Questions About Dredging and Dredged Material Disposal in Long Island Sound

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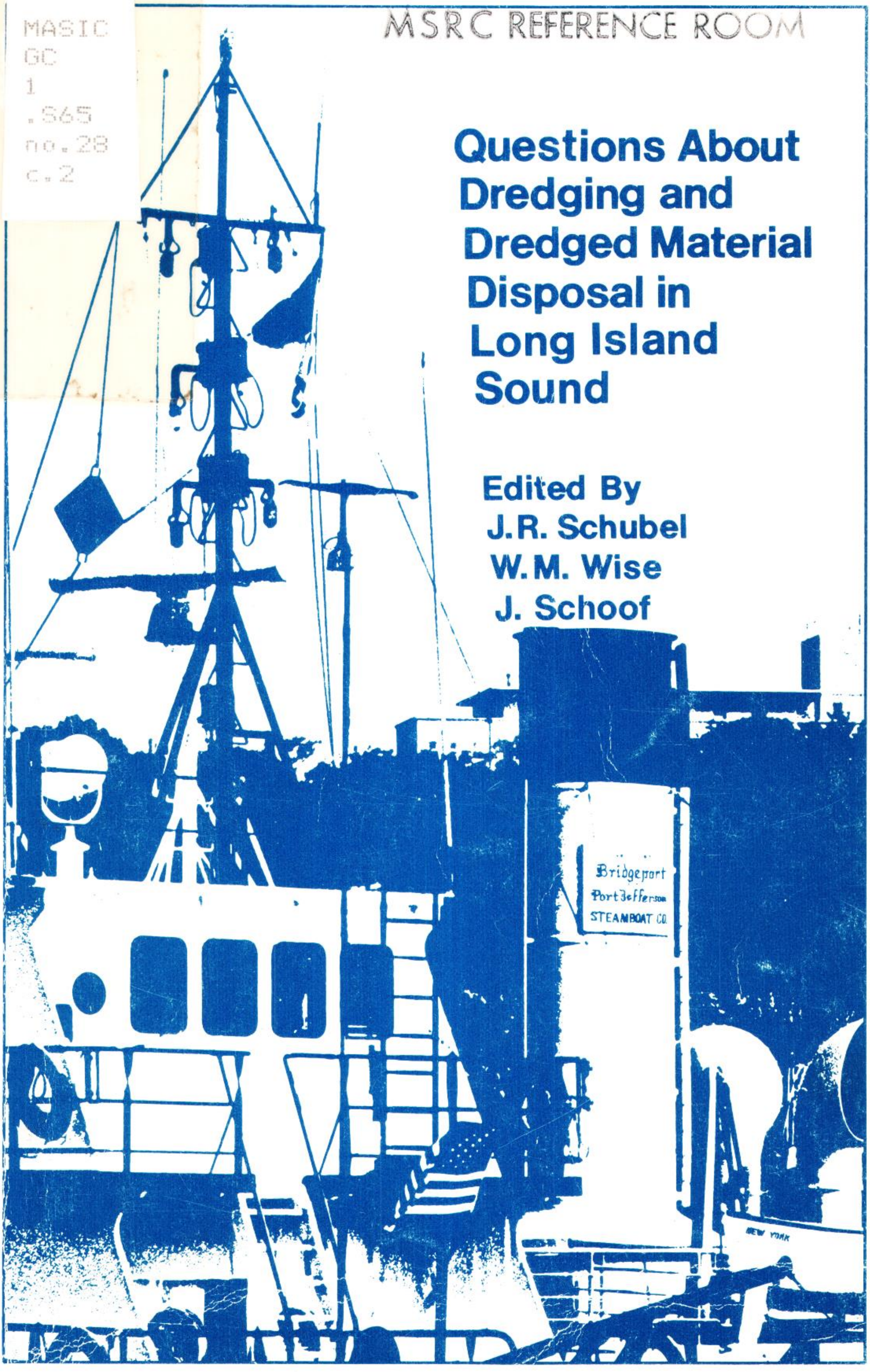

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STONY BROOK, NEW YORK 11794

QUESTIONS ABOUT DREDGING AND DREDGED MATERIAL DISPOSAL IN LONG ISLAND SOUND

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Special Report 28

Reference 79-11

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ACKNOWLEDGEMENTS

Preparation of this report was supported by the New York Sea Grant Institute. We are indebted to its Director, Professor D. F. Squires, for his advice and encouragement, and his patience. The participants' agencies generously provided their time.

The manuscript was typed by Connie Hof and graphic arts were by Carol Cassidy and Marie Eisel.

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1. INTRODUCTION

1.1 WHAT IS DREDGING AND WHY IS IT NECESSARY?

Dredging is the removal of submerged materials by hydraulic or mechanical means. Dredging is most commonly used to create or maintain waterways or to gather materials (often sand and gravel) for fill, construction aggregate, or other commercial purposes. Dredging is necessary to maintain the depth of many shipping channels and of the water adjacent to many docking facilities, including those used to support recreational boating and commercial fishing.

Estuaries, including those tributary to Long Island Sound, are areas of rapid sedimentation. If there were no more dredging, harbors would gradually fill in and marine transportation would be severely limited. Recreational boating would be constrained by reduction in access to marine facilities. Commercial and recreational fishing would be adversely affected by a lack of docking facilities. Naval operations would be hampered by reduced access to shore facilities.

1.2 WHAT WAS THIS BOOKLET DESIGNED TO DO?

This booklet was designed to provide, when read from start to finish, an over-view of the history of dredging and dredged material disposal in the Long Island Sound (LIS), an assessment of how these activities have affected the Sound and its biota, an examination of alternative modes of disposal, and a general discussion of research priorities. This booklet was also designed to provide answers to specific questions you may have about these topics without having to read the entire volume.

The questions were compiled at a series of workshops in which scientists, environmental decision makers, and lay people participated.

1.3 HOW SHOULD YOU USE THIS BOOKLET?

As pointed out in 1.2, this booklet was designed to be read in conventional fashion and to be used as a reference document to answer specific questions. To find answers to specific questions, identify the subject in the Table of Contents and proceed to the indicated page.

1.4 WHAT UNITS ARE USED?

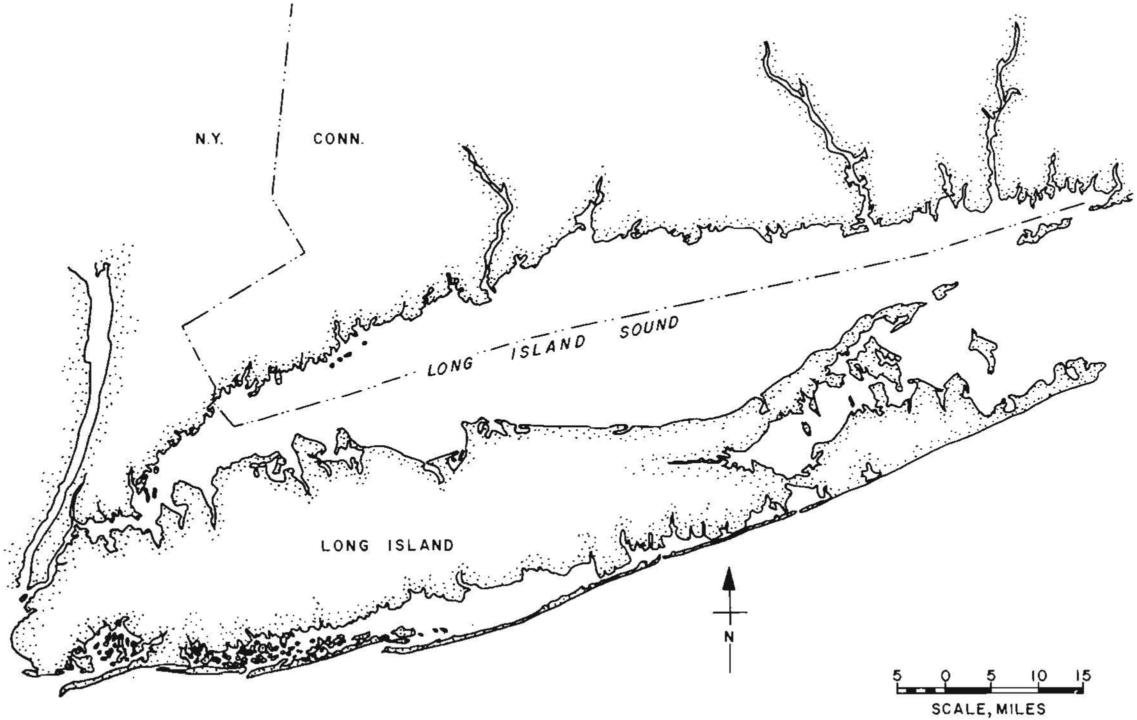
Units are reported in British engineering units to conform with standard dredging terminology. Metric equivalents are usually presented. The Table below gives factors for converting British engineering units to metric units.

Table 1.4

Conversions from British Engineering to Metric Units.

To Convert From	To	Divide By
inches (in)	centimeter (cm)	0.3937
feet (ft)	meters (m)	3.2808
nautical miles (NM)	Kilometers (km)	0.5396
sq. statute miles (mi^2)	sq. kilometers (km^2)	0.3861
acres	sq. kilometers (km^2)	247.1054
cubic feet (ft^3)	cubic meters (m^3)	35.3147
cubic yards (yd^3)	cubic meters (m^3)	1.3080
feet/sec (ft/s)	centimeters/sec (cm/s)	0.3208
knot	meters/sec (m/s)	1.9425
short ton	metric ton	1.1023

2. LONG ISLAND SOUND: A GEOLOGICAL PERSPECTIVE.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2.1 WHAT IS LONG ISLAND SOUND?

Long Island Sound is an estuary--a semi-enclosed coastal body of water freely connected to the sea within which sea-water is measurably diluted by fresh-water from runoff. Long Island Sound has two connections to the Atlantic Ocean. Its eastern end communicates with the Atlantic Ocean through Block Island Sound and remains at near-oceanic salinities, while its western end communicates with New York Harbor through the East River. New York Harbor remains at reduced salinities because of the fresh-water discharge of the Hudson River. In addition, there is substantial fresh-water discharged directly into the Sound. Within the Sound this results in a progressive admixture of low salinity water with sea-water producing a gradient of decreasing salinity from east to west.

Long Island Sound is also characterized by strong tidal motions transmitted from the Atlantic Ocean through Block Island Sound. The existence of these tidal motions and the horizontal salinity variations described produces a characteristic two-layer gravitational circulation; saline bottom water flows westward into the Sound while fresher surface water flows eastward out of the Sound through the Race. Estuarine properties are repeated on a smaller scale in many harbors and river mouths along the shores of the Sound. The Sound is, therefore, a large estuary with many small estuaries, such as New Haven Harbor and the mouth of the Connecticut River along its margins.

Pritchard, D.W. 1967. What is an estuary: physical viewpoint. Pages 3-5 *in* G.H. Lauff, ed. Estuaries. Amer. Assoc. Adv. Sci., Washington, D.C.

Riley, G.A. 1956. Oceanography of Long Island Sound. Bingham Oceanographic Collection Bulletin, v.15.

2.2 HOW AND WHEN WAS LONG ISLAND SOUND FORMED?

The depression that today contains Long Island Sound was carved some 50 million years ago by a large river that flowed east and west across the ancient continent. Long Island Sound did not come into existence, however, until much later, after the last great glaciations of the Pleistocene period. Twenty thousand years ago, all of New England as well as the area now occupied by the Sound was under an ice sheet more than 1,000 feet (300 m) thick. As the glacier receded, it left behind not only long ridges of sediments (called moraines) that form the backbone of Long Island and the southern shore of the Sound, but also a thick blanket of sand and gravel that lined the basin between Long Island and Connecticut. Immediately after the ice had receded, however, sea level was much lower than it is today and much of the region between Connecticut and Long Island, and even south of Long Island, was dry land. Glacial meltwaters pouring down from the north formed a large fresh-water lake in the deepest portions of the basin north of Long Island. This area remained a fresh-water lake until about 8,000 years ago. At this time sea level, which had been gradually rising, finally flooded the trough, creating Long Island Sound as a saline arm of the sea. The Sound is, therefore, a very young coastal feature, geologically speaking.

Bokuniewicz, H.J., J.A. Gebert, and R.B. Gordon. 1976. Sediment-mass balance in a large estuary, Long Island Sound. Est. Coast. Mar. Sci. 4:3523-536.

2.3 WHAT ARE THE NATURAL GEOLOGIC PROCESSES AFFECTING LONG ISLAND SOUND? HOW DO THEY AFFECT IT?

The waters of Long Island Sound are supplied with sediments from both the rivers of Connecticut and the wave-cut cliffs of the north shore of Long Island. Sands and gravels are swept along the shore by the waves and tides to form beaches and spits around the Sound. Fine-grained sediments are transported throughout the Sound by tidal currents and the slow estuarine circulation. In the central and western basins a large amount of silt has accumulated.

Every tidal cycle a layer of sediment 1-2 mm thick (less than a tenth of an inch) is eroded from the Sound floor by the tides and redistributed within the central basin. Throughout the Sound, tidal streams resuspend and redeposit more than seven million tons of sediment daily. Despite this activity fine silt is accumulating in the western and central basins at a rate of about 1 mm/yr. In the eastern Sound the sea floor is sandy, and strong tidal currents have worked the Sound floor into large underwater dunes or sand waves. The estuarine circulation superimposed on the tidal currents produces a net westward transportation of sand out of the eastern Sound into the accreting muddy basin of the central Sound.

2.4 WHAT ARE THE SOURCES OF MOST OF THE SEDIMENT DREDGED FROM LONG ISLAND SOUND HARBORS?

Most of the sediment that accumulates in dredged channels comes from nearby tidal flats and adjacent deposits of marine muds in shallow water. Fine-grained sediment particles tend to settle out of the quiet harbor waters onto the harbor floor. These sediments are easily stirred up, however, by occasional storms and much of this material finds its way into the harbor's deeper, dredged channel. The New Haven Harbor channel, for example, was dredged in 1974 but the severe winters of 1977-78 and 1978-79 caused serious shoaling and parts of the channel had to be dredged again in 1979.

So the sediment that must be dredged from the channels comes from the harbor floor, but where does the sediment on the harbor floor come from? There are several possible sources. It could be supplied by rivers draining into the harbors; or it could be washed out from the eroding harbor shore. It could be composed of the shells of tiny animals that live in the harbor water; or it could be carried into the harbor by the tides from the Sound itself. For harbors along the Connecticut coast this last source is most important. Almost all of the sediment on the harbor floor has been carried in from the Sound by the daily tidal streams. For the harbors on the Long Island coast, the supply of sediment particles from the eroding shore is probably also important, but, none-the-less, much, if not most, is supplied from the Sound by the tidal exchange.

The next question is "what is the source of fine-grained suspended sediment in the waters of

Long Island Sound?" The floor of the central and western Sound is blanketed by deposits of marine mud. In some places these deposits are more than 45 ft (15 m) thick. The Sound's marine muds have accumulated over the last 8 to 9,000 years. The Connecticut River has been the principal supplier, although undoubtedly some sediment has been contributed by the erosion of the north shore of Long Island and by tidal exchange with the ocean. The tidal currents are sufficient to disturb these sediments and, every tidal cycle, a layer of sediment a few millimeters thick is resuspended, redistributed and deposited again within the Sound. Throughout the Sound, the tidal streams resuspend and redeposit more than seven million tons of sediment daily. Despite this activity, marine muds are presently still accumulating in the Sound at a rate of about a millimeter per year.

So most of the sediment that must be removed from navigation channels originally came from the shore of Long Island and the rivers of Connecticut, primarily the Connecticut River. These particles, however, probably went through many cycles of erosion, transportation and deposition before they found their way into the harbor channels.

Bokuniewicz, H.J., J.A. Gebert, and R.B. Gordon, 1976. Sediment mass-balance in a large estuary, Long Island Sound. Est. Coast. Mar. Sci. 4:523-536.

Davies, D.S., E.W. Axelrod and J.S. O'Connors. Erosion of the north shore of Long Island, Marine Sciences Research Center Tech. Rpt. 18, State University of New York, Stony Brook, N.Y.: 101pp.

2.5 WHERE ARE THE AREAS IN LONG ISLAND SOUND IN WHICH FINE-GRAINED SEDIMENTS ARE NATURALLY ACCUMULATING? ...AT WHAT RATES?

Fine-grained sediments are accumulating primarily in two large basins in the central and western Sound. The rates of accumulation vary spatially, but the average rate of accumulation in these areas is about 1 mm/yr. The eastern Sound floor is sand. Sand also is generally found in a narrow band along the shore, although harbors, channels, and salt marshes serve as local traps for mud at the shoreline. The sedimentation rates in the channels are especially high, usually several cm/yr (Table 2.5).

Bokuniewicz, H.J., J.A. Gebert, and R.B. Gordon. 1975. Sediment mass balance in a large estuary, Long Island Sound. Est. Coast. Mar. Sci. 4:523-536.

Bokuniewicz, H.J., J.A. Gebert, R.B. Gordon, P. Kaminsky, C.C. Pilbeam, M. Reed, C.B. Tuttle. 1977. Field study of the effects of storms on the stability and fate of dredged material in subaqueous disposal areas. Tech. Rpt. # 77-2 U.S. Army Corps of Engineers, WES, Vicksburg, Miss.

Table 2.5

Dredging Characteristics of Connecticut Harbors

Harbor	Dredging Frequency Months	Volume of Last Dredging Project 10^4 m^3	Channel Area 10^4 m^2	Average Accumulation Rate cm/yr
Branford	100	7.1	11.3	7.6
Bridgeport	150	13.5	95.0	1.0
Clinton	100	2.4	5.4	5.2
Five Mile River	120	3.6	5.6	6.4
Greenwich	110	3.0	5.4	1.5
Guilford	120	5.6	7.3	7.7
Mianus River	150	1.4	5.9	1.9
Milford	170	3.0	11.8	1.8
Norwalk	70	4.8	43.0	1.9
Average Accumulation Rate for all Sites				3.9

2.6 WHAT ARE THE IMPACTS OF MAN'S ACTIVITIES ON SEDIMENTATION RATES IN LONG ISLAND SOUND?

Man's activities have had little effect on the sedimentation rate in Long Island Sound because urbanization and farming have not changed substantially the sources of sediment delivered to the Sound. The principal suppliers of sediment to the Sound are the rivers of New England and the bluffs along the north shore of Long Island. Sediment particles enter the rivers primarily by erosion of the river banks. Urbanization and farming, while they of course have a large impact on the land's surface, have not significantly changed the river banks where the erosion is occurring. The same is true along the bluffs of Long Island. Most of the area of the bluff face has been relatively untouched by man's activities and the erosion of the cliff face is therefore little affected by land use.

Gordon, R.B. 1979. Erosion rates determined from sedimentation in Long Island Sound, Am. Jour. Sci. 279:632-642.

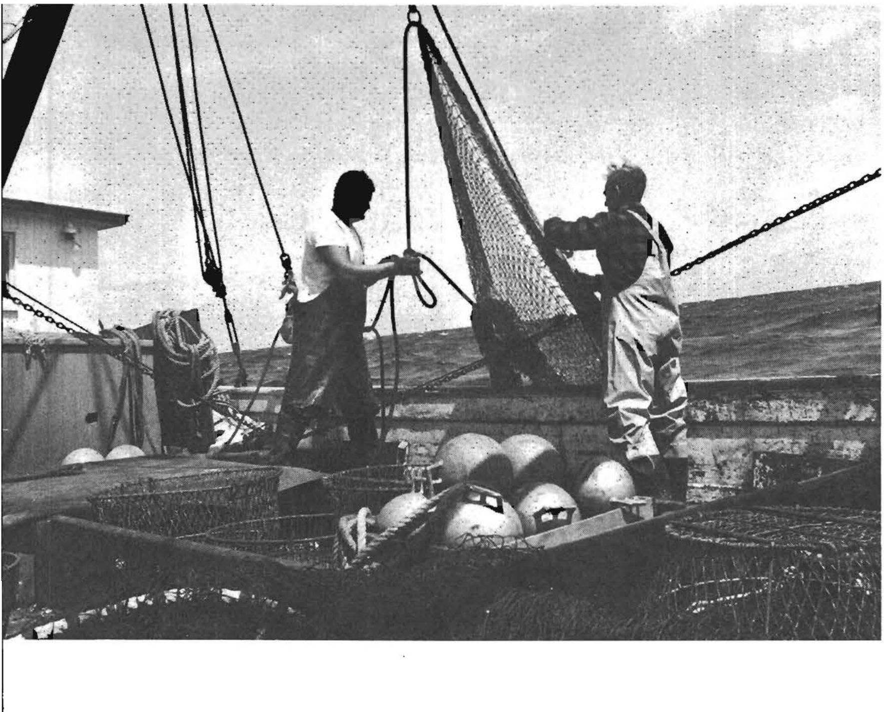
2.7 WHAT HAS BEEN THE IMPACT OF MAN'S ACTIVITIES ON SEDIMENT ACCUMULATION IN HARBORS BORDERING THE SOUND?

Most of the sediment accumulating in the harbors comes from the Sound itself. It is brought in by the local estuarine circulation of each harbor which has not been changed significantly by man's activities.

In some harbors waste solids are being discharged from sewers and from treatment plants. While the volume is not large it has been an important source of degradation of sediment quality. Locally, discharge of industrial wastes (as from the paper plants in New Haven) has caused channel shoaling.

Dredged channels in most harbors tend to fill rapidly. Some of this material comes from the Sound and rivers but most is material moving off surrounding shallows within the harbor. Continued maintenance dredging will be required. Harbor protection works (such as breakwaters) may have altered the rate of channel shoaling locally, but overall man's impact has been relatively small.

3. LONG ISLAND SOUND: HUMAN USES AFFECTED BY DREDGING AND DISPOSAL.



3.1 WHAT TYPES AND LEVELS OF COMMERCIAL SHIPPING EXIST ON LONG ISLAND SOUND?

Waterborne commerce on Long Island Sound is essential to the economic vitality of the surrounding region. The ten principal ports on the Sound--New London, New Haven, Bridgeport, the Connecticut River below Hartford, Stamford, Eastchester, Hempstead, Port Jefferson, Manhasset, Northville--together with secondary harbors and rivers, handled 40 million tons of cargo in 1971 (Table 3.1).

Petroleum products--residual oil for power plants and factories, distillate oil for home and commercial heating, gasoline for automotive use, kerosene for aviation use--constitute the major cargos handled by marine transportation on the Sound, both in terms of volume (tonnage), and in terms of importance to the region (Table 3.1).

Most petroleum shipments enter the Sound from the east through the Race, and are presently delivered to 15 port areas, including the LILCO powerplant at Northport and the offshore terminal at Northville. Energy demand in the Sound region is expected to grow at an average annual rate of over 5 percent, and since the future role of alternative energy sources like nuclear power is unclear, deliveries of fossil fuels to Long Island Sound ports are likely to increase steadily for years to come (NERBC, 1975a).

Construction materials--sand, gravel, crushed stone--constitute the other major type of waterborne cargo shipped on the Sound (Table 3.1). Such products originate at sand pits on Long Island and quarries in Connecticut and the upper Hudson River, and are presently handled at 4 Long Island and 10 Connecticut and mainland New York ports on the Sound.

Like petroleum products, the regional demand for construction products is expected to grow, with waterborne transport continuing to play an essential role (NERBC, 1975b).

Table 3.1

1971 LONG ISLAND SOUND WATERBORNE COMMERCE

Commodity	Connecticut Ports*		Long Island Ports	
	Tons (Millions)	%	Tons (Millions)	%
Residual Oil	10.6	42.3	1.8	12.5
Distillate	6.5	25.7	3.5	25.0
Gasoline	4.3	18.5	3.2	23.0
Jet Fuel/Kerosene	.9	.4	--	--
Other - primarily sand, gravel and stone; (construction materials, chemicals, scrap, etc.)	3.4	13.1	5.5	39.5
Total	26.0	100.0	14.0	100.0

*Includes mainland New York State ports.
Source: NERBC, 1975a.

New England River Basins Commission. 1975a. People and the Sound: Marine Transportation. New Haven, Conn., Feb. 1975.

New England River Basins Commission. 1975b. People and the Sound: Mineral Resources and Mining. New Haven, Conn., May 1975.

U.S. Army Corps of Engineers. 1977. Waterborne Commerce of the United States: Part I, Atlantic Coast. Waltham, Mass.

3.2 WHAT LEVELS OF RECREATIONAL BOATING EXIST ON THE SOUND AND WHERE IS THIS ACTIVITY CONCENTRATED?

An estimated 80,000 recreational craft, with a total estimated value of $368 million, are berthed within the bays and harbors surrounding Long Island Sound (NERBC, 1974). The Sound is accessible to over 7 million people living within the surrounding region, but only an estimated 44 thousand slips and moorings, and 360 boat ramp lanes are presently available (Table 3.2). Most of the existing facilities are located in the heavily-populated western end of the sound.

The existing boating demand exceeds the supply of boating facilities by an estimated 10% on Long Island, and by an undetermined percentage in Connecticut, especially in the southwestern portion of the State (NERBC, 1974). To meet the projected 1990 demand for boating facilities, about 15,000 new slips and moorings, and 600 boat ramp lanes will have to be built. To meet the projected demand in 2020 about 46,000 new slips and moorings, and 1,200 new boat ramp lanes will have to be built (Table 3.2). Most of this increased demand will be located in the western end of the Sound, which, as stated earlier, is already the most heavily used portion.

Boating Almanac Co., Inc. 1978. Boating Almanac Volume 2: Long Island, Connecticut, Rhode Island. Severna Park, Md.

New England River Basins Commission. 1974. Recreation: An Interim Report. New Haven, Ct.

Table 3.2

Long Island Sound Boating Facilities:
Existing Supply and Projected Demand*

	Number of slips and moorings			Number of boat ramp lanes		
	Year					
	1970	1990	2020	1970	1990	2020
1	4,200	5,200	7,900	60	120	180
2	4,100	5,500	9,200	50	120	200
3	4,400	5,600	8,300	60	130	200
4	2,900	4,200	6,300	20	60	100
5	12,600	16,200	24,400	80	190	290
6	11,900	14,800	20,100	50	180	240
7	3,500	5,900	11,400	30	110	200
8	400	1,300	2,500	10	70	140
9						
Total	44,200	58,700	90,100	360	980	1,550

*Data from New England River Basin Commission (NERBC), 1974

3.3 WHAT IS THE EXTENT OF THE COMMERCIAL FISHERY IN LONG ISLAND SOUND?

Commercial fishing has been going on in Long Island Sound for well over 150 years. Because the early fisheries were of small scale and used relatively unsophisticated gear, the protected waters of the Sound once accounted for a substantial portion of the total marine landings of Connecticut and New York. With the introduction of the otter trawl and the development of larger, more seaworthy vessels, the contribution of the Sound to overall landings in both states has decreased markedly, particularly for many finfish species.

In the 1940's the blackback flounder fishery supported as many as 40 to 50 otter trawl vessels with an average length of 40 ft. This was basically a winter fishery. During the same time span, but in the spring and summer, two other resources were of prime importance; the sea bass and scup or porgy. As these fisheries declined, many of the vessels either left the area or transferred their efforts to other resources. Many entered the pot fishery for lobster which has been expanding continually since the late 1940's. The lobster fishery today supports as many vessels as existed in the trawl fishery in the 40's. In the last 5 years there has been a rejuvenation of the trawl fishery in Long Island Sound. The vessels, now larger and more mobile, can range from Eatons Neck, N.Y. to Orient Point on any given day.

Combined New York and Connecticut commercial landings from Long Island Sound are presented in Table 3.3. The importance of shellfish to the overall catch is apparent, accounting for more than one-half the total landed weight and 90% of the total landed value. The oyster industry of Long Island Sound has declined considerably since its peak in the late 19th-early 20th century, although the oyster (*Crassostrea virginica*) still ranks first in both landed weight and value in Long Island Sound. The lobster supports a sizable fishery in the Sound, with nearly 900,000 lbs. landed in 1977, worth nearly 2 million dollars. Landings of hard clam in 1977 were slightly more than 400,000 lbs. with a landed value of over 1/2 million dollars.

There is a small (approximately 2 million lbs. in 1977) commercial fishery for food finfish in Long Island Sound, until recently based on winter flounder (*Pseudopleuronectes americanus*) but now dominated by scup (*Stenotomus chrysops*) and weakfish (*Cynoscion regalis*). The principal gears used in this fishery are otter trawls and pound nets set along the north fork of Long Island. A sizeable shad fishery exists in the Connecticut River, landing approximately 250-300,000 lbs. per year, mainly by drift and anchor gill nets.

Wise, W.M. 1975. The Fisheries and Fisheries Resources of Long Island Sound. Master's Thesis, Marine Sciences Research Center, SUNY at Stony Brook, 122pp.

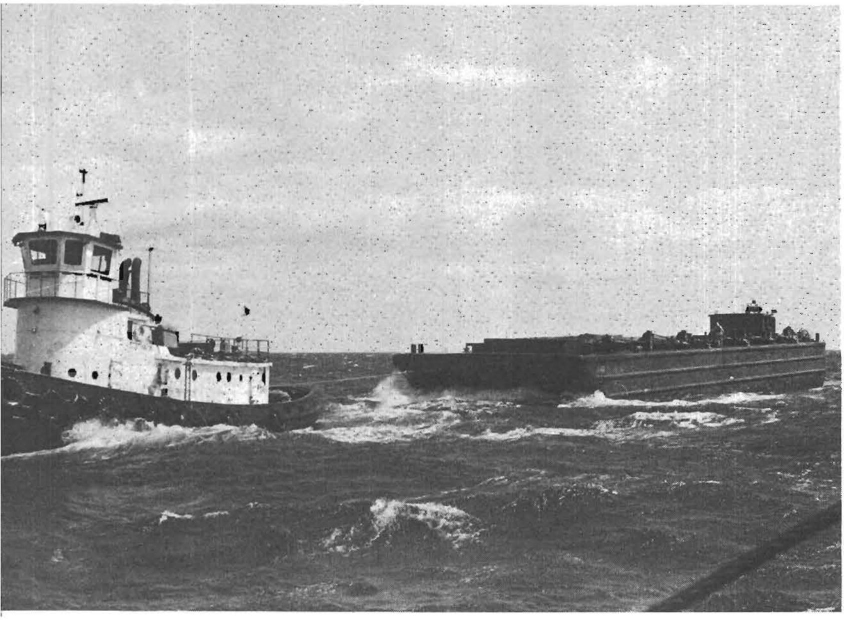
National Marine Fisheries Service, unpublished data.

Table 3.3 1977 COMMERCIAL LANDINGS FROM LONG ISLAND SOUND*

Finfish	lb.	$
Alewife	6,130	4,914
Anglerfish	800	214
Bluefish	70,700	14,565
Butterfish	42,200	13,528
Carp	600	72
Catfish	4,300	860
Eel, Common	17,400	8,747
Flounder, Blackback	25,000	5,914
Flounder, Fluke	48,500	32,872
Hake, Red	600	86
Herring, Sea	1,000	107
Mackeral, Atlantic	61,600	18,036
Menhaden	108,500	5,436
Scup	607,400	161,865
Sea Bass, Black	3,500	2,038
Searobin	3,400	399
Sea Trout, Gray	172,100	45,529
Shad, Atlantic	332,400	149,580
Shark, Greyfish	13,000	2,149
Shark, Unclassified	1,700	246
Skate	3,500	507
Spot	100	14
Striped Bass	92,300	73,167
Sturgeon, Common	2,400	595
Swellfish	300	519
Tautog	20,500	2,316
White Perch	12,600	5,515
Whiting	1,100	163
Finfish, Unc. for food	2,700	522
Finfish, Unc. for bait	274,900	13,745
Total Finfish	1,931,230	564,220
Shellfish		
Lobster, American	894,700	1,909,150
Clam, Hard (Public)	183,300	393,549
Clam, Hard (Private)	218,300	233,010
Clam, Soft	19,400	28,529
Conch	53,200	30,117
Mussel, Sea	300	195
Oyster (Public)	300	735
Oyster (Private)	1,145,700	2,733,892
Squid	9,700	8,704
Total Shellfish	2,524,900	5,337,881
GRAND TOTAL	4,456,130	5,902,101

*Includes combined landings of New York and Connecticut
Source: Unpublished data, National Marine Fisheries Service

4. LONG ISLAND SOUND: DREDGING AND DISPOSAL ACTIVITIES.



4.1 WHERE ARE THE FEDERALLY-MAINTAINED WATERWAYS IN LONG ISLAND SOUND? IN WHICH OF THESE PORTS IS PRIVATE DREDGING IMPORTANT?

The U.S. Army Corps of Engineers currently maintains 41 Federal Navigation Projects in Long Island Sound, Fig. 4.1. Sixteen of these waterways are in New York waters under the authority of the New York District of the Corps and twenty-five are in Connecticut waters under the authority of the New England Division of the Corps.

Most of the privately-dredged material in Long Island Sound comes from Connecticut. The three most important ports in terms of volume of private dredging are the Thames River-New London area, Niantic Bay and Harbor, and New Haven. Only 25% of the Sound-wide private dredging work is done in New York waters, where the center of activity is in New Rochelle Harbor.

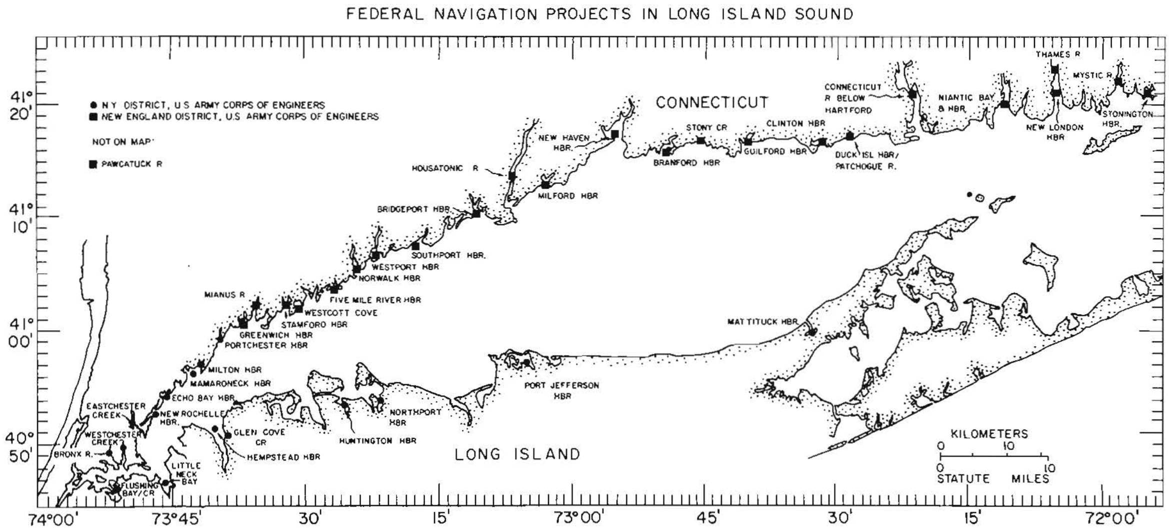


Fig. 4.1 Federal Navigation Projects in Long Island Sound

4.2 HOW MUCH MATERIAL HAS BEEN DREDGED FROM LONG ISLAND SOUND IN THE PAST CENTURY AND WHERE HAS THIS MATERIAL BEEN DUMPED?

Accurate data on dredging operations in Long Island Sound are available only for Federal Navigation Projects maintained by the U.S. Army Corps of Engineers. Cumulative dredging volumes for these Projects since 1890 are given in Fig. 4.2. The data are continuous except for the period 1921-1928, for which a conservative estimate of 500,000 yd^3/yr (380,000 m^3/yr) has been used to make the plot continuous.

Since 1890, a minimum of 100 million yd^3 (75 million m^3) have been dredged from Federally-maintained waterways bordering Long Island Sound (Fig. 4.2)[1]. Approximately 80% of this volume has come from Connecticut, the remainder from ports in Westchester County and along the north shore of Long Island Sound.

Very few data are available on private dredging in Long Island Sound. From 1968-1977, 240 applications for private dredging in the Sound totalled 6.9 million yd^3 (5.3 million m^3), an average of approximately 0.8 million yd^3/yr (.6 million m^3/yr). These data include 2.9 million yd^3 (2.2 million m^3) from the U.S. Navy New London improvement project. How representative this rate is of the long-term average of private dredging in the Sound is not known.

Dredged material from Long Island Sound is placed in one of three kinds of disposal areas: (1) upland sites adjacent to the dredging area, (2) the Mud Dump Site in the New York Bight and (3) in open-water sites in Long Island Sound proper. Data on the partitioning of the total volume of dredged material among these three disposal alternatives are incomplete. Upland

[1]Unpublished data from New York District, U.S.A.C.E.

disposal was probably used extensively in the early decades of this century prior to the heavy industrialization of many areas bordering the Sound and before the ecological value of nearshore areas and marshes was recognized. The viability of upland disposal has decreased in recent years because of a lack of suitable sites. At present this alternative is used very infrequently in the Sound, being primarily restricted to maintenance dredging of several rivers in Connecticut. The Mud Dump Site in the New York Bight is occasionally used for the disposal of material dredged from a number of ports in western Long Island Sound, particularly Flushing Bay, Bronx River and Eastchester and Westchester Creeks. The vast majority of the material dredged from the borders of the Sound has been dumped at open-water sites within the Sound.

The cumulative volume of dredged material and other wastes disposed of in open-waters of Long Island Sound is given in Fig. 4.2. The data are continuous except for the years 1932-1945, for which a conservative estimate of 2 million yd^3/yr (1.5 million m^3/yr) has been used to make the plot continuous.

Since 1890 more than 126 million yd^3 (97 million m^3) of material have been placed in open-water disposal sites in Long Island Sound. The overwhelming majority of this total volume has been dredged material. These data include materials taken from Federal Navigation Projects *and* from privately dredged areas.

New England River Basins Commission. 1979. Interim Plan and Draft Environmental Impact Statement for the Disposal of Dredged Material in Long Island Sound. Ninety-Day Draft Review. 55pp.

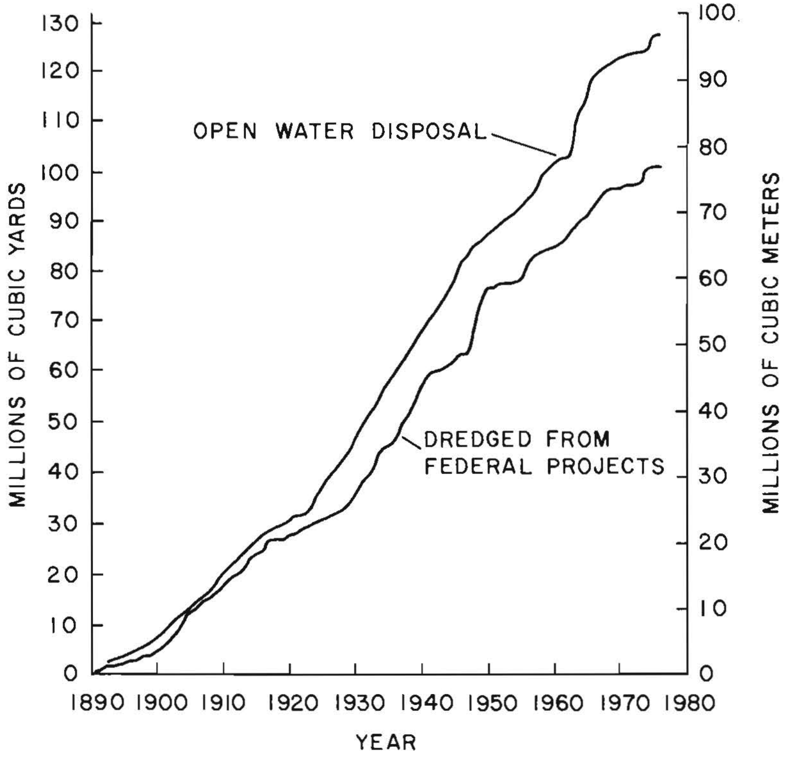


Fig. 4.2 Volume of dredged material disposed of at open-water sites in LIS (upper curve) and volume of material dredged from Federal projects bordering the Sound (lower curve).

4.3 WHAT DISPOSAL SITES IN THE SOUND HAVE RECEIVED THE MAJORITY OF THE DREDGED MATERIAL IN RECENT YEARS?

Data on the volumes of dredged material disposed of at each of the historically-used disposal sites in the Sound are available back to the mid-1950's and are presented in the Fig. 4.3. Since 1954 four disposal sites--Eatons Neck, Bridgeport, New Haven and New London--have received a combined total of 28.2 million yd^3 (21.5 million m^3), approximately 80% of the total volume of material disposed at all sites during this period.

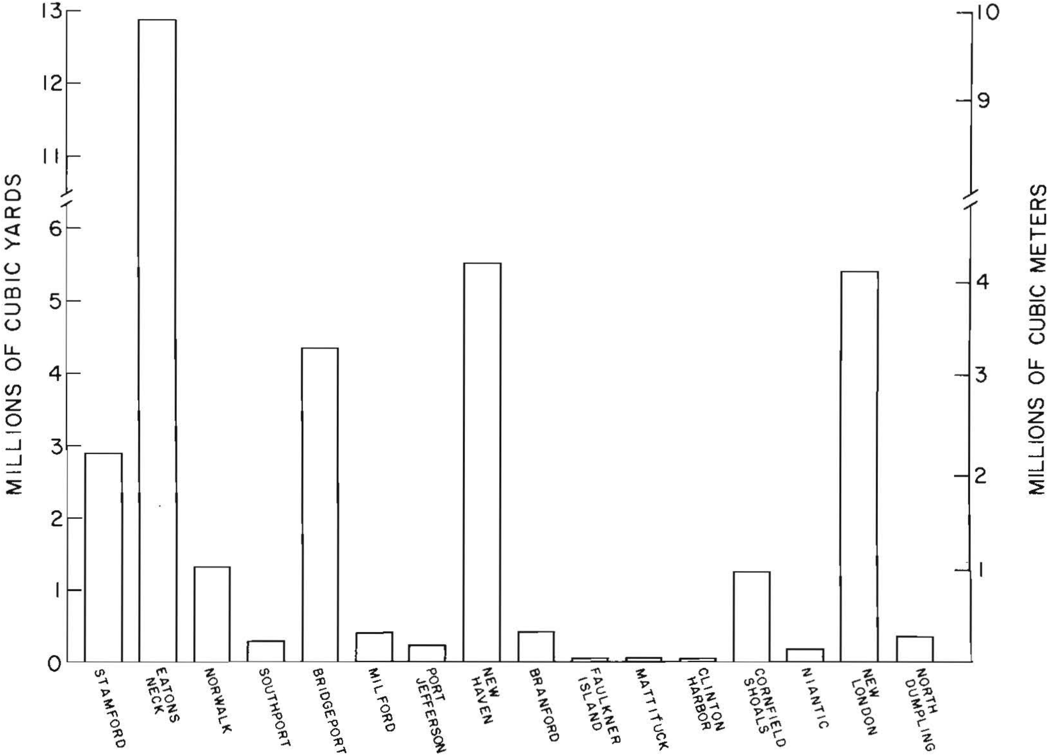


Fig. 4.3 Dredged material disposal in LIS (1954-1956) by disposal site.

4.4 WHAT ARE THE PROJECTED DREDGING VOLUMES FOR LONG ISLAND SOUND FOR THE NEXT 10 YEARS?

In the next decade about 20 million yd^3 (15.3 million m^3) of material will be dredged from the borders of Long Island Sound. Scheduled maintenance dredging by the U.S. Army Corps of Engineers totals 5.2 million yd^3 (4.0 million m^3), Table 4.4. Improvement dredging is scheduled for New Haven Harbor and the Thames River totalling 8.4 million yd^3 (6.4 million m^3). Dredging by the U.S. Navy in the Thames River will amount to 2.75 million yd^3 (2.1 million m^3). Total private and municipal dredging will produce approximately 3.5 million yd^3 (2.7 million m^3).

Table 4.4

Scheduled 10-year Maintenance Dredging in Federal Navigation Channels in Long Island Sound.

	1000 yd^3		1000 yd^3
Connecticut			
Greenwich Harbor	50	Patchogue River	80
Mianus River	25	Connecticut River	1700
Stamford Harbor	200	Niantic Bay	40
Westcott Cove	40	Thames River	200
Five-Mile River	70	Pawcatuck River	60
Norwalk Harbor	200	New York	
Westport Harbor	80		
Southport Harbor	40	Port Chester Harbor	200
Bridgeport Harbor	400	Mamaroneck Harbor	165
Housatonic River	200	Eastchester Creek	150
Milford Harbor	600	Little Neck Bay	150
New Haven Harbor	800	Glen Cove Creek	100
Stony Creek	28		
Guilford Harbor	70	TOTAL	5,258
Clinton Harbor	125		

Unpublished data, N.Y. and N.E. Districts, U.S. Army Corps of Engineers

5. DREDGING AND DISPOSAL METHODS COMMONLY USED IN LONG ISLAND SOUND AND THEIR ENVIRONMENTAL EFFECTS.

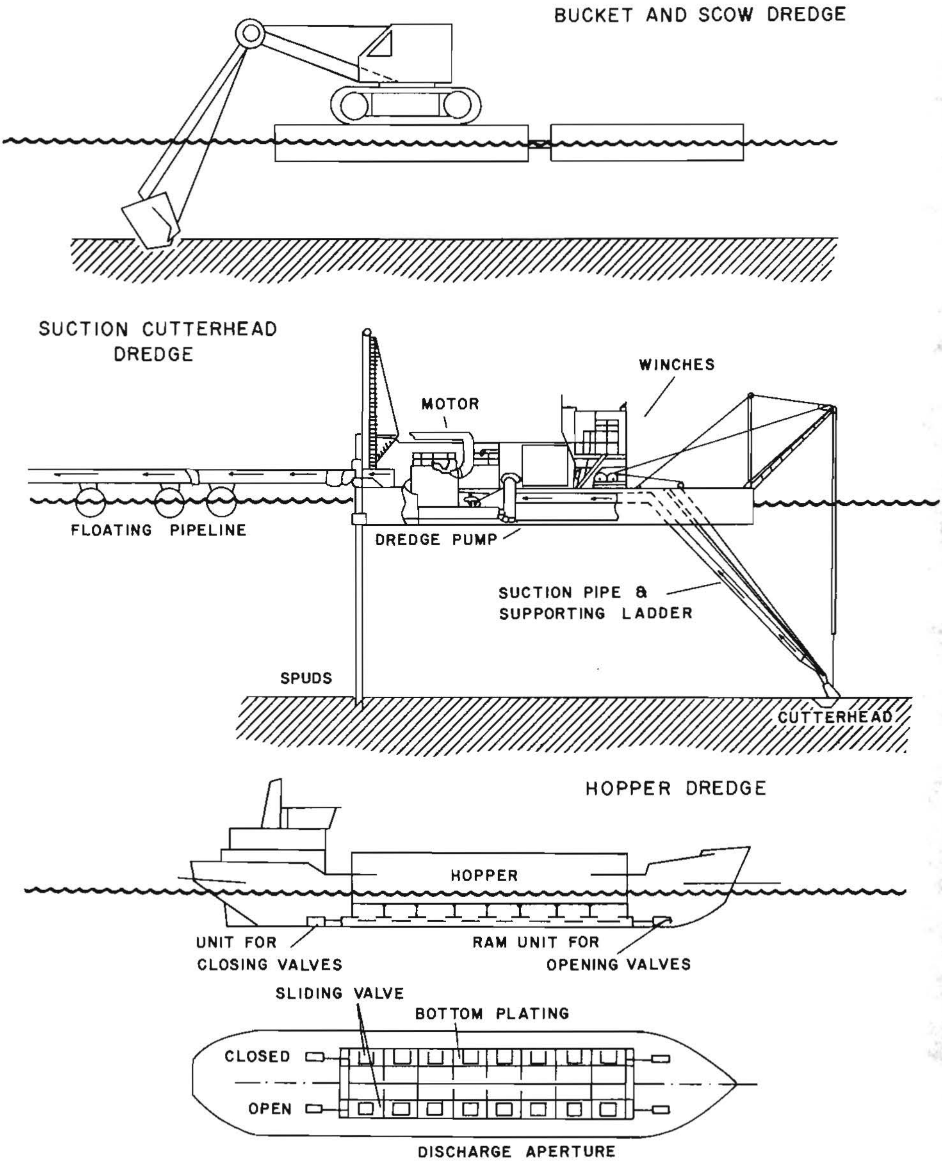


Fig. 5.1 Three kinds of dredges used in Long Island Sound.

5.1 WHAT ARE VARIOUS METHODS OF DREDGING COMMONLY USED AROUND LONG ISLAND SOUND?

Three kinds of dredges used around Long Island Sound are (1) section-cutterhead, (2) hopper, and (3) crane and bucket. They are described below and in Fig. 5.1 and Table 5.1.

Suction-Cutterhead Dredge

A suction-cutterhead dredge has a rotating cutter on the end of a dredge ladder which physically excavates the materials and dilutes them with water so they can be pumped. Dredged materials are usually discharged through pipelines to open water or enclosed disposal areas. Cutterhead dredges are the basic tool of the private dredging industry in the U.S.

These dredges are most frequently used in Long Island Sound for maintenance dredging of several rivers and estuaries in Connecticut, such as the Housatonic, the Five-Mile, the Patchogue and the Connecticut. During these operations, the dredged material is piped to diked disposal sites along the banks of the river. In the past 15 years approximately 1.2 million yd^3 (0.9 million m^3) have been removed by suction-cutterhead dredging from Federal navigation projects along Long Island Sound.

Hopper Dredge

A hopper dredge is a self-propelled vessel equipped with centrifugal pumps, drag arms extending down to the bottom, and hopper bins to receive the dredge material and transport it to the disposal site. Dredged materials are usually discharged through doors in the bottom of the hoppers.

Soft bottom materials are pumped aboard through the drag arms and discharged initially in the hoppers. If no overflow is permitted, the hoppers must then be discharged. Under "economic load" conditions, overflow of water and low density, fine-grained material is permitted until the maximum load of material is retained in the hopper before disposal operations begin.

Hopper dredges have not been used in Long Island Sound since the mid-1950's. Prior to that time they were occasionally used in large-scale dredging in some of the major Federal navigation projects in Connecticut such as Bridgeport and New Haven Harbors.

Bucket and Scow

A crane and bucket dredge, frequently termed a clam-shell dredge, is simply a steamshovel placed on a floating barge. The bucket of the steamshovel is modified to allow excess water to drain, making the dredge more efficient. The dredged material is loaded into bottom-dumping scows which are towed to the disposal area where the dredged material is discharged. Crane and bucket operations are restricted to relatively shallow water.

Bucket and scow dredges are the most frequently used dredging method along Long Island Sound. The increasing unavailability of upland disposal areas in close proximity to many frequently dredged areas makes open-water disposal of dredged material attractive. The small-scale of many operations combined with the low cost of bucket and scow relative to hopper dredging makes bucket and scow the most attractive dredging alternative. Over the past

15 years, 14.2 million yd^3 (10.8 million m^3) have been removed from Federal navigation projects around Long Island Sound by bucket and scow operations.

Table 5.1 SOME DREDGING TECHNIQUES APPROPRIATE FOR USE AROUND LONG ISLAND SOUND

	DREDGE TYPE		
	Hopper Dredge	Cutterhead (hydraulic) Dredge	Clam Shell (Orange Peel Bucket) Dredge
Dredging Principle	Sediment is removed and picked up together with dilution water by drag-head sliding over bottom (or stationary) and flows through suction piping, pump, and discharge piping into hoppers of vessel.	Sediment is removed with a rotary cutter (or plain suction inlet in light material), picked up with dilution water by the suction pipe, and transported through the pump and the discharge line.	Removes sediment by forcing opposing bucket edges into it while dredge is stationary. Lifts bucket and deposits dredged material in a conveyance or on a bank.
Material Transport	After material is in hoppers, transport is over any suitable waterway. Material can be bottom dumped or pumped out (if so equipped). Pump-out is similar to pipeline dredge operation.	Dredged material moved by pipeline. Length of discharge line depends on available power, but can be extended with booster pump units to a total length of several miles.	Transport occurs in barges, trucks, or cars; dredge does not transport material. Material disposal occurs in many ways.
Density of Mixture of Dredged Material and Water	Diluted to an average of 1200 g/ℓ.	Diluted to an average of 1200 g/ℓ.	Approaches in-place density in mud and silt. Approaches dry density in coarser material.
Comments	Suitable for all but very hard materials. Production depends on travel time to dump and mode of discharge.	Suitable for all but very hard materials. High production for size of plant.	This machine can be assembled by placing a crane on a barge. Suitable for all but the hardest materials. Low production for its size.

After Mohr, A.W. 1974. Development and future of dredging. J. Waterways Harbors and Coastal Engineering Division, Amer. Soc. Civ. Eng. 100(WW2):69-84.

5.2 WHAT ARE THE FACTORS THAT DETERMINE WHAT METHOD OF DREDGING AND DISPOSAL WILL BE USED ON A PARTICULAR PROJECT?

The primary factors in determining what method of dredging and disposal will be used are the nature and location of the disposal area, and the bidding process. An upland site available in close proximity to a dredging site is currently viewed by many regulatory offices as the most attractive choice. In such a case, the dredging/disposal method used would most probably be hydraulic pipeline. There are however relatively few upland sites available in close proximity to important navigation channels in Long Island Sound.

If the only practical alternative is open-water disposal, the proximity of the identified spoil disposal site to the dredging site and the water depth at the disposal site are the factors that govern the choice of dredging/disposal methods. If the open-water disposal site is within 3 mi. (4 km) of the dredging site, hydraulic pipeline would be the method most frequently used. If the disposal area is farther than this distance and the water at the disposal site is relatively shallow, a bucket and scow operation would most probably be used. Hopper dredging and disposal is most frequently employed when a long run to the disposal area is involved and the water depth at the disposal site is greater than 30 ft (9 m).

Most of the Federally-financed dredging operations are done by private dredging concerns who bid competitively for a particular job. Hydraulic pipeline operations are generally cheaper than hopper dredging, and bucket and scow operations are the cheapest of the three methods.

5.3 HOW DOES THE COST OF DISPOSAL VARY WITH DISTANCE FROM THE DREDGING SITE?

The rule-of-thumb is that the cost of barge or scow disposal is directly proportional to the distance of the disposal site from the dredging site; doubling the distance doubles the cost of the disposal operation.

5.4 WHAT IS OVERBOARD DISPOSAL?

Overboard disposal is the term usually used to describe the discharge of dredged materials in unconfined (open-water) disposal sites in rivers, lakes, estuaries and other water bodies. The sites are usually relatively close to the area being dredged. The terms "overboard disposal" and "open-water disposal" are frequently used interchangeably.

5.5 WHAT OBJECTIONS HAVE BEEN RAISED TO DISPOSAL OF DREDGED MATERIAL IN LONG ISLAND SOUND?

General Objections

The principal pervasive objection to disposal of dredged materials in the Sound is that there exists no comprehensive dredged material management plan. The general perception is that alternative disposal options have not been adequately examined and that coordination among the several regulatory agencies involved is poor. Lacking a comprehensive plan, decisions on methods and areas of disposal have been made on a case-by-case basis with apparently little thought given to the cumulative effects of a multitude of small disposal operations.

There is also considerable concern over chronic effects that contaminated dredged materials may have on the biota of the Sound. If such contaminants are physically, chemically, or biologically reactive on long time-scales, adverse impacts on water quality and biota could occur. Although unacceptable short to intermediate term impacts have not been demonstrated by intensive post-dump monitoring at the New Haven and New London disposal sites or in other similar estuarine settings, concern over longer term effects persists. In general, most monitoring studies have not been of sufficient duration to adequately assess any long-term impacts of disposal of contaminated material in open estuarine waters. Recent concerns have also focused on aperiodic transport phenomena i.e., unique weather events and their potential to disperse dredge spoils from "containment" disposal sites.

There have also been objections regarding the short-term impacts of disposal operations on water quality and biota, especially lobsters. Research has shown, however, that acute effects of disposal are transitory.

Site-specific Objections

1. Western Basin

This area suffers from degraded water quality, and disposal of dredged material is commonly viewed as an unnecessary and unwarranted aggravation to the already heavily-stressed biota of the region. It is also considered desirable to dispose of dredged material where it has been disposed of in the past and little disposal activity has taken place in the western basin of the Sound. Moreover, the area is small, its borders are heavily populated and it is used intensively for navigation and recreation. Many objectors feel there is insufficient room to accommodate frequent, large-scale disposal operations.

2. Central Basin

The only apparent site-specific objections to disposal in the central basin of the Sound are raised in connection with the Eatons Neck disposal area. This area probably supports the most intensive concentration of lobster pots in the Sound. It is also a highly productive recreational fishing area. Both the lobstermen and the recreational fishermen feel strongly that dredged material disposal operations will deleteriously affect their activities. There is little scientific documentation available to test this hypothesis. There are even those who contend that the good fishing and lobstering are a result of past disposal operations.

Another frequently-voiced objection to disposal operations in this region is that the water quality and water-use patterns existing in the central Sound are already subjected to a variety of pressures associated with growing urbanization and that further pressures from disposal of dredged materials could seriously degrade the area.

3. Eastern Sound

Most of the eastern part of the Sound is considered by many to be a high-energy, erosional environment. This would make this area a poor site for containment of dredged materials. The dominant feeling is that material placed anywhere in the eastern Sound will eventually be dispersed by tidal currents and the estuarine flow. The concerns of commercial lobstermen and sportfishermen concerning the Eatons Neck disposal site are echoed for the New London disposal area. However, recent monitoring of disposal operations at this site failed to reveal any impacts on either finfish or lobster populations at the site or on the surrounding area.

4. Shallow Water Areas

The shallow borders of the Sound, with water depths of less than 60 ft (20 m), are generally high-energy, erosional environments or are heavily used for recreation. Both factors render these areas undesirable for unconfined disposal of fine-grained dredged materials. There is little objection to disposal of coarser grained, uncontaminated materials (sand) in shallow areas of the Sound.

5.6 WHEN DREDGED MATERIAL IS RELEASED FROM A SCOW OR HOPPER DREDGE, WHAT HAPPENS TO IT?

Material released from a scow or hopper dredge is deposited on the sea floor in three steps (Fig. 5.6). Upon release, the dredged material descends rapidly through the water column as a well-developed jet of high density which may contain some solid blocks. This jet has been observed to fall at speeds in excess of 2 knots (100 cm/sec). Ambient water is entrained during descent and the total volume of the descending jet may be increased a hundredfold before it reaches the sea floor in depths of about 65 ft (20 m).

After sinking through the water column, the material hits the bottom. Some of the released material spreads radially outward from the impact point as a donut-shaped density surge only a few yards thick. This bottom surge slows and thins as it travels outward and has been observed to run a few hundred yards, at most, from the point of impact. Initially, the surge moves swiftly and carries material away from the impact point until the surge velocity is reduced sufficiently to permit deposition.

These three steps--descent of the jet, impact on the bottom, and spread of the bottom surge--have been observed to occur under a wide range of hydrographic conditions, dredged material characteristics, and dredging and disposal equipment. The limiting conditions under which these steps will occur have not been determined but they have been documented in water depths of up to 220 ft (67 m) and in currents of up to 4 knots (200 cm/sec).

A small fraction of the released material will be found in the water column above the bottom surge. This is material that has spilled over the top of the hopper before discharge, has been washed out of the hopper or scow after the discharge, or has been left behind by the descending jet and the spreading surge. This diffuse cloud of residual material drifts with the currents and settles slowly. While the cloud of turbid water may be noticeable around the dredge or scow, this drifting material accounts for only about 1-5% of the total mass of material released and persists for only a short period of time.

Bokuniewicz, H.J., J.A. Gebert, R.B. Gordon, J.L. Higgins, P. Kaminsky, C.C. Pilbeam, M.W. Reed and C. Tuttle. 1978. Field Study of the Mechanics of the Placement of Dredged Material at Open-Water Disposal Sites. Final Report. Tech. Rept. D-78-F. Vol. I. U.S. Army Corps of Engineers Waterways Experiment Station, Environmental Effects Lab., Vicksburg, Miss. 94 pp. and appd.

Gordon, R.B. 1974. Dispersion of dredge spoil dumped in near-shore waters. Est. Coast. Mar. Sci. 2:349-358.

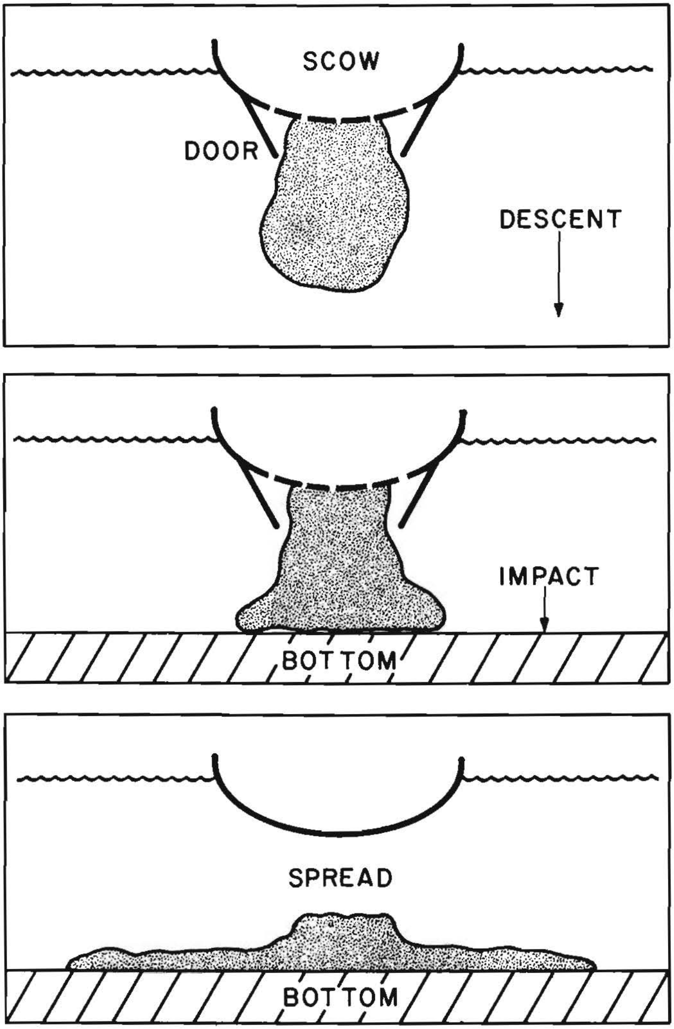


Fig. 5.6 Behavior of dredged material released from a scow.

5.7 WHAT EFFECT DOES OPEN-WATER PIPELINE DISPOSAL HAVE ON THE TURBIDITY OF LOCAL WATERS?

Less than 5% of the total amount of solid material discharged by open-water pipeline disposal is incorporated into the turbid plume; more than 95% goes rapidly to the bottom very close to the source--within a few tens of yards--as a density flow. Studies in Gulf Coast estuaries showed that only about 1%-2% of the solid material discharged during open-water pipeline disposal operations was incorporated into the plume. While no such estimates have been made for Long Island Sound or its tributary estuaries, they would be similar to those found for estuaries along the Texas, Louisiana, Florida and Maryland coasts since the sediments are generally of similar texture. In some environments, a fluid mud layer may form near the bottom and spread over relatively large areas.

Schubel, J.R., H.H. Carter, R.E. Wilson, W.M. Wise, M.G. Heaton, M.G. Gross. 1978. Field Investigations of the Nature, Degree and Extent of Turbidity Generated by Open-Water Pipeline Disposal Operations. Final Report. Technical Report D-78-30, U.S. Army Corps of Engineers Waterways Experiment Station, Environmental Effects Lab., Vicksburg, Miss. 257 pp.

5.8 IS THERE ANY EVIDENCE THAT DISPOSAL OF DREDGED MATERIAL IN LONG ISLAND SOUND HAS RESULTED IN ANY PERSISTENT DEPRESSION IN THE LEVELS OF DISSOLVED OXYGEN? DISCUSS.

During dumping of dredged material, the sediment settles out so rapidly that the oxygen demand is limited because only a small fraction of this material is reactive on a time scale comparable to that associated with settling of the bulk of the mass of particulate matter. Between 95-99% of the dredged material is deposited within a few tens to a few hundreds of seconds after disposal. Once dredged material is deposited, its oxygen demand on the overlying waters is initially dependent on the expulsion of interstitial water during compaction, and beyond this is diffusion limited. The strong tidal currents preclude localized areas of low oxygen over disposal areas.

The dissolved oxygen (D.O.) distribution within a body of water reflects an interplay between diffusional exchange at the air-sea interface, vertical and horizontal mixing within the water column and biological and chemical processes that result in D.O. generation and consumption.

Dissolved oxygen enters the water through the sea surface and may be generated within the photic zone. In the first process, oxygen diffuses across the air-sea interface; dissolved oxygen may be lost if the surface is supersaturated or gained if the water is undersaturated. The second input is by means of photosynthetic liberation of dissolved oxygen. The magnitude of the photosynthetic output of D.O. depends upon the nutrient concentration and the temperature of the surface water and upon those factors which affect the duration and extinction of light. The bottom waters become dependent upon the processes of advection and diffusion from the surface layers for D.O. replenishment.

Dissolved oxygen is consumed from the water column primarily by the respiration of both plants and animals and the D.O. requirements for aerobic bacterial decomposition of organic matter, and secondarily by inorganic chemical oxidations. It is evident that, unlike the restriction to surface layers for oxygen regeneration, oxygen consumption may occur at any depth. However, suspended particles settle out fairly rapidly so that a large fraction of microbial decomposition occurs at the bottom. Events which favor the establishment of vertical stability create a condition by which the rate of respiratory activity, at lower depths, may exceed the rate of D.O. replenishment from the surface waters. The rate of oxygen depletion is mainly a function of the intensity of microbial activity. The metabolic activity of microbial decomposers is temperature dependent and therefore the rate of D.O. consumption increases with temperature and minimum D.O. levels are expected near the end of the annual warming cycle, i.e., late summer.

Significant oxygen depletion is confined primarily to the lower layer of the Sound west of Lloyd Point during the summer when the large inputs of sewage plant effluents from the East River are compounded by extended calm, hot periods which increase the thermal stratification of the water. The sewage-derived nutrients stimulate phytoplankton blooms. When these organisms die, they sink to the bottom and consume oxygen. Strong thermal stratification can nearly cut off the supply of oxygen from the upper layer.

Hardy, C.D. and P.K. Weyl. 1971. Distribution of dissolved oxygen in the waters of western Long Island Sound. MSRC Tech Report #11. 37pp.

5.9 ARE NUTRIENTS RELEASED DURING DREDGING AND OPEN-WATER PIPELINE DISPOSAL OPERATIONS AND, IF SO, WHAT EFFECTS DO THEY HAVE ON PHYTOPLANKTON?

An investigation was made of the gross biological effects of open-water pipeline disposal in the upper Chesapeake Bay between November 1965 and November 1968. Total phosphate and nitrogen were increased in the immediate vicinity of the dredge by factors of 50 and 1000 respectively, but limited field experiments did not show any detectable effects on photosynthesis by phytoplankton. The increases in the levels of nutrients were local and did not persist. Furthermore, any stimulation of phytoplankton that might have resulted from increased nutrients was more than offset by the increased levels of turbidity which reduced light penetration. The net effect was to produce local and temporary reductions in photosynthesis. The release of nutrients from scow disposal operations and their effects on phytoplankton would be even less than those for pipeline operations.

There are no field data from Long Island Sound on the release of nutrients during dredging and disposal, but the results would be similar to those for Chesapeake Bay. Observations at the New London dump site of dissolved oxygen, total suspended solids, pH, eH, turbidity, and dissolved organic carbon showed that these parameters, returned to background predump, levels within 2 hours of a scow dumping operation.

Flemer, D.A. 1970. Project B. Phytoplankton. Pages 16-25 *in* . Gross Physical and Biological Effects of Overboard Spoil Disposal in Upper Chesapeake Bay. Special Rept. No. 3, Natural Resources Institute, University of Maryland, page 66.

Natural Marine Fisheries Service, 1977. Physical, chemical and biological effects of dredging in the Thames River (CT) and spoil disposal at the New London (CT) dumping ground. Final report to U.S. Navy and Interagency Scientific Advisory Subcommittee. Div. of Environmental Assessment Report 2.

5.10 DO DREDGED MATERIALS PLACED AT THE VARIOUS DISPOSAL SITES IN LONG ISLAND SOUND REMAIN IN THE DISPOSAL AREAS OR ARE THEY DISPERSED BY CURRENT AND WAVE ACTION?

Disposal sites are chosen partly on the basis of the amount of dispersion expected; minimum dispersion is an important objective. This is achieved by selecting sites, partly on the basis of water depth, where current and wave action will be relatively known--relative to other parts of the Sound.

Past experience at disposal sites suggests that, with appropriate precautions in site choice, significant dispersion is not observed. For example, material from the Thames River dredging project is currently being placed at the New London dump site. Even though this site might appear to be rather exposed, preliminary observations indicate that significant dispersion of the dumped material is not occurring.

Post-dump monitoring of open-water disposal at the New Haven dump site has also failed to detect significant migration of dredged material beyond the immediate area of the disposal site.

National Marine Fisheries Service, 1977. Physical, chemical and biological effects of dredging in the Thames River (CT) and spoil disposal at the New London (CT) dumping ground. Final Report to U.S. Navy and Interagency Scientific Advisory Subcommittee. Div. of Environmental Assessment, Rept. No. 2.

Bokuniewicz, H.J., J.A. Gebert, R.B. Gordon, P. Kaminsky, C.C. Pilbeam and M.W. Reid. 1975. Environmental consequences of dredge spoil disposal in Long Island Sound, Phase II: Geophysical Studies, November 1973-November 1974. Dept. of Geology and Geophysics, Yale University, New Haven, Conn. 68pp.

5.11 HOW LONG DOES IT TAKE AFTER A DUMPING OPERATION FOR REPOPULATION OF A DISPOSAL AREA? WHAT FACTORS CONTROL THE RATE OF REPOPULATION AND THE COMMUNITY STRUCTURE?

Most monitoring studies of open-water disposal sites have documented drastic reductions in benthic abundance, total biomass, and species diversity immediately following deposition of dredged material. When the grain-size (texture) of the dredged material was similar to that of the natural sediments in the disposal area, and when the dredged material was not grossly contaminated, recolonization of the mound of dredged material was initiated within days, perhaps even hours, after cessation of disposal. In most studies, recolonization was complete within 1 to 1-1/2 years; community structure and abundance could not be distinguished from pre-dredging conditions. These observations of disposal site benthic recovery have been documented in a number of estuaries throughout the world.

Recolonization usually begins with the appearance of "pioneering" organisms, primarily tube-dwelling polychaete worms, which can repopulate an area quickly, develop rapidly, and reproduce many times each year. These early colonizers generally feed from the water column or the sediment-water boundary. These organisms have a very high recruitment and their immediate post-dump abundance may be very high. Following this initial peak abundance, these opportunistic species often experience high mortality and another group of species begins to appear on the spoil mound. These organisms are characterized by intermediate death and recruitment rates, and by lower peak abundance than the more opportunistic species. The least effective colonizers appear last, but have a lower mortality rate than the two previous groups. Members of this group of benthic colonizers also have fewer reproductions per year, tend to be large and mobile, and are primarily deposit feeders. They might be termed "equilibrium" species. This recolonization pattern, featuring a succession of species types, is characteristic of marine and estuarine systems. The specific factors which eliminate the early colonizers and allow the less opportunistic but more ecologically stable species to become dominant are not well-known, but may include intra-specific competition for food or space.

In Long Island Sound the constant resuspension of the top layer of muddy bottom sediments by tides and in shallower areas by storm waves, help transport fresh organic matter as well as larvae and juveniles to a dump site from surrounding bottom areas. These larvae settle out from the water column and establish themselves on the new seafloor. In addition, relatively mobile adult macrofauna like the polychaete worm *Nephtys incisa* are able to immigrate by swimming to the new sediment surface from the surrounding seafloor.

A number of factors control the rate of repopulation and the community structure of a new dump site.

First, since the presence of larvae in the water column varies with time of year, the rate of recruitment will vary seasonally. The availability of a new seafloor before periods of intensive recruitment will affect the numbers of colonizing individuals.

Second, natural year-to-year variations of the numbers and kinds of larvae in the Sound will affect the rate and density of repopulation, as well as the species composition of colonizing organisms.

Third, the presence of contaminants such as hydrocarbon compounds in the dredged sediment can (1) deter larval settlement and development, and (2) deter movement of animals into the sedimentary deposit, thus limiting the density and diversity of those organisms that can colonize the new sediment surface.

Fourth, the lack of readily-useable food items below the surface sediment layer will also limit deep-burrowing deposit-feeders and will restrict feeding to the sediment surface or the overlying water. Gradual biogenic reworking of the organic rich surface layer into the disposal mound helps promote the establishment and growth of microorganisms--through sediment reworking and irrigation.

Thus, the kinds of organisms and their interrelationships, as well as the nature of the animal-sediment interactions on a disposal site change over time scales ranging from days to months or even years.

Rhoads, D.C., P.L. McCall and J.Y. Yingst. 1978. Disturbance and production on the estuarine seafloor. American Scientist 66:577-586.

5.12 WHAT KINDS OF DREDGED MATERIAL ARE SUITABLE FOR SALT MARSH CONSTRUCTION? ARE CONTAMINANTS ASSOCIATED WITH DREDGED MATERIAL MOBILIZED BY SALT MARSH PLANTS?

It is possible to utilize almost any type of dredged material for the construction of new salt marsh areas. Initial growth of marsh grasses, following their introduction by seeding or transplanting, is roughly proportional to nutrient supply, especially that of nitrogen. Because fine-grained or highly organic material can become anoxic establishment of new marsh often may be more rapid on sandy substrates despite a lower nutrient supply. With time and surface stabilization almost any material can be successfully colonized, artificially or in many situations naturally, if it is placed at the correct inter-tidal elevation and has sufficient protection from erosion.

Normal zonation of salt marsh grasses and other plants is governed mainly by elevation relative to the pattern of local tide levels. Successful marsh construction is possible only if the dredged material is stabilized at the correct elevation for the species introduced. Once established, long-term patterns of plant growth and sediment accretion depend mainly on the dissolved and suspended burdens of the covering tides, although the physical characteristics of the original dredged material, such as percolation, drainage, diffusion, and aeration are more important initially.

The capacity of salt marsh plants to mobilize metals associated with dredged material is dependent on the character of the sediment--particularly its texture and the levels and forms of the associated metals--and on the chemical conditions within the sediments, such as pH, oxidation-reduction potential, salinity, and sulfide concentrations.

There are conflicting reports as to whether *all* metals taken-up by roots are actually translocated to above-ground leaf material where they are more likely to be transferred to other organisms. Lee et al. (1976) found no significant translocation of any metals to leaf tops when roots were incubated in oxidizing nutrient solutions containing various metal and salt concentrations. In experiments conducted under natural sediment conditions, Gambrell et al. (1977) reported that mercury was more rapidly incorporated into leaves via roots under oxidizing sediment conditions and in weakly alkaline soils, than under reducing conditions and in acidic soils. Cadmium content in above-ground tissues was increased by exposing roots to oxidizing, acidic soils, while iron uptake and translocation to leaves was favored by acidic, reducing soils. Gambrell et al. also stated that metal uptake under similar geochemical conditions is species-dependent because some plant species may create their own local geochemical environment by modifying initial sediment chemical conditions. This appears to result from the species' ability to transport oxygen or reducing substances to the plant root system.

In light of their findings, Gambrell et al. recommended that dredged material disposal strategies designed to minimize metal release should depend on the metal composition and chemical conditions of the sediments. For example, cadmium-containing, reduced sediments should be maintained in a reduced state during and after disposal. Lead-contaminated sediments should be maintained at alkaline pH. The existence of several plant species which behave differently with regard to metal uptake in a given physico-chemical environment could be a valuable management tool in tailoring plant species to dredged material/disposal use alternatives.

Very little research has been conducted on mobilization of chlorinated hydrocarbons by salt marsh grasses from sediments. The Environmental Protection Agency is currently investigating chlorinated hydrocarbon uptake in salt marsh plants. However, other rooted plants, mainly cropland plants, do have the ability to transfer hydrocarbons from roots to leaves and it is reasonable to expect that rooted salt marsh plants have a similar capacity.

Backo, J.W., R.M. Smart, C.R. Lee, M.C. Landin, T.C. Sturgis R.N. Gordon. 1977. Establishment and growth of selected freshwater and coastal marsh plants in relation to characteristics of dredged sediments. Final Report, Tech. Rept. D-77-2, U.S. Army Corps Engineers Waterways Experiment Station, Environmental Effects Lab., Vicksburg, Miss., 41 pp.

Falco, P.K. and F.J. Cali. 1977. Pregermination requirements and establishment techniques for salt marsh plants as affected by eH, pH, and salinity. Final Report, Tech. Rept. D-77-40, U.S. Army Corps Engineers Waterways Experiment Station, Environmental Effects Lab., Vicksburg, Miss., 124 pp.

Gambrell, R.P., R.A. Khalid, M.G. Verloo and W.H. Patrick, Jr. 1977. Transformation of heavy metals and plant nutrients in dredged sediments as affected by oxidation reduction potential and pH. Final Report, Contract Report D-77-4, U.S. Army Corps Engineers Waterways Experiment Station, Environmental Effects Lab., Vicksburg, Miss., 336 pp.

Kadlec, J.A. and W.A. Wentz. 1974. State of the art survey and evaluation of marsh plant establishment techniques: induced and natural. Vol. I: Report of Research. Tech.

Rept. D-76-5. U.S. Army Corps Engineers Waterways Experiment Station, Environmental Effects Lab., Vicksburg, Miss., 47 pp. + appendices.

5.13 WHAT ARE THE DIFFERENT KINDS OF DREDGED MATERIAL?

There is a spectrum of dredged materials that ranges from clean sands as one end number to contaminated fine-grained materials as the other. Sand should be considered as a resource to be utilized. Potential uses include: fill, construction aggregate, beach nourishment, and sand for ice control on roads. Fine-grained materials, silt and clay, range from "clean" to "highly contaminated."

Most of the materials (more than 75% by volume) dredged from harbors and bays bordering Long Island Sound are composed predominantly of silt and clay. To select appropriate disposal sites and strategies, it is important to characterize the material properly and to assess what environmental effects it would have if disposed of in a variety of different kinds of sites: upland, overboard in LIS, in fringing wetland areas, etc.

5.14 WHAT ARE THE CLASSES OF CONTAMINANTS FREQUENTLY FOUND IN DREDGED MATERIAL AND WHY ARE THESE SUBSTANCES OF CONCERN TO THE PUBLIC?

Important "classes" of contaminants frequently found in association with dredged material include: 1) heavy metals, including Cd, Hg, Pb, Ni, and Cr; 2) halogenated hydrocarbons, including such industrial chemicals as PCBs and pesticides like DDT, Aldrin, and Dieldrin; 3) pathogenic bacteria and viruses; 4) petroleum hydrocarbons; 5) other exotic organic and inorganic chemicals, and 6) O_2-demanding substances. These constituents are of concern to the public because of their potential deleterious effects on the marine ecosystem, and perhaps man, if they are released during a dredging/disposal operation and enter the marine food web.

Metals, nutrients, and organic material are naturally occurring components of all sediments and will always be found in varying concentrations in dredged sediments. Sediments may also contain these constituents from sources of contamination. Some heavy metals have been shown to be toxic to estuarine organisms at relatively low levels of concentration.

Nutrients, organic material, and other oxygen-demanding substances contained in dredged material can have an adverse impact on the dissolved oxygen content of the disposal site waters but the effects are temporary and local.

Halogenated and petroleum hydrocarbons are not naturally found in sediments and are attributable solely to man-related contamination. There are a great number of halogenated hydrocarbons, some of which have been demonstrated to be toxic to marine organisms at relatively low levels of concentration and some of which have been shown to be carcinogenic.

Pathogenic viruses and bacteria, if mobilized during dredging and disposal operations, may be taken-up by filter feeding shellfish and then transmitted to man.

The extent to which the sediments in a particular location are contaminated with one or more of these pollutants is primarily related to two parameters, the proximity of the area sources of contaminants and the grain size of the sediments in the area. In general, the sediments in the immediate vicinity of a point source of these pollutants are more heavily contaminated than sediments well-removed from the area. However, current action within the waterbody may transport contaminated suspended sediment appreciable distances from the point of contaminant introduction. Texture is an important factor in determining the level of contamination of marine sediments. Fine-grained material has a larger capacity to adsorb pollutants than does coarser material. Areas that are characterized by a high percentage of fine-grained, organic-rich sediments will probably contain higher levels of contaminants than areas in the same waterbody where the bottom sediments are coarser. Areas frequently containing high percentages of fine-grained, organic-rich sediment include inner harbor areas, dredged navigation channels, and natural and dredged holes.

5.15 BY WHAT MECHANISMS MAY CONTAMINANTS IN DREDGED MATERIALS BE MOBILIZED AND RELEASED?

Contaminants in dredged material deposits may be mobilized in a variety of ways:

(1) Contaminants may become dissolved in the interstitial waters of the dredged material and then transferred out of the deposit by

- (a) diffusion into the overlying waters.
- (b) expulsion of interstitial waters as a result of compaction.
- (c) movement of interstitial waters as a result of groundwater flow.
- (d) alternate wetting and drying of the subaerial deposit.

(2) Contaminants may be taken up by the roots and transferred to other parts of the environment or to other organisms.

(3) Contaminants may be ingested by burrowing organisms.

(4) Contaminants may be released by resuspension of subaqueous dredged materials by waves and currents.

(5) Contaminants may be released by gas bubbles that migrate up through deposits of dredged material gathering contaminants on their surfaces as they move.

5.16 HOW CAN MOBILIZATION OF CONTAMINANTS FROM DEPOSITS OF DREDGED MATERIAL BE REDUCED?

The mobilization of contaminants from dredged material deposits can be decreased:

(1) By reducing the solubility of contaminants by maintaining the dredged material under reducing conditions.

(2) By inhibiting diffusion from the pile of dredged material by covering it with clean material.

(3) By placing the dredged material in a location of minimum ground water discharge.

(4) By keeping the dredged material covered with water to prevent drying and the development of dessication cracks.

(5) By placing the dredged material in sufficiently deep water so that plants cannot grow on it due to lack of light.

(6) By covering the deposit of dredged material with clean material of sufficient thickness so that burrowing organisms are confined to the layer of clean material.

(7) By placing the material in locations where there are no strong bottom currents and at a depth where waves generated by storms are sufficiently attenuated to prevent resuspension.

(8) By placing the dredged material at a depth sufficient to inhibit the formation of gas bubbles.

(9) By reducing the surface area of the deposit to reduce the rate of mobilization.

5.17 HOW MAY VARIOUS MODES OF DREDGED MATERIAL DISPOSAL AFFECT THE MOBILIZATION OF CONTAMINANTS AND THEIR UPTAKE BY ORGANISMS?

MODE OF DISPOSAL	PATHWAYS OF CONTAMINANT RELEASE
Confinement upland	(1) Contaminants may be dissolved in the interstitial waters and enter the ground water system.
	(2) Contaminants may be concentrated in the surface layer of sediment by alternate wetting and drying of the deposit.
	(3) Contaminants may be taken up by plants.
Confinement underwater	(1) Contaminants may be dissolved in the interstitial waters and expelled during compaction and consolidation.
	(2) Contaminants may be mobilized by burrowing organisms.
	(3) Contaminants may be taken up by plants in shallow areas.
	(4) Contaminants may be scavenged by gas bubbles that form within the deposit and rise through it.
Confinement on island; allowed to dry	(1) Contaminants may be concentrated in the surface layer of sediment by alternate wetting and drying of the deposit.
	(2) Contaminants may be returned to the water in dissolved and particle-associated forms by rain runoff.
	(3) Contaminants may be taken up by plants.

MODE OF DISPOSAL	PATHWAYS OF CONTAMINANT RELEASE
Confinement on island; kept wet	(1) Contaminants may be returned to surrounding water by overflow of ponds resulting from excess of precipitation over evaporation.
	(2) Contaminants may be taken up by plants.
	(3) Contaminants may be taken up by burrowing organisms.
	(4) Contaminants may be scavenged by gas bubbles that form within the deposit and rise through it.
Placed on wetlands	(1) Contaminants may be taken up by plants.
	(2) Contaminants may be taken up by burrowing organisms and other deposit feeders.
	(3) Contaminants may be concentrated in the surface sediment layer by alternate wetting and drying of the deposit and leach back into the water.
Overboard disposal	(1) Contaminants may be released to the water column in dissolved and particle-associated forms during the disposal operation.
	(2) Contaminants may, in shallow areas, be taken up by rooted plants.

MODE OF DISPOSAL	PATHWAYS OF CONTAMINANT RELEASE
Overboard disposal (continued)	(3) Contaminants may be taken up by burrowing organisms and other deposit feeders. (4) Contaminants may be scavenged by gas bubbles that form within the deposit and rise through it. (5) Contaminants may be released by the periodic resuspension of the material by waves and currents.

5.18 WHAT ENVIRONMENTAL CONDITIONS WOULD MINIMIZE THE MOBILIZATION (RELEASE) AND DISPERSAL OF CHLORINATED HYDROCARBONS FROM DEPOSITS OF DREDGED MATERIALS? DO THESE CONDITIONS OCCUR IN LONG ISLAND SOUND, AND IF SO, WHERE?

There are five environmental conditions which would minimize the mobilization and dispersal of chlorinated hydrocarbons (CHCs) from deposits of dredged materials: (1) high clay content, (2) high organic content, (3) a reducing environment, (4) a high sedimentation rate and (5) low tidal velocities.

Sediments with a high fraction of very fine silts and clay tend to have a high adsorption capacity for CHCs. The clay content is most significant in determining this capacity. The clay particulates offer large surface areas onto which CHCs can bind and, therefore, act as a sink for these compounds by removing them from the water column.

CHCs also have a strong sorption tendency for organic solid materials present in the sediments and water column. Humic and fulvic acids associated with particulates, common in the coastal waters, are important in transporting, precipitating and concentrating CHCs. The organic content of the water column could affect the adsorption and desorption of CHCs by competing for sorption sites or by affecting the soluble in lipid and lipid-like materials. The association of CHCs with naturally occurring soluble or colloidal organic matter could lead to their deposition if the organic matter were to become sorbed or flocculated by changes in salinity or redox conditions. Then the organics would act as binding and depositing agents.

Reducing conditions would be important. Presence and maintenance of a reducing environment would result in flocculation and coprecipitation of organic materials, metals and CHCs and thus hinder mobilization.

High sedimentation rates and low tidal velocities tend to minimize mobilization caused by resuspension. A high sedimentation rate could increase the deposition of sorbed CHCs due to the additional number of sorption sites and aid in the burial of deposited material. Low tidal velocities result in minimal tidal resuspension so that the sediments and their contaminants tend to remain confined.

These conditions do occur in Long Island Sound, particularly in the western basin, west of Stratford Shoals, and in the central basin southeast of New Haven. These two areas can be characterized by the following conditions: mostly silt, high organic content in the sediments and waters, reducing sediments, high sedimentation rates and low tidal velocities. They appear to be locations where the mobilization and dispersal of CHCs from contaminated sediments (spoils) would be minimized.

Fulk, R., D. Gruber and R. Wullschlager. 1975. Laboratory study of the release of pesticide and PCB materials to the water column during dredging and disposal operations. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg. Contr. Rep. D-75-6.

Hague, R., D.W. Schnedding and V.H. Freed. 1974. Aqueous solubility, adsorption and vapor behavior of polychlorinated biphenyl Aroclor 1254. Environ. Sci. Technol. 8:139-142.

Lee, G.F., M.D. Piwoni, J.M. Lopez, G.M. Mariani, J.S. Richardson, D. Homer and F. Saleh. 1975. Research study for the development of dredged material disposal criteria. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg. Contr. Rep. D-75-4.

5.19 WHAT ARE THE LEVELS OF PCBs IN FINE-GRAINED SEDIMENTS NATURALLY ACCUMULATING IN LONG ISLAND SOUND AND IN DREDGED MATERIALS DISPOSED OF IN THE SOUND?

The concentrations of PCBs in fine-grained sediments naturally accumulating in Long Island Sound range from about 0.1-0.4 ppm (parts per million) on a dry mass basis and average about 0.2 ppm. Concentrations of PCBs in dredged materials disposed of in the Sound range from about 0.1-0.8 ppm on a dry mass basis and average about 0.3 ppm. There is an east-west gradient of PCBs in Sound sediments; concentrations increase from east to west.

Chytalo, K.N. 1979. PCBs in Dredged Materials and Benthic Organisms of Long Island Sound. Unpublished Master's Thesis, State University of New York at Stony Brook.

5.20 WHAT ENVIRONMENTAL CONDITIONS WOULD MINIMIZE THE MOBILIZATION (RELEASE) AND DISPERSAL OF METALS FROM DEPOSITS OF DREDGED MATERIALS? DO THESE CONDITIONS OCCUR IN LONG ISLAND SOUND: IF SO, WHERE?

To minimize the release of metals it will be necessary to preserve the environmental conditions from which the materials are dredged. Since much dredged material is fine-grained it is reasonable to dispose of the dredge spoils in areas where fine-grained sediments presently accumulate. This will preserve both the chemical and the physical aspects of the environment. The chemical aspects will remain reducing or oxygen free and the water above the spoil mound will likely be quiescent. These two factors will minimize the remobilization of metals.

These conditions occur in Long Island Sound where fine-grained deposits exist today. This is primarily in the two central basins or deeper areas which are filled with mud. The main spoil disposal sites in use today lie within these basins.

Bokuniewicz, H.J., Gebert, J., and Gordon G.B. 1976. Sediment mass balance of a large estuary: Long Island Sound. Est. Coast. Mar. Sci. 4:523-537.

5.21 DO BURROWING ORGANISMS TAKE-UP CONTAMINANTS FROM DREDGED MATERIALS AND/OR SEDIMENTS NATURALLY ACCUMULATING IN LONG ISLAND SOUND?

In aquatic environments, heavy metals, hydrocarbon compounds, industrial chemicals, and pesticides are sometimes present in sediments in concentrations that significantly exceed normal environmental background concentrations. The relatively few studies of bio-accumulation of contaminants from sediments indicate that these contaminants *are* accumulated in the tissues of bottom-dwelling organisms from both the water and sediment they ingest. The principal contaminants of Long Island Sound sediments and, in particular, dredged materials are metals and hydrocarbons.

The availability of metals to deposit-feeding infaunal organisms is influenced by the particle size, organic content, and calcium carbonate content of the sediment, as well as by the binding strength of the metals to both inorganic and organic particles, (Cross, Duke and Willis, 1970; Luoma and Jenne, 1977; and Luoma and Bryan, 1978). Cross, et al. (1977) found that concentrations of Zn, Mn and Fe in surface and subsurface deposit-feeding polychaetes did not reflect the concentration of these trace metals in the sediments, most likely due to the binding strength of the metals to the sediment particles. Turekian, et al. (1979) examined copper and zinc concentrations in macro-infauna from New Haven Harbor and the New Haven Dump site and found that the quantity accumulated at a given location by individual species varied greatly and did not correlate directly with the concentration of that metal in the sediment. As the strength of metal-sediment binding increases, the concentrations of silver, cobalt, and zinc accumulated by the clam *Macoma balthica* declined (Luoma and Jenne, 1977). The concentration of one metal can also influence the degree to which another metal is taken up by organisms. Luoma and Bryan (1978) found that as the iron content in the sediment increased, the lead concentration in the deposit-feeding clam *Scrobicularia plana* decreased. In addition, organic-complexation plays an important role in binding metals to sediment (Jenne and Luoma, 1977). In estuarine regions like Long Island Sound with relatively high concentrations of organic matter, this may be an significant factor influencing the quantity of heavy metals accumulated by deposit-feeding organisms.

Boehm, P.D. and J.G. Quinn. 1977. Hydrocarbons in sediments and benthic organisms from a dredge spoil disposal site in Rhode Island Sound. U.S. EPA *Ecological Research Series*, EPA-600/3-77-092. Narragansett, R.I.

Cross, F.A., T.W. Duke and J.N. Willis. 1970. Biogeochemistry of trace elements in a coastal plain estuary: distribution of manganese, iron, and zinc in sediments, water, and polychaetous worms. Chesapeake Science 11:221-234.

Jenne, E.A. and S.N. Luoma. 1977. The forms of trace elements in soils, sediments, and associated waters: an overview of their determination and bioavailability. Pages 110-143 *in* H. Prucher and R.E. Wildung, eds. Biological Implications of Metals in the Environment. U.S. NTIS, LONF-750929, Springfield, Vermont.

Luoma, S.N. and G.W. Bryan. 1978. Factors controlling the availability of sediment-bound lead to the estuarine bivalve *Scobicularia plana*. J. Mar. Biol. Asso. U.K. 58:793-802.

Luoma, S.N. and E.A. Jenne. 1977. The availability of sediment-bound cobalt, silver and zinc to a deposit-feeding clam. Pages 213-231 *in* H. Prucher and R.E. Wildung, eds. Biological Implications of Metals in the Environment.

Turekian, K.K. New Haven Harbor Ecological Monitoring Studies Summary Report (1979), United Illuminating Report to Connecticut Department of Environmental Protection.

5.22 WHAT ARE THE ADVANTAGES AND DISADVANTAGES OF USING SHALLOW NEARSHORE AREAS FOR DISPOSAL OF DREDGED MATERIALS?

Advantages

(1) Protection of shoreline against wave erosion.
(2) Possible creation of fastlands for development.
(3) Possible creation of wetlands.
(4) Accelerate colonization by plants and animals.
(5) May facilitate access to deep water.

Disadvantages

(1) Loss of existing shoreline ecotome and benthic and shallow water biota already present.
(2) Contaminants may be mobilized and may damage the biota.
(3) Shoaling or erosion may be accelerated in areas adjacent to filled area.
(4) May impede access to water from present shoreline.
(5) May impede water navigation near shore.
(6) May increase turbidity in nearshore waters.

Woodhouse, W.W., Jr., Seneca, E.D., Broome, S.W. 1974. Propagation of *Spartina alterniflora* and salt marsh development. U.S. Corps of Engineers, Ft. Belvoir, Va. Report #46.

6. DREDGED MATERIAL MANAGEMENT IN LONG ISLAND SOUND

6.1 WHAT IS THE HISTORY OF DREDGED MATERIAL MANAGEMENT IN LONG ISLAND SOUND?

The Port Supervisors Act of 1888 (33 USC 441) empowered the Supervisor of the Port of New York to issue permits for the dumping of dredged and other waste materials in Long Island Sound and other coastal bodies of water. The Act called for material originating east of Throg's Neck to be disposed of in the Sound. However, inspection of U.S. Army Corps of Engineers records from the late 1890's indicates that material dredged from several areas west of Throg's Neck (Flushing Bay, Bronx River, Eastchester and Westchester Creeks) was also routinely disposed of in Long Island Sound. The 1888 Act listed 19 official dump sites in the Sound for disposal of dredged and other waste material. Although a number of these sites are located within Connecticut State waters, the Supervisor of the Port of New York (who, at that time, was also the Chief Engineer of the New York District of the Army Corps of Engineers) regulated dumping throughout the entire Sound. It is probable that several of the sites listed in the Act had been in use prior to 1888, but an extensive search of government records failed to reveal any earlier mention of specific dredged material disposal sites in the Sound. The rationale behind the designation of the original 19 sites is not known, but prime considerations were most probably proximity to frequently-dredged ports and water depth.

While both the State of New York and the State of Connecticut have been peripherally involved in dredged material management in the Sound since the early 1950's they have assumed an active role only in the last decade. At a conference in 1971 on the pollution of the interstate waters of the Sound (sponsored by the U.S. Environmental Protection Agency) an agreement was reached that open-water disposal of polluted dredged materials in the Sound should be prohibited. The conferees did not define the word "polluted."

For lack of a better definition, the so-called "Jensen Criteria" were subsequently used by New York State to determine whether dredged materials were polluted. This approach was used in evaluating a small number of private dredging projects which required State Certification under Section 21-b of the Water Quality Improvement Act of 1970 (P.L. 91-224). The importance ascribed throughout the U.S. to the Jensen Criteria which were developed in conjunction with federal research in the Great Lakes in the 1960's was not warranted either legally or scientifically and they were eventually dropped. Their use as a means of assessing the polluting potential of sediments to be disposed of in the Sound was discontinued following establishment by both States of water quality standards, subsequent to enactment of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500).

New York and Connecticut became more directly involved in the management of dredged material in Long Island Sound in 1973 when the States joined in a lawsuit brought by private parties against the U.S. Navy and the U.S. Army Corps of Engineers to halt improvement dredging of the Thames River near New London (CT), by the U.S. Navy. New York objected to the proposed action on the grounds that the Navy had understated the impacts of disposal, had inadequately assessed alternative disposal methods, and that any decision on the proposed project should be made as part of a comprehensive, Sound-wide dredged material management plan. The lawsuit resulted in a settlement in which the Navy agreed to intensively monitor the impact of disposal at the New London disposal site (part of which lies in New York waters) and the Corps of Engineers agreed to prepare a regional dredged material management plan and an environmental impact statement for that plan.

During discussion of the New London dredging project, informal meetings between personnel of the New York State Department of Environmental Conservation and Connecticut's Department of Environmental Protection were initiated. These discussions led to an understanding that the two State agencies shared a common view of the dredged material problem in Long Island Sound. To guide decision-making in the absence of a comprehensive management plan to be developed by the Corps, in the spring of 1977 the two states published a bi-state interim program for the disposal of dredged material in Long Island Sound.

The revised interim Plan includes five major elements:

1. Controlled and carefully monitored open water disposal at specified disposal points within three designated interim disposal areas in Long Island Sound.
2. Establishment of operational guidelines for the evaluation of potential polluting characteristics of materials to be dredged and proposed for disposal in Long Island Sound.
3. Application of these operational guidelines on a case-by-case basis to determine under what conditions open-water disposal may be utilized and when alternatives to open-water disposal in Long Island Sound should be mandated.

4. Establishment of a Dredging Management Committee consisting of representatives from public agencies with legal responsibilities affecting open-water disposal and ad hoc representation from the public sector and research community in order to concentrate the technical expertise and jurisdictional concerns in a positive approach to solving specific dredged material disposal problems.
5. Development of a dynamic long-term management program to examine and implement feasible disposal alternatives and provide continuing assessment of the effectiveness and impact of dredging management decisions.

The Interim Plan will be the subject of public hearings during the summer of 1979 on both sides of Long Island Sound to finalize the plan. Principal responsibility for completion and adoption of the Interim Plan has been assumed by the New England River Basins Commission. The program should be completed in 1979.

The Marine Sciences Research Center of the State University of New York with support from the New York Sea Grant Institute and the New England Division of the U.S. Army Corps of Engineers are also preparing planning documents for dredged material disposal in Long Island Sound.

New England River Basins Commission. 1979. Interim Plan and Draft Environmental Impact Statement for the Disposal of Dredged Material in Long Island Sound. Ninety-Day Draft Review. 55pp.

6.2 IS ALL DREDGED MATERIAL "SPOIL"?

Spoil is the term commonly used for any and all dredged material. Because of the obvious connotation of quality the term "spoil" carries, "dredged material" has been suggested as a substitute. If "spoil" is considered to be contaminated material that must be gotten rid of because it will degrade the environment, then clearly not all dredged material is spoil. The polluting (degrading) potential of dredged material depends primarily on the amount of material involved and on the degree of similarity between its physical and chemical properties and those of the sediments at the designated disposal site. Dredged materials range from clean sands at one extreme to contaminated, organic-rich muds at the other; most materials fall somewhere between these two end members. Coarse-grained sediments, sand and gravel, are a valuable resource for fill and construction aggregate, and for beach replenishment. Most fine-grained material dredged from channels of harbors surrounding Long Island Sound is not measurably different from the sediments accumulating in areas contiguous to the channels. These materials may differ in their levels of contaminants from sediments of similar grain size accumulating naturally within the Sound.

Many fine-grained materials could be put to constructive uses, but to date the alternatives to "disposal" rarely have been economically attractive. The only exception is construction or replenishment of wetlands.

6.3 HOW CAN ONE CHARACTERIZE THE POTENTIAL BIOLOGICAL IMPACT OF SEDIMENTS TO BE DREDGED?

The sediments can be characterized by either measuring the concentration of pollutants in the sediment or by studying their physiological impact on sensitive organisms, usually under laboratory conditions.

To analyze for potentially harmful chemicals in the sediment, one must select the specific elements or compounds for which an analysis is to be carried out and the material must be separated from the sediment for analysis. To obtain the bulk concentration of the contaminant, one uses strong acids or solvents to remove the material. Since some of the contaminant may be strongly bound to the sediment, the bulk concentration is always larger than the fraction that would be available for uptake by organisms. The bulk composition gives an upper limit to the pollution hazard.

In order to separate the readily-available from the tightly-bound contaminants, an elutriate test can be carried out. In this test, the sediment is resuspended in "clean" sea water from the proposed disposal site. After the sediment has settled out, the sea water is analyzed for changes in concentration of specific pollutants. The results depend on the specific procedure employed. The concentration of pollutants in the water can actually be reduced in some cases because of adsorption by the sediment. The actual mobilization of pollutants from the sediment in passing through an organism will differ for different organisms and is not simulated realistically by the elutriate test.

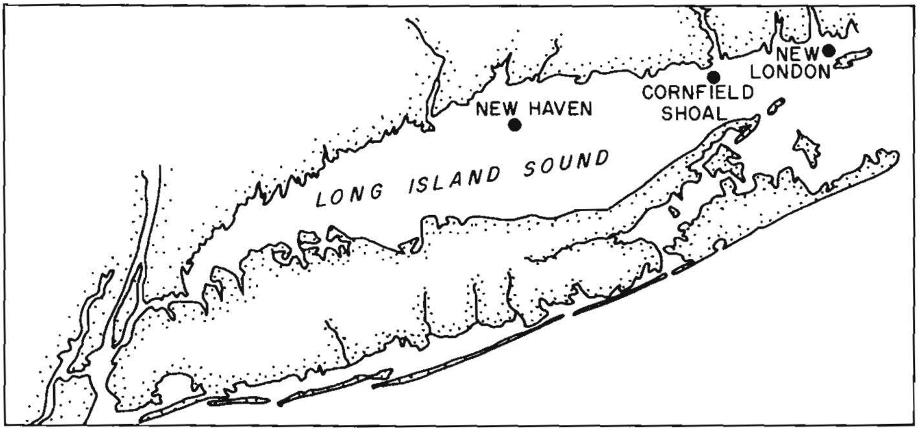
6.4 WHAT ARE THE APPROVED DISPOSAL SITES IN LONG ISLAND SOUND? WHAT KINDS AND QUANTITIES OF MATERIAL ARE THEY APPROVED FOR?

Under the current Interim Dredged Material Management Program which was adopted in 1977, three areas in Long Island Sound have been designated as open-water disposal sites (Fig. 6.4).

1. A two square mile area centered on 41° 08.0'N, 72° 53.0'W in the middle of the Sound south of New Haven, Connecticut, in the vicinity of the historical New Haven dumping grounds. This site is to be referred to as the "Central Long Island Sound Regional Dredged Material Disposal Area."
2. A one mile square area centered on 41° 12.6'N, 72° 21.6'W in the middle of the Sound south of the mouth of the Connecticut River, in the vicinity of the historical "Cornfield Shoals" dumping grounds. This site is to be referred to as the "Connecticut River Regional Dredged Material Disposal Area."
3. The historical New London dumping grounds is designated on an interim basis pending results and recommendations of ongoing disposal monitoring and research. This site is a one nautical mile square area centered on 41° 16.3'N, 72° 04.6'W south of the mouth of the Thames River, New London, and Groton.

The Central and New London sites are "containment" sites and are approved for dredged material of all types. The Connecticut River site is a "dispersal" site and can only be used for disposal of non-degrading materials.

New England River Basins Commission. 1979. Interim Plan and Draft Environmental Impact Statement for the Disposal of Dredged Material in Long Island Sound. Ninety-Day Draft Review. 55pp.



6.5 IN THE NEXT TEN YEARS, WHAT PORTS ON THE SOUND WILL PROVIDE THE BULK OF THE FINE-GRAINED, CONTAMINATED MATERIAL?

Most of the contaminated dredged material requiring disposal in the next ten years will come from several Connecticut ports along the Sound, although maintenance dredging scheduled for Port Chester Harbor and Eastchester Creek in New York will also produce substantial quantities of these materials.

The New England District of the U.S. Army Corps of Engineers has compiled a qualitative ranking of the relative degree of pollution in the sediments found in navigation projects in Connecticut, based primarily on bulk analysis of these sediments for heavy metals. The four harbors heading the list, in decreasing order, are: Bridgeport, New Haven, Stamford, and Norwalk. Projected maintenance dredging volumes for these four harbors over the next decade total approximately 1.6 million yd^3 (1.2 million m^3), most of which will most probably be relatively high in contaminants. Additionally, New Haven Harbor is scheduled for improvement dredging totalling 6.5 million yd^3 (5.0 million m^3) during this period, although what percentage of this material will be fine-grained and contaminated is not known. These four harbors will, then, provide the bulk of the contaminated dredged material during the next ten years, although smaller quantities of potentially contaminated material may be produced from such harbors as Greenwich and Milford.

Scheduled maintenance and improvement dredging by the Corps of Engineers and the Navy in the Thames River area will produce nearly 4.0 million yd^3 (3.0 million m^3) in the next ten years. However, sediment data supplied by the Corps indicate that this material will contain lower levels of potentially harmful contaminants than does the material removed from more western harbors along Long Island Sound.

6.6 HOW DOES NEW YORK DEFINE CONTAMINATED SEDIMENT? WHAT IS CONNECTICUT'S DEFINITION?

Under existing laws and regulatory procedure, neither State legally defines "contaminated" sediments. The primary "yardstick" used by the states to assess the polluting potential of sediments to be dredged are set forth by the U.S. Environmental Protection Agency in "Guidelines for the Discharge of Dredged Materials in Navigable Waters" (40 CFR 230.1). These guidelines assist that state in whose waters the material is to be disposed in assessing the degree to which the disposal will permanently violate state water quality standards.

Additional guidelines on assessing the contaminant status of sediments to be dredged have been jointly developed by the Connecticut Department of Environmental Protection and the New York Department of Environmental Conservation as part of the Interim Plan for the disposal of dredged materials in Long Island Sound, now the responsibility of the New England River Basin's Commission. Excerpts from these guidelines are reproduced below.

> Classification of materials to be dredged: water content, grain size, volatile solids, and oil and grease are broad spectrum indicators of sediment quality which provide a means for evaluating the biological impact of dumping various types of material at designated sites in Long Island Sound. Here, they are utilized to subjectively classify dredged material in terms of its polluting potential or characteristics.
>
> Dredged material sediment is classified as follows:

	Class I	Class II	Class III
Percent oil and grease			
(hexane extract)	< 0.2	0.2-.75	> .75
Percent volatile solids			
(NED method)	< 5	5-10	> 10
Percent water	< 40	40-60	> 60
Percent silt-clay	< 60	60-90	> 90

In actual practice, results of sediment analyses may yield Class III percent silt-clay, Class II percent water, and Class I percent volatile solids and oil and grease, or any other combination. Relative to the subjective probability for adverse environmental impact these parameters rank: oil and grease > volatile solids > percent water > percent silt-clay. In the above example, the sediment would be judged as Class II material; similarly, Class I silt-clay, Class I water, Class II volatile solids, and Class III oil and grease would be judged Class III material.

Class I sediments are often relatively coarse-grained with high solids content, and low concentrations of volatile solids, oil and grease, heavy metals, and other potential pollutants. Class I sediment may be judged "clean," "relatively clean," and/or "non-degrading," based on a case-by-case subjective evaluation of the dredge site and/or metals concentration. Class I materials include non-recent and recent sediments which are suitable for capping materials at open water dump sites, for habitat creation projects, or rehandling for productive uses including beach nourishment and land fill cover.

Class II sediments are often relatively

fine-grained with moderate solids content. Class II materials may be moderately enriched with potential pollutants, volatile solids, oil and grease, and metals, at levels often sufficient to be a cause for concern. A subjective evaluation of the dredge site and metals is needed to designate this material as either "non-degrading" or, "potentially degrading." Class II sediments may be suitable for habitat creation projects and for capping Class III material.

Class III sediments are usually fine-grained with low solids content. These materials are often highly enriched with potential pollutants, volatile solids, oil and grease, and metals. Class III sediments may be judged "potentially degrading" or "potentially hazardous" based on the relative concentrations of pollutant constituents. The probability for Class III sediments being "toxic" to marine bottom fauna may be high. Subjective evaluation of metals and other pollutants, and objective review of bioassay and/or bioaccumulation test results, may be required to determine the suitability of Class III material for open water disposal at Long Island Sound regional disposal areas. Demonstrably "toxic" materials will not be dumped at the regional sites unless there is an adequate quantity of suitable Class I or II cap material available. Land disposal and containment of Class III sediment should be given priority.

Statistical analysis of metals data on sediments from numerous ports and harbors, as well as non-spoil sediments from the vicinity of open water disposal areas, suggest the following operational limits are appropriate to enable confirmation of the sediment class designations described above. Average and range values for metals in Central Long Island Sound sediments are included for comparative purposes.

	Central Sound Sediment Average (ppm dry basis)	Range	Level of Enrichment		
			Low	Moderate	High
Hg	.05	.05	< 0.5	0.5-1.5	> 1.5
Pb	27.8	6-63	< 100	100-200	> 200
Zn	87.8	2.3-214	< 200	200-400	> 400
As	--	--	< 10	10-20	> 20
Cd	1.3	1-2.9	< 3	3-7	> 7
Cr	28.8	2-108	< 100	100-300	> 300
Cu	69.6	2-269	< 200	200-400	> 400
Ni	11.2	2-40.6	< 50	50-100	> 100
V	--	--	< 75	75-125	> 125

*Long Island Sound Benthic Survey, Sandy Hook Laboratory Ecosystems Investigations, Interim Report December 1972.

In addition, the following operational limits for organo-chlorides will be used to confirm sediment classification. For PCBs, concentrations above, 1.0 milligrams per liter will be considered as confirmation of high contamination, for DDT > .05 and Dieldrin > .01.

Class I material is considered clean material acceptable for beach nourishment or open water disposal at regional disposal sites or at a site of similar lithologic background. Class II material may be discharged at one of the three identified disposal sites. Class III material is considered to be contaminated and may only be considered for open water disposal if (1) there is a compelling necessity to accomplish the dredging; (2) no upland sites are available even at considerable cost; and (3) special mitigating measures such as capping or seasonal constraints are employed to prevent adverse environmental impacts. In addition, bioassay tests will be required on Class III material for projects not given prior disposal approval during the initial 30-day review. Bioassay tests will be conducted in accordance with the EPA manual for Section 103 of Public Law 92-523, Ecological Evaluation of Proposed Discharge of Dredged Material in Ocean Waters (as updated).

New England River Basins Commission. 1979. Interim Plan and Draft Environmental Impact Statement for the Disposal of Dredged Material in Long Island Sound. Ninety-Day Draft Review. 55pp.

6.7 WHAT SEDIMENT AND WATER QUALITY STANDARDS GOVERN DISPOSAL OF DREDGED MATERIAL IN LONG ISLAND SOUND?

Water quality standards have been developed by New York and Connecticut pursuant to the 1972 Federal Water Pollution Control Amendments. To date, there are no standards governing dredged sediment quality for open-water disposal in the Sound. Pursuant to Sec. 404 of the Clean Water Act (P.L. 95-12), the Environmental Protection Agency and the Army Corps of Engineers have adopted *guidelines* for the evaluation of dredged material. These guidelines include determination of testing requirements, interim test procedures, guidelines for interpreting test results and also guidelines for selection of disposal sites. For a disposal project to be permitted, the applicant must demonstrate that the disposal operation does not permanently violate any of the standards delineated for the waters of the State in which the operation takes place. The standards of the two State's are listed below

NEW YORK

Quality Standards for Saline Surface Waters

Items	Specifications
1. Garbage, cinders, ashes, oils, sludge or other refuse	None in any waters of the Marine District as defined by Environmental Conservation Law
2. pH	The normal range shall not be extended by more than one-tenth (0.1) pH unit
3. Turbidity	No increase except from natural sources that will cause a substantial visible contrast to natural conditions. In cases of naturally turbid waters, the

	contrast will be due to increased turbidity.
4. Color	None from man-made sources that will be detrimental to anticipated best usage of waters.
5. Suspended, colloidal, or settleable solids	None from sewage, industrial wastes or other wastes which will cause deposition or be deleterious for any best usage determined for the specific waters which are assigned to each class.
6. Oil and floating substances	No residue attributable to sewage, industrial wastes or other wastes, nor visible oil film nor globules of grease.

Quality Standards for Class "SA" Waters[1]

Items	Specifications
1. Coliform	The median MPN count value in any series of samples representative of waters in the shellfish growing area shall not be in excess of seventy (70) per one hundred mℓ.
2. Dissolved Oxygen	Shall not be less than 5.0 mg/ℓ at any time.
3. Toxic wastes and deleterious substances	None in amounts that will interfere with use for primary contact recreation or that will be injurious to edible fish or shellfish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor or sanitary condition thereof or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

[1]According to New York Class "SA" waters shall be suitable for shellfishing for market purposes and for primary and secondary contact recreation.

CONNECTICUT

Quality Standards for Coastal and Marine Waters, Class SA[2]

	Items	Specifications
1.	Dissolved oxygen	Not less than 6.0 mg/ℓ at any time.
2.	Sludge deposits - solid refuse - floating solids, oils and grease - scum	None other than of natural origin[3].
3.	Silt or sand deposits	None other than of natural origin except as may result from normal agricultural, road maintenance, construction activity, or dredge material disposal provided all reasonable controls are used[3].
4.	Color and turbidity	None other than of natural origin except as may result from normal agricultural, road maintenance, construction activity, or dredge material disposal provided all reasonable controls are used. A secchi disc shall be visible at a minimum depth of 1 meter, SA - criteria may be exceeded.
5.	Coliform bacteria per 100 mℓ	Not to exceed a median MPN of 70 and not more than 10% of the samples shall ordinarily exceed an MPN of 230 for a 5-tube decimal dilution or 330 for a 3-tube decimal dilution.
6.	Taste and odor	None allowable.
7.	pH	6.8 - 8.5
8.	Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 83°F or in any case raise the normal temperature of the receiving water

		more than 4°F. During the period including July, August, September, the normal temperature of the receiving water shall not be raised more than 1.5°F unless it can be shown that spawning and growth of indigenous organisms will not be significantly affected.
9.	Chemical constituents	None in concentrations or combinations which would be harmful to human, animal or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, impair the palatability of same, or impair the waters for any other uses.

[2]Connecticut defines SA waters as being suitable for all sea water uses including shellfish harvesting for direct human consumption (approved shellfish areas), bathing, and other water contact sports. They may be subject to absolute restrictions on the discharge of pollutants; authorization of new discharges other than cooling or clean water or dredged materials would require revision of the class to Class SB which would be considered concurrently with the issuance of a permit at public hearings.

[3]Except within designated dredged material disposal areas, waters shall be substantially free of pollutants that: a) unduly affect the composition of bottom fauna; b) unduly affect the physical or chemical nature of the bottom; and c) interfere with the propagation and habitats of shellfish, finfish, and wildlife. Dredged materials dumped at approved disposal areas shall not pollute the waters of the State and shall not result in: 1) floating residues of any sort; 2) release of any substance, biological or chemical constituents which may result in long-term or permanent degradation of Water Quality Standards overlying or adjacent to the dumping grounds; 3) unintentional dispersal of sediments outside a mixing zone enclosing the designated dump points; and 4) biological mobilization and subsequent transport of toxic substances to food chains.

6.8 WHAT PERMITS ARE REQUIRED BEFORE A DREDGING/ DISPOSAL OPERATION CAN TAKE PLACE IN LONG ISLAND SOUND?

Dredging Permits

Under Article 15 of the Environmental Conservation Law of the State of New York and Part 608 of the New York Code of Rules and Regulations, anyone wishing to dredge in the marine district of the State must first obtain a permit from the New York State Department of Environmental Conservation. The basis for the issuance of a permit under this provision is a finding that the proposed dredging is reasonable and necessary, will not endanger the health and welfare of the people of the State and will not cause "unreasonable, uncontrolled or unnecessary damage to the natural resources of the State."

If the dredging area is within a tidal wetland (including salt marshes, shoals and flats, and open waters less than six feet deep at mean low water) approval under Article 25 of the Environmental Conservation Law and Part 661 of the New York Code of Rules and Regulations is required. This is a tidal wetlands permit, issued by the New York Department of Environmental Conservation. This permit certifies that the proposed action "...will not directly or indirectly substantially alter or impair the natural condition, function or values of any tidal wetland..."

The proposed dredging operation must also obtain certification under Public Law 95-12, Section 401 which mandates that any action must not irreparably damage water quality in the area of the dredging site.

Section 25-11 of the General Statutes of Connecticut requires a permit for any dredging activity in Connecticut waters other than that involving maintenance dredging of an existing channel, turning basin, vessel berth, mooring area or other existing waterfront facility. Such a permit is issued only after it has been determined that the dredging activity will not adversely affect the environment.

Disposal Permits

When the disposal site is in New York, the applicant must obtain a Water Quality Certificate from the New York State Department of Environmental Conservation pursuant to Section 401 of the Federal Water Pollution Control Act, 1977 Amendment, stating that the proposed disposal operation will not permanently impair water quality in the disposal area. The State has published a list of water quality standards that must be adhered to in any dredging/disposal operation.

If the dredged material is to be used as fill either in water or in a wetland, the above noted Water Quality Certificate is required, and in addition permits under parts 661 and/or 608 of the New York Code of Rules and Regulations.

If land disposal is being considered, a solid waste permit under Part 360 of the New York Code of Rules and Regulations must be obtained. If there is liquid runoff from the disposal site to a nearby waterbody, a discharge permit under Parts 750-757 must also be obtained.

It is common practice for the New York State Department of Environmental Conservation to process applications for the several permits required by a dredging/disposal operation simultaneously.

For the discharge of dredge material in Connecticut waters, on the State level, a Water Quality Certificate is required persuant to Section 401 of the FWPCA Act of 1977. See question 6.7 for the provisions of the Connecticut State Water Quality requirements.

On the Federal level, the Environmental Protection Agency published proposed guidelines (see 40 CFR 230) for the discharge of dredged or fill material in navigable waters. These guidelines were published pursuant to Section 404 of the Federal Water Pollution Control Act Amendments of 1977.

The Implementation Manual for Section 103 of the Ocean Dumping Act entitled, "Ecological Evaluation of Proposed Discharge of Dredged or Fill Material in Navigable Waters" provides further guidance on the selection of acceptable open-water disposal sites.

These guidelines provide the Army Corps of Engineers and other cognizant State/Federal Agencies procedures by which to evaluate the issuance of a permit to discharge dredge material in navigable water under their 404 permits program.

The definitive regulatory procedure which guides disposal decisions at the Corps level is a State 401 Water Quality Certificate which must be furnished or waived before the Corps can issue a permit or, proceed with one of their own projects.

New England River Basins Commission. 1979. Interim Plan and Draft Environmental Impact Statement for the Disposal of Dredged Material in Long Island Sound. Ninety-Day Draft Review. 55pp.

6.9 WHO HAS THE RESPONSIBILITY AND AUTHORITY FOR DESIGNATING DISPOSAL SITES IN LONG ISLAND SOUND?

Through its regulatory programs the U.S. Army Corps of Engineers has the authority to designate disposal sites not only in Long Island Sound but in all waters of the United States and territorial seas pursuant to Section 404 of the Federal Water Pollution Control Act Amendments of 1977 (Clean Water Act of 1977) and the Environmental Protection Agency's Guidelines for the discharge of Dredge or Fill Material in Navigable Waters (40 CFR Part 230). Long Island Sound is in a unique situation because the responsibility for designation of disposal sites is divided between the New England Division of the U.S. Army Corps, 424 Trapelo Road, Waltham, Massachusetts 02154, responsible for the jurisdiction in the State of Connecticut's waters, and the New York District of the U.S. Army Corps, 26 Federal Plaza, New York, New York 10007, responsible for jurisdiction in the State of New York's waters.

6.10 WHY IS MONITORING OF DREDGING AND DISPOSAL OPERATIONS NECESSARY, AND WHAT PARAMETERS SHOULD BE MEASURED?

The monitoring of dredging and disposal operations is necessary for political and environmental reasons. Although changes in physical conditions, primarily weather, may affect the predicted configuration of the discharge plume, and thus possibly the extent of the dredged material mound, these effects are probably small. However, it is important to monitor the dredging and particularly the disposal operation to insure that the dredged material is discharged into the authorized disposal area and to document any unanticipated medium-to-long range effects.

While short term monitoring of the chemical and physical impacts of dredging and disposal is probably of little value, long-term monitoring of the chemical and physical interactions of the dredged material with the surrounding water and sediments may be of great value. The ability to predict short-term chemical, physical, and biological interactions of dredged material and the environment is probably adequate considering their limited diagnostic value. This is not the case for long-term effects of these interactions. The data are few and the predictive capability poor. A better understanding of these effects can be best obtained through long-term monitoring of dredged material deposits in a variety of environments.

To date, only two extensive monitoring studies of dredging and disposal operations have been completed in Long Island Sound; a third is in progress. One was carried out by scientists from Yale University on the dredging of New Haven Harbor and open-water disposal at the New Haven dump site. The other study, conducted by the National Marine Fisheries Service and scientists of the University of Connecticut, monitored U.S. Navy dredging of the Thames River (CT) and disposal at the New London dump site. Results from these studies, and others conducted elsewhere in the country, indicate that the acute effects of dredging and disposal of fine-grained material are short-lived and confined to the immediate vicinity of the operations.

The third study which is in progress is designed to assess the feasibility of capping contaminated material placed on the ambient sea floor with clean material. Tests are being made to determine the relative effectiveness of fine-grained and coarse-grained "caps" in preventing erosion of the pile of contaminated material and in isolating it from the benthic community. The contaminated material was dredged from Stamford Harbor; the uncontaminated material from New Haven Harbor.

In an effort to generate information on the chronic, long-term impacts associated with controlled open-water disposal, the Connecticut Department of Environmental Protection and the New York State Department of Environmental Conservation have developed a preliminary framework for a monitoring program, to be implemented at each disposal area in the Sound. Elements of this monitoring program are excerpted and outlined below:

A) General Monitoring Program Design

1. Specific operation details and design of the monitoring program should be coordinated through the Technical Advisory Committee.
2. The monitoring program for each disposal area should include a minimum of two

blocks, a "spoil-mound block" and a "reference" or "control block."

3. Monitoring programs for each disposal site should be standardized and coordinated in terms of sampling dates, data acquisition, and data reduction procedures.
4. With the exception of disposal area bathymetry, physically, chemically and biologically *conservative* parameters within each block should be sampled at least twice a year, in early summer and late fall.
5. The spoil-mound block should have stations added as the disposal buoy is relocated. Spoil-mound stations should be occupied until:
   a) measurements merge with reference stations, or -
   b) sufficient information is obtained, or -
   c) sampling becomes redundant, or -
   d) station data become statistically stable.
6. The size of the reference and control blocks should be dictated by the spacial and/or temporal conservativeness of the parameters being evaluated.

B) General Parameters to be Measured in a Minimum Monitoring Program

1. Chemical and physical analyses of sediments giving special attention to "tags" including molluscan assemblages in the surficial spoil and recent sediments as well as deeper and geologically older sediment in both spoil and reference

blocks.

2. Bathymetry, including profiles through spoil mounds of interest and bathymetric reference stations (annually).
3. Reproductive and settlement success of the macrobenthos and/or key components of the macrobenthic communities of spoil mound and control blocks.
4. Visual inspection of stations in both block-types by SCUBA.
5. Potential toxicant body burdens in key components of infaunal or sessile components of benthic communities.
6. Bio-accumulation studies of selected food chain organisms.

Gordon, R.B. and C.C. Pilbeam. 1974. Environmental consequences of dredge spoil disposal in central Long Island Sound: Geophysical studies, Contr. Report to United Illuminating, New Haven, Conn.

National Marine Fisheries Service. 1975-1976. An environmental survey of the effects of dredging and spoil disposal, New London, Connecticut. 4th, 5th and 6th Quarterly Rept., Nat'l. Mar. Fish. Serv., Sandy Hook Lab.

Peterson, S.A. and K.K. Randolph. 1977. Management of bottom sediments containing toxic substances. Environmental Research Lab., U.S. Environmental Protection Agency Rept. 600/3-77-083.

New England River Basins Commission. 1979. Interim Plan and Draft Environmental Impact Statement for the Disposal of Dredged Material in Long Island Sound. Ninety-Day Draft Review. 55pp.

6.11 WHY ARE DREDGING PERMITS REQUIRED FOR A SMALL PROJECT WHEN ITS ENVIRONMENTAL EFFECTS ARE PROBABLY INSIGNIFICANT?

Though the effect of any one small operation may be negligible, the cumulative effect of many operations could be significant. Just as the exhaust of any one automobile would not lead to air pollution, the operation of many cars can lead to poor air quality. Protection of the environment from the cumulative impact of many individually insignificant sources of pollution requires the regulation of all inputs.

6.12 COULD THE NEED FOR MAINTENANCE DREDGING BE ELIMINATED BY ENFORCEMENT OF STRICT SOIL CONSERVATION PRACTICES?

The ultimate method of controlling the sediment that rivers contribute to estuaries is to control erosion at the source. The possibility of complete control, however, is remote. Erosion is basically a natural phenomenon. All land, whether in its natural state or altered by man's activities, yields a certain amount of sediment. Because the natural processes of erosion are less subject to control than are man's influences on these processes, perhaps the best that one can hope for is to keep erosion down to its natural level. But even this is probably a vain hope.

In spite of the marked reduction that conservation measures have caused in soil erosion since they began to be applied in earnest over 30 years ago, cultivated farmland in the eastern United States, for example, continues to yield sediment at about 10 times the rate of equivalent areas of forested land. In places where former croplands and grazing lands have been replanted in forests and grasses, sediment yields have been considerably reduced. Although it is true that as long as men cultivate land, there seems to be little hope of reducing sediment yields to their natural rates--rates typical of heavily vegetated lands--much more effort should be directed at reducing sediment yields through appropriate soil conservation practices. If these controls are enforced not only for agriculture, but also for strip mining, urbanization, and highway construction, significant reductions in sediment inputs to estuaries will result. These reductions will, within a period of decades, be manifested in reductions in the dredging activity required to maintain many shipping channels; and may result in improvement in water quality of the estuarine zone, particularly if nutrient inputs are decreased. The need for dredging will, however, persist. This is particularly true for the harbors and bays bordering the Connecticut side of Long Island Sound.

Most of the sediment accumulating in the bays and harbors along the Connecticut shore comes from the Sound. This is material that was previously deposited in the Sound during a period of lowered sea level and is now being removed (resuspended) by tidal currents and wind waves and carried into these embayments by the estuarine (upstream) flow in their lower layers.

Meade, R.H. 1969. Errors in using modern steam-load data to estimate material rates of denudation. Geol. Soc. Amer. Bull. 80:1265-1274.

6.13 WHAT CREATIVE USES COULD BE MADE OF TYPICAL, FINE-GRAINED SEDIMENTS DREDGED FROM LONG ISLAND SOUND AND CONTIGUOUS WATERS?

At present, only one creative use--formation of wetlands--appears practicable for fine-grained dredged material from Long Island Sound. There exist few available sites along the shoreline of the Sound suitable for creation of wetlands, but in contiguous bays and tributary rivers a large number of publicly-owned potential sites exist.

A large proportion of the natural tidal wetlands on the Sound, especially those along the Connecticut shore (few ever existed on most of the Long Island side), have been destroyed by past filling and dredging. Wetlands have important ecological values, such as nursery grounds for fish species, wildlife support areas, pollution abatement functions, and open space amenities. Addition of new wetland areas would partly replace those that have been lost.

An appropriate site for creation of a wetland is a shallow submerged area that is accessible, sufficiently protected from waves for marsh plants to grow and reproduce, and an area whose value would be enhanced by conversion to wetland. Where such an area can be identified, it can be diked and filled to a level just below mean high water. After settling and consolidation, marsh plants, seeds, or seedlings can be introduced.

Other economically and environmentally attractive creative uses for fine-grained dredged material may be developed in the future.

Woodhouse, W.W., Jr., E.D. Seneca, S.W. Broome. 1974. Propagation of *Spartina alterniflora* for substrate stabilization and salt marsh development. U.S. Army Corps of Engineers, Coastal Engn. Res. Ctr. Tech. Mem. No. 46.

6.14 ARE THERE PREFERRED TIMES OF YEAR TO MINIMIZE THE PROBABILITY OF DAMAGE FROM DREDGING AND DISPOSAL OPERATIONS?

While none of the field and laboratory studies to date have indicated any persistent deleterious effects of dredging and disposal on the biota or aesthetic qualities of Long Island Sound or its Harbors, one can minimize the probability of impact on any particular kind (group) of organisms or activities by restricting the times of year when dredging and disposal are permitted. It is clear, however, that no matter what period is specified, there is potential for impact on some kind (group) of organisms or conflict with some activities.

From the data presently available, September through February appears to be the most desirable time of year to schedule large dredging and open-water disposal operations to reduce the probability of adverse environmental impact on the greatest number of organisms and activities. From the operational standpoint of the dredges, late fall to early spring is not the best time to dredge; weather and sea conditions are less favorable and ice can be a problem. These factors are particularly important for open-water pipeline disposal operations. More frequent breakdowns means greater costs and extended periods of dredging. As more data become available, the span of this "dredging window" should be adjusted to provide appropriate protection of the Sound's resources at acceptable economic costs.

6.15 WHY SHOULD MATERIAL DREDGED FROM CONNECTICUT BE DISPOSED OF IN NEW YORK WATERS?

The jurisdictional boundary between New York and Connecticut runs down the middle of Long Island Sound. This boundary has no relevance to potential impacts dredged material disposal in the Sound may have on it or on the organisms that inhabit it. The selection of dredged material disposal sites should be based primarily on environmental and economic criteria. If the "best" location requires transporting dredged material across State lines, it will be to the ultimate advantage of the residents of both States.

6.16 CAN AREAS OF THE BOTTOM OF LONG ISLAND SOUND BE DELINEATED WHERE DISPERSAL OF DREDGED MATERIALS WOULD BE VERY LOW AND THE MOBILIZATION OF CONTAMINANTS MINIMAL?

The fate of dredged sediment released in the Sound is difficult to predict because it depends upon many things--the type of material dredged, the method of dredging, as well as how, when, and where the sediment is discharged. Some areas of the Sound may be chosen, however, as having characteristics that would make them favorable places for the containment of dredged sediment. Such places would be characterized by relatively low current speeds and high rates of natural, mud accumulation. Based on these two factors, the three most favorable locations in Long Island Sound for the containment of mud are shown in Fig. 6.16.

Bokuniewicz, H.J. and R.B. Gordon. 1979. Containment of particulate wastes at open-water disposal sites. Pages 109-130 *in* H.D. Palmer and M.G. Gross, eds. Ocean Dumping and Marine Pollution, Dowden, Hutchinson and Ross, Inc., Stroudsburg, Pennsylvania.

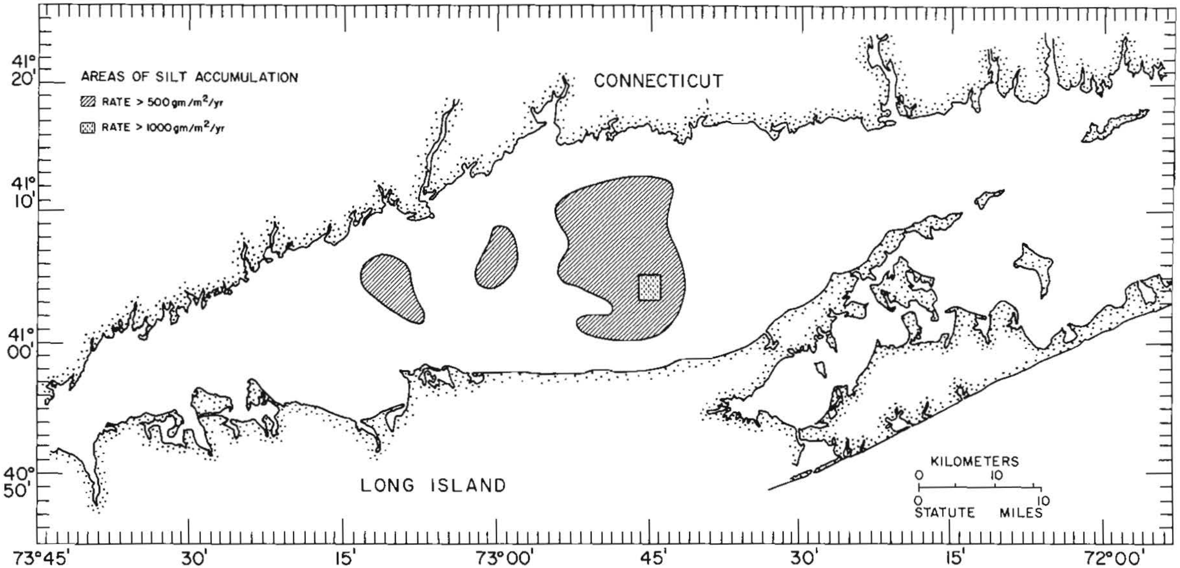


Fig. 6.16 Areas of L.I.S. in which fine-grained sediments are naturally accumulating.

6.17 IS IT BETTER TO BROADCAST DREDGING SPOIL OR SHOULD IT BE PLACED SO THAT ITS SURFACE AREA IS MINIMAL?

If the material is fine-grained and uncontaminated, broadcasting the material over existing muddy bottoms would have minimal physical effects on the biota.

If the material is contaminated, depositing it in constricted depressions in which there is little erosion would minimize the surface area and its impact on the biota.

6.18 ARE THERE ANY DEEP HOLES IN THE SOUND THAT WOULD MAKE GOOD DISPOSAL SITES? IDENTIFY THEM!

Most of the natural isolated deep holes in the Sound are deep because fine-grained sediments, silt and clay, are unable to accumulate in them because of high tidal energy. Placement of fine-grained dredged materials in these holes is likely to result in dispersion rather than retention.

6.19 ARE THERE EXPLOITABLE DEPOSITS OF SAND AND GRAVEL IN LONG ISLAND SOUND? IF SO, WHERE ARE THEY LOCATED?

Almost half of the floor of Long Island Sound is blanketed with sand primarily in the eastern part, Fig. 6.19. Gravel is found in the deepest parts of the Race where tidal currents are strongest. Some sand mining has been done in harbors and nearshore for beach nourishment and aggregate. Mining the more extensive sand deposits on the floor of the eastern Sound would be more difficult because of the deeper water and strong tidal currents. The material from maintenance dredging can not be used as commercial sand and gravel because of the high content of silt and clay.

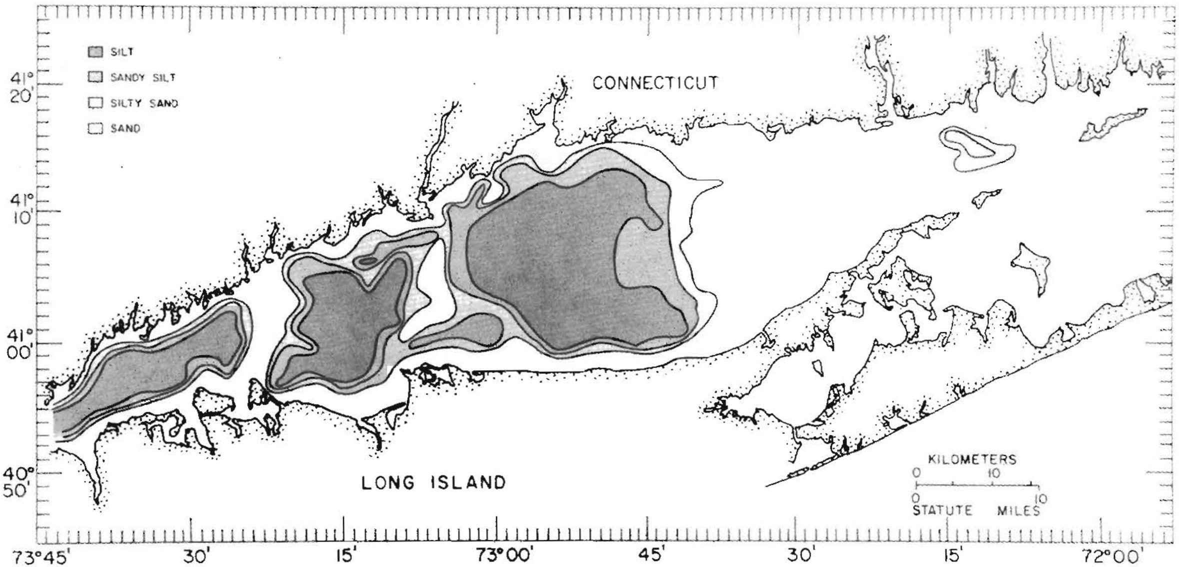


Fig. 6.19 Distribution of sediments in L.I.S.

6.20 COULD THE MINING OF SAND AND GRAVEL IN LONG ISLAND SOUND BE COMBINED WITH DISPOSAL OF CONTAMINATED DREDGED MATERIALS IN THE BORROW PITS?

Yes, provided the contaminated dredged material is deposited in the borrow pit without significant dispersion of material into the ambient water. The size of the hole must be chosen so that there is no subsequent erosion of the contaminated material. Capping with clean material would probably be required.

These procedures are within the capability of currently available technology, but would increase the cost of dredging and disposal.

6.21 HOW CAN PRIVATE CITIZENS PARTICIPATE IN THE MANAGEMENT AND PLANNING OF DREDGING AND DREDGED MATERIAL DISPOSAL IN LONG ISLAND SOUND AND CONTIGUOUS WATERS?

All dredging and dredged material disposal projects in Long Island Sound waters require a permit from the Army Corps of Engineers. The Corps issues a public notice of each application received, well *before* it is acted upon. Individuals can keep track of such notices in newspapers or at organizations which receive and post or file them. If desired, they can request that copies be sent to them personally.

Each such notice includes a request for information on the anticipated effects of a proposed project from any private individual or organization which may have this information. If sufficient interest is shown, as evidenced by communications received or on the basis of Corps decision, a public hearing will be scheduled on an application. Anyone may present a statement at the hearing or submit a written statement within a prescribed period following the hearing. All statements will be considered by the Corps before a decision is made whether or not to issue a permit for the project.

In practically all cases approvals are also necessary, from State and/or local agencies. A private citizen can also present information to these agencies or at hearings instituted by them. Public notice of these actions is generally required, just as in the case of Corps permit applications.

Direct communication with elected officials and legislators is often appropriate since the legislators themselves will usually have significant input to management decisions in their districts. This input is likely to reflect their constituents' wishes and interests.

6.22 WHAT ELEMENTS SHOULD A DREDGING PLAN CONTAIN?

A dredging and dredged material management plan should:

(1) identify approved navigation channels and their characteristic dimensions.

(2) establish a policy for frequency of maintenance dredging of approved channels.

(3) establish a mechanism for acting on proposals for new dredging work.

(4) establish criteria for characterizing dredged material as to its suitability for different modes of disposal--overboard, upland, marginal, filling, confinement on an island, etc.

(5) designate and rank different kinds of disposal sites for different "types"--quantities and qualities--of dredged material.

(6) assign designated disposal sites to projects that require maintenance dredging.

(7) provide mechanisms for amending the plan to take account of changes in utilization of the Sound, improvements in dredging and disposal technology, and increased knowledge of environmental effects of different dredging and disposal strategies. A feedback mechanism to assess the effectiveness of the plan in a recurrent fashion is essential.

To be effective, a dredging and dredged material management plan must have built into it the authority to carry it out. This will occur only if the plan becomes a legal document.

6.23 WHAT AGENCIES SHOULD CITIZENS CONTACT FOR INFORMATION ABOUT A PARTICULAR DREDGING AND DISPOSAL PROJECT (FEDERAL/CONNECTICUT/ NEW YORK)?

In Connecticut contact:

Water Resources Unit
Department of Environmental Protection
State Office Building
Hartford, Connecticut 06115
(203)566-7160

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APPENDIX

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Glossary of Terms

Agglomerate - a composite particle composed of two or more individual particles held together by relatively weak binding forces. Agglomerates are produced by physico-chemical processes and by organisms.

Benthos - marine organisms which live in or on the sea floor.

Biomass - the amount of living matter per unit areas or volume expressed in units of mass/area or mass/volume.

Biota - the plant and animal life of a given region.

Continental Shelf - a zone adjacent to a continent or island and extending from the low water line to the depth at which there is a marked increase in the slope of the sea floor to great depths.

Delta - a deposit of sediment formed at the mouth of a river, stream or tidal inlet.

Density Flow - the flow of one water mass through, under or around another which retains its identity because of density differences from surrounding waters.

Deposit Feeder - an organism that feeds at or near the sediment-water boundary.

Depositional Plain - a low, flat area of sediment on either side of a river deposited during floods.

Detritus Feeder - an organism that feeds on the bacterially-decomposed remains of plants and animals, or on the bacteria themselves.

Drainage Basin - the land drained by a river or river system.

Fathometer - an instrument using sound impulses to measure water depth.

Fluid Mud Layer - a dense layer of fine-grained, unconsolidated sediment flowing along the sea floor, driven by gravity or by tidal currents.

Freshet - a flood or overflowing of a river, caused by heavy rain or melting snow.

Gradient - the rate of change of one quantity with respect to another; e.g., the rate of decrease of temperature with water depth.

Ground Water - that part of the subsurface water below the water table.

Heavy Metal - metallic elements with high molecular weights; some of these are toxic at low concentrations to plant and animal life.

Infauna - organisms permanently residing below the sediment-water boundary.

Interstitial Water - water contained in the pore spaces between the grains of rock or sediments.

Littoral Zone - the zone along the shore extending from the high tide line to some arbitrary shallow depth.

Nekton - swimming organisms that can direct their own movements against the action of marine currents.

Nutrient - any one of a number of compounds or elements used by photosynthetic organisms in the production of living material.

Otter Trawl - a large commercial fishing net using kite-like wooden boards at the corners of the mouth of the net, so angled that water pressure drives them apart, keeping the mouth of the net open as it is dragged through the water.

Oxidation - the process of chemical combination with oxygen or more generally, the removal of one or more electrons from an atom or molecule.

Percolation - process by which water passes through the pore space of rock or sediments.

pH - a chemical measure of the relative acidity of an aqueous solution.

Photic Zone - the layer of water which receives sufficient light for photosynthesis to occur; usually no deeper than 60m.

Photosynthesis - the production of organic compounds with the aid of radiant energy, principally light and carbon dioxide.

Plankton - plants (phyto) and animals (zoo) whose swimming powers are relatively weak. They usually float and drift passively in the water.

Polychaete - one of an order of marine worms, most of whom are segmented.

Primary Productivity - the amount of organic matter produced by plants from inorganic nutrients in a unit time per unit area or unit volume.

Recruitment - the increase in the size of biologic population through the addition of new individuals.

Reduction - the process of chemically removing oxygen from a compound or, more generally, the addition of one or more electrons to an atom or molecule.

Spawning - the release of masses of eggs by fishes, mollusks, crustaceans, amphibians, etc.

Species Diversity - an index number based on the ratio between the number of different species in an area and either the total numbers of individuals belonging to those species or their biomass.

Tidal Excursion - the horizontal distance a water parcel travels during one-half a tidal cycle.

Topography - the surface configuration of an area, including its vertical relief.

Turbidity - reduced water clarity resulting from the presence of suspended material.

Zonation - the organization of an area into more or less separate and distinct areas with different plant and animal associations.

Zooplankton - animal components of the plankton, including various crustaceans, jellyfish, worms, mollusks and the eggs and larvae of a wide variety of other organisms.