HOW DO "TRANSIENT PHYSICAL PROCESSES" BESIDES RAIN AFFECT COASTAL WATER QUALITY?

Rev 8/9/13

"One hundred years ago, we could not predict whether it would be sunny or rainy the day after tomorrow. Now we can predict the weather as much as 10 days in advance. By the middle of the 21st century, we ought to be able to predict the weather at the beach…both above and below the water line." (Raubenheimer, 2004)

WEBSITES FOR INTERPRETING BACTERIA, ALGAE AND FLOATABLE DATA

RAIN - RUTGERS WX - SEA GIRT ETC. DAILY TOTALS (With precitipation data: Sea Bright, Sea Girt, Oceanic Bridge, Gooseneck Point Bridge; without precipitation data: Sandy Hook, Eatontown, Ocean Grove) http://climate.rutgers.edu/njwxnet/dataviewer-stnpt.php

RAIN - RUTGERS WX - SEA GIRT ETC. MONTHLY TOTALS
http://climate.rutgers.edu/njwxnet/dataviewer-stnnopt.php

RAIN - COCORAHS - COMMUNITY COLLABORATIVE RAIN, HAIL AND SNOW NETWORK.
http://www.cocorahs.org/state.aspx?state=nj

KEYPORT WEATHERUNDERGROUND
http://www.wunderground.com/weatherstation/WXDailyHistory.asp?ID=KNJKEYPO2

RAIN FORECAST - NATIONAL WEATHER SERVICE (NOAA) FORECAST PHILADELPHIA
http://www.erh.noaa.gov/forecast/MapClick.php?CityName=Freehold&state=NJ&site=PHI or www.Weather.gov/phi

RAIN FORECAST - NWS AREA FORECAST DISCUSSION ISSUED BY NWS MT. HOLLY, NJ
http://forecast.weather.gov/product.php?site=NWS&issuedby=PHI&product=AFD&format=CI&version=1&glossary=0&highlight=off

WEATHER IN MOTION
http://www.weather.com/weather/map/interactive/07748?animation=true

View 24 Hour Storm Reports (Hourly)
http://www.weather.com/weather/hourbyhour/graph/07748

CURRENTS STEVENS URBAN OCEAN OBSERVATORY AT THE CENTER FOR MARITIME SYSTEMS http://hudson.dl.stevens-tech.edu

WIND, WATER TEMP - STATION SDHN4 - 8531680 - SANDY HOOK, NJ
http://www.ndbc.noaa.gov/station_page.php?station=sdhn4

WIND - WINDFINDER - Real Time Wind & Weather Report West Long Branch
http://www.windfinder.com/report/west_long_branch

MC Snapshot = Waves, Tide, etc. (on bottom right of page) from Swellinfo.com
http://shore11.org/welcome

TIDES - NOREAST.COM http://www.noreast.com/tidecharts/selectlocation.cfm?region_ID=31&

HIGH WATER TIDES - SANDY HOOK NOAA (also Bergen Point and the Battery) - NOAA
http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=8531680+Sandy+Hook+%2C+NJ&type=Tide+Data&submit=Click+to+Select+Station

HIGH WATER TIDES - STEVENS' STORM SURGE DATA FROM SANDY HOOK
http://hudson.dl.stevens-tech.edu/SSWS/

MOON PHASES - NOREAST.COM http://www.noreast.com/moon/

ALGAE - CHLORAPHYLL A - NJDEP http://depchlorophyll.rutgers.edu/
http://www.nj.gov/dep/bmw/phytoplankton.htm

DEP BEACH www.NJBeaches.org

DISSOLVED OXYGEN - Station JCTN4 - Buoy 126, Jacques Cousteau Reserve, NJ
http://www.ndbc.noaa.gov/station_page.php?station=jctn4

SANDY IMPAIRED 2013

CURRENTS, WATER TEMP, DISSOLVED OYYGEN, CHLORAPHYLL A –
NYHOPS PRESENT CONDITIONS TIME SERIES AND DOWNLOADS http://hudson.dl.stevens-tech.edu/maritimeforecast/PRESENT/data.shtml

CURRENTS - RUTGERS HIGHER RESOLUTION CURRENTS DATA - 5 MHz is the low resolution shelfwide data and the 13 MHz is the new higher resolution nearshore coverage.
http://marine.rutgers.edu/cool/maracoos/imagery/

ALGAE - CHLORAPHYLL A - RUTGERS
http://marine.rutgers.edu/cool/sat_data/?product=chlor&region=latte&nothumbs=0

LAST READING 2012-07-10 14:51 - 2012-07-30 13:08
DISSOLVED OXYGEN - RU-COOL Slocum Glider Mission Control
http://marine.rutgers.edu/cool/auvs/index.php?did=353&view=imagery

Many more links are at the end of the document.

I.

Not much is known about how currents and other "transient physical processes" besides rainfall might be affecting bacterial survival in the coastal surf zone, although other areas of the country have already begun to incorporate this type of information into their lake sampling programs.

In 2004, the United States Geological Survey developed a "NowCasting Beach Advisory" model to predict Escherichia coli levels at beaches in Ohio on the Great Lakes by comparing wave height, weighted rainfall in the past 48 hours, and log10 turbidity (in contrast to conditions at ocean beaches, waves and turbidity in a lake can be more predictive of elevated E. coli levels than rain). Their model explains 38 percent of the variability in E. coli concentrations. A threshold probability of 29% was established as the criteria to post an advisory against swimming. The model predicted exceedance of the swimming standard more accurately than using the previous days E. coli sampling results; they found that using the standard approach of closing a beach after waiting for a lab analysis resulted in closing beaches more than was necessary (Francy and Darner, 2006). For additional information from their website, click on http://www.ohionowcast.info/ohionowcastunderstand.htm **.**

In the more dynamic and complex estuarine environment, a Chromophoric Dissolved Organic Matter (CDOM) tracer model has been incorporated into NYHOPS webpage for the NY Harbor that is maintained by the Stevens Institute of Technology since October 2006 (websites are listed in the "Links" section at the end). The CDOM model will help understand the mechanisms by which this material accumulates and is degraded in the marine environment, and eventually how it affects the way light spreads through the ocean and affects marine life. It produces 48-hr graphical forecasts for CDOM concentrations from five endpoints, the Hudson, Raritan, Passaic, and Hackensack Rivers, and the Port Richmond Water Pollution Control Plant (PR-WPCP) (Blumberg, 2006). The CDOM model is based on a hydrodynamic model and a modification of an available "pathogen fate model" that Stevens has already developed.

PHYTOPLANKTON AND PHYSICAL PROCESSES

While not much is known about how currents affect bacterial growth, there is a great deal of relevant research about how currents and winds can determine phytoplankton blooms. In 1976, the worst marine die-off in New Jersey's history, which resulted in more than $550 million in losses to shellfishing and related industries, happened as a result of anomalous meteorological conditions, including (among others) unusually persistent southwesterly winds that slowed and even reversed the normal southwestward flow of bottom currents on the shelf (Sinderman et al., 1979; Walsh, 1979). The wind driven, convergent circulation pattern created a strong thermocline that concentrated a massive bloom of the dinoflagellate Ceratium tripos in the bottom waters – a species usually found in small numbers that prefers cooler waters (Malone et al., 1979; Sinderman et al., 1979; Swanson et al., 1979). (When the surface water warms faster than the bottom, the water column stratifies and forms a thermocline, a thermal barrier that isolates the surface water from the bottom water (Chant et al., 2004a)). When the bloom ultimately depleted critical amounts of nutrients and dissolved oxygen, the phytoplankton rapidly suffocated and decomposed, creating an 8600 square kilometer dead zone of hydrogen sulfide in the bottom waters, 10 to 100 kilometers offshore from Sandy Hook to Cape May. This lasted until October 1976, when lower temperatures and vertical mixing finally broke up the thermocline, introducing oxygen back into the bottom waters (see Appendix for more details) (Malone et al., 1979; Reid, 2006; Sinderman et al., 1979; Swanson et al., 1979; Walsh, 1979). [1]

Phytoplankton studies may provide ideas about how fecal indicator bacteria may be affected by transient physical processes. Enterococci are no longer believed to be solely associated with sewage discharges, or to perish quickly in the environment. Under the right conditions during the summer, they can survive and even reproduce for weeks to months in sediments, seaweed, zooplankton etc. (for a summary of the various ways enterococcus is known to persist in the environment, see the article by Smith et al. for the National Park Service listed in the references). A notable difference is that phytoplankton bloom in colder water temperatures that fecal indicator bacteria are dormant in. The spring bloom of diatoms occurs in water temperatures that are similar to the refrigerator-like temperatures that are required for storing samples of enteric bacteria in order to minimize artifactual changes in colony size. This may explain in part why southerly winds that lower water temperature provide conditions where phytoplankton can potentially thrive, but where bacterial growth is constrained.

The remainder of this report is an overview of the coastal environment in Monmouth County and some of the processes that affect water quality in the nearshore. Understanding these processes is prerequisite to understanding how bacterial levels are altered by their environment.

II.

THE HUDSON-RARITAN ESTUARY

An estimated 50% of the world's population lives within less than ¾ of a mile of an ocean coast (Chang et al., 2002). Over 20 million people live in the watershed of the Hudson Raritan Estuary, which has been the most urbanized estuary in the US for over 100 years (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 (Jeffries, 1962; NJ Scuba Diver, 2005; NY/NJCOST, 2004). More than 85% of the freshwater discharges into the Bay under the Verrazano-Narrows Bridge (NY/NJCOST, 2004).

About one tenth of this average of 23,000 MGD is from wastewater plants, storm drains, and Combined Sewer Overflows (2300 MGD); New York has about 450 of the 700 Combined Sewer Overflows discharging raw sewage into the NY Bight when it rains, and NJ has a little more than 1/3 , about 250, from Perth Amboy north (Harbor Estuary Program, 2005; NY/NJCOST, 2004). The Raritan River, and the Passaic River draining through Newark Bay each discharge 1,150 MGD (both rivers combined discharge another 2300 MGD) (NY/NJCOST, 2004). The vast majority is discharged from the East River draining Long Island Sound (7,000 MGD) and the Hudson River (11,400 MGD) (NY/NJCOST, 2004). Another source describes the general volume of discharge as follows: the mean volume leaving the NY Harbor is 1000 cubic meters per second (m3s-

1); 600 m3s-1 is from the Hudson, Raritan and Passaic Rivers, 300 m3s-1 from the East River, and 100 m3s-1 from sewage outflow (Chant and Geyer, 2007).

During the years 1946-2004, the peak for the average Hudson River discharge was in January (824 m3/s), and the low was in July (249 m3/s) (Pullen, 2006). The Hudson River has an annual mean discharge of 550 cubic meters per second (m3/s), and a maximum mean flow during April of 1000 m3/s. The Raritan and Passaic Rivers each contribute 100 m3/s in the spring; about equal to the total amount of stormwater and sewage that flows into the harbor (Chant et al., 2004b). Wind can change the dynamics by overcoming the effects of tidal flow in or out of the Kills; when high westerly winds pushes water towards Sandy Hook Bay, there are higher flows out of Kill van Kull (and Newark Bay) into Raritan Bay (NY/NJCOST, 2004).

The HR plume can reach more than 93 miles south of the Battery in NY to Cape May, NJ, where it is obscured by the plume from Delaware Bay (Chant et al., 2004b; Geyer and Chant, 2007). Most of the nitrogen that is discharged into the ocean is in the more available inorganic form, in contrast to the Chesapeake Bay Estuary, where most nitrogen is taken up by algae in the estuary and then exported into the ocean in an organic form (Chant et al., 2004b). Biological production is three time higher in the HR plume than in its estuary Chant et al., 2004b).

The estuary has the typical circulation pattern where brackish surface water flows seaward and more saline bottom water flows shoreward. The HR plume flows to the south along NJ or to the north towards Long Island, with the highest flows in the spring and minimum flows in the late summer. The average flow on the ocean shelf is to the southwest, generally following the shoreline; while surface currents follow the wind, flow along the bottom generally moves towards the shore. However, nor'easters form strong longshore currents directed onshore, which causes sea level to rise along the coast, but with an offshore flow along the bottom. Shelf water between Cape Hatteras and Cape Cod takes about a year to be entrained into the Gulf Stream. Dinoflagellate blooms are associate with a stable, nutrient rich water mass, high water temperatures and high levels of sunlight; zooplankton are dominated by copepods, with the lowest populations in the winter and the highest in late spring and summer (Connor et al., 1979).

Ocean water is three percent more dense than freshwater; salt/fresh water interfaces have higher turbidity levels, and an increase in turbidity is often associated with an increase in bacterial levels. The estuarine turbidity maximum is a region of elevated suspended sediment concentrations, usually landward of the salinity intrusion into freshwater; this is caused by a number of reasons, including "salinity-induced sediment flocculation" (Woodruff et al., 2001). Flocculation (clumping) and deflocculation of soil and other particles occur as their ionic charges are altered during the transition from fresh to salt water (Chang et al., 2002). An ETM is found on the west side of the Hudson River channel, 10-20 kilometers north of the Battery; spring freshets and other high discharge events can push this salinity gradient towards the mouth of the NY Harbor (Woodruff et al., 2001).

Currents in the Hudson River Estuary, north of the Battery, are usually higher over the deepest part of the channel (the thalweg) and lower on the shallower banks; however, local changes in geometry vary current speed and direction across and along the estuary (Blumberg et al., 2004). Once past the Verrazano-Narrows Bridge, the thalweg discharges near channels that have been dredged for shipping: the Chapel Hill Channel that leads south to the Raritan Channel and to Port Monmouth, and the Ambrose Channel, which like the Raritan Channel, leads to the ocean. According to a 1993 Navy report, in Sandy Hook Channel, 0.4 miles west of the tip, the average maximum tidal current velocities are 2 knots (102.8 cm/s) for flood tide and 1.6 knots (51.4 cm/s) for ebb (1 knot = 0.5144 meters per second or 51.4 cm/s; 1 knot = 1.15 mph); while 2 miles west of Sandy Hook point, for both flood and ebb, velocities are 0.6 knots (30.84 cm/s) (DN, 1993). Current velocities between Nantucket and Sandy Hook in the NY Bight are usually about 0.1 knots (5.14 cm/s) to the south-southwest, but during storms they can reach 2-2.5 knots (102.8- 128.5 cm/s) driven in the direction of the wind (DN, 1993). The current in the (usually) clockwise eddy that forms off Sandy Hook shifts direction about 30 degrees per hour for all directions of the compass during a 12.4 hour tidal cycle, with velocities less than 3 knots (DN, 1993).

The phenomena of tidal trapping in coves and inlets along the Hudson River may be relevant to investigating how bacteria might adapt to an increase in residence time due to transient "ponding" at certain river and bay beach configurations during changes in the tide. "The basic concept of tidal trapping is that geometry irregularities can temporarily trap a water parcel as it passes by and then release it at some later time. This effectively removes a small amount of water from the original main channel water mass and then adds it back later to a new main channel water mass. For example, a water parcel with low salinity is removed from its original low salinity main channel water mass, and then added later to a new main channel water mass with higher salinity" (Blumberg, 2004).

A trapped "water parcel" can also contribute to bacterial growth. In NJ, for example, the 2004 and 2005 enterococcus closures at part of the ocean beach at Allenhurst were due secondarily to the increased residence time of water "ponding" behind an L-shaped jetty that was providing habitat for mussels and attracting a resident flock of seagulls (the closures ended when the mussels were removed by the Department of Public Works and the birds left). While several ocean beaches in Monmouth County (near the Elberon and Deal Rocks, for example) have mussel washups that attract sea gulls but without a consistent pattern of bacterial exceedences, Allenhurst has the only beach with a prominent L-jetty that blocks and pools the longshore current.

NEARSHORE CURRENTS

The general flow of shelf waters in the Middle Atlantic Bight – Cape Cod to Cape Hatteras – is southerly until reaching Cape Hatteras, where the shelf width constricts and the southerly flow mixes with the northerly Gulf Stream current (Townsend et al., 2006). The inner edge of the Gulf Stream passes about 150 nautical miles to the southeast of Sandy Hook (DN, 1993).

The two predominant currents along the New Jersey coastline flow in a northerly or southerly direction. A wind-driven current known as the littoral drift moves sand along the shoreline towards the north in Monmouth County, depositing sand on the south side of jetties (the "updrift side") due to the prevailing southerly winds during the summer (ACE, 1974; Herrington, 2005; USDI, 2004). [2]

A second ocean current, located further offshore and flowing to the south, is driven by the Hudson-Raritan plume. 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, lower salinity, warmer plume has been detected along the NJ coast more than 93 miles south of the NY harbor, and is associated with floatable and other pollution events (Chant et al., 2004b). Local circulation patterns can run counter to this southerly current and cause it to slow down and reverse direction, altering the biological and chemical conditions of the water, and trapping floatables, which will then drift with onshore winds onto beaches. For example, the area around the discharges of the Manasquan River and Barnegat Inlet have small nodes of current bifurcation, where fresh water discharges can actually flow north against the prevailing southerly current of the ocean (Ashely et. al., 1986). These are also areas where floatables from the Hudson–Raritan plume predictably wash up following heavy rains and strong onshore winds.

Currents do not follow the direction of the wind exactly because they are turned by the rotation of the earth. The "Coriolis force" and "Ekman transport" causes each layer of water to change angle slightly, creating a clockwise spiraling affect in the water in the northern hemisphere. Ideally, the surface current moves at 45 degrees to the right of the wind direction and successively deeper layers of water move increasingly to the right until at some depth the water is moving opposite the wind direction; the net transport is 90 degrees to the right of the wind direction (Oceanworld, 2006). This effect is greatest at the poles and there is no deflection for currents moving east-west over the equator (Sell, 2002). The deflection follows this idealized pattern:

WIND FROM THE	SURFACE CURRENT FLOWS TO	BOTTOM CURRENT FLOWS TO	CURRENT DIRECTION TO COAST
S	NE	E	OFFSHORE
SW	E	SE	OFFSHORE
W	SE	S	OFFSHORE
NW	S	SW	?
N	SW	W	ONSHORE
NE	W	NW	ONSHORE
E	NW	NW	ONSHORE
SE	N	NE	?

EDDY SYSTEMS, DOWNWELLINGS AND UPWELLINGS

In the open ocean, upwellings occur when nutrient rich, cyclonic (counter clockwise in the northern hemisphere) whirling systems with cold cores bring bottom waters of the thermocline closer to the surface and increase planktonic growth (primary production) (Perkins, 2003; Sell, 2002). Downwellings are associated with nutrient deficient, anticyclonic (clockwise) systems with warm core eddies (Perkins, 2003; Sell, 2002). Smaller eddies rotating in the opposite direction to these systems can form along their edges due to friction (Perkins, 2003). In the NY bight, for example, as the Gulf Stream turns towards Ireland, the current along its western boundary, which is fast, deep and relatively narrow, can produce warm or cold core eddies that sometimes detach from the stream and affect nearshore water temperatures (deVilliers, 2006; Sell, 2002). The edges of eddy systems are often targeted by fishermen because they provide conditions for abundant planktonic growth (Perkins, 2003).

In cyclonic eddies associated with upwellings in the open ocean, water spreads out from the center; while downwellings cause surrounding water to converge into its ring (Sell, 2002). It is somewhat different in the atmosphere; in the northern hemisphere, a low pressure system like a hurricane is cyclonic with ascending air that flows into the center, whereas a high pressure system is anticyclonic with descending air flowing out from it (Howstuffworks, 2006).

In the NY Bight during upwellings, cold, nutrient-rich bottom water flows in towards the NJ shoreline, and a less turbid Hudson Raritan plume detaches from the bottom water and disperses offshore towards Long Island (Chant et al., 2004a; Chant et al., 2004b; Yankovsky et al., 1997). Dr. Scott Glenn of Rutgers' Institute of Marine and Coastal Sciences commented in an email on 10/2/06 that there was an upwelling on 7/7, weak winds on 7/8, then a strong upwelling on 7/9 and 10. Wind was from the south, surface water was blown offshore, and cold bottom water was upwelling at the beach; lots of bottom water was nearshore, flushing in and out of the estuaries with the tides (Glenn, 2006). An image of this day's upwelling is at http://marine.rutgers.edu/cool/show/?file=../regions/nybight/sst/noaa/2006/img/060707.188.1002.n12.jpg .

On 7/10, almost all of the 62 bacterial samples taken that day for the beach program were at or below detection (10 colonies). Upwellings may create conditions that lower water temperatures and mix or dilute nearshore bacteria water by directing warmer, lighter, less saline water away from the shore. July 10th was one of the occasional sampling days that happen a few weeks every summer when almost all the sampling sites are at or below detection – the water has the very lowest bacteria levels. These transient low bacteria events that happen every summer may be associated with upwellings. Lower water temperatures can provide conditions where phytoplankton can potentially thrive but where bacterial growth is constrained. During the summer of 2006 when it was predominated by southwesterly winds, the water temperature data at Long Beach Island sometimes showed a saw tooth pattern, that may have been from "impulsive" upwellings that were vertically mixing the water column (and also limiting temperature stratification) (Herrington, 2006).

The opposite of an upwelling - a downwelling - causes light nearshore surface water to remain inshore, and is associated with northerly winds and warmer water, which create conditions that may increase nearshore bacteria levels. For example, it is known that persistent northerly winds cause downwelling along the NJ coast when the warmer, nutrient-rich and less saline Hudson Raritan plume floating on the ocean surface becomes narrow and turbid, extending down to the bottom of the water column as it is compressed along the NJ coast (Chant et al., 2004b).

While the cold temperatures and current shifts during upwellings might be expected to lower bacteria levels from non point pollution, the opposite could happen from point sources. Sewage effluent discharging below the thermocline from an outfall on the seafloor off Huntington Beach in California was moved shoreward near the bathing area by upwellings (Boehm, 2002). In July and August of 1988, water temperatures off the coast of Monmouth County was sometimes as low as 55F (NJDOH, 1990). Greaseballs from a malfunctioning sewer plant that cobbled 2.5 miles of shoreline for 3 weeks during that period may have been swept inshore even more strongly because of the concurrent upwelling.

RESEARCH ABOUT UPWELLINGS IN THE NY BIGHT

Marine research in the NY Bight increased in the late 1960's due to concerns over ocean dumping, and intensive studies began just three years before a massive die-off of shellfish and finfish in 1976 (Swanson et al., 1979). The 1976 catastrophe invigorated interest in studying phytoplankton ecology, particularly the ability to predict bloom development and consequences (Swanson et al., 1979). In October 1992, the Rutgers' Coastal Ocean Observation Lab was established at its Institute of Marine and Coastal Sciences. In 1994, the Marine Remote Sensing webpage was created, and in 1997 Rutgers' Coastal Ocean Observatory Laboratory Room (aka COOLroom) webpage went online.

At Stevens Institute of Technology, their New York Harbor Observing and Prediction System (NYHOPS) was established in part to provide a knowledge of meteorological and oceanographic conditions both in real-time and forecasted out to 48 hours in the Hudson River, the East River, NY/NJ Estuary, Raritan Bay, Long Island Sound and the coastal waters of New Jersey. Rutgers Lagrangian Transport and Transformation Experiment (LaTTE) was launched in 2002 and is studying how "wind forcing" affects the coastal currents along NJ in four specific areas (http://marine.rutgers.edu/mrs/latte/latte2006.htm). Phytoplankton blooms develop in these four centers and rapidly deplete dissolved oxygen from saturation levels of 6-7 milliliters per liter to hypoxic levels of 2 milliliters per liter or less. Three recurrent "upwelling centers" are located in drowned river deltas off coastal inlets: off the Barnegat Inlet, the Mullica River Estuary, and the Townsend/Hereford Inlets (Chant et al. 2004b; Glenn et al., 2006; Kohut et al. 2004). The only one off Monmouth County is an upwelling center that forms in about 20 meters of ocean water at the mouth of the NY Harbor; where the nutrient-rich Hudson Raritan plume rounds Sandy Hook (and depending on wind direction, will then flow towards Long Island or be deflected back into the Monmouth shoreline, concentrated in an area from Long Branch north). (Pullen, 2006). (Chant et al. 2004b; Glenn et al., 2006; Kohut et al. 2004).

UPWELLINGS AND PHYTOPLANKTON BLOOMS

The prevailing warm and humid southwesterly winds during the summer in the NY Bight are driven by the Bermuda High (RUCOOL, 2006). When air descends from the upper atmosphere and rotates in an anticyclone circulation - clockwise in the Northern Hemisphere - the air flows outwards in all directions from the central area of high pressure, causing a general increase in barometric pressure: a high pressure system (Wikipedia, 2006). The Bermuda High is centered near Bermuda in the summer; in the winter and early spring, it migrates east and is primarily centered near the Azores, and called an Azores High) (Wikipedia, 2006).

Other factors that determine conditions for upwellings are the strength of the rainfall-driven Hudson-Raritan plume; heavy rains can create currents that counter the effect of winds and impede the formation of upwellings (Glenn et al., 2004). The frequency and magnitude of "late summer mixing storms, " or severe winter storms can mix the surface and the bottom of the ocean so that thermocline formation is weakened and upwelling events decrease (Bowers, 2004; Glenn et al., 2004).

When southwest winds persist for several days to a week during the summer an upwelling is created, where warm light surface waters are blown offshore and replaced inshore by unseasonably cold and nutrient-laden bottom water (Reid, 2006). Even though the water temperature may drop below 60 degrees F – bacteria associated with the intestines of warm blooded animals prefer warmer temperatures - plankton growth is stimulated by the increased nutrient levels. So much so that they can cause their own death when they rapidly consume all the nutrients and dissolved oxygen (sometimes this produces an odorous brown floc that washes up on jetties and beaches and is often mistaken for sewage) (O'Connor, 1979; Swanson et al., 1979). Dissolved oxygen crashes - described as hypoxia: less than 2 mg/l oxygen, or anoxia: 0-1.0 mg/l oxygen - along ocean coasts worldwide are often linked to upwellings that cause phytoplankton blooms (Reid, 2006; O'Connor, 1979; Swanson et al., 1979)

Variations in the depth of the water along the shore and rougher bottom topography can amplify the effect of upwelling winds. Shoaling, hills, or other bottom topography associated with the sand that had built up during ebb and flood tides around ancient river deltas can change the direction of current meanderings (Chant et al., 2004a; Glenn et al., 2004; Glenn et al., 2006; Kohut, et al., 2004). Local changes in bottom topography in upwelling centers off the NJ coast can form a cyclonic (counterclockwise in the northern hemisphere) current moving counter to the direction of the main current in a circular motion on the downslope side of hilly areas of the seafloor associated with an ancient river delta (Glenn et al., 2004; Glenn et al., 2006; Chant et. al, 2004a). When this cyclonic eddy will forms over the upwelling center, it pulls phytoplankton and other organic matter from the wider shelf area down into a vortexing trap of cold, less oxygenated water (Glenn et al., 2004; Glenn et al., 2006). The increase in phytoplankton can then deplete up to 75% of the dissolved oxygen levels when the ocean has become stratified into distinct layers (a thermocline has developed) due to the absence of a storm sufficient to mix the bottom and surface water (Glenn et al., 2004). It is not known if transient countercurrents or changes in the turbulence or the direction of currents might also briefly change local bacteria densities like they do for phytoplankton, physically concentrating them like a centrifuge so that they converge into dense colonies.

UPWELLINGS AND THE SEA BREEZE

The air heats over land faster than over the ocean, creating an area of weak low pressure; when the heated air can rise no more, it spreads horizontally over the cooler air of the ocean, and sinks (RUCOOL, 2006). This creates an area of weak high pressure over the ocean, and as the two pressure zones come into equilibrium, an onshore wind is created from the area of high pressure – a sea breeze (RUCOOL, 2006). Sea breezes can change the direction of ocean currents, with a lag time of up to one or two hours (RUCOOL, 2006).

Sea breezes most often occur during the spring and summer months; however, one occurred in every month but February during a study from 1996 to 2002 (Bowers, 2004; RUCOOL,2006). The normal westerly and southwesterly direction of the wind during the summer will be shifted to a northeasterly, easterly, or southeasterly direction by sea breezes (RUCOOL, 2006). During the night, a weaker land breeze also forms (Bowers, 2004).

The numerous inlets and barrier islands along the NJ coast create irregularities in the sea breeze front, as does the orientation of the coastline (Bowers, 2004). The coastline of NJ is oriented from north to south from Sandy Hook to the southern end of Long Beach Island; and from the southwest to the northeast from LBI to Cape May (Bowers, 2004). The convex shaped north-south coastline, for example along Sandy Hook, is most favorable for sea breeze formation, while a concave shoreline, like the gap between Sandy Hook and Long Island off Raritan Bay, retards their formation (Bowers, 2004). Sea breeze fronts rarely extend south of Ocean City and Great Egg Harbor Bay because the coastline takes on a more concave shape (Bowers, 2004).

By further cooling ocean temperatures, coastal upwellings can strengthen the sea breeze and bring the sea breeze front further inland (sea breezes are also enhanced by upwellings) (Bowers, 2004).

A study of the NYC sea breeze found that without opposing winds, the sea breeze starts early in the day and can penetrate 25 to 30 kilometers (15-18 miles) inland; if it is fighting a wind, it begins during the afternoon and will reach only a few kilometers inland (Bowers, 2004). Opposing winds greater than 15 knots and temperature differentials of less than 10C (50F) between the land and ocean tend to keep the sea breeze front from penetrating inland (Bowers, 2004).

The "heat island effect" can intensify sea breezes, but they can be diminished by up to 50% by friction as they approach NYC (Bowers, 2004; Pullen et al., 2006). Lines of summer thunderstorms have spilt and gone around the NYC metropolitan region due to urban heating (Pullen, 2006). Raritan Bay breezes are rare; they seem to occur only on days of weak land breezes when the primary sea breeze is penetrating more than 30 kilometers inland along the coast (Bowers, 2004).

THERMOCLINE FORMATION AND THE MAB COLD POOL

While the surface and bottom ocean water in the NJ shelf is well mixed during the winter, beginning in April or early May the surface warms faster than the bottom and the water column stratifies and forms a thermocline, generally less than 17 feet thick, that separates the surface water from the bottom water (Chant et al., 2004a). Most often the thermocline is defined as the depth where the temperature is between 1C to 1.5C cooler than the surface temperature (Blumberg, 2006). The surface water above the thermocline, which reaches a maximum during July, can be as much as 68 degrees F warmer than the bottom, in 66 feet of water (Chant et al., 2004a). The cold water at the bottom is fed by the Middle Atlantic Bight Cold Pool; and the combination of surface heating and the supply of cold water maintains the stratification (Chant et al., 2004a). By mid August of 2006, Stevens' NYHOPS observing and forecasting system (www.stevens.edu/maritimeforecast was showing a 10C top to bottom difference off of Long Beach Island (the surface was about 23C (Blumberg, 2006).

The source of this cold water, the Middle Atlantic Bight Cold Pool, is a distinct layer of bottom water that remains 8 degrees Celsius or less over the summer, shoreward of the shelfbreak between Georges Bank and the Virginia Capes (Glenn et al., 2004). It is part of the large scale circulation pattern of the western North Atlantic Ocean, and its origin may be the glacial melt along the southern Greenland coast (Glenn et al., 2004; Kohut et al., 2004). The MAB Cold Pool is trapped below the thermocline during the summer. Colder weather enlarges the Pool and move its western boundary closer to the NJ shore, and most significant summer upwelling events have followed cooler than average autumns and winters (Glenn et al., 2004; Kohut et al., 2004).

JETTIES/GROINS

Almost all the jetties (groins) in Monmouth County have submerged tips that extend for 20 to 30 yards (Freda, 2007). At the end of most jetties in Monmouth County is a deep hole on the northeast-facing side, where fish may congregate, that develops as the south-to-north littoral flow traps sand on the southern side of the jetty (Freda, 2007). The southeast side of the jetty is the most shallow, and rip currents can form here over these high spots/small bars that form as the sand builds up (Freda, 2007). Rip currents may keep the water in the swimming zone mixed – and not allow bacteria levels to concentrate - by moving the water offshore along structures such as jetties.

APPENDIX

1976

In sensitive systems that are already stressed by local pollution, like the NY Bight, an imbalance in the normal cycle of physical environmental conditions by itself could begin an irrevocable chain of events - as was seen in a massive die-off of marine life in 1976 off NJ caused by the explosive growth of a normally insignificant species of algae (O'Connor, 1979; Swanson et al., 1979).

July 4, 2006 was the 30th anniversary of the first reports of a floc-covered seafloor of dead and dying shellfish seen by divers in sulfide-blackened bottom waters less than 20 km off the Manasquan coastline (Mahoney, 1979; Walsh, 1979). At its peak during the bicentennial summer of 1976, an 8600 square kilometer dead zone developed in the bottom waters 10 to 100 kilometers offshore from Sandy Hook to Cape May (this is an area just smaller than all the 8 counties in NJ from Burlington and Ocean south) (Sindermann et al., 1979). By the time lower temperatures and vertical mixing finally oxygenated the bottom waters that October, more than $550 million had been lost to shellfishing and related industries. It was declared a resource disaster area by the Federal government - the worst marine die-off in the state's recorded history (Sinderman et al., 1979; Walsh, 1979).

It is well documented that nutrients from storm and wastewater discharges contribute to the local blooms of diatoms, like the dinoflagellate Olisthodiscus luteus, along the NJ coast most summers, as well as to the declining dissolved oxygen levels that reach their low in August as the ocean water stratifies into isolated surface and bottom layers (Mahoney, 1979; Sinderman et al., 1979). But while this die-off had happened near the highly polluted Hudson-Raritan Estuary, as well as the sludge and spoils dumpsites that existed in the NY Bight in 1976, it has since been proven that there were not enough nutrient inputs from human sources to account for the scale of the event (Swanson et al., 1979). Instead, it was the way that weather and currents came together that year.

Unseasonably warm air temperatures during February and March produced amounts of runoff that were not usually seen until April, while storms during the warm spring and summer were only half the 25 year average. [3] The early warming of the ocean surface and the reduction in storms resulted in the development of a salinity (halocline), temperature (thermocline) and density (pycnocline) stratification that isolated the surface layer of water from the cooler, denser, and less oxygenated bottom layer - six weeks earlier than usual (Sinderman et al., 1979; Swanson et al., 1979).

Perhaps most significantly, southerly winds began in late winter rather than in April, and southwest winds persisted for 4-6 weeks from May and June (Malone et al., 1979; Sinderman et al., 1979; Swanson et al., 1979). The wind driven, convergent circulation pattern created a strong thermocline that concentrated a massive bloom of the dinoflagellate Ceratium tripos in the bottom waters – a species usually found in small numbers that prefers cooler waters and functions efficiently at low light levels, and that is minimally grazed by copepods (Malone et al., 1979; Sinderman et al., 1979; Swanson et al., 1979). The winds moved it from offshore where it accumulated in the sealed-off bottom waters from February until July (Malone et al., 1979; Sinderman et al., 1979; Swanson et al., 1979). The southwesterly winds slowed and even reversed the normal southwestward flow of bottom currents on the shelf, massing the algae in sluggish currents until they depleted critical amounts of nutrients and oxygen (Malone et al., 1979; Sinderman et al., 1979; Swanson et al., 1979). Then the bloom crashed, the decomposition proceeding earlier and more rapidly in the Sandy Hook-Manasquan area, moving south towards Cape May (Mahoney, 1979).

As the mass decomposed, it rapidly consumed the remaining oxygen until the sulfate in the water was reduced to hydrogen sulfide, a gas with the odor of rotten eggs that turns the water black and is lethal to marine life, especially benthic (sediment dwelling) organisms – like surf clams, ocean quahogs, lobsters and sea scallops - that could not avoid the area like most finfish, although some finfish like ocean pout that did not avoid these areas died hiding in the rocks (Reid, 2006; Sinderman et al., 1979; Swanson et al., 1979).

Significantly, this bloom did not develop to the north or south of NJ. The waters off Long Island, are about 50% deeper than the NJ coast, and the greater volume of water off Long Island may have contained about 44 percent more oxygen available in its bottom waters. Furthermore, the shallower waters off NJ were also more responsive to the southerly upwelling winds than the waters off Long Island (Armstrong, 1979; Mayer et al., 1979). And it did not happen to the south: the NJ shelf is about 44 percent wider than the Delmarva shelf, and so has a slower flushing rate (Armstrong, 1979).

Twenty years later, in August of 2006, an area of lethally low dissolved oxygen levels off the Oregon coast that had first developed in 2002, expanded to 1,235 square miles, about the size of Rhode Island (Dean, 2006). Unlike the hypoxic zone in the Gulf of Mexico, which has developed due to nutrient rich stormwater and sewage runoff from the Mississippi River watershed, this dead zone in the northwest was generated by a "perfect storm" of wind and currents bringing oxygen-poor, nutrient-rich bottom water to the surface – an upwelling (Dean, 2006).

HUDSON CANYON

The headwaters of the Hudson River near Mt. Marcy start about 360 miles north of Manhattan. The Hudson River Canyon begins about 20 miles southeast of Sandy Hook, and extends about 300 miles southeastward from NY Harbor to the edge of the continental shelf; it is the deepest canyon off the east coast, with a terminal depth of 15,000 feet, and is 7.5 t 9 miles wide (Connor et al., 1979). The head of the Hudson Shelf Valley is located in the Christiansen Basin at a depth of about 30 meters, and extends 150 kilometers to the southwest to a depth of about 85 meters near the head of the Hudson Canyon (Butman et al., 2003). The inshore section is locally called the Mud Gorge, and the offshore is called the Hudson Canyon (Sorensen, 2005). The canyon was formed by "catastrophic drainage" from melting glaciers 12000-14000 years ago during the Pleistocene. Large glacial lakes that existed north of the NY Bight may have breached the terminal moraine of the glacier in NY and NJ, draining the present Long Island Sound and the Hudson-Raritan Estuary (Butman et al., 2003). The Hudson River may have received the drainage from the Great Lakes region until the St. Lawrence River was exposed by the retreating glacier (Stumpf et al., 1988). Borings at the Verrazano Narrows indicate that more than 100 meters of Pleistocene and Cretaceous sediment was eroded; the Hudson Canyon is the only submarine canyon that has eroded into the eastern continental shelf (Butman et al., 2003; Stumpf et al., 1988). A "sand wave field" 70-80 meters deep in the lower canyon – too deep to for these wave patterns to form recently – is thought to be part of a catastrophic flood deposit that was quickly drowned by "the most rapid sea-level rise in the late Quarternary"; normally, these sand patterns would be destroyed by a gradual change from shoreline processes to deep water deposition (Butman et al., 2003; Sorensen, 2005). Beyond the canyon, at the edge of the continental shelf, is the continental slope; at the base of the slope is a sedimentary apron, the continental rise, and beyond that, the abyssal plain (Connor et al., 1979).

NOTES

1. In contrast, because of the lack of mixing storms and the record warm temperatures from November 2006 through January 2007, the thermocline off NJ was still intact as of January 15, 2007 (Bates, 2007a). The ocean surface water temperature off Sandy Hook was 49^{o} F, while the average water temperature for this time of year should be 37^{o} F (Bates, 2007a). On New Year's Day, the water temperature at a buoy 26 miles off Cape May reached 52^{o} F, breaking a 50^{o} F record set in 2002 and 1991 (Bates, 2007a). The record warming was due to an El Nino event, as well as the polar jet stream staying to the north, a lack of high pressures systems from the north so that air moving west across the nation did not pick up cold northern air, below-normal snow cover in North America, and global warming (Bates, 2007b).

2. In addition, net sand movement along the coast reverses direction around a dynamic nodal point between the Manasquan Inlet and Ortley Beach, due to the location of Long Island, NY. Because Long Island shelters the Monmouth County coast from large winter waves generated by Nor'easters, a greater proportion of wave energy from the southeast dominates the Monmouth county shoreline, leaving more sand on the south side of jetties (ACE, 1974; Herrington, 2005; RSCNJCRC, 2006; USDI, 2004). The opposite happens south of the Barnegat Inlet; because Nor'easter waves reach this part of the coast unimpeded, net littoral drift deposits more sand on the north side of jetties. (ACE, 1974; Herrington, 2005; USDI, 2004).

3. The winter of 1975-76 occurred during a "La Nina" event in the Pacific (UIUC, 2007).

REFERENCES

Armstrong, R. 1979. Chapter 6. Bottom oxygen and stratification in 1976 and previous years. In Oxygen Depletion and Associated Benthic Mortalities in the New York Bight, 1976. NOAA Professional Paper 11. Rockville Md. December.

Army Corps of Engineers. 1974. The District: A History of the Philadelphia District, U.S. Army Corps of Engineers 1866-1971. Chapter 19. Preserving a coastline.
http://www.usace.army.mil/publications/misc/un16/c-19.pdf

Ashley, F., Halsey, S., Buteux, C. 1986. New Jersey's Longshore Current Pattern. Journal of Coastal Research. Vol 2 No. 4. pps. 453-463.

Bates, T. 1/15/07a. Warm winter spurs record ocean temperatures. Asbury Park Press. Page B1.

Bates, T. 1/7/07b. Where the heck is winter? Asbury Park Press. Page AA1.

Boehm, A, Sanders, B. and Winant, C. 2002. Cross shelf transport at Huntington Beach. Implications for the fate of sewage discharged through an offshore ocean outfall. Environmental Science and Technology. Vol. 36. Pps. 1899-1906. http://www.stanford.edu/~aboehm/internaltides.pdf

Blumberg, A and Hellweger, F. 2004. Hydrodynamics of the Hudson River Estuary. Stevens Institute of Technology, Hudson NJ. http://www1.coe.neu.edu/~ferdi/files/hres2004.pdf

Blumberg, A. 2006 . Email. August 18, 2006. Dept of Civil, Environmental and Ocean Engineering. Stevens Institute of Technology. Castle Point on Hudson. Hoboken, NJ.

Bowers, L. 9/2004. Masters: The Effect of Sea Surface Temperature on New Jersey Sea Breeze Dynamics. Coastal Ocean Observation Lab, Institute of Marine and Coastal Sciences, Rutgers University. http://marine.rutgers.edu/cool/thesis/bowers_thesis_oct_2004.pdf

Butman, B., Middleton, T., Thieler, E., and Schwab, W. 2003. Topography, shaded relief, and backscatter intensity of the Hudson Shelf Valley, offshore of New York. USGS Open File Report 03-372. http://pubs.usgs.gov/of/2003/of03-372/images/pdf/ofr.pdf

Chang, G.; Dickey, T.; Schofield, O.; Weidermann, A.; Boss, E.; Pegau, W.; Moline, M.; and Glenn, S. 2002. Nearshore physical processes and bio-optical properties in the New York Bight. Journal of Geophysical Research. Vol. 107 No. C9, 3133. http://misclab.umeoce.maine.edu/boss/manuscripts/Changetal_JGR_2001/Changetal_JGR_2002.pdf or http://misclab.umeoce.maine.edu/documents/Changetal_JGR_2002.pdf

Chant, R.; Glenn, S.; and Kohut, J. 2004a. Flow reversal during upwelling conditions on the New Jersey inner shelf. Journal of Geophysical Research. Vol. 109, C12S03. http://marine.rutgers.edu/pubs/private/2004Chant_JGR.pdf

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

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.

Dean, C. 8/6/06. 'Dead zone' reappears off the Oregon coast. NY Times.

Department of the Navy. 1993. Draft environmental impact statement. Fast combat support ship (AOE-6 Class) homeporting. Naval Weapons Station Earle, Colts Neck, NJ. Facilities Engineering Command.

deVilliers, M. 2006. Windswept. Walker and Company

Francy, D. and Darner, R. 2006. Procedures for Developing Models To Predict Exceedances of Recreational Water-Quality Standards at Coastal Beaches. U.S. Geological Survey, Techniques and Methods 6–B5. http://pubs.water.usgs.gov/tm6b5/

Frankenstein, G. 2000. Blooms of Ulvoids in Puget Sound. Puget Sound Water Quality Action Team. http://www.psat.wa.gov/Publications/blooms_report.pdf

Freda, J. 6/8/07. Shore catch on the fly. Bass, blues will hit flies on the beach now. Asbury Park Press.

Geyer, W. and Chant, R. Accessed 7/27/07. The Physical Oceanography Processes in the Hudson River Estuary. Rutgers Univ.Ppt posted on http://www.esf.edu/efb/limburg/watershedEcology/2006/Chapt_3.pdf

Glenn, S.; Arnone, R.; Bergmann, T.; Bissett, Q.; Crowley, M.; Cullen, J.; Gryzmski, J.; Haidvogel, D.; Kohut, J.; Moline, M.; Oliver, M.; Orrico, C.; Sherrell, R.; Song, T.; Weidemann, A.; Chant, R. and Schofield, O. 2004. Biogeochemical impact of summertime coastal upwelling on the New Jersey shelf.

Journal of geophysical Research, Vol. 109, C12So2. http://marine.rutgers.edu/mrs/coolresults/papers/2003JC002265_Glenn_Biogeochemical.pdf

Glenn, S.; Crowley, M.; Haidvogel, D. and Song, D. Accessed 5/29/06. Underwater observatory captures coastal upwelling off New Jersey. American Geophysical Union (AGU) http://www.agu.org/sci_soc/eisglenn.html

Glenn, S. 10/2/06. Email. Rutgers University. New Brunswick, NJ.

Harbor Estuary Program. Accessed 12/12/05. "Fact Sheet. Combined Sewer Overflows in the NY/NJ Harbor Estuary." http://www.hudsonriver.org/hep/pdf/hep_cso.pdf

Herrington, T. 6/20/05. Email. Stevens Institute of Technology.

Herrington, T. 8/19/06. Email. Stevens Institute of Technology.

Howstuffworks.com. Accessed 8/1/06. How Hurricanes Work. http://www.howstuffworks.com/hurricane.htm

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

Kohut, J.; Glenn, S.; and Chant, R. 2004. Seasonal current variability on the New Jersey inner shelf. Journal of Geophysical Research. Vol 109. C07S07. http://osec.rutgers.edu/mrs/coolresults/papers/kohut_jgr_2003JC001963.pdf

New Jersey Department of Health. 1990. Ocean Health Study. A study of the relationship between illness and ocean beach water quality in New Jersey. Final Report. September 1990. Division of Occupational and Environmental Health. Environmental Health Service. Trenton, NJ.

Mahoney, J. 1979. Chapter 9. Plankton dynamics and nutrient cycling. Part 2. Bloom decomposition. In Oxygen Depletion and Associated Benthic Mortalities in the New York Bight, 1976. NOAA Professional Paper 11. Rockville Md. December.

Malone, T., Esaias, W. and Falkowski, P. 1979. Chapter 9. Plankton dynamics and nutrient cycling. Part 1. Water column processes. In Oxygen Depletion and Associated Benthic Mortalities in the New York Bight, 1976. NOAA Professional Paper 11. Rockville Md. December.

Mayer, D., Hansen, D., and Minton, S. 1979. Chapter 7. Water movement on the New Jersey shelf, 1975 and 1976. In Oxygen Depletion and Associated Benthic Mortalities in the New York Bight, 1976. NOAA Professional Paper 11. Rockville Md. December.

New Jersey Scuba Diver. Accessed 12/12/05. Natural Rock Formations. http://www.njscuba.net/biology/misc_bottom.html

New Jersey Scuba Diver. Accessed 4/1/07. Water Composition. http://www.njscuba.net/biology/misc_water.html

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

Oceanworld. Accessed 7/10/06. Glossary. http://oceanworld.tamu.edu/resources/glossary.htm

O'Connor, J. 1979. A perspective on natural and human factors. In Oxygen Depletion and Associated Benthic Mortalities in the New York Bight, 1976. NOAA Professional Paper 11. Rockville Md. December.

Perkins, S. 2003 Oceans aswirl – massive eddies influence Earth's climate, marine ecosystems, even big business. Science News Online. June 14, 2003. http://www.findarticles.com/p/articles/mi_m1200/is_24_163/ai_104523253

Pullen, J., Holt, T., Blumberg, A., and Bornstein, R. 2006. Atmospheric response to local upwelling in the vicinity of the NY/NJ Harbor. May4, 2006. http://www.theworldisyourocean.net/papers/2006jam.pdf

Raubenheimer,B. 2004. Shaping the Beach, One Wave at a Time. WHOI. Oceanus. http://oceanusmag.whoi.edu/v43n1/raubenheimer.html

Reid, R. 8/11/06. Email. National Oceanic and Atmospheric Administration. Sandy Hook NJ.

Richard Stockton College of NJ Coastal Research Center. Accessed 8/11/06. New Jersey Geologic History. The NJ Beach Protection Network. http://gannet.stockton.edu/njbpn2004/2004/nj_geologic_history.htm

Richard Stockton College of NJ Coastal Research Center. Accessed 8/11/06(b). New Jersey Shoreline Protection and Vulnerability. The NJ Beach Protection Network. http://gannet.stockton.edu/njbpn2004/2004/nj_shoreline_protection.htm

Rutgers University Coastal Ocean Observation Lab. Accessed 10/12/06. Sea Breeze Tutorial. http://marine.rutgers.edu/cool/seabreeze/tutorial.html

Sell, A. 2002. Eddies – an introduction: impact on marine food chains. University of Hamburg, December, 2002. http://www.biologie.uni-hamburg.de/ihf/downloads/LV-SelTop/Eddies.pdf

Sindermann, C. and Swanson, L. 1979. Chapter 1. Historical and regional perspective. In Oxygen Depletion and Associated Benthic Mortalities in the New York Bight, 1976. NOAA Professional Paper 11. Rockville Md. December.

Smith, Wendy, Meredith Nevers, and Richard Whitman. 2006. Advances in recreational water quality monitoring at Indiana Dunes National Lakeshore. Park Science 24(1): 19-23. http://www2.nature.nps.gov/ParkScience/index.cfm?ArticleID=49

Sorensen, D. 12/5/05. Email. Monmouth County Health Department.

Stumpf, R. and Biggs, R. Surficial Morphology and Sediments of the Continental Shelf of the Middle Atlantic Bight. In Pacheco, A. 1988. Characterization of the Middle Atlantic Water Management Unit of the Northeast Regional Action Plan. NOAA Technical Memorandum NMFS_F/NEC-56. US Department of Commerce. National Oceanic and Atmospheric Administration. Sandy HooK Lab, National Marine Fisheries Service, Highlands NJ.

Swanson, L., Sindermann, C. and Han, G. 1979. Oxygen depletion and the future: an evaluation. In Oxygen Depletion and Associated Benthic Mortalities in the New York Bight, 1976. NOAA Professional Paper 11. Rockville Md. December.

Townsend, D., Thomas, A., Mayer, L., Thomas, M. and Quinlan, J. 2006. Oceanography of the northwest Atlantic Shelf (1,W). in Robinson, A and Brink K. (eds.) The Sea: The Global Coastal Ocean: Interdisciplinary Regional Studies and Synthesis. Harvard University Press. http://grampus.umeoce.maine.edu/dave/N-Atl-Final.pdf

United States Department of the Interior. 2004. Environmental Survey of Potential Borrow Areas Offshore Northern New Jersey and Southern New York and the Environmental Implications of Sand Removal for Coastal and Beach Restoration. Chapter 3. Regional Geomorphic Change. Minerals Management Service. http://www.oceanscience.net/mms_nj_ny/project%20report.htm

University of Illinois at Urbana-Champaign. Accessed 1/17/07. El Nino a warm current of water. Department of Atmospheric Sciences. http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/eln/def.rxml

Walsh, J. 1979. Forward – Oxygen Depletion and Associated Benthic Mortalities in the New York Bight, 1976. NOAA Professional Paper 11. Rockville Md. December.

Woodruff, J., Geyer, W., Sommerfield, C. and Driscoll, N. 2001. Seasonal variation of sediment deposition in the Hudson River estuary. Marine Geology. Vol. 179 P. 105-119.

Yankovsky, A. and Chapman, D. 1997. A simple theory of the fate of buoyant coastal discharges. Journal of Physical Oceanography. Vol.27. Pps 1386-1401. http://www.whoi.edu/science/PO/dept/personnel/chapman/Yankovsky_Chapman_buoyant_1997.pdf

III. LINKS

NOAA Time Conversion Table – UTC To Eastern Standard (less 5 hrs)
http://www.nodc.noaa.gov/dsdt/cwtg/TimeConversionTable.htm

ALGAE

RUTGERS – CHLORAPHYLL A
http://marine.rutgers.edu/cool/sat_data/?product=chlor&region=latte&nothumbs=0

NJDEP – CHLORAPHYLL A
http://depchlorophyll.rutgers.edu/
http://www.nj.gov/dep/bmw/phytoplankton.htm

NJDEP – WATER QUALITY SENSORS
http://www.state.nj.us/dep/wms//bmw/sensorhome.htm
http://www.state.nj.us/dep/beaches/

NYHOPS PRESENT CONDITIONS TIME SERIES AND DOWNLOADS - CLOR, WAVE HT, WATER TEMP. http://hudson.dl.stevens-tech.edu/maritimeforecast/PRESENT/data.shtml

MONMOUTH UNIV. URBAN COAST INSTITUTE COASTAL WATER QUALITY REAL-TIME MONITORING PROGRAM
http://www.monmouth.edu/urban_coast_institute/coastal_water_quality/default.asp

DISSOLVED OXYGEN - Station JCTN4 - Buoy 126, Jacques Cousteau Reserve, NJ
http://www.ndbc.noaa.gov/station_page.php?station=jctn4

DISSOLVED OXYGEN - RU-COOL Slocum Glider Mission Control
http://marine.rutgers.edu/cool/auvs/index.php?did=353&view=imagery

BLOGS

DR. JEFF MASTERS' WUNDERBLOG (WEATHERUNDERGROUND)
http://www.wunderground.com/blog/JeffMasters/show.html

CHARTS

CHARTMAKER
http://chartmaker.ncd.noaa.gov/staff/charts.htm

CURRENTS ETC.

RUTGERS HIGHER RESOLUTION CURRENTS DATA
The 5 MHz is the low resolution shelfwide data and the 13 MHz is the new higher resolution nearshore coverage. The default image is from our 5 MHz system. You can move the box around the large image to the left to zoom in on certain regions of the coverage. To access the new 13 MHz product just use the dropdown in the upper left corner and select 'avhrrsst-hfr13mhz'. The click the 'Get Imagery' button. This

will give you an image of the currents over the sea surface temperature. This is an average of both over the last 24 hours. If you unselect 'Composites' and hit 'Get imagery' you will see the most recent instantaneous map. The time step buttons will allow you to back and forth in time.
http://marine.rutgers.edu/cool/maracoos/imagery/

RUTGERS LATTE - CODAR
http://marine.rutgers.edu/cool/sat_data/?product=sst_codar&region=latte&nothumbs=0

STEVENS URBAN OCEAN OBSERVATORY AT THE CENTER FOR MARITIME SYSTEMS
http://hudson.dl.stevens-tech.edu

RUTGERS UNIVERSITY COASTAL OCEAN OBSERVATION LAB CODAR: MID-ATLANTIC BIGHT - CENTER: SURFACE CURRENTS (most accurate as of 9/21/10)
http://rucool.marine.rutgers.edu/index.php/CODAR-Mid-Atlantic-Bight-Center/

RUTGERS LONG-RANGE CODAR REAL-TIME DATA – VELOCITY
http://marine.rutgers.edu/cool/codar/real-time/raw_lr_nearshore.html

RUTGERS NORTHERN NEW JERSEY COASTAL CURRENT - VELOCITY
http://marine.rutgers.edu/cool/codar/real-time/breezy_rads.html

RUTGERS STANDARD RANGE - NY HARBOR VELOCITY
http://marine.rutgers.edu/cool/codar/real-time/archiveviewer_sr1day.php

RUTGERS LONG RANGE NEW YORK BIGHT VELOCITIES
http://marine.rutgers.edu/cool/codar/real-time/archiveviewer_lr.php

RUTGERS STANDARD RANGE CODAR REAL-TIME DATA MAIN PAGE – VELOCITY
http://marine.rutgers.edu/cool/codar/real-time/real_time_std.html

RUTGERS LONG-RANGE CODAR REAL-TIME DATA MAIN PAGE – VELOCITY
http://marine.rutgers.edu/cool/codar/real-time/real_time_lr.html

RIP CURRENTS
http://www.erh.noaa.gov:80/phi/ripcurrent/getSRF.php

RUTGERS LATTE – RARITAN BAY AND RIVER PLUMES
http://marine.rutgers.edu/cool/latte/satellite_photo2005.htm

STEVENS – BOTTOM TOPOGRAPHY – NY HARBOR AND RARITAN BAY
http://nauticalcharts.noaa.gov/csdl/op/nynj/ny_topo.html

NJDEP – WATER QUALITY SENSORS
http://www.state.nj.us/dep/wms//bmw/sensorhome.htm

ATLANTIC CURRENTS
http://oceancurrents.rsmas.miami.edu/atlantic/atlantic.html

HFRADAR DERIVED SURFACE CURRENTS FOR US
http://cordc.ucsd.edu/projects/mapping/maps/

CORMIX - USEPA-supported mixing zone model – plume pictures http://www.cormix.info/picgal/index.php

NEW JERSEY SHELF RESEARCH
http://njshelf.blogspot.com:80/

EMERGENCY

GEOMAGNETIC ACTIVITY, SOLAR RADIATION, RADIO BLACKOUTS, ENERGETIC PARTICLES, SOLAR WIND - NOAA Space Weather Forecasts
http://www.swpc.noaa.gov/ftpdir/latest/three_day_forecast.txt?utm_source=NHC+Master+List&utm_campaign=f5a1784dda-DR600&utm_medium=email

http://www.swpc.noaa.gov/ftpdir/latest/forecast_discussion.txt?utm_source=NHC+Master+List&utm_campaign=f5a1784dda-DR600&utm_medium=email

NWS CURRENT BRIEFING (Storms) - Weather Briefing Packages
http://www.erh.noaa.gov/er/phi/briefing/packages/
http://www.erh.noaa.gov/er/phi/briefing/packages/current_briefing.pdf

NWS MT. HOLLY http://weather.gov/phi

GOOGLE CRISIS RESPONSE http://www.google.org/crisisresponse/

WXNATION RADAR http://www.wxnation.com/newyorkcity/

NOAA NATIONAL WEATHER SERVICE RADAR MAIN PAGE
http://www.nws.noaa.gov/radar_tab.php

NOAA NATIONAL WEATHER SERVICE ENHANCED RADAR IMAGE LOOP NATIONAL MOSAIC - FULL RESOLUTION http://radar.weather.gov/Conus/full_loop.php

NOAA NATIONAL WEATHER SERVICE ENHANCED RADAR MOSAIC NORTHEAST SECTOR
http://radar.weather.gov/ridge/Conus/northeast.php

NOAA LOOP CONTAINS THE PAST 24 HOURS OF IMAGES OF THE UNITED STATES
http://www.weather.gov/sat_loop.php?image=ir&hours=24

NOAA NATIONAL WEATHER SERVICE HURRICANE CENTER
http://www.nhc.noaa.gov/index.shtml

CARIBBEAN HURRICANE ACTIVITY (ATLANTIC LOOP)
http://www.intellicast.com:80/Storm/Hurricane/AtlanticSatellite.aspx?animate=true&enlarge=true

TROPICAL WEATHER
http://www.wunderground.com/tropical/

BOAT US HURRICANE FORECASTING http://www.boatus.com/hurricanes/

ASBURY PARK PRESS HURRICANE RESOURCES www.app.com/hurricaneresources

NOAA MT. HOLLY EMERGENCY PLANNER

http://www.erh.noaa.gov/er/phi/emerman.htm

SEVERE WEATHER
http://www.wunderground.com/severe.asp

US ARMY CORPS OF ENGINEERS EMERGENCY OPERATIONS
http://209.225.176.11/ceerp/

STONY BROOK STORM SURGE RESEARCH GROUP – COASTAL ALERTS[2]
http://stormy.msrc.sunysb.edu

STEVENS' STORM SURGE DATA FROM SANDY HOOK
http://hudson.dl.stevens-tech.edu/SSWS/

RIVER & LAKE LEVELS INCLUDING SANDY HOOK
http://www.weatherforyou.com/wxinfo/hw3/hw3.php?forecast=riversnearby&place=red+bank&state=nj&zipcode=07701&country=us&county=34025&zone=NJZ013

Station 44009, National Data Buoy Center, 26 NM Southeast of Cape May, NJ
http://www.ndbc.noaa.gov/station_page.php?station=44009

Station 44066 - Texas Tower #4
http://www.ndbc.noaa.gov/station_page.php?station=44066

NOAA Mean Sea Level Trend - 8531680 Sandy Hook, New Jersey
http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8531680

NJDEP DROUGHT PAGE
http://www.njdrought.org/regions.html

SHIP LOCATORS http://www.marinetraffic.com/ais/ http://shipfinder.co/

FORECASTS

DEP WEATHER FORECASTS (RAIN)
http://ready.arl.noaa.gov/READYcmet.php
http://www.wbuf.noaa.gov/bufkit/bufkit.html
http://www.erh.noaa.gov/phi/bufkit.htm
http://www.cnrfc.noaa.gov/weather_models.php
http://www.erh.noaa.gov/er/phi/
http://www.wunderground.com/radar/radblast.asp?ID=DIX

NATIONAL WEATHER SERVICE (NOAA) FORECAST PHILADELPHIA
http://www.erh.noaa.gov/forecast/MapClick.php?CityName=Freehold&state=NJ&site=PHI or www.Weather.gov/phi

NOAA NWS AREA FORECAST DISCUSSION ISSUED BY NWS MT. HOLLY, NJ
http://forecast.weather.gov/product.php?site=NWS&issuedby=PHI&product=AFD&format=CI&version=1&glossary=0&highlight=off

WXNATION RADAR http://www.wxnation.com/newyorkcity/

INTELLICAST
http://www.intellicast.com/Local/Weather.aspx?location=USNJ0308

ACCUWEATHER
http://www.accuweather.com/index.asp?partner=accuweather&traveler=0&zipChg=1

NY NJ PA Weather
http://www.nynjpaweather.com/

NOAA Graphical Forecasts Philadelphia, PA
http://www.weather.gov/forecasts/wfo/sectors/phi.php

New Jersey Buoy Data - Graphical
http://www.pdfamily.com/weather/buoy/NJbuoy.php

FIRE SERVICE etc.
http://kamala.cod.edu/nj/

CURRENT RAIN MT HOLLY (BASE REFLECTIVITY LOOP)
http://radar.weather.gov/radar.php?rid=dix&product=N0R&overlay=11101111&loop=yes

NATIONAL WEATHER SERVICE (NOAA) FORECAST MOUNT HOLLY NJ
http://www.erh.noaa.gov:80/phi/

NOAA CLIMATE PREDICITON CENTER – 30 DAY PROGNOSTIC
http://www.cpc.ncep.noaa.gov/products/predictions/long_range/fxus07.html

ATLANTIC SATELLITE - HURRICANE
http://www.intellicast.com/Storm/Hurricane/AtlanticSatellite.aspx?animate=true

BUOYWEATHER.COM
http://www.buoyweather.com/index.jsp

MARINE FORECAST – WEATHER UNDERGROUND (ALSO GLOBAL WATER TEMPS)
http://www.wunderground.com/MAR/AN/355.html

NOREAST.COM
http://www.noreast.com/weather/selectarea.cfm?region_ID=31&

RUTGERS –(WIND AT 10 METERS, AIR TEMP, 1-HR PRECIPITATION, AND OTHER FORECASTS WIND AT 10 METERS, AIR TEMPERATURE, SEA-LEVEL PRESSURE, AND ACCUMULATED RAINFALL) [1]
http://marine.rutgers.edu/cool/weather/WRF/

UNYSIS NAM MODEL GRAPHICAL FORECAST
http://weather.unisys.com/nam/4panel/nam_pres_4panel.html

NOAA NARRATIVES ON PREVIOUS STORMS
http://www.erh.noaa.gov/er/phi/archives.html

OLD WEATHER SURVEY
http://www.oldweather.org/?utm_source=NHC+Master+List&utm_campaign=aadb35c88f-DR_5749_22_2011&utm_medium=email

RAIN ETC.

WUNDERMAP – WEATHER UNDERGROUND
http://www.wunderground.com/stationmaps/gmap.asp?lat=40.29449844&lon=-73.99517822&zoom=10

RUTGERS WX - SEA GIRT ETC. DAILY TOTALS (With precitipation data: Sea Bright, Sea Girt, Oceanic Bridge, Gooseneck Point Bridge; without precipitation data: Sandy Hook, Eatontown, Ocean Grove)
http://climate.rutgers.edu/njwxnet/dataviewer-stnpt.php

RUTGERS WX - SEA GIRT ETC. MONTHLY TOTALS
http://climate.rutgers.edu/njwxnet/dataviewer-stnnopt.php

WUNDERGROUND HISTORY FOR KNJKEYPO2 VAN DEVENTER PARK, KEYPORT, NJ
http://www.wunderground.com/cgi-bin/findweather/getForecast?query=07735&sp=KNJKEYPO2

USGS KEANSBURG (TIDE STATION)
http://waterdata.usgs.gov/nj/nwis/uv?cb_00045=on&format=gif_default&period=10&site_no=402657074085101

USGS
http://waterdata.usgs.gov/nj/nwis/current/?type=weather&group_key=basin_cd

USGS WATER ALERT NETWORK
http://water.usgs.gov/wateralert/

NOAA/NATIONAL WEATHER SERVICE PRECIP DATA (On the left menu, under Precipitation, click Multisensor Obs)
http://weather.gov/marfc

COCORAHS - COMMUNITY COLLABORATIVE RAIN, HAIL AND SNOW NETWORK.
http://www.cocorahs.org/state.aspx?state=nj

NJ STATE CLIMATOLOGIST
http://climate.rutgers.edu/stateclim/

RUTGERS WX CLIMATE MAPS (.1, 1, 2" RAIN)
http://climate.rutgers.edu:80/stateclim/?section=menu&%20target=clim_maps

SALINITY

New York Harbor Observing and Prediction System (*NYHOPS*) Google Earth
http://hudson.dl.stevens-tech.edu/maritimeforecast/google/index.shtml

STREAMFLOW-USGS

NJ - http://waterdata.usgs.gov/nj/nwis/rt

NY - http://waterdata.usgs.gov/ny/nwis/rt

USGS MASTER MAP
http://waterwatch.usgs.gov/?m=real&r=nj&w=map

MANASQUAN RIVER
Squankum
http://waterdata.usgs.gov/nj/nwis/uv/?site_no=01408000&PARAmeter_cd=00065,00060

Allenwood (Including Turbidity)
http://waterdata.usgs.gov/nj/nwis/uv/?site_no=01408029&PARAmeter_cd=00065,00060

SHARK RIVER
Neptune City
http://waterdata.usgs.gov/nj/nwis/uv/?site_no=01407705&PARAmeter_cd=00065,00060

Jumping Brook near Neptune City
http://waterdata.usgs.gov/nj/nwis/uv/?site_no=01407760&PARAmeter_cd=00065,00060

RAHWAY RIVER
Rahway (Closest To Raritan Bay)
http://waterdata.usgs.gov/nj/nwis/uv/?site_no=01395000&PARAmeter_cd=00065,00060

RARITAN RIVER
Below Calco Dam At Bound Brook
http://waterdata.usgs.gov/nwisweb/graph?agency_cd=USGS&site_no=01403060&parm_cd=00060&period=60

NY STATE MAP USGS
http://waterwatch.usgs.gov/?m=real&r=ny&w=real%2Cmap

HUDSON RIVER ENVIRONMENTAL CONDITIONS OBSERVING SYSTEM (HRECOS) – Water Temp, Wind, etc.
http://www.hrecos.org/joomla/index.php?option=com_content&view=section&id=13&Itemid=56

HUDSON RIVER - SOURCES OF REAL-TIME DATA
http://www.hrecos.org/joomla/index.php?option=com_content&view=article&id=108&Itemid=82

POUGHKEEPSIE ON HUDSON RIVER (CLOSEST TO NYC WITH STREAM GAGE)
http://waterdata.usgs.gov/nwis/nwisman/?site_no=01372058

USGS REAL-TIME WEATHER/WATER DATA - NATIONAL
http://water.usgs.gov/waterwatch/wqwatch

USGS to get gage data when in the field
http://water.usgs.gov/waternow/

TIDES and LUNAR

NOAA - SANDY HOOK TIDES AND HIGH WATER (also Bergen Point and the Battery)
http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=8531680+Sandy+Hook+%2C+NJ&type=Tide+Data&submit=Click+to+Select+Station

STEVENS' STORM SURGE DATA FROM SANDY HOOK
http://hudson.dl.stevens-tech.edu/SSWS/

THE OLD FARMERS ALMANAC (by zipcode)
http://www.almanac.com/nature/tides/NJ

NOREAST.COM
http://www.noreast.com/tidecharts/selectlocation.cfm?region_ID=31&

RIVER & LAKE LEVELS INCLUDING SANDY HOOK
http://www.weatherforyou.com/wxinfo/hw3/hw3.php?forecast=riversnearby&place=red+bank&state=nj&zipcode=07701&country=us&county=34025&zone=NJZ013

HISTORIC TIDE TABLES (edit the year you want from '05' in url address)
http://www.co-ops.nos.noaa.gov/tides05/tpred2.html

HISTORIC TIDE TABLES – NORTHEAST.COM
http://www.noreast.com/tidesnew/selectlocation.cfm?region_ID=31&IndexHistory=952

NOAA CLEARINGHOUSE
http://nowcoast.noaa.gov/

NOAA TIDESONLINE – NJ
http://www.tidesonline.com/state.php?state=New+Jersey

NOAA TIDESONLINE HOME
http://tidesandcurrents.noaa.gov/

NOAA – NY PORT WEATHER AND TIDE INFORMATION
http://tidesandcurrents.noaa.gov/nyports/nyports.shtml?port=ny

COAST GUARD TIDE PREDICTOR – NATIONAL SITES
http://tbone.biol.sc.edu/tide/sites_allalpha.html

SALT WATER TIDES
http://www.saltwatertides.com/dynamic.dir/newjerseysites.html#sandy

USGS TIDE GAUGES BY WATERSHED IN NJ
http://nj.usgs.gov/lf-cgi/by_watershed.pl?gage=tdc&shed=all

TIDAL IMPACT TABLES FOR MC
http://www.erh.noaa.gov/er/phi/tide/monmou.pdf

Daily Moon Phases by Month
http://www.almanac.com/moon/calendar/zipcode/07748/2010-01

NOREAST.COM
http://www.noreast.com/moon/

NASA PHASES OF THE MOON: 1995-2014 [4]
http://eclipse.gsfc.nasa.gov/TYPE/moonphase.html

PHASES OF THE MOON
http://aa.usno.navy.mil/data/docs/MoonPhase.html

LUNAR, TIDES etc
http://www.njfishing.com/

LUNAR PERIGEE AND APOGEE CALCULATOR
http://www.fourmilab.ch/earthview/pacalc.html

NASA TWELVE YEAR PLANETARY EPHEMERIS: 1995 – 2006 [4]
http://eclipse.gsfc.nasa.gov/TYPE/phenom2.html

ULTRAVIOLET

EPA
http://epa.gov/sunwise/uvindex.html

NOAA FORECAST
http://www.cpc.ncep.noaa.gov/products/stratosphere/uv_index/uv_current_map.shtml

Air Quality Forecast For Emergency Generator Testing
http://www.nj.gov/dep/aqpp/aqforecast/index.htm
http://www.njaqinow.net/Default.htm

WATER AND AIR TEMPERATURE, WAVES, ETC.

USGS RARITAN BAY AT KEANSBURG (WATER TEMP ETC)
http://waterdata.usgs.gov/nj/nwis/uv?cb_00035=on&cb_00036=on&cb_00011=on&format=gif&period=14&site_no=01407081

STATION SDHN4 - 8531680 - SANDY HOOK, NJ
http://www.ndbc.noaa.gov/station_page.php?station=sdhn4

AMBROSE LIGHT – WATER AND AIR TEMP, WIND
http://www.ndbc.noaa.gov/station_page.php?station=ALSN6
Station 44065 - Entrance to New York Harbor
http://www.ndbc.noaa.gov/station_page.php?station=44065

MONMOUTH UNIV.: CLOR, WAVE HT, WATER TEMP. NYHOPS SITES IN MONMOUTH
http://www.monmouth.edu/urban_coast_institute/coastal_water_quality/default.asp
http://hudson.dl.stevens-tech.edu/maritimeforecast/PRESENT/data.shtml

SURFING WAVE HEIGHTS
http://www.surfline.com/surf-report/belmar-northeast_5157/ [3]

http://magicseaweed.com/New-Jersey-New-York-Surf-Forecast/22/

http://surfinfo.surfline.com/html/heightne.html

SWELLINFO http://www.swellinfo.com/surf-forecast/monmouth-new-jersey.html

RUTGERS WX: AIR TEMPS, WIND SPEED, WIND GUSTS - STATE
http://climate.rutgers.edu/njwxnet/mapviewer.php?t=cur&m=temperature

WEATHER UNDERGROUND – ALL NJ WEATHER SITES
http://www.wunderground.com/US/NJ/

RUTGERS NJ SEABREEZE
http://marine.rutgers.edu/cool/weather/njcoastalweather.html

Dave Grant – Observations at Sandy Hook
http://ux.brookdalecc.edu/staff/sandyhook/dgrant/facts/index.htm

NOAA Rip Current Forecasts
http://ripcurrents.noaa.gov/forecasts.shtml

WIND

Wind Map Created by visualization specialists Fernanda Viegas and Martin Wattenberg
http://hint.fm/wind/?utm_source=NHC+Master+List&utm_campaign=07725af25f-DR_585&utm_medium=email

STATION SDHN4 - 8531680 - SANDY HOOK, NJ
http://www.ndbc.noaa.gov/station_page.php?station=sdhn4

WINDFINDER - Real Time Wind & Weather Report West Long Branch
http://www.windfinder.com/report/west_long_branch
Wind & weather statistic
http://www.windfinder.com/windstats/windstatistic_west_long_branch.htm
NJ http://www.windfinder.com/windreports/windreports_online_usnj.htm

NJ HARBORS FORECASTING MONMOUTH BEACH
http://nj.usharbors.com/node/1449

RUTGERS –(WIND AT 10 METERS, AIR TEMP, 1-HR PRECIPITATION, AND OTHER FORECASTS WIND AT 10 METERS, AIR TEMPERATURE, SEA-LEVEL PRESSURE, AND ACCUMULATED RAINFALL) [1]
http://marine.rutgers.edu/cool/weather/WRF/

HUDSON RIVER ENVIRONMENTAL CONDITIONS OBSERVING SYSTEM (HRECOS) – Water Temp, Wind, etc.
http://www.hrecos.org/joomla/index.php?option=com_content&view=section&id=13&Itemid=56

IWINDSURF.COM
http://www.iwindsurf.com/windAndWhere.iws?regionID=192&regionProductID=1&timeoffset=0

SAILFLOW.COM
http://sailflow.com/windandwhere.iws?regionID=106&regionProductID=29&timeOffset=0

FISHWEATHER.COM
http://www.fishweather.com/windandwhere.iws?newHomeRegionID=192

WINDGURU - Sandy Hook
http://www.windguru.com/int/index.php?sc=264

JET STREAM
http://www.weatherbank.com/free/grafx/jsnh.gif

NJ SCUBA – WAVES AND WIND OVERVIEW
http://njscuba.net/biology/misc_waves_weather.html

NOAA Aviation Weather Center Aviation Digital Data Service (ADDS)
http://aviationweather.gov/adds/winds/ It provides hourly wind forecasts for a number of different altitudes (3, 6, 9, 12, 15, 18, 24, 30, 36, 42, and 48 thousand feet). It also associates the altitudes with different pressure levels (e.g., 6000 ft is listed as 800 mb), though I'm not sure if the maps are bound to the altitude or to the pressure level. I don't think it will make much difference for your needs though, as the winds shown will at least be close to the listed altitude. An explanation of the wind barb convention is provided here. http://aviationweather.gov/adds/winds/description.php . Daylight Saving Time DST started on Sunday, March 14, 2010 at 2:00 AM local standard time DST ends on Sunday, November 7, 2010 at 2:00 AM local daylight time
http://www.timeanddate.com/worldclock/city.html?n=179 (-4 from UTC for daylight savings time, -5 hrs from UTC if we are in eastern standard time)
NOAA Fallout Winds Daily Forecast http://www.srh.noaa.gov/data/WNO/FOFUS
Reported as "iii ddss ddss ddss". Specifically, iii = 3-letter or number site identifier (jfk); dd = true direction, in tens of degrees clockwise from true north on the scale 01 to 36, toward which particles would fall from 100 mb level; ss = distance, in tens of statute miles from the station, at which particles take 3 hours to fall to the ground from 100 mb (or specific level). When local computations are made based on the sounding data and the sounding ends below 100 millibars (mb - near 60,000 ft.***), the ddss group will include a fifth digit hddss where h=height of the highest sounding level, in ten thousands of feet, either 30,000 ft (h=3), 40,000 ft(h=4), or 50,000 feet (h=5). If a sounding terminates below 30,000 ft., no fallout winds can be calculated.
http://www.weather.gov/directives/sym/pd01005018curr.pdf. *** See also "Forecasting Thermals Made Easy"(Larry Huffman): Because instruments that measure altitude operate on barometric pressure and the rate of pressure change is not always the same, these altitudes are referred to as pressure levels. Inches of mercury are the units we are used to seeing for barometric pressure but upper level soundings use millibars. 100 mb = 53,000 ft; 300 mb 30,000 ft, etc. http://people.consolidated.net/lhuffman/therm/fore.htm

WEBCAMS

RUTGERS
http://climate.rutgers.edu/njwxnet/njWebcams.jsp

STEVENS
https://cmn.dl.stevens-tech.edu/

NY CITY CAMS AND WEATHER LINKS – WEATHER NATION
http://www.wxnation.com/newyorkcity/

NJ WEBCAMS

http://surfinfo.surfline.com/html/surfcams.html

http://www.jerseycam.com/

http://webcamlocator.com/united_states/new_jersey.htm

http://www.webcam-index.com/USA/New_Jersey/

http://www.belmarbeachcam.com/

NJ TRAFFIC CAMS

SANDY HOOK – HIGHLANDS BRIDGE WEBCAMS
http://www.state.nj.us/transportation/traffic/cameras/rt36/rt36_map.shtm

http://metrocommute.com/cgi-bin/metro/video

http://metrojersey.com/njwebcams.htm

NOTES TO LINKS

1. RUTGERS – WIND, RAIN AND OTHER FORECASTS

The first drop down box includes animations of the forecast run at 6 km out to 60 hours. It also includes a higher-resolution nested product at 2 km resolution out to 48 hours. The second drop-down box includes a variation of the same 6 km domain, but since it uses different physics, it provides a slightly different outcome. These first two set of forecasts are best to look at the fine scale details of the weather over the next two days or so. The first set of forecasts is usually ready by 7 AM, the second by 9 AM.

The third box is an experimental run at 1.75 km, which is primarily used to forecast the sea breeze along the NJ coast. It is only run out to 12 hours.

The fourth and fifth box, both 18 km forecasts are run out to 5 days over a large area. The last box is 75 km and spans the entire North Atlantic.

2. STONY BROOK STORM SURGE RESEARCH GROUP – COASTAL ALERTS

Coastal alerts based on an arbitrary predicted rise in sea level above MHHW benchmark. The normally green squares turn yellow if sea level is predicted to rise more than one foot above MHHW within the current 60-hour prediction, and red if more than 2 feet above MHHW. If you click on a square, it takes you to a table listing the predicted maximum surge and when it will occur for all listed stations. The trigger levels will be adjusted at a later time based on flooding experiences for a given location. The alert system is presently restricted to locations where there are NOS or USGS tidal stations.

3. Surfline click cams and reports, slide over to click northeast, and then click Belmar. This gives a wave report, updated by 7:30 am and then again in the afternoon. It has full tide info as well as wind info. It will allow you to see the webcam for a minute, just long enough to see the conditions. This is not a forecast. Surfline actually has a spotter that looks at it every day. Others make there forecast based on wave models and buoy info.

4. In Terrestrial Dynamical Time, which is approximately equal to Greenwich Time, or UTC. UTC−5 is the time offset used in the North American Eastern Time Zone during standard time; UTC-4 for daylight savings time. An image of the UTC-5 timezone is at Wikipedia - http://en.wikipedia.org/wiki/Image:Timezones2008_UTC-5.png .

MCHD 10/18/06