OCEAN DISPOSAL OF WASTE MATERIAL

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ABSTRACT

The anticipated increase of sewage sludge and other wastes being discharged off the New Jersey Atlantic Coastline has aroused the concern of numerous parties. At meetings called by the concerned parties the United States Public Health Service was requested to proceed with investigation of the effects of off-shore waste dumping and present recommendations for dump site locations and procedures.

The initial studies by the Northeast Marine Health Sciences Laboratory of the two main sewage sludge dump areas, the New York Bight serving the New York Metropolitan Area and a site off Delaware Bay serving Philadelphia and others in the Delaware River region, were planned to aid in defining the problem and in the planning of future investigations. Emphasis was given to the spread of bacterial contamination caused by the discharge of sewage sludge.

The health significance of sewage sludge dumped in deep seawater is the possible contamination of surf clams that may be harvested for human consumption. Shellfish are capable of concentrating and holding bacteria, viruses, and toxic substances that they ingest from their marine environment. In turn they can transmit these concentrations to consumers of the shellfish. The quantity of sewage sludge disposed of at present is approximately 12,600 cubic yards per day in the New York Bight and 1,400 cubic yards per day off Delaware Bay.

The results of the investigations showed that there was a rapid decrease of the coliform indicator. The decrease was presumably due to die-off in seawater and the large dilution volume of the sea. Samples taken in the wake of a discharging barge resulted in total coliform MPN of 150,000 per 100 ml for the Off Delaware Bay Study and in excess of 2,400,000 per 100 ml for both fecal and total coliforms in the New York Bight Study. Only 15 of the 85 samples taken during the regular sample schedule off Delaware Bay resulted in positive coliforms i.e., greater than 3 MPN per 100 ml and 25 of the 165 taken in the New York Bight resulted in total coliform MPN of greater than 100 per 100 ml.

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1. Contribution No. 28 from Northeast Marine Health Sciences Laboratory, National Center for Urban and Industrial Health, Bureau of Disease Prevention and Environmental Control, Public Health Service, Department of Health, Education, and Welfare, Narragansett, Rhode Island, 02882.

There was considerable sludge covering the bottom of the New York Bight disposal area. This is detrimental to production of surf clams which need a sand or gravel bottom. The possibility of a similar bottom build-up in the Delaware Bay dump area and its possible spread into coastal areas has caused concern.

The bacteriological data indicate that a well regulated sewage sludge disposal program would not cause widespread bacterial contamination. What the effects of the sludge blanket are and to what extent it will spread remains to be studied.

High concentrations of copper were found in seawater samples collected in the New York Bight Acid Waste Dump. They were approximately four times greater than the copper concentrations found in Narragansett Bay water.

INTRODUCTION

The concern for pollution by man's waste of inland and estuarine waters extends also to the open seas. As the capacity to produce waste increases larger disposal areas are sought and the vast expanse of the ocean is one that comes under consideration. To load some areas of the ocean with wastes without knowledge of what the end-long term effect will be on the biological populations might have serious consequences. The destruction of certain forms in one area could trigger a chain reaction felt in others. Accumulation of contaminants at one step in the food web could affect successive steps.

The prime mission of a health agency is to prevent injuries to the health of the people. One area of such responsibility lies in the prevention of edible shellfish and other marine food products, with bacterial, virological, chemical, and toxicological contamination from reaching the public. Discharges of waste materials off the New Jersey Atlantic coast have received attention as being a potential health hazard, shoreline defiler, and/or disrupter of the marine ecosystem.

BACKGROUND

Municipal sewage sludge, cellar mud, and rubble-excavation dumping in the New York Bight has been practiced for many years. Discharge of garbage, rubbish and other floatables is no longer allowed in the waters near New York Harbor. An acid waste disposal area was established in the 1940's and the Middle Atlantic Section of Atlantic States Marine Fisheries Commission and sportsmen groups were active in the 1940's and 1950's regarding the effects of acid waste disposal in the New York Bight on sport fish. At present the regular waste disposals off Delaware Bay are sewage sludge begun in 1961. In 1963 the Shellfish Sanitation Branch of the U. S. Public Health Service was requested to undertake the classification of Sea Clam (Surf Clam), Spisula solidissima areas beyond the territorial limits of the states. This led to preliminary studies on surf clam bacteriological sampling techniques and field trips on harvest boats were taken in preparation for studies of the waste disposal areas.

Then in 1965 Baltimore, Maryland proposed future disposal of that city's sewage sludge off Delaware Bay. This was followed by a proposal from a transportation company to begin operating a transport service of waste products from industrial plants not having access to ocean disposal. The collected wastes would then be barged to sea. The wastes the company proposed transporting were classified as: (a) city sludge, (b) inert industrial waste; (c) alkali waste; and (d) acid waste. The scope of these proposed operations increased the concern of state and Federal Health Agencies, conservation groups and agencies, including the shellfish industry over the disposal problem of wastes at sea. Conferences in March, May, and August 1966 by interested groups resulted in the request that the U. S. Public Health Service investigate the effects of waste discharges in the New York Bight and off Delaware Bay.

The requested investigations were undertaken by the Northeast Marine Health Sciences Laboratory and were very preliminary in nature. The role of NEMHSL in the National Shellfish Sanitation Program required that the main part of the investigation be directed toward shellfish growing water protection. The principal shellfish growing area criteria at present is based on bacteriological quality of the area waters so the primary work on the studies was directed to determining the extent to which bacterial pollution spread from the sewage sludge dump site.

Location of Surf Clam Resources and Waste Disposal Areas

Commercially important beds of the surf clam are found in an extensive area along the United States Atlantic Coast as shown in Figure 1 (Bureau of Commercial Fisheries, 1966).

The waste disposal areas investigated during the present study are located with respect to the mainland in Figure 2. Figure 3 presents the dump sites and the sample station locations in the New York Bight. Figure 4 depicts the sewage sludge disposal area and the sample station locations off Delaware Bay.

Quantities of Wastes

The quantity of sewage sludge discharged in the New York Bight from sources in the New York Metropolitan area presently averages approximately 12,600 cubic yards per day. The sludge is thickened prior to loading on the hauling vessel. Table 1 lists, by source, the total annual sludge volume disposed of in the New York Bight. The quantities of wastes listed in Table 1 were directed to be discharged southeast of Station 1 on Figure 3 in not less than 72 feet of water. The disposal of sewage sludge off Delaware Bay in the area shown on Figure 4 is listed in Table 2.

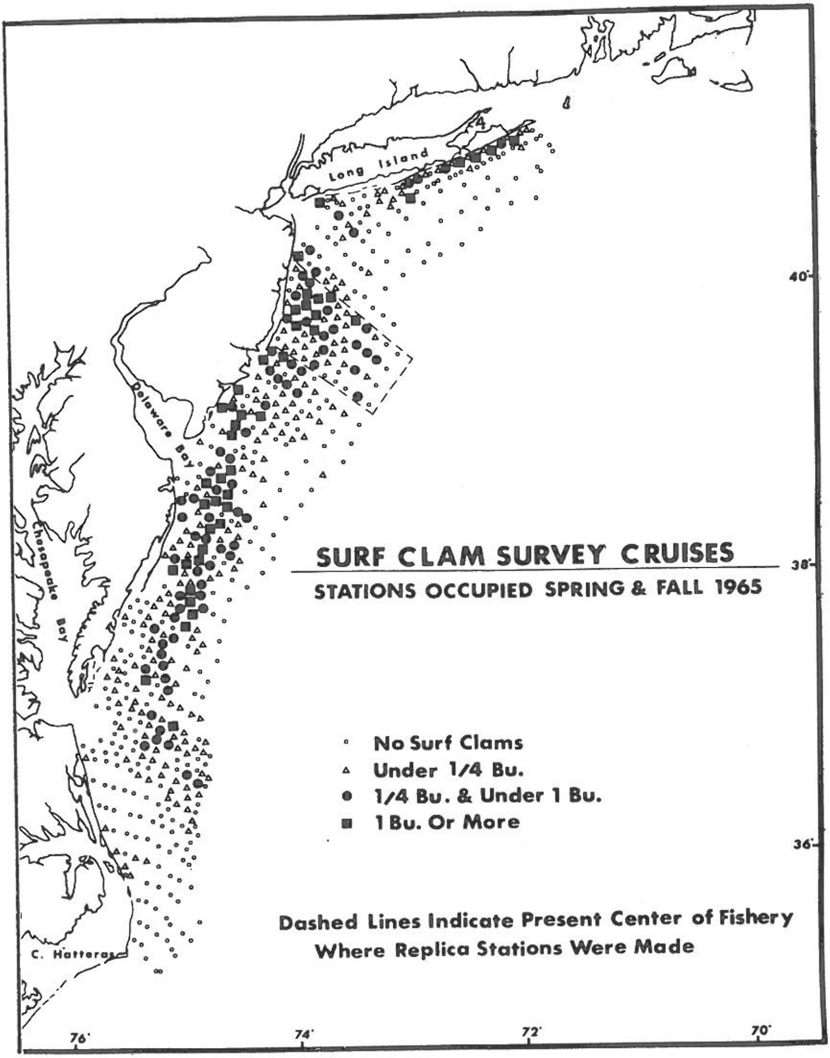

FIGURE 1

(Taken from the United States Bureau of Commercial Fisheries Biological Laboratory, Oxford, Maryland, Technical Report, Progress in Surf Clam Biological Research, June 1966.)

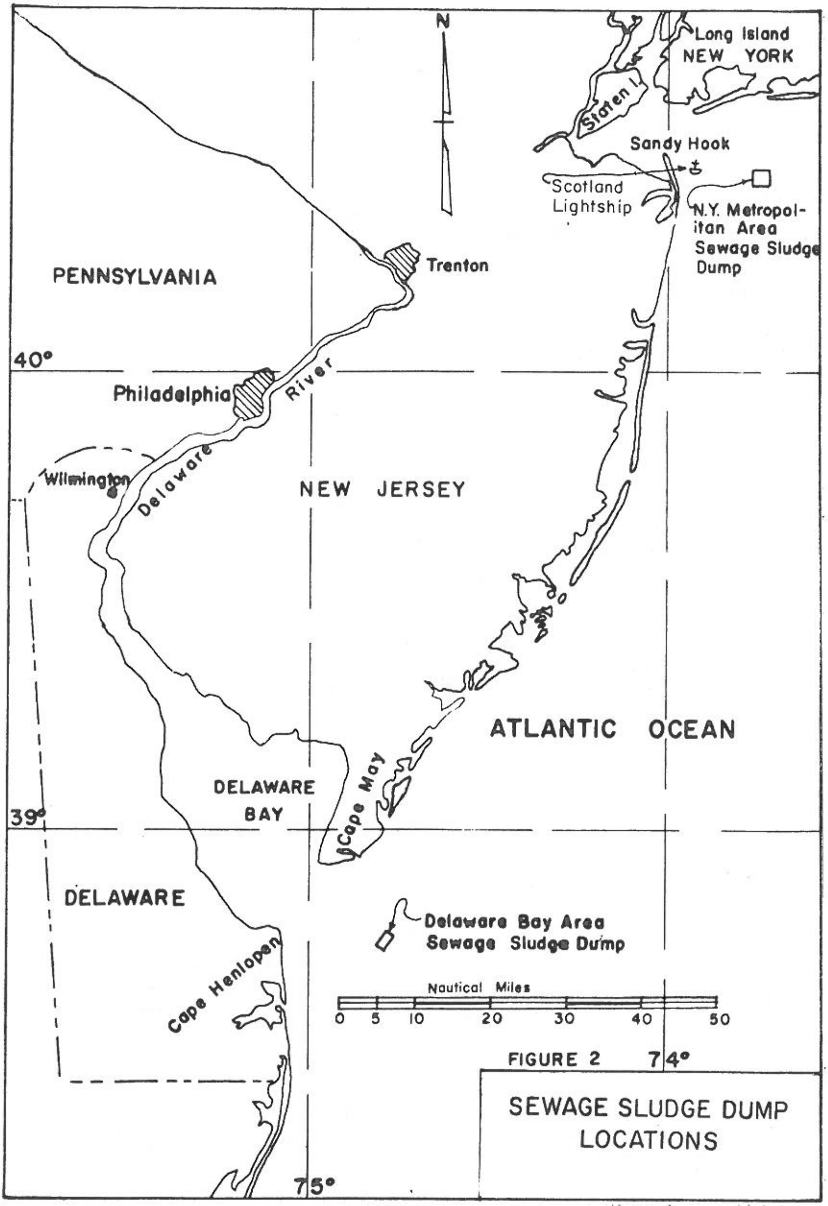

FIGURE 2

SEWAGE SLUDGE DUMP LOCATIONS

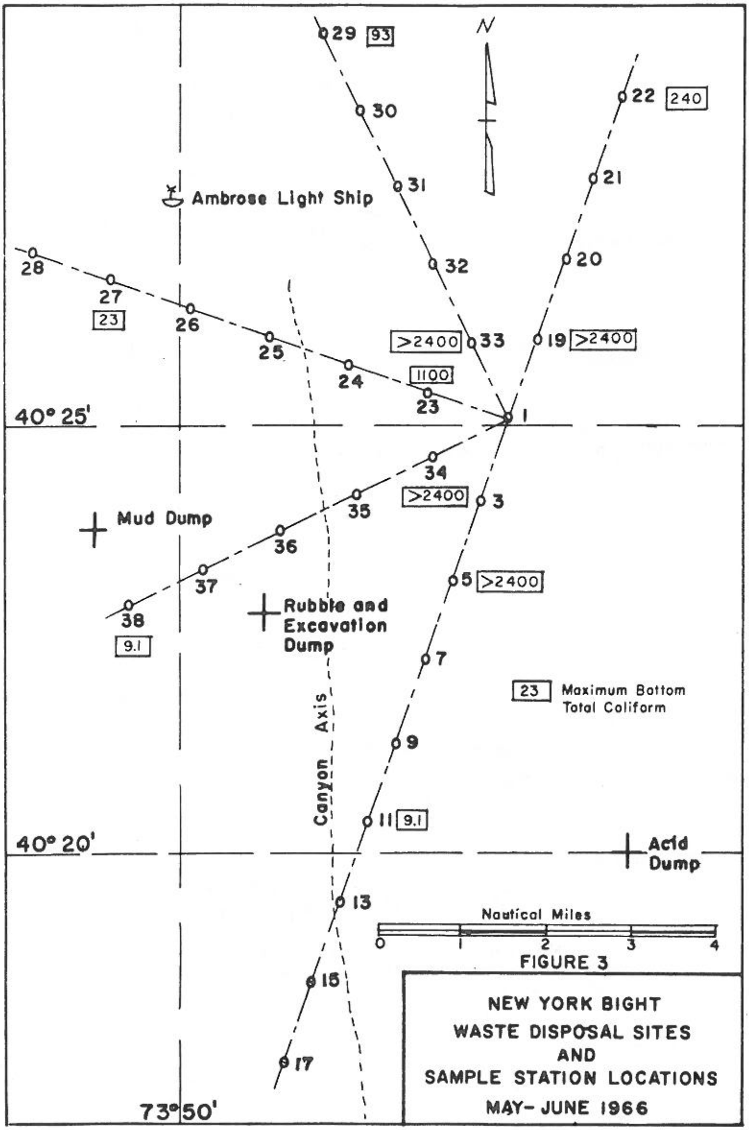

FIGURE 3

NEW YORK BIGHT
WASTE DISPOSAL SITES
AND
SAMPLE STATION LOCATIONS
MAY- JUNE 1966

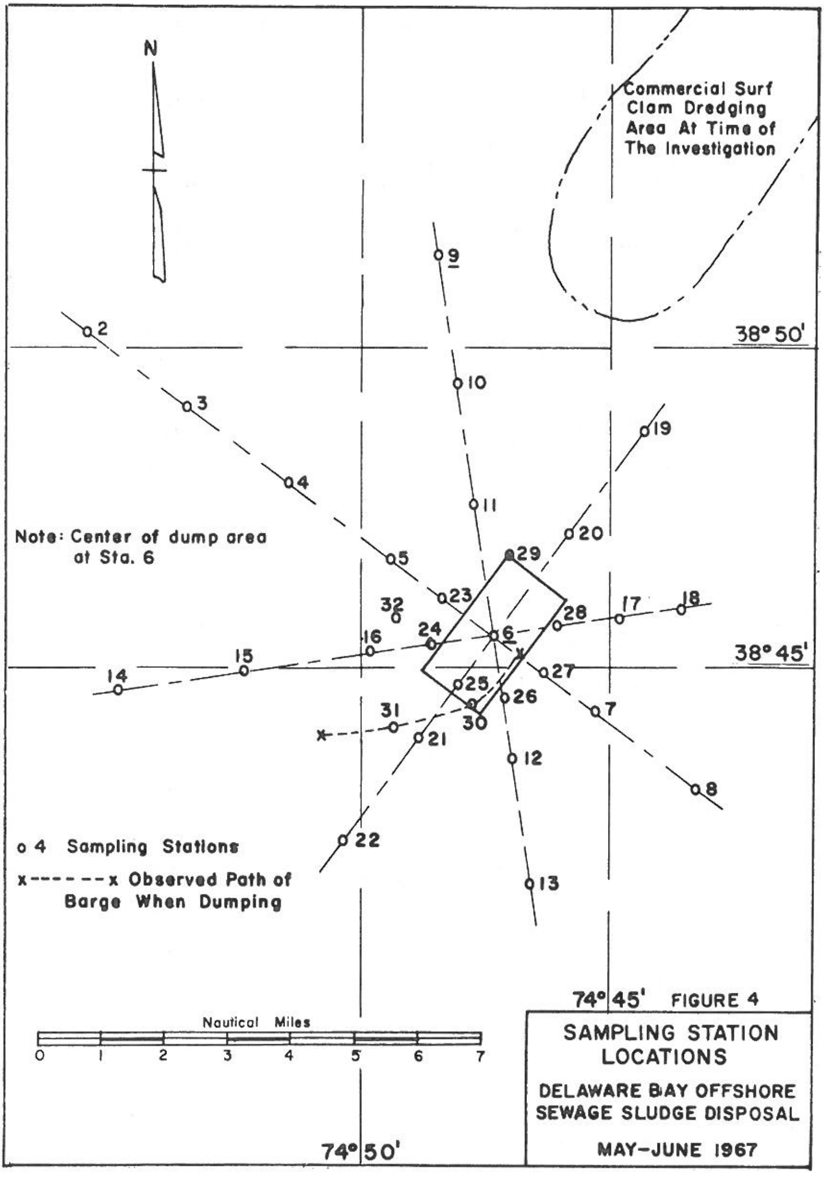

FIGURE 4

SAMPLING STATION LOCATIONS

DELAWARE BAY OFFSHORE SEWAGE SLUDGE DISPOSAL

MAY–JUNE 1967

TABLE 1

TOTAL SEWAGE SLUDGE VOLUMES DUMPED IN THE NEW YORK BIGHT FROM NOVEMBER 1964 THROUGH OCTOBER 1965*

SOURCE	VOLUME Cu.Yd.
Linden-Roselle, N. J.	107,880
Elizabeth Port, N. J.	150,780
Passaic Valley, N. J.	666,240
Middlesex County, N. J.	384,780
Bowery Bay, N. Y.	218,240
26th Ward, N. Y.	62,744
Coney Island, N. Y.	281,336
Wards Island, N. Y.	1,022,122
Tallmans Island, N. Y.	137,216
Glen Cove, N. Y.	12,960
Jamaica, N. Y.	105,672
Rockaway, N. Y.	43,928
Hunts Point, N. Y.	245,720
Rockaway Inlet, N. Y.	216,000
Yonkers, N. Y.	54,810
Port Richmond, N. Y.	18,016
Owls Head, N. Y.	237,432
Total	3,965,876 = 10,865 cu.yd. per day average

Note: Newtown Creek, N. Y. completed 1967 contributes an additional 1,800 cubic yards per day.

*Obtained from New York District Office of U. S. Army Engineers.

TABLE 2

VOLUMES OF SEWAGE SLUDGE BEING DUMPED OR PROPOSED FOR DUMPING OFF DELAWARE BAY

SOURCE	YEARLY VOLUME Cu.Yd.	STATUS OF DUMPING
City of Philadelphia, Pa.	446,000	In operation
City of Camden, N. J.	69,000	In operation
City of Baltimore, Md.	495,000	Proposed for 1970

Acid waste disposal in the New York Bight is directed to take place southeast of the point for acid waste dumping shown in Figure 3. The waste disposed of at this site is said to consist in part of 9% dilute H_2SO_4, 7% $FeSO_4$, and 25% inert solids. The waste is hauled in a barge with rubber lined tanks (eight acid and 2 mud tanks). The barge is 286 feet feet long, 52 feet wide and has a draft of 17 feet. The barge averages 1.6 trips per day.

BACTERIOLOGICAL RESULTS

Stored Sewage

Samples of stored sewage sludge from three of the sources disposing in the New York Bight were analyzed for coliform indicator organisms. Table 3 contains the results of these samples with one showing greater than 2.4×10^9 MPN per 100 ml for both total and fecal coliforms.

TABLE 3

COLIFORM MPN's PER 100 ML IN STORED SEWAGE

SAMPLE NO.	COLIFORM MPN PER 100 ML	
	total	fecal
1	$>2.4 \times 10^9$	43×10^6
2	$>2.4 \times 10^9$	$>2.4 \times 10^9$
3	4.3×10^6	4.3×10^5

The only sewage sludge sample analyzed from a source disposing off Delaware Bay showed a total coliform MPN of 7×10^6 and fecal coliform of 7.9×10^5 per 100 ml.

Sewage Sludge Dump

A water sample taken in the wake of a vessel as it discharged sewage sludge in the New York Bight was analyzed as having MPN values in excess of 2,400,000 per 100 ml for both total and fecal coliforms. A similar sample taken off Delaware Bay showed MPN per 100 ml of 150,000 total and <3,000 fecal coliforms.

Water

Surface, mid-depth and bottom (approx. 0.5 meter above bottom) water samples were taken twice at most of the sample locations of Figures 3 and 4 for bacteriological analysis. The sample stations were located by the crews of the chartered research vessels with the use of loran. The water samples were iced until they could be set up on shore. Total coliform and fecal coliform determinations were conducted according to APHA recommended procedures. Twenty-eight split samples were set up on the Research Vessel CHALLENGER (New York Bight) immediately after collection and at the shore laboratory after the days run was completed to determine the effects of icing and holding the samples for a few hours. The results showed that icing and holding the samples had no significant effect.

The maximum total coliform results from bottom samples in the New York Bight for points near the vertex and toward the ends of the sampling rays are indicated on Figure 3. The counts were greatly diminished at five miles or greater from Station 1, the point where discharge was to begin. In the New York

Bight only 25 samples in 165 showed total coliform MPN >100 per 100 ml. Off Delaware Bay where the waste discharge was much less and dumping averages once every three days instead of three times daily, only two water samples in 85 showed any positive coliform results at a distance of greater than two miles from the center of the dump site.

The vessels observed discharging in the New York Bight were all in the general designated disposal area but covered a range of at least two miles north or south of Station 1. It is easy to surmise that discharges could occur either short of or beyond the designated point without stationary markers indicating the point to begin discharge. Where shellfish sanitation is concerned the mile or two discrepancy would be important. We were unable to take samples east of Station 1 because of time limitations. Since the discharge protocol specifies that dumps are to be made while the barge is moving in a southeasterly direction, high counts would be expected at distances greater than five miles east and southeast of Station 1. The one discharge observed off Delaware Bay took the path shown on Figure 4 with approximately two thirds of it occurring outside the designated dump area. The tug towing the sludge barge was not equipped with loran and used radar reference to Capes May and Henlopen to determine its location. The dump path was determined from loran fixes by the crew of the R/V WOLVERINE chartered for this study.

The New York Bight results show that except when sampling closely followed a sludge discharge in the area being sampled, the higher coliform determinations were found in the bottom water samples. Those samples in which the total coliform MPN values were found to be greater than 100 per 100 ml are arranged in Table 4. The two high count surface samples at Station 5 on May 2 and 3 both reflect the effects of a sewage discharge influenced by a sludge discharge during the time of sampling. The majority of sludge appeared to settle rapidly after discharge as observed from the deck of the sampling vessel. A small portion of the discharged material remained on the surface in a visible pattern for at least two hours when the seas were relatively quiet. The 25 samples in Table 4 consisting of 16 bottom, 7 surface and only 2 mid-depth lend support to the visual observation that the major sludge components are either rapid settling or floating.

TABLE 4

TOTAL COLIFORM MPN's >100 PER 100 ML NEW YORK BIGHT
WASTE DISPOSAL AREA

Station	Date May 1966	Time EDST	Total Coliform MPN per 100 ml		
			Surface	Mid-depth	Bottom
1	2	1100			240
3	3	1105			>2,400
5	2	1220	11,000		
5	3	1125	>2,400	1,100	>2,400
7	3	1140	460		
19	6	1055		460	>2,400
20	6	1040	150		460
21	6	1025			240
22	6	1005			240
23	6	1115			1,100
24	6	1125			1,100
25	6	1140			210
26	6	1150	150		460
28	6	1220	460		
31	7	1003			460
32	8	0917			>2,400
33	8	0930			>2,400
34	7	1057			>2,400
35	7	1105	210		240

Table 5 contains the coliform determinations for the 15 samples that showed positive (>3 MPN per 100 ml) off Delaware Bay. The same pattern of sludge settling is shown here as in Table 4 with six bottom and only one each of surface and mid-depth samples showing >3.6 MPN.

TABLE 5

WATER QUALITY-BACTERIOLOGICAL SAMPLES OF
POSITIVE COLIFORM MPN>3

Station Number	Date June 1967	Depth	Total Coliform (MPN Per 100 ml)	Fecal Coliform (MPN Per 100 ml)
2	1	M*	3.6	
4	2	M	3.6	
5	1	B**	9.1	
	2	B	9.1	3.6
6	1	M	3.6	
		B	9.1	
7	2	S***	9.1	
20	2	B	3.6	
21	2	S	3.6	
		M	3.6	
22	2	M	3.6	
23	5	B	1,100	43
	7	M	9.1	
		B	15	
32	7	B	7.3	

*Mid-depth
**Bottom
***Surface

The results in Tables 4 and 5 also indicate that coliforms can survive for a time when concentrated in the bottom sludge. The samples taken at Stations 32 and 33, 8 May 1966, give such an indication (Table 4). According to the sludge dump schedule the last discharge prior to sample collecting should have occurred by 1730 hours on 7 May 1966. This would mean a time elapse of about 16 hours between the last reported discharge and sample collection on 8 May at 0930. The quantity of sludge discharged was large and this could have some bearing on the high counts. The bottom sample at Station 23, 5 June 1967 in Table 5 showed the highest coliform of any of the samples taken off Delaware Bay here and at least four hours had passed since a sludge discharge had been made.

After the sludge discharge shown on Figure 4 a series of samples were collected at Stations 30 and 31 that were in the dump path. Table 6 contains the results of these samples.

TABLE 6

BACTERIOLOGICAL DATA FOLLOWING DUMPING OF SEWAGE SLUDGE OFF DELAWARE BAY

Date 1967	Station No.	Time EDST	Depth	Total Coliform MPN	Fecal Coliform MPN	Time Elapsed Following Dumping (Minutes)	Temp. °C
June 7							
			S*	150,000	<3,000	1-2	
	30	1220	S	<3	<3	55	13.8
			M**	<3	<3		10.9
			B***	93	23		10.6
		1325	S	<3	<3	120	14.5
			M	3.6	3.6		11.1
			B	15	3.6		10.7
		1400	S	<3	<3	155	14.6
			M	3.6	3.6		10.6
			B	7.3	3.6		10.5
	31	1245	S	<3	<3	90	15.7
			M	3.6	<3		10.8
			B	3.6	<3		10.8
		1350	S	<3	<3	155	14.8
			M	<3	<3		10.7
			B	9.1	<3		10.8
		1420	S	<3	<3	185	14.1
			M	<3	<3		10.8
			B	<3	<3		11.0

*Surface
**Mid-depth
***Bottom

Barge began discharging at 1110 and was through at 1135.
Passed Station 31 at 1115.
Passed Station 30 at 1125.

Regrettably, there was considerable delay before the series was begun due to difficulty in finding markers along the dump path after returning from observing completion of the dump. Although visible evidence existed on the surface for over two hours, the water samples all resulted in low coliforms. The samples were taken along the dump path because of our inability to track the rapid settling sludge. Samples in the apparent direction of the travel of the settling discharge were taken at Stations 23 and 32 (Figure 4) between 3 to 3½ hours after discharge. They resulted in low positive MPN values for these Stations on 7 June (Table 5).

Sampling done in both studies was probably not intensive enough to eliminate the possibility of concentration of wastes in places not sampled. The rapid reduction of coliforms shown in the results of these studies can best be explained by a combination of dilution with the receiving seawater and die off in the water column due to the disinfecting power of seawater.

Clams

The bottom conditions in the New York Bight disposal area were badly fouled with mud, sludge, rubble, and other debris that would inhibit the surf clam which is a sand and gravel bivalve mollusk. Some shells but no surf clams were recovered in the clam dredge. One drag in the vicinity of Station 20 (Figure 3) produced some black quahaugs, Arctica islandica, which had MPN per 100 ml of 490 total and 78 fecal coliforms.

The result of the surf clam sample collected off Delaware Bay are in Table 7. Seven of the 10 clam samples analyzed showed positive for total coliforms with only one >2,400 MPN per 100 ml.

TABLE 7

SURF CLAM AND ASSOCIATED WATER BACTERIOLOGICAL DATA OFF DELAWARE BAY

		Clam		Water	
		Total Coliform	Fecal Coliform	Total Coliform	Fecal Coliform
Date 1967	Station No.	MPN per 100 ml		MPN per 100 ml	
May					
29	6	4,900	130	<3	<3
31	7	20	<18	<3	<3
31	8	<18	<18	<3	<3
31	17	20	<18	<3	<3
31	18	<18	<18	<3	<3
29	20	490	36	<3	<3
		330	36	<3	<3
June					
5	23	790	45	1,100	43
5	26	<18	<18	<3	<3
5	28	20	<18	<3	<3

Only one of the associated water samples taken with the clams had positive coliform MPN's. The coliforms in the clams might be attributed to the ability of the clam to concentrate coliforms or the possibility of survival of the coliforms in marine sediments. Bacteriological analysis of some bottom sediments should be done to ascertain if bottom sediments in the dump areas do maintain coliform populations. Greenberg (1956), reports that there is survival of enteric organisms in marine mud. This aspect may be very important. Water quality a few inches above the bottom may be meaningless if sewage sludge deposits contaminate only the water in immediate contact with the bottom and the clams then draw their food supply from this contaminated source. A further possibility for contamina- may occur if the clams are burrowing in a predominantly sewage sludge substrate. Some of each kind of microorganism found in raw sewage will survive sewage treatment processes such as digestion and holding of sewage sludge. Thus, sewage sludge contains numbers of the pathogenic bacteria and viruses found in raw sewage (Kabler, 1959).

HYDROGRAPHIC CONSIDERATIONS

New York Bight

The only hydrographic measurements made in the New York Bight were routine temperature and salinity. There was little evidence to indicate that stratification was of any consequence in the dump area during the time of the study. Temperatures rarely varied more than two degrees in up to 150 feet of water and salinities normally varied less than 2‰ with the lower salinities occurring at Stations nearest New York Harbor as would be expected. Wind conditions encountered did not produce any unusual changes in temperature or salinity. Winds during sampling were as high as 28 knots and ranged down to no measurable velocity but were usually rather brisk. The direction of the winds was extremely variable.

Several comprehensive hydrographic studies have been conducted in this area by others. Studies by Redfield (1951); Miller (1952); Howe (1962); and Bumpus (1965) provide an invaluable store of data on the area under consideration. The generalized surface flow during the month of May is south and shoreward. There is some indication that a surface drift may head toward the western tip of Long Island or perhaps toward Raritan Bay (Bumpus, 1965). Although Howe (1962) did not conduct spring studies, he did measure velocities at depth. Velocities adjacent to the New York Bight are shown in Table 8.

TABLE 8

CURRENTS NEAR NEW YORK HARBOR*

Depth (Meters)	Velocity (cms)	Date
9	8.5	July-August 1961
25	4.0	July-August 1961
10	6.8	November 1961
30	4.5	November 1961

*After Howe (1962)

The velocities are about one-half the observed non-tidal drift velocities shown by Redfield (1951) for the Scotland Lightship area off Sandy Hook, N. J. (Figure 2). The at depth velocities shown by Howe (1962) correspond well with Redfield (1951) and the differences are small considering the extreme variability of conditions that occur.

Several factors affect the behavior of a waste discharged at sea. The sludge waste studied did not contain excessive oil or floatables that are likely to act as a coherent mass or drift toward the shore on the surface. The material normally settles and accumulates on the bottom. Some of the fine suspended particles will remain in suspension for long periods of time. Based on surface drift observations by Redfield (1951) it can be assumed that approximately ten percent of the movement of the surface materials will be toward the shore. The bottom accumulation is another problem. The dump site is very close to the head of the Hudson Canyon. Although we obtained only eleven bottom core samples these indicated that there is a southerly drift of the sludge along the bottom. Discharge into the head of the canyon may appear to be a solution to waste disposal but biological considerations may be more important. Some evidence exists to indicate the presence of large populations of lobster and red crab in the lower parts of the canyon. The breeding zone, however, is apparently in the shallow upper reaches of the canyon. Long term dumping in the present location may endanger this entire marine population and food resource.

Apparently little attention has been given to the effects of waste disposal on marine organisms. Conferences have been concerned with the visual effects, dangers to beaches, sport fishing and adequate dispersal of pollutants but not with the environment. Long term detailed analyses of sludge drift and bottom currents are needed in the entire region as well as environmental information of the bottom organisms.

Delaware Bay Area

Several studies were completed prior to any waste disposal in the vicinity of Delaware Bay, but only a few were in reference to the specific problem. One such study was a survey made of the local ocean fisheries resources (June and Reintjes, 1957) in response to the possibility that certain chemical wastes might be discharged at sea in the offshore neighborhood of Delaware Bay. In view of increasing numbers of proposals for disposing of waste substances into the ocean, Reintjes and Roithmayr (1960) listed several recommendations. These included an expansion of the geographical area under surveillance, establishment of a fisheries statistical system, initiation of exploratory fishing, and a study of the surf clam populations. They also called attention to the need for a detailed knowledge of the near-shore circulation, monitoring the area during and subsequent to any waste-disposal operations, and the collection and analysis of bottom deposits and organisms.

Baselines to the natural history and ecology of the area can be found in other studies. For example, Deevy (1960), from an intensive zooplankton collection in the Delaware Bay region from 1929 to 1953, provides the only long-term observations upon variations in abundance and species composition in the area off Delaware Bay. A comparable comprehensive zooplankton study, but for the Delaware River estuary, was reported by Cronin et al (1962).

The existing situation poses the question of whether the discharged sludge flows toward nearby surf clam beds or toward shellfish relay beds within Delaware Bay. One commercial surf clam bed now in use lies five miles northeast of the center of the disposal area while the mouth of Delaware Bay is nearly twelve miles westward.

Tidal currents adjacent to and in the mouth of Delaware Bay indicate a strong tidal influence across the ten mile wide mouth. Velocities of nearly three knots may exist (U. S. Coast and Geodetic Survey, 1960). It is not unreasonable to assume that if any suspended materials are within three miles of the mouth they will be swept into the Bay during flood tide. Velocities of 1.0 to 2.0 knots could sweep materials across the relay beds within three hours. Redfield and Walford (1951) indicate that fine suspensions, such as can be found in most waste discharges, are transported for great distances. However, their survey also indicated that dilutions of the discharged material with seawater was more than 250 times within thirty seconds after dumping. The minimal rate of surface drift shown by Ketchum (1953) averaged four miles per day. Thus it would take three days waterborne material to enter the Bay if a direct path was taken.

Miller (1952) conducted both theoretical and actual studies and arrived at a confused inshore eddy and a general southerly flow offshore. The general current pattern is north-south along the coast, predominantly in a southerly flow. Work by Howe (1962) in the vicinity of Delaware Bay shows velocities of 4.3 miles per day at a depth of 30 feet and 5.9 miles per day at a depth of 86 feet and both moving in a southerly direction. This trajectory was reviewed by Shuster (1963) in a general discussion of the general current pattern along the Delaware coast. This was also shown in drift studies by Bumpus (1965) and the U. S. Navy (1965).

The series of studies conducted since 1951 indicate that the location originally proposed for acid waste dumping, one or two miles further south, is more desirable than the present sludge dumping site in regards to shellfish beds within Delaware Bay and northward on the ocean side of Cape May. The normal southerly flow, plus the tremendous dilution factor appears to assure the safety of the surf clam beds to the north and the shellfish beds in Delaware Bay from sewage sludge discharged twelve miles from shore in the present dump area but the surf clam beds to the south will be in direct line to receive the discharged sludge carried by the prevailing southerly currents. Reference to Figure 1 shows heavy concentrations of surf clams south of Delaware Bay. A small amount of the finely suspended material will occasionally move shoreward, but is not likely to physically affect the shellfish beds within the Bay.

The present danger to the Bay or adjacent surf clam beds arises from indiscriminate dumping. Dumping in unmarked areas is guesswork at best. The size of the present dumping areas and methods of discharge are not compatible. A barge usually discharges at maximum speed to achieve the greatest possible dilution, this means the barge operator must discharge the waste material within ten minutes or turn around and retrace his path. A larger area, clearly defined, would permit barge operators to keep within the dump site.

Adequate hydrographic data have been collected which permit an overall evaluation of the present site. Unless detailed, long-term studies on current structures and bottom deposits were contemplated, little additional information could be gained.

CHEMICAL STUDIES

The acid waste disposal area in the New York Bight appears as a light yellow-green body in the surrounding dark green sea. A sharp line of demarcation indicates that an interface exists between the diluted waste and the surrounding sea. The crew on the sample vessel stated that a horizontal boundary at 30 to 50 ft. depth as well as a vertical boundary contained this waste. The acid dump patch extended for several miles. The effects of this waste have been studied by Redfield (1951). He determined that the acid-iron waste when discharged was rapidly diluted and the acidity neutralized; that the chemical properties of the receiving water would not be expected to be changed to any great distance or depth from the discharge point; that there were no observable damaging effects on the populations of fish or bottom animals in the discharge area and that no bottom accumulations had resulted during the relatively short period that disposal had been practiced. Recommendations were made for investigating each type of waste individually and continued monitoring for long-term effect and increased discharges (Redfield, 1951). A subsequent "unpublished manuscript," Report 57-5 by Woods Hole Oceanographic Institute reported that analysis of sediment samples from the disposal area during 1956 showed no cumulative change in iron content during the years of dumping since 1948.

We obtained four one-gallon samples of seawater taken from various depths in the area colored by the acid waste discharges at a point midway between Stations 5 and 7 (Figure 3) on 22 May 1966. They were analyzed for certain organic and inorganic components by the NEMHSL Chemistry Section. A "base line" sample taken from Narragansett Bay was analyzed along with them. In addition, three mud cores and two samples of black quahaugs were analyzed.

The inorganic ion determinations of the seawater samples are presented in Table 9.

Some of the more obvious organic compounds to be found in various industrial chemical wastes are represented by the group types of organic compounds indicated in Table 10.

TABLE 9

INORGANIC IONS - SEAWATER - NEW YORK BIGHT

Depth of Sample	PH	Sulfate (PPM)	Chloride (PPM)
Surface	8.3	1.402	10.59
20 ft.	8.4	1.392	10.35
30 ft.	8.5	1.497	11.07
Bottom - 100 ft.	8+	1.528	11.27
Base Line	8.33	1.671	16.74

Narragansett Bay Water, Sampled 3 February 1967.

Note: Samples collected in the acid dump area between Stations 5 and 7 on 22 May 1966.

TABLE 10

ORGANIC GROUPS IDENTIFIED IN THE ETHANOL EXTRACT IN SEAWATER AND MUD SAMPLES
(Feigl Spot Tests employed)

Sample	Amino	Org. Sulfide	Aromatic	Nitro	Nitro 50	Carboxy Acid	Phenol
1. Surface, Water	+	-	+	+	-	-	+
2. 20' depth	+	-	+	+	-	-	+
3. 30' depth	+	-	+	+	-	-	+
4. Bottom, Water	Very Marginal	-	+	+	-	-	Very Marginal
Narragansett Bay	+	-	+	+	-	-	+
Station 24 Mud	+	-	+	+	-	-	+
Station 26 Mud	+	-	+	+	-	-	+
Station 28 Mud	+	-	+	-	-	-	+

Note: + = present in sufficient quantities for detection.
- = absent or insufficient quantity for detection.

The New York Bight seawater trace metal values shown in Table 11 are very similar to those found in Narragansett Bay water with the exception of copper. The average copper level for Narragansett Bay is approximately 0.03 ppm. The values found in the New York Bight samples represent a water value approximately 4.0 times larger. One is hard pressed to offer an explanation for this elevated level. This could well be a passing incidence of pollution. A number of continuous samples would furnish an answer. Open-ocean seawater has lower levels of trace metals than those usually found within polluted estuarine and coastal waters and are given in Table 12 (Goldberg, 1957).

The trace metal concentrations of cobalt, copper, nickel and zinc in the black quahaug samples given in Table 13 are similar to those usually found in the Northern quahaug, *Mercenaria mercenaria*, also shown in Table 13. The black quahaug value for cadmium is not much greater than the average found in the Northern quahaug. However, the values shown for chromium and manganese appear to be in excess of those usually found for the Northern quahaug. The tissue levels in the case of iron and lead are very significantly elevated beyond those usually found in *Mercenaria*.

Table 14 contains chemical analysis of surf clams collected off Delaware Bay at stations shown on Figure 4. The normal heavy metal values mentioned for the Northern quahaug in Table 13 may be used for comparison since no such values have been determined for the surf clam. Work is being done at NEMHSL to establish "normal" heavy metals concentration values to be expected in surf clams gathered from areas believed to be free of contamination from waste discharges. Establishing these normal values will enable improved evaluation of the results found in this investigation.

The values in Table 14 do not appear to be abnormally high in any of the samples with regard to cadmium, cobalt, copper, lead, manganese and zinc. The concentrations of iron found are also considered normal. All samples were found to be high in chromium and four of them high in nickel when compared to the Northern quahaug.

TABLE 11

TRACE METALS IN SEAWATER SAMPLES - NEW YORK BIGHT ACID DUMP

Sample Depth	Trace metal expressed as PPM								
	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Surface	<0.10	<0.20	<0.20	0.120	< 0.10	< 0.18	<0.20	<0.15	<0.10
20 ft.	<0.10	<0.20	<0.20	0.122	< 0.10	< 0.18	<0.20	<0.15	<0.10
30 ft.	<0.10	<0.20	<0.20	0.133	< 0.10	< 0.18	<0.20	<0.15	<0.10
Bottom - 100 ft.	<0.10	<0.20	<0.20	0.131	< 0.10	< 0.18	<0.20	<0.15	<0.10
Narragansett Bay	0.032	0.191	<0.20	0.031	0.141	0.054	0.225	0.375	0.15

Note: The less than symbol (<) preceding a value indicates that the number given is the lowest level at which the analyses were made

TABLE 12

AVERAGE TRACE METAL LEVELS FOUND IN SEAWATER FREE OF POLLUTION
After Goldberg, E. D., 1957.

Trace Metals in PPM								
Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
0.00011	0.00027	0.00005	0.003	Soluble 0.0026 Total 0.0062	0.002	0.0054	0.00003	0.01

TABLE 13

TRACE METALS IN BLACK QUAHAUG SAMPLES -

Expressed as mg/kilo drained wet weight.

Sample	Trace Metals (mg/kilo or PPM)								
	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Station 20 (7 specimens)	0.138	<0.20	0.19	2.44	426.0	-	<0.20	4.61	12.70
Station 22 (3 specimens)	0.24	<0.20	5.78	4.68	1,331.0	22.40	<0.20	7.50	23.61
Northern Quahaug (Ave. value)	<0.10	<0.20	<0.20	1-7	50-70	3-7	<0.20	<0.15	20-40

TABLE 14

CHEMICAL ANALYSIS FOR HEAVY METALS IN SURF CLAM SAMPLES TAKEN OFF DELAWARE BAY

Date 1967	Sample Station	Cd	Co	Cr	Ni	Pb	Cu	Mn	Zn	Fe
May										
29	6	<0.15	<0.10	2.00	<0.10	<0.15	2.00	2.35	10.25	120.15
31	7	<0.15	<0.10	7.49	3.72	<0.15	3.88	2.58	11.24	138.24
31	8	<0.15	<0.10	0.82	<0.10	<0.15	1.93	0.68	12.43	42.60
31	17	<0.15	<0.10	1.05	1.34	<0.15	2.82	0.86	12.64	47.80
31	18	<0.15	<0.10	1.28	<0.10	<0.15	2.38	2.79	12.69	96.88
29	20	<0.15	<0.10	4.47	3.28	<0.15	2.82	2.53	9.90	142.20
June										
5	23	<0.15	<0.10	0.62	<0.10	<0.15	4.59	1.54	12.60	74.52
5	26	<0.15	<0.10	5.61	2.44	<0.15	2.07	2.27	12.72	91.59
5	28	<0.15	<0.10	2.19	<0.10	<0.15	1.16	2.16	12.69	88.00

Note: All results in Mg/Kg drained weight of shellfish meats or PPM.

Within the scope of this preliminary study on bacteriological, hydrographic, and chemical features of offshore waste disposal in shellfish-producing waters, we have not reached a satisfactory determination of the precision required in setting the size of the dump area and/or the control of the dumping so that the sanitary quality of nearby shellfish growing waters may be protected. We believe that it will be necessary to have adequately marked dump areas as well as surveillance of the dumping operations before meaningful shellfish growing area classification can be achieved. In any case, once the area classification is made, it is essential that dumping be confined to the designated location(s). Patrol of the dumping region must be adequate to assure deposition in the proper area. Classification will be done in accordance with the National Shellfish Sanitation Program Manual of Operations, Part I, Sanitation of Shellfish Growing Areas (NSSP, 1965).

Further studies are needed to define the extent of the sludge dispersion and depth of deposit within and adjacent to the dump areas. Long term bottom current studies to supplement available surface current data in order to establish normal drift patterns would aid in determining the suitability of the present disposal areas under present conditions and impending increased loading.

Determinations of the survival and growth of indicator organisms in the bottom sediments would be of value for shellfish sanitation purposes.

High concentrations of some heavy metals in both water and shellfish would indicate that additional chemical analysis be done. The limited samples taken are of value mainly to show where any future work should be directed.

No approval of the present disposal areas or decision for relocation of them can be justifiably recommended using the limited findings. The New York Bight mud, rubble-excavation and sewage sludge dump area is so badly fouled that changing of location would be of little help in the immediate area. However, considerations must be given to the possibility of these deposits, from long term dumping, drifting into the Hudson Canyon and causing harm to certain marine populations.

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