The Greenwich Bay Fish Kill – August 2003

Causes, Impacts and Responses

Rhode Island Department of Environmental Management
September 3, 2003

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I. Introduction and Summary

Rhode Islanders and all who care about Narragansett Bay just witnessed a sad and telling event. More than one million fish, primarily menhaden, were reported killed on August 20, 2003. This was the result of an environmental condition that would kill any human - no oxygen to breathe. A fish kill of this magnitude - many have called it the worst in the last fifty years - makes us stop and take a hard look at the health of Narragansett Bay and how we use, manage and protect this resource that is key to the state's economic and ecological vitality. As Governor Carcieri recently said, "Rhode Island is Narragansett Bay."

This report was prepared by the Department of Environmental Management (DEM) at the Governor's urgent request for an assessment of causes and impacts, as well as recommendations for actions that might prevent, or at least minimize, the recurrence of an event like this. Given the short timeframe in which it was drafted, the report is by definition preliminary, and less than definitive in all respects. While we believe we have a relatively good understanding of what happened and why, more information would need to be collected and analyzed to further characterize and quantify impacts. There is also no perfect scientific consensus about the relative importance of various factors contributing to the event, and thus no complete consensus as to what the most appropriate policy or programmatic responses are or in what order of priority they should be pursued.

As much as we must acknowledge these limitations, we urge that they not be used as an excuse to delay action. We have sufficient knowledge and scientific understanding to move forward aggressively with certain actions, at the local and state level, by government and non-government entities, to address both short and long term issues. To put it bluntly, there is less immediate need for more study and new initiatives than for better implementation of existing programs that were developed to address the very issues raised by the fish kill. That means ensuring key programs have adequate capacity. It means getting serious about pollution reduction: eliminating cesspools, upgrading sewage treatment plants, mandating tie-ins to sewers or smaller scale treatment facilities where septic systems cannot provide adequate treatment, and either preventing direct discharge of storm water or providing adequate treatment. As we continue to improve our scientific understanding of, for example, circulation and distribution of contaminated water in Narragansett Bay or the time it takes for groundwater that discharges to the Bay to cleanse itself from contamination, we should not suspend or slow down the work we know must be done to further reduce the loading of nutrients and other pollutants into the Bay and its tributaries.

The report's major findings are:

1. There is *no magic solution, no quick fix*. It is unlikely that we will ever be able to prevent fish kills from happening at all. Nor can we guarantee that any action or combination of actions will reduce the risk of a recurrence significantly within a short period of time, say a year. Other findings explain why.

2. The fish kill was not a simple or isolated event. It was *part of a much larger event* going on in Greenwich Bay and other parts of Narragansett Bay this year, and part of a trend that has been observed for many preceding years and will likely continue. The kill affected not only menhaden, but also other finfish, eels, crabs and in particular soft shell clams, the latter also in locations north of Greenwich Bay. Additional mortality occurred among clams as this report was being written, and could occur among additional species if low or no oxygen conditions continue. In all likelihood, a much broader and deeper impact on the Bay's ecosystem is occurring from events like this, including loss of quality habitat and changes in assemblages of resident species.

3. The immediate cause for the kill was lack of oxygen, but there is a *broad and complex range of factors resulting in a severe and prolonged pattern of oxygen depletion*. They include factors that cannot be controlled, at least not quickly or directly, such as rain, wind, temperature, geology and hydrodynamics. They also include pollution from various sources, including effluent from wastewater treatment facilities and septic systems, storm water runoff and groundwater flow from polluted areas, and perhaps discharges from vessels using the Bay. Some of these, point sources, are more easily identified and dealt with than so-called non-point source pollution. All of these pollution sources need to be controlled, and all of the controls require significant resources, time and political will, to be implemented and to be effective.

4. The fish kill happened during a summer that also saw an *extraordinary number of beach closings* around Narragansett Bay, including locations that have not been usually affected in previous years. This has added to the concern that something unusual has been taking place in the Bay and that a comprehensive effort is needed to address the larger phenomenon. On the one hand, some of the same factors have contributed to poor water quality at beaches and to the fish kill, in particular an unusual amount of rain and storm water runoff. On the other hand, the phenomena are clearly different, one being caused by lack of oxygen and the other by high concentrations of bacterial pathogens. While there is some overlap in strategies to deal with these phenomena, it could be confusing and counterproductive, in our view, to merge them completely.

5. Rhode Island has had much success in improving its environment, including water quality in Narragansett Bay. Yet, events like this show us that *the progress we have made is not good enough*. We must raise the bar. We can not rely on our luck and hope that, for example, the weather will cooperate and keep fish kills and beach closures within tolerable dimensions. We have to accelerate our pollution control efforts and adopt more ambitious targets, in particular for nitrogen removal. We also need to consider to what extent we may be interfering with critical processes like circulation within, and flushing of, embayments, and may have to adjust our policies and practices.

6. Rhode Island has many programs in place that are relevant to our understanding of, and response to, this event. Between federal and state agencies, academic institutions and environmental organizations, we actually have a relatively good understanding of what happened and what must be done. Three things must happen to make us collectively more effective. First, we must ***allocate adequate resources*** to programs with key responsibility, both at the state and local level. Several state programs, including marine fisheries, water quality restoration and

enforcement are struggling to meet their mandates. Local initiatives, for example to deal with poorly functioning septic systems or storm water, are frustrated by lack of resources or available expertise. Second, to make these programs more effective and make the best use of limited resources, we must ***coordinate and integrate*** them better, at and between all levels. We need a statewide, if not watershed-wide, mechanism by which we pool our resources, share, use and disseminate information, develop and implement joint strategies, and avoid wasteful duplication. And finally, we need better ***accountability***, a structure and transparency for our efforts, so they can be evaluated on a regular basis, by a range of experts and by the public.

These three principles, adequate resources, coordination and accountability, are also the common ingredients of various proposals to develop a long term plan, or at least a better planning process, for Narragansett Bay. And indeed, the fish kill presents many Bay issues mentioned in those proposals. If anything, the event underscores the urgent need for such a proposal to be implemented and offers an obvious, initial and high-priority task to be addressed by participants. We urge the Governor to articulate this mandate and to provide the needed leadership in making sure this process will be focused on getting actual results, not just many meetings and lengthy documents.

II. Description of Event - August 20

Figure 1

Early on Wednesday, August 20, 2003, DEM received two fish kill reports. By mid morning, reports indicated that tens of thousands of fish had died in the vicinity of Greenwich Bay Marina (Figure 1). This estimate was adjusted by Marine Fisheries staff around noon to approximately one million (Figure 2). The kill consisted of mostly small juvenile menhaden, but many (hundreds) of small crabs (calico and others), an occasional larger (4 or 5 inch) blue crab, grass shrimp, a few blackfish, some horseshoe crabs, and some good sized (about 12-15 inch) American eels were also observed along the shore or floating at the surface. The menhaden which washed up on Wednesday appeared intact (no lesions such as noted in Pfiesteria incidents). The eels appeared to be the largest animals affected. Along the western shore of the bay, many noted a rotten egg smell associated with hydrogen sulfide (toxic to organisms) being produced by sediment chemistry and bacterial processes.

III. Cause(s)

The fish kill was caused by the absence of dissolved oxygen (anoxia) in the waters of Greenwich Bay, particularly in its deeper waters and near its western shore. The condition caused fish and other marine animals living in these areas of the bay to suffocate.

This conclusion is solidly based on continuous measurements made by DEM in the western bay before the event was reported, and by surveys made throughout the bay on the day that the kill was first reported. Readings from a monitoring station set up in June 2003 at a Greenwich Bay Marina dock, at the mouth of Apponaug Cove, showed dissolved oxygen levels had dropped to zero in that area. Later in the day, DEM staff determined that anoxia extended out to the mouth of Greenwich Bay at the bottom and covered the entire water column at the western end of the bay (Figure 3, next page).


Figure 2

Anoxia or hypoxia (low oxygen) is often caused, as it was in this case, by blooms of tiny marine plants. This rapid growth occurs in response to an increase in nutrients, for example when storm water enters a water body and carries with it an increased load of pollutants that include nutrients, in particular nitrogen. Heavy rainfall tends to cause significant increases in nutrient loading. Other weather factors, such as wind direction and strength, and temperature play a role as well, either providing favorable conditions under which blooms can develop and persist, or disrupting the process by mixing and oxygenating the water. Shallow bays and coves may have poor circulation and flushing, and thus be more vulnerable to nutrient loading, blooms and prolonged low oxygen conditions.

The fastest growing species are microscopic phytoplankton that are suspended in the water column, often coloring the water green or brown. They produce oxygen during daylight hours and take up oxygen from the water column at night. This is reflected in a daily cycle of dissolved oxygen levels, increasing during the day, dropping off during the night, and at their lowest in the early morning hours. Growth will slow and stop when there are no more nutrients or light can no longer penetrate the water column. Oxygen production drops and phytoplankton begin to die off. The decay uses up more oxygen as "decomposing" bacteria (not the same as those associated with fecal contamination and beach closures) break down the dead phytoplankton. The result can be, as it was here, a very rapid depletion of oxygen, especially when the preceeding bloom is large.

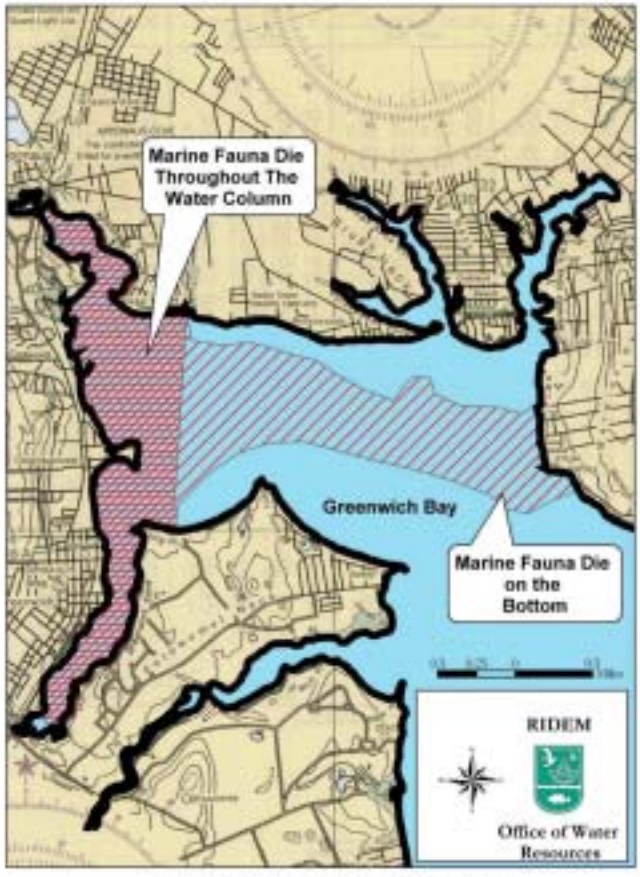
Data collected by DEM and others confirm that this scenario led to the August 20 fish kill. Significant rainstorms were followed by a significant bloom in the shallow bay, itself followed by a gradual and then very rapid decline in dissolved oxygen. The loading from storm water probably happened through both surface flow and groundwater flow, including from areas still served by septic systems. An additional, significant source of nutrient loading was the East Greenwich sewage treatment plant. While anoxia does not necessarily kill fish – they need to be present in the area – fish were abundant in Greenwich Bay at the time the oxygen dropped to zero throughout the water column, and were left with no escape. Later reports from local residents said that fish could be seen gulping for air at the surface the evening of August 19.

The data also show, however, that this event was part of a much larger event involving blooms and low oxygen levels in a larger area of Narragansett Bay; that its timeframe extends from well before to well after August 20; that the contributing factors are many and complex; that the impact goes well beyond the fish kill itself; and that part of the problem is the amount of nutrient loading that goes on even in the absence of unusual weather patterns as seen this year.

IV. Scope and Context

There have been problems with low oxygen levels and fish kills occurring nearly every summer for at least the last ten years around the upper half of Narragansett Bay. A DEM presentation at a Narragansett Bay Estuary Program (NBEP) symposium in September 1998 on nutrient removal treatment presented evidence that several areas of Narragansett Bay (including Greenwich Bay) seemed to be exhibiting low oxygen impacts like small localized fish kills and dominance of pollution-tolerant bottom species. Although these incidents draw some attention, and regulators and scientists are following up on them, it seems that we have always been able to miss having a really big kill. Except for this year.

Figure 3



Anoxic / Hypoxic Areas in Greenwich Bay
Based on DEM Measurements of August 20, 2003

Chronology

Two rainstorms passed through the area in early August. The first

storm on August 1 dropped slightly more than an inch of rain in the vicinity of Greenwich Bay. The second storm, the largest of the summer, dropped 3.75" of rain on the watershed on August 7-8. The influence of these two storms was seen initially as two pulses of fresh water that were observed to enter the bay immediately following the storms, lowering salinity (saltiness) at the surface and bottom of western Greenwich Bay. The records indicate that the fresh water was not completely mixed with salt water until approximately a week after the end of the second storm.

The rain events were followed by phytoplankton blooms. Phytoplankton contain chlorophyll, which is measured at DEM's monitoring station at the mouth of Apponaug Cove. The data show that phytoplankton levels topped out three to seven days after the rain storms. Peak values occurred August 11-13 and were the highest seen all summer. Favorable conditions included warm temperatures, plenty of light and abundant nutrients.

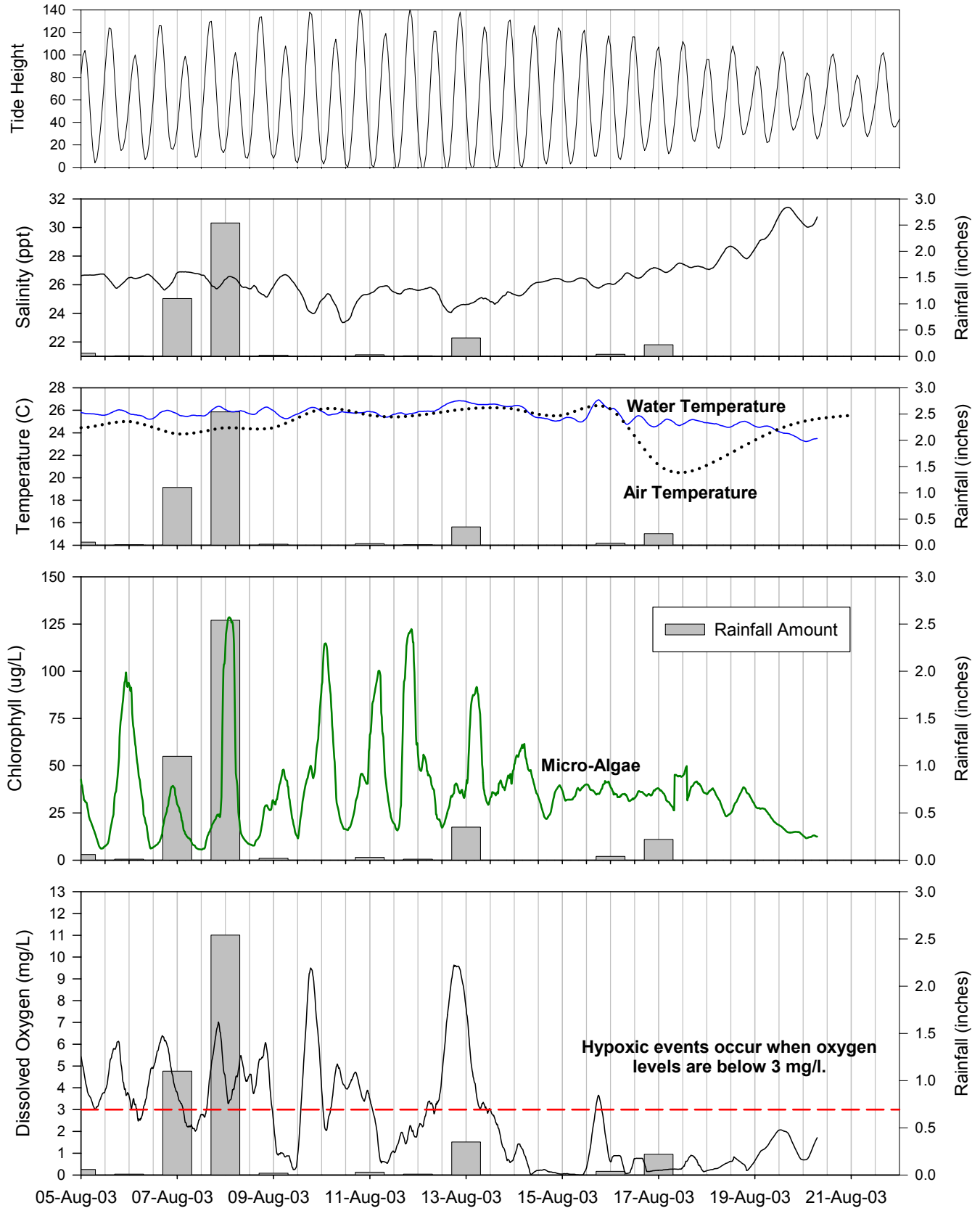
Measurements of dissolved oxygen reflect the daily cycle, then a steady drop-off after August 13, when the second bloom ended. Oxygen levels were very low at both the surface and bottom on the western side of Narragansett Bay on the morning of August 14 (Graphs 1 and 2, next two pages). Bottom conditions remained anoxic through August 20 (and beyond to the last readings on August 25). Levels were apparently low near the surface (1-4 mg/l) but sufficient to sustain animals able to reach and stay in that part of the water column. Around low tide on August 18 and 19, dissolved oxygen dropped to zero, first briefly, then staying at zero from the evening of the 19th on.

Other researchers working in the area (A. Altieri, Brown U.; B. Sullivan and D. Gifford, URI) began to see hypoxia building up on the western side of Greenwich Bay one to two weeks before the fish kill. URI researchers taking measurements once a week from a dock at the mouth of Greenwich Cove found anoxic conditions from 12' to 20' depth on August 14, similar to the readings at Apponaug Cove. A Brown University researcher studying bottom organisms off Chepiwanoxet Point over the last year observed stressed worms and an absence of crabs and fish, as well as development of white bacterial mats while diving at the site on August 7; and dead worms and crabs when he returned on August 19. A DEM underwater survey on August 21 corroborated the white bacterial mats and dead organisms on the bottom (fish, crabs and shrimp).

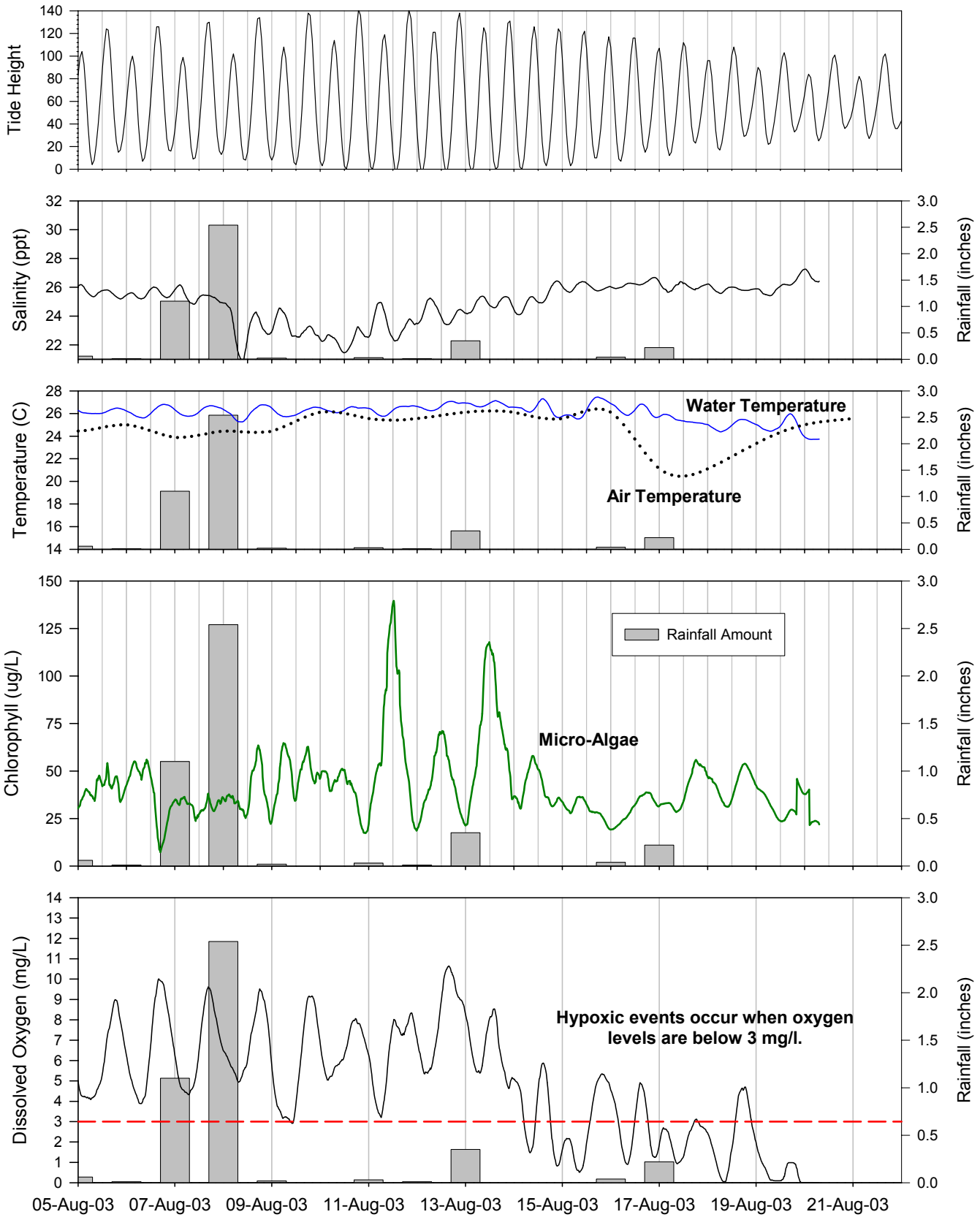
Another indicator that impacts were occurring well before August 20, and continued thereafter, is the die-off of soft shell clams. The first report of a clam kill in Greenwich Bay came several weeks before the fish kill. And on August 25-26, a massive die-off occurred, both within Greenwich Bay and at points north, with millions of juvenile soft shells washing ashore.

Conditions around Narragansett Bay – August 2003

The effect of the August rain events was not limited to the side embayments of the bay. A record available from the Narragansett Bay Commission for a continuously monitoring buoy (near Bullocks Point Light) indicated conditions in the central Providence River. The near-surface record showed that the response of the Providence River to the August storms was very similar to that of Greenwich Bay. The August 7-8 storm was followed by a drop in salinity (increased river flow) that spiked a chlorophyll bloom from the 11th -13th. The peaks of the chlorophyll levels in the lower Providence River were simultaneous with those in Greenwich Bay, indicating



Graph 1 Bottom Sonde at Greenwich Bay Marina (Depth Varies Between 1.9 and 3.8 meters)



Graph 2 Surface Sonde at Greenwich Bay Marina (Depth at 1.1)

that the blooms in the two areas are independent, resulting from similar environmental conditions and nutrient inputs. Following the end of the bloom, dissolved oxygen in the Providence River also dropped to low values (between 1 - 2.5 mg/l). Although these numbers are not as low as those seen in Greenwich Bay, they are also not sufficient to sustain sensitive animal life for very long.

A station (maintained by URI/GSO under the "Bay Window" federal grant) in upper Narragansett Bay east of Warwick Point indicates that the bottom oxygen dropped to near zero on August 18 and was lowest at the end of the record on the 20th.

A federally funded collaborative monitoring effort, the "Bay Window" has been looking at the oxygen issue in the Bay for the last 3-4 years. This effort, which includes URI, Brown University, the Narragansett Bay Estuary Program, DEM's Division of Fish and Wildlife, and the NOAA National Marine Fisheries laboratory in Narragansett, has involved continuous monitoring at several buoys around Prudence island as well as monthly tows of an undulating instrument to measure oxygen levels as well as other parameters. This latter survey was conducted out on Thursday August 20, 2003, and covered most of Narragansett Bay except for Greenwich Bay (too shallow for the instrument used). The results showed that near-bottom severe hypoxia (< 2 mg/l) extended from Field's Point (below the sewage treatment plant), down the ship channel to the middle of the upper Bay, and continued into the West Passage all the way to the Jamestown Bridge! This was the greatest extent of severe hypoxia ever recorded for Narragansett Bay, although the dry-weather August 2002 hypoxic event documented by volunteer monitors may have been as extensive (the volunteer evening survey can only cover down to Quonset with small 20' boats). Mount Hope Bay was hypoxic only in the upper half (near Fall River down to just below the state line).

A recent volunteer monitoring survey on the eve of August 25, 2003 (7PM-2 AM) found hypoxia (2-3 mg/l) still occurring in the Providence River and parts of the western side of the upper Bay, as well as near Fall River, while the West Passage continued to experience more severe hypoxia (< 2 mg/l) near the bottom, and Greenwich Bay still had a significant volume of anoxic water (essentially no oxygen) below about 12' depth, especially on the western side.

An underwater video camera was used on the August 25 evening survey to look at a small number of areas in the upper Bay which had low oxygen (hypoxic levels, but not anoxic). These areas did not appear to have mats of bacteria or dead organisms as was the case on the western side of Greenwich bay.

Much of this evidence suggests that Greenwich Bay is not the only area experiencing the problem, but it does seem to be particularly vulnerable to the most extreme impacts (i.e. no oxygen).

Conditions around Narragansett Bay - Historically

Although the magnitude of the fish kill (and the clam kill) is unusual, the phenomenon is not new. Nor is evidence of high nutrient and low oxygen levels. In fact, events of this type have been reported in Greenwich Bay for every year since we began to collect information except for

the year 2000. Events reported in Greenwich Bay for July 15, 1998 and July 26, 1999 resulted in the deaths of hundreds of fish and other animals. DEM staff documented the 1999 event, finding gray-green water extending along the entire western shore of Greenwich Bay, including Greenwich Cove (Figure 4). Daytime dissolved oxygen levels at the surface were below 2 mg/l. No fish kills were reported from this event, probably because bait fish were not present in the area. A June 23-24, 2001 event was similarly documented that caused the deaths of thousands of fish and other animals (Figure 5, next page). The area affected by this event was apparently restricted to the western edge of the bay, particularly north of Chepiwanoxet Point. Although 2002 was a relatively dry year, a bloom event that caused odors and discolored water, but no fish kill, was reported in Warwick Cove.

Low oxygen and fish kills have not been limited to Greenwich Bay. As mentioned above, evidence was presented in 1998 that several areas of Narragansett Bay (including Greenwich Bay) seemed to be exhibiting low oxygen impacts like fish kills and low oxygen-tolerant bottom species. Subsequently, the Narragansett Bay Estuary Program began to organize and coordinate a purely voluntary dissolved oxygen survey of the upper half of Narragansett Bay during summer neap tides. A small federal grant award received from NOAA enabled the purchase of several oxygen monitoring instruments, and local scientists at URI, Brown University, Roger Williams University, EPA Narragansett Lab, the Massachusetts Bays National Estuary Program and Save The Bay volunteered to be trained to use them, and have collaborated each summer since 1999 for 2-4 evening surveys.

Results of the volunteer evening oxygen surveys since 1999 have clearly revealed a consistent pattern of low oxygen in the Providence River slightly past Conimicut point, Greenwich Bay (especially the western end), as well as the western upper bay (Rocky Point side) and the upper part of the West Passage. The East Passage has low oxygen on a much less frequent basis due to the natural inflow of oxygenated seawater up this deeper natural channel. Mount Hope Bay has less data available due to shortage of volunteer boats and crew, but the data so far suggest that low oxygen tends to be mainly near the Fall River ship channel, with occasional problems at the mouth of the Lee and Cole Rivers in Massachusetts.

V. Sources of Nutrient Loading

We understand that increased runoff from land surfaces and through groundwater convey increased nitrogen loads to Greenwich Bay. The origins of these nutrients in the watershed are

very difficult if not impossible to measure directly, so their pathways to the Bay are best determined indirectly. The most comprehensive study of this issue to date was conducted by Urish and Gomez for the Greenwich Bay Initiative (1998). They constructed a loading budget based on land use, including the number of unsewered homes, lawn, roof and street areas, and other sources.

The work of Urish and Gomez was extended by DEM in 2001 to allow a comparison of watershed loads (non-point source) with those from the East Greenwich wastewater treatment facility (point source). This estimate included direct measurements of nutrients from the principal tributary streams. This comparison is our best estimate of the relationship between treatment plant and watershed loads during the sum-mer season. For this estimate, the relative contributions of lawn, wastewater (i.e. ISDS), road, and atmospheric sources were taken from Urish and Gomez.

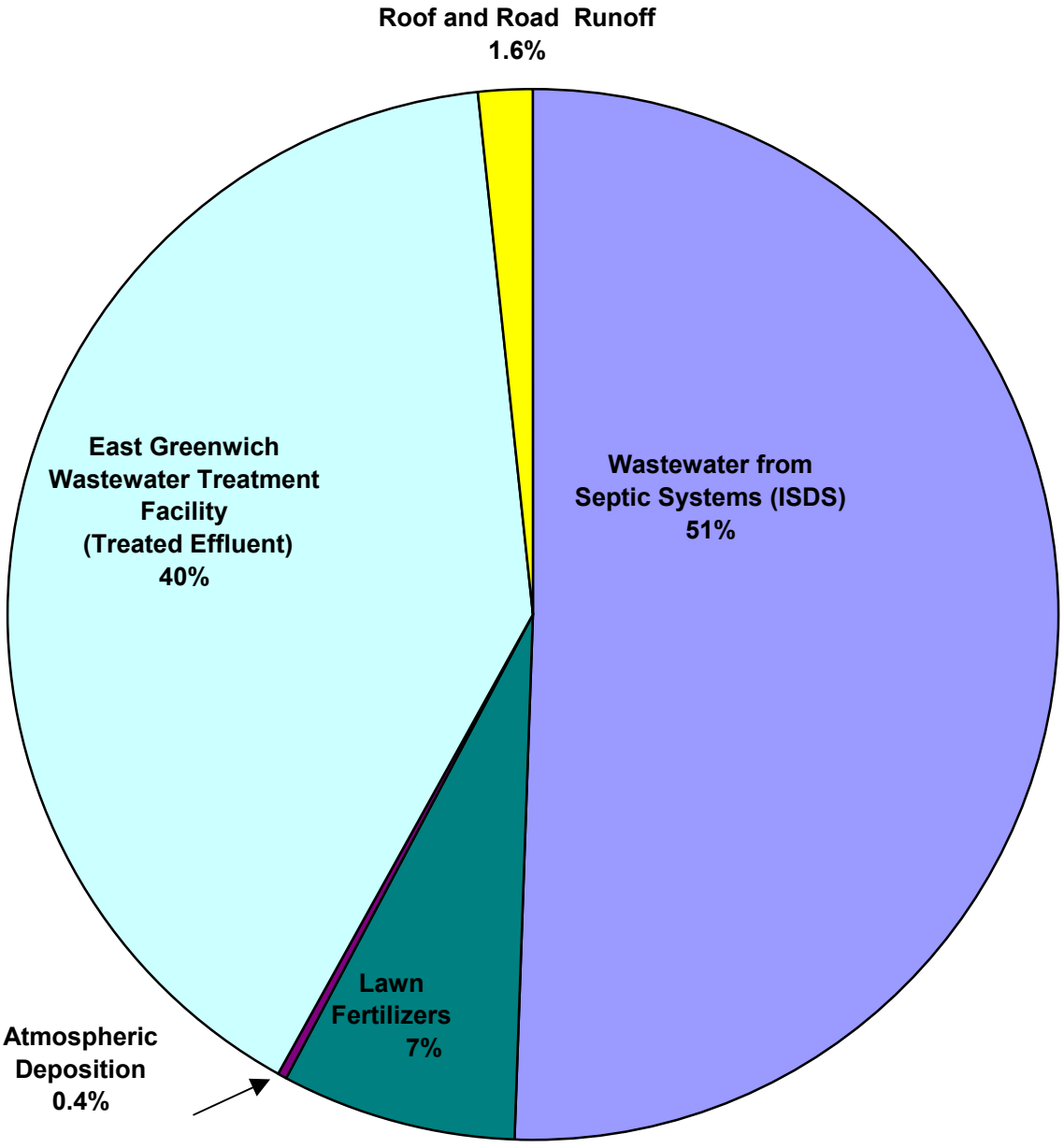
Figure 5

The pie chart (Fig 6, next page) shows that watershed loads appear to be dominated by ISDSs on the whole (51%). It should be kept in mind that even adequately working septic systems release significant amounts of nitrogen into the groundwater, which slowly transports it to nearby streams and even directly into the shoreline area of Green-wich Bay. Loads from storm water could carry nitrogen (and bacteria) from failing systems. The wastewater treatment facility is the second largest source (40%). Lawn fertilizer, road run-off, and direct atmospheric deposition account for less than 10% of the total, suggesting those sources are not dominant factors.

There is one additional, important process that merits discussion. Tides entering and leaving Greenwich Bay every 12.4 hours carry with them nutrients from Narragansett Bay that may come from further north in the Bay, or from as far south as Rhode Island Sound. A water quality model developed for Greenwich Bay by Brush in a 2002 URI dissertation indicated that nitrogen exchanges with upper Narragansett Bay may act as the largest external nitrogen source to Greenwich Bay.

This has been a serious concern for several researchers, who have pointed out that the beneficial effects of source reductions within the Greenwich Bay watershed may not be fully realized without changes to the nitrogen loads to the Providence River. DEM agrees this is a legitimate concern, and believes it underscores the necessity of controlling nitrogen loads bay-wide. Concerns with local sources of nutrients should not become an excuse to ignore larger, bay-wide

Figure 6 Watershed Nitrogen Sources to Greenwich Bay



issues. Nor should further study and debate of those larger issues delay the implementation of common sense measures that can reduce loading from local sources.

Point and Nonpoint Pollution Sources

In August 2002, despite a severe drought (opposite of this summer), low oxygen levels covered almost half of the Bay, including the Providence River, the East Passage, Upper Bay, and West Passage (Figure 7, map below). Unfortunately, Greenwich Bay was not covered due to an inadequate number of boats. However, other researchers working in the area at the time corroborate that a severe low oxygen event was occurring there also.

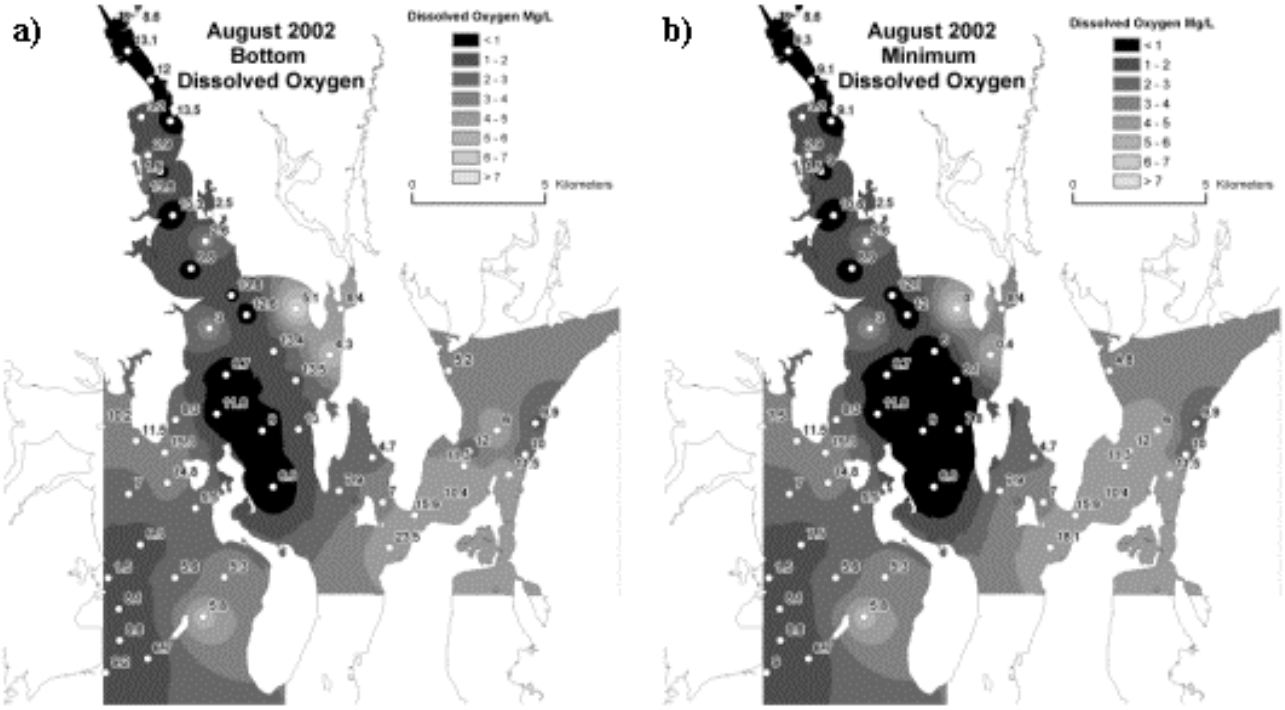


Figure 7 Dry weather hypoxia in Narragansett Bay , August 6, 2002 . (From Deacutis et al, 2003)

This finding is a key issue in the debate over point versus nonpoint sources. This recent event seems driven by rainfall-related nonpoint nutrient loadings. However, in August 2002, the severe hypoxia was clearly not due to rainfall, but to "baseline" conditions driven by nutrients from the point sources (sewage treatment plants) and what groundwater was entering the Bay (river flow was very low). These two contrasting years clearly indicate that we need to deal with nutrients from all the major sources, point and non-point.

An analysis of the 2001-02 data by the Narragansett Bay Estuary Program and Brown University scientists showed that high runoff, low salinity surface water was not required to get very low oxygen values, only a low energy situation (i.e. very weak neap tide and low winds). Nutrients are the problem source, algae provide the organic "fuel" to the bacteria, and the weak neap tides maintain the layering (stratification) necessary to decrease oxygen in the lower water layers.

This is why weak neap tides are the periods of maximum risk for the Bay. The late Dr. Dana Kester of URI predicted that August 2003 would be a high-risk period for parts of Narragansett Bay based on tidal current projections.

VI. Impacts

The obvious symptoms of the fish kill will likely disappear very rapidly, in a matter of days to weeks. Dead fish will be scavenged and buried. The stench of their decay will dissipate. Stronger tides and cooler weather with stronger wind will eventually mix water masses and raise oxygen levels.

A fish kill resulting from hypoxia or anoxia conditions is an acute symptom of nutrient pollution or over-enrichment. Anoxic conditions (dissolved oxygen concentrations below 0.5 mg/l), such as occurred over large areas of Greenwich Bay, will produce lethality of 75-90% in fish species that are not able to leave the area. Based on what we know of the kill, it appears that fish losses occurred mainly in the western side of Greenwich Bay, especially the Apponaug/Greenwich Bay Marina area. There are no reports or indications of fish losses in the Providence River or elsewhere in the Bay so far, suggesting that most fish were able to escape the poor quality but less lethal bottom conditions elsewhere. Greenwich Bay, due to its geographic orientation in relation to prevailing winds (which "protects" it from the mixing energy of most wind directions) and the poor flushing rate of the western side, may make it more prone to hypoxic events and fish kills.

In addition to the apparent mortality, a severe hypoxic/anoxic event can cause significant and long-lasting, ecological changes, particularly to bottom communities, which are more difficult to evaluate. Menhaden stocks are not likely to be significantly affected since they are large and migratory. Shellfish are able to survive short periods of anoxia but particularly the young are likely to succumb. The massive die-off of juvenile soft shell clams reflects this. Soft shell clams naturally experience wide swings in populations, so it will be difficult to accurately estimate the impact on that population, but it is likely to be significant after the second kill. the soft shell clam is not as heavily exploited commercially as the hard shell clam (quahog), there is a significant recreational fishery in Greenwich Bay. Adult quahogs are very resistant to low oxygen (they literally "clam up" and lower their metabolism to survive) and most likely will survive, but will not grow or reproduce during this stressful period. The newest sets of quahogs, however, may have been affected, as they are more vulnerable to low oxygen (cannot "hold their breath" as well). If anoxic conditions were to persist for months, impacts may extend to adult quahog population. Although it is too early to tell, impacts on the quahog fishery cannot be ruled out.

Complete recovery of a system that has suffered severe anoxia may take over five years and the "mature" community that develops after recovery may not resemble the original community. If the quahog adults are not killed, that resource may come back more rapidly, but the more sensitive non-commercial bottom species may not. Based on the volunteer evening oxygen surveys, the western area of Greenwich Bay has likely experienced these types of conditions before, so the bottom communities there are probably of the more opportunistic, pollution-tolerant type and will rapidly re-colonize the area once the cooler weather sets in.

Chronic effects are less obvious but much more important. Over-enrichment leads to frequent low oxygen conditions during summer months, changing ecological structure and function. The most sensitive species die off first (crabs, shrimp, lobster, followed by starfish, sea urchins, and sensitive marine worms). For Narragansett Bay species, lethality for sensitive species generally begins at dissolved oxygen levels below 3 mg/l. Growth of many species, particularly in larval form or juveniles, is reduced at levels less than 5 mg/l. Recruitment is diminished and diversity lowered by hypoxic conditions. Resistance to disease and other stresses is reduced. Bottom (demersal) species like flat fish typically decline while pelagic or water column species may increase.[1] Bottom habitat quality is reduced,[2] pollution tolerant benthic organisms predominate,[3] and microbial activity increases along with oxygen demand by the sediment, causing such areas to more rapidly deplete oxygen next time conditions are "ripe."[4]

VII. Recommendations

Rhode Island has many programs in place that focus in part or entirely on the health of Narragansett Bay, including ways to reduce pollutant loading. These programs use both regulatory and non-regulatory approaches for purposes like protecting the fisheries of Narragansett Bay, establishing and assuring compliance with water quality standards, water quality monitoring, biological monitoring, complaint and incident investigation, development and implementation of water quality and habitat restoration plans and watershed action plans. Within DEM, programs include wetlands and ISDS permitting, the non-point source pollution abatement (section 319) program, point source and storm water permitting (RIPDES), the Narragansett Bay Estuary Program, which is part of the National Estuary Program, the No Discharge (of wastewater by vessels into state waters) program, and beach monitoring (with the Department of Health). The Coastal Resources Management Council plays a critical role through its wetlands and coastal permitting program, its policies affecting coastal development (for example, requiring buffer zones) and its Special Area Management Planning (SAMP) program (through which denitrification systems have been required for on-site wastewater treatment, and which is currently developing a Plan for Greenwich Bay). Besides state agencies,

[1] DEM Division of Fish and Wildlife trawl survey data has shown such a shift in Narragansett Bay.

[2] Along with fish kills and low oxygen, loss of eelgrass (due to loss of water clarity) and replacement of sensitive bottom species with low-oxygen tolerant species have been noted nationally when estuaries like Long Island Sound and Chesapeake Bay are impacted by excess nutrients. Eelgrass provides a refuge, breeding ground and nursery for coastal fish, crustaceans, and shellfish (particularly scallops). Narragansett Bay is known to have had more extensive eelgrass beds in many areas of the upper half of the Bay, including Greenwich Bay, the Palmer River, off Quonset, and even the lower Providence River. All disappeared by the late 40's, early 1950's, and have not returned. Scallops, which are often associated with eelgrass also disappeared. The only viable eelgrass beds today begin at the lower end of Prudence Island due to the impacts of nutrient (especially nitrogen) loading into the upper Bay. Restoration efforts in over-enriched areas of the upper Bay and Greenwich Bay have failed.

[3] Work done in 1978 and more recently in 2001-02 by the EPA Narragansett Lab and a consultant firm (SAIC) indicates that the species of bottom organisms living in parts of the upper Bay above Jamestown seem to be more of the low-oxygen tolerant variety than in areas from Jamestown and south towards the mouth of the Bay (where low oxygen would be much less likely).

[4] Nutrient over-enrichment has other harmful effects in addition to reducing oxygen levels and the associated impacts. Algal species composition can be altered, favoring less desirable dinoflagelates and, in some cases, harmful species. Water clarity is severely reduced by algal blooms. Macroalgae growth is favored and can outcompete other more desirable habitat. The stench of dead and decaying macroalgae has been a frequent complaint in the Greenwich Bay and other upper Bay areas in recent years.

coastal communities, watershed and other environmental organizations, and many academic programs are actively involved in tracking and trying to improve conditions in the Bay.

Collectively, these efforts have allowed us to make significant progress in improving water quality. To a lesser degree, progress is also being made in habitat restoration. Such progress can lead to complacency. Although we often point to the shortcomings of our efforts, and caution that significant ecological and economic impacts are still possible, we may have gotten used to thinking that we are on the right track and close to attaining adequate and sustainable levels of water quality. We are aware of mishaps like sewer overflows and spills, and of events like algae blooms and minor fish kills, but perhaps no longer alarmed by them.

What an event like this massive die-off illustrates is that our successes are not good enough. Pollutants are still being loaded into the Bay on a regular basis. Even the loading that occurs during periods of dry weather appears to be setting us up for disaster when weather or other conditions change. That suggests that we should raise the bar for our pollution reduction efforts and try to protect water quality, not just under optimal conditions, but under unusual conditions that can suddenly cause an intensification and escalation of environmental impacts. This reevaluation and adjustment is needed throughout our programs and throughout the Narragansett Bay watershed (including Massachusetts).

In this context, we make the following recommendations:

1. Conduct a public workshop on the fish kill within one month

As noted, this report is by definition preliminary. Additional information will be collected that may raise or clarify additional issues or suggest additional responses. Although this report relies on input from various quarters, it is important to give a broader range of experts and interested parties an opportunity to comment. This is also a critical element of building support for the additional recommendations below.

The workshop can serve as an opportunity to debrief experts and interested parties on the fish kill, and to discuss appropriate follow-up strategies with a particular focus on Greenwich Bay. Given that the report and this workshop will be very relevant to the work done on a Special Area Management Plan for Greenwich Bay by CRMC and the Coastal Resources Center, we recommend the workshop be held in the context of that effort, and conducted by CRMC and DEM jointly. We further recommend the Coastal Institute as a key participant or co-sponsor, for reasons explained in recommendations 6 and 7 below. Scheduling the workshop within a month should allow for additional data to be considered, as well as assist in implementing the last two items in recommendation 6.

2. Consider new bond funding to revitalize assistance programs

As noted several times in this report, the availability of technical as well as financial assistance is critical to the implementation of many of the state's programs, in particular those that rely on partnerships with cities and towns, watershed organizations, etc. Previously, programs like Aquafund were available for this purpose and served as a catalyst for many successful water

quality improvement projects, especially at the local level. Another important aspect was that limited amounts of state funding could leverage significant contributions from other sources. Bond funding for these programs has essentially dried up. A new bond issue is needed. A proposal is attached as Appendix 1.

3. Accelerate nutrient upgrades at sewage treatment facilities

Recognizing that nitrogen is considered the key nutrient providing the "fuel" for excessive algae blooms and low oxygen conditions in marine waters, we should step up our control of known sources of nitrogen loading. Further upgrades for denitrification need to be made to our wastewater treatment facilities to reduce the significant amount of nitrogen that is now discharged directly to Narragansett Bay or to its tributaries. These retrofits are expensive but necessary. DEM has identified 11 facilities that should construct such upgrades (and three more in Massachusetts). In one case (Woonsocket), construction is complete. In three (Bucklin Point, Warwick and West Warwick), construction is underway. Four communities (Cranston, East Greenwich, Burrillville and Smithfield) are in the planning and design phase. At Fields Point, there is agreement that nutrient reductions are necessary, but disagreement about how much. East Providence and Warren have not yet been approached.[5]

DEM and the communities or districts should evaluate schedules that have been negotiated to date to see if any acceleration is possible (especially at the East Greenwich plant). At Fields Point, the largest point source of nutrient loading, the Narragansett Bay Commission should agree to the 5 mg/l limit DEM has proposed. East Providence and Warren must adopt their schedules as soon as possible. And pending construction of permanent upgrades, relatively simple, interim measures that were pioneered by Warwick should be implemented at all facilities.

4. Improve septic system management

More properties currently using septic systems need to utilize systems that remove nitrogen. In the case of Greenwich Bay, Warwick is doing a good job providing new sewers and assistance to homeowners who want to take advantage of them. However, the rate of participation is currently 50% and needs to increase. Warwick and other communities with similar problems need to consider making tie-ins mandatory. More cities and towns need to take or share responsibility for septic system management, and take advantage of tools like management districts. At the state level, legislation or regulations should be adopted to finally phase out cesspools, which provide no treatment. Programs that used to provide technical and financial assistance need to be revitalized and, if necessary, provided with more capital (for example to increase the capacity of the State Revolving Fund). Experience tells us that cost-sharing is the way to go, that financial incentives are necessary to get cooperation and participation, and that such assistance needs to be a mix of grants and loans.

[5] Appendix 2 provides additional background information on nitrogen removal at wastewater treatment facilities.

5. Improve storm water management

New DEM regulations, mandated by the federal EPA, require cities and towns to develop stormwater management plans. DEM made grants available for this purpose and also expects to issue a general permit in the near future that will provide additional guidance. Although cities and towns are developing these plans, many have major concerns about how they can implement them. Once again, cost sharing is becoming an issue. DEM is working with the congressional delegation to ensure 319 nonpoint source pollution funds can be used for this purpose. Cities and towns should take advantage of legislation allowing them to establish stormwater management districts and, through them, raise revenue. Some have questioned whether DEM's draft general permit requires more than the absolute minimum that EPA is looking for. The fish kill provides a clear example of why we cannot afford to go "light."

6. Improve monitoring and assessment

The event in Greenwich Bay was preceded over a period of several weeks by smaller events prior to the fish kill. Dead juvenile softshell clams had been washing up in significant numbers over that period on beaches on the west side of the Bay. Without a more comprehensive and consistent environmental monitoring program to measure things like dissolved oxygen and nutrients, we were unable initially to establish a link to low oxygen and determine that a serious problem of unusual proportions was building. We also did not have the ability to assess what was causing the softshell clam kill (lack of oxygen or other environmental conditions such as low salinity). Although DEM has arrangements with academic and volunteer programs to help with monitoring and assessment, and should try to expand such arrangements, it lacks adequate staff in its Marine Fisheries and Water Quality programs just to participate in and coordinate these efforts.

Rhode Island has been engaged in an effort, with EPA, to create a statewide monitoring plan, covering both fresh and salt water, and targeting both chemical and biological components. The State currently invests less than $100,000 in ecological monitoring and, as a result, has rather meager monitoring data, much of it drawn from volunteer efforts which are subject to the vagaries of inconsistent funding streams and may or may not have the ability to provide data over the long term. We lack baseline data for many locations and parameters, as well as trend data (as opposed to snapshots). The statewide monitoring plan should identify gaps in our data (including economic data) and address inefficiencies as well as adequacy of resources among a broad range of data collection activities.

Besides better data collection, data management needs to be improved. Rhode Island should once and for all commit to better coordination and quality control of the collection, storage, use, exchange and accessibility of data related to Narragansett Bay. The Coastal Institute at URI and its Environmental Data Center are logical candidates to be tasked with this challenge, especially within the context of Bay planning.

Specific assessment issues that scientists believe are part of the Greenwich Bay nutrients problem but have not been adequately addressed include:

- Is groundwater flow contributing significant levels of nutrients into the bay?
- Does Greenwich Bay's circulation pattern and flushing rate in the coves contribute to the creation of low-oxygen zones, particularly along the bay's western shore? Has this circulation changed recently due to shoreline changes?
- Are lawn fertilizers contributing significantly to nutrient loads in storm water runoff to the Bay, or are septic systems (including adequately working systems) a much bigger factor?
- Where are the most serious "hot spots" for pollution inputs?
- What is the percent usage of the pumpouts by areas of high density of large (less than 25') boats?
- What is the compliance rate with the no discharge into marine waters rule?
- Are gray water / septic systems at near-shore and shore-side restaurants contributing nutrients?
- Are significant amounts of nutrients being transported into Greenwich Bay from the upper Bay?
- Do unsewered areas correspond with levels of nutrient inputs?
- If nutrient inputs from groundwater are significant, how long will it take polluted groundwater to clean up if we take appropriate action today?

Specific recommendations regarding monitoring and assessment relevant to the fish kill include:

- Repeat the shellfish survey and beach seine survey conducted just before the fish kill in Greenwich Bay as soon as possible; also survey a reference site nearby but outside Greenwich Bay. (DEM's Division of Fish and Wildlife began planning this today.)
- Adopt standard quantitative field methods to assess losses of fish and bottom (benthic) organisms lost in these types of kill incidents to ensure good estimates. Procedures for documenting and investigating fish kills are well established and can be adopted for RI needs.
- Develop a Bay-wide comprehensive monitoring plan, based on work and information from the recent "Ecological Indicators" workshop. Integrate monitoring such as the fisheries trawls and beach seines with water quality monitoring to ensure a better understanding of habitat quality. Work with the state's Congressional delegation to restore funding for the "Bay Window" collaborative monitoring effort (ending this fall due to depletion of available federal funds). Provide for long term operation and maintenance of the continuous monitoring buoy system.
- Acquire a small ("Acrobat") undulating platform mounted with a fast-response SeaBird oxygen-CTD sensor (the fastest available is critical) and integrated GPS to allow for rapid mapping of hypoxic zones from a small (19-22') boat during fish kills and for baseline work.
- Acquire a towable sled-mounted submersible video camera with integrated GPS and (DC) VCR –TV and marine electronic cable, and develop a statistically valid transect design for the Bay to literally "see" and map the condition of the benthic community. This could possibly be done in conjunction with the EPA AED lab in Narragansett, which has already offered to help with efforts in response to the kill.
- Communicate the need for better monitoring and response capacity, as well as nutrient removal capabilities to and through the congressional delegation. Other

coastal states, including New York, Connecticut, New Hampshire and states bordering on Chesapeake Bay have received significant federal funds in this regard. As an estuary designated by Congress as of national significance, Narragansett Bay needs the same level of support.

- Work with stakeholders to develop a monitoring and modeling program to assess the impact of new nutrient controls at sewage treatment facilities and whether additional modifications are necessary. Coordinate and direct federal, state and university resources toward development of a single water quality model for the Bay.
- Institutionalize through Memoranda of Understanding collaboration with the Coastal Institute and Sea Grant program at URI towards the establishment of a "consortium" that can bring in local, regional and national expertise when needed to assess and respond to challenges we face in Narragansett Bay. Create a network of experts in areas including but not limited to chemistry, biology, ecology, resource economics, engineering and law.
- Invite the Coastal Institute to take the lead on development of a rapid assessment program that can quickly mobilize relatively small teams of scientific experts to assess and respond to a variety of circumstances and incidents affecting the health of Narragansett Bay. This program should be led by a marine ecologist or fisheries biologist with adequate training in this area, and include data collection and management protocols. The program should be coordinated with efforts to develop baseline data for the Bay, and with emergency response programs such as the one developed by DEM for oil spills.[6] Given that many of the pieces are already in place, it should be possible to have a formal structure and interagency agreement in place by the end of October, which would accommodate some review and comment by interested parties.

With respect to beach closings:

- Develop a separate assessment and response protocol to investigate problems leading to beach. Although there is overlap between these issues and occurrences like the fish kill, they are fundamentally different in nature, involve very different assessment and response techniques, and require different expertise and skills in the person who leads the effort. Beach closings are human health issues, and do not typically impact or otherwise involve Bay ecology. Combining the efforts could lead to serious dilution of capacity and to confusion. A similar but separate assessment and response program can be developed to focus in particular on issues like local storm water drainage, sources of contamination within the watershed, evaluation of unsewered areas and septic system failure rates, techniques to better characterize pollution and pinpoint its sources (for example, DNA/RNA analyses, dye studies and compliance inspections). This program should obviously be linked to the program described above, as well as the larger planning and data management effort described below.

[6] DEM is already collaborating with the Coastal Institute in the area of emergency response. The (interagency) RI Oil Spill Science Team recently completed a GIS and Mapping Plan to support scientific response activities, including natural resource damage assessment. The plan details everything from organizational structure and chain of command to people and equipment that have been committed to specific assessment and response tasks. It will be relatively easy to build on this model and apply it to situations like a fish kill.

Our recommendation is that R.I. Department of Health be the lead agency, working closely with EPA (e.g., its Flagship Beaches program) and DEM, and with URI and other institutions. A formal structure and agreement should be completed in the same timeframe, i.e. by the end of October.

7. Improve Bay Planning

The problem of nutrient over-enrichment in Narragansett Bay is only one of a number of major issues facing us that will require the cooperation of many in Rhode Island and in Massachusetts (which contains 60% of the watershed). This cooperation should be in the context of an overall plan and process to protect and restore Narragansett Bay and its watershed, both now and in the future. This plan should set clear goals supported by the public, measure results, and hold agencies and local governments accountable. The process should also produce a formal agreement between Rhode Island and Massachusetts that clearly communicates what must be done to ensure a more healthy future for Narragansett Bay. Our recommendation is that the Coastal Institute serve as a neutral venue for this process, and that a Narragansett Bay Science Advisory Committee be created to provide technical guidance.

What is needed is an initiative would bring together different organizations that are working toward the same ends but have not had the advantage of an institutional structure under which to work together with a sufficient level of administrative and technical support. If designed properly, it would clarify roles, responsibilities and commitments. It would also provide a collective charge to overcome bureaucratic barriers as well as to remove the artificial wall that often separates agencies, organizations and the public in working together to build collaborative solutions for our most critical Bay problems. It could give us the ability to avoid a repetition of the devastating ecological event that we saw in Greenwich Bay this past August.

APPENDIX 1 – BOND PROPOSAL

Form 2: Project Information

Department/Agency: Department of Environmental Management	
Project Name: Clean Water 2004	Project Identifier:
Priority Ranking:	Year First Shown in Agency CIP: 2004
Project Start Date: July 2005	Project End Date: June 2010
Is Project in Approved CIP?	Geographic Location: Statewide

Description:

The Department of Environmental Management is proposing $15 million in new authority to provide matching grants to state and local agencies, nonprofit organizations and for-profit businesses to abate sources of pollution causing beach closures, fish kills and other problems identified in water quality restoration plans (WQRPs) including federally mandated Total Maximum Daily Load (TMDL) plans.

The Clean Water 2004 funds will be targeted to implement WQRPs scheduled for completion by 2007. To date, WQRPs for fifteen waterbodies have been completed by DEM and approved by US Environmental Protection Agency. WQRPs for an additional 41 waterbodies are scheduled for completion by the end of 2007 (see attached 2002 303(d) list). Each plan identifies the watershed specific actions needed to abate both point and nonpoint sources of pollution causing the identified water quality impairments.

The proposed bond issue will address a critical water quality need in Rhode Island. In November 2000, voters approved the Clean Water 2000 Bond adding $60 million to buy down the State Revolving Fund (SRF) interest rate. These loan funds are available for a range of key projects including combined sewer overflows, wastewater treatment plan upgrades and local sewer projects. Despite the positive aspects of the SRF Program, it does not address several significant areas of need identified by the federally mandated water quality restoration planning effort:

- *Local nonpoint source pollution abatement projects:* It's generally not feasible to use SRF funds to finance nonpoint source projects, even at zero percent interest. This is due to the need to provide collateral for the loan and the lack of a dedicated local revenue stream for nonpoint projects such as storm water treatment. Projected costs to abate nonpoint pollution far outweigh the federal funds available. For critical nonpoint source pollution abatement projects, the state needs to provide a financial incentive to leverage local corrective actions.

- *For-profit businesses and organizations pollution abatement*: State and Federal law specifically render for-profit businesses (including farms) and organizations ineligible for funding under the SRF Program. The only pollution abatement program available to businesses, the State's Non-Governmental Fund administered by DEM, has provided vital assistance to farmers and other businesses; however, is exhausted.
- *Enhancing riparian buffers/habitat restoration*

Reason for Project/Benefits:

Nonpoint Source Pollution Abatement Projects - $11 million

As required by the federal Clean Water Act, the DEM compiles available information and assesses the quality of the state's waters. In assessing the state's waters, data are compared to established water quality standards--pollutant specific criteria that define the levels that must be maintained to be protective of various uses, such as fish and shellfish consumption, drinking water, swimming, and aquatic life. Through this process, DEM identifies those waters that fail to meet water quality standards. Once identified as "impaired" or polluted, the state is required by the federal Clean Water Act to develop a WQRP or TMDL for each waterbody and each pollutant causing the impairment (e.g., pathogens, nutrients, metals). The 2002 list of impaired waters identifies 130 waterbodies for which water quality restoration plans must be developed. Many of these waterbodies are polluted in part or wholly due to nonpoint sources of pollution including storm water.

In each water quality restoration study, DEM identifies both the point and nonpoint source pollution control actions that will needed to restore water quality conditions. The actions for point sources, e.g. WWTFs, are generally addressed via RIPDES permit changes and modifications to operations to improve treatment. Significant upgrades to WWTFs have been assisted via the SRF; e.g. upgrading the three WWTFs discharging to the Pawtuxet River for advanced treatment (nutrient removal). In the past, the SRF has generally been able to meet the needs of interested borrowers. With the scale of the CSO project and wastewater treatment facility projects underway, there is now a constraint on the amount of funding available for loans that could possibly delay needed projects. The CWFA is currently investigating ways to avoid a situation in which there is an unmet demand for wastewater project financing. For those 41 waterbodies for which water quality restoration studies are slated for completion by 2007, it is estimated that a total of $31.8 million will be needed to abate nonpoint sources of pollution excluding DOT expenses. The resources needed for nonpoint pollution abatement are expected to grow over the next two decades as the state completes the required water quality restoration studies for the remaining waterbodies identified as "impaired."

DEM estimates that $24.6 million will be needed beginning in 2005 through the period of the bond to abate nonpoint pollution problems which are causing degraded water quality conditions including the recent fish kills in Greenwich Bay and the loss of such uses as shellfish harvesting, swimming, and habitat to support healthy fish populations. While DEM is mandated to prepare the water quality restoration plans, much of the responsibility of implementing the corrective actions falls upon municipalities. In addition, watershed councils and other non-profit organizations play a vital role in gaining popular support and in implementing these water

quality initiatives. DEM anticipates that $300,000 of federal funds will be available annually to provide grants to communities and non-profit organizations to implement the nonpoint source pollution related corrective actions outlined in the plans. For the five-year bond period, these funds directly reduce needs by only $1.5 million. These grants require a match that the proposed state bond would assist in meeting. In addition, municipalities will need an additional $811,000 per year for capital expenditures required to comply with Phase II Storm Water Permit requirements. To date, the state has provided $25,000 to 36 municipalities to develop stormwater management plans. In summary, a total of $27.1 million (adjusted for anticipated EPA nonpoint source abatement funding) is needed for the period of the proposed bond.

DEM is proposing $11 million in state bond funds to allow continued financial assistance to implement nonpoint pollution abatement projects recommended in water quality restoration and watershed action plans. Examples of the types of projects likely to be funded include: installing structures to treat storm water, eliminating illegal connections to storm drains, abating areas of chronic septic system failures, and improving farm management practices, among others. See the list of example projects at the end of this section. The proposed program will provide assistance to state and municipal agencies and nonprofit organizations, and is expected to leverage a minimum of $11 million as match (approximate 50% grant: 50% match) in additional public and private sector investment in pollution abatement.

Assistance for Pollution Abatement by For-Profit Businesses - $2 million

State and Federal law specifically render for-profit businesses and organizations ineligible for funding under the SRF Program. The only pollution abatement program available to businesses, the State's Non-Governmental Water Pollution Control Facilities Bond Fund (NGWPCFF) administered by DEM, has provided vital assistance to farmers and other businesses; however is exhausted. With respect to stormwater controls on private properties, such assistance is viewed as vital incentive to getting action on needed pollution abatement projects in priority areas including watersheds of Greenwich Bay, Woonasquatucket River, and Blackstone River, and developed villages in South County. DEM requests $2 million in bond funds for this purpose.

Riparian Buffer Enhancement/Habitat Restoration - $2 million

The enhancement and restoration of riparian and coastal habitats can play an important role in protecting water quality by preventing pollutants from reaching streams, rivers, lakes or coastal waters. Over the past five years, significant investments have been made in planning for habitat restoration. In the coastal zone, detailed mapping of opportunities to restore eelgrass, salt marshes and fish runs has been completed and, with an infusion of state matching funds to access significant federal dollars, there are many beneficial restoration projects that could be implemented in the near future. For freshwater ecosystems, a technique for mapping and prioritizing restoration opportunities was developed and demonstrated in the Woonasquatucket River Watershed. Related projects have focused on enhancing riparian (river) buffers. In combination, these planning initiatives provide a strong technical framework for investing in restoration. Based on this work, DEM has identified a significant need for state financial assistance. For example, based on the projects completed in the Woonasquatucket River watershed, the implementation of 62 wetland restoration projects anticipated to improve water quality is estimated at $6.2 million; and the implementation of 36 riparian buffer projects is estimated to be at least $2.4 million. DEM actively seeks federal funds to support restoration

projects. Such funds will continue to be made available by both the Army Corps of Engineers as well as NRCS (via the Farm Bill). However, Rhode Island needs state match to leverage such funds as well as to develop partnerships with other potential funding sources including the Corporate Wetlands Restoration Program. In the past, the state has provided funds on a project specific basis, but there is now a clear need for a more predictable, on-going source of funding to support targeted habitat restoration implemented primarily at the local level. DEM requests $2 million in bond funds for this purpose.

Benefits of Cleaning-up Polluted Waters

The Clean Water 2004 Bond is needed to abate nonpoint sources of pollution and clean up the state's polluted waters - making them available for shellfish harvesting, swimming, and fishing. Polluted waters cost the state in lost revenue from marine resource and tourism based industries. More specifically relating to the quahog industry, the total value of landings in 1998 is $4 million. To account for the total value of income generated from the harvest of quahogs, state and university studies support application of a 4.24 multiplier. Applying this multiplier brings the total value of the quahog industry in 1998 to $16.96 million. With the successful implementation of water quality restoration plans slated for completion by 2005 (excluding Providence River and Upper Bay waters expected to benefit from the completion of the NBC CSO project), an additional 2,514 acres of waters will be open to shellfishing. Applying a proportional value from the 1998 landings data, an annual additional total revenue of $387,000 is projected. Taken over the five-year planning period, the total revenue associated with the re-opening of these waters to shellfishing is $1.9 million.

Restoring the state's polluted waters will also translate into improved quality of life for Rhode Islanders in terms of improved recreational opportunities, such as swimming, and fishing. Improved water quality also provides greater public health protection, in terms of fewer fish-consumption advisories and higher quality of "raw" water sources of drinking water, which has the added benefit of reducing treatment costs.

Stormwater impacts have been associated with many beach closures. This year, for the first time in recent memory, Scarborough Beach has been closed due to storm water pollution. Although the economic impacts are uncertain, they are noteworthy. This bond will help to abate storm water pollution and mitigate this type of problem in future years.

Example: Stafford Pond Water Quality Restoration Plan

An example of how state bond funds have been used to leverage local and federal resources is the ongoing restoration of Stafford Pond, an important regional drinking water supply in Tiverton. A grant of $107,000 from the State Nonpoint Source Pollution Bond program was used to conduct a study of the pond. The TMDL study, completed in 1997, identified excessive phosphorus loads to the pond that were causing algal blooms, leading to problems for the water treatment plant. Runoff from a dairy farm and two storm drains were identified as the major sources of pollution. With the TMDL as a catalyst, a restoration plan for the Stafford Pond watershed was developed that outlined several options for reducing pollutant loads into the pond. Since 1998, over $600,000 in state and federal grant funds have been allocated to support six different projects aimed at restoring water quality in the pond. The improved drainage structures

and farm best management practices (BMPs) have been installed. State personnel and volunteer continue to monitor the pond's water quality to track improvements.

The State's critical water quality improvement needs should be met via a comprehensive funding strategy including a combination of loans and grants. The Clean Water 2004 bond issue is necessary for the state to continue to meet its obligations to abate water pollution and avoid litigation occurring in other states. Lawsuits have been filed in 37 States and the District of Columbia compelling EPA to establish TMDLs--due to unsatisfactory progress on the part of the individual states in doing so. State resources are far better spent on addressing the pollution problems identified through the TMDL process than on legal fees defending the State's position.

Status of On-going Project:

Proposal represents request for new bond authority.

Other Projects Affected:

DEM estimates that a total of $207.5 million will be needed between now and 2010 to implement both point source and nonpoint source pollution controls provided for in the water quality restoration plans slated for completion by 2007 (see attached table). This estimate is based upon a waterbody specific analysis of identified and likely corrective actions needed to restore water quality. Of this amount, $156 million is expected to be in Clean Water Finance Agency loans to upgrade municipal wastewater treatment facilities and to provide Community Septic System Loans for the upgrade and repair of failing septic systems. It is estimated that another $26.7 million is needed for water quality improvements to the drainage systems associated with state roads.

This bond issue will also complement the on-going distribution of available federal EPA funds to support water quality restoration. Current estimates are that at least $300,000 will continue to be available and awarded annually for distribution as nonpoint pollution abatement grants targeted to TMDL implementation.

Historically, DEM has relied upon bond funds to provide matching state funds for federal nonpoint source grants. However, these bond funds (Non-Governmental, Nonpoint Source Pollution, and Aquafund for Narragansett Bay) are essentially exhausted. Since EPA funding requires a matching contribution of 40% the proposed bond program will also help to sustain the necessary match to allow the state to fully utilize future federal grant awards.

Outside Agency Clearance or Coordination Needed:

No clearance needed. Coordination with a number of other federal, state and local agencies will continue in the overall watershed restoration effort. The competitive grant selection process will include input from other stakeholders such as the established advisory group Partners in Resource Protection (PRP). In addition to the EPA, DEM also coordinated closely with the following federal agencies that administer federal programs that may assist in watershed restoration and pollution abatement: US Department of Agriculture (USDA), Natural Resources

Conservation Service (NRCS), United States Geological Survey (USGS), US Fish & Wildlife, Army Corps of Engineers and NOAA.

Coordination among state and local entities is accomplished in each watershed via advisory groups or other mechanisms.

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EXAMPLES OF IDENTIFIED ACTIONS NEEDED TO ABATE NONPOINT SOURCE POLLUTION

Installing structures to treat stormwater

- In the Greenwich Bay watershed, eighteen stormwater outfalls (nine state owned, nine town owned) identified by DEM (in draft Bacteria TMDL) as priorities for construction of water quality treatment structures.
- Ten outfalls (all town owned) identified in Narrow River Bacteria TMDL for water quality treatment structures, construction completed on one and another under design. Another four outfalls (three state owned, one town owned) discharging to the Narrow River tributary, Crooked Brook, have been identified for retrofit. TMDLs' goal is the restoration of shellfishing use to the Narrow River
- On the Saugatucket River, DEM has identified six stormwater outfalls (2 town owned and 4 state owned) contributing to bacteria impairments which make the river unsafe for primary contact recreation and contribute to shellfish closures in Upper Point Judith Pond.
- Hunt River Bacteria TMDLs identify twelve stormwater outfalls contributing to bacteria impairments along the Hunt River and its tributaries.

Eliminating illegal connections to stormdrains

- Draft Bacteria TMDL for Sakonnet River at Portsmouth Park and The Cove at Island Park has identified a number of illicit connections to storm drain systems; further investigation and elimination of illicit connections is required as part of overall wastewater management strategy to ensure adequate wastewater treatment and disposal system(s) for the Island Park and Portsmouth Park neighborhoods

Abating areas of chronic septic system failure

- State bond funds have been used successfully to plan for local on-site wastewater management programs in 19 communities. Plans to address untreated or inadequately treated wastewater are priority activities to restore Greenwich Bay, Green Hill and Ninigret Ponds, and the Sakonnet River at Portsmouth Park and The Cove at Island Park.
- Municipalities are encouraged to take advantage of the Community Septic System Loan Program offered by the Clean Water Finance Agency to assist homeowners in making necessary upgrades to septic systems.

Improving Farm Management activities

- A number of farms in the Kickemuit Reservoir, Crooked Brook, Saugatucket River, and Palmer River watersheds have been identified as contributing bacteria and/or nutrients to impaired waters. Funding is needed to leverage with NRCS grants to assist farmers in implementing improved farm management practices.

APPENDIX 2 – NITROGEN REMOVAL

Status of Nutrient Removal at Wastewater Treatment Facilities in RI

Studies have demonstrated that approximately 66% of the Nitrogen input to the Upper Narragansett Bay watershed is from 22 municipal wastewater treatment facilities (WWTF). Ten of the WWTFs are located in MA and 12 in RI. The impact of each facility depends on the loading from the facility and water quality conditions in the vicinity of the discharge (for example, background concentrations and flushing characteristics). As a result it is anticipated that 3 MA facilities and 11 RI facilities need to reduce nitrogen to protect the Upper Bay. Nitrogen reduction at a WWTF is typically accomplished by a two step biological process: ammonia is converted to nitrite, then to nitrogen gas which is released to the atmosphere.

To determine the required degree of nitrogen reduction, RI DEM has been developing a watershed action plan or TMDL. Development of a water quality model that simulates the fate and transport of nitrogen is necessary to determine the acceptable level of nutrients that may be discharged to the Bay. RIDEM has been working with a contractor to develop a water quality model for the Upper Bay.

Meanwhile, RI DEM has also been conducting site-specific evaluations to determine if WWTF are discharging unacceptable levels of toxic pollutants such as chlorine and ammonia. When it has been determined that a WWTF is required to reduce ammonia, DEM has been working with the community and their design engineers to evaluate the costs and benefits of providing the additional treatment necessary to reduce nitrogen. This process has involved careful consideration of the available levels of technology, available water quality data and whether is is prudent to await the completion of the water quality restoration plan to ensure the capital investment is appropriate. There is consensus that reductions in WWTF nutrient loadings will improve water quality, increase dissolved oxygen levels and reduce algae blooms. However, the reduction necessary to achieve water quality standards and whether natural conditions will prevent full attainment of water quality standards is not known. It is generally accepted that natural conditions will result in some algae blooms and low dissolved oxygen events, but their magnitude and frequency can be greatly reduced.

Below is a summary of the status of nutrient removal at the 11 RI WWTFs that discharge to the Providence River / Upper Bay. It is anticipated that construction at all facilities will be complete by 12/08 and the amount of nitrogen discharged will be reduced 35%.

1 - construction complete (Woonsocket)
3- construction underway & on track (NBC Bucklin Point, Warwick, West Warwick,
5 – planning or design underway (Burrillville, Cranston, Fields Point, Smithfield, East Greenwich)
2- evaluation has not commenced (Warren, East Providence)

The Narragansett Bay Commission Fields Point facility is the largest WWTF input and it discharges to an area very susceptible to nutrient problems. Therefore, it is anticipated that this facility will need to provide the highest level of nitrogen treatment. Given the financial implications, it has been difficult to proceed with nutrient reductions absence a water quality

model to establish appropriate treatment levels. NBC has completed planning activities but does not intend to submit a report to DEM and has suspended further action until the TMDL is completed.