

The site-designation EIS for the San Francisco Bay Channel site emphasized the turbulent conditions of the disposal site

19-26 levels of initial concentrations are evaluated during the permit process. At that time, specific levels are deemed either acceptable or unacceptable. Future guidelines may be specific regarding absolute level values.

19-27 This is the best estimate currently available.

19-28 The worst-case estimate presented in the DEIS (Chapter 4) is based on factors that are not likely to occur. In reality, much lower values will probably be the case. The first model (p. 4-16) forms the basis of predicted impacts. Both models predict site water column loading to result from wastes loaded aboard the vessel in 100% concentrate form.

The model applied through Chapter 4 assumes that all residues released in 1 year remain within the site boundaries; an instantaneous input of 1 year's residue. Obviously, such an occurrence will not happen. Even at this unattainable rate, water quality criteria are nearly met.

19-29 In relation to the quantity destroyed, their emissions are insignificant.

19-30 The DEIS (p. 4-25) predicts that deep-sea and benthic organisms will be insulated from residue by the extreme water depth at the site. Organisms inhabiting the water column of the site are transitory. No single organism is a permanent resident. See also responses 7-7 and 7-16.

environment and the likelihood that the organisms residing there would be particularly well-adapted to the stresses associated with dumping. The present EIS should point out the converse: the stable conditions at the proposed site are likely to make the resident species especially sensitive to stresses associated with dumping.

It should also be recalled in this regard that, after extensive public testimony and consideration of scientific views, EPA several years ago decided not to shift sewage sludge dumping from its present nearshore location to the more distant Deepwater Dumpsite 106. A primary basis for this decision was the desire to not subject sensitive deepsea organisms, about which much less is known than their nearshore counterparts, to the stresses associated with ocean dumping.

20

SOUTHEASTERN WASTE TREATMENT, INC
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February 13, 1981

Mr. T.A. Wastler
Environmental Protection Agency
Washington, D.C. 20460

Dear Sir,

As an operator of a land based incinerator, I must object to the Agency's recent vigorous support of incineration at sea. I also object to incineration at sea in general.

20-1 My objection to the Agency's support is based on the fact that permitted facilities have enough problems in siting and expansion without giving our critics the ability to say "the EPA says...".

20-2 My objection to the concept of incineration at sea relates to potential for devastating accidents. Transportation of wastes to a ship-board terminal is no different conceptually than transport to a land based facility. The problems arise at sea in the form of collisions and storms which could cause a release of material which would be dispersed over an area limited only by biodegradability and currents. An oil spill, even the largest, is a minor occurance compared to a

20-3 chemical spill of this nature. A land based accident is naturally contained and correctable.

Finally, to say that the ocean is compatible with the emissions of unscrubbed incineration is fine if the ocean is involved. With what little I know about weather phenomena, I have to believe that

20-4 the ocean will never see the emisaions under certain atmospheric conditions, such as thermals, winds and etc.

Respectfully submitted,

James M. Henderson
President

JMH/sj

20-1 EPA concurs that permitted facilities have siting and expansion problems. However, EPA believes that land-based incineration facilities are one of the alternatives for hazardous waste management. EPA has certified two land-based incineration facilities for the destruction of hazardous wastes materials. At-sea incineration is considered a viable disposal method, due to its remoteness from inhabited areas, thereby affording some increased safety measures not attainable at land-based facilities.

20-2 EPA recognizes the devastating potential of accidents involving a loaded incineration vessel, hence stringent safety precautions must be rigidly adhered to in this type of operation. There is no evidence to support the argument that a spill of this type would be far more devastating than the largest oil spill, although both possess potential for highly significant environmental damage. Hence, as with all environmentally hazardous substances, regulations are applied to the handling of these substances to minimize all potential hazards.

20-3 Although spills at land-based facilities could be more easily contained, these same problems can readily lead to other environmental hazards in and around populated areas and affect air quality or possible ground water contamination.

20-4 It is recognized that some residues will have atmospheric residence times on the order of days or months. However, studies in the Gulf of Mexico have demonstrated that residues rapidly begin to descend to the water surface and begin exchange into the water column. The bulk of the residue, HCl, is instantly neutralized. Ultimately, all residues will be brought to equilibrium from atmospheric suspension. The phenomenon of dispersion of residues through a vast volume of air and water in a remote oceanic region of reduced biological productivity reduces potential impacts from this waste elimination process.

21

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ANTHONY J. CICCONE, JR.

February 24, 1981

BY HAND

Mr. T. A. Wastler
Chief, Marine Protection
Branch (WH-548)
Environmental Protection Agency
Washington, D.C. 20460

Re: Draft Environmental Impact Statement (EIS) For Proposed North Atlantic Incineration Site Designation

Dear Mr. Wastler:

Enclosed please find a two-page letter prepared by Waste Management, Inc. (WMI) for filing in the above-referenced matter. This letter was transmitted to the undersigned by WMI via telecopier on February 23, 1981, but was not received until early this morning due to malfunctioning equipment. While we recognize that comments in this matter were due to be filed on February 23, 1981, under the circumstances, we respectfully request that the enclosed letter be accepted for filing.

As you will note from the enclosed, WMI has a vital interest in the prompt designation of a North Atlantic incineration site. The acceptance of its letter will be of value to EPA in its evaluation of this subject and will not be prejudicial to any other party.

Thank you for your consideration.

Very truly yours,

Marc J. Fink
Counsel for
Waste Management, Inc.

MJF/tdc
Enclosure

F-73

21

Waste Management, Inc.
900 Jorie Boulevard - Oak Brook, Illinois 60521

February 23, 1981

Mr. T. A. Wastler
Chief, Marine Protection Branch (WH-548)
Environmental Protection Agency
Washington, D.C. 20460

RE: Draft Environmental Impact Statement (EIS)
For Proposed North Atlantic Incineration
Site Designation

Dear Mr. Wastler:

Waste Management, Inc. (WMI) has reviewed the draft Environmental Impact Statement (EIS) which has been prepared by or at the direction of the Environmental Protection Agency (EPA) in conjunction with its designation of a proposed site in the North Atlantic for at-sea incineration of certain wastes. WMI believes that the draft EIS is a satisfactory environmental assessment of the impact of the use of the proposed site for at-sea incineration of hazardous chemical wastes. A final EIS and site designation should, we submit, be made available as soon as possible. (40 C.F.R. Sec. 228.6(b)).

WMI has a vital interest in the prompt designation of a site for at-sea incineration. Recently, it purchased the M.T. VULCANUS, one of the few ocean incineration vessels in the world. She is now operating off the coast of Europe. The M.T. VULCANUS, as noted in the draft EIS, is the only vessel which has ever incinerated toxic wastes off the coast of the United States. WMI expects to make the M.T. VULCANUS available for use to waste generators in the United States in the near future and expects to have permits issued to it by EPA so as to enable it to incinerate various toxic wastes at sea.

There is, at the present time, only one approved ocean incineration site and that is located in the Gulf of Mexico. WMI expects to collect a substantial volume of toxic wastes in the north-eastern section of the United

F-79

312/654 8800 - Telex 253094 - TWX 810 651 0029

States and to have those wastes transported to a terminal located on the Atlantic coast. An ocean incineration site in the North Atlantic is of direct and immediate importance to WHI.

If the M.T. VULCANUS were required to load toxic wastes at a terminal on the East Coast and then transport those wastes to an incineration site in the Gulf of Mexico, the cost and efficiency of its operations would be adversely effected. As noted in the Draft EIS:

> The ability of this site (in the Gulf of Mexico) to assimilate the tremendous volume of wastes which are generated on the Gulf and east coast is unknown, and as this study indicates, this site would require several ships operating simultaneously to handle the projected volumes of waste. Additionally, the potential environmental hazards and economic burden of waste transported render this alternative untenable. (Draft EIS at xiii-xiv)

Ocean incineration of toxic wastes has proven to be technically, environmentally and economically feasible. EPA and other federal agencies have indicated that an at-sea incineration capability in this country is necessary in order to meet this nation's hazardous waste disposal problem. See Report Of The Interagency Ad Hoc Work Group For The Chemical Waste Incinerator Ship Program, September 1980. By its acquisition of the M.T. VULCANUS, WMI has demonstrated that it is ready, willing and able to provide this service. To enable WHI to provide this valuable service, EPA should, pursuant to 33 U.S.C. Sec. 1412(c) designate an ocean incineration site in the North Atlantic as soon as possible.

21-1 For the foregoing reasons, WHI requests that EPA finalize its EIS and site designation as soon as possible.

Sincerely,

Frank R. Krohn
General Counsel
CHEMICAL WASTE MANAGEMENT, INC. &
Co-ordinator - Ocean Incineration Program

FRK:saal

F-80

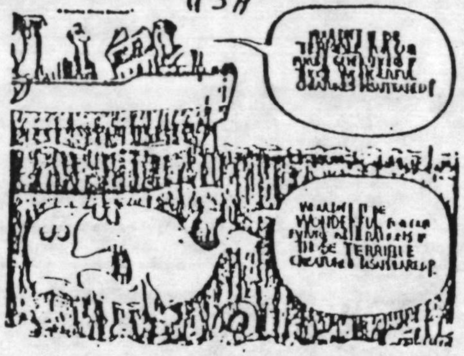
21-1 Thank you for your review and comments.

We do not want the DUMPING.
New Jersey has the highest Cancer Rate in the USA

Editorial

Who(?) are they protecting? Us?

22-1



HERE WE WERE, residing all year 'round in a vacationers' paradise at the Jersey Shore — relaxing when we could get the time, enjoying life and not at all concerned about pollution, toxic chemicals and other urban poisons. We live far enough away from city dirt, pollution, grime and crime that it has little to do with us and our way of life. Right?

Wrong!

We're right in the midst of our own mess, and no one seems to know what to do about it.

The first warning — that of skyrocketing juvenile delinquency rates — should have told us something a decade ago. But alas, we thought that was a temporary or neighborhood problem— those city people moving here with kids whose hoodlum-like habits were already formed.

We know now — watching continually climbing crime rates — that the problem didn't go away. In fact, it got worse.

When we learned that seashore municipalities were storing summer sewage virtually untreated, for winter dumping into the Atlantic Ocean, we were appalled. But they told us the ocean is vast, that it can handle it. A recurring Red Tide which periodically closes our beaches now tells us otherwise. Today, even pleasure boats can no longer be flushed overboard.

Toxic waste contamination was confined to urban centers — or less modern societies in the boondocks — so we thought. But pollution of water wells first in Dover Township's Pleasant Plains, then in rural Jackson Township, more recently in southern Ocean County, tells us otherwise.

Astute observers say residents of Ocean County are the last to catch on to the newest dress fads — the mini skirt, the designer jeans, and so forth.

It appears we have a better score when it comes to polluting our very own environment.

This is an environment in which we not only live and play — but which others pay our tourist industry to visit and play in. We are risking that — our largest industry — by not paying more attention to what we are doing with our environment.

Besides having a nuclear generating plant — of which an accident of the proportions of Three Mile Island could financially destroy Ocean County — we have a "dead sea" where New York dumps refuse off our coast, drinking water flowing through asbestos cement pipelines, garbage dumps reaching the overfull mark, a woefully inadequate public bus system which forces more and more pollution spewing cars on our roads, and more and more and more.

But we have agencies to deal with this kind of thing. We have the N.J. Department of Environmental Protection and the U.S. Environmental Protection Agency, besides various boards of health and still more government funded agencies.

We wonder if maybe they're not doing their jobs too well. Or maybe they're just approving what they consider to be best for us. Or maybe their just putting the stamp of approval on what we really want for ourselves.

Right now, we're half way into a new EPA proposal to incinerate toxic waste at sea — 130 miles off the New Jersey Coast. The U.S. EPA released an impact statement on Jan. 9 calling for 45 days of public comment, before issuing its final statement. Well, there is already an at sea munitions dump there, and some radioactive material has been dumped there. So, the EPA has chosen that spot. Burned at sea, organic waste, pesticides and carcinogenic chemicals, [illegible] 27 tons of it in an eight year period.

The proposal strikes us as part of our government's Out of Sight, Out of Mind philosophy. We think that the keepers and protectors of our environment are out of *their* minds.

It's time we looked long and hard at our paradise, before it becomes Paradise Lost.

And we ought to start now, with the newest suggestion from the EPA. The address? U.S. Environmental Protection Agency, Marine Protection Branch, Washington, D.C. 20201

22-1 Waste to be disposed at the proposed site will not be directly <u>dumped</u>, rather they will be <u>incinerated</u> at the site. At-sea incineration is being investigated as an option in the treatment and ultimate disposal of vast quantities of hazardous wastes which do, and will continue to, accumulate on the east coast, as well as throughout other parts of the country. The recognized advantage of at-sea incineration is its removal from populated areas, decreasing potential hazards to surrounding communities of land-based incinerator facilities, or contamination of surface or ground waters.

23

ironbound

January 16, 1981

Mr. T.A. Wastler
Chief Marine Protection Branch
EPA
Wash., D.C. 20460

Community Corporation
83 Fleming Ave.
Newark, N.J. 07106
(201) 344-7210

Children's Center
146 Wilson Ave.
Newark, N.J. 07105
(201) 589-6873

Community School
432 Lafayette St.
Newark, N.J. 07103
(201) 589-0860, 0861

Community Health Project
83 Fleming Ave.
Newark, N.J. 07105
(201) 589-4848

Community Information Center
Senior Citizen Project
Adult Education Project
83 Fleming Ave.
Newark, N.J. 07105
(201) 344-7206, 7210

Summer Day Camp

Dear Mr. Wastler,

On behalf of the groups listed below, I would like to request that public hearings are held in the cities of Elizabeth and Newark, New Jersey concerning the EPA Environmental Impact Statement for a proposed incineration site in the north Atlantic ocean. 23-1

The groups requesting these hearings are:

Coalition for a United Elizabeth
New Jersey Committee on Occupational Safety and Health
New Jersey Public Interest Research Group
Essex Sea Alliance
Ironbound Community Health Project
Bayonne Against Tanks
New Jersey Toxics Project

Sincerely,

Arnold Cohen
Ironbound Health Project
Coordinator

F-82

Rec'd. 2/13/81

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Mr. Arnold Cohen
Ironbound Health
Project Coordinator
95 Fleming Ave.
Newark, New Jersey 07105

Dear Mr. Cohen.

23-1 I am writing in response to your letter of January 15, 1981 in which your organization and six others requested public hearings on the proposed incineration site in the North Atlantic.

In order for the Environmental Protection Agency to determine if a public hearing is needed on a particular subject, we need to know the specific issues that are of concern and amenable to discussion in a public hearing.

If the organization will submit these specific issues in writing we will give the hearing request further consideration and inform you of our decision.

Sincerely yours,

T. A. Wastler, Chief
Marine Protection Branch (WH-585)

24

Greater Newark Bay Coalition
95 Fleming Ave.
Newark, N.J. 07105
(201) 344-7210

4/3/81

T.A. Wastler
Chief, Marine Protection Branch (WH-445)
U.S. Environmental Protection Agency
Washington D.C. 20640

Dear Mr. Wastler:

24-1 We, the undersigned citizens and environmentalists, have requested that a public hearing be held on the EPA's Draft Environmental Impact Statement concerning the designation of a site in the North Atlantic for the incineration of hazardous wastes. We have many concerns related to this proposal and would like to have a chance to address them in a public forum. Some, but not all, of our concerns are mentioned below.

The on shore impacts of ocean incineration have not been addressed in the EIS. In the process of at-sea incineration most of the activities of transportation and transfer take place on land. The location of a site in the North Atlantic will involve risks to East coast port communities and the exact location of the site and the volumes deemed appropriate for disposal will have a real impact on shore. For instance an alternative of several low volume incineration sites might have less on shore impact than one large one. These issues need to be studied.

F-84

Detoxification has not been properly considered as an alternative disposal method. This method is one in which the real costs, economic and environmental are internalized by the waste generator.

The possibility of illegal dumping of wastes at sea has not been admitted. The waste handleing industry has painfully demonstrated a tendancy to take this path of disposal when it is the cheapest and it will be less expensive to dump raw wastes than to burn them at the designated site. The EPA should at least evaluate the potential that this will occur and discuss the impact to be expected if it does.

The ability and responsibility of the government agencies to regulate and monitor at-sea incineration has not been addressed. The environmental impact will be largely determined by the quality of government regulation and so it is appropriate to cover it in the EIS.

The volumes of wastes used as the basis for the EIS are much too low. The volume of 189,000 tonnes/year used as a basis for the EIS compares to a voluntary first year minimum of 220,000 tonnes/year planned by a corporation which has already acquired land for a facility in Newark N.J. 189,00 tonnes/year might not open the activity to more than one or two companies.

Rec 4/16/81

Only the short term effects of the "trace" unburned toxins have been considered. The possibility of long term effects should be examined on the assumption of ocean incineration becoming the prevailing mode of waste disposal.

At-sea incineration will present the least expensive method of toxic waste destruction and will act to discourage exploration of more sound methods such as detoxification and recycling. This should be considered in the EIS since it might dictate allowing at-sea incineration on a short term basis with a schedule for phasing it out in a way that will provide incentives for developing other methods.

The contention that toxic wastes will not enter the upper atmosphere has not been adequatly supported

The probability and consequences of near shore shipping acidents has not been fully considered.

In light of these and other concerns about the impacts of at-sea incineration on the marine and urban shore environments we ask that a public hearing be scheduled in the Northern New Jersey area, and in any other areas which the activity is likely to effect.

Sincerely,

Joseph Schaney NJCOSH

Kathleen V. Prentice, lawyer, Newark resident

Bernice Washington

Arnold Cohen, Ironbound Community Health Project

John B. Sergeant Essex S.E.A. Alliance

Robert Cartwright Ironbound Community Corp.

Bonnie Corsted

Matthew R. Kautin NJCOSH

Donald Silvey Elizabeth Fire Dept.

Joe Lee N.J. COSH

John A. MacDonald, Rutgers Law School Envirn. Law Coun.
Local Board of N.J. P.I.R.G.

Donna Aroyagan, Newark Resident

J. Marasforky New Jersey Public Interest Research Gr

MAY 5 1981

Greater Newark Bay Coalition
95 Fleming Ave.
Newark, N.J. 07105

Dear Members:

24-1 This is in response to your letter of April 3, 1981, requesting a public hearing on the Draft Environmental Impact Statement (DEIS) on the designation of a North Atlantic Incineration Site.

The public comment period on the DEIS closed on February 22, 1981, and the Final EIS is now in the last stages of preparation. This is one of a large number of EIS's being prepared on ocean dumpsites by contract, and it would not be feasible to disrupt the schedule at this time. However, a hearing can be held on the Final EIS or the proposed site designation if you feel your concerns have not been addressed adequately by that time.

Some of the concerns expressed in your letter are similar to concerns mentioned by other commenters and will be addressed in the Final EIS. Other concerns are more properly addressed on a case-by-case basis in the permit issuing process. Ample opportunity is given for public review and comment before each permit is issued.

A number of the concerns you have expressed have already been addressed in previous reports published by EPA. I am enclosing several of these for your information. These reports address the relative merits of land-based vs. at-sea incineration and describe in detail two at-sea incineration operations done previously. I hope these reports will allay some of your concerns about our ability to regulate this type of disposal effectively and to prevent illegal dumping of wastes from incinerator ships.

Should you still feel a public hearing is desirable, we will be happy to hold one at the Final EIS or proposed site designation stage of the process.

Sincerely yours,

T. A. Wastler, Chief
Marine Protection Branch (WH-585)

Enclosures