US Army Corps
of Engineers
Baltimore District

Maryland Port
Administration

Baltimore Harbor Anchorages and Channels, Maryland

Integrated Feasibility Report and Environmental Impact Statement

Technical Appendices

APPENDIX B - ENVIRONMENTAL DATA

March 1997

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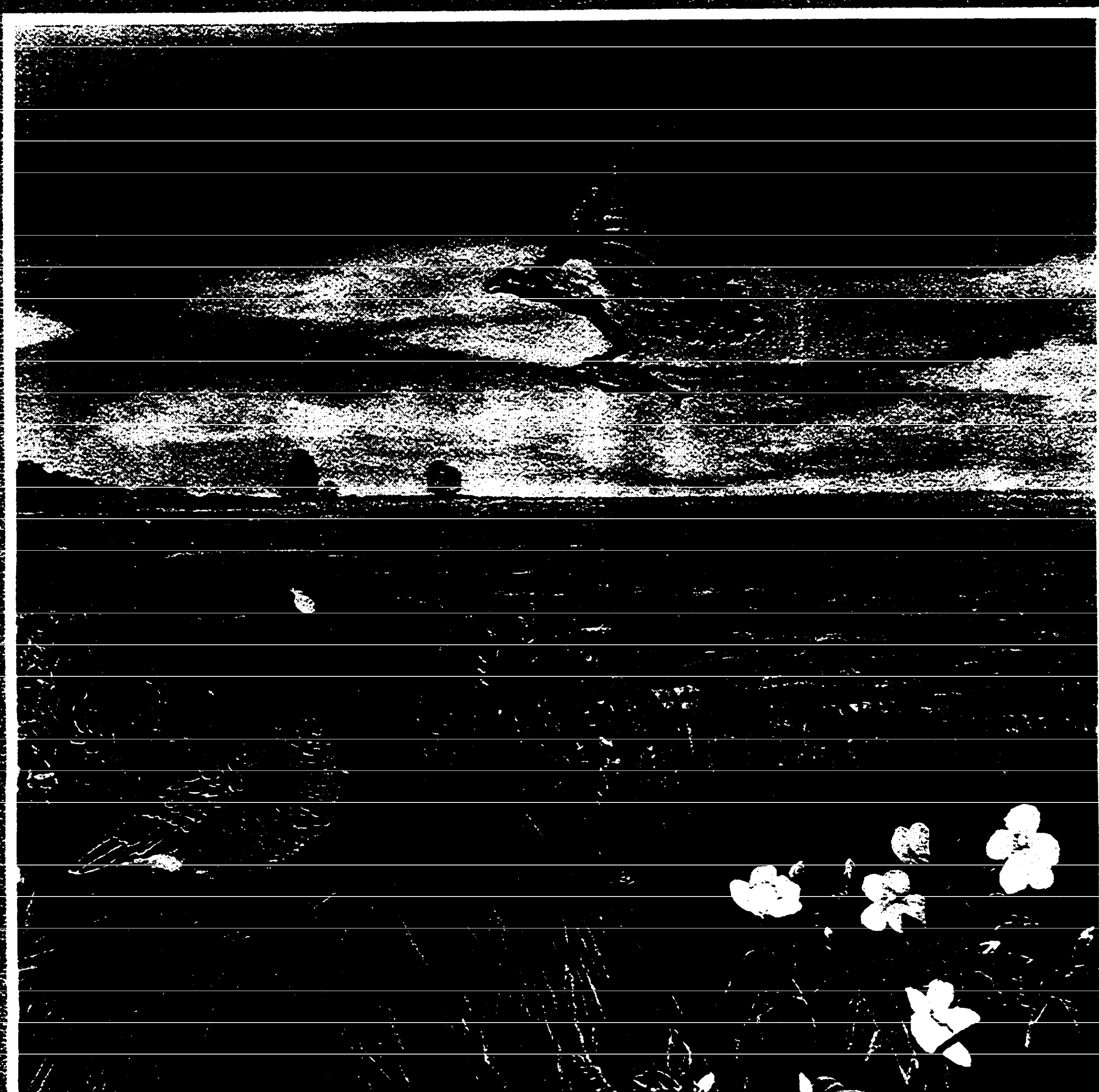

JANUARY 1992

Baltimore Harbor Anchorages and Access Channels
Reconnaissance Study

Baseline Biological Conditions and Potential Impacts

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U.S. Army Corps of Engineers
Baltimore District

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ABSTRACT

This report provides planning aid information to assist the Baltimore District, U. S. Army Corps of Engineers, in a reconnaissance level study of potential navigation improvements for the Baltimore Harbor anchorages and access channels. The study is investigating enlargement of the anchorage capacity to accommodate larger vessels. The report contains information on the baseline biological conditions, potential environmental impacts, and further studies to address fish and wildlife concerns. The information is derived from existing data sources. The suspected contamination of the sediments is a major factor influencing project planning, particularly the need for confined disposal.

Key Words: Baltimore Harbor, navigation, dredging, dredged material disposal

INTRODUCTION

The Baltimore District, U. S. Army Corps of Engineers, is conducting a reconnaissance level study of potential navigation improvements for the Baltimore Harbor anchorages and access channels. The study is investigating enlargement of the anchorage capacity to accommodate larger vessels. This report contains planning aid information on the baseline biological conditions, potential environmental impacts, and further studies to address fish and wildlife concerns. It is submitted in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and Section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.).

BASELINE BIOLOGICAL CONDITIONS

For the purposes of this report Baltimore Harbor is considered to encompass the tidal portion of the Patapsco River out to its mouth. The natural water depths are typically less than 20 feet, but there are numerous dredged areas including the main navigation channel which is maintained at a depth of 50 feet. The tidal range is only approximately one foot (U.S. Department of Commerce 1989). The salinity regime varies with time, depth, and location; typical values would be 5 parts per thousand (ppt) at the surface and 15 ppt at the bottom. The freshwater inflow is small compared to the volume of the tidal river. This facilitates an unusual three-layer density-driven circulation with water entering from Chesapeake Bay at the surface and bottom, and leaving in a mid-depth layer (Maryland Environmental Service 1974).

The major land use in the basin is urban. Extensive industrial and port-related activities exist along the harbor shoreline. Over the years tremendous amounts of a wide variety of pollutants have been released into the harbor. Many of the pollutants have accumulated in the bottom sediments which exhibit significant toxic properties (Tsai et al. 1976). Although the spatial pattern is somewhat variable, in general the contamination is greatest in the inner harbor and becomes progressively less toward the Chesapeake Bay.

The water quality is stressed by the heavy volume of urban runoff and extensive industrial discharges. At depths below 15 feet the concentration of dissolved oxygen frequently fails to meet the 5 milligrams per liter State standard for aquatic life (Maryland Environmental Service 1974).

The harbor's biological resources are substantially diminished. Extensive shoreline alteration over the years eliminated many of the abundant vegetated wetlands that historically existed. Today, the harbor has relatively few wetlands for its size. There are essentially no beds of submerged aquatic vegetation.

The benthic invertebrate fauna is reduced in biomass and species diversity compared to other comparable Chesapeake Bay embayments. Based on his benthic community study Pfitzenmeyer (1971) divided the harbor into three zones: semi-healthy, semi-polluted, and polluted (Figure 1). The semi-healthy zone showed a lack of certain species normally seen in similar

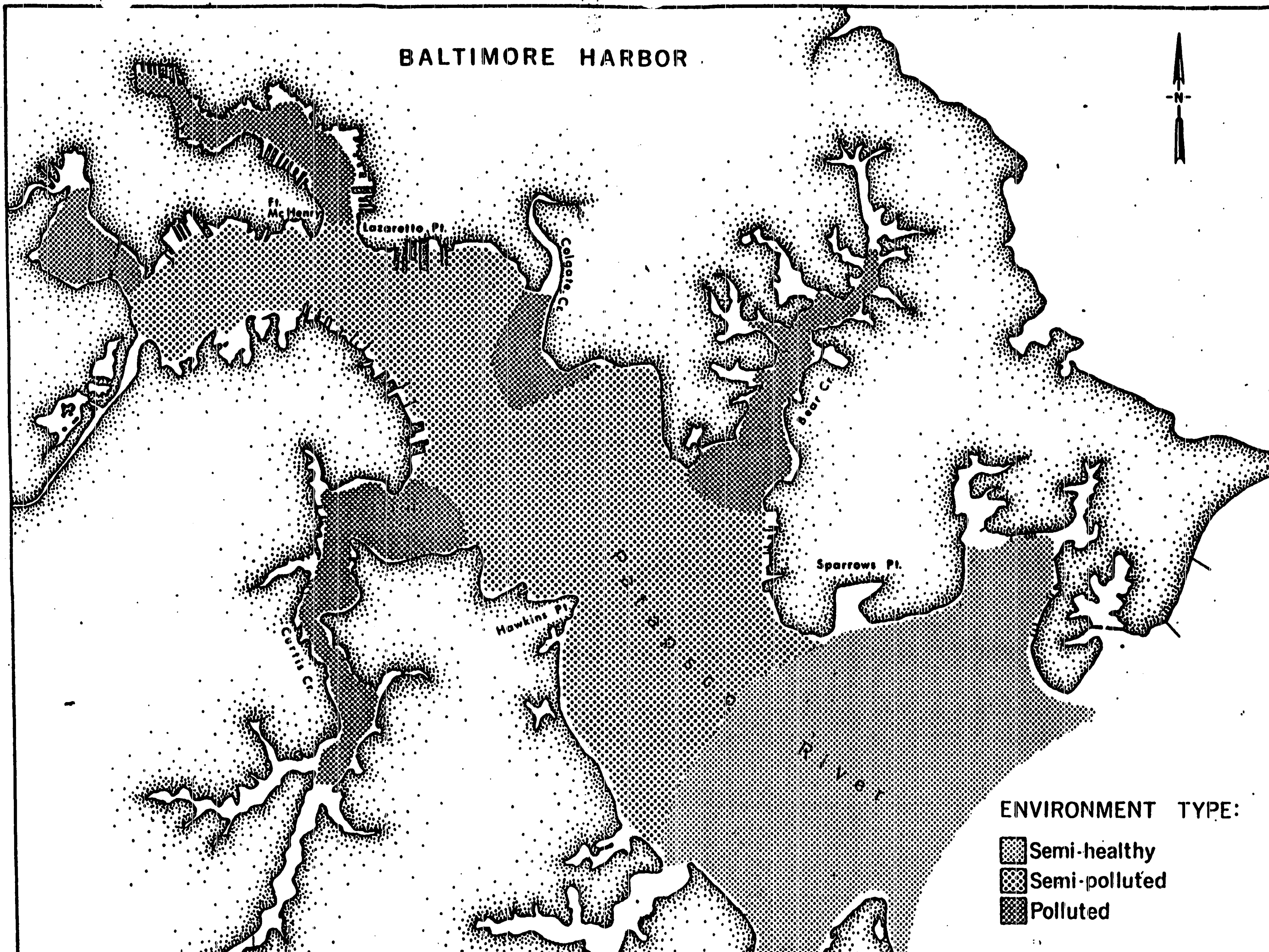

Figure 1. Environmental zones for Baltimore Harbor benthos (Pfitzenmeyer 1971)

unaltered environments and rather low biomass (mean of 2.9 g/m^2). In many respects, however, the community in this zone appeared relatively normal. The semi-polluted zone exhibited a substantial reduction in the number of species, but most of the common taxonomic groups were represented. Tubifex worms, an indicator of pollution, were fairly common. The mean biomass in this zone was 1.6 g/m^2. The polluted zone was characterised by very low biomass (mean of 0.02 g/m^2) and low species diversity. Almost no crustaceans and very few molluscs were found in this zone.

A number of resident and migratory fishes inhabit Baltimore Harbor. Table 1 shows a list of fish species collected in a comprehensive survey by Wiley (1971). White perch was the most abundant species with large numbers of both adults and juveniles present. Overall fish abundance was substantially reduced in the inner region of the harbor and bottom dwelling species were noticeably lacking. There was a relatively high incidence of various diseases, which was considered to be a response to the pollution stress.

Many of the tributaries to Baltimore Harbor are utilized for spawning by anadromous river herring (alewife and/or blueback) and white perch (O'Dell 1975). The Maryland Department of Natural Resources is proceding with a major restoration project to modify four dams on the main stem of the Patapsco to permit passage of anadromous fishes for spawning purposes.

The harbor supports a fair amount of recreational fishing activity especially in the outer region. Frequently sought after species include white perch, channel catfish, striped bass, bluefish, and blue crab. There are no oyster bars within the harbor.

A variety of waterfowl inhabit the harbor during the wintering period. The more common species include: scaup (Aythya marila and A. affinis), canvasback (Aythya valisineria), bufflehead (Bucephala albeola), goldeneye (Bucephala clangula), ruddy duck (Oxyura jamaicensis), mallard (Anas platyrhynchus), black duck (Anas rubripes), and Canada goose (Branta canadensis).

There are two waterbird nesting colonies near the harbor. An established nesting colony of black-crowned night-herons (Nycticorax nycticorax) is located at Sollers Point near the northern end of the Key Bridge. The colony currently has approximately 360 breeding pairs. Approximately 500 pairs of herring gulls (Larus argentatus) have been nesting at a site on Sparrows Point since 1988.

ENDANGERED SPECIES

Peregrine falcons (Falco peregrinus) have been consistently nesting on the United States Fidelity and Guaranty Building in downtown Baltimore and on the Key Bridge. Although it is well known that pigeons comprise a large part of their diet, they also feed on various waterbirds. This could be a potential pathway by which the birds could come in contact with contaminants that are mobilized from the bottom sediments as a result of the dredging and disposal operations. There may also be some limited feeding activity in the harbor by bald eagles (Haliaeetus leucocephalus). An eagle nest site is located in the vicinity of Black Marsh near the mouth of Back River.

FUTURE CONDITIONS WITHOUT THE PROJECT

The Baltimore Harbor water quality has been showing an improving trend due to increased treatment of industrial and domestic pollution sources. There is good potential for further improvement which should enhance the presence of fish and crabs. (Regional Planning Council 1981). Recovery of the benthic community is more difficult because of the persistent contaminants in the bottom sediments. Nevertheless, a slow improvement in the benthos is expected as less contaminated sediments cover the bottom (U.S. Environmental Protection Agency 1977).

BIOLOGICAL IMPACTS OF THE PROJECT

Dredging would remove the existing benthos, but recolonization is expected to occur readily. The dredging will produce a temporary, localized increase in suspended sediments. The physical effects of an increase in suspended sediments could produce stress in various planktonic, nektonic, and benthic organisms, particularly filter-feeding species, but the overall impact should be relatively minor. The dredged material may have significant chemical contamination that could pose an additional biological threat. The significance of the chemical effects on the biota is difficult to predict and will depend on the nature of the contamination and the amount of material that is released. There may be a small decrease in dissolved oxygen that could have some effect on the biota in the immediate vicinity of the dredging area since the existing oxygen levels are often below the desirable standards. However, this effect should not be severe since the dredging areas are in relatively open locations that will facilitate flushing.

The potential impacts associated with the disposal of the dredged material are difficult to address at this time since the disposal site and volume of material are unknown. Because of contamination, material dredged from Baltimore Harbor typically requires the use of a contained disposal site. A law passed by the Maryland General Assembly in 1975 prohibits disposal of material dredged from Baltimore Harbor in the open waters of Chesapeake Bay. Construction of containment sites invariably has substantial impacts on fish and/or wildlife habitat. Even if an existing site such as the Hart-Miller Island facility is utilized, the disposal of the project material will have the effect of hastening the need to develop a replacement site.

If the dredged material is found to contain a substantial portion of uncontaminated material, it may be possible to use the material as part of a habitat development project in Baltimore Harbor. The State of Maryland and the Baltimore District are engaged in developing a long-term management strategy for dredged material disposal for the Port of Baltimore. A variety of disposal options are under consideration including several that would use dredged material to create or protect biological productive habitats. One potential option within Baltimore Harbor is the creation of a tidal marsh adjacent to Sparrows Point.

PRELIMINARY MITIGATION MEASURES AND ENHANCEMENT OPPORTUNITIES

We have no specific mitigation measures or enhancement opportunities to recommend at this stage of project planning.

FURTHER STUDIES TO ADDRESS FISH AND WILDLIFE CONCERNS

The volume of material to be dredged needs to be determined in order to help define the magnitude of the project. The dredged material needs to be characterized as to its grain size and chemical constituents. This information will be important in defining the disposal options. If options other than confined disposal are planned, sediment bioassays should be conducted.

Because of the availability of the Hart-Miller Island disposal site, navigational dredging in Baltimore Harbor has been a relatively routine activity in recent years. If adequate disposal capacity remains available, only a low level of Service effort would be necessary in the feasibility phase of the project. However, the situation could significantly change if new disposal areas must be developed to accommodate the project material.

Table 1. Fish species collected by other trawl at 12 stations in Baltimore Harbor during 7 collection periods from April 1970 through February 1971 (Wiley 1971).

SCIENTIFIC NAME	COMMON NAME
Anguilla rostrata	American eel
Alosa aestivalis	Blueback herring
Alosa pseudoharengus	Alewife
Anchoa mitchilli	Bay anchovy
Carassius auratus	Goldfish
Cyprinus carpio	Carp
Notemigonus crysoleucas	Golden shiner
Notropis hudsonius	Spottail shiner
Ictalurus catus	White catfish
Ictalurus natalis	Yellow bullhead
Opsanus tau	Oyster toadfish
Fundulus diaphanus	Banded killifish
Fundulus heteroclitus	Mummichog
Menidia sp.	Silversides
Morone americana	White perch
Morone saxatilis	Striped bass
Lepomis gibbosus	Pumpkinseed
Perca flavescens	Yellow perch
Pomatomus saltatrix	Bluefish
Leiostomus xanthurus	Spot
Trinectes maculatus	Hogchoker

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Baltimore Harbor Anchorages and Channels Feasibility Study

Planning Aid Report: Baseline Environmental Conditions and Potential Effects Associated with Dredging

August 1994

U.S. FISH & WILDLIFE SERVICE

Baltimore Harbor Anchorages and Channels
Feasibility Study

Planning Aid Report:
Baseline Environmental Conditions and Potential Effects Associated with Dredging

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U.S. Army Corps of Engineers
Baltimore District

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ABSTRACT

This report provides planning aid information to assist the Army Corps of Engineers, Baltimore District, in their feasibility study of navigation improvements for Baltimore Harbor anchorage areas and access channels. The study is investigating the deepening and widening of anchorage areas and terminal access channels. The report contains information on the baseline biological conditions, potential environmental effects of the project, and mitigation measures. The information, which is derived from existing data services, is directed only to the proposed dredging areas. The disturbance caused by dredging will moderately increase the level of contaminant exposure for biota. The effect will not be great because the existing contaminant problem is widespread and the limited fauna is composed mainly of tolerant species. Potential environmental benefits from removal of contaminated sediments will be diminished by subsequent recontamination from adjacent areas and possible worsening of the low summer dissolved oxygen problem.

Key Words: Baltimore Harbor, Patapsco River, navigation, dredging, contaminant

INTRODUCTION

The Army Corps of Engineers, Baltimore District, is conducting the Baltimore Harbor Anchorages and Channels, Baltimore, Maryland Feasibility Study. The primary focus of the study is deepening and widening of Baltimore Harbor anchorage areas and branch channels. This report provides information on the baseline biological conditions in the proposed dredging areas, environmental effects of dredging these areas, and mitigation measures. It is submitted in accordance with provisions of the Fish and Wildlife Coordination Act (49 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) and Section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*).

BASELINE BIOLOGICAL CONDITIONS

Baseline biological conditions for Baltimore Harbor were previously described in our Planning Aid Report dated January 1992 for the Baltimore Harbor Anchorages and Access Channels Reconnaissance Study. The present report updates this information as appropriate and provides additional detail for the proposed dredging sites.

The main project area is located adjacent to the Seagirt and Dundalk Marine Terminals (Figure 1). According to the Corps' 1993 survey, depths in this area typically range between 30 and 40 feet. A second small project area is located adjacent to the South Locust Point Terminal. Depths in this region typically are between 15 and 25 feet. The tide range is approximately one foot (U.S. Department of Commerce 1989). Salinity measurements taken at the mouth of the Middle Branch during the Chesapeake Bay Long-term Benthic Monitoring surveys in 1991 and 1992 showed a range of 5 to 15 ppt.

The water quality in the harbor is stressed by the heavy volume of urban runoff in combination with industrial/commercial discharges. Nutrient levels are relatively high and algae blooms (chlorophyll greater than 50 μ/g) are frequent (Maryland Department of Environment 1994). Waters below the pycnocline frequently become hypoxic (dissolved oxygen less than 2 mg/l) during the summer months (Scott et al. 1991).

Geotechnical investigations conducted by the Baltimore District for this project have shown that the bottom sediments are generally characterized as soft, highly plastic, organic silty clays. The upper layer of sediment, varying from one half to three feet thick, exists primarily in a semi-liquid state.

Baltimore Harbor sediments contain a variety of contaminants at levels that pose a threat to living resources. The Executive Council of the Chesapeake Bay Program has identified Baltimore Harbor as one of three Toxics Regions of Concern in Chesapeake Bay. Trace metals have received the most study and Table 1 summarizes the findings of several surveys that have been conducted in the vicinity of the project anchorages. To indicate the potential level of toxicity, Table 1 also shows the low and median effect ranges (ER-L and ER-M) reported by Long et al. (1994). The ER-L concentration represents the lower 10th percentile of the range of concentrations that have been observed to be associated with biological effects. The ER-M concentration represents the

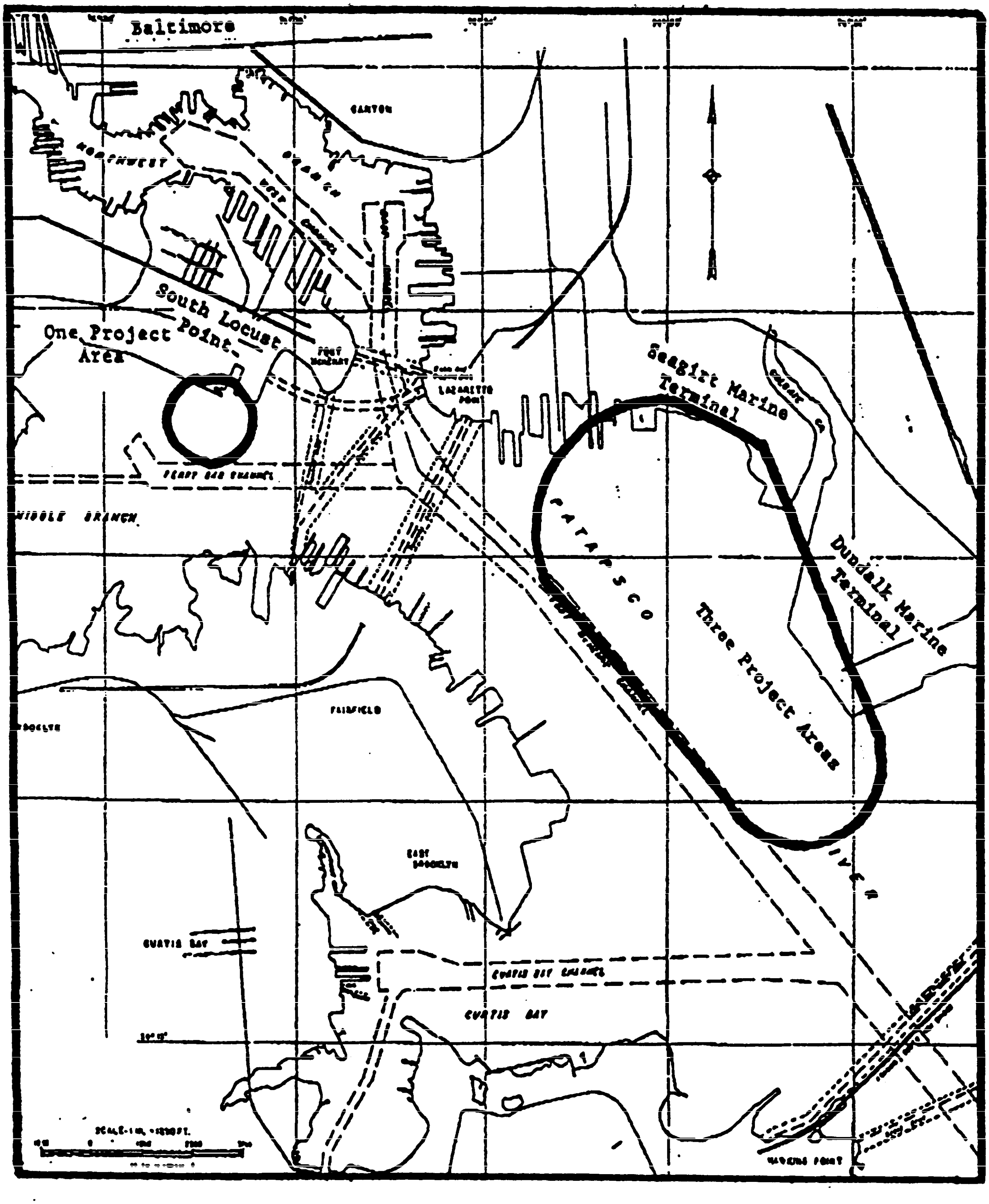

Figure 1: General location of the proposed project dredging areas.

Table 1. Mean concentrations (ppm) of metals in the bottom sediments in the vicinity of the project anchorage areas.[1] The low and median effet range guidelines (ER-L and ER-M) developed by Long et al. (1994) are shown to indicate levels of toxicity.

	Cd	Cr	Cu	Pb	Hg	Ni	Zn
1974[2]	2	473	247	186	0.81	30	556
1977[3]	3	318	227	180	0.74	59	570
1981[4]	NA	345	NA	NA	NA	72	575
1984[5]	4	460	285	60	0.68	NA	800
1986[6]	3	560	270	190	0.80	75	690
1987-91[7]	NA	157	77	82	0.27	38	343
1994[8]	BQL*	83	47	38	0.19	33	166
ER-L	1	81	34	47	0.15	21	150
ER-M	10	370	270	218	0.71	52	410

1. This table is modified from CHM2Hill (1994).
2. Villa and Johnson (1974). Median value calculated from sites in or near project area.
3. U.S. EPA (1977). Median value calculated from sites in or near project area.
4. Sinex et al. (1981). Median value calculated from sites in or near project area.
5. U.S. Army COE (1984). Median value calculated from 5 sites within anchorage areas 3 and 4.
6. NOAA (1991). Mean value for Middle Harbor, grain size adjusted, 1986 sampling.
7. MES (1993). Unpublished data from sites in or near project area.
8. U.S. Army COE (1994). Mean value of composited cores, approximately 11 to 18 feet long from 7 locations within the project area

* Below Quantitation Limit

50th percentile of the range where biological effects were observed. Based on these guidelines, the concentrations of several metals in project area sediments are high enough to expect occasional to frequent incidence of biological effects.

Baltimore Harbor sediments also contain a variety of organic contaminants, but reliable survey data is sparse. A limited data set compiled by (CHM2Hill 1994) revealed that many organic compounds including polycyclic aromatic hydrocarbons (PAHs) and DDT occur at concentrations in the range between the ER-L and ER-M guidelines, indicating that occasional biological effects are expected (Table 2). The sediment concentrations of polychlorinated biphenyls (PCBs) and chlordane lie above the ER-M guidelines, indicating that a frequent incidence of biological effects can be expected. Chlordane has been found in the edible tissues of channel catfish (*Ictalurus punctatus*) and American eel (*Anguilla rostrata*) at concentrations high enough to necessitate the issuance of a public health advisory by the Maryland Department of Environment recommending that consumption of these species taken from Baltimore Harbor be limited.

Bieri et al. (1982) analyzed surface sediments from 40 stations within Baltimore Harbor for the presence of mainly aromatic and polar organic compounds. Approximately 480 compounds were identified and quantified. Total aromatic concentrations ranged from 6.1 to 2,700 ppm. Unsubstituted polycyclic aromatic hydrocarbons comprised about 50% of the total resolved concentration. Based on these results, the harbor sediments were characterized as severely polluted.

The level of sediment contamination varies with the depth below the surface of the bottom. Under the assumption that a zinc concentration below 210 ppm. represents a background or only slightly contaminated level, Sinex et al. (1981) calculated that the contaminated sediment layer may be three meters or more in thickness in the inner harbor near Fort McHenry. This analysis also showed that the thickness of the contaminated layer becomes progressively less toward the mouth of the Patapsco River where it was believed to be less than 0.5 meter. Concentrations of various metals such as zinc, chromium, cobalt, nickel, and iron did not show any systematic change with sediment depth for the first meter at various locations in Baltimore Harbor including the area in the vicinity of the project.

The U.S. Environmental Protection Agency (EPA) (1977) collected twenty 10-foot long cores throughout the harbor. Although there was substantial variability among stations, a major decease in the concentration of most metals and hydrocarbons was generally observed at a sediment depth of approximately 5 feet ±2 feet. Sinex et al. (1981) analyzed two deep cores from near Fort McHenry. The concentrations of zinc and chromium (two metals which show high anthropogenic contamination within the harbor) were reduced by 75% and 66% respectively at depths of approximately 10 feet versus their concentration at 5 feet (Table 3).

The trend for a reduction in metal concentrations below sediment depths of five feet appears to be reflected in the Corps' 1994 data on metals from the project area. This data, which was derived from composited cores approximately 11 to 18 feet long, shows substantially lower concentrations of

Table 2. Sediment Organic Contaminant Concentrations at the Baltimore Harbor Sites[1]

All values in (ppm)	1986-88	Effects Range[4] ER-L	ER-M
2-methylnaphthalene[2]	0.092	0.070	0.670
Anthracene[2]	0.089	0.085	1.100
Benzo(a)anthracene[2]	0.336	0.261	1.600
Benzo(a)pyrene[2]	0.395	0.430	1.600
Chlordane[3]	0.0095	0.0005*	0.006*
Total DDT[2]	0.033	0.0016	0.046
Dieldrin[3]	0.0025	0.00002*	0.008*
Fluoranthrene[2]	0.700	0.600	5.100
Fluorene[2]	0.041	0.019	0.540
Hexachlorobenzene[3]	6.4	NA	NA
Mirex[3]	0.42	NA	NA
Naphthalene[2]	0.347	0.160	2.100
PAH[3]	11.000	4.022	44.792
PCBs[2]	0.68	0.023	0.180
Pyrene[2]	0.700	0.665	2.600

Sources:
1. Modified from CHM2HILL (1994)
2. Maryland Environmental Services, (1993) (average of 1987-88 results for a site near project area)
3. NOAA, (1991) (mean value for Middle Harbor, grain-size adjusted - 1986 sampling)
4. Long et al. (1994)

* Long and Morgan (1991)

Table 3. Concentrations (ppm) of chromium and zinc in two deep cores taken near Fort McHenry.[1]

Core No.	Sample Depth (feet)	Chromium	Zinc
132 (In navigation channel)	4-5.5	900	890
	9-11	330	290
	14-15.5	110	120
	19-21	130	110
	24-25.5	110	92
	29-31	120	93
	34-35	76	68
128 (Outside navigation channel)	3.5-5	1400	820
	8.5-10	250	290
	14-15.5	26	12
	24-25.5	4	6
	34-35.5	4	2

1. Sinex et al. 1981.

most metals than was reported from previous studies from 1974 to 1986 which sampled sediments within a meter of the surface (Table 1). The inclusion of deeper and presumably less contaminated sediments in the Corps' samples is the most likely reason for the lower metal concentrations reported.

There is data indicating that the upper few centimeters of sediment may be less contaminated than the deeper material. Concentrations of most trace metals in the upper two centimeters of sediment from 1991 samples from the harbor between Curtis Bay and Sparrows Point were found to average approximately 50% less than comparable measurements made during a 1973 study (Eskin et al. 1994). This suggests that sedimentation by cleaner material during the period since 1973 has blanketed the bottom. It is unclear whether a similar pattern exists in the inner harbor region because the sediments there are subject to greater mixing in response to physical disturbance (Reinharz 1983).

The toxicity of Baltimore Harbor sediments has been assessed using bioassay procedures. Tsai et al. (1979) exposed mummichogs (*Fundulus heteroclitus*), spot (*Leiostomus xanthurus*), and soft-shell clams (*Mya arenaria*), to a series of concentrations of suspended sediment from ten harbor locations for test periods of 24 and 48 hours. All three species exhibited mortality which increased with the suspended sediment concentration. The test conditions, ie., constant stirring and aeration, are much different than the in-situ conditions in the harbor. Therefore, the results should be viewed as a relative indication of potential toxicity. The degree of measured toxicity at the different stations was significantly correlated with benthic invertebrate diversity. The study characterized the sediments in the project area as moderately to highly toxic (Figure 2).

Pinkney and Rzemien (1993) tested the toxicity of surface sediments from several Baltimore Harbor locations including the outer harbor, Bear Creek, Curtis Bay, and Middle Branch. They measured mortality of amphipods (*Leptocheirus plumulosus*) after 10-day exposure to static test conditions in accordance with applicable guidelines of the American Society for Testing and Materials. Sediments from Bear Creek were frequently toxic with 100% mortality occurring in several tests. Sediments from the other harbor locations did not exhibit toxicity in these tests.

Surveys indicate that the benthic invertebrate community in the project area is poorly developed. Because of the low biomass and diversity Pfitzenmeyer (1975) characterized conditions for benthos in these areas as ranging from semi-polluted to polluted. He found that tubifex worms, an indicator of pollution, were fairly common, but that crustaceans and molluscs were scarce.

Reinharz (1983) studied the benthic community at 15 stations in Baltimore Harbor. He found that diversity declined from the mouth to the head. In the region of the anchorage the benthos consisted mainly of ephemeral, surface-dwelling opportunistic species, while longer-lived, deep-dwelling species were absent. Annelids comprised over 90% of the benthic community. Although the larvae of the common Baltic clam (*Macoma balthica*) settled in large numbers, they did not survive to achieve any significant growth.

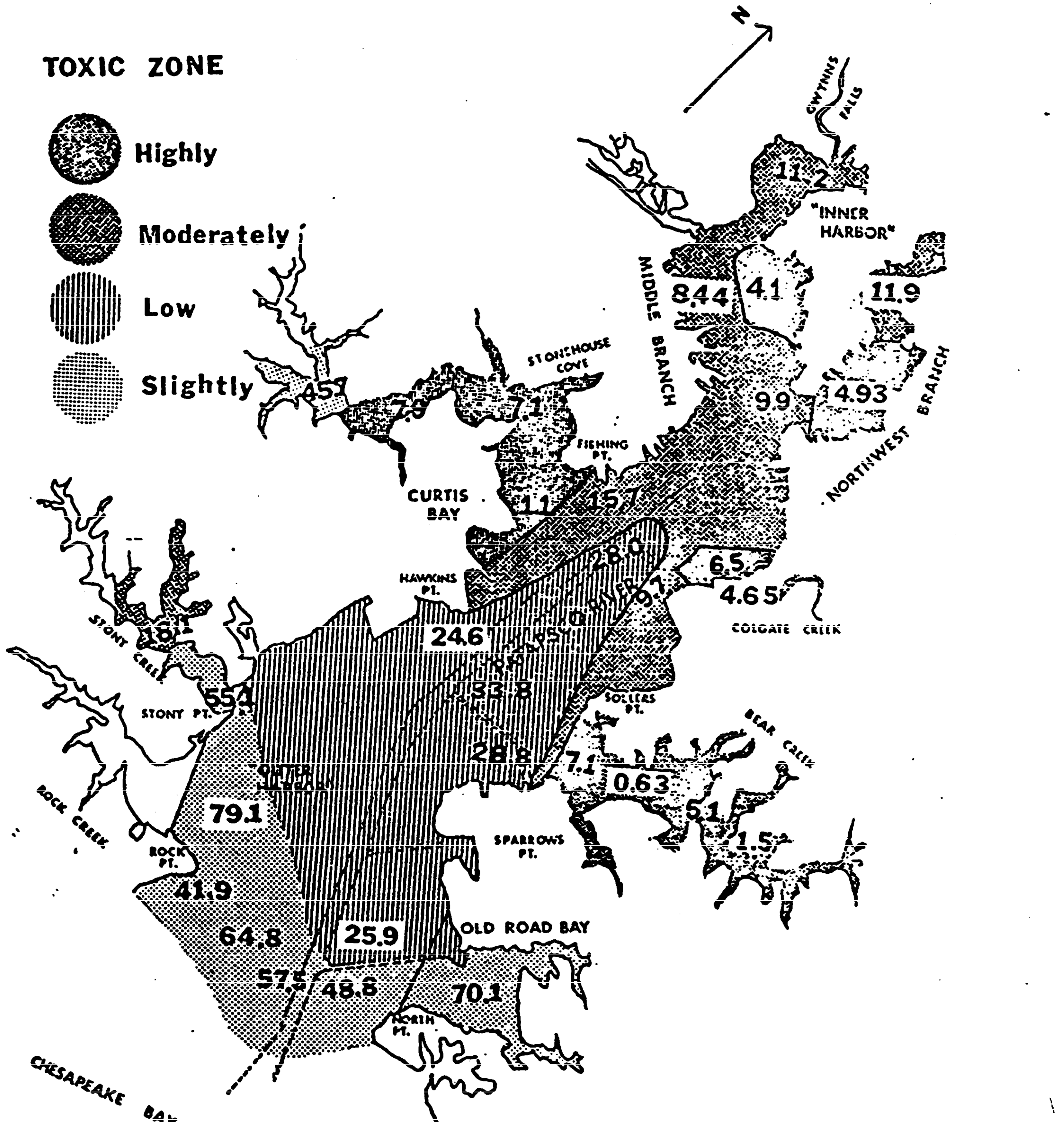

Figure 2: Distribution of Baltimore Harbor toxic zones based on sediment bioassays and diversity of benthic invertebrates (Tsai et al. 1979). The index values are inversely proportional to the level of toxicity.

The Maryland Chesapeake Bay Long-term Benthic Monitoring and Assessment Program has conducted annual surveys in four regions of the harbor: outer harbor, near Sparrows Point, Bear Creek, Curtis Bay, and Middle Branch. Based on sampling conducted between 1989 and 1992, each of these areas was categorized as severely degraded (Ranasinghe et al. 1993).

Several factors contribute to the poor condition of the benthos. Low dissolved oxygen concentrations in the summer appear to be limiting for benthic fauna in the deeper waters below the pycnochine. The depth at which anoxic or hypoxic conditions develop can vary depending on location within the harbor, degree of stratification, temperature, and other factors. Based on dissolved oxygen profiles taken in Baltimore Harbor for the Long-term Benthic Monitoring Program, it appears that at a minimum waters below 8 meters can be expected to experience regular oxygen depletion to levels below 2 mg/1. Scott et al. (1991) determined that during the summers of 1989 and 1990 benthic invertebrate species diversity was significantly less at depths below 5.5 m than at shallower depths for the Middle Branch, Curtis Bay, and Sparrows Point regions of the harbor. Based on limited concurrent measurements and generally known trends, low dissolved oxygen was postulated as the probable reason for the low diversity in the deeper areas.

The sediment contaminant burden may also be restricting the development of the benthos. This is clearly the case in Bear Creek where sediment bioassay tests have clearly shown acute toxicity. The presence of toxic sediments is suspected as the reason why Bear Creek was the only harbor region sampled by Scott et al. (1991) that did not have significantly greater biodiversity in the shallower waters. It is clear that sediments in the project area contain contaminants in concentrations capable of causing adverse biological effects, but the actual extent of toxicity and effect on the benthic community is not really known.

The layer of fluid mud which exists in most of the project area constitutes a poor substrate for many benthic species. In addition, this material is easily disturbed by the harbor's ship traffic and related activities. Based on examination of sediment cores, including radionuclide and pollen dating, Reinharz (1983) concluded that the surface sediments at the head of the Patapsco are subject to frequent mixing resulting from physical disturbance, and that biological colonization would be limited by the relatively unstable sediment condition.

Because of the water quality problems and degraded benthic habitat, the abundance and diversity of finfish in the project area is also expected to be low. Anadromous species, particularly alewife (*Alosa pseudoharengus*) and blueback herring (*A. aestivalis*) migrate through the Patapsco subestuary on route to and from spawning areas in the upper non-tidal section of the river. An anadromous fish passage restoration plan is being implemented on the Patapsco River. As part of this plan, alewife and blueback herring have been stocked into the Patapsco to help reinvigorate the spawning run.

ENDANGERED SPECIES

Peregrine falcons (*Falco peregrinus*) have been consistently nesting on the U.S. Fidelity and Guaranty Building in downtown Baltimore.

FUTURE CONDITIONS WITHOUT THE PROJECT

Since the mid-1970's there has been a significant reduction in industrial contaminant loading to the harbor (Warner et al. 1992). This trend may continue, but at a slower rate. As a result, contaminant concentrations in the project area sediments can be expected to slowly decrease as less contaminated sediments are deposited. This process of improvement is expected to be very gradual. The relatively high degree of mixing of the surface sediments in this region will slow the improvement.

As the Chesapeake Bay nutrient reduction strategy continues implementation, the problem of low summer dissolved oxygen should become less severe. An important part of the reason for development of low dissolved oxygen conditions in the harbor is the entry of anoxic water from Chesapeake Bay (Ranasinghe et al. 1994). Therefore, the intensive effort to reduce the severity of anoxia in Chesapeake Bay would hopefully improve this aspect of the harbor's water quality. The extent of future improvement is difficult to gauge. Monitoring of the Bay's low dissolved oxygen waters from 1984 through 1988 revealed substantial annual variation which was correlated with early summer meteorological events, volume of river flow into the Bay, and the resultant intensity of water column stratification (Barth et al. 1989). This variability makes it difficult to detect any trends.

Evidence indicates that the general condition of the harbor has been improving. Reports of fish kills in the harbor in recent years are lower than they were 10 to 15 years ago (Charles Poukish, Maryland Department of the Environment, pers. com.). In 1992 an area lying just east of the Rock Point/North Point line at the mouth of the Patapsco, was opened to shellfish harvesting after a long period of closure.

The Chesapeake Bay Long-term Benthic Monitoring Program provides information to assess how well Baltimore Harbor has responded to the bay-wide effort to reduce nutrient and toxic loading. An assessment of benthic monitoring data collected between 1984 and 1991 and historic data collected from the 1970's indicates that conditions in the outer harbor (Sparrows Point region) have measurably improved but that conditions in the inner harbor (Middle Branch region) have not (Ranasinghe et at. 1994).

The inner harbor region including the project area is subjected to stresses that will limit its potential for habitat improvement. The tremendous volume of nonpoint source pollution which enters the area from the Baltimore metropolitan region will likely remain a significant problem. The effects of this pollutant input will be compounded by the fact that this area of the harbor has hydrographic characteristics that make it a deposition area for very fine silt and clay size material (Sinex and Helz 1982). This material not only has an affinity for absorbing contaminants, but it also provides a poor substrate for benthic colonization. This sediment includes material so fine that it resists consolidation and may remain in a semi-liquid state. The material not only comes from the Patapsco watershed, but it is apparently also imported from the Chesapeake Bay (Sinex and Helz 1982).

ENVIRONMENTAL EFFECTS OF THE PROJECT

The proposed dredging will remove the existing benthic invertebrate fauna, but this will be a minor short-term impact, especially considering the poor condition of this community. The dredging will cause suspension of bottom sediment into the water column. This will result in a slight decrease in dissolved oxygen, a release of nutrients primarily in the form of ammonia, and an increase in the level of contaminant exposure for biota. The impact of these effects should not be great because of the existing degraded conditions. While the plume of suspended sediment will move with the current for a distance away from the dredging site, it should not affect any sensitive habitats and will abate shortly after dredging is terminated. The bottom disturbance and subsequent sedimentation associated with dredging will contribute to the bottom sediment mixing which apparently characterizes this region and which prevents the older more contaminated sediments from being covered by natural sedimentation of newer, cleaner material.

The potential for a long-term effect on habitat quality due to a change in the bottom sediment characteristics in the dredged area must be considered. Because the deeper sediments are generally less contaminated, dredging could potentially remove the upper more contaminated sediment and leave behind a less contaminated bottom for subsequent benthic colonization. Evaluation of this effect is difficult because of several factors. The project dredge depth has not been decided except that depths up to 45 feet are being considered. According to the Corps' 1993 survey, the bottom depth within the project area varies considerably from less than 15 feet to more than 40 feet. Therefore, the final project depth would result in the selective removal of material to a variable distance below the existing bottom. There is relatively little information relating sediment contaminant concentrations to depth below the bottom for the project area. Based on limited data it appears that contaminant concentrations will decline at sediment depths greater than approximately five feet. Therefore, dredging below this depth could potentially leave the exposed bottom in a less contaminated condition.

From a practical standpoint the dredging is unlikely to completely remove the upper sediments down to the project depth. Dredging in the harbor is typically accomplished with a clamshell dredge. The clamshell will likely not be effective in removing the upper sediments, particularly the fluid mud layer. Hydraulic dredging techniques, especially without a cutterhead, would be capable of removing more of the fluid mud layer. If the dredging were able to cleanly remove the upper more contaminated sediments and fluid mud layer, it remains unclear how much improvement would accrue to the benthic community. The deepening could potentially exacerbate the problem of low dissolved oxygen. Much of the proposed dredged area has depths in the 30 to 35-foot range which are below the typical pycnocline depth. Consequently this portion of the dredged area is already subject to episodes of low dissolved oxygen. Some worsening of the duration, extent, or frequency of low dissolved oxygen may occur in these areas. Some areas particularly at South Locust Point have depths in the range of 15 to 20 feet. Dredging in these areas could substantially worsen the summer dissolved oxygen levels.

Over time, the bottom in the dredged area is likely to become contaminated by sediments moving in from adjacent areas. The fluid mud layer of the surrounding bottom would be especially prone to move into the dredged area due to gravitational forces and instability caused by disturbance from ship traffic, dredging, or natural events. It is noteworthy that even though Anchorage Areas 3 and 4 were dredged in 1985, they don't have any less fluid mud or contaminants than other areas in the vicinity which were not dredged. Potential improvement in the benthic conditions due to dredging of contaminated sediments will also be limited by the hydrographic conditions which promote deposition of very fine grain material, and by the heavy influx of nonpoint pollution from the Baltimore metropolitan area.

MITIGATION MEASURES

Because of the high contaminant burden and presence of a fluid mud layer, it would be preferable to use a hydraulic dredge rather than a clamshell dredge in order to minimize the suspension of sediment into the water column. A hydraulic suction dredge would be more effective in removing the fluid mud layer than a hydraulic cutterhead dredge.

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DEPARTMENT OF THE INTERIOR

U.S. FISH AND WILDLIFE SERVICE

Annapolis Field Office

The Annapolis Field Office (AFO) is the primary operational arm of the U.S. Fish and Wildlife Service for the protection and conservation of living resources in Delaware, Maryland, and Virginia. Working in close cooperation with other Federal, State, and private agencies, AFO has responsibility for protection of threatened and endangered species, and protection and enhancement of sensitive and unique habitat areas such as wetlands and productive water bodies. The Service and AFO also have a major responsiblity for assessing potential impacts to fish and wildlife resources, and ensuring that development is planned and designed to avoid or have minimal effects on the resources.

The cover illustration, depicting a wetlands scene, is adapted from a 16 by 8 foot mural in the conference room of the U.S. Fish and Wildlife building in Annapolis, Maryland. The scene was painted as a volunteer effort by muralist Valerie Solarz.

Preserve Our Natural Resources

Baltimore Harbor Anchorages and Channels

Contamination Conditions Report

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Executive Summary

Introduction

Existing information was collected about chemical contamination and resource trends in Baltimore Harbor. The information focused on the Baltimore Harbor anchorage and channels project area identified by the U.S. Army Corps of Engineers. The project area includes one triangular shaped part that includes the Ferry Bar Channel and extends north toward the shoreline. The second part is rectangular in shape and includes the Fort McHenry Channel and waters to the northeast between the Fort McHenry Angle and the southern boundary of the Dundalk Marine Terminal. Both parts are considered to be a single project. The two parts are included within a 0.5 mile radius study area. The size of the study area was defined by the Corps of Engineers.

The U.S. Army Corps of Engineers, Baltimore District maintains a system of deep-draft navigation channels in the Chesapeake Bay to facilitate movement of vessels entering from the Atlantic Ocean. The Corps of Engineers conducted a Channels Reconnaissance Report in 1992 to summarize available information on existing conditions, current and future navigation problems and alternative actions to address navigation problems in Baltimore Harbor. The findings of the reconnaissance study indicated that existing anchorage dimensions within the Port of Baltimore are not sufficient in depth and width to accomodate the types of vessels currently calling on the Port. It was suggested that additional studies be conducted to address the feasibility of increasing branch channel dimensions at the South Locust Point, Seagirt and Dundalk marine terminals and improving anchorage areas within the harbor.

The Corps of Engineers is conducting a feasibility study of the Baltimore Harbor Anchorages and Channels. The purpose of the study is to provide all the necessary documentation to permit project authorization by the U.S. Congress for the detailed design and construction of a Federal project, if justified. The feasibility report is intended to examine navigation problems in the Baltimore Harbor anchorages and branch channels and the opportunities offered by constructing deeper and wider anchorage areas and widening branch channels. The feasibility report will include an assessment of the environmental effects of possible solutions and the preparation of an Environmental Impact Statement.

The purpose of the Contamination Conditions Report is to:

- identify and describe trends in the occurrence and effects of contamination and
- describe the most likely future chemical and biological conditions in the project area in the absence of the proposed Federal action.

The information presented is based on existing information readily available from Federal and state agency monitoring and sampling reports and from other agencies and parties (e.g., university researchers, consultants).

The State of Maryland is in the process of completing their own studies of environmental conditions in the Baltimore Harbor area. These include a toxics assessment report; an assessment of land use, aquatic living resources, sediment quality, and water quality; and a Harbor Action Plan. Their schedule for completing these studies, however, does not conform to the Corps of Engineers' schedule requirements. As a result, the State's data was not entirely available for use in this Contamination Conditions Report.

Environmental Conditions

Data collected on sediment quality in the area included studies conducted by the U.S. Environmental Protection Agency (EPA) from the early 1970's through unpublished sediment quality data collected between 1986-1992 by the Maryland Department of the Environment (MDE). The area that includes the anchorage and channels project was classified as "Moderately Toxic Zones" and "Low Toxic Zones" by the EPA in the 1970's based on moderately high PCB and hexane concentrations and low heavy metal concentrations, respectively. A comparison of sediment metals data with National Oceanic and Atmospheric Administration (NOAA) sediment quality criteria, determined that Cr, Cu, Pb, Hg, Ni, and Zn exceeded NOAA's Effects Range - Low (ER-L) levels (i.e., concentrations expected to affect 10% of an exposed population). The Effects Range - Medium (ER-M) level (i.e., concentration expected to affect 50% of an exposed population) was exceeded for Cr, Pb, Ni, and Zn. Although the metals concentrations appeared to decrease between 1974 and 1991, the most current sediment quality data (from samples collected between 1987 and 1991) still exceed the ER-L for Cr, Cu, Pb, Hg, Ni, and Zn, while the ER-M was exceeded by only Cr and Zn.

The MDE data also included an analysis of organic contaminants. Those for which standards were available generally exceeded the ER-L, but not the ER-M. The only organic contaminant to exceed the ER-M was PCBs. The organics exceeding the ER-L included: 2-methylnaphthalene, anthracene, benzo(a)anthracene, chlordane, DDT, dieldrin, fluoranthene, fluorene, naphthalene, petroleum aromatic hydrocarbons, PCBs, and pyrene.

Toxicity tests conducted on Baltimore Harbor sediments with the amphipod, *Leptocheirus plumulosus,* indicated that sediments in Baltimore Harbor near Bear Creek were frequently toxic. Sediments from other locations in Baltimore Harbor were not as toxic. Maryland expects to release their toxic assessment report in the summer of 1994 and should provide more information on the toxicity of bottom sediments in Baltimore Harbor.

Comparisons of the spatial distribution of contaminants indicates that Baltimore Harbor sediments had higher concentrations than similar sized sediments in Chesapeake Bay. Areas with the greatest proportion of silt and clay material appear to have higher concentrations of contaminants than areas with coarser grained sediments. Analyses of deep burrowing benthic invertebrates appear to suggest that the deeper sediments are more contaminated than the upper sediment layers. Particulate deposition in the Harbor is about 1-2 mm/year. Because contaminant loadings to the Harbor from point source discharges have been significantly reduced over the years, the upper layer of sediment is probably less contaminated than the deeper sediments. Field techniques to collect and separate these thin layers have not been refined and the chemical transformation of contaminants from deeper layers through the surface layers is not completely understood.

Contaminants come from many sources including permitted point source discharges from industrial and municipal dischargers, stormwater and aerial deposition. Contaminant loadings to the Harbor also originate much farther upstream in the watersheds from tributaries that drain into the Harbor.

Circulation patterns are not clearly understood. They are affected by wind conditions and by density factors related to denser, tidal waters moving into the Harbor and converging with less dense freshwater inputs.

Water quality in the Harbor is generally poor. Most of the available water quality data dealt with nutrients. Loadings of phophorus and nitrogen come from point source wastewater discharges, stormwater, and aerial deposition. Nutrient loadings become a problem when biological activity is accelerated when environmental conditions, such as light, temperature and nutrient input, are favorable to growth. The result is an increase in oxygen consumption or oxygen depletion in the water column. Bottom waters in the Chesapeake Bay and Baltimore Harbor are affected by oxygen depletion on a regular basis between March and October resulting in benthic communities comprised of mainly pollution-tolerant species.

The area of the harbor that includes the Baltimore Harbor anchorage and channels area was characterized by researchers in the early 1970's as being semi-polluted based on the composition of the benthic invertebrate community. Current research indicates that environmental conditions are improving due to the decline in point source contaminant loadings. Macrobenthic abundance has increased eight-fold between the 1970's and the late 1980's. The amphipod, *Leptocheirus plumulosus*, and the bivalve, *Macoma mitchelli*, have accounted for much of the increase in benthic abundance. The frequency and occurrence of summer low dissolved oxygen conditions was noted to be as bad in the late 1980's as it was in the early 1970's. These episodes create stress on the benthic community and results in dominance by less desirable species.

Even though water quality and sediment quality conditions adversely affect the Harbor, the area does support fish and shellfish. The standing stock of these species is low and would probably improve if the extent of low dissolved oxygen events decreased. The Harbor had the lowest annual mean zooplankton densities compared with other locations in Chesapeake Bay based on samples collected between 1985 and 1992. Historically, hogchoker, river herring, anchovy, silversides, and white perch comprise common resident species of finfish. The blue claw crab is a common shellfish.

Anadromous species, such as the alewife and blueback herring spawn in the lower Patapsco River and use juveniles have been collected in the harbor. White perch, channel catfish, bay anchovy, silversides, and naked goby are resident fish species that have been collected in the harbor area.

The Maryland Department of the Environment has collected specimens of finfish and shellfish from areas near the anchorage and channels project area to evaluate contaminants in tissue. The results of these studies indicate that levels of chlordane in the tissue of spot and channel catfish have exceeded the Food and Drug Administration action level of 0.3 ppm. In general, the studies contaminant studies conducted by the state have indicated that urban estuaries have higher contaminant levels for chlordane, PCBs and metals than do estuaries in more rural areas. The state did issue an advisory to fishermen using the Baltimore Harbor area due to the level of chlordane reported.

Conditions Without the Project

The information collected and reviewed for this report lacked detailed assessments of long-term trends in Baltimore Harbor. Considering todays heightened awareness towards the environment by government, industry and the public, environmental conditions in Baltimore Harbor are likely to improve, barring any catastophic release of contaminants (such as a major oil spill), in the future. Dredging the anchorage and channels project area would remove some of the underlying contaminated sediments. If the area was not dredged, these underlying contaminated sediments may continue to be a source of contamination through resuspension by propellor wash or by vessel movements. Biological activity (e.g., burrowing) also can mobilize contaminants in deeper sediment layers. In contrast, the settling of "cleaner" sediments may create a barrier and minimize the mobility of the deeper more contaminated sediments. The available data that was reviewed for this report did not have sufficient detail to predict the effects of dredging these areas vs. not dredging. The frequency and extent of low dissolved oxygen events is more related to contaminant loadings and should not be affected with or without the Corps' proposed dredging project. Likewise, the use of the Harbor by finfish and shellfish should not be directly affected if this project is not implemented. The feasibility report and environmental documentation to be prepared by the Corps of Engineers may provide more detail on these issues.

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BALTIMORE HARBOR ANCHORAGES AND CHANNELS CONTAMINATION CONDITIONS REPORT

Introduction

This report is submitted to the U.S. Army Corps of Engineers, Baltimore District to provide information about chemical contamination and resource trends in the vicinity of the Baltimore Harbor Anchorages and Channels Feasibility project area (Figure 1). This report identifies and summarizes the results of contaminant-related sediment, water quality and biological monitoring and sampling in the study area, and describes trends and most likely future conditions without the proposed project.

The Corps is currently conducting a feasibility study of the Baltimore Harbor Anchorages and Channels. It includes increasing the existing branch channel dimensions at the South Locust Point, Seagirt, and Dundalk marine terminals and improving anchorage areas within the harbor. The purpose of the feasibility study is to provide all the necessary documentation to permit project authorization by the U.S. Congress for detailed design and construction of a Federal project, if justified. The Corps' feasibility study, which will include an Environmental Impact Statement, will incorporate the findings of this report.

The intent of this report is to summarize existing conditions information from executive summaries or conclusions that have been generated from previous studies and assessments conducted in the project area. Existing conditions include sediment, water quality and biological trends as they may relate to contaminated sediments or contaminated conditions in general. An attempt was made to collect existing data that would have some relevance in support of the Corps of Engineers' need to prepare a sediment testing program. The sediment test data is required for determining the impacts related to dredging. In addition, the sediment test data will be used for determining the ultimate disposal sites for the material to be dredged from the anchorage and channels area in the Corps' environmental document to be prepared in compliance with National Environmental Policy Act (NEPA) and U.S. Army NEPA implementation guidance.

The Baltimore Harbor anchorage and channels project area is shown on Figure 1. The study area was defined by the Corps of Engineers as a 0.5 mile radius around the anchorage and channels project area. The initial effort to collect data focused on the study area. Sediment quality, water quality and biological resource data were not as extensive as anticipated and, therefore, pertinent data from nearby areas was included in this summary of findings as applicable.

Although the Chesapeake Bay Program has sampling stations in the Patapsco River and the Chesapeake Bay proper, most are too far from the anchorage and channel study area to be considered relevant for evaluating site-specific sediment contamination. A reasonable assessment of conditions representing conditions found in the study area includes the area upstream from the Francis Scott Key Bridge. To the extent possible, this report focuses on this study area.

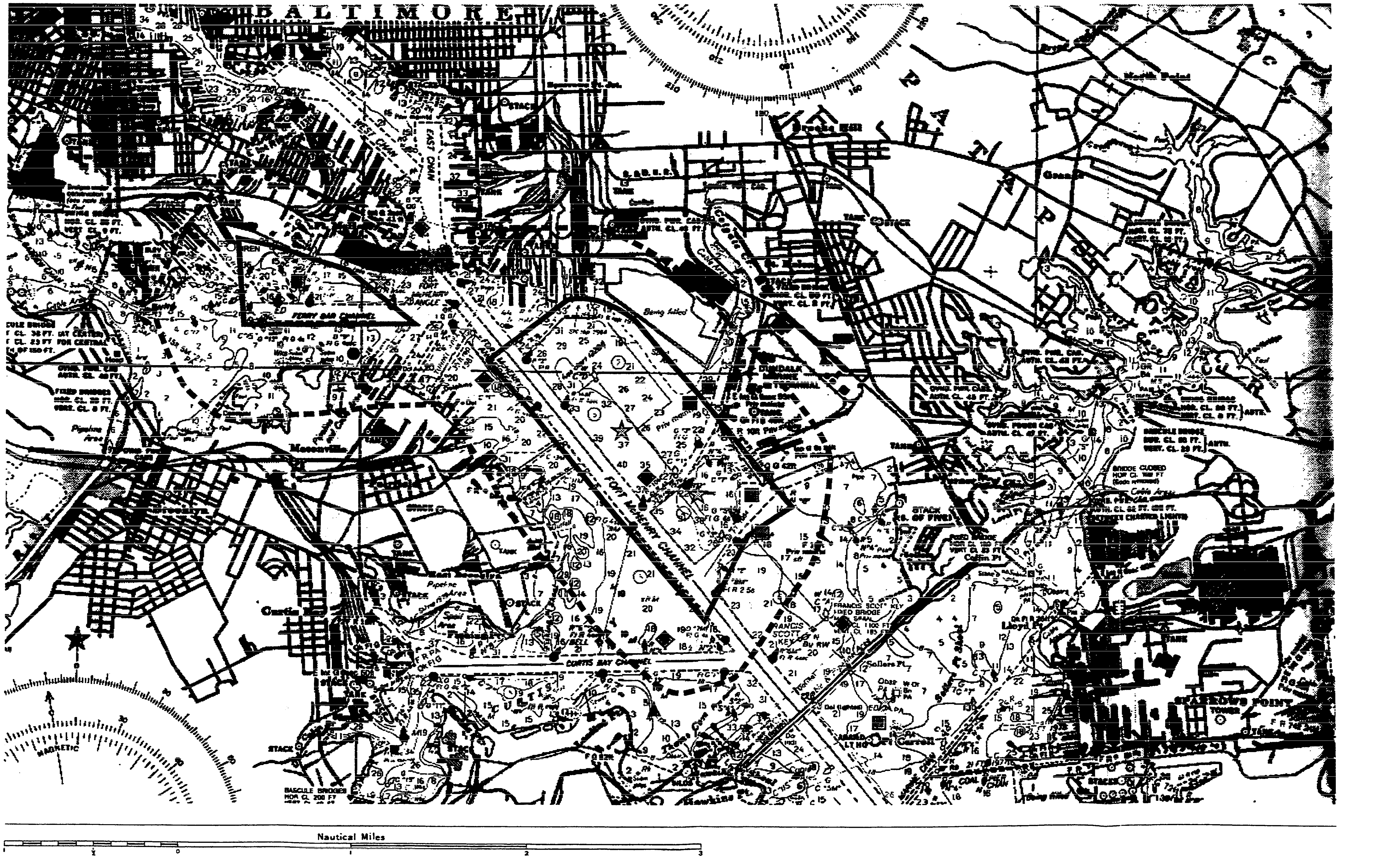
The Corps has attempted to coordinate their feasibility study with the State of Maryland and requested available information concerning chemical and biotic data in the project area from the state. The Maryland Department of the Environment (MDE) has undertaken their own investigations of conditions within Baltimore Harbor. By the summer of 1994, MDE is scheduled to complete an assessment of land use, aquatic living resources, sediment quality, and water quality. They are in the final stages of a sediment toxicity assessment report. MDE also will complete a Harbor Action Plan to address toxic pollution in Baltimore Harbor. Much of the data from the studies being conducted for MDE was not readily available for use in this Contamination Conditions Report. Given the general lack of summary data, the Contamination Conditions Report presents trend information from the data sources available. A bibliography of reports reviewed is included.

Sediment Quality

Results of sediment quality studies indicated that generally those areas containing high concentrations of heavy metals, PCBs, and hexane extract are also those areas determined as highly toxic from bioassay results (unpublished data from MDE). Metals concentrations, except Mn, decrease gradually toward the mouth of the harbor and the entrance to the Bay. The horizontal distribution of heavy metals from 1977 showed a remarkable correlation to 1974 data, in light of dredging, storms, and ship traffic over the three years (USEPA, 1977). This lack of dispersion may be affected by the following factors: the stability of the metal within the sediment; contaminant loadings are sufficient to replace any metal concentrations removed or transferred; circulation and dredging patterns; or distribution of point and nonpoint source discharges.

Based on the results of former studies of the community structure and diversity of benthic-macroinvertebrates and on the results of bioassay tests, an EPA study (1977) concluded that toxicity may be correlated to a significant degree with the high levels of pollutants contained in the sediments of Baltimore Harbor. The study classified the project site(s) as "Moderately Toxic Zones" (moderately high PCB and hexane extract concentrations) and as "Low Toxic Zones" (generally low heavy metal concentrations). Figure 2 shows the distribtion of toxic zones in and around Baltimore Harbor as described in EPA (1977).

Table 1 indicates the median metals concentrations for sediments in the immediate vicinity of the project sites. The approximate locations of these sediment stations are shown on Figure 1. Two ranges of concentrations are provided as toxicity criterion for the metals. The first are the sediment quality criteria developed by NOAA (1991): effects range-low



Anchorage and Channel Project Area

Study Area (including 0.5 mile radius around Anchorage and Channel Area)

MES Sediment Stations

NOAA Status and Trends Station

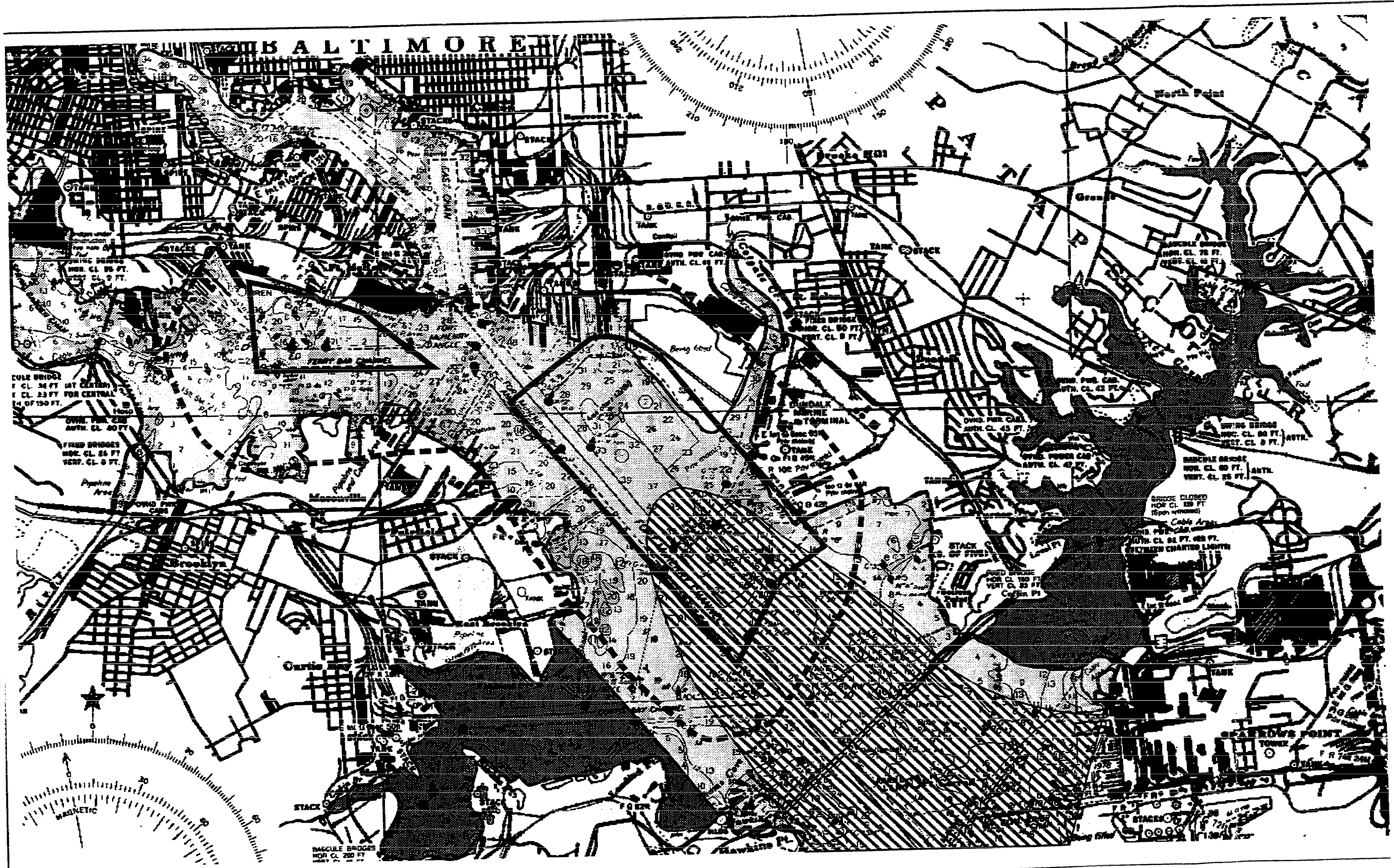
Versar, 1989

Villa and Johnson, 1974

USEPA, 1977

Figure 1
LOCATION MAP
BALTIMORE HARBOR ANCHORAGE AND CHANNELS STUDY AREA
AND APPROXIMATE SEDIMENT SAMPLE LOCATIONS

CH2M HILL



Nautical Miles

1 ½ 0 1 2 3

Anchorage and Channel Project Area

Study Area (including 0.5 mile radius around Anchorage and Channel Area)

Toxic Zones

High

Moderate

Low

Figure 2
LOCATION MAP
BALTIMORE HARBOR ANCHORAGE AND CHANNELS STUDY AREA
TOXIC ZONES DELINEATED IN EPA (1977)

CH2M HILL

(ER-L), a concentration at the low end of the range in which effects have been observed, and the effects range-midway (ER-M), a concentration approximately midway in the range of reported values associated with biological effects. The second set of criteria are actual bioassay results using Baltimore Harbor water and expressed as the least toxic concentration and the most toxic concentration.

Sediment toxicity tests were conducted at various locations in Baltimore Harbor during 1992 (Pinkney and Rzemien, 1993). The tests are intended to provide researchers with preliminary information on the spatial extent and variability in sediment toxicity. The top two centimeters of sediment grab samples collected as part of the Maryland Long-Term Benthic Monitoring Program were used for the toxicity tests. The amphipod, *Leptocheirus plumulosus*, was placed in jars containing sediment and water and tested in accordance with ASTM standards. Survival was measured during 10 days of exposure. The data indicated that sediments near the Bear Creek area of Baltimore Harbor were frequently toxic, with 100% mortality occuring on several occasions. Sediments from other Harbor areas were not as toxic. The results suggest considerable spatial variability in toxicity in the Bear Creek area. Pinkney and Rzemien (1993) reported no sediment toxicity in other Harbor strata, while McGee et al (1993) have reported sediment toxicity in Curtis Bay.

Table 1
Baltimore Harbor Project Sediment Contamination and Criteria

(ppm)	Cd	Cr	Cu	Pb	Mn	Hg	Ni	Zn
1974[1]	2	473	247	186	435	0.81	30	556
1977[2]	3	318	227	180	856.5	0.735	59	569.5
1981[3]	NA	345	NA	NA	1150	NA	72	575
1986[4]	3.4	560	270	190	NA	0.8	75	690
1987-91[5]	NA	157	77	82.5	1161	0.268	38.24	342.7
NOAA Criteria[6]								
ER-L	5	80	70	35	NA	0.15	30	120
ER-M	9	145	390	110		1.30	50	270
Bioassay[6]								
least toxic	2.0	335	158	213	NA	0.4	70	738
most toxic	22.8	1646	1071	512		1.6	97	1804

Sources:
1. Villa and Johnson, 1974 (median value calculated from sites in or near project area)
2. USEPA, 1977 (median value calculated from sites in or near project area)
3. Sinex et al., 1981 (median value calculated from sites in or near project area)
4. NOAA, 1991 (mean value for Middle Harbor, grain-size adjusted, 1986 sampling)
5. MDE, 1993 (unpublished data from sites in or near project area)
6. Long and Morgan (NOAA), 1991

A long-term study by the Maryland Department of the Environment on sediment quality in the Patapsco River provided limited organics contamination data for the project area (unpublished data from MDE). The average values for a single sampling location over the 1987-88 period is provided in Table 2. It should be noted that the concentrations reported for 1988 were sometimes 2-3 times that of the 1987 concentrations. No reason for this phenomenon was provided in the literature. NOAA effects range values are also included as comparative criteria values.

Table 2
Sediment Organic Contaminant Concentrations at the Baltimore Harbor Sites

All values in (ppm)	1986-88	Effects Range[3] ER-L	ER-M
2-methylnaphthalene[1]	0.092	0.065	0.670
Anthracene[1]	0.089	0.085	0.960
Benzo(a)anthracene[1]	0.336	0.230	1.600
Benzo(a)pyrene[1]	0.395	0.400	2.500
Chlordane[2]	0.0095	0.0005	NA
DDT[1]	0.033	0.003	0.350
Dieldrin[2]	0.0025	0.00002	0.008
Fluoranthrene[1]	0.700	0.600	3.600
Fluorene[1]	0.041	0.035	0.640
Hexachlorobenzene[2]	6.4	NA	NA
Mirex[2]	0.42	NA	NA
Naphthalene[1]	0.347	0.340	2.100
PAH[2]	11.000	4.000	35.000
PCBs[1]	0.68	0.050	0.400
Pyrene[1]	0.700	0.350	2.200

Sources:
1. Maryland Environmental Services, 1993 (average of 1987-88 results for a site near project area)
2. NOAA, 1991 (mean value for Middle Harbor, grain-size adjusted- 1986 sampling)
3. Long and Morgan (NOAA), 1991

Distribution of Contaminants

Results from an EPA study (Villa and Johnson, 1974) indicated that concentrations of all metals (in sediments) analyzed from Baltimore Harbor were about 3-50 times greater in value than their counterparts from the Chesapeake Bay. The difference was not attributed to different sediment compositions because Baltimore Harbor and the Chesapeake Bay have generally similar sand, silt and clay ranges, with both averaging about 84% silt and clay. Within the Harbor, the Middle Branch sediments showed considerably lower metals levels than other harbor areas. However, a few isolated high lead and zinc levels were found.

Examining sediment depth profiles, an EPA study (Sinex et al., 1981) found that most sediment contaminants in Baltimore Harbor show no systematic change in concentration with depth. They speculated that the observed homogeneity could be caused by mixing from propeller wash, especially since the Harbor had not been dredged recently. Two deep cores near Fort McHenry showed elevated metals (specifically, Cr, Mn, Fe, V, and Zn) in the upper 10-13 feet (3-4 meters). The study further speculated that this area may be one of high deposition (Sinex et al., 1981).

A more recent study (Holland et al., 1989) found that some deep burrowing macrobenthic organisms experience higher than normal mortalities in the Baltimore Harbor. They suggested that the reason for this phenomenon could be that older, deeper Harbor sediments are toxic and that the recently deposited surface sediments are not. The study noted that overall, no appreciable reduction in the sediment metal concentrations were observed betweem the 1970's and the 1984-1987 timeframe from data collected by Holland et al (1989). Because sediment accumulation rates are on the order of several millimeters per year, except in deep dredged channels, only careful sampling and testing of the surficial sediments (i.e., upper 1-2 mm) would indicate the apparent reduction in contaminant concentrations.

Sources of Contaminants

Recent studies have shown an improvement in benthic communities (Holland et al., 1989). The apparent factor contributing to improvements in environmental conditions in Baltimore Harbor is the large decline in point source contamination loadings from major industrial discharges. Information from NPDES permits indicate that there have been significant decreases in permitted pollutant loadings to Baltimore Harbor from 43 major industrial point source discharges. The data did not include non-point source, municipal, or the 121 "minor" industrial point source loadings.

Circulation Patterns

Complex circulation patterns in the Baltimore Harbor result in site-specific zones dominated by local conditions. In general, a salinity gradient is created by denser, tidal waters moving into the Harbor from the lower Bay covered by less dense freshwater inputs from tributaries. This results in an unusual three-layer, density-driven circulation with water entering from the Chesapeake Bay at the surface and the bottom, and exiting within a mid-depth layer (USACOE, 1992).

Water Quality

Water quality in the Harbor is generally poor. As part of a study conducted to assess the potential impacts from marinas and boats in Baltimore Harbor, Smith et al (1991) evaluated nutrient loading (i.e., total nitrogen and total phosphorus). Their study suggested that the four sub-basins draining into Baltimore Harbor are all under eutrophication stress. Under certain favorable conditions (i.e., sufficient light, temperature, nutrient inputs), biological activity increases resulting in a net loss of oxygen in the water column. Depressed levels of dissolved oxygen develop, especially in bottom waters, resulting in fish kills or benthic community composition dominated by fauna adapted to living in a stressed environment.

Dissolved oxygen levels below 15 feet (4.6 meters) are usually below the Maryland standard for aquatic life (4 mg/l). Measurements of bottom dissolved oxygen levels in 1987 indicated that water quality was as bad or worse than it was in the 1970s and early 1980s (Holland et al., 1989). Stormwater and point source discharges contribute toxic contaminants to the Harbor. Heavy metals, pesticides and organic debris enter the system as sediments and water discharging from storm drains. While pollutant loadings have decreased over the last 20 years, the Harbor is still subject to industrial discharges, urban runoff, regular influxes of sediment-bound nutrients, and periodic small oil releases. The table below presents a comparison of concentrations of selected heavy metals from water quality sampling stations within the project area in 1976 and 1992. More detailed water quality data is expected from the MDE studies, which are scheduled for completion in the summer of 1994.

METALS (μg/l)	Cd	Cr	Cu	Pb	Mn	Hg	Ni	Zn	As
Seagirt-Dundalk Area (filtered) 1976	10	<5	17	50	455	0.2	43.75	37	8
Anchorage and Channels study area (unfiltered) 1992	<5	<10	<10	<10	NA	<0.2	<10	<20	<5.5

Source: USEPA, 1977 (average of four locations within and in proximity to the project area)
MDE, 1994 (unpublished data for the average of five locations in the Baltimore Harbor area)

Biological Conditions

In the 1970's the biological resources of Baltimore Harbor had become reduced because of extensive industrial development and port-related activities that released a wide variety of pollutants into the Harbor over the years. These activities had severely impacted the biota of the harbor. At that time, the benthic macroinvertebrate community in Baltimore Harbor was reduced in biomass and species diversity compared to historical conditions. The following section on benthic invertebrates summarizes the findings of Holland et al (1989) regarding the long-term status of the benthic community in Baltimore Harbor.

Benthic Invertebrates

Pfitzenmeyer (1975) examined the macroinvertebrate community in Baltimore Harbor, and classified it into three zones: semi-healthy, which stretches from the mouth to Fort Carroll; semi-polluted, which includes the central part of the Harbor from Fort Carroll to Fort McHenry; and polluted, which includes the inner harbor and tributaries. The anchorage and channels project area lies within zones classified by Pfitzenmeyer as being semi-polluted. The semi-polluted zone exhibits low species diversity and a significant reduction in the number of species and biomass compared with healthy conditions. Species indicators of pollution, such as Tubifex worms, were relatively common in the semi-polluted zone (Pfitzenmeyer, 1975).

Holland et al (1989) states that environmental conditions in Baltimore Harbor are improving because of the large decline in point source contaminant loadings from industrial sources. Macrobenthic abundance in the entire harbor area has increased approximately eight-fold since the 1970's, from 3,000 to 25,000 individuals per m^2. While abundances in the inner harbor have remained steady at about 4,000 individuals per m^2. The organism contributing most to the observed increases is a small crustacean, *Leptocheirus plumulosus*. This amphipod was essentially absent from the harbor during the early 1970's. Another species absent from the harbor area in the 1970's, but abundant today, is the bivalve *Macoma mitchelli* (Holland et al., 1989). Many factors contributed to the reduced pollutant loadings to Baltimore Harbor including improved enforcement of pollution control regulations, conversion of the Inner Harbor from an industrial complex into a tourism center, and a general reduction in industrial activity within the Harbor.

The frequency and extent of summer low dissolved oxygen concentrations were as bad in 1984-1987 as in the early 1970's (Holland et al, 1989). Levels of DO below 4 mg/l were detected in bottom waters of Baltimore Harbor between May and October 1992 at stations sampled as part of the Chesapeake Bay Water Quality Monitoring Program (Ranasinghe et al., 1993). The low DO condition of Baltimore Harbor has resulted in a depauperate benthic community. However, although many species abundances were lower in the Harbor than in other comparable habitats, others exhibited contrary patterns. For example, *Leptocheirus plumulosus* abundances in the Harbor were high between 1985 and 1988, although they decreased somewhat thereafter. *Heteromastus filiformis*, a burrowing deep deposit feeder, was more abundant in the Harbor than in the low mesohaline Choptank, deep Potomac, and Patuxent Rivers. The presence of this organism suggests that sediment conditions were less toxic after 1985. On the other hand, the low sustained abundances of the deeper burrowing *Macoma balthica* suggest that Baltimore Harbor sediment conditions are not adequate to support organisms less tolerant of toxic sediments. Primary, opportunistic species, such as *Streblospio benedicti* maintain large standing stock abundances.

S. benedicti is typically the first species that recolonizes areas after hypoxic or other stress events (Scott, et al 1991). The sustained high abundances of this species are an indication that, although conditions in the Harbor have improved, they are, at best, marginal.

Water quality characteristics, namely salinity and dissolved oxygen concentration, are primary factors affecting benthic abundances and biomass. Some areas in the Harbor have improved over time. Some hypoxic events are localized and not contiguously connected to hypoxic waters of the deep central mainstream of the Chesapeake Bay. If containment and nutrient loadings into Baltimore Harbor are further reduced, the extent of localized pockets of hypoxic waters should decrease. Clean-up efforts in the Harbor have led to increases in some pollution-sensitive organisms (i.e. *Leptocheirus plumulosus*) and deposit feeders (i.e. *Heteromastus filiformis*). Further efforts would be required to enable the survival of longer-lived, deep burrowing, high biomass organisms, such as *Macoma balthica* (Ranasinghe et al, 1992).

Planktonic Organisms

The planktonic community in several harbors and river systems in the Chesapeake Bay estuary were sampled in 1971 by Dovel, and from 1985 to 1992 by Versar, Inc. An estuarine system, with salinities usually below 10 o/oo, like Baltimore Harbor, would normally function as nursery for marine fishes. The Dovel (1975) plankton study was conducted to investigate how a polluted system, such as Baltimore Harbor functions in this capacity.

In regard to distribution of fish species within the Baltimore Harbor, Dovel (1975) states that the dominant species of fish larvae found there was river herring, bay anchovy, naked goby, silversides, and white perch. Hogchoker larvae and eggs were absent from the list of species collected in Baltimore Harbor. This species is common in most tributaries of the Chesapeake Bay. No other flat fishes, such as winter flounder, were found during the Dovel study either. The absence of larvae or eggs from these species may have been attributed to the condition of the sludge-laden bottom of the Harbor (Dovel, 1975).

The Versar (1994) plankton study measured annual mean zooplankton densities in several water bodies of the Chesapeake Bay, including the Baltimore Harbor. The Harbor had the lowest mean abundance of all systems sampled in 1985, 1986, 1989, and 1992. Large abundance and biomass peaks did occur in the winter/spring of 1987 and 1988. During the 8 year study, the mean density of zooplankton was lowest in 1986 (4,926 sp/m^2). The highest mean density was recorded in 1990 (17,265 sp/m^2). However, zooplankton mean densities fell off again in 1992 (7,031 sp/m^2). The reason for the rise and fall of annual mean densities of zooplankton in the Baltimore Harbor may be attributed to pollution stresses or natural causes.

Fisheries Resources

Garland (1952) stated that fishing at the entrance of the Harbor was good, but within the Harbor, fishing and crabbing had diminished during the last quarter of a century and had, by that time, come to a stop. He concluded that the lack of successful fishing resulted from waste discharges in the Harbor. Several anadromous and local fish species have been found in the Harbor, although species abundance was greatly reduced by the 1970's. Few bottom dwelling species inhabited the Harbor and there was a high occurrence of disease attributed by Wiley (1971) to pollution stress. At that time, anadromous fish using the Harbor for spawning habitat included alewife, blueback herring, and white perch. Recreational fishing occurs primarily in the outer areas of the Harbor. Sport fish that occurred in the Patapsco River included white perch, channel catfish, striped bass, bluefish, and bluecrab.

The Dovel (1975) study indicates that several species of fish eggs and/or larvae were collected (including river herring, bay anchovy, naked goby, Atlantic silversides, and white perch) in the Harbor. In addition, adult specimens of these species and alewife, blueback, gizzard shad, pumpkinseed, mummichog, killifish, American eel, striped bass, and catfish were collected. The Atlantic silversides was the most abundant species collected, followed by white perch. Given the range of growth forms, eggs, larvae, and adults captured, the study concluded that the Harbor provides nursery and adult habitat for a number of fish species.

Bottom feeding fish and crabs prey on several species of polycheates, crustaceans, and bivalves. The standing stock of these invertebrates are low in the Baltimore Harbor because of low DO and sediment toxicity. If DO and toxic sediment conditions in the harbor area improve, benthic biomass would probably increase and these areas would support larger populations of fish, crabs, and other predators (Ranasinghe et al, 1992)

Striped bass, *Morone saxatilis,* historically has been one of the most important finfish species in Chesapeake Bay. Water quality degradation in spawning and nursery grounds, along with overfishing, have contributed to significant population decreases. Maryland, along with other Mid-Atlantic states have established moratoria on commercial and recreational fishing for this species. The state, has focused most of its resources on studies of primary striped bass habitat in the Choptank River, Nanticoke River and the Upper Chesapeake Bay. The striped bass does not spawn in the Patapasco River (King, 1994, personal communication). All that exists regarding the occurrence of striped bass in the Baltimore Harbor area is anecdotal information from fishermen. It is believed that juvenile striped bass nurse and feed near the mouth of the Patapsco River to Curtis Bay (King, 1994, personal communication).

Biota Contamination

A survey of organochlorine pesticide and metal concentrations in Chesapeake Bay finfish performed by the Maryland Department of the Environment (1988) concluded the following as it relates to finfish in the Baltimore Harbor area:

- Mean levels of chlordane were found to exceed the Food and Drug Administration (FDA) action level of 0.3 ppm in channel catfish from the Back River and spot from the Patapsco River.

- Levels of all contaminants measured except chlordane, in all species were well below the recommended FDA action levels.

- Fish collected from urban estuaries contained higher levels of chlordane, DDE and DDD than fish collected from more rural locations.

- Significant positive correlations were found between lipid content and levels of chlordane in finfish. The same was true fish length and chlordance levels.

In 1986, the Maryland Department of Health and Mental Hygiene issued an advisory to recreational fishermen concerning consumption of certain fish species. Channel catfish and American eels in Back River and the Baltimore Harbor consistently contained levels of chlordane in excess of the FDA action level.

The Maryland Department of the Environment (1986) has conducted tissue analyses from blue crabs collected in Baltimore Harbor, Assawoman Bay and Chesapeake Bay. When compared to crabs from other Maryland locations for heavy metals, PCBs and chlordane, Baltimore Harbor crabs were shown to contain significantly higher values of copper, PCBs and chlordane. However, the levels are not high enough to constitute a human health risk.

Ongoing and Future Monitoring Programs in the General Project Area

The State of Maryland and other agencies have sponsored programs to evaluate physical, chemical and biological conditions in waters of the state, including the Chesapeake Bay. Programs that we understand are likely to continue and which may include portions of the Corps study area include the following:

- Fish Inventory Data - MDE periodically inventories fish species at several locations around the bay. The Patapsco River is included and some of their sampling stations may be near or relevant to the Corps study area.

- Water Toxics Data - The MDE collected water samples from a few sites in the Patapsco River between 1988 and 1990. The samples were analyzed for the 126 priority pollutants (with the exception of dioxin and asbestos). The data would be useful for characterizing water quality conditions in the Corps study area.

- U.S. EPA - Environmental Monitoring and Assessment Program - This multidisciplinary program initiated the collection and analysis of data at locations in the Chesapeake Bay in 1990. No trend results are available because the program is in its infancy. Future monitoring is planned and this program should serve as a benchmark monitoring program to assess trends. The next round of sampling is planned for 1996.

- MDE - Plans to start water quality monitoring starting January 18, 1994.

- MDE - Fish/Shellfish Tissue Monitoring Program - Routinely monitors contaminant levels in resident finfish species. Contaminants analysis in blue crabs and soft shell clams also is included.

- NOAA - The Office of Ocean Resources Conservation and Assessment is planning to initiate their study of distribution and abundance of fishes and invertebrates of mid-Atlantic estuaries in February 1994. The program should include stations that may be relevant to the BCOE study area.

Conditions Without the Project

In the absence of a suitable amount of trend data on the sediment, water quality and biological conditions in the project area, it is difficult to interpret the conditions that might exist if the two study areas are not dredged. Factors that should be incorporated into BCOE's feasibility study and for consideration in any subsequent environmental assessment include the following:

- Sediment data suggests that existing sediment conditions exceed NOAA guidelines for several parameters.

- Baltimore Harbor is an estuary, and although the waters and sediments have been stressed by anthropogenic sources, some evidence exists that the benthic invertebrate community is increasing in abundance and quality. Changes in the abundance and composition of benthic and fishery resources can be attributed to natural and human-related (i.e., spills, contaminant loadings from point source and nonpoint source discharges) conditions.

- The large decline in point source contamination from major industrial discharges may have affected sediment quality, suggesting that the surficial sediment layer is less contaminated than deeper sediments. The reduction in loadings of contaminants related to improved environmental regulation since the 1970's suggests that sediment conditions could be less contaminated. The layer of this "cleaner" sediment is probably very thin, on the order of millimeters, and sampling protocols are not adequate for separating this thin veneer and testing it separately from the underlying sediments that have been deposited over a much longer period of time. The available information is not sufficient to suggest that this thin veneer impedes the migration of contaminants into the water column. Most areas in which bottom sediments are regularly resuspended, due to bottom currents of from ship movements, likely do not have a layer of less contaminated sediments.

- Dredging of the channels and anchorage area does have the potential to remove contaminated sediments from the river bottom. The disposal of these sediments in upland contained disposal sites would reduce the possibilities that contaminants associated with those sediments could be introduced into the water mass due to other manmade or natural phenomena.

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