Salt Ponds Coalition

The Tidal Page

News of the Rhode Island Salt Ponds

www.saltpondscoalition.org Official Watershed Council for the Salt Ponds Winter 2012/2013

Hurricane Sandy Pounds Southern RI--and Opens Our Eyes

In late October, Hurricane Sandy paid its unwelcome visit to the northeast. Locally, we have had a number of near misses from forecasted major storms since the last time we really got hit. So despite days of warning and "hype" about the approaching "Frankenstorm," many of us were skeptical that Sandy would prove any different from previous false alarms. Sandy, however, did turn out to be a true monster, proving the skeptics wrong, and also proving that forecasts of severe weather and evacuation orders must be taken very seriously.

Here are some amazing statistics on megastorm Sandy (from Jeff Masters's Weather Underground Blog):

- Area covered by tropical storm-force winds: 560,000 sq. miles (nearly 1/5 the area of the contiguous US)
- Area of ocean with 12 foot seas: 1.4 million sq. miles (nearly ½ the area of the contiguous US)
- US coast spanned by tropical storm-force winds at landfall: 943 miles (widest on record; simultaneously caused damage to buildings 1200 miles apart)
- From USGS tide gauges, some storm surge heights: Watch Hill

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Post-Sandy Breachway Status

As you may recall from the Spring 2012 Tidal Page, dredging of the Charlestown breachway was completed ahead of schedule and under budget. With the approach of superstorm Sandy, the Town of Charlestown, Salt Ponds Coalition, and the many other people who worked so hard to make this project happen were concerned that the storm would re-fill the channel and sedimentation basin with sand. However, if Charlestown could document how much sand was deposited in the channel as a direct result of Sandy, FEMA funds could potentially be procured to re-dredge.

Fortunately, the town of Charlestown had the foresight to plan for this contingency. Last spring, the town purchased a survey-quality GPS unit which also very accurately measures elevation. Steve McCandless, Geographic Information Systems (GIS) specialist for the Town of

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Sandy Focuses Attention on Winnapaug

Perhaps the south county salt pond most seriously impacted by Sandy was Winnapaug Pond, in Westerly. Images out of Misquamicut showing broken buildings, neighborhood flooding, and great piles of sand went viral in the days after the storm and suggest that many biproducts of human habitation were swept up in the maelstrom. These materials ranged from shattered building materials to human sewage and household chemicals and cleaners. Weeks after the storm, a dumpster was still visible in the pond as were remnants of stairs and other broken bits of buildings. Along the north shore of the pond, wrack lines containing shredded buildings, lifeguard stands, propane tanks and picnic tables were evident.

As was the case with all of the ponds, sand inundation from wave over-wash did not seem to be an issue within the

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Message From Our President

Dear Members,

Happy New Year to you! Make it a healthy and safe one.

Oyster farmer Jeff Gardner, SPC President Art Ganz, and Executive Director Elise Torello plan an excursion to look for effects of Hurricane Sandy on Winnapaug Pond.

Well, here we are at the beginning of another year which will be our 28th. Much of this issue will report on Super Storm Sandy. If it wasn't a hurricane, it sure acted like one! Elise, Mark and I have toured most of the ponds to record the changes. If you have not viewed our website, do so to get an appreciation of the changes. Additional photos, including stunning aerials taken by Suzanne Paton of US Fish and Wildlife, are at hurricanesandyrisaltponds.shutterfly.com. Trustom Pond breached and Winnapaug Pond is full of debris. Fortunately our aquaculture farms sustained minimal damage and only subtle changes were observed in the ponds. The scallop harvest seemed not to be affected. The majority of damage was to the beach face and developed properties along the beach. Misquamicut was most severely hurt and we have been meeting with Westerly officials to offer advice and experience. We were hoping that the storm would stimulate more serious discussion over breachway maintenance. Rocks have tumbled into each of the channels adding more safety concern. Thanks to Steve McCandless and volunteers, storm related shoaling of Charlestown and Quonnie Breachways has been determined and that information went to FEMA.

This will be a busy spring for repair to our coastal salt ponds and barrier beach ecosystem. There will be countless opportunities to help. Local beach associations should be restoring their sand dunes, which were key to minimizing much of the damage. Stabilizing using beach grasses and shrubbery plantings will take many hands. A list of recommended plants is available through the Coastal Resources Management Council. Several of our local landscape companies have developed a specialty for dune fencing and planting. CRMC has been giving out emergency repair permits, but is expected to make significant changes in reconstruction practices. For approximately two years, CRMC has been attempting to fund a Coastal Change Special Area Management Plan (Beach SAMP) for the south coast. This will provide the guidance and governance for building and infrastructure. As funding is beginning to flow, Salt Ponds Coalition plans to play an important part in this project.

Roy Jeffrey will be contacting Pond Watchers to see if they will continue their service in 2013. We will be looking for additional volunteer pond watchers. We are also looking for a volunteer to operate our Salt Pond Safari program next year. We need someone good with children and some very basic fish identification – or be willing to be trained. Contact Elise at the office 322-3068.

Our best wishes go out to our good friend Dr. Jon Boothroyd, who fell and broke his hip right after the storm. When we thought he was out assessing the storm damage, he was in a nursing home. He is home now and on the mend.

Again, thank you for your continued support!

Art Ganz

Thank You--and Help Wanted!

On October 22nd, SPC said a heartfelt "Thank You!!!" to our volunteers with a barbeque and oysters and chowder generously provided by Board member John Crandall. We truly appreciate our 30 steadfast pond watchers, who faithfully collect samples every two weeks from May-October. This is such a tremendous commitment for the benefit of our ponds, and we are very grateful. Several long-time pondwatchers were recognized: George Hill (12 years); Pam Ganz, Gudman Lovoll, and Ralph Minopoli (11 years); Don Rocheleau (9 years); Ted Truslow (8 years); Ted Callender (6 years); Mark Bullinger, Al Depersia, Tom Dodd, Barbara Engel, Susan Jenson, and Dick Sartor (5 years). Fantastic!

Thanks also to our Kettle Pond Visitor Center front desk volunteers, who commit hours of their time each month to help us pay our rent. Their efforts allow us to have use of this wonderful facility for meetings and gatherings. SPC needs more volunteers to work at the front desk--if you can help, please let us know.

We also are looking for a volunteer to help host our popular Salt Pond Safaris. On the first Saturday of the summer months, we meet at Ninigret Pond to introduce children to the wonders of life in the pond. We use a 30' seine net to capture fish, crabs, and other pond creatures, which capture the hearts of the children and their parents!

Board member John Crandall shucks his donated oysters for SPC's volunteers--thank you, John!

So, if you enjoy meeting people and watching children having fun and learning about the environment and would like to volunteer at KPVC or on safaris, please call 401-322-3068 or email saltpondscoalition@gmail.com.

Many, many thanks to you all!!!

Batten Down the Hatches

Many of us were surprised by the size of the storm surge from Hurricane Sandy. Perhaps we had secured docks, boats, outdoor furniture, and such in advance of the storm's arrival, only to find our preparations inadequate given the severity of the tide, wind, and waves. Debris was evident in the high-water wrack lines in some places around the ponds. Some of the debris looked to be of recent origin, but there was also debris that appeared to have been hidden or buried for some time and dislodged by the storm.

Hurricane Sandy was a big wake-up call on the importance of cleaning up and securing properties near the ponds before a big storm, especially if a storm surge is predicted. It is especially critical to make sure that paint cans, gas/oil cans, lawn/garden fertilizers, pesticides, and herbicides, and other household chemicals are not stored where they might end up in the ponds in the event of a higher than expected storm surge. Hopefully lessons learned thanks to Sandy will help us all be better protectors of the ponds for the next storm!

Trustom Pond Breached

Trustom Pond breached for the first time in about six years thanks to the storm surge and huge waves of Hurricane Sandy.

Trustom Pond is a coastal lagoon with an undeveloped shoreline (Moonstone Barrier) in South Kingstown. It lies between Cards Pond to the east and Green Hill Pond to the west. Since Trustom had not been connected to the ocean via a breach since the mid-2000s, it had gradually become a freshwater ecosystem. Only freshwater fishes such as sunfish and largemouth bass were present, along with freshwater aquatic plants including the invasive Eurasian milfoil. The pond was exhibiting signs of impaired water quality, including low water clarity, algal blooms, elevated nutrients, and high bacteria counts (S. Faubl, *A Management-Oriented Water Quality Investigation of Trustom Pond National Wildlife Refuge*).

Photo by S. Paton, US Fish and Wildlife

Breaching drastically changed Trustom Pond. Over time, freshwater inputs the water level in the pond had risen relative to the ocean. Therefore, when the breach opened, Trustom's water level dropped significantly. The pond is transitioning to a marine system for now—freshwater fish and plants were killed by the influx of ocean water and replaced by saltwater species.

It is important to note that as a coastal lagoon, intermittent breaching to the ocean is a natural process for Trustom Pond. Although some freshwater species were displaced, other species, including threatened shorebirds, will benefit.

Because Trustom Pond is located within a National Wildlife Refuge, Salt Ponds Coalition does not perform water quality monitoring there. However, the US FWS has been monitoring the pond for many years and will continue to study the pond and breach. FWS is also consulting with experts about when the breach may close naturally by deposition of sand transported along the shore. FWS biologists are studying waterfowl populations in the pond, and next summer will conduct studies of aquatic vegetation and fish populations

Photo by T. Tetzner.

So, if you want to observe the dynamic nature of coastal lagoons, visit Trustom Pond off Matunuck Schoolhouse Road in South Kingstown.

Winnapaug Pond

Continued from front page 1

pond itself. This is likely due to the water level in the ponds being so high during the worst of the storm. Sand-bearing waves swept over the dunes until they met with the high pond waters, where they lost momentum and dropped the sand well above the normal tideline. Sand berms were formed – often covering marsh grass – but did not make it into the pond in very many areas. Credit also goes to broad swaths of native vegetation that helped slow the waves and capture sand.

Having toured the pond by water and by land, it seems the effects of the storm fall into two basic categories: 1) the physical wreckage that litters the pond and shoreline; and 2) the unknown

quantities and types of contamination that washed into the water. There might also have been some additional sedimentation brought in through the breachway, but unlike Charlestown, Westerly doesn't have a baseline survey for comparison.

Rhode Island DEM tests for bacteria levels in the pond and cleared it for the sale of shellfish shortly after the storm. SPC sampling is finished for the 2012 season, but will commence again in May 2013. Our sampling program's emphasis is on long-term trends and will show if there were significant systemic changes to nutrient levels in the pond.

One potentially positive consequence of the storm is that it might speed the way to dredging and habitat restoration within Winnapaug Pond, which is choked with sand bars and sediment. The beach interests in Misquamicut are desperate for good beach sand to help restore and fortify the Misquamicut beaches and there are tens of thousands of cubic yards of the stuff in the pond, where it has built up over the past sixty years. The tragic damages associated

with Sandy could be the catalyst needed to get a broad coalition of interests pulling together to seek funding and permitting. Some may be in it for the environment, some for the sand, but as long as their interests fundamentally overlap, that's how public projects get things done.

In the meantime, cleanup of the barrier beach area goes on. The great sand flows that covered everything in the heart of Misquamicut have been stockpiled in the state beach parking area. Mechanical sifters are hard at work cleaning all kinds of materials from the sand so it can be pushed back onto the beach before Memorial Day. Plans are also being developed as to how septic systems scoured from the sand dunes will be replaced.

Flooding Effects: Septic Systems Vs. Sewers

Since denitrifying wastewater treatment systems were mandated near the coast, many people have wondered how such systems would fare if inundated. Superstorm Sandy provided a first look at the facts on the ground--and under the water.

In Misquamicut, where several hundred buildings were flooded, impacts were varied. Inland of the dune-line, many green fiberglass tanks--normally flush-mounted in the ground--were broken loose due to buoyancy and askew or missing. When the tanks lifted, PVC pipes broke, wastewater was released, and the tanks filled with seawater. To repair this situation, a crew would have to re-excavate the site, replace the tank, and anchor it down.

Electronic connections, pumps, and fans in the tank assembly may have been damaged by flood waters. These are modular and can be replaced--not inexpensive, but much less than a new system. Additional electrical components in or on the house may be destroyed by floodwaters.

The other major component of most high-tech systems is the bottomless sand filter, where treated effluent is released into the ground. The sand filters are often constructed using landscaping ties that extend above grade. There is a layer of breathable pea stone on top, then layers of sand, and then the native soil. In some cases, the above-ground wooden structures were damaged by flowing water. In systems where the soils were soaked with saltwater and the breathable layers of the system were clogged with sand and silt, these layers ceased to be breathable. This situation could kill off beneficial bacteria that are part of the treatment process. Measuring the effect of this will be hard, as it probably won't affect how efficiently water soaks into the ground. Systems may appear to be working normally, but nitrogen reduction rates might be reduced.

Another big question is how sewer lines would have done. According to experts we consulted, modern sewers would probably have been okay. Given their depth below street level, they likely wouldn't have been directly damaged by the storm. Advocates of sewers claim that modern pipes are water tight; however, they can be overwhelmed with flood waters if the houses they were connected to are washed away, or if ground water from the inundated area is forced through the joints. Could a surge of water entering the system cause backups into homes, or overflows at the pumping station in Misquamicut? Or could a surge of water overwhelm the treatment plant? Those are important questions as sewers in Misquamicut are studied further.

Any system installed along the shoreline is exposed to high risk. In these areas the only truly safe options are to have structures up on pilings and to have waste handled by composting toilets or tight storage tanks with the infrastructure slung under the floor, high above ground level.

Hurricane Sandy

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Yacht Club (5.86 ft.), Weekapaug breachway (6.39 ft.), Ocean House Marina in Ninigret Pond (3.97 ft.), Green Hill Beach (8.43 ft.), Skip's Dock in Pt. Judith Pond (6.59 ft.).

As the impacts of Sandy on the southern RI shoreline became known in the days after the storm, I couldn't help thinking that Dr. Jon Boothroyd, RI State Geologist and University of RI Research Professor Emeritus, had real told-you-so rights. At SPC's annual meeting Dr. Boothroyd had spoken about southern RI's glacial history, the transient nature of coastal barriers, sea level rise, climate change, and increased storm hazards. He even spoke about how much worse it was to have a major storm pass to the west of us since the onshore winds would push the storm surge further inland. And here we were less than three months later watching the processes he described in action, up close and personal.

Determining what damaging effects, if any, Sandy had on our southern RI coastal lagoons will take time. While there was a tremendous amount of sand that was washed over the coastal barriers, this is part of the natural landward migration of these barriers (see the article about glacial origins in the Fall 2012 Tidal Page). Thus, this washover process can't really be called "damage" to the pond or barrier. However, the winds, storm surge, and huge waves unleashed by Sandy distributed large quantities of debris in and around the ponds. Some of this garbage appears to have been hidden in brush and grass or buried in sand around the ponds for some time, and then was washed loose during the storm. Debris from damaged buildings has also ended up in the ponds. Charlestown Harbor Master Justin Vail has been cleaning up debris as large as utility poles, and also trying to reunite wayward docks with their owners.

The two most overarching issues on many coastal residents' and business owners' minds post-Sandy, however, are rebuilding their homes/businesses, and rebuilding the beaches for the 2013 summer season. According to RI Coastal Resources Management Council's (CRMC) web site, "Any structures in Type 1 waters that were damaged in this storm will have to be assessed by CRMC staff on a case-by-case basis, as well as those with exposed septic systems...Long-term, the CRMC will monitor the southern coast of RI to determine if it will replenish itself through the natural process." The entire south coast of RI is adjacent to Type 1 waters. Some of the sand lost in the storm is already starting to return in some areas of the shoreline, but towns are also looking for other ways to replenish the beaches. In Misquamicut, sand scooped off of Atlantic Ave and other areas must be screened to remove debris before being put back on the beaches. The town of Westerly is looking for other potential sources of sand, such as dredging Winnapaug Pond.

In this issue of The Tidal Page, we will present several articles related to Hurricane Sandy. No doubt, the lasting impacts of Sandy will be visited in future issues of the Tidal Page as well.

Breachways

Continued from front page 1

Charlestown, used this GPS from Harbor Master Justin Vail's boat to perform a detailed, highly accurate pre-storm survey of the bottom of the dredged channel. Once the storm had passed and conditions were safe enough, Steve went back out with Justin and performed a post-storm survey.

They found that thanks to the prevailing wind direction being from the east/northeast (across rather than directly into the mouth of the channel), Sandy did not re-fill the dredged channel to the extent feared. According to Steve's measurements, 3,240 cubic yards of sand entered the breachway during the storm, and of that 3,200 cubic yards had stopped in the sedimentation basin. This is approximately the same amount of sand that had accumulated in the channel during the previous two months. The capacity of the sedimentation basin is 57,000 cubic yards.

Steve is estimating the cost of dredging the volume of sand brought into the breachway by Sandy and working with the Coastal Resources Management Council to apply for FEMA funds for this amount. This would be reserved for covering this portion of the total cost of the next maintenance dredge of the breachway, which will likely be within the next 4-5 years.

More challenging and potentially more expensive damage to the Charlestown Breachway resulted from the pounding of storm waves against the east wall of the channel. According to Coastal Pond Management Commission chairman Rob Lyons, a number of rocks were pushed into the channel from the wall. This is causing parts of the wall to be nearly underwater at high tide, and the wall is no longer safe for fishermen to walk on. Charlestown and the State of RI are also applying for FEMA funds to pay for the removal of the rocks from the channel and for the repair of the breachway walls.

We know less about possible damage to Quonochontaug Breachway. Since the breachway has not been dredged recently, it was not feasible to try to account for damage from Sandy to apply FEMA funds. As in Charlestown Breachway, the indirect prevailing wind direction seems to have prevented large-scale filling of the channel. The channel walls also appear largely undamaged.

Dredging of Quonochontaug breachway is part of the Army corps of Engineers South Shore Restoration Project and is in the planning stages. However, dredging and restoration in Winnapaug pond is next in line in this project. SPC will advocate for the completion of the South Shore Restoration Project for the benefit both ponds.

Hurricane Sandy's Effects on the Salt Ponds


Photo by T. Tetzner


Photo by E. Torello

The high storm surge from Hurricane Sandy, on top of a full-moon spring tide, caused significant damage to private and commercial docks withi
Ninigret Pond. Center photo: Green Hill Pond. Right photo: Jim's Dock, Pt. Judith Pond.


Photo by Don and Nate Bousquet, courtesy of the Nopes Island Conservation Association


Photo by Don and Nate Bousquet, courtesy of the Nopes Island Conservation Association

The storm surge from Sandy caused significant overwash of sand onto the coastal barriers which separate the salt ponds from the ocean. The tw
dle), show the Quonochontaug Barrier before and after the storm. Note the location of the "slip slope", or pondward boundary of the overwash, re
at lower left of each photo. The top of the slip-slop indicates the high-water level in the pond--this is where the storm surge dropped sand when it
(above right). Also note that Japanese black pines planted on the western end of the barrier (top of photos) prevented sand from washing over,
"reflective" rather than "dissipative" dune front. Sand also washed over the Green Hill Barrier (below, left) and East Matunuck beach in front of Po
but did not reach the ponds. Surprisingly, most of the major overwash on the Misquamicut Barrier (below, right) also did not appear to reach Winn


Photo by E. Torello


Photo by S. Paton, US Fish and Wildlife Service

Photo by T. Tetzner

in the ponds. Left photo:

Photo by M. Bullinger

o photos above (left, mid-
lative to the small building
reached the pond waters
creating a higher, steeper
tter Pond (below, middle)
apaug Pond.

Photo by R. Petrocelli

Photo by T. Tetzner

Photo by R. Lyons

Pounding storm waves pushed large rocks from the east wall of the Charlestown Breachway into the channel. FEMA funds are being sought to repair the damage.

Photo by R. Petrocelli

The pounding waves in Misquamicut revealed an...interesting...method of dune-building used after the Great Hurricane of 1938. The car even had low miles!

Photo by R. Petrocelli

Photo by E. Torello

Hurricane Sandy brought some rare, out-of-state visitors to our coastal lagoons. A white pelican doesn't quite fit in with the local gulls on a newly revealed gravelly bar in Trustom Pond just before Thanksgiving! Several brown pelicans were also brought north by the storm.

The photo below shows storm waves and overwash on the much flatter Weekapaug Barrier beach.

Weekapaug Barrier after Sandy, courtesy of Vik Dvorak.

Sea Level Rise and Storm Hazards in the Salt Pond Region

Thanks to Hurricane Sandy, sea level rise and increasing storm hazards due to climate change are topics that have been very much on the minds of those of us living near the coast. Thus, Dr. Jon Boothroyd's presentation at SPC's annual meeting, which discussed these very issues, could not have been more timely and relevant. In the last issue of The Tidal Page we summarized the portion of Dr. Boothroyd's talk explaining the glacial origins of the southern RI salt pond region. In this article, we will discuss sea level rise and storm hazards. Two documents which contain much of the material in Dr. Boothroyd's talk and were valuable resources for this article are: *Rhode Island's Salt Pond Region: A Special Area Management Plan* (Salt Pond SAMP), available online at www.crmc.ri.gov/regulations/SAMP_SaltPond.pdf; and *The State of Rhode Island Coastal Resources Management Program*, available online at www.crmc.ri.gov/regulations/RICRMP.pdf (RI CRMP).

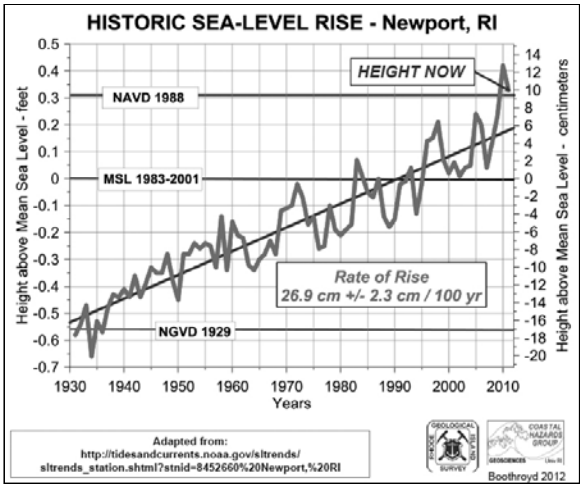


Figure 1. SLR in Newport, RI (from Dr. Boothroyd).

Sea Level Rise

Sea level rise (SLR) has been happening since the ice began melting from the last glaciation about 20,000 years ago. Since then, global sea level has risen by about 400 feet. Human activities in the past century have accelerated the rate of global warming, which in turn has accelerated the rate of SLR. In addition, destabilization of ice sheets on land, such as those on Greenland and Antarctica, could potentially cause a "meltwater pulse," or additional rapid rise in sea level from glacial melt water. There is still uncertainty about the potential contribution of land ice to SLR, and scientists have only recently been including this in their SLR models.

SLR does not occur at the same rate at every coast on the planet. Relative SLR at any particular location depends on both global changes (melting of glacial ice and thermal expansion of seawater, both of which are accelerated by rising global temperatures) and regional factors (land rebounding (rising) after a glacier has retreated, or land subsiding due to water or oil extraction). As it turns out (unfortunately for us in RI), according to a recent paper published in Nature Climate Change (Sallenger et al, 2012, www.nature.com/nclimate/journal/v2/n12/full/nclimate1597.html), the northeast Atlantic coast of North America is experiencing relative SLR rate increases ~3-4 times higher than the global average. In the last century, sea level recorded by the Newport tide gauge rose about 10 inches (Figure 1), and the RI Coastal Resources Management Council (CRMC) is currently planning for an additional 3 to 5 foot SLR by 2100.

Rising sea level will impact the coast of RI in multiple ways. According to the RI CRMP, these impacts will include:

- Displacing coastal populations
- Threatening infrastructure (residential/commercial structures, roads, and bridges)
- Reducing the effectiveness and integrity of existing shoreline protection which was designed for lower water levels
- Intensifying coastal flooding and coastal erosion
- Causing the loss of recreation areas and public space
- Drowning of salt marsh habitat. The rate of increase of marsh elevation is slower than rate of SLR and coastal development prevents marshes from migrating landward.
- Causing further saltwater intrusion into aquifers; threatening wastewater treatment systems in the coastal zone with higher water tables.

Storm Hazards

Dr. Boothroyd stated, "The sea may be rising long term – but instantaneous storm surges elevate sea level now." During Hurricane Sandy, most of the serious damage to coastal structures was due to the storm surge and pounding storm waves. As was the case with the Great Hurricane of 1938, the storm happened to coincide with a spring tide (higher than usual tide due to full or new moon). In addition, Sandy was so huge that it affected the coast of RI during several high tides, compounding the damage.

The factors that can combine to build the magnitude and destructiveness of storm surges include:

- High winds blowing across the surface of the ocean, pushing and piling up ocean water against the coast
- Reduced atmospheric pressure within the storm reducing pressure on the ocean surface
- Tidal phase during the storm--spring high tide is worst
- Whether the storm passes to our west or our east.

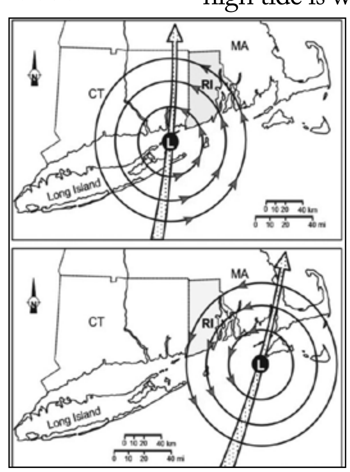


Figure 2. Storm path and effect on winds and storm surge (adapted from Salt Pond SAMP). Passage to the west (top) results in maximum onshore wind and severe storm-surge flooding. Passage to the east (bottom) results in offshore wind and minimum storm-surge.

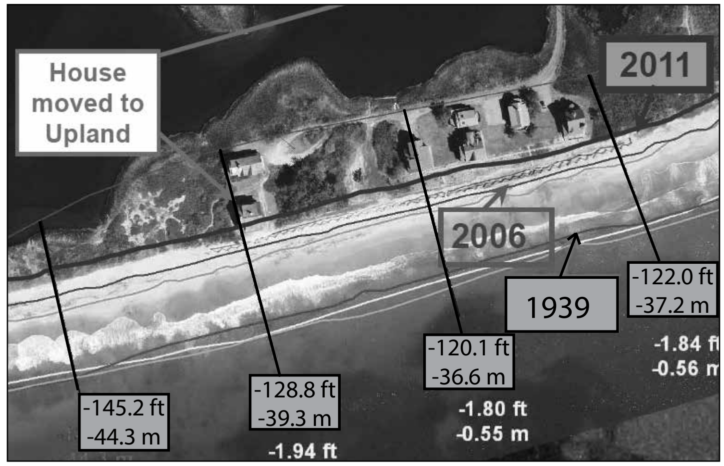


Figure 4. Frontal erosion at Browning Cottages, 1939-2011 (slide from Dr. Boothroyd's presentation). The barrier has eroded over 120 feet since 1939.

With counterclockwise wind circulation, if a storm passes to our west, the storm winds are onshore and are added to the forward velocity of the storm resulting in a more severe storm surge. If the storm passes to our east, the storm winds are offshore and the forward speed of the storm is "subtracted" from the storm wind speed (Figure 2).

Dr. Boothroyd pointed out in his talk that storms are the most important driver in coastal change. Superimposing storm surges and waves on accelerated SLR will make the shoreline of RI more vulnerable to flooding and erosion. According to the RI CRMP, CRMC accepts the consensus of the overwhelming majority of climate scientists that global temperatures will continue to rise into this century, likely increasing the frequency of intense storms. Higher sea levels will cause storm surges and storm waves to reach further inland.

On undeveloped coastal barriers, storm surge overwash supplies sand to the back side (pond side) of the barrier and increases the elevation of the barrier. This also causes the barrier to migrate landward over time. However, development on the barriers usually results in overwashed sand being moved back to the beach side of the barrier, starving the back side of the barrier of sand and preventing the barrier from growing in elevation. With increased SLR, this will make the barrier much more susceptible to breaching or drowning.

This is exactly the situation we are observing on the Misquamicut barrier in Westerly, as overwashed sand 4-5 feet deep on Atlantic Ave. has been scooped up and piled onto the beach parking lots. This sand will be screened to remove debris and placed back on the beach. Meanwhile, the dunes formerly on the beach are small or non-existent, the beach continues to erode, and the back side of the barrier is not built by overwashed sand.

The landward migration of the Moonstone Barrier in South Kingstown is very apparent at the location of the historic Browning Cottages, where the barrier has eroded more than 120 feet since 1939 (Figures 3 and 4). Sadly, several of these cottages are being razed due to irreparable damage from Hurricane Sandy.

Inundation Modeling

Going forward, models predicting SLR and inundation zones will be very useful to scientists and policy-makers developing climate change adaptation strategies. Using accurate digital land elevation data and computer software known as Geographic Information Systems (GIS), scientists can create models to predict where land would be inundated by various amounts of sea level rise. These models are sometimes referred to as "bath tub ring models"—picture water rising up the sides of a bath tub as it fills.

Figure 3. Aerial photo by S. Paton of US Fish and Wildlife Service taken several days after Sandy, showing overwashed sand on the coastal barrier in front of Cards Pond in South Kingstown. Note the location of the Browning Cottages at the right edge of the photo.

Hurricane Sandy presented an opportunity to document the actual inland extent of flooding from a significant storm surge on top of SLR. The high-water line from the storm left tell-tale "wrack lines," or lines of aquatic vegetation and debris deposited at the high tide line (Figure 5). University of Rhode Island Professor Peter August and Environmental Data Center scientists Chuck LaBash, Greg Bonynge, and Mike Bradley along with graduate student Erica Tefft collected GPS coordinates of the high water mark on pond-side properties and elsewhere along the RI coast. They took photographs, noted the direction of water flow, and recorded the landscape setting of the wrack line at each location. This effort will not only document the extent of flooding from Sandy in RI, but can also be used to validate, or ground-truth, GIS models of storm surge inundation.

Modeling the extent of inundation from SLR and storm surges is of great importance in assessing future flood risk. These models can be used to assess where infrastructure and property are vulnerable to SLR and storm surges.

Figure 5. Photo from Professor Peter August showing a wrack line with debris from Sandy.

Sandy vs. 1938: In RI, Not Even Close

After Hurricane Sandy was over and the extent of the destruction along the RI shoreline became clear, a question that kept coming up was "How does this compare with the Hurricane of 1938?" Anyone old enough to remember and who was in southern RI or CT during that storm would likely answer "Not even close."

As devastated as Misquamicut is after Sandy, it is nowhere near the catastrophe that was wrought upon the Long Island, CT, and RI shorelines by the Great Hurricane of 1938. Tragically, 253 people including 131 in the US lost their lives during Sandy, according to NOAA, and the destruction in NY and NJ was far worse than here in RI. Still, the Hurricane of 1938 was deadlier, with a death toll at between 600 and 700 people; of these, 136 were in the stretch from Mystic, CT to Narragansett, RI according to Lewis R. Greene in his book, *The Hurricane Sept. 21, 1938: Westerly, Rhode Island and Vicinity—Historical and Pictorial (1938)*. In addition, 1018 houses and cottages were destroyed in this region. Over 400 buildings on Misquamicut Beach and 55 on Fort Rd. from Watch Hill to Napatree Point were completely demolished. The entire south coast of RI was utterly devastated.

The Hurricane of 1938, which made landfall as a Category 3 storm, caught shoreline visitors and residents by surprise on a seemingly ordinary September afternoon. The storm raced north toward Eastern Long Island and New England at an estimated 70 mph—the fastest known forward speed of a hurricane. Adding this astounding forward speed to the wind speed on the eastern side of the storm, where the wind direction was from the south due to the storm's counterclockwise rotation, resulted in wind gusts of over 180 mph over CT and RI. Plus, the storm hit a few hours before high tide during higher than usual tides due to the combination of the Autumnal Equinox and a new moon.

These factors combined to produce 30-50 foot waves and storm tides of 14 to 19 feet across the southern New England and Long Island coasts. Downtown Providence experienced a storm surge of almost 20 feet. One damage estimate in 2008 dollars is between $4.5 and $6 billion (Grossi, 2008).

Sandy, a Category 1 storm, was huge, spreading its destructive power over an extensive area (see article on p. 1). However, the storm made landfall well to our southwest and was moving at between 15 and 20 mph. Thus, sustained winds in RI were in the 40-50 mph range, with gusts at the coast over 80 mph. Maximum storm tides here were in the 4-6 foot range. All of this was enough to do a great deal of damage to structures on the shore of RI and bring widespread, extended power outages, but nowhere near the devastation of 1938.

In the Caribbean, NY, and NJ, Sandy was catastrophic. With the terrible death toll and damage estimates at $63 billion in the US as of the end of November (NOAA), Sandy is currently the second costliest storm on record after Katrina.

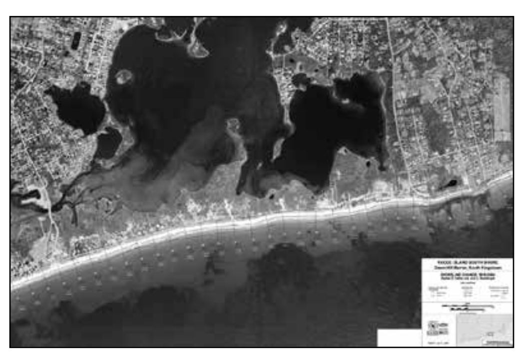
For an excellent description of the Hurricane of 1938, read Professor Scott Mandia's summary at www2.sunysuffolk.edu/mandias/38hurricane/weather_history_38.html. Another excellent document is *The 1938 Great New England Hurricane: Looking to the Past to Understand Today's Risk* by Patricia Grossi, RMS, Inc., 2008 (www.rms.com/publications/1938_Great_New_England_Hurricane.pdf). A good description of Sandy's weather history and statistics may be found at the NOAA link www.srh.noaa.gov/bro/?n=2012event_hurricaneseasonwrap, and also at the NASA link www.nasa.gov/mission_pages/hurricanes/archives/2012/h2012_Sandy.html.

Shoreline Change Maps Illustrate Dynamic Nature of Coastline

Hurricane Sandy vividly illustrated the dynamic nature of our coastline, particularly the sandy coastal barriers that separate the salt ponds from the ocean. These barriers have been changing ever since their formation after the last glaciation. In 2007, Professor Jon Boothroyd and Rachel Hehre prepared 150 maps for Narragansett Bay, plus 23 maps for the south shore of RI, which document and quantify these changes since 1939. These fascinating maps are online at www.crmc.ri.gov/maps/maps_shorechange.html.

These maps are used by the RI CRMC to calculate average yearly rates of change for the coastline. These rates are used to calculate minimum distances of approved activities (buildings, new septic systems, etc.) from the inland boundary of a coastal feature. Thus, according to the RI Coastal Resources Management Program: "The minimum distance of a setback shall be not less than 30 times the calculated average annual erosion rate for less than four dwelling units and not less than 60 times the calculated average annual erosion rate for commercial, industrial or dwellings of more than 4 units. At a minimum however, setbacks shall extend either 50 feet from the inland boundary of the coastal feature or 25 feet inland of the edge of a Coastal Buffer Zone, whichever is further landward." However, importantly for property owners wanting to rebuild after Sandy, "The setback provisions do not apply to minor modifications or restoration of structures that conform with all other policies and standards of this program."

CRMC is evaluating each damaged property to determine whether the owner can rebuild in the same location, and whether modification and/or relocation of the septic system is necessary.



Tale of Two Ponds: Ninigret and Green Hill

At the core of SPC's mission is its water quality monitoring program. Every year, dedicated volunteers collect samples every two weeks from May - October at twenty-five sites in six RI salt ponds. Here we present monitoring results for Ninigret and Green Hill Ponds through 2011. Point Judith and Potter Ponds will be discussed in the next Tidal Page.

As in Part 1 (Fall 2012 Tidal Page), water quality results are presented as Aquatic Health Indices (AHI). The AHI scores sampling parameters on a scale of 0 to 100, like a school report card. Thus, a score of less than 35 for a water quality parameter is poor and a score of greater than 65 is good. An average AHI score is calculated for each testing site, and from the site averages an average AHI is calculated for each pond to give an overall picture of pond health. We produce a report for each pond with a table of AHI values and a map with symbols for each AHI score (see below). These reports are available on our web site: www.saltpondscoalition.org/monitoring.html. There are also more detailed data reports for each sampling site available through our web site.

Ninigret and Green Hill Ponds, located in Charlestown and South Kingstown, are connected by a narrow channel which passes under a bridge on Charlestown Beach Rd. All exchange of water with the ocean for both ponds occurs through the Charlestown breachway into Ninigret Pond, which was dredged in early 2012.

Figure 1 is a plot of average AHI values for sampling sites in Ninigret Pond. Each value is an average of the AHI values for individual data parameters at each site. Crawford Dock, at the far western end of Ninigret Pond furthest from the breachway, has been sampled for more years than the other sites in Ninigret Pond. The AHI at the Crawford Dock site is in the "Poor" AHI category--the worst water quality of any of the sites in this pond--and appears to be declining. A linear regression line of the AHI values at Crawford Dock has a slope of -4.8, with an r^2 value (correlation coefficient) of 0.83, indicating a strong fit of the data points to the regression line. A possible cause of the poor water quality at this site is the tendency of winds to pile macroalgae on the shore adjacent to the dock. The decaying organic matter consumes dissolved oxygen (DO) and releases ammonium (NH_4^+) and dissolved organic nitrogen (DON) to the water column. Low DO and high NH_4^+ and DON are the factors that result in poor water quality for the years 2006 to 2011.

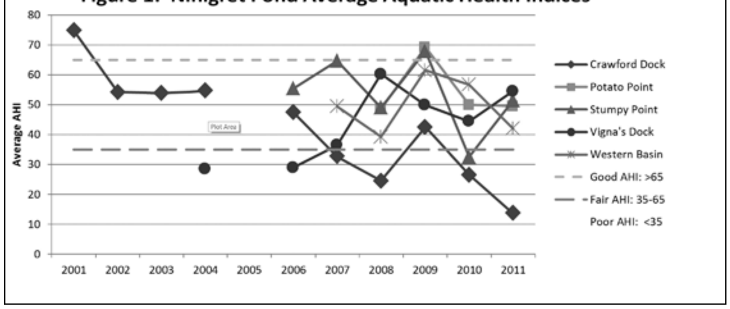


Figure 1: Ninigret Pond Average Aquatic Health Indices

Water quality at the remaining sites was fair. Stumpy Point's AHI score improved by 18 points versus 2010, Vigna's Dock's AHI improved by 11 points, and Potato Point's AHI remained unchanged. Overall, water quality at Vigna's Dock appears to be improving since 2004. A regression line of the data has a slope of +3.9 and an r^2 of 0.58. Water quality at Potato Point, Stumpy Point, and Western Basin is remaining about the same. It will be interesting to see whether the 2012 data show any benefit to water quality from the dredging of the breachway in early 2012.

Figure 3 is a plot of average AHIs for Green Hill Pond sites. Water quality has been heavily impacted by dense housing development around much of the pond. Furthermore, exchange of pond water with clean ocean water is restricted by the channel to Ninigret Pond. In 2010, all four sites in Green Hill were in the poor AHI category. Two sites (In Pond and Teal Rd.) had slightly improved 2011 AHIs versus 2010, while the other two (Indigo Point and Sea Lea) had worse AHI scores. Trend lines for the data all had negative slopes, indicating declining water quality; however, at Sea Lea the decline was slight and there was a very poor fit of the regression line to the data.

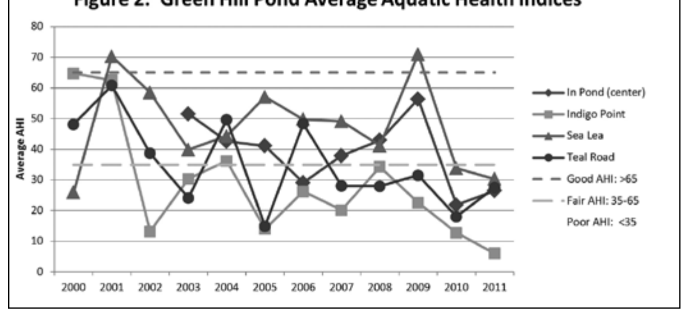


Figure 2: Green Hill Pond Average Aquatic Health Indices

The regression line at the In Pond site was steeper (slope = -2.0), but there was also a weak fit of the regression line to the data. The regression lines at Indigo Point (slope = -3.6, r^2 = 0.49) and Teal Rd. (slope = -2.4, r^2 = 0.36) also showed declines in water quality and had moderate r^2 values.

Green Hill is the most negatively impacted of our salt ponds. It has been closed to shellfishing since the 1990s due to unacceptable bacteria levels. Dense development adds nutrients to the pond through septic systems, lawn fertilizer, and pet waste. Resident Canada goose populations make their "contributions" to nutrient enrichment through their droppings. Properly maintaining septic systems, limiting fertilizer use, picking up after pets, and discouraging geese all help reduce nutrient enrichment of the ponds.

Salt Ponds Coalition
PO Box 875
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