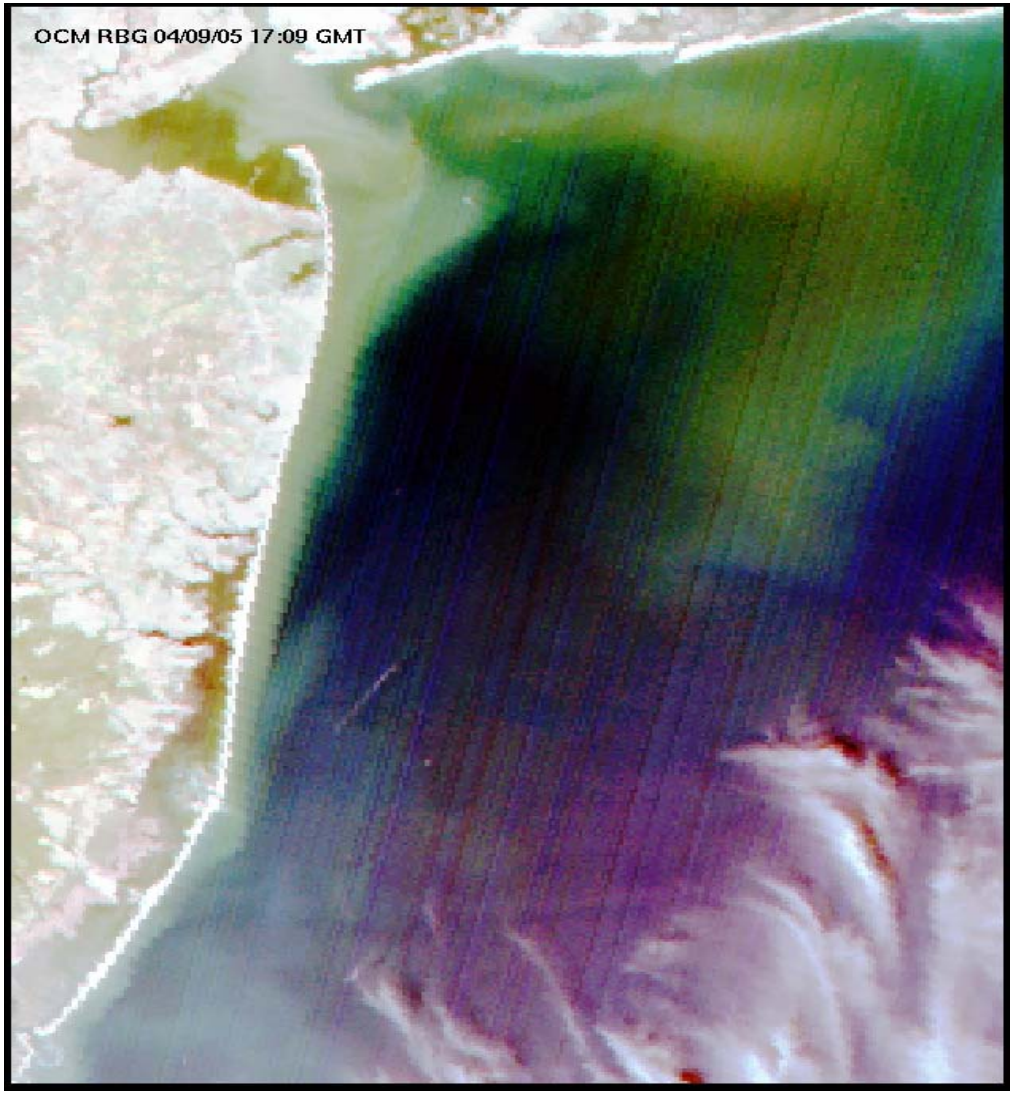
PART 2 – RARITAN BAY



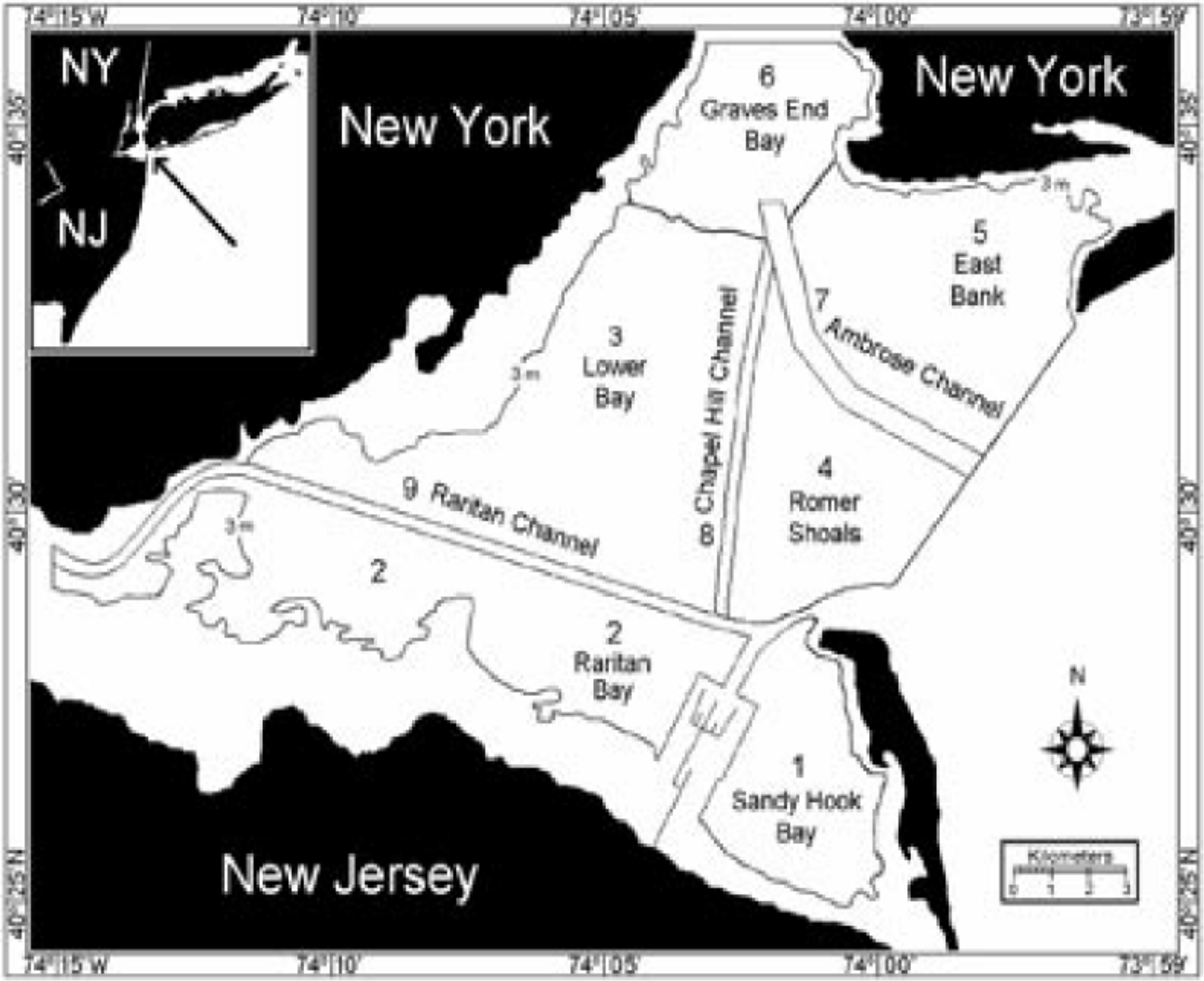
Bob Chant (Rutgers), Scott Glenn (Rutgers), Bob Houghton (Lamont), Bernie Gardner (U. Mass), John Wilkin (Rutgers), John Reindfelder (Rutgers), Bob Chen (U.Mass). 2005. An Interdisciplinary Process Study of the Hudson River Plume in an Operational Research Observatory. Lagrangian Transport & Transformation Experiment. Powerpoint. Rutgers.

The **Hudson-Raritan plume** enters the ocean at the five and a half mile opening between Sandy Hook, N.J. and Rockaway Point, N.Y., and generally landfalls between Monmouth Beach and Long Branch in Monmouth County. This less dense, warmer plume can flow more than 93 miles south of the NY harbor along coastal NJ, and is associated with floatable and other pollution events (Chant et al., 2004b).

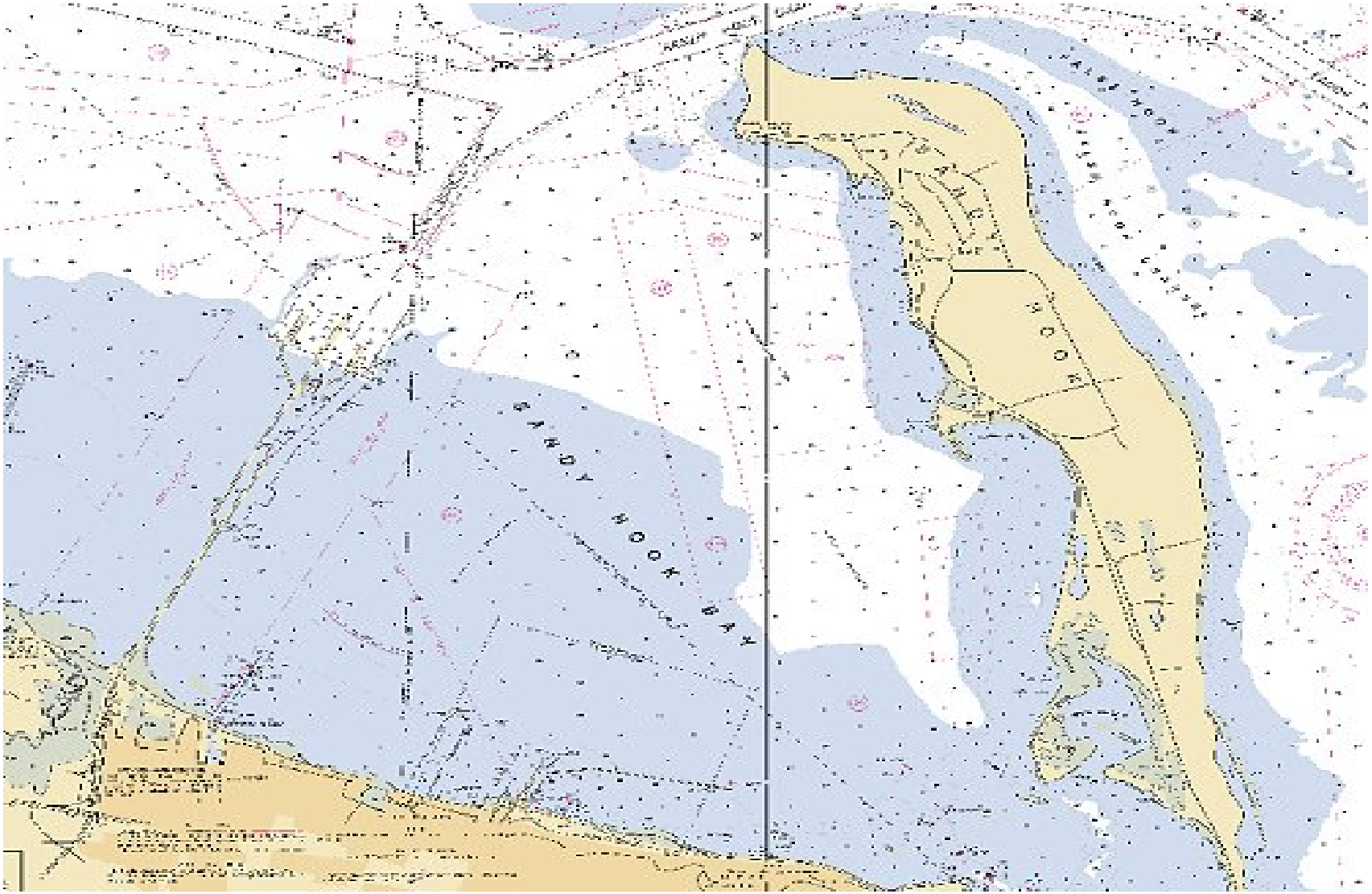
The Hudson-Raritan plume discharges an average of 23,000 million gallons a day of freshwater into the ocean through a five and a half mile opening between Sandy Hook, NJ and Rockaway Point, NY, where the bottom is armored with pea gravel due to the strong tidal flow (NY/NJCOST, 2004). More than 85% of the freshwater discharges into the Bay underneath the Verrazano-Narrows Bridge (NY/NJCOST, 2004).

Chant, R.; Reinfedler, J.; Glenn, S.; Schofield, O.; Wilkin, J.; Houghton, R.; Chen, B; Zhou, M.; Bissett, P.; Moline, M. and Frazer, T. 2004b. Collaborative Research: Lagrangian studies of the transport, transformation, and biological impact of nutrients and contaminant metals in a buoyant plume: A process study in an operational ocean observatory. Grant proposal, The Center for Coastal Marine Sciences at California Polytechnic State University. San Louis Obispo, Ca. http://www.marine.calpoly.edu/researchprograms/latte/Latte_proposal.pdf

NY/NJ Clean Ocean and Shore Trust, Columbia University Department of Earth and Environmental Engineering, and the NYC DEP. 2004. The 2003 New York Harbor Water Quality Report. http://www.scc.rutgers.edu/coastweb/NYCDEPHarbor_survey/docs/hqr.pdf



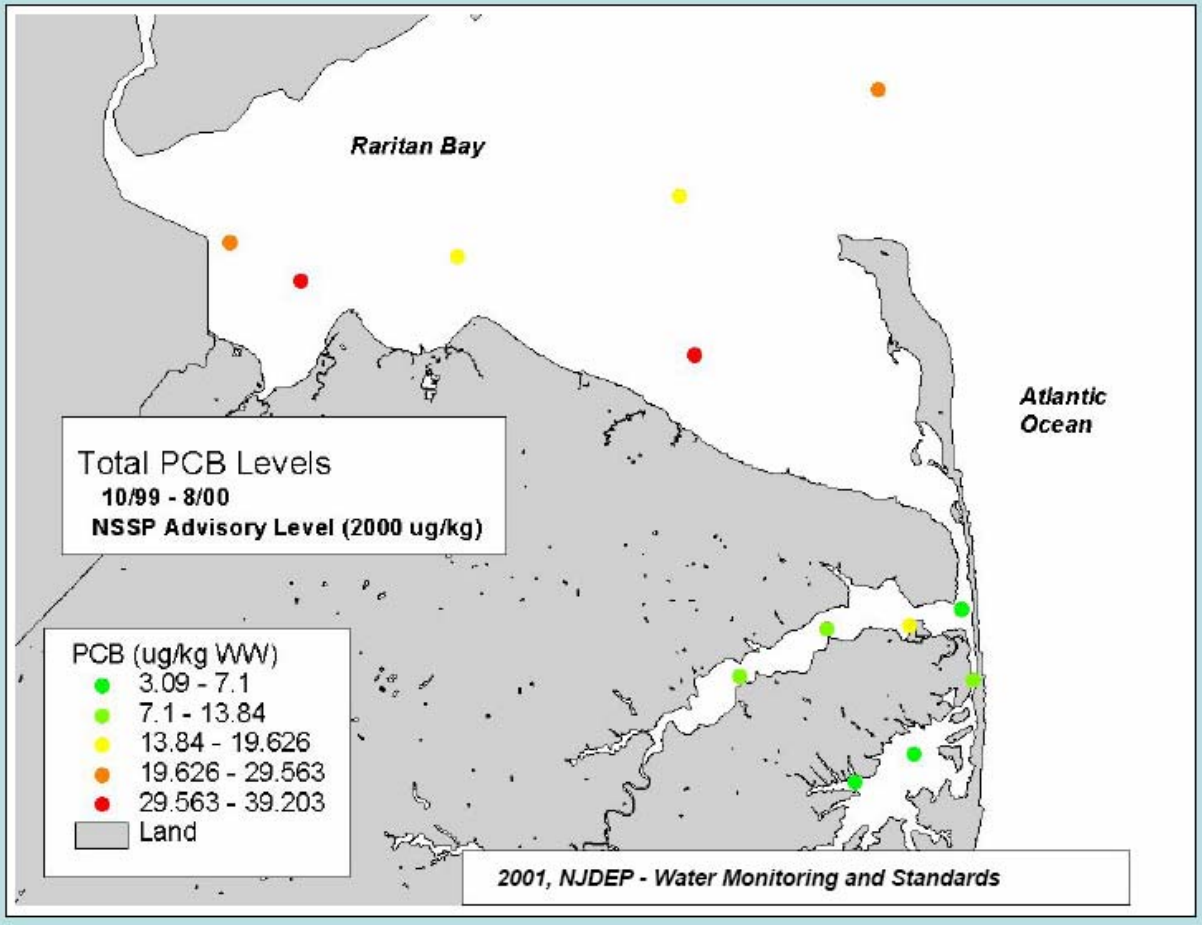
Stehlik, L, Rikanowski, R, and McMillan, D. 2004. The Hudson-Raritan Estuary as a crossroads for distribution of blu (Callinectes sapidus), lady (Ovalipes ocellatus), and Atlantic rock (Cancer irroratus) crabs. Fisheries Bulletin. 102:693-710. http://fishbull.noaa.gov/1024/stehl.pdf



The white area is the 20’contour, i.e. the channels.

The Navesink-Shrewsbury channel intersects north of the navy pier channel with the Chapel Hill Channel from NY, and the Sandy Hook Channel.

PCB's in Hard Clams



Why are PCB levels in the estuary highest near the Monmouth shoreline?

Connell, R. 9/27/2006. Shellfish Toxics Monitoring in NJ Estuarine Waters. NJDEP. NJ Water Monitoring Council.
http://www.state.nj.us/dep/wms//NJDEP%20Shellfish%20Toxics%20Monitoring.pdf

The NJ Bayshore's muddy shoreline is predominantly shaped by runoff from the Raritan River, not the Hudson River, which is silica-poor (Officer and Ryther, 1980; Steimle et al., 1989). (It's also the major source of nitrate (Jeffries, 1962).)

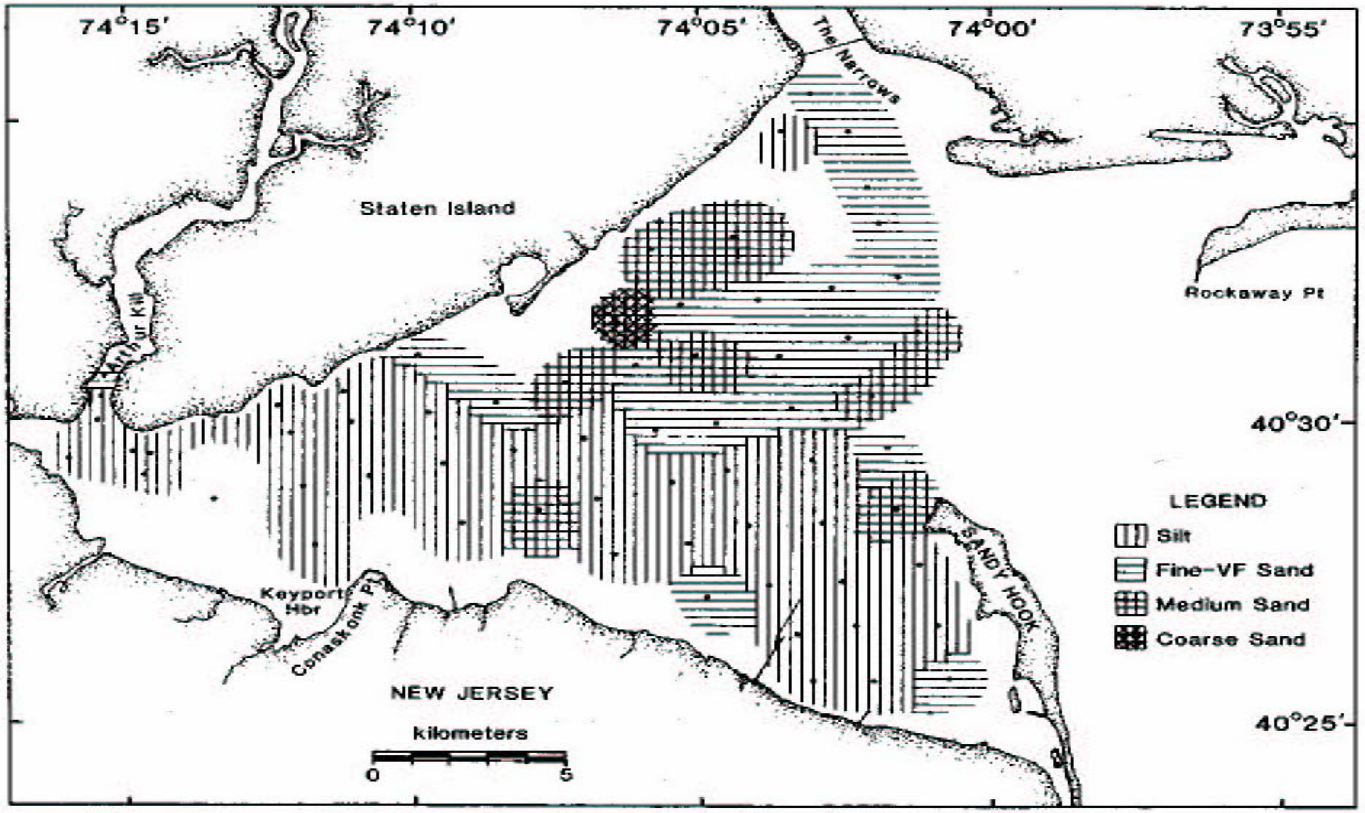
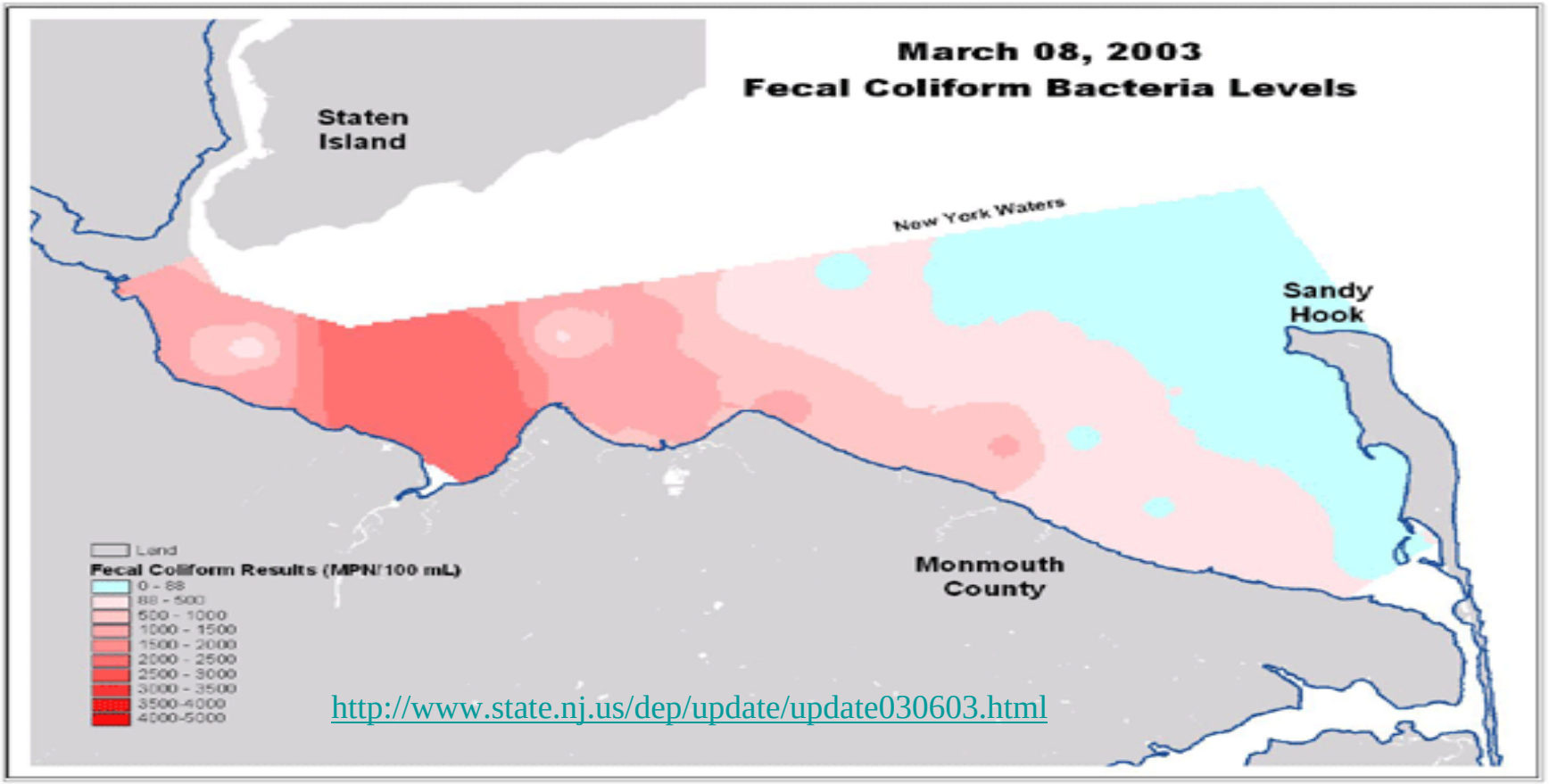


Fig. 2. Mean grain size of Raritan estuary sediments, based on 1973 data; blank areas indicate 1973 data not available.

Officer, C. and Ryther, J. 1980. The possible importance of silicon in marine eutrophication. Marine Ecology Progress Series. Vol 3; 83-91. http://www.int-res.com/articles/meps/3/m003p083.pdf .

Steimle, F. and Caracciolo-Ward, J. 1989. A reassessment of the status of the benthic macrofauna of the Raritan Estuary. Estuaries. Vol112, No. 3, p. 145-156. http://estuariesandcoasts.org/cdrom/ESTU1989_12_3_145_156.pdf



Although the Raritan River discharges only 7% of the total freshwater into the Bay, its muddy discharge dominates water quality along the southern coast along Monmouth County, especially when heavy rain occurs during an ebbing tide (Jeffries, 1962; NY/NJCOST, 2004; USGS, 2007). The water quality of the southern coast is also driven by the Middlesex County Utility Authority's outfall in the Bay off Cheesequake Creek in Sayreville (map is of 2003 malfunction).

Jeffries, H. 1962. Environmental Characteristics of Raritan Bay, A Polluted Estuary." Narragansett Marine Laboratory. No. 35. Rhode Island.
NY/NJ Clean Ocean and Shore Trust, Columbia University Department of Earth and Environmental Engineering, and the NYC DEP. 2004. The 2003 New York Harbor Water Quality Report. http://www.scc.rutgers.edu/coastweb/NYCDEPHarbor_survey/docs/hqr.pdf
United States Geological Survey. Accessed 1/29/07. Geologic History of Raritan Bay. http://3dparks.wr.usgs.gov/nyc/morraines/raritanbay.htm

NOTE CTR CLOCKWISE GYRE BETWEEN PT. COMFORT AND PIER

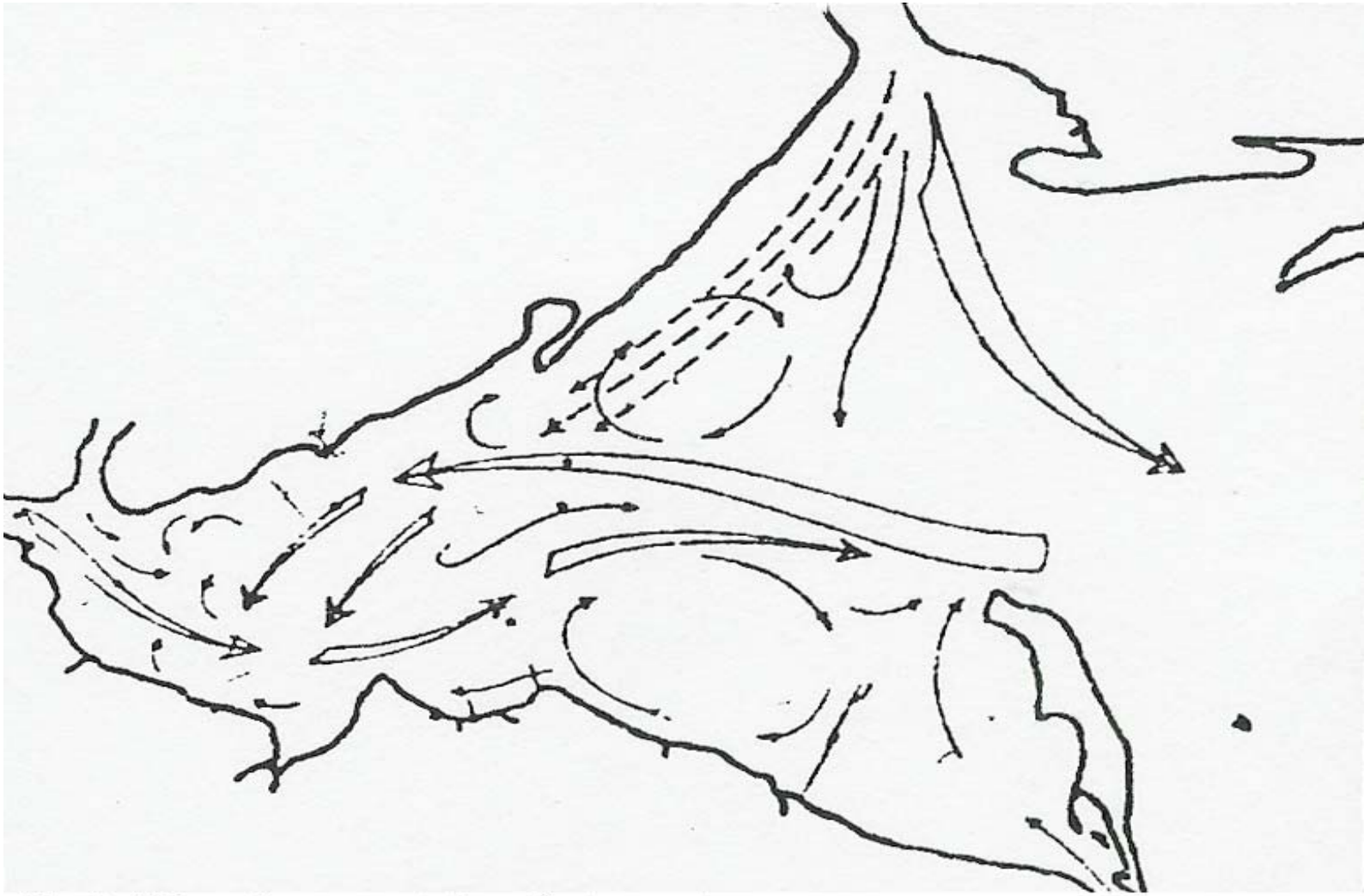


Fig. 2. Schematic representation of net currents in Raritan and Lower Bays.

Jeffries, H. 1962. Environmental Characteristics of Raritan Bay, A Polluted Estuary." Narragansett Marine Laboratory. No. 35. Rhode Island.

Thousands of dead fish wash ashore

DEP blames algae in bay

By LISA R. KRUSE 6-24-88
Press Shrewsbury Bureau

A MASSIVE fish kill in Sandy Hook Bay caused tens of thousands of fish to wash ashore yesterday in Atlantic Highlands and the Leonardo section of Middletown Township.

The state Department of Environmental Protection said the fish died from oxygen starvation, caused by a 5-mile-long brown algae bloom that grew in Raritan Bay earlier this week.

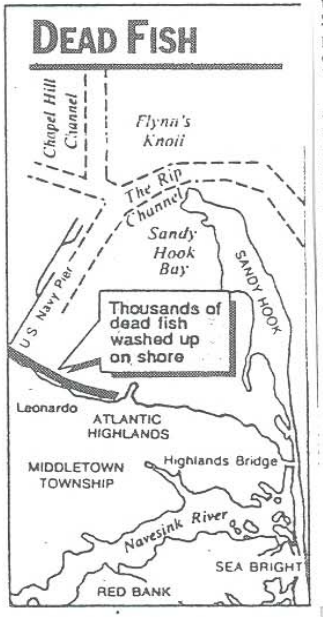
But scientists with the National Marine Fisheries Laboratory, who walked the beach yesterday afternoon, said the nature of the kill made it too soon to determine a cause without further laboratory tests.

"It's very unusual to see a kill like this," said Stuart Wilk, chief of environmental analysis, National Marine Fisheries Laboratory, as he picked through the dead fish to catalog the species. "I've been here 25 years and I've never seen anything like it. This is probably the worst kill I've ever seen in this area."

While a few fish were scattered among the seaweed covering the beach, thousands of dead fish could be seen bobbing within 10 feet of the shoreline. The surf was thick with fish, the bay bottom hidden by the multitudes of white, lifeless bodies.

The scientists identified the dead fish as fluke, windowpane flounder, small-mouth flounder, sea robins, sundials, porgies, blackfish, eels, ling, crabs, pike, blowfish, winter flounder, grubbies, and stargazers.

Wilk said the fish apparently died within the previous 24 hours, at the most 48 hours. The predominant species was fluke of all sizes. One fluke weighed 8 pounds. Reports of the kill started filtering in shortly after 1 p.m. yesterday.



James M. Staples, a DEP spokesman, said that because the dead fish have been decaying for an unknown amount of time, they should not be eaten by humans.

"It's heartbreaking to see something like this," said George Carmichael, an official with the Middletown Township Health Department, as he gathered samples from the water.

This fish kill appears to be the

See FISH, page A2

More dead fish seen in Sandy Hook Bay

By LISA R. KRUSE 6-28-88
Press Shrewsbury Bureau

SEVERAL THOUSAND more dead fish were seen floating in Sandy Hook Bay yesterday as scientists continue probing and workers cleaned beaches of debris from last week's massive fish kill.

James Staples, state Department of Environmental Protection spokesman, said DEP staff in a helicopter yesterday observed several thousand dead fish floating in Sandy Hook Bay between the Leonardo Marina and Sandy Hook. The DEP believes, Staples said, that the fish are part of the original fish kill that occurred Wednesday and Thursday nights.

Water samples taken yesterday and over the weekend continue to show the dissolved oxygen levels at the bottom of the bay to be normal, said Herman Phillips, spokesman for the federal Environmental Protection Agency.

Thousands of dead fish, representing 18 species of fish, crab and shrimp, washed ashore Thursday on the beaches of Atlantic Highlands and the Leonardo section of Middletown Township.

The DEP has said it believes that oxygen depletion, caused by the algae bloom in Raritan Bay early last week, killed the fish.

The cause, however, is still under investigation by the National Marines Fisheries Laboratory, based at Sandy Hook. Scientists there have said the scope of the fish kill make it unusual.

"Our agency is not refuting what other agencies are saying," Wilk said. "We're just not committing to that line because there are other possibilities."

Among the theories being investigated by the marine fisheries laboratory is that the fish died of oxygen depletion caused by the algae bloom; the fish produced naturally occurring toxins that killed the other fish; that something man-made killed the fish; and a combination of the above.

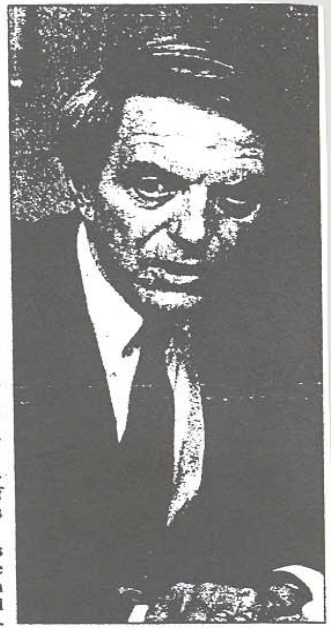
The beaches at Leonardo were cleared of all dead fish and seaweed by yesterday afternoon, said George Carmichael, township health official. Carmichael has estimated that workers cleared the beach of more than 100,000 dead fish over the three-day period of Friday, Saturday and yesterday.

The EPA has not officially declared the algae bloom as the cause of the fish kill, although Phillips said it is a likely theory.

But the DEP said the oxygen levels are misleading, since the samples are taken during the day when oxygen levels tend to be higher. Staples said that photosynthesis by the algae occurs during the day, increasing oxygen levels. At night, no photosynthesis occurs. The DEP believes that the fish kill happened Wednesday or Thursday night, when bacteria used up all the oxygen in the bay, causing the fish kill.

Meanwhile, Sen. Richard Van Wagner, D-Monmouth, announced yesterday that the Senate Special Committee to Study Coastal and Ocean Pollution would have a public hearing in Middletown Township sometime during the week of July 11 to explore the possible causes of the fish kill.

Wilk said scientists were finishing up some chemical tests, and should be able to list probable theories by the end of the week.



SEN. RICHARD VAN WAGNER
Announces hearing on fish kill

"This was a real quick demise to the fauna of a total area," Wilk said. "All the fish that occur on the bottom during the summer months were there. . . . Something stressed the marine environment. It takes an awful lot to cause what we saw on the beach."

These fish died: American Eel, Striped Cusk-eel, Silverside, northern pipe fish, black sea bass, porgies, blackfish, cunner, northern stargazer, northern sea robin, striped sea robin, grubby, small mouth flounder, fluke, windowpane flounder, winter flounder, hogchokers, blowfish, shore shrimp, sand shrimp, blue crabs and lady crabs.

The nursery in the flats east of the Navy pier in Leonardo was the site of a multi-species fishkill from 6/22 to 6/28/1988, after an algae bloom arrived that had developed at the mouth of the Raritan River.

Up to 1 million sea robins, summer flounder, winter flounder, bluefish, American eels, etc. died after "**localized hypoxia created by wind and tidal concentration of phytoplankton** from a bloom of Heterosigma carterae, Katodinium rotundatum and Eutreptia lanowii."

As of 2002, it was the second largest kill reported in the HR Estuary (the largest was a 2000 kill of 3.9 million juvenile menhaden in Little Silver Creek in the Shrewsbury watershed; "bunkers" have a kill almost every summer because it schools so densely that it depletes dissolved oxygen).*

* Reid, R., Olsen, P., and Mahoney, J. 2002. A compilation of reported fish kills in the Hudson-Raritan Estuary during 1982 through 2001. Northeast Fisheries Science Center Reference Document 02-09. www.nefsc.noaa.gov/nefsc/publications/crd/crd0209/crd0209.pdf

The Leonardo nursery remains productive; for example, numerous horseshoe crab "sheds" washed up here after Tropical Storm Ernesto in 9/06

Worm reef (Sabellaria vulgaris) in Belford. Facing west, standing in front of Ware Creek and the Navy Pier.

MUD HOLDS MORE POLLUTANTS THAN SAND

PARTICAL SIZE: its biological relevance must be acknowledged to predict pollutant dynamics.

"Colloidal and the smaller suspended particles (less then about 10 micrometers) are the particles that cause turbidity. Smaller particles and colloids remain suspended in the waters because their gravitational settling is less than 0.01 cm/sec (Stumm, W. andf J.J. Morgan,1981. Aquatic Chemistry. John Wiley and Sons)

Sand	**Silt**	**Clay**
2000 - >62 microns (um)	**<62 - 4 um**	**<4 um - .24 um**

"It is widely recognized that **sediments less than 63 um in size are the most important fraction for contaminant adsorption and transport**, due to their relatively large surface area and geochemical composition" (Stone and Droppo 1994 quoted in Wood and Armitage.1997. Biological Effects of Fine Sediment in the Lotic Environment. Env.Manage. V.21, N.2,pp.203-217).

In the NY/NJ Harbor, "**95% of fine sediments contained at least 1 contaminant exceeding the Effects Range Median … compared to 16% of sandy sediments** … fine grade sediments are continually supplied to the NY/NJ Harbor from tributaries … and scavenge toxics from the water." – Cd, Cu, Dioxin, PCBs, PAHs, and N in the NY/NJ Harbor. Boehme, S. 2000 (NYAS).

MOST POLLUTANTS REMAIN IN ESTUARIES

Freshwater colloidal fines, along with the adsorbed bacteria and pollutants, clump together into aggregates, self compact, sink, and accumulate in estuaries. It has been estimated that up to **80% of freshwater pollutants accumulate in estuaries.**

"Many of the fines in Monmouth County that are present in the ocean bottom outside the footprint of the barrier spit are old bay sediments (5000-6000 years)." – Jeffrey Pace, IMCS, 1/30/04. "Probably less than 5% of the sediment reaching the coastal zone in the Atlantic seaboard of the U.S. is transferred to the continental shelf or to the deep sea" – Meade (1982) in Riverine Transfer of Particulate Matter to Ocean Systems (Depetris, Pedro).

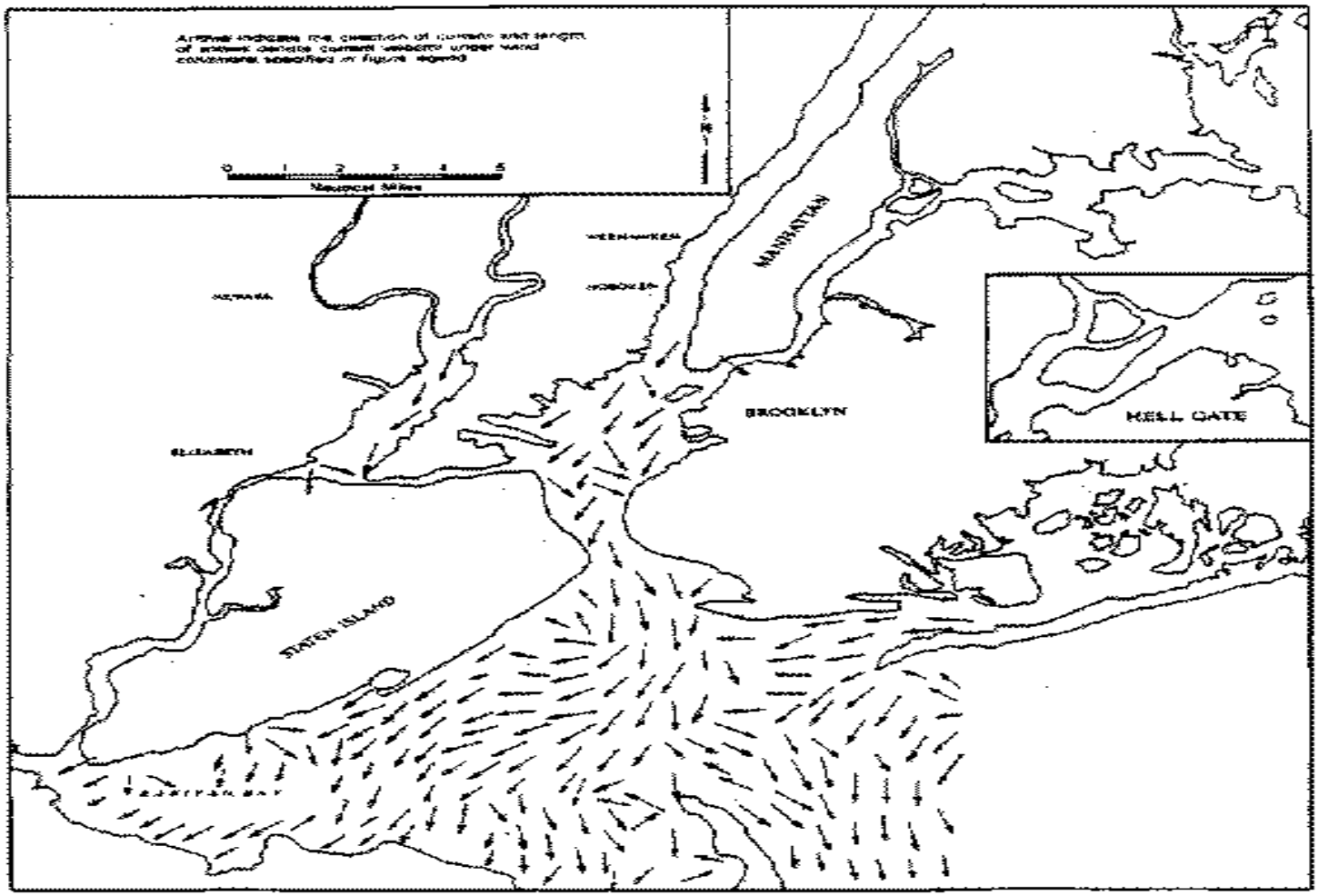
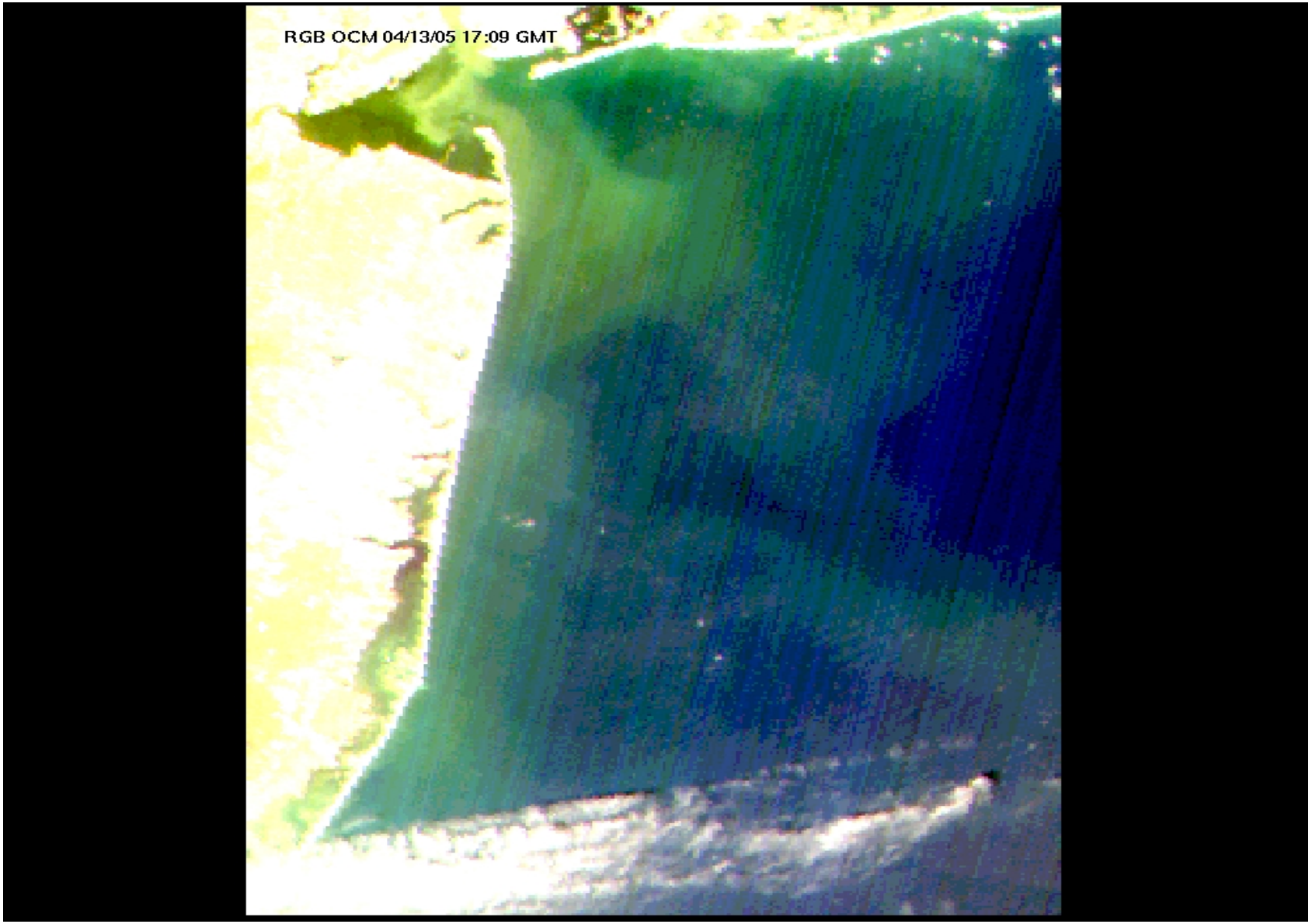


Figure 9d. Wind-driven Currents in the Hudson/Raritan Estuary. Northeasterly Winds

DEP 1987 NJ Floatables Study: Possible sources transport & beach survey results.



http://marine.rutgers.edu/cool/latte/pics/2005/sat_fullimage/050413.1709.ocm.rgb.jpg . Chant, R. 10/16/06. Personal communication.

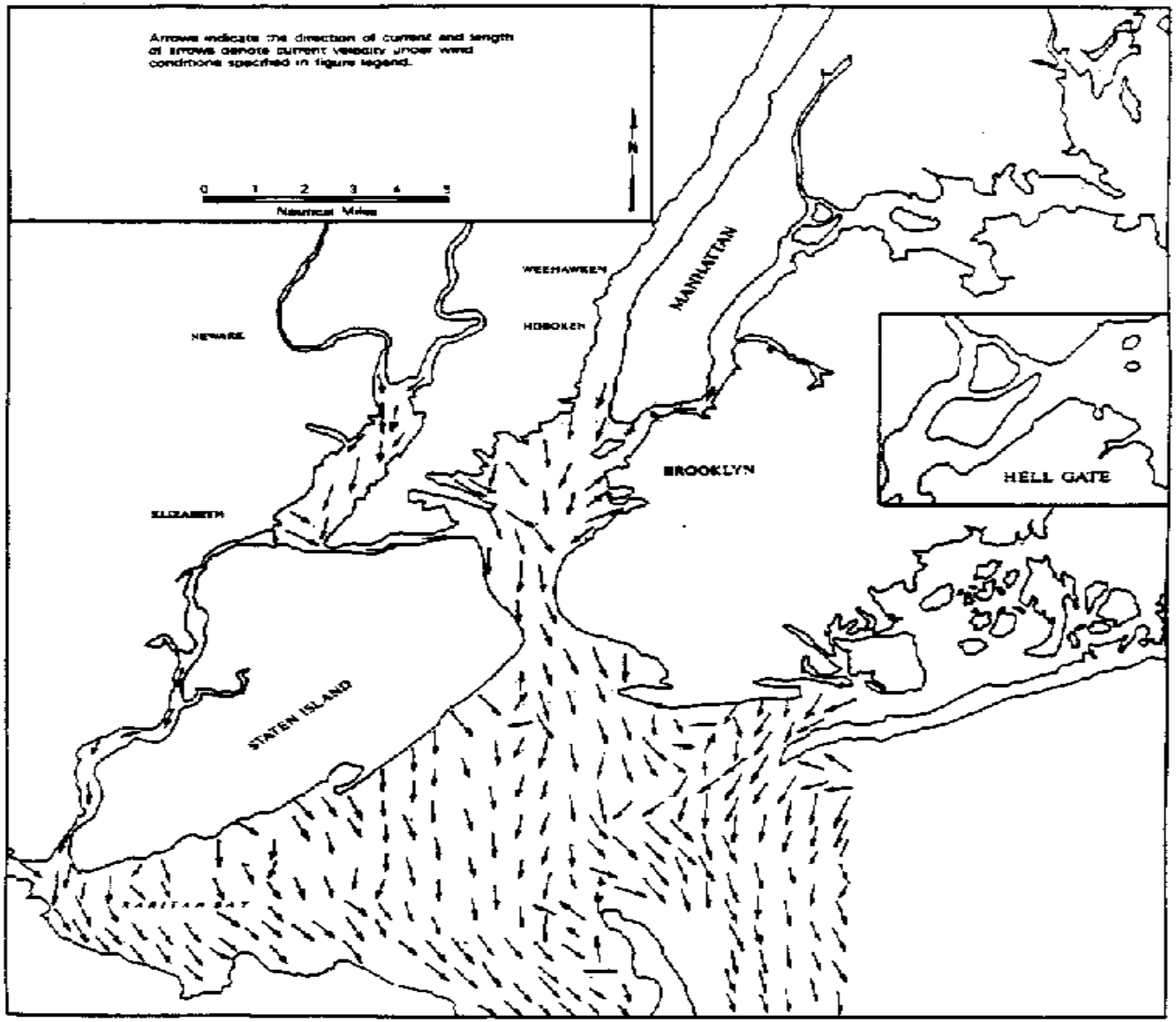
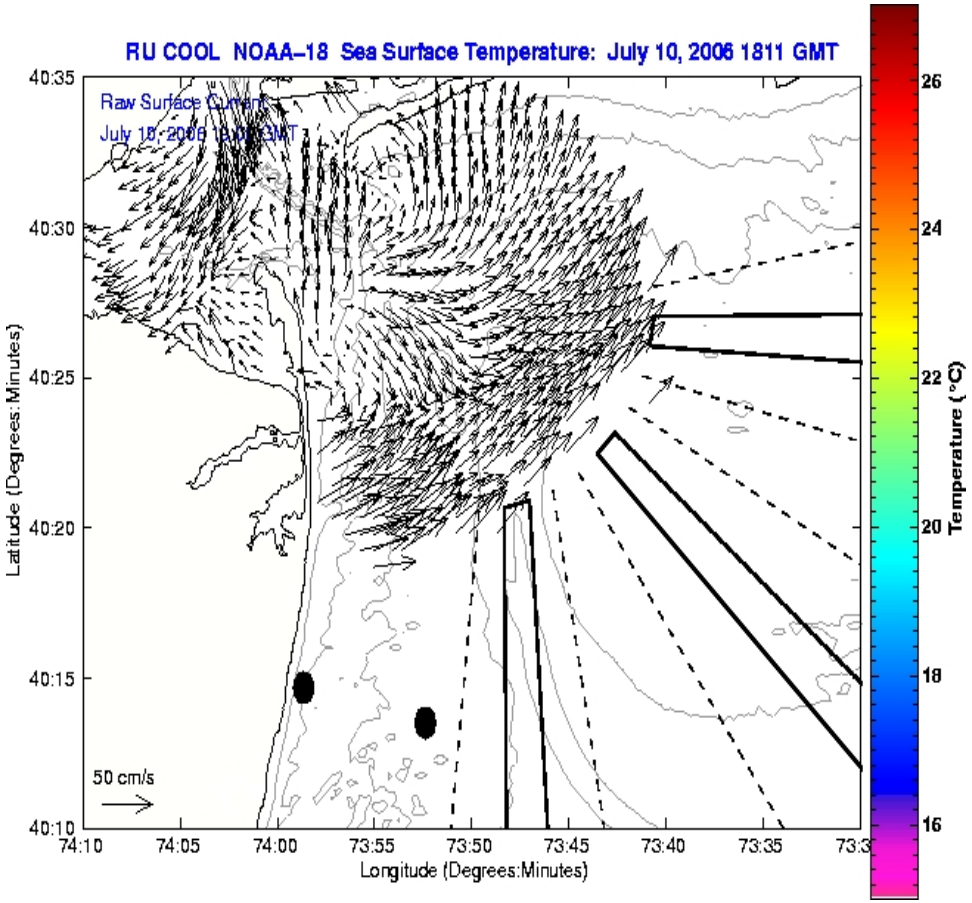


Figure 9b. Wind-driven currents in the Hudson/Raritan Estuary. Northwesterly winds.

DEP 1987 NJ Floatables Study: Possible sources, transport & beach survey results.



SOUTHWESTERLIES & UPWELLINGS

On 7/10/06, cold bottom water moved towards MC shore, as SW winds blew the surface water and the HR plume towards Long Island.

http://marine.rutgers.edu/cool/show/?file=../regions/latte/sst_codar/noaa/2006/img/060710.191.1900.sro.jpg

TEMPERATURE IDEALS ARE DIFFERENT FOR PHYTOPLANKTON AND INDICATOR BACTERIA

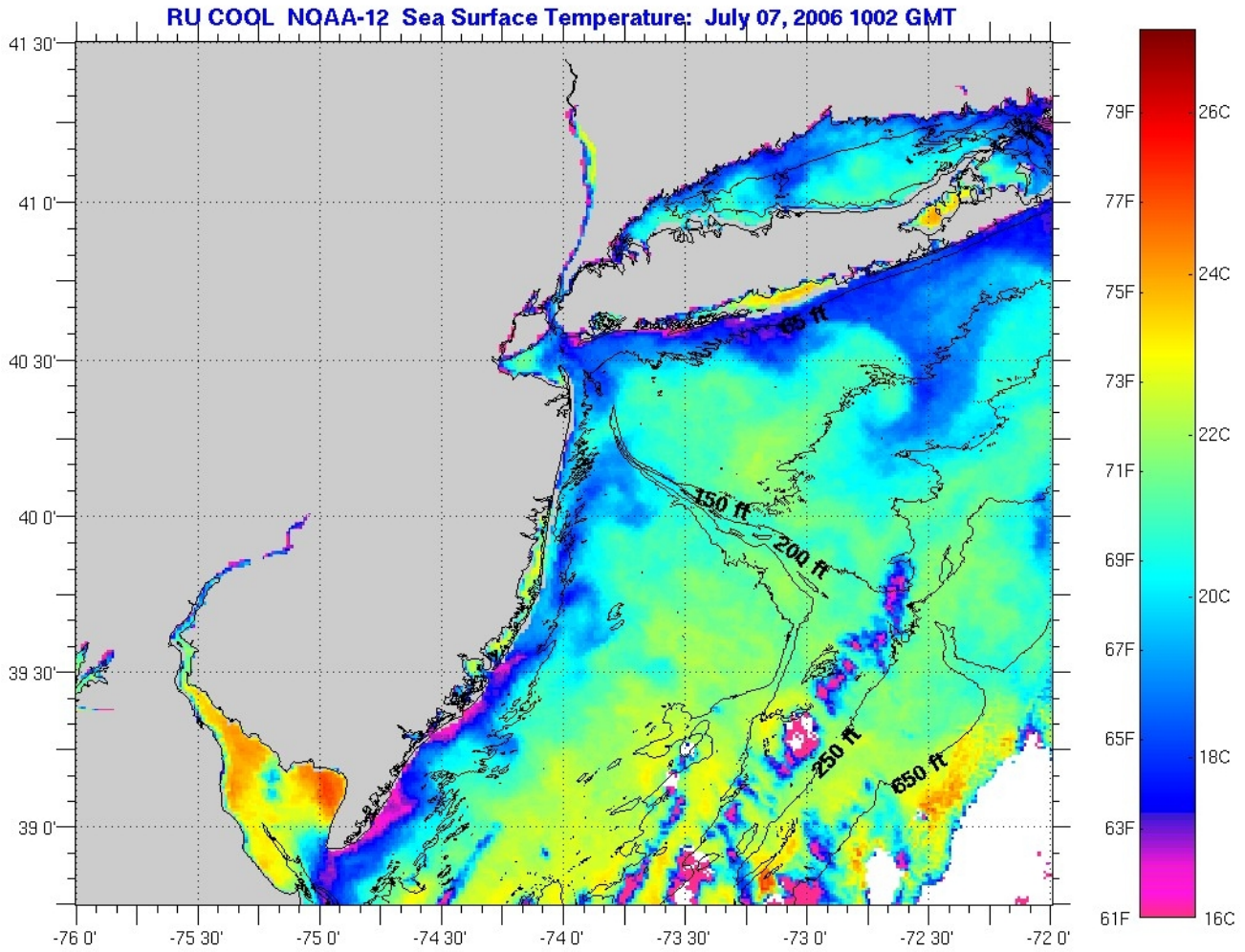
Sustained southerly winds that lower water temperature provide conditions where phytoplankton can potentially thrive, in their primary habitat, but where bacterial growth is constrained. The small spring blooms of diatoms occur in water temperatures that are similar to the refrigerator-like temperatures that are required for storing samples of bacteria, whose primary environment is the gut of warm-blooded mammals (surface water is a secondary habitat for bacteria). But upwellings can also cause microbial community shifts: the diversity of planktonic bacteria associated with phytoplankton decreased during the onset of an upwelling off Great Egg Harbor in 1995.

Kerkhof, L.., Voytek, M., Sherrill, R., Millie, D. and Schofield, O. 1999. Variability in bacterial community structure during upwelling in the coastal ocean. Hydrobiologica 401: 139-148. http://marine.rutgers.edu/mrs/coolresults/papers/Kerkhof_etal_Hydrobiologia_401_p139-148_1999.pdf

On 7/10/06, almost all 62 samples were at or below detection (10 colonies).

TOWN	SITE	BOT#	Date Coll		Ent	TOWN	SITE	BOT#	Date Coll		Ent
MANASQUAN	STOCKTON LAKE - NON-BATHING	58	10-Jul-06		80	SPRING LAKE	BROWN AVENUE SOUTH - BATHING	53	10-Jul-06	<	10
NEPTUNE CITY	MYRON & WILSON AVE - NON-BATHING	44	10-Jul-06		40	SEA GIRT	THE TERRACE - BATHING	61	10-Jul-06	<	10
SANDY HOOK	HORSESHOE COVE - NON-BATHING	15	10-Jul-06		40	SEA GIRT	BEACON BVLD - BATHING	68	10-Jul-06	<	10
SANDY HOOK	FORT HANCOCK STP - BATHING	14	10-Jul-06		30	SPRING LAKE	ESSEX AVENUE - BATHING	52	10-Jul-06	<	10
SANDY HOOK	SPERMACETTI COVE - NON-BATHING	17	10-Jul-06		30	SPRING LAKE	WASHINGTON AVE - BATHING	51	10-Jul-06	<	10
LONG BRANCH	LAIRD AVENUE - BATHING	27	10-Jul-06		20	SPRING LAKE	NEWARK AVE - BATHING	64	10-Jul-06	<	10
NEPTUNE TWP.	RIVERSIDE & THE PLAZA - BATHING	43	10-Jul-06	<	10	SPRING LAKE	WORTHINGTON AVENUE - BATHING	50	10-Jul-06	<	10
AVON	SYLVANIA AVENUE - BATHING	42	10-Jul-06	<	10	KEYPORT	BROAD STREET - NON-BATHING	1	10-Jul-06	<	10
BELMAR	20TH AVE - BATHING	71	10-Jul-06	<	10	UNION BEACH	FRONT STREET - NON-BATHING	2	10-Jul-06	<	10
BELMAR	12TH AVENUE - BATHING	48	10-Jul-06	<	10	KEANSBURG	BEACHWAY & RARITAN - NON-BATHING	3	10-Jul-06	<	10
BELMAR	7TH AVE - BATHING	70	10-Jul-06	<	10	HIGHLANDS	CONNERS STREET BEACH - BATHING	10	10-Jul-06		10
BELMAR	ROUTE 71 BRIDGE - NON-BATHING	46	10-Jul-06		10	HIGHLANDS	RECREATION CENTER - BATHING	7	10-Jul-06	<	10
BELMAR	L STREET - BATHING (RAIN PROVISIONAL)	45	10-Jul-06	<	10	HIGHLANDS	MILLER STREET BEACH - BATHING	8	10-Jul-06	<	10
BRADLEY BEACH	EVERGREEN AVENUE SOUTH - BATHING	41	10-Jul-06	<	10	HIGHLANDS	SOUTH BAY AVENUE BEACH - BATHING	9	10-Jul-06	<	10
BRADLEY BEACH	OCEAN PARK AVENUE - BATHING	40	10-Jul-06	<	10	MIDDLETOWN	IDEAL BEACH - BATHING	4	10-Jul-06	<	10
OCEAN GROVE	BROADWAY - BATHING	39	10-Jul-06	<	10	PORT MONMOUTH	NON-BATHING	5	10-Jul-06	<	10
OCEAN GROVE	MAIN STREET - BATHING	38	10-Jul-06	<	10	LEONARDO	THOMPSON AVENUE - BATHING	6	10-Jul-06	<	10
ASBURY PARK	ASBURY AVENUE - BATHING	37	10-Jul-06	<	10	SEA BRIGHT	PUBLIC BATHING BEACH - BATHING	20	10-Jul-06	<	10
ASBURY PARK	3RD AVENUE - BATHING	36	10-Jul-06	<	10	SEA BRIGHT	NON-BATHING	22	10-Jul-06	<	10
ASBURY PARK	7TH AVENUE - BATHING	35	10-Jul-06	<	10	BEACH	AVENUE - NON-BATHING	24	10-Jul-06	<	10
LOCH ARBOR	VILLAGE BEACH CLUB - BATHING	63	10-Jul-06	<	10	BEACH	MONMOUTH BEACH CLUB - BATHING	23	10-Jul-06	<	10
ALLENHURST	CEDAR AVENUE - BATHING	33	10-Jul-06	<	10	LONG BRANCH	BATHING	25	10-Jul-06	<	10
DEAL	DEAL CASINO - BATHING	32	10-Jul-06	<	10	LONG BRANCH	JOLINE AVENUE - BATHING	26	10-Jul-06		10
ELBERON	ELBERON BATHING CLUB - BATHING	31	10-Jul-06	<	10	LONG BRANCH	SOUTH BATH AVENUE - NON-BATHING	29	10-Jul-06	<	10
MANASQUAN	NON-BATHING	59	10-Jul-06	<	10	LONG BRANCH	NORTH BATH AVENUE - BATHING	65	10-Jul-06	<	10
MANASQUAN	EAST MAIN STREET - BATHING	57	10-Jul-06	<	10	ELBERON	BATHING	69	10-Jul-06	<	10
SEA GIRT	NEPTUNE PLACE - BATHING	56	10-Jul-06	<	10	LONG BRANCH	OCEAN BEACH CLUB - BATHING	30	10-Jul-06	<	10
SEA GIRT	PHILADELPHIA BOULEVARD - BATHING	62	10-Jul-06	<	10	SANDY HOOK	SURF BEACH - BATHING	18	10-Jul-06	<	10
SPRING LAKE	YORK AVE - BATHING	66	10-Jul-06	<	10	SANDY HOOK	AREA E - BATHING	60	10-Jul-06	<	10
SPRING LAKE	UNION AVE - BATHING	67	10-Jul-06	<	10	SANDY HOOK	ARMY RECREATION BEACH - BATHING	12	10-Jul-06		10
						SANDY HOOK	SANDY HOOK LIGHT - NON-BATHING	13	10-Jul-06	<	10

UPWELLING 7/7/06 – 7/10/06 http://marine.rutgers.edu/cool/sat_data/?product=sst_codar&region=latte&nothumbs=0



"**UPWELLING** on 7/7, weak winds on 7/8, then strong upwelling on 7/9 & 10.
Wind is from the S, surface water is blown offshore, and cold bottom water upwells at the beach.
Lots of bottom water nearshore, that gets flushed in and out of the estuaries with the tides."

Glenn, Scott.10/12/06.Email. Rutgers Institute of Marine and Coastal Sciences

Normally, the average flow on the ocean shelf is to the southwest, generally following the shoreline, until mixing with the Gulf Stream at Cape Hatteras. During upwellings the flow turns to the north.

Conner, W., Aurand, D., Leslie, M., Slaughter, J., Amr, A., and Ravenscroft, F. 1979. Disposal of Dredged Material within the New York District. Volume 1. Present Practices and Candidate Alternatives. The Mitre Corporation, Virginia, for the US Army Corps of Engineers. Contract No.: DACW51-C-77-0061.

Caveat: The KILLs and Westerly Winds

The Arthur Kill, by the mouth of the Raritan River, is not considered a significant source of water draining into Raritan Bay, although it **exerts a "milking action which accelerates the seaward movement of freshened water along the south shore of Raritan Bay**" (Jeffries, 1962).

Westerly winds tends to cause water to flow out of Newark Bay, and pushes water towards the eastern end of Raritan Bay; if this occurs for several days, it can result in **higher net flows out of Kill van Kull, transferring water from Newark Bay into Raritan Bay** (NY/NJCOST, 2004; Pence et. al., 2005). Easterly winds cause water to flow into Newark Bay (NY/NJCOST, 2004; Pence et. al., 2005).

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