The State of Napatree Report: 2016

A Summary of Monitoring, Stewardship, Management, and Education Programs

Photo credit: Janice Sassi

Compiled By:

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Napatree Point Conservation Area
Watch Hill Conservancy & Watch Hill Fire District

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Contents

State of Napatree Report: 2016
Introduction & Acknowledgements

The purpose of the State of Napatree (SoN) report is to summarize the results of environmental and educational programs in the Napatree Point Conservation Area (NTPCA), Watch Hill, RI. Scientists, educators, and naturalists working at Napatree in 2016 have contributed short, concise summaries of their projects and the results they obtained. The SoN report is a permanent record of the important science, education and stewardship underway at Napatree. This is the fourth year we have published the SoN report.

We welcome feedback on what and how we present material in the State of Napatree reports. Last year's addition of a section on NTPCA staff was a result of terrific feedback from a reader. This year, the Executive Summary and Geography sections were suggestions from readers of the 2015 State of Napatree. Please send Napatree manager Janice Sassi (manager@napatreepoint.info) any ideas that you might have on improving the State of Napatree Report. And if you are interested in volunteering to assist with our projects, particularly horseshoe crab monitoring, please contact Janice. We can use your help!

Compiling this report was a team effort. Janice Sassi coordinated report writing, review, and final report production. Peter August provided reviews of the SoN contributions and assisted in final production. Christian Fox provided a thorough review of all chapters. The following people contributed significantly to the work reported here: Grant Simmons, Janice Sassi, Kevin Rogers, Jessica Cressman Greene, Laura Craver-Rogers, Stephen Brown, Hugh Markey, Tom Pappadia, Alyssa Peterson, Josh Beuth, Nicole Rohr, Lindsay Green, Ivy Burns, Anne Filteau, Fiona MacKechnie, Marguerite Kinsella, Hannah Madison, Carol Thornber, Hope Leeson, Christian Fox, David Gregg, Kira Stillwell, Bryan Oakley, Scott Rasmussen, Keith Killingbeck, Reynold Larsen, Pam Loring, Brett Still, Judith Swift, Amber Neville, Ayla Fox, Caitlin Chaffee, Ryan Kleinert, Emily Bodell, and the URI Watershed Watch program. We are grateful for the ongoing guidance from the Napatree Point Conservation Area Science Advisors: Peter August, Keith Killingbeck, Peter Paton, Hope Leeson, Howard Ginsberg, Nicole Rohr, and Bryan Oakley.

The SoN report was made possible by the support we receive from the Watch Hill Conservancy, the Watch Hill Fire District, the Roberts Foundation, as well as the USDA Renewable Resources Extension Act. Grants from The Sounds Conservancy of the Quebec-Labrador Fund, the National Science Foundation, the Washington Trust Company, and the URI Coastal Institute were instrumental in completing many of the projects undertaken in 2016.

Sharon Ahern
Executive Director
Watch Hill Conservancy

Grant G. Simmons III
Chairman, Park Commission
Watch Hill Fire District

Special Thanks To:

A. M. Roberts Charitable Foundation

The Roberts Foundation supports projects that maintain the character and sense of place of Watch Hill. It has generously provided funding for the annual operations of the Napatree Point Conservation Area. The work described in the State of Napatree Report would not be possible were it not for the continued generosity of the Roberts Foundation.

The URI Coastal Institute

The URI Coastal Institute has been a strong supporter of the environmental stewardship programs we conduct at Napatree. We are grateful for its assistance and look forward to many fruitful collaborations in the future.

It Take a Village - Our Volunteers

Volunteers make a difference on Napatree. In 2016, 739 hours of volunteer time were provided by our interns, science advisors, and horseshoe crab monitors. This is equivalent to a full-time employee working for the NTPCA for almost one-half of a year.

Our Partners

The work that is done on Napatree is a powerful collaboration of many organizations. The logo cloud showing our partners (next page) is an impressive demonstration of the importance of Napatree and the commitment made by many to steward the conservation area and deliver effective education programs.

Our Partners

Napatree Point Conservation Area
Mission & Vision

DESCRIPTION

The Napatree Point Conservation Area (NTPCA) is managed by the Watch Hill Fire District and the Watch Hill Conservancy. The NTPCA stewards the Napatree Point ecosystem, monitors its environmental condition, and delivers environmental education programs to children, students, and adult learners.

MISSION STATEMENT

We protect and enhance the ecological condition and ecosystem resilience of Napatree Point in order to make it a safe, enjoyable, and informative destination for all visitors.

OUR VISION

The Napatree Point Conservation Area is recognized as a national model for natural area stewardship and is regarded as a premier destination for visitors to enjoy its dramatic natural beauty and spectacular wildlife.

OUR CORE VALUES

- *We base management and stewardship decisions of the Napatree Point Conservation Area on the best available science and data.*
- *We strive to enhance the resilience to human and natural disturbances of the Napatree Point ecosystem.*
- *We monitor the condition of the fauna and flora, and the ecosystem and geological processes of Napatree Point.*
- *We share data and information with the local community, students, scientists, and decision-makers, and make lessons learned and best management practices available to other natural areas across the country.*
- *We engage and educate school-aged children in the ecology of Napatree Point and instill in them a curiosity and respect for the natural world.*
- *Napatree Point is a community resource and is open to all visitors.*

WE ACHIEVE OUR MISSION

- *Through our Investigators Program; we engage and educate school-aged children of the ecology of Napatree Point, instill in them a curiosity for nature, and establish a respect for the environment.*
- *Through our Naturalist staff and programs; we educate visitors to Napatree Point of the natural history of the site and encourage respectful behaviors that do not disturb wildlife or damage the ecosystem.*
- *Through our scientific monitoring of the ecological and geological condition of Napatree; we know the driving processes and degrees of variation in the system and can assess the impact of future natural and human-caused disturbances.*
- *Through our restoration programs; we enhance the biological diversity and resilience of the Napatree Point ecosystem.*
- *Through the State of Napatree Reports, lectures, hosted visits, and multimedia outreach materials; we share the results of our monitoring and education programs with the public, scientists, and decision-makers.*

State of Napatree Report: 2016
Executive Summary

The following are highlights from this year's State of Napatree Report. This section was requested by a reader of the 2015 State of Napatree report (SoN) and we are pleased to provide these brief summaries of the information presented in this S0N.

- Napatree Point is a dynamic landscape. Agents of change are storms, rising tides, visitor traffic, and constantly shifting geological and ecological processes. We have taken a snapshot of the geography of Napatree in 2016 and provide a quantitative description of the physical and ecological characteristics of the Napatree Point Conservation Area (NTPCA). *For more information, see Chapter 5 (page 13) by Peter August et al.*

- The Investigators youth education program continues to run at maximum capacity. This year, 70 children from 47 families (from Westerly, Stonington, and North Stonington) received 574 hours of programming on Napatree. *For more information, see Chapter 6 (page 24) by Stephen Brown et al.*

- Given the paucity of significant storms in 2016, little dune erosion has occurred in the past year. The trend for the last few years is an increasing volume of sand on Napatree and an increase in the elevation of the foredune crest. The Napatree shoreline has remained relatively constant for the past three years. *For more information, see Chapter 7 (page 28) by Bryan Oakley.*

- Water quality at the NTPCA monitoring sites was good in 2016 and is indicative of a healthy marine ecosystem. Bacteria levels were low all summer. *For more information, see Chapter 8 (page 51) by Christian Fox et al.*

- Eight pairs of Piping Plovers initiated 10 nesting events in 2016. Seven Plover chicks fledged. The number of nesting pairs, eggs laid (34), and nestling hatched (21) were higher this year than last year. *For more information, see Chapter 9 (page 64) by Kevin Rogers.*

- Horseshoe crabs were extremely abundant on Napatree in 2016. Monitors counted 4,759 spawning horseshoe crabs in 20 surveys. The number of horseshoe crabs observed per survey in 2016 was almost double what has been observed over the past 4 years. *For more information, see Chapter 10 (page 69) by Laura Craver-Rogers & Kevin Rogers.*

- The number of visitors to Napatree appears to be increasing each year. On average, there were 778 visitors to the NTPCA on weekend days and 398 visitors on week days. Visitors to Napatree arrive by foot and enter at the east gate, and by boat. On July 3, 562 boats were anchored off the north (bayside) shore of NTPCA. There were relatively few violations of the dog ordinance, however, an average of 5.3 dogs per day are turned away at the gate from May to September. *For more information, see Chapter 11 (page 76) by Kevin Rogers.*

- Camera trapping in 2015/2016 yielded one new species of mammal to the NTPCA species list, a raccoon (*Procyon lotor*). Coyote abundance remained similar to last year. Mink visits were markedly higher than previous years and red fox sightings decreased substantially in 2016. A camera trap set inside a roped-off Piping Plover nesting area recorded humans passing through the area on a number of occasions but no dogs were observed. *For more information, see Chapter 12 (page 85) by Peter August et al.*

- The diversity of bats on Napatree is similar to what is observed in other parts of the state. Five species of bats were recorded in bat surveys with red bats being the most common. The Pines had the highest diversity and levels of activity on Napatree. The abundance of bats on Napatree Point was low (in terms of bat passes/hour) compared to high-quality habitats in Rhode Island. *For more information, see Chapter 13 (page 95) by Peter August et al.*

- Monitoring of the condition of previous years' plant restorations showed that high levels of herbivory, especially by meadow voles, to a number of plant species in 2016. Of the species planted in 2014, 66% were surviving in 2016. Of the eight species planted in 2015, all survived in 2016. Patches of invasive Japanese knotweed, Morrow's honeysuckle, and porcelain berry that were treated in previous years showed no signs of regrowth in 2016. Control treatments were applied to black swallowwort, glossy buckthorn, and tree of heaven. These populations will continue to be monitored and treated in the future. *For more information see Chapter 14 (page 104) by Hope Leeson et al.*

- The fish fauna of the Napatree Lagoon contains the common species found in these habitats in Rhode Island. Eight species of fish were captured in 2016; two (winter flounder, pipefish) were new species for the Napatree Lagoon. Fish abundance was lowest when dissolved oxygen was low, as observed in 2015. *For more information see Chapter 15 (page 119) by Nicole Rohr et al.*

- The abundance and diversity of seaweeds in the Napatree Lagoon varies seasonally and among sampling locations. Seaweed abundance was highest in July. Sampling in 2015 and 2016 has resulted in 32 different species being found. This is higher than other coastal lagoons in Rhode Island. A small fish-kill in the lagoon on 6 July 2016 might have been driven by very high algae levels at that time. *For more information, see Chapter 16 (page 134) by Lindsay Green et al.*

- Shrub patches on Napatree are very dynamic. Contrary to our predictions, bayberry patches increased in aerial extent and height much more than *Rosa* patches in the last two years. This has many interesting, and important, implications for the upland habitats on Napatree. *For more information see Chapter 17 (page 148) by Jessica Cressman Greene et al.*

- Six months of data from a tide gauge deployed in the Napatree Lagoon show that the timing of high and low tides are one hour later than high/low tide times at Montauk, NY and the magnitude of the tides are almost exactly the same. This has very important implications for all management activities on Napatree. We will continue logging tidal data in 2017. *For more information see Chapter 18 (page 155) by Scott Rasmussen.*

Napatree Point Conservation Area
2016 Staff

Grant Simmons
Napatree Park Commissioner

Senior liaison between WH Conservancy and WH Fire District. Coordinates water quality sampling and oversees all Napatree Programs.

Janice Sassi
Napatree Manager

Has managed Napatree for past 7 years. Responsible for all stewardship and management programs.

Stephen Brown
Director of Ed Programs

M.E. Elementary Education, RIC
Science Dept. Chair, Pine Point School, CT
Developed Investigators program on Napatree 10 years ago.

Hugh Markey
Napatree Educator

B.A. Journalism, URI
English Faculty, Pilgrim High School
Has delivered Investigators program on Napatree for 9 years.

Tom Pappadia
Napatree Gate Keeper & Naturalist

Charter Member of Napatree Team. Monitors and welcomes visitors at main entrance. Assists with beach projects and programs.

Ryan Kleinert
Napatree Naturalist

M.S. Conservation Biology, URI
Work experience as field ecologist with the US Fish & Wildlife Service.

Christian Fox
Napatree Naturalist

M.S. Earth & Hydrological Science, URI
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Joshua Beuth
Napatree Naturalist

M.S. Wildlife Ecology, URI
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Alyssa Peterson
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M.S. Conservation Biology, URI
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Kevin Rogers
Napatree Naturalist

M.S. Conservation Biology, URI
Previous work as a field ecologist US Fish & Wildlife Service

Laura Craver-Rogers
Napatree Naturalist/Educator

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Educator, Denison Pequotsepos Nature Center
Napatree Naturalist for past 3 years

Emily Bodell
Napatree Naturalist Intern

B.S. Candidate, Environmental Science
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Assisted in all Napatree stewardship and ed programs

Jessica Cressman Greene
Napatree Naturalist

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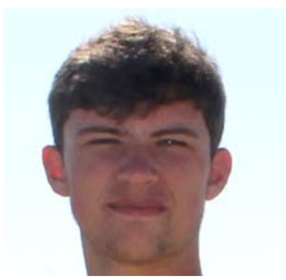
Environmental Data Center

Nick Moore
2016 Napatree Investigator
Program Assistant



L. Arthur Renehan
2016 Napatree Investigator
Program Assistant

The Geography of the Napatree Point Conservation Area

Peter August [1], Janice Sassi [2], Kevin Rogers [2] & Jessica Cressman Greene [1,2]
[1] Department of Natural Resources Science, University of Rhode Island
[2] Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

Photo credit: Kevin Rogers

The Geography of the Napatree Point Conservation Area

Peter August [1], Janice Sassi [2], Kevin Rogers [2] & Jessica Cressman Greene [1,2]
[1] Department of Natural Resources Science, University of Rhode Island
[2] Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

INTRODUCTION: The purpose of this chapter is to describe the physical and ecological geography of the Napatree Point Conservation Area (NTPCA). We hope it will serve as the single go-to reference for Napatree facts and figures. Note, however, that Napatree is a dynamic landscape and is always changing. The statistics we present here are a snapshot of conditions on the date the source data were recorded. These results are a baseline from which future comparisons can be made.

METHODS: The maps and measurements reported here were made with ArcGIS (v 10.3.1) geographic information system (GIS) software (Environmental Systems Research Institute, Redlands, CA). We used the best available data for each of the categories reported on. Some of the geospatial data used in our tabulations were obtained from the Rhode Island Geographic Information system (RIGIS) database (www.rigis.org). Other data were developed by Napatree staff or scientists. This compilation will be a dynamic document and will be updated in future years as new data become available or significant changes occur on Napatree.

For each theme, we describe the feature measured, where we obtained the source data, and how the feature was measured using the GIS. For each theme we present a map and a statistical summary. Measurements are given in both metric and English units.

RESULTS:

<u>Size of the Napatree Point Conservation Area</u>

Source Information: Area and length measurements were taken from the 2016 shoreline of the NTPCA. The shoreline was heads-up digitized from the digital orthophotography obtained for the 2016 eelgrass mapping project. The imagery is true color with a 0.5 m (1.64 foot) pixel size and was obtained in June 2016. It is available from RIGIS. The last high-tide swash line was considered the shoreline in the imagery. This is consistent with the shoreline definition used by Napatree geologist Dr. Bryan Oakley and reported in the current and previous State of Napatree reports. A number of factors affect shoreline position: tidal state when the imagery was obtained, deposition or erosion of sand, or recent storms.

On the north shore of NTPCA, the bayside shoreline measurements extended from the entrance to the conservation area to the eastern border of the lagoon. The lagoon shoreline circumnavigated the lagoon. The cobble shoreline north and west of the lagoon extended from the western entrance to the lagoon to the western rocky shore of Napatree. The ocean beach extended from the western rocky shoreline to the jetty on the eastern end of the conservation area. The eastern border extended from the entrance of Napatree to the jetty on the ocean side. To calculate the area of the lagoon, a polygon was formed by closing off the lagoon at the current breach where it connects with Little Narragansett Bay.

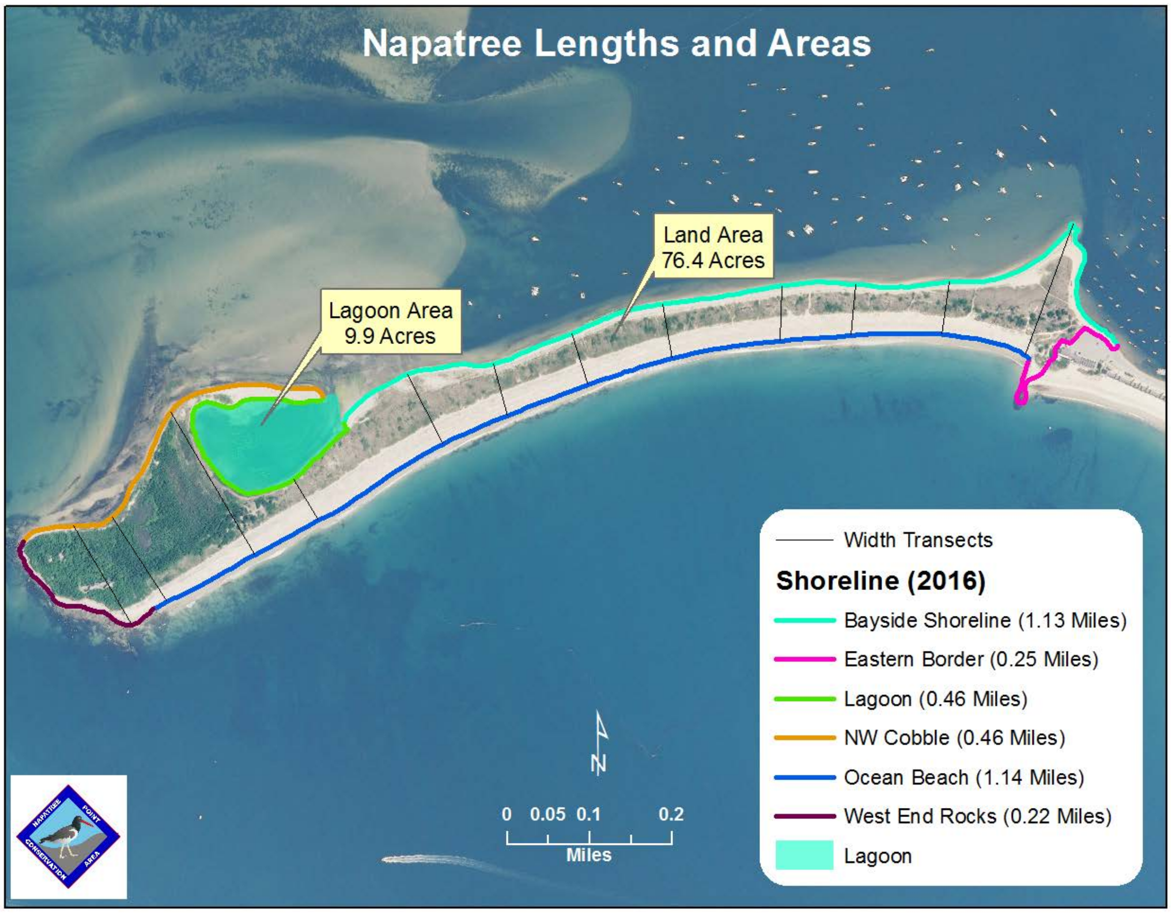


Figure 1. Areas and distances in the Napatree Point Conservation Area

Statistical Summary

Land Area	76.35 Acres	30.9 Hectares
Lagoon Area	9.90 Acres	4.02 Hectares
Total Area (Land and Lagoon)	86.25 Acres	34.92 Hectares
Bayside Shoreline	1.13 Miles	1.82 Kilometers
Lagoon Shoreline	0.46 Miles	0.74 Kilometers
NW Cobble Shoreline	0.46 Miles	0.75 Kilometers
Rocky Western End	0.22 Miles	0.36 Kilometers
Ocean Beach	1.14 Miles	1.84 Kilometers
Eastern Border	0.25 Miles	0.39 Kilometers
Total Perimeter of NTPCA	3.67 Miles	5.90 Kilometers
Average Width of Barrier (12 Cross Sections Along the Barrier)	517.4 Feet	157.7 Meters
Width at Fort Mansfield	734.8 Feet	223.9 Meters
Width in Salt Marsh West of Lagoon	1,061.4 Feet	323.5 Meters
Width From Bay-side Jetty (East End) to Ocean	892.9 Feet	272.2 Meters

Elevation and Depth of Napatree Point Conservation Area

Source Information: Elevations were obtained from the 2014 NOAA Post Sandy Topobathymetric Lidar digital elevation model obtained from RIGIS. Lagoon depths were taken from the bathymetry dataset developed by the Napatree Point Conservation Area (Rohr et al., 2014 State of Napatree report). The bathymetry of the Napatree lagoon appears to have changed somewhat since the 2014 mapping survey. This is likely a result of circulation changes in the lagoon resulting in the change in the location of the opening with Little Narragansett Bay. A new bathymetric survey should be conducted in the near future. All elevations and depths are given relative to the North American Vertical Datum (NAVD) 1988.

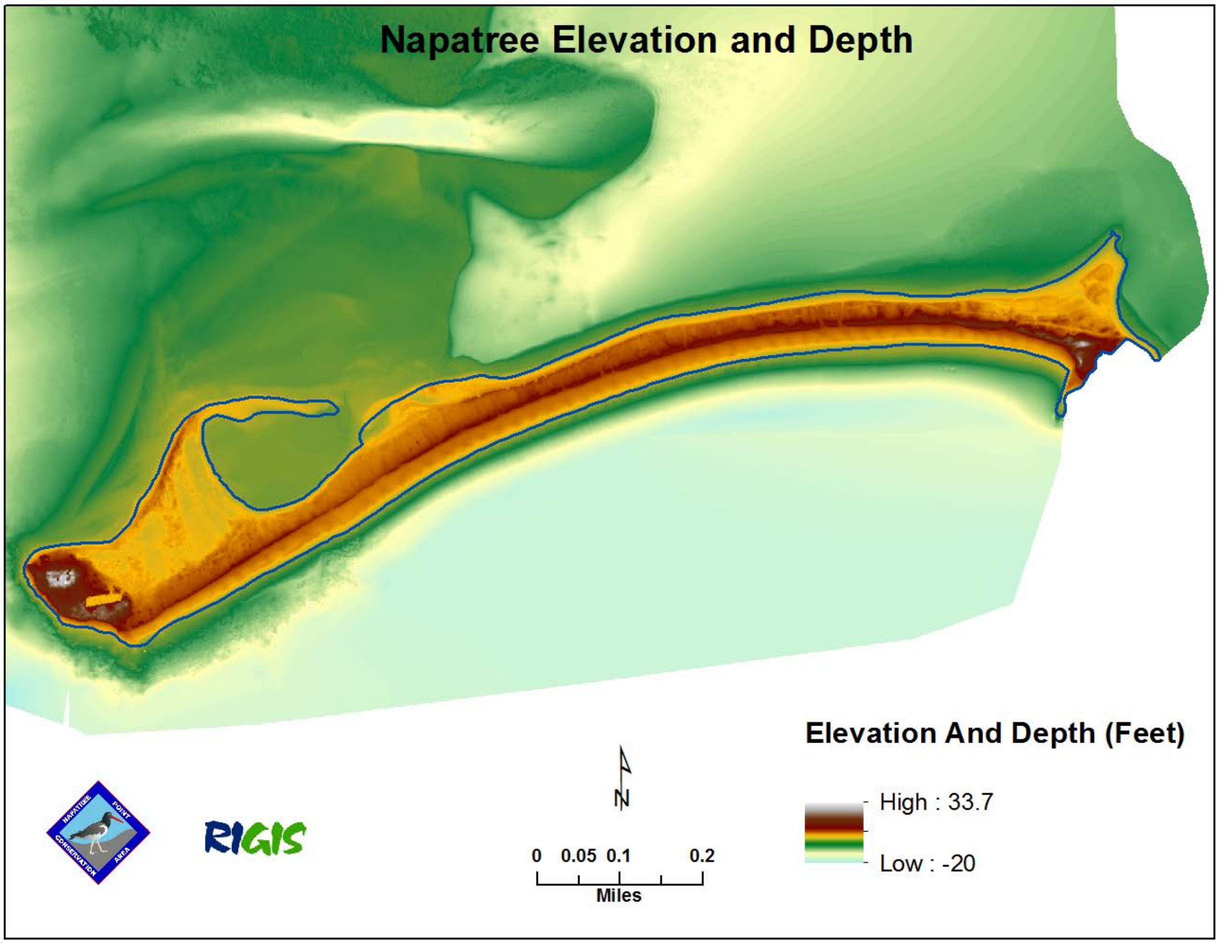


Figure 2. Elevations and depths in the Napatree Point Conservation Area

Statistical Summary

Maximum Land Elevation	33.7 Feet	10.27 Meters
Average Land Elevation	6.21 Feet	1.89 Meters
Elevation At Top of Dune On Eastern-most Dune Crossing Path	28.8 Feet	8.78 Meters
Dune Crest Along Paths	10 – 13 Feet	3 – 3.9 Meters

Average Depth of Lagoon	-0.44 Feet	-0.13 Meters
Maximum Depth of Lagoon	-3.3 Feet	-1.0 Meters

Habitats

Source of Information: Eelgrass (*Zostera marina*) data were taken from the 2012 eelgrass survey of Rhode Island available from RIGIS. All eelgrass patches between Napatree Point and Sandy Point are included in the summary. Mussel beds (*Mytilus edulis*) were delineated in the field (2013) using a hand-held GPS receiver (Garmin, WAAS-enabled) at low tide by Kevin Rogers. The minimum mapping unit was 5 square feet (0.46 square meters). Patches of sparse mussel density were not included in the data. Natural community data were photo-interpreted from the 2011 RIGIS orthophoto imagery (available on RIGIS) by Kevin Rogers using the RI Ecological Communities Classification System (Enser et al. 2011; http://www.edc.uri.edu/rieccatlas/). The minimum mapping unit was approximately 0.25 acres (0.10 hectares).

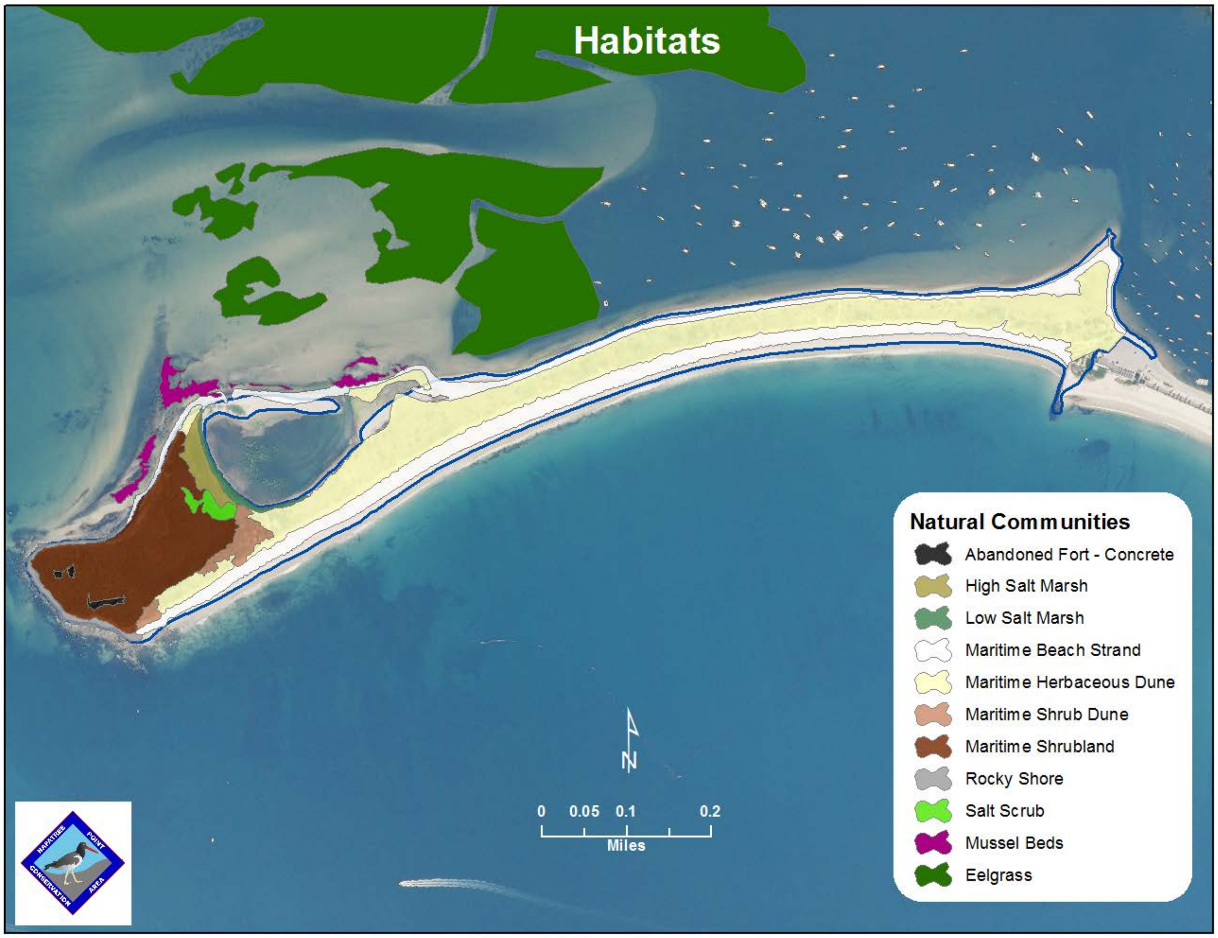


Figure 3. Habitats in the Napatree Point Conservation Area

Statistical Summary

Concrete (Abandoned Fort)	0.30 Acres	0.12 Hectares
High Salt Marsh	1.34 Acres	0.54 Hectares
Low Salt Marsh	0.77 Acres	0.31 Hectares
Maritime Beach Strand	18.74 Acres	7.58 Hectares
Maritime Herbaceous Dune	28.99 Acres	11.73 Hectares
Maritime Shrub Dune	1.81 Acres	0.73 Hectares
Maritime Shrubland	14.27 Acres	5.77 Hectares

Rocky Shore	1.26 Acres	0.51 Hectares
Salt Scrub	0.7 Acres	0.28 Hectares
Mussel Beds	2.24 Acres	0.91 Hectares
Eelgrass Beds	200.69 Acres	81.21 Hectares

Property Ownership

Source of Information: Parcel boundaries and ownership data were obtained from Town of Westerly parcel database downloaded from their web site on November 16, 2016. The data were current to September 23, 2016. Area values were taken from the GIS calculation of the size of each parcel. The data were clipped to the NTPCA eastern boundary. The total land area of the parcels dataset will slightly differ from the total area presented in the Area/Length data because of different shorelines used to delineate the outline of Napatree.

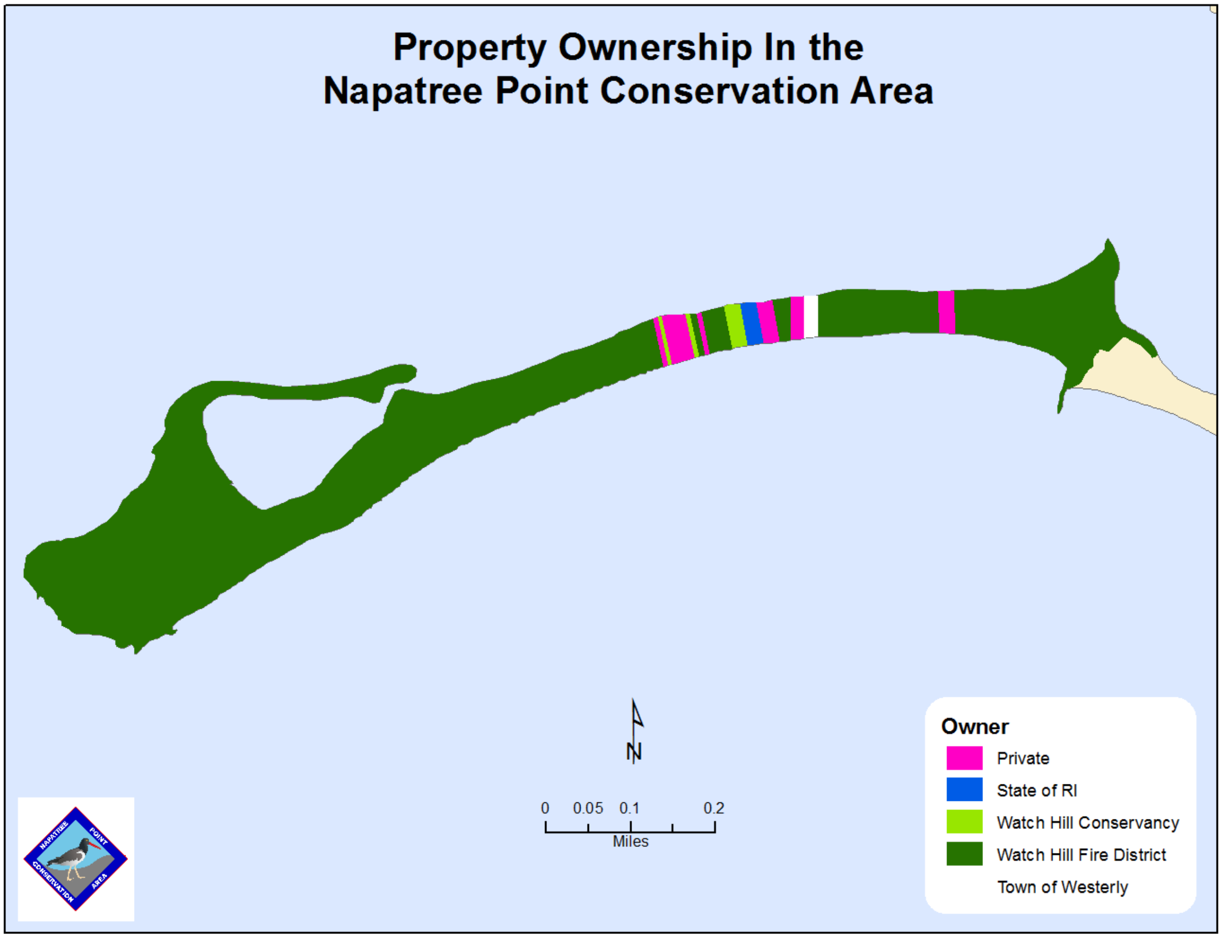


Figure 4. Property ownership in the Napatree Point Conservation Area

Statistical Summary

Total Privately Owned Parcels (6 parcels)	3.50 Acres	1.42 Hectares
Parcels Owned by Watch Hill Fire District (11)	69.49 Acres	28.12 Hectares
Parcels Owned by Watch Hill Conservancy (3)	1.08 Acres	0.44 Hectares
Parcels Owned by State of RI (1)	0.69 Acres	0.28 Hectares
Parcels Owned by the Town of Westerly (1)	0.62 Acres	0.25 Hectares
Total Area of All Parcels (22)	75.39 Acres	30.51 Hectares

Trails (Paths)

Source of Information: Path data were collected in 2012 by Jessica Cressman Greene by walking all trails with a hand-help GPS. Path pole locations were collected by Peter August in November 2016 using a hand-held GPS receiver (Garmin eTrex, WAAS-enabled). The 2012 trails were categorized into two categories – cross dune trails (extending from bay to ocean) or lateral trails which ran east-west and parallel to the shoreline or extended a short distance into the dune to connect to a lateral trail. The 2016 trails were those approved trails as of November 2016.

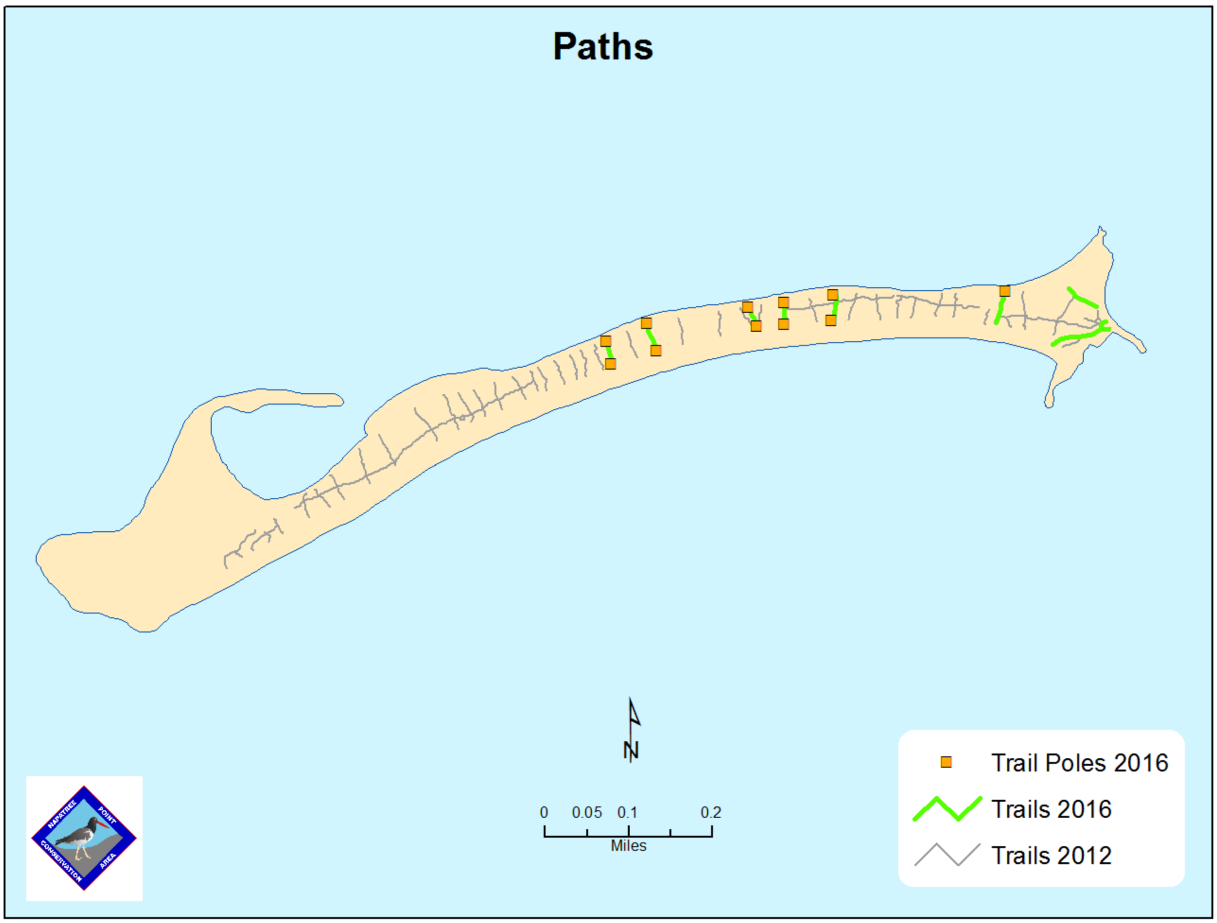


Figure 5. Trails in the Napatree Point Conservation Area

Statistical Summary

2012 Cross Dune Trails (40 trails)	1.43 Miles	2.30 Kilometers
2012 Lateral Trails (24)	0.99 Miles	1.59 Kilometers
2012 Total Trails (64)	2.42 Miles	3.89 Kilometers
2016 Cross Dune Trails (7)	0.28 Miles	0.45 Kilometers
2016 Lateral Trails (1)	0.04 Miles	0.06 Kilometers
2016 Total Trails (8)	0.32 Miles	0.51 Kilometers

CONCLUSIONS: As new data are collected on Napatree, or existing data are revised, we will update this descriptive geography. Until then, we recommend using these data as standard facts and figures describing the Napatree Point Conservation Area.

DATA MANAGEMENT: The data used in this compilation are in the NP_Data DropBox folders:

NP_Data\Physical\GIS\Shoreline\2016_Shoreline
NP_Data\Physical\GIS\2016_Lagoon
NP_Data\Physical\GIS\Trails\TrailPoles_2016
NP_Data\Physical\GIS\Trails\Trails_2012
NP_Data\Physical\GIS\Trails\Trails_2016
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NP_Data\Biological\GIS\Misc\Mussel_Beds_2013
NP_Data\Social\GIS\Parcel_Data\WesterlyParcels_23Sept2016\NTPCA_Parcels_Only

ACKNOWLEDGEMENTS: This project was supported by the University of Rhode Island Coastal Institute, the USDA Renewable Resources Extension Act, and the URI College of the Environment and Life Science Extension Program in Natural Resource Conservation and Management, the Watch Hill Conservancy, and the Watch Hill Fire District.

Napatree Point Children's Education Program:
Investigators 2016

Stephen Brown, Hugh Markey & Laura Craver-Rogers
Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

Photo credit: Janice Sassi

Napatree Point Children's Education Program:
Investigators 2016

Stephen Brown, Hugh Markey & Laura Craver-Rogers
Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

INTRODUCTION: The Investigator program is a free, hands-on learning experience for children ages 7-14. Children spend two hours on the beach observing natural biotic and abiotic elements, as well as analyzing or researching their finds using age-appropriate picture pamphlets. The program goals are to foster a curiosity for, and appreciation of, the fauna and flora of the various habitats, as well as to learn facts about the ecosystems of the Napatree Point Conservation Area. While guiding the Investigators, Naturalists model proper beach conservation, such as picking up trash, staying on trails, respecting all forms of life, and avoiding climbing dunes. At the same time, Naturalists discuss how these behaviors foster the preservation of Napatree, encouraging the children to become lifelong protectors of beach habitats.

OUTREACH: We advertise the program in various ways: we email all families who previously attended the program; we provide a sign-up sheet in the children's area of the Westerly library; and we send flyers to the Westerly and Stonington School Districts, as well as to the local parochial and independent schools in the same towns. Registration is done online via Gmail, with the parents completing a questionnaire. These data are compiled on a Google spreadsheet (see Results). Families must sign a consent form that includes a photo and video release, an acknowledgement of the child's physical condition, and a liability release for the Watch Hill Conservancy. Parents may sign up for one of three sessions offered each week.

PROGRAM FORMAT: Each session begins at the gazebo in Watch Hill with Naturalists taking attendance, answering parent questions, conducting introductions and exploring the theme of the day's program. The latter part may involve the Naturalists accessing prior knowledge through the use of questioning and/or visual aids.

The program is two hours long and focuses on a specific theme each week, but students are encouraged to share any and all findings made on the beach. The themes include: wrack line, horseshoe crabs, fish, crabs, mollusks, and shells/rocks/seaweeds. The summer's program concludes with the opportunity for students to collect small abiotic items in a collection box that they can keep for future reference. Other topics covered informally include: jellyfish, birds, tides, conservation, food chains, predator/prey, camouflage, minerals, temperature impacts, adaptations, and wildlife tracking.

Each program ends with the group sharing their findings and what they have learned during the session. Families pick up their children at the gazebo.

RESULTS: We educated 70 different children over a seven-week period this summer, with a total of 912 total *registered* child hours on Napatree Point. Because of two cancellations due to inclement weather and children being absent, we had 574 actual child hours. The percentage of students who actually attended the program (cancellations not included in the data) after registering was 69%. This is down three percentage points from 2015 (72%), and up seven percentage points from 2014 (62%). Of the 47 families attending the program, there were 35 from Westerly, 11 from Stonington, and one from North Stonington. We had between 18 and 25 participants signed up for each day (Figure 1).

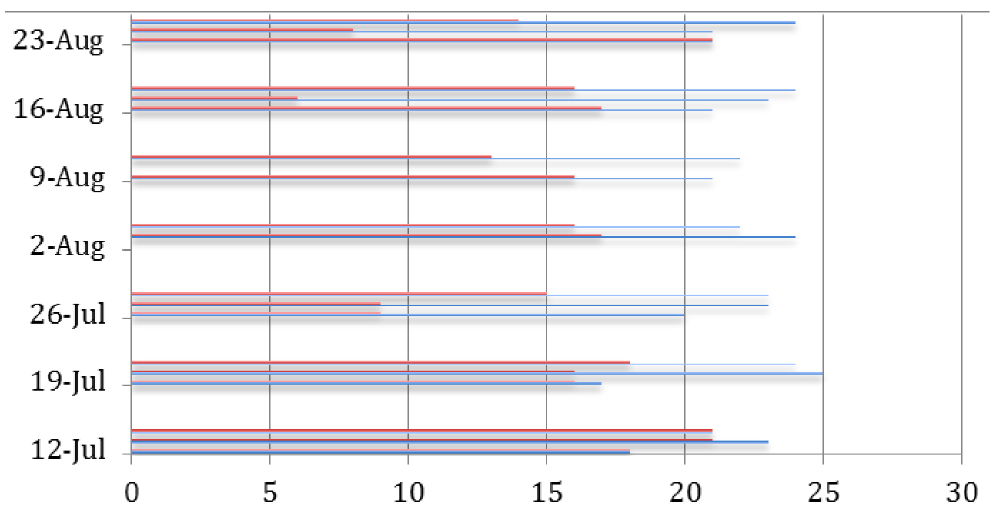

Figure 1. Registered students (blue) and students actually attending (red) by class day (Tuesday, Wednesday, Thursday) for each week of instruction during the summer of 2016. Three sessions were cancelled due to inclement weather.

CONCLUSIONS: Due to the high registration numbers, we suggest that a team of three Naturalists be employed each year, with both genders represented. Though the actual number of participants was only 69% of those registered, there were still four sessions that had at least eighteen participants. Also, since the actual number of children who came to the program was fewer in number than those registered, the registration cut-off can be set at 25 participants.

Issuing flyers to all local schools, along with sending out an email to all the contacts should be continued in light of the high registration numbers. Using the Gmail account helped to improve the organization of communications and thus improved the efficiency and ease of registration.

DATA MANAGEMENT: Stephen Brown manages The Google spreadsheet of registrant data until the end of the season, when it is sent to the Watch Hill Conservancy Office. The mailing addresses are recorded from the documents for correspondence purposes. Stephen Brown keeps the copies on his computer. The final consent form is also kept on the same computer. Perhaps In the future, these documents can be placed in the system Drop Box under "Investigator Program."

ACKNOWLEDGEMENTS: We are grateful for the excellent help we received from the 2016 Napatree Investigator Program Assistants – Nick Moore and L. Arthur Renehan. Napatree summer intern Emily Bodell provided superb assistance with many of our classes.

Understanding the Short and Long-term Shoreline Change of Napatree Barrier Using RTK-GPS Beach Profiles and Mapping of the Last High Tide Swash: 2016 Update

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Photo credit: Janice Sassi

Understanding the Short and Long-term Shoreline Change of Napatree Barrier Using RTK-GPS Beach Profiles and Mapping of the Last High Tide Swash: 2016 Update

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Department of Environmental Earth Science, Eastern Connecticut State University

INTRODUCTION: The objective of this project, which began in July 2013, is to examine the short- and long-term response of the Napatree barrier and headland to storms using beach profiles (Figure 1) and the position of the last high tide swash (LHTS) (commonly referred to as the wet-dry line or wrack line) (Figures 2, 3). The lack of infrastructure and development on the Napatree barrier make it an ideal location to examine shoreline change in the absence of the 'line in the sand' mentality inherent on more developed portions of the coastline. Storms (both hurricanes and extra-tropical cyclones), not sea level rise, are the driving force in shoreline change (Hayes and Boothroyd, 1987), particularly at the decadal scale (Morton, 2008). Napatree Barrier has migrated > 60 m (200 feet) landward (towards Little Narragansett Bay) between 1939 and 2014 (Boothroyd and Hehre, 2007; Boothroyd et al., 2015) (Figure 3), via storm surge overwash and deposition of washover fans. This means the landform itself has 'rolled over' almost one barrier width since 1939! Much of this measured migration likely occurred during the 1944 and 1954 (Carol) hurricanes, and the Ash Wednesday Storm, a significant extra-tropical storm that impacted the mid-Atlantic and southern New England 6-8 March, 1962 (Dolan, 1987). The first vertical aerial photographs in Rhode Island were collected in 1939, so the shoreline position prior to the 1938 hurricane is not known. Analysis of historical aerial photographs shows these events overwashed much of the barrier. 'Superstorm' Sandy, a tropical/extra-tropical storm that made landfall in New Jersey in October 2012, impacted Napatree with portions overwashed (particularly at the western end of the barrier) (Figure 4, 5) and other sections experiencing extensive frontal erosion. While this study began after Sandy, it provides an excellent laboratory to examine the recovery of the shoreline following a storm event.

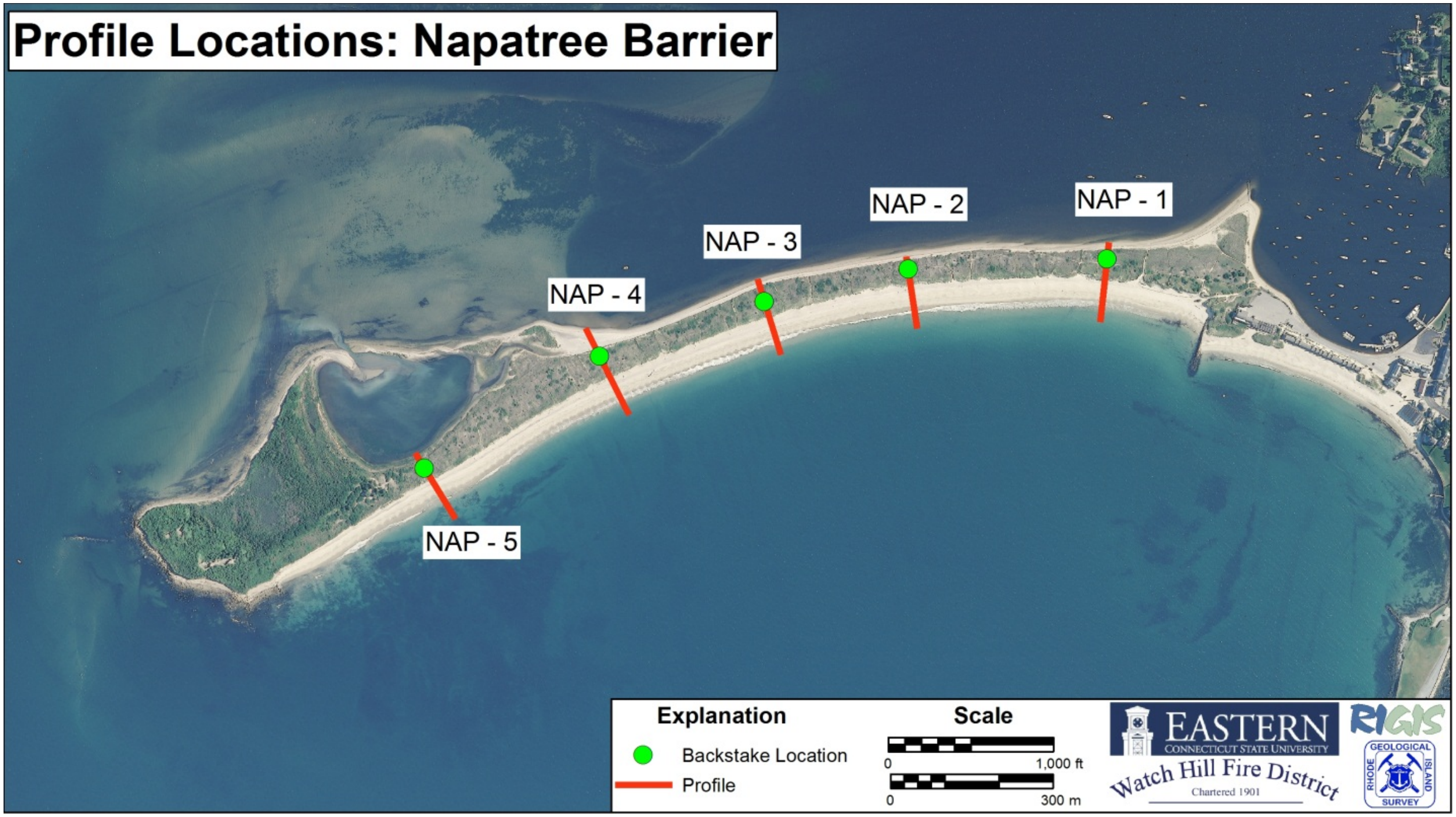


Figure 1. Benchmark and profile locations along the Napatree Barrier. Base map is the 2012 Eelgrass orthophotograph downloaded from RIGIS.

Figure 2. Last high-tide swash (LHTS), on the Little Narragansett Bay shoreline of the Napatree Barrier 18 December 2013.

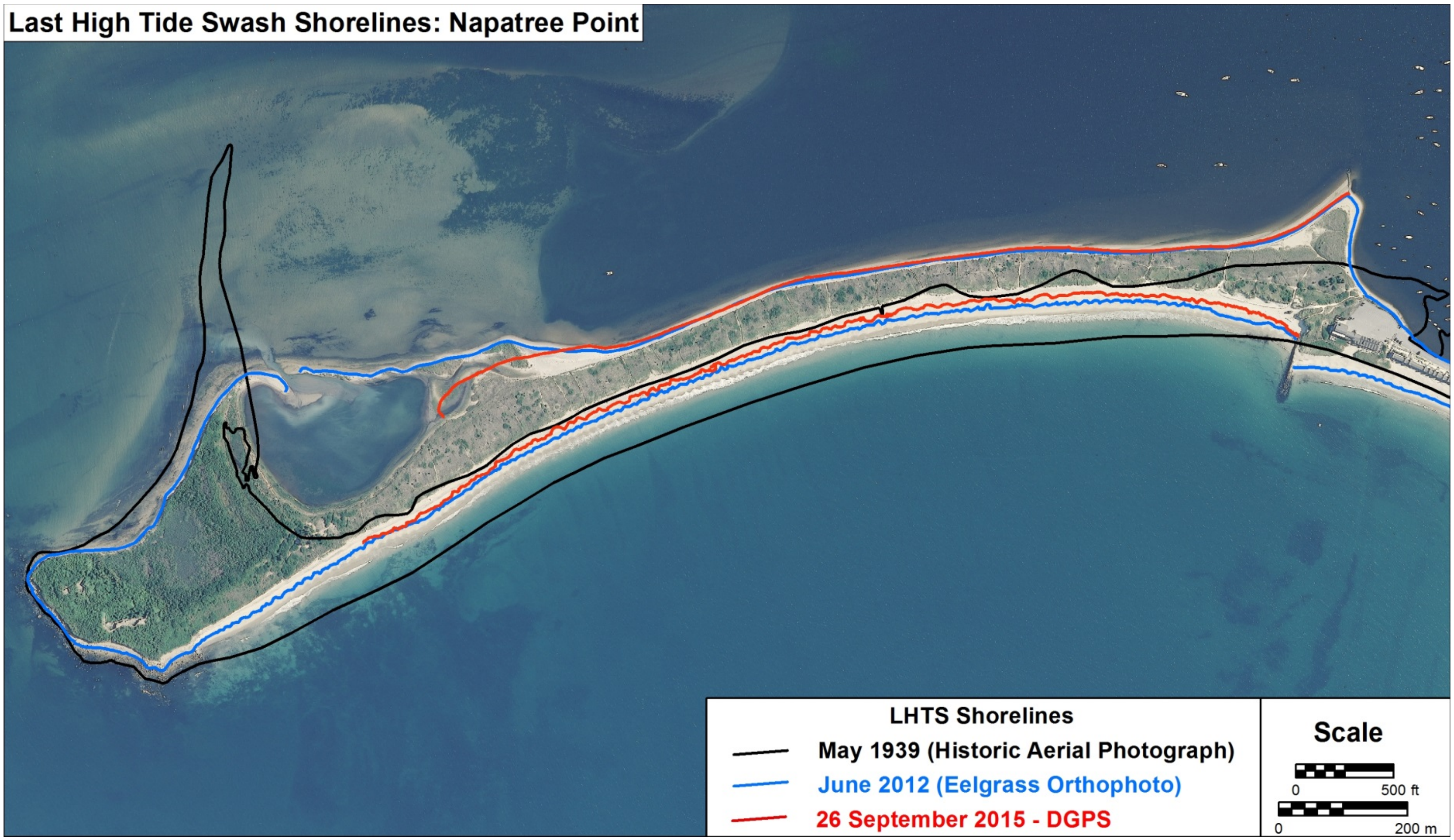


Figure 3. Last High Tide Swash (LHTS) (aka the wet-dry line) derived shoreline positions from 1939 (Boothroyd and Hehre, 2007), 2012 (Pre Sandy) (Boothroyd et al., 2015) and September 2015 (collected using differential GPS)

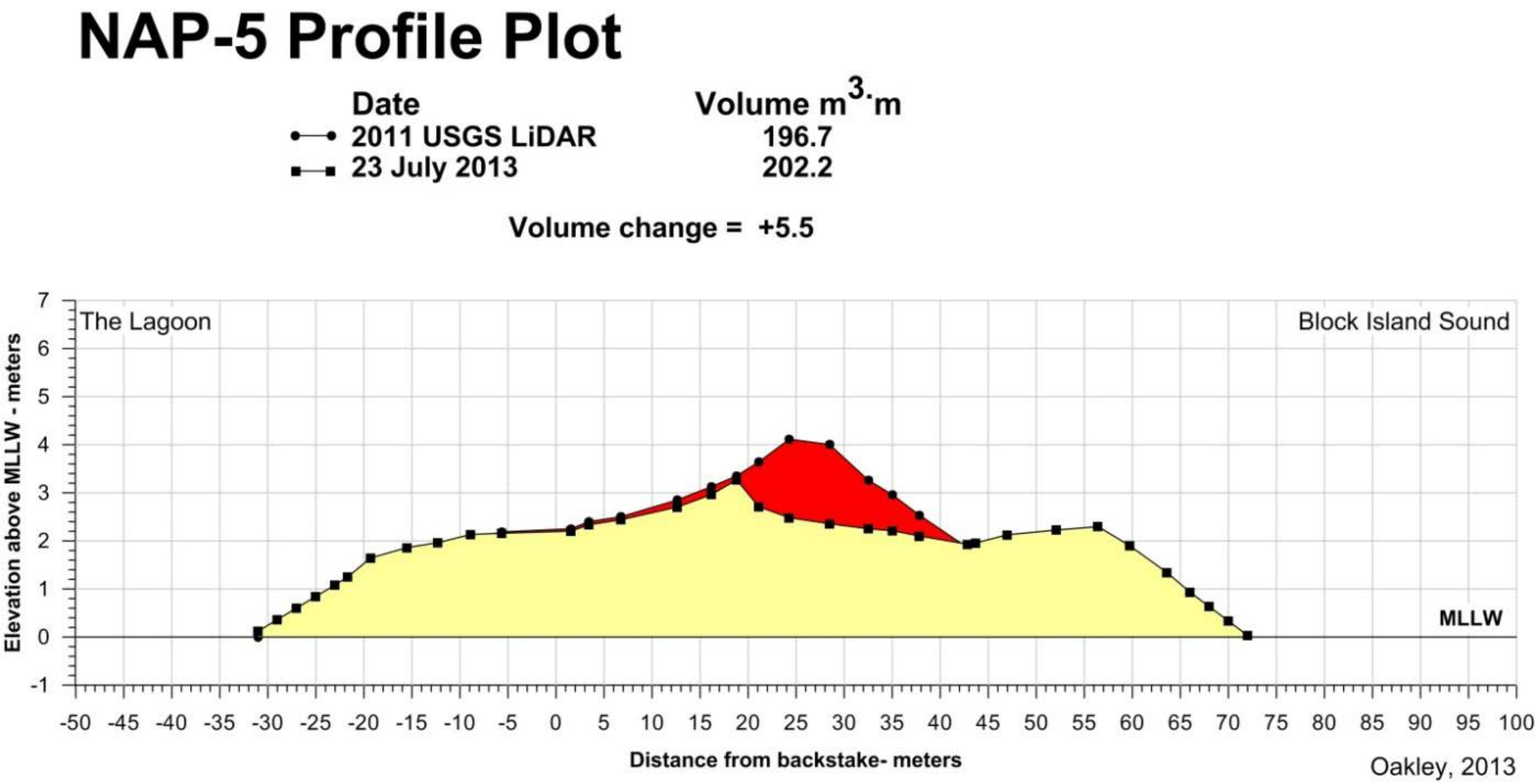


Figure 4. Plotted profile for NAP-5 (Figure 3) comparing the 2011 U.S.G.S. LiDAR data with RTK-GPS beach profile from 23 July 2013. Note significant erosion of the foredune (red), interpreted to have occurred during Hurricane Sandy.

Figure 5. Google Earth image of Napatree Point from April, 2013. Areas of bright sand represent fresh deposition of washover fans. Red lines indicate the location of the beach profiles measured

METHODS:

Beach profiles

Beach profiles are measured quarterly (typically in March, June, September, December) using real-time kinematic GPS (RTK-GPS), which collects an X,Y, Z (northing, easting relative to Rhode island State Plane Feet, 1983 and elevation relative to NAVD88) for points along the profile (Figure 3). Points are surveyed approximately every 2 m, as well as at major morphologic features (i.e. the dune crest, berm crest, etc., (Figure 6)), using 6-second topo points. Elevation is collected relative to NAVD88, and is converted to mean lower low water (MLLW) using the V-Datum tool published by the National Oceanic and Atmospheric Administration. Profiles extend as close to MLLW as possible, and traverse the barrier from Little Narragansett Bay to Block Island Sound (Figure 1).

Last High Tide Swash (LHTS)

The position of LHTS is mapped using a Trimble 6000XH handheld differential Global Position System, and follows the protocol of Psuty and Silveria (2011) developed for the National Park Service on the Atlantic coastline. The position of the shoreline is measured by walking or riding an ATV along LHTS, carrying the handheld GPS. The Trimble 6000XH collects a point every 3 seconds, with a post-processed reported accuracy of >1 m for 75 - 85% of positions recorded, with >95% of positions measured with better than a 2 m accuracy. Using LHTS as a proxy for shoreline position, GPS shoreline positions can be directly compared to shoreline positions digitized in historic vertical aerial photographs, as well as present and future orthophotographs.

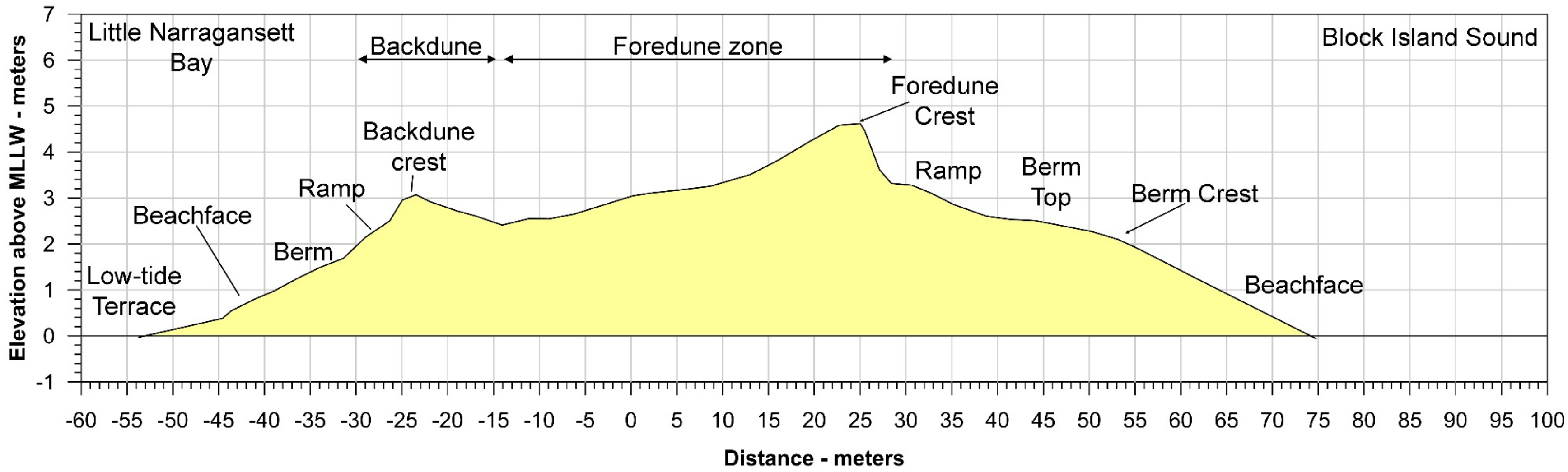


Figure 6. Major geomorphic features of the Napatree Barrier. Not all profiles show all of the features, and many variations can occur. Profiles NAP-1 and NAP-5 lack an appreciable backdune, and the profiles can show multiple berms on the Block Island Sound shoreline.

RESULTS:

Beach profiles

The extended period of fair weather throughout 2016 has been mostly depositional along the barrier. The summer of 2016 included few periods of high wave energy, and the lack of storms produced little or no net erosion at the profile sites during that period. The overall volume of the profiles has increased since we began profiling in July 2013 (Table 1; Figure 7). The offshore passage of Tropical Storm Hermine (early September 2016) produced minor erosion of the berm on the Block Island Sound shoreline, but the lack of storm surge with this system prevented any erosion of the ramp or foredune. A consistent trend in the profiles is the increased elevation of the foredune zone on all five profiles; a result initially thought by the author to be error in the GPS surveys, however the consistency of the trend is 'real,' even though changes in elevation in subsequent surveys barely (or does not) exceeds the error of the surveying system (+/- 3 cm), the net accretion can be seen in all five profiles (Figure 8). The elevation gain can also seen in comparison plots of the first profiles (July 2013) compared against the September 2016 (figures 9-13). The steady increase in elevation of the upper portion of the active beach and foredune is readily visible via the Adobe PDF files of the entire time-series of plotted profiles, which can be downloaded via my website: http://www1.easternct.edu/oakleyb/napatree-point-shoreline-change/.

Profile	**Volume change (m^3 m^{-1}): July 2013 - September 2016**	**Percent change in volume: July 2013 – September 2016**
NAP-1	20.3	7.9 %
NAP-2	34.9	14.2 %
NAP-3	17.4	6.4 %
NAP-4	-8.4	-2.5 %
NAP-5	6.7	3.3%

Table 1. Volume change (expressed as $m^3 \cdot m^{-1}$ and as a percentage of change) for the profiles between July 2013 and September 2015. The initial profiles collected in July 2013, with coarser point spacing, appear to slightly underestimate the volume of the profiles (overestimating the deposition on the east end and underestimating the erosion on the west end), however the overall trends remain valid.

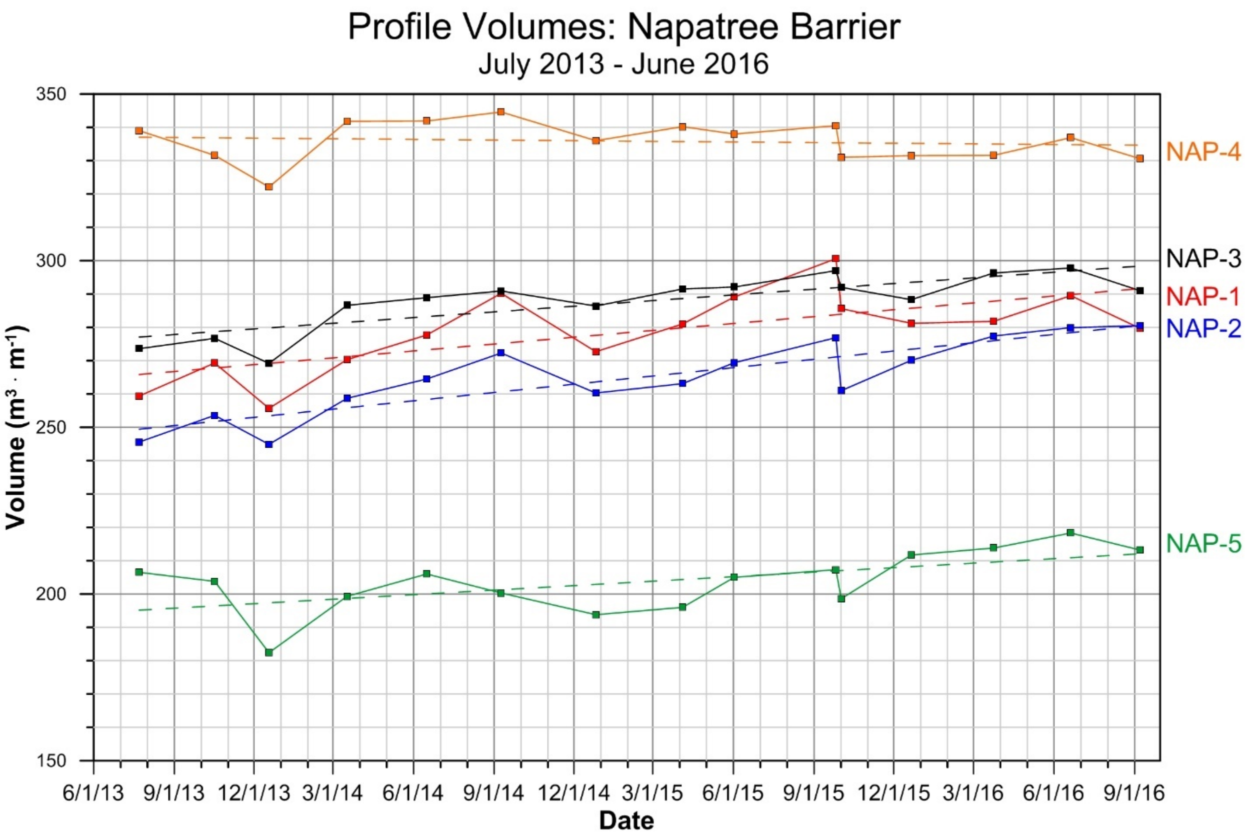


Figure 7. Profile volume (m^3 m^{-1}) for profiles NAP-1 – NAP-5. Dashed lines represent the interpolated linear trend. All profiles except NAP-4 have a positive (depositional) trend.

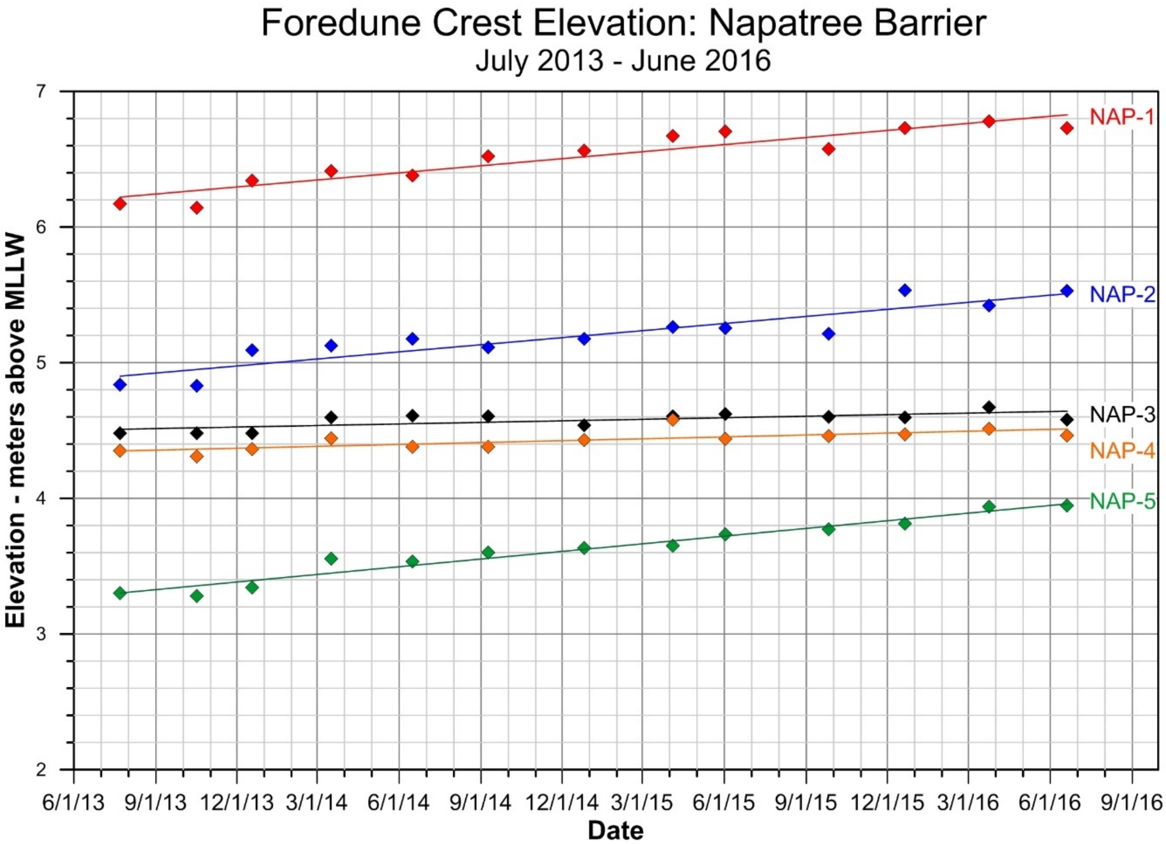


Figure 8. Foredune crest elevation on measured profiles between July 2013 and September 2016. Solid line is the interpolated linear regression

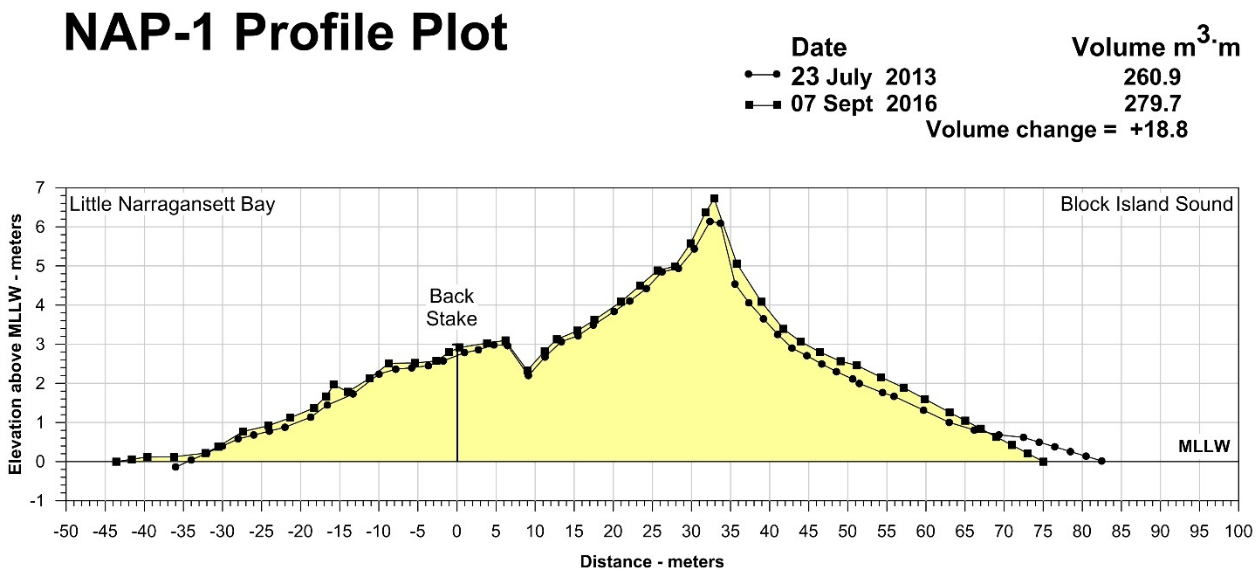


Figure 9. Plotted profile of NAP-1 comparing the 23 July 2013 and 7 September 2016 profiles; note accretion in the foredune and on the ramp (seaward slope in front of the dune). See figure 6 for location of the different morphologic zones of the barrier.

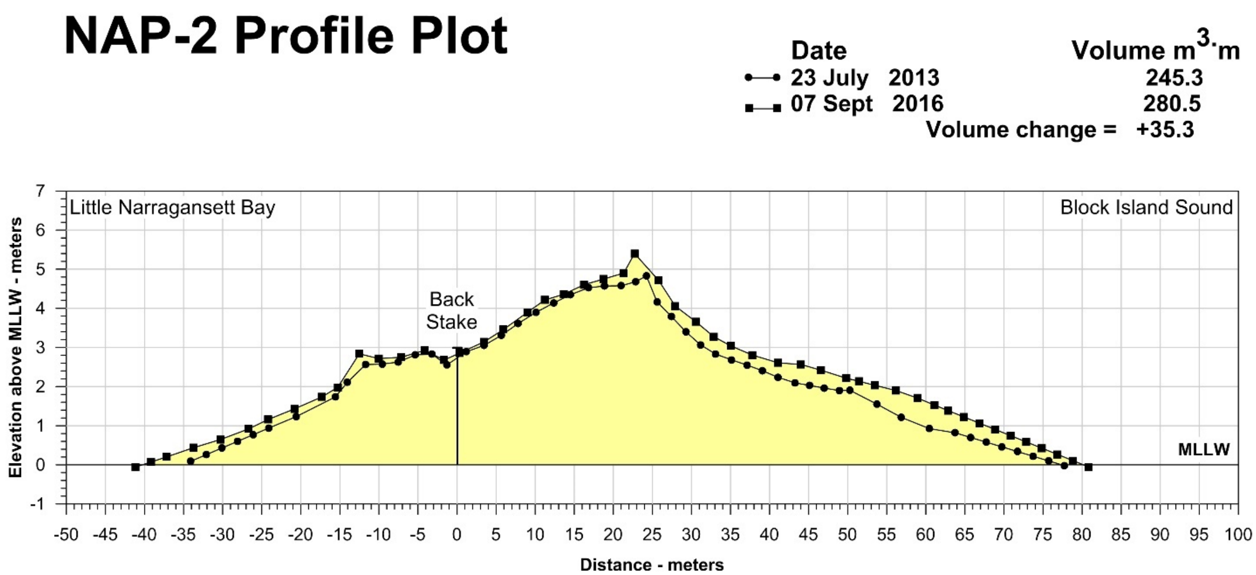


Figure 10. Plotted profile of NAP-2 comparing the 23 July 2013 and 7 September 2016 profiles; note accretion in the foredune and on the ramp (seaward slope in front of the dune). The backdune (small dune on the Little Narragansett Bay shoreline) has shown some increase in width and height.

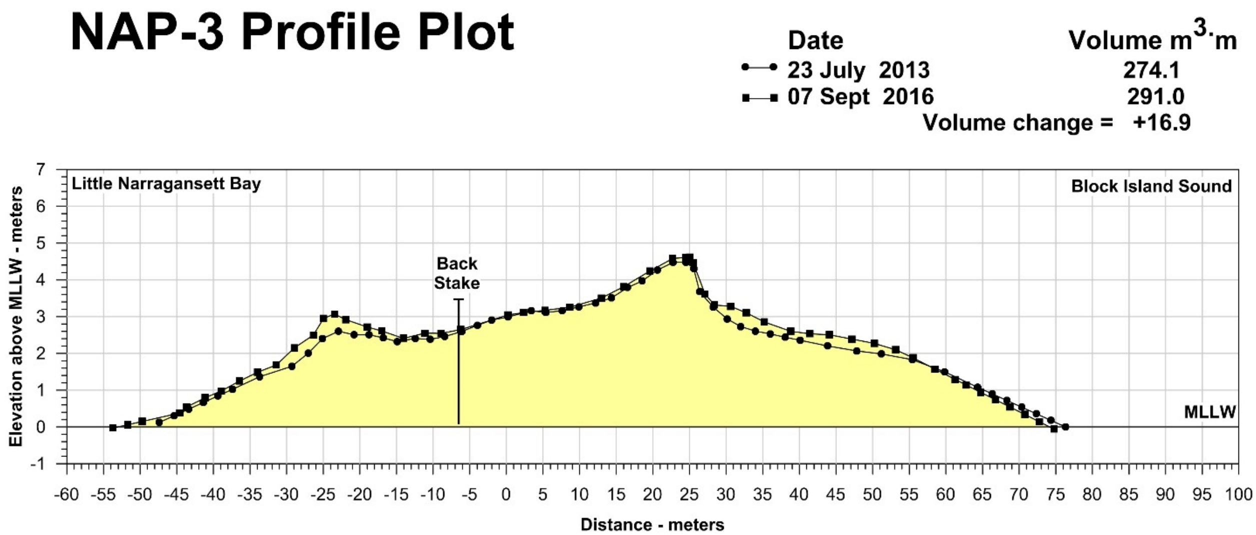


Figure 11. Plotted profile of NAP-3 comparing the 23 July 2013 and 7 September 2016 profiles; note slight accretion in the foredune and on the ramp (seaward slope in front of the dune). The backdune crest has increased in height and width.

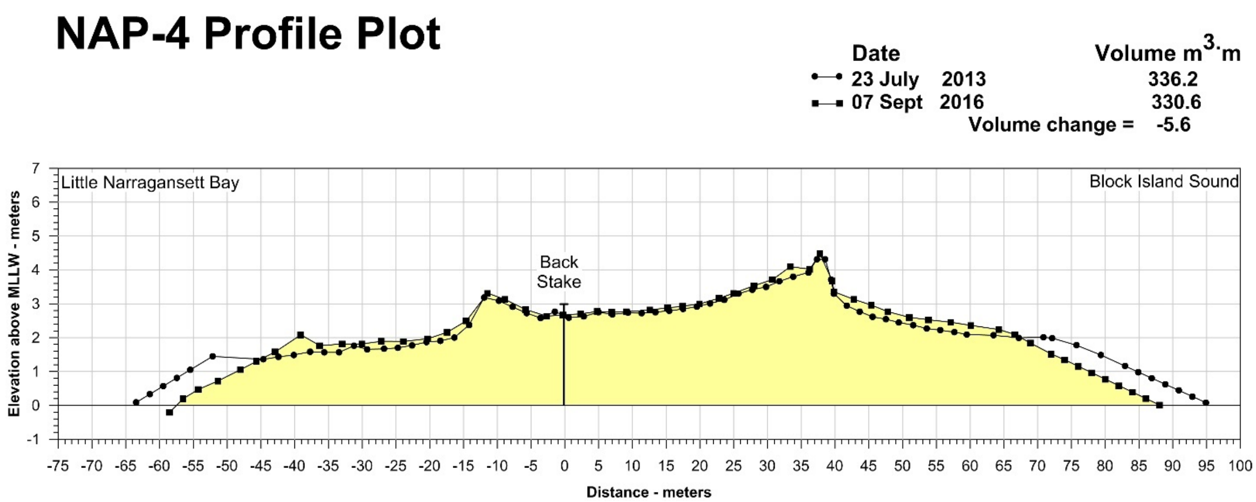


Figure 12. Plotted profile of NAP-4 comparing the 23 July 2013 and 7 September 2016 profiles. The berm on the Little Narragansett Bay shoreline has retreated some, as the washover fan deposition from Superstorm Sandy has been subsequently modified. Accretion in the foredune and backdune is less obvious and spread over a larger area.

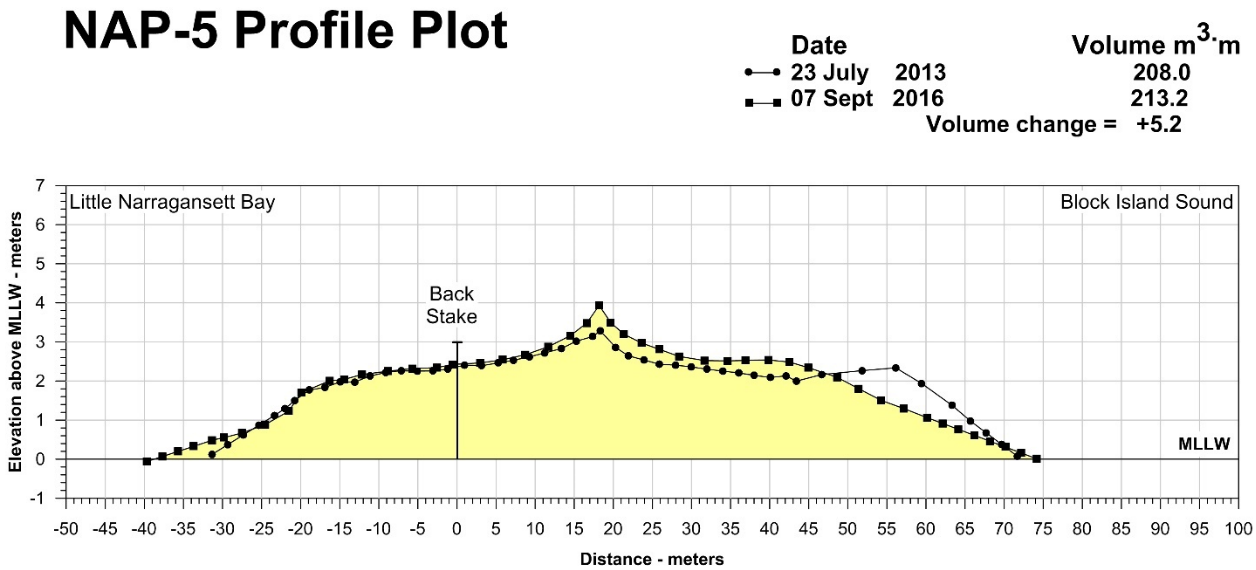
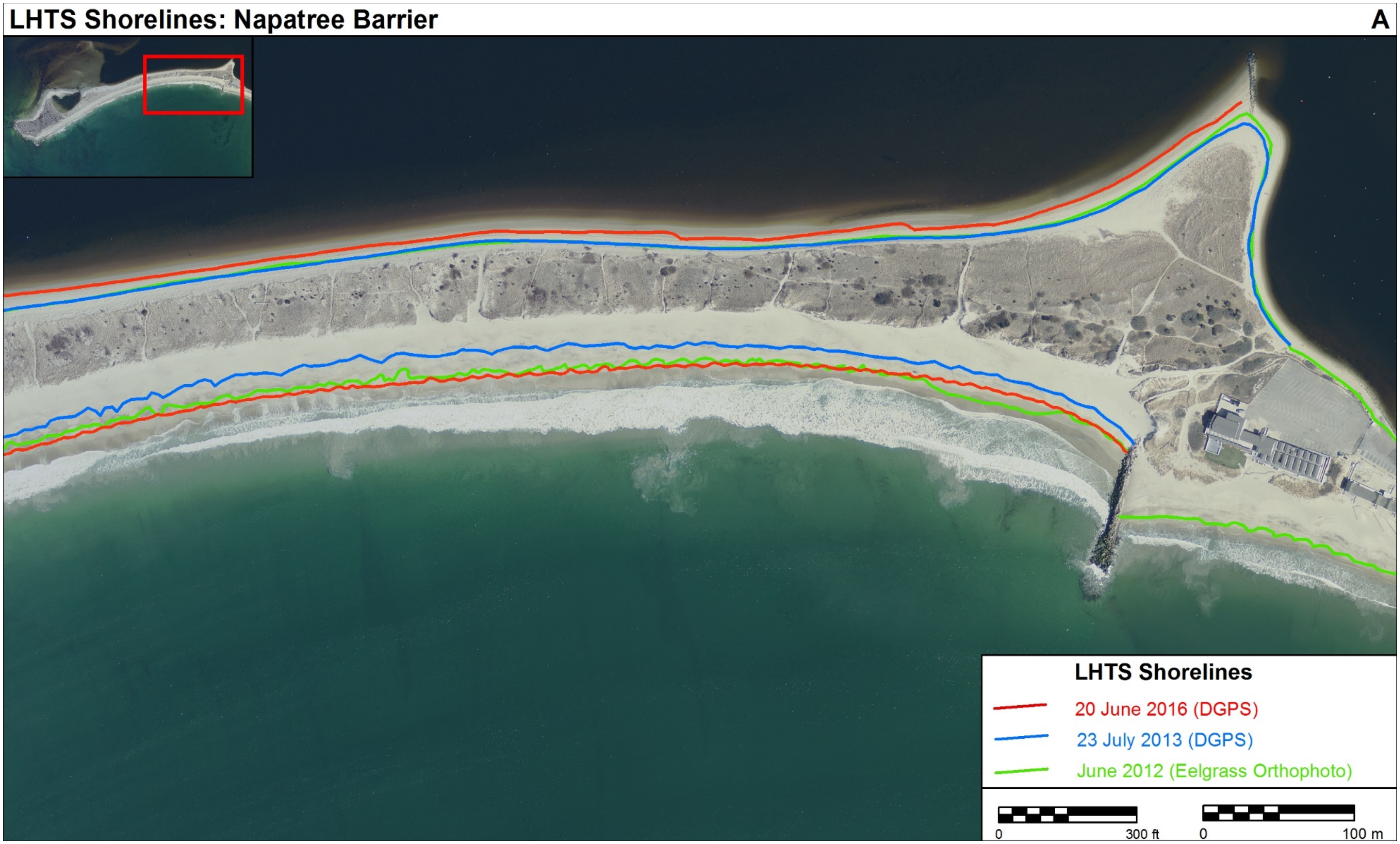


Figure 13. Plotted profile of NAP-5 comparing the 23 July 2013 and 7 September 2016 profiles; note minor deposition on the berm on the Little Narragansett Bay. Note the accretion in the foredune and ramp (area just seaward of the dune).

<u>Shoreline Position</u>

Subsequent LHTS positions have shown little significant change between July 2013 and September June (Figures 14A-C). Minor variations in shoreline position are the result of changes in beach morphology and variations in wave height and run-up on the different survey days. Shoreline position varies substantially, but remains an important metric for tracking long-term changes to the barrier, particularly following a storm event. There was little to no change in LHTS position along the Little Narragansett Bay shoreline, however one notable change is the continued migration onshore of the spit along the western shoreline of the lagoon (14C). The position of the spit and high tide line along the northern shoreline of the lagoon and headland will be remapped during the October, 2016 survey.


LHTS Shorelines: Napatree Barrier
A
LHTS Shorelines
20 June 2016 (DGPS)
23 July 2013 (DGPS)
June 2012 (Eelgrass Orthophoto)
0
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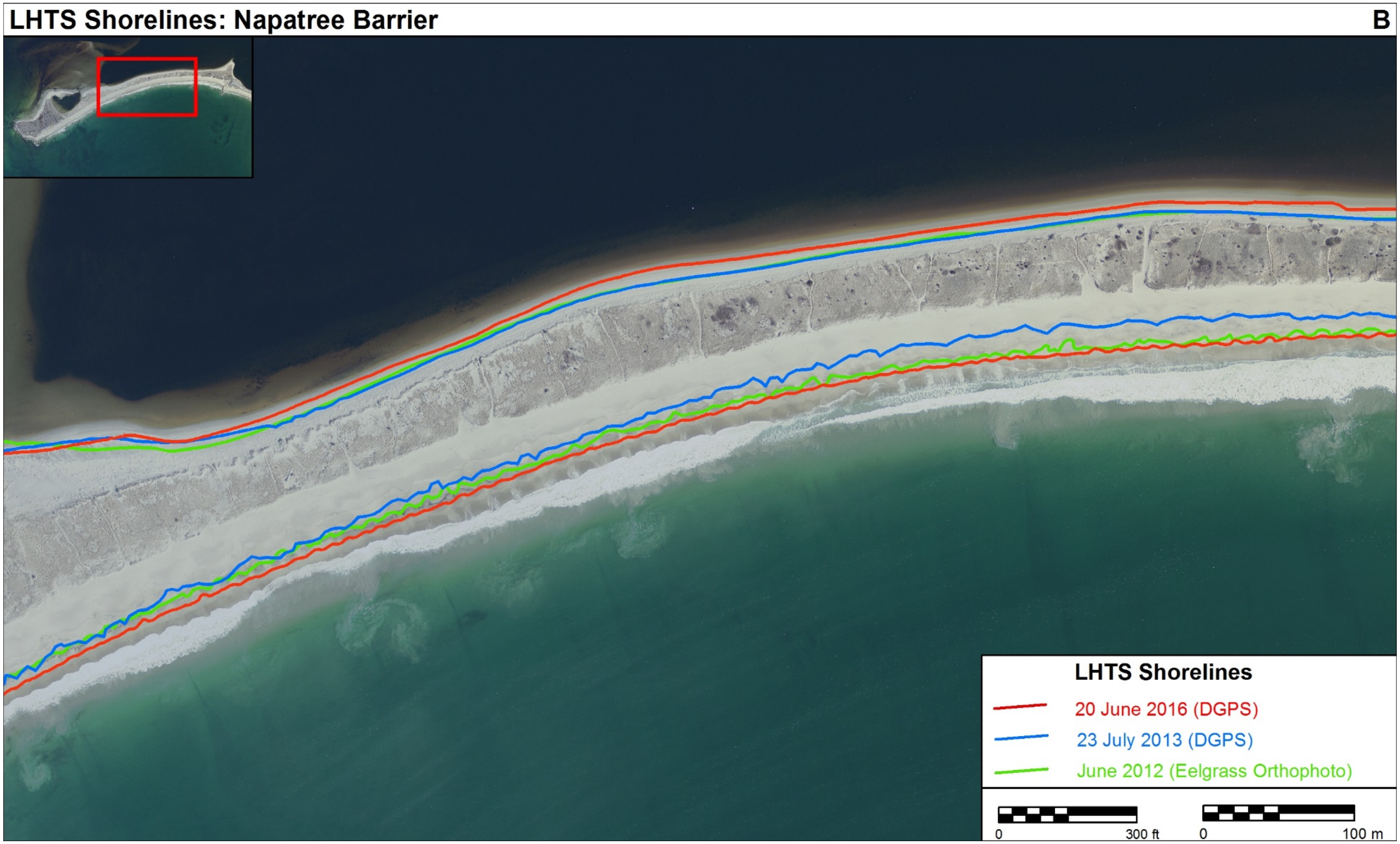
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June 2012 (Eelgrass Orthophoto)
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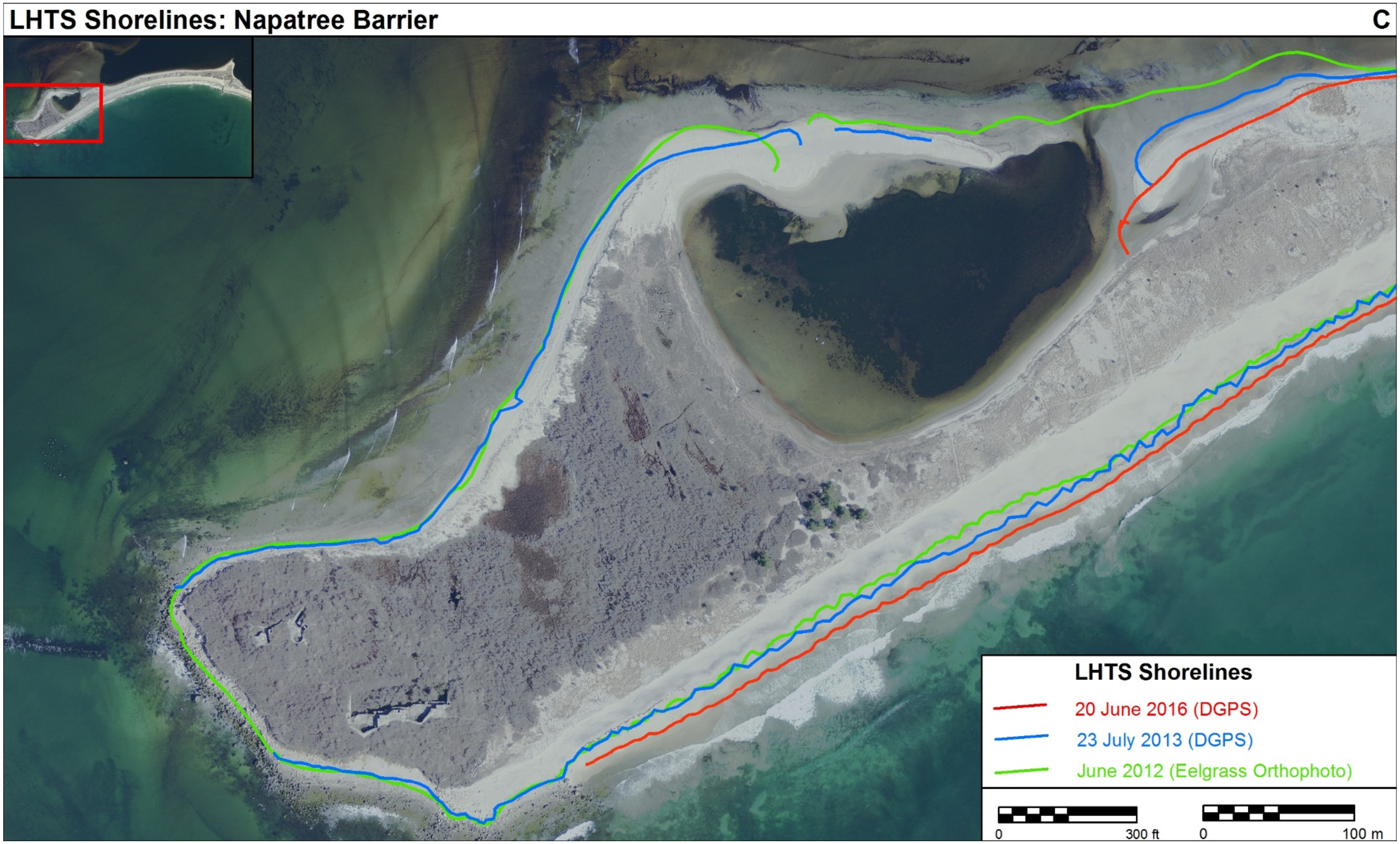

Figures 14 A,B,C. Shoreline positions in June 2012 (digitized from 2012 Eelgrass orthophotograph), July 2013 and September 2015 (differential GPS) along the eastern (A), central (B), and western (C) portions of the barrier. 2014 USGS orthophotograph basemap

DISCUSSION: While too early in the project to reach any significant conclusions, monitoring will continue to track the changes to the barrier. The initial profiles collected in July 2013, with a coarser point spacing that slightly underestimate the volume of the profiles. This overestimates the deposition apparent on the (profiles NAP-1, NAP-2, NAP-3 and 5) and underestimates the (minor) erosion (NAP-4). This does not change the conclusions so far, but these results should be viewed as a short-term trend, rather than discrete quantitative results. The slight decrease/no change in volume at NAP-4 and increase in volume at the other profiles could represent redistribution of sand from the wide, post-Sandy berm on the west end of the profile during the subsequent period of fair weather; however, because there was only a minor amount of erosion at NAP-4, this does not explain all of the increased volume on NAP-1, NAP-2, NAP-3 and NAP-5. Much of the sediment added to the profiles over the last three years was likely transported onshore from the portion of the shoreface known as the depositional platform. This sandy geologic habitat has been mapped along other portions of the Rhode Island south shore, and is interpreted to represent the sediment actively exchanged between the intertidal beach and the shoreface (Oakley et al., 2009).

Sediment is transported on shore by the combined action of wave orbital motion and longshore transport to the east (driven by southwesterly sea breezes) during periods of fair weather. Given the dominant longshore transport direction on the south shore of RI (to the east) (Boothroyd et al., 1985) it seems likely that if any sediment bypasses around Watch Hill, it would happen during periods of easterly swell, and probably does not contribute much (if any) sediment to Napatree. The northward migration of Sandy Point (and the continual dredging of the navigation channel) suggests sediment transport here is to the north, and significant amounts of sediment are probably not being transported from Little Narragansett Bay to the seaward side of the Napatree barrier. Sand from the berm is then transported onshore by eolian (wind) processes and deposited in the center of the barrier. Southerly winds transport sand from the Block Island Sound shoreline; northerly winds transport sand from the Little Narragansett Bay shoreline. The vegetation (and limited sand fencing) in the foredune and backdune zones baffles the wind, and sediment is deposited in the wind shadow. The increase in foredune height is very apparent when examining the over 3 years of data gathered for this project (Figures 8; 9-13).

Barring another major storm, the barrier will continue to accrete, and foredunes will continue to slowly accrete as vegetation baffles the wind, and sand is transported from the berm. Small storms (i.e. the late September/early October extra-tropical storm in 2015; Tropical Storm Hermine in 2016) will continue to erode the berm (followed by subsequent recovery), and during larger storms, low-lying areas of the barrier (i.e., NAP-5, Figure 1) will continue to be overwashed. While the perception exists that installing sand fences or otherwise creating a more reflective profile is necessary to maintain the barrier (see the ubiquitous ‘keep off the dunes’ signs along the coastline), geologically this is not correct. Studies on adjacent segments of barriers in the Netherlands have shown that while the addition of sand fences affected to morphology of the barrier, they did not directly affect the total volume of sediment in the foredune (De Jong et al., 2014). The importance of leaving Napatree as a natural laboratory cannot be overstated, and a lower, more dissipative profile probably reflects the historical shape of the barrier (Figure 15). Allowing most of the barrier to evolve in the absence of sand fencing or other structures is crucial to helping understand the response of a shoreline to storms.

Overwash during a significant storm event should not be viewed as a negative process; overwash and the subsequent deposition of washover fans create a more dissipative profile, and is the natural process that allows the barrier to evolve in response to storms and sea level rise. Deposition of washover fans is the primary process that allows the landward portions of the barrier (known as the backbarrier flat and surge platform) to accumulate sediment (Leatherman, 1979). It has been known for some time (Godfrey and Godfrey, 1976; Leatherman, 1979), and recently reinforced, (Houser and Hamilton, 2009; Timmons et al., 2010) that overwash and subsequent deposition of washover fans on the backbarrier is critical for barriers to continue to migrate in response to storms and sea level rise. This geologic process, which can look 'catastrophic' in the immediate aftermath of a storm, is *vital* to the evolution of Napatree in response to future storms and sea level rise. The lower, wider dissipative profile configuration is also generally less erosive for any given storm than a reflective barrier (Dolan, 1972). Figure 16 compares dissipative and reflective barrier configurations. An added benefit is that these wider, more dissipative barriers promote a more diverse array of habitats than those typically found on many managed shorelines (Dolan et al., 1973).

Figure 15. Undated, pre-1938 photograph of Watch Hill, Napatree and Sandy Point. Note the presence of Sandy Point (yellow arrow) in the background, and the relatively low foredune along both the Napatree (red arrow) and Sandy Point barriers. Photo retrieved from the Napatree Point Conservation Area Facebook Page, April, 2015

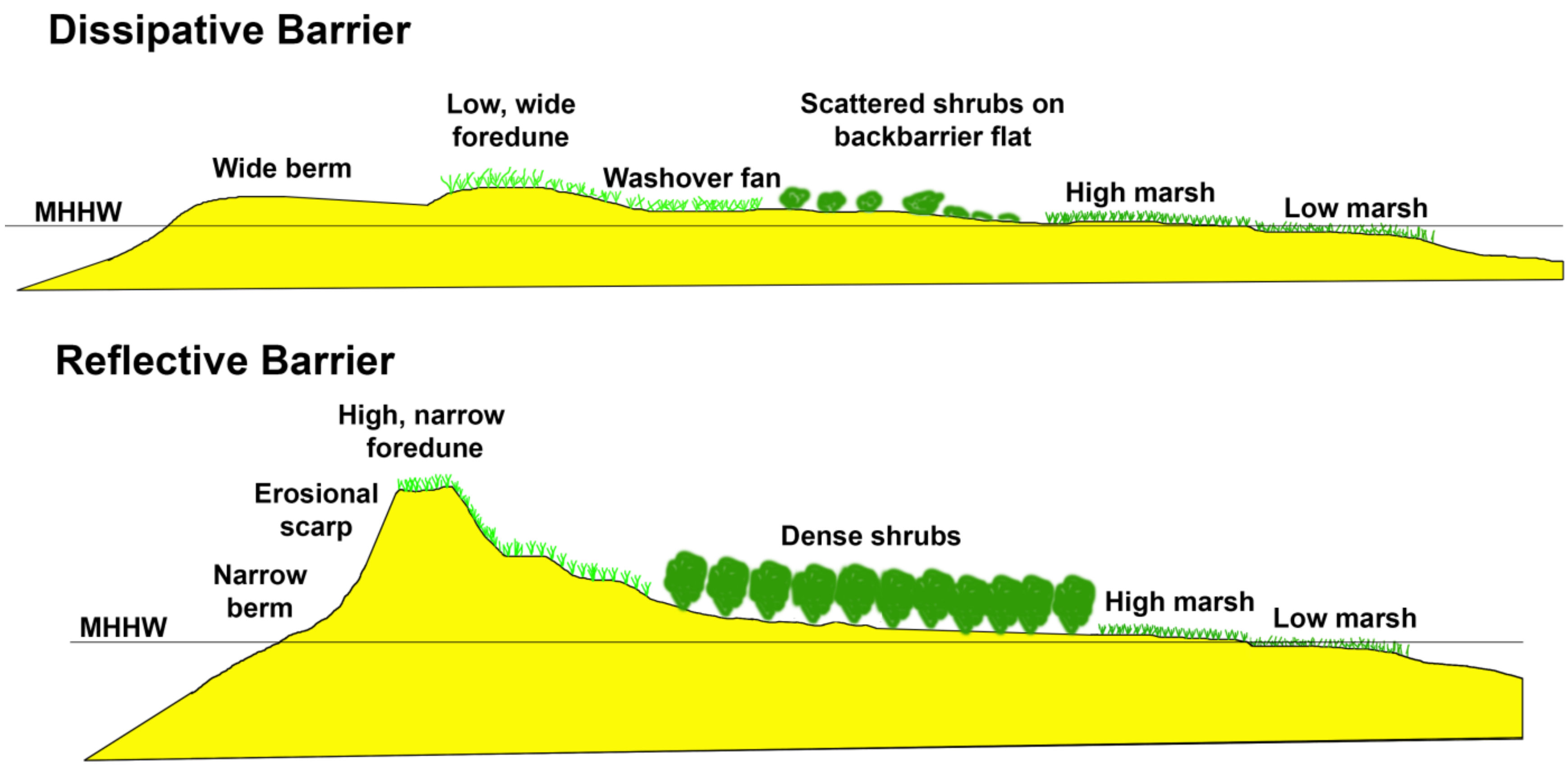

Figure 16. Comparison of idealized profiles of dissipative and reflective barriers (Modified from Dolan, 1972).

ACKNOWLEDGEMENTS: Fieldwork has been assisted by: Janice Sassi and Kevin Rogers (Watch Hill Conservancy & Watch Hill Fire District), Joshua Bartosiewicz, Tim Ciskowski, Jennifer Croteau, Cody Murphy and Brandan Sumeersarnauth (Eastern Connecticut State University undergraduate students) and Drew Hyatt (Eastern Connecticut State University faculty). This work was supported by grants from the Watch Hill Conservancy & Watch Hill Fire District, Rhode Island Bays Rivers Watershed Coordination Team, and the Eastern Connecticut State University Exemplary Program Fund. Pete August provided constructive edits of this document.

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Water Quality: 2016

Christian Fox, Grant Simmons & Kevin Rogers
Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

Photo credit: Richard Youngken

Water Quality: 2016

Christian Fox, Grant Simmons & Kevin Rogers
Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

INTRODUCTION: The waters surrounding Napatree dictate nearly all aspects of the ecology and economy of Napatree Point and Watch Hill. Storms shape the dynamic dune system that is the interior of our study area, while tides and currents move sediment and the flotsam and jetsam of the wrack line along the beach. Viewed through a biological lens, it is a marine-based food chain, driven by physical factors, that supports the resident and migratory shorebirds that thrive on Napatree. This section examines the exact factors that constitute water quality and, in part, make the conservation area such a popular destination.

To gather the best available science on the water quality surrounding Napatree, the Napatree Point Conservation Area (NTPCA) has partnered with the University of Rhode Island Watershed Watch Program (URIWW); a statewide volunteer water quality monitoring program that began in 1988. As stated by Watershed Watch, the goals of this program are "to promote active individual participation in water quality protection, to educate the public on water quality issues, to obtain multi-year surface water quality information and data to ascertain current conditions and to track trends, and to encourage management programs based upon sound water quality information." The NTPCA began monitoring the waters surrounding Napatree Point in 2008 with one location sampled on the ocean side of the beach (Figure 1). Since then, two more sites have been added: one off the bayside of the beach and one in Foster's Cove. Data from previous years are available on line on URI Watershed Watch's website (www.uri.edu/ce/wq/ww). This partnership between the NTPCA and URIWW benefits both organizations as we collaborate to share equipment, manpower, and information.

Long-term water quality monitoring at Napatree Point is important both for the NTPCA to understand what is happening immediately around Napatree Point, but also for regional environmental managers: Napatree sits at the outflow of the Wood-Pawcatuck Watershed, where nearly one-third of the entire landmass of Rhode Island drains to the sea[1]. This means that anything washed into the streams and rivers of the watershed could eventually show up in the waters around Napatree. Monitoring this outflow allows us to see not only how boat and shore use in Little Narragansett Bay impacts the beach directly, but also what activities much farther afield can find their way to our coast.

[1] *Please see wpwa.org for more information on the Wood-Pawcatuck Watershed.*

Figure 1. Sampling sites in relation to Napatree Point. Background imagery from RIGIS.

METHODS: This year, water quality monitoring was conducted at three sites in Watch Hill, Rhode Island: two inside Little Narragansett Bay (Bayside and Cove), and one on the ocean side of Napatree beach (Figure 1). Monitoring began on May 12, 2016 and concluded mid-October, 2016. Water collection was conducted every Thursday or Friday between 07:30 and 10:00 in the morning and was canceled only if the weather was unfavorable (i.e., thunderstorms or heavy fog). If canceled, attempts were made to sample on the following day. A total of 16 sampling weeks were submitted to URI in 2016. This number is lower than in other years (19 sampling days in 2015) due to staff limitations in September and October.

Data were collected each week and measurements were made on water Dissolved Oxygen concentration, Chlorophyll-A concentration, water clarity, temperature, and salinity at each of the three locations. During every third week of the month, additional samples were collected and brought to URI where they were analyzed by Watershed Watch staff to assess the levels of Chlorophyll-A, phosphorous, nitrite and ammonium nitrogen as well as the concentration of fecal coliform and enterococci bacteria. Note that nutrients (phosphorus and nitrogen) data are not presented here.

All of these parameters are collected because together they give a comprehensive view of the "health" of the estuary. Dissolved oxygen (DO) is of concern because if levels fall below 5 mg/L it can be stressful to aquatic organisms. Concentrations below 2 mg/L can be potentially lethal to marine life; low DO is responsible for fish kills, as seen in the Providence and Seekonk

Rivers summer 2015[2]. Water clarity is one of the oldest and most universally collected measurements in both salt and fresh water. Water clarity varies depending on a number of factors, including suspended sediment, dissolved plant matter, and algae blooms.

Chlorophyll-A is recorded in conjunction with water clarity to help distinguish between these factors; more Chlorophyll-A indicates higher density of algae in the water column. Excessive growth of algae can be hazardous to people and lead to anoxic (oxygen deprived) water conditions. Watershed Watch assigns categories to reflect the status of water bodies based on chlorophyll concentrations. Chlorophyll levels above 20 parts per billion (ppb) are considered suggestive of a "poor" or unhealthy marine ecosystem. Water temperature and salinity give a good indication of mixing and oceanic flushing; both vertically at each site and laterally between sites. Additionally, water temperature directly impacts dissolved oxygen concentration, as a given volume of warm water can hold less oxygen than the same volume of cooler water. Nutrients available in the water dictate plankton, seaweed, and aquatic plant growth, and are frequently a limiting factor in harmful algal and bacterial blooms.

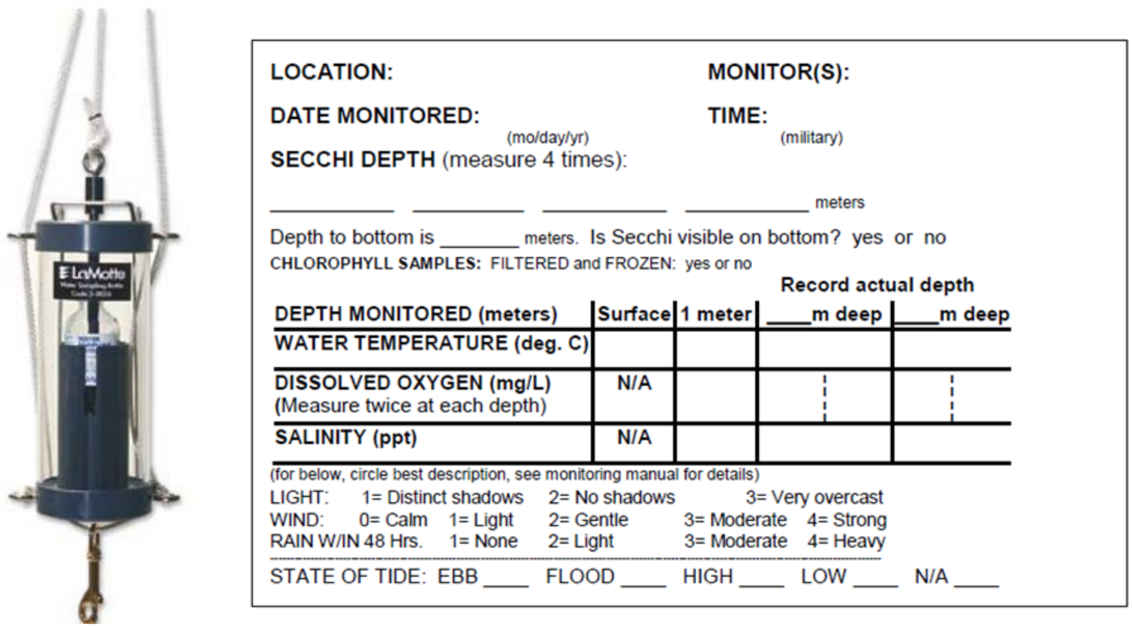
Two groups of bacteria were sampled once a month to indicate the presence of human sewage and other disease-causing pathogens in the water: fecal coliforms and enterococci. By Rhode Island Department of Environmental Management (RI DEM) and the Connecticut Department of Energy and Environmental Protection (CT DEEP) standards, waters containing shellfish beds cannot exceed 14 fecal coliform parts per 100 ml sample. In waters used for recreational purposes, such as swimming, the Rhode Island Department of Health requires that a single water sample cannot exceed 104 enterococci parts per 100 ml[3].

At both the ocean and the bayside sites, water was collected at two different sampling depths: a "shallow" sample collected 1 m below the surface and a "deep" sample collected 1 m above the bottom. On the ocean side, water was collected on average at 5 m (deep) and at 1 m (shallow) below the surface. On the bay side, water was collected on average at 2 m (deep) and 1 m (shallow). Only a 1 m sample was collected in Foster Cove due to the shallowness of the inlet. All water was collected using the sampling device (Figure 2) provided by URI Watershed Watch. The device is weighted and attached to a rope marked off in 1 m increments. Each device has a stopper that can be pulled out once the device is lowered to the desired depth, thus ensuring the water sampled is being collected at the appropriate depth.

Dissolved oxygen of each site and depth was processed on land using the Winkler titration method with a URIWW-provided test kit. This kit is manufactured by the LaMotte Company and specifically designed to allow users to quickly and accurately analyze DO in the field. Chlorophyll-A was sampled by filtering on site and returning the filters to the URI Watershed

[2] *See article online at http://www.ecori.org/natural-resources/2015/7/29/large-fish-kills-on-providence-and-seekonk-rivers*
[3] *See URIWW's information sheet on Bacteria Monitoring for more information: http://cels.uri.edu/docslink/ww/water-quality-factsheets/Bacteria.pdf*

Watch laboratory for processing. Water clarity was determined using a Secchi Disk, which is lowered through the water column until it is no longer visible. The depth (in meters) at which it becomes impossible to see is recorded. Salinity was evaluated on site using a handheld refractometer and temperature was recorded using a thermometer at each sampling depth. All data processed on site were recorded on sampling post cards provided by URI Watershed Watch and was submitted monthly (Figure 2).



LOCATION: **MONITOR(S):**

DATE MONITORED: (mo/day/yr) **TIME:** (military)

SECCHI DEPTH (measure 4 times):

________ ________ ________ ________ meters

Depth to bottom is _______ meters. Is Secchi visible on bottom? yes or no

CHLOROPHYLL SAMPLES: FILTERED and FROZEN: yes or no

			Record actual depth	
DEPTH MONITORED (meters)	**Surface**	**1 meter**	**____m deep**	**____m deep**
WATER TEMPERATURE (deg. C)				
DISSOLVED OXYGEN (mg/L) (Measure twice at each depth)	**N/A**			
SALINITY (ppt)	**N/A**			

(for below, circle best description, see monitoring manual for details)

LIGHT: 1= Distinct shadows 2= No shadows 3= Very overcast

WIND: 0= Calm 1= Light 2= Gentle 3= Moderate 4= Strong

RAIN W/IN 48 Hrs. 1= None 2= Light 3= Moderate 4= Heavy

STATE OF TIDE: EBB ____ FLOOD ____ HIGH ____ LOW ____ N/A ____

Figure 2. Water sampling device and monitoring postcard. Note that ambient and antecedent weather conditions are also recorded.

RESULTS: A total of 16 sampling weeks were included in this report regarding dissolved oxygen, temperature and salinity data. Results regarding Chlorophyll-A and bacteria were obtained from URI Watershed Watch and include 11 sampling weeks. Graphs from the water quality chapter of the *State of Napatree Report 2015* have been included here, unaltered, to examine any interannual changes occurring in the coastal environment.

<u>Dissolved Oxygen & Temperature</u>

Overall, the concentration of Dissolved Oxygen (DO) at all sampling locations remained above 5 mg/L at both shallow and deep depths, which is suggestive of a healthy water system (Figures 3 and 4). The paired graphs in both figures show similar patterns between 2015 and 2016, yet this year’s average Bay and Cove concentrations are slightly higher than last year’s, indicating a decrease in bacterial growth that consumes oxygen from the water column. Average annual DO for the Oceanside site was lower in 2016; however, it is suspected that a single low data point in min-June is a statistical outlier for the shallow water samples.

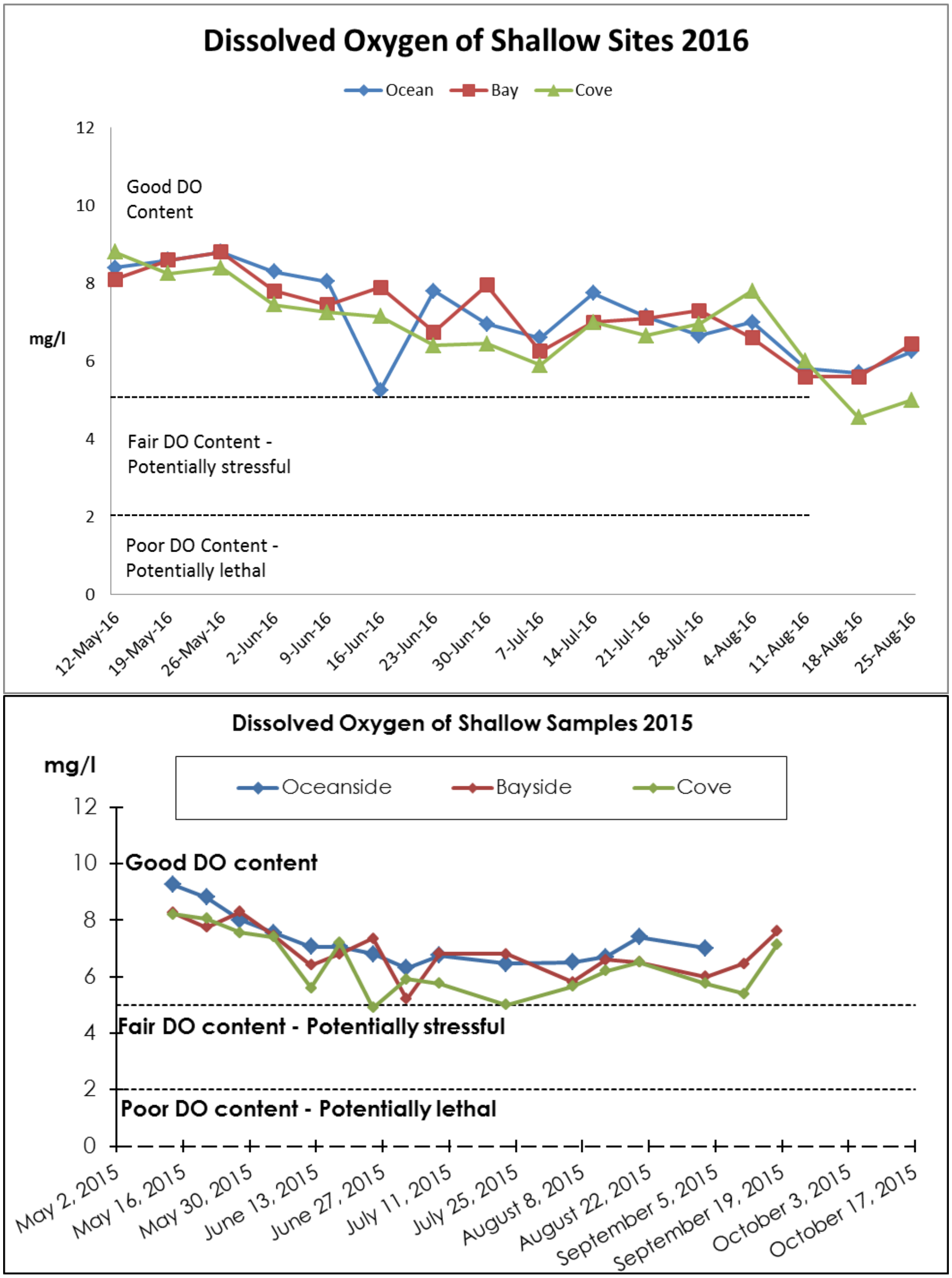


Figure 3. Dissolved oxygen content of shallow samples for 2016 and 2015, units are in mg/L

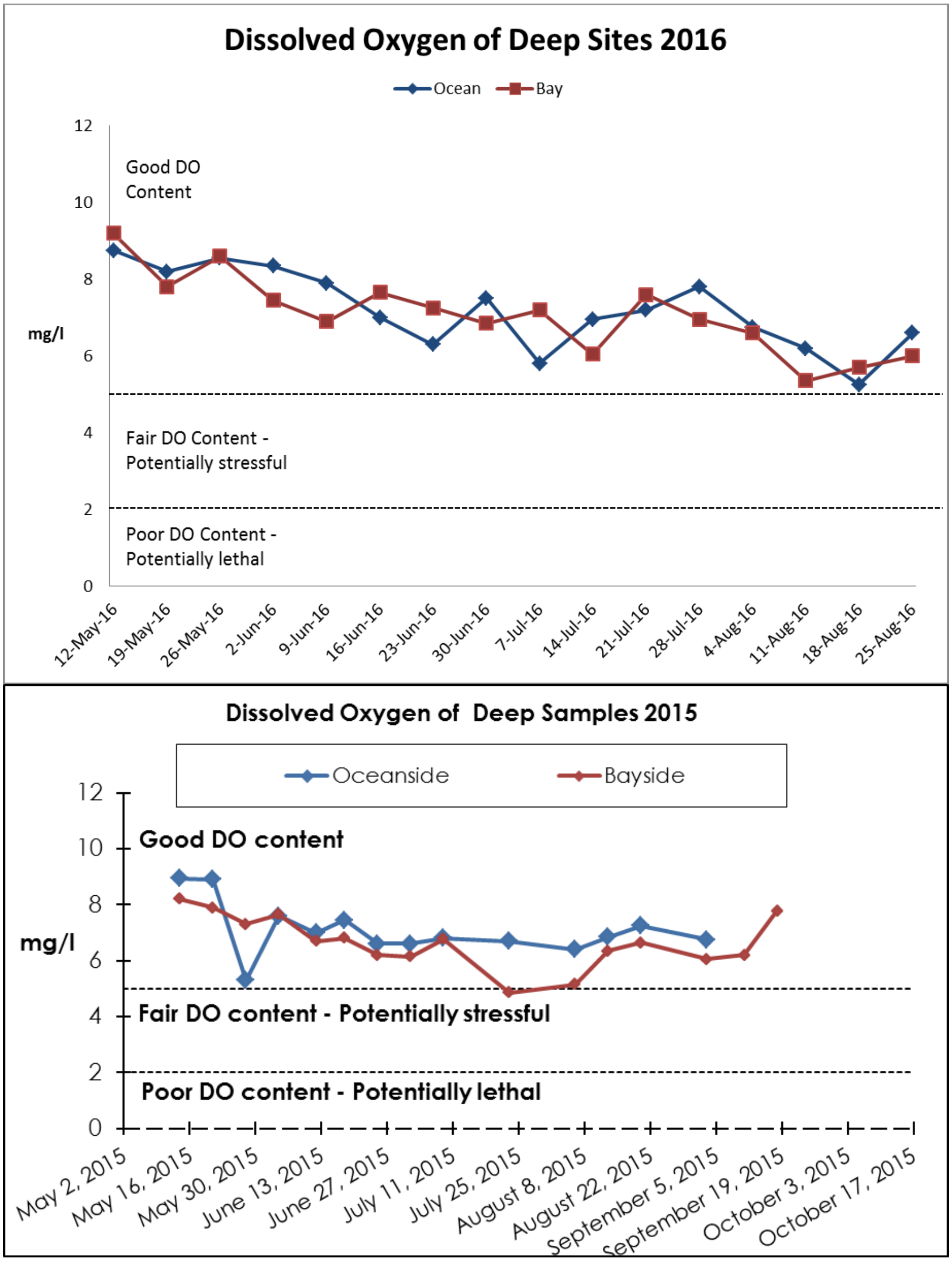


Figure 4. Dissolved oxygen content of deep samples for this and last year, units are in mg/L

<u>Chlorophyll-A</u>

The mean chlorophyll levels at the ocean, bay and cove sites varied throughout the sampling period, but remained below the Watershed Watch threshold of 20 ppb for a heavily impacted waterbody. In fact, algae levels at the Oceanside site were lower in 2016 than they were in 2015, indicating that available nutrients in the water were like that of an unimpacted, healthy water body (Figure 5). Additionally, both the Cove and Bayside sites were lower overall as well, suggesting some decrease in nutrients added either in the immediate vicinity or in the greater watershed.

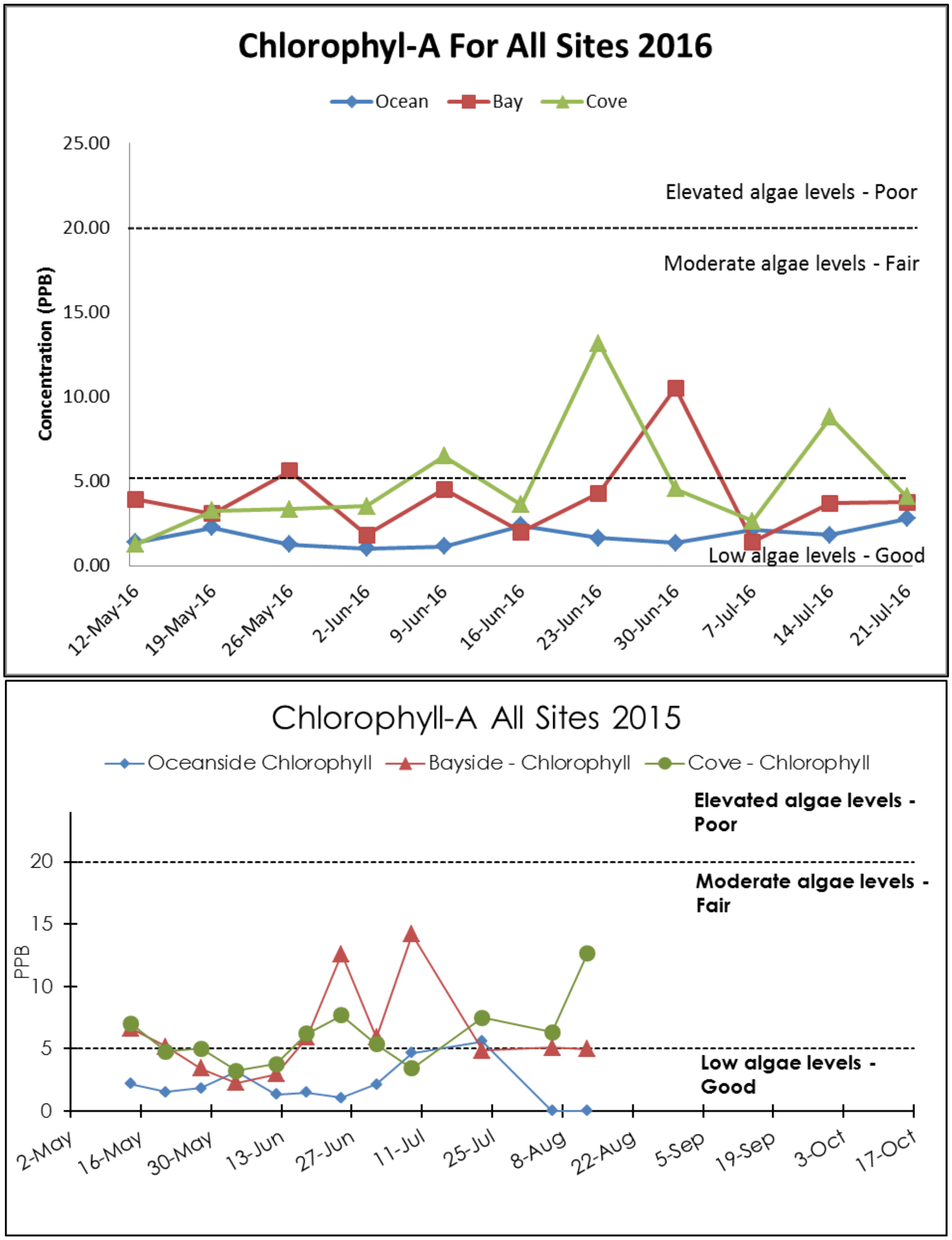


Figure 5. Mean chlorophyll concentrations, units are in parts per billion.

Secchi Depth

Water clarity is our most variable parameter every sampling day, as well as between 2015 and 2016. Over the course of the summer clarity neither improved nor diminished, and could experience over 2 meters of change between one week and the next (Figure 6). Secchi depth at one site could not be used to predict clarity at another on the same day, and no correlation exists between corresponding sampling weeks of the two years. Instances where the secchi was visible on the bottom occurred twice in the Bay in both 2015 and 2016, as well as 4 times in 2015 and 5 times in 2016 in Foster's Cove. While originally expected to correspond with tidal state at sampling time, an examination of the data indicated that clarity all the way to the bottom can occur in any tidal condition. Future investigation could examine the factors most impacting visibility; it seems likely that suspended solids and dissolved material, not phytoplankton, have the greatest influence.

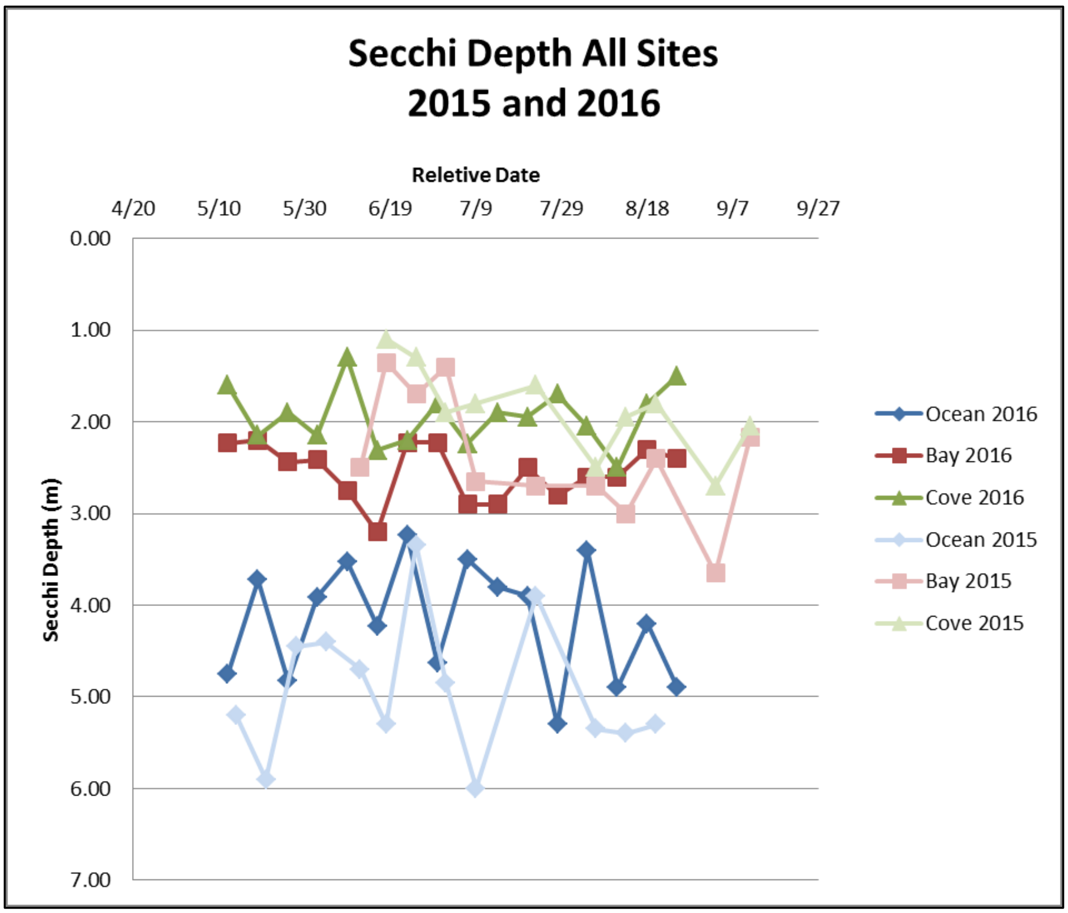


Figure 6. Water clarity in meters.

Temperature

All three of our sampling locations experienced a gradual climb in temperature over the course of the summer (Figure 7). Given the shallowness of the sites this is to be expected. Additionally, it is of note how similar the temperatures of 2015 and 2016 remained for each sampling week.

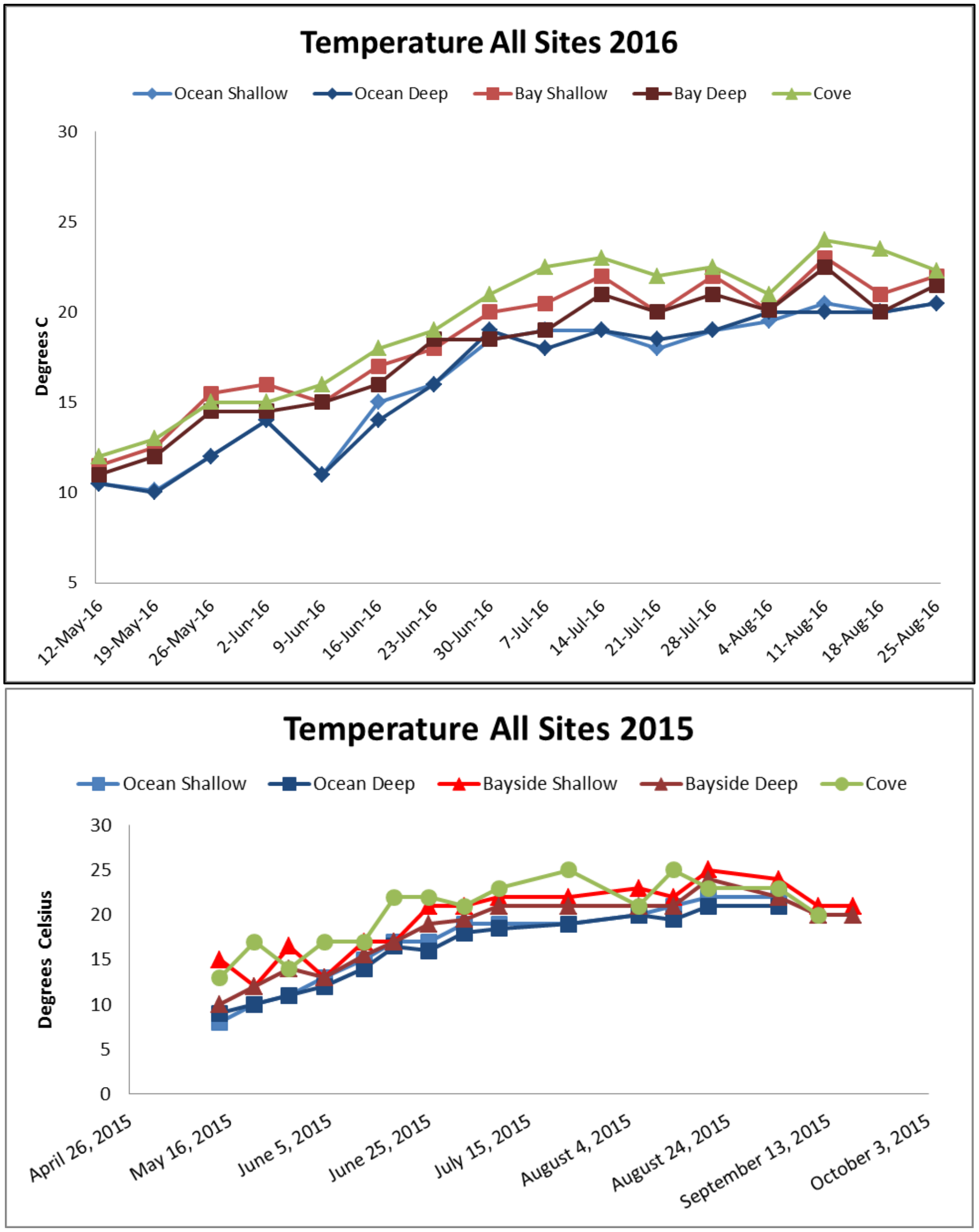
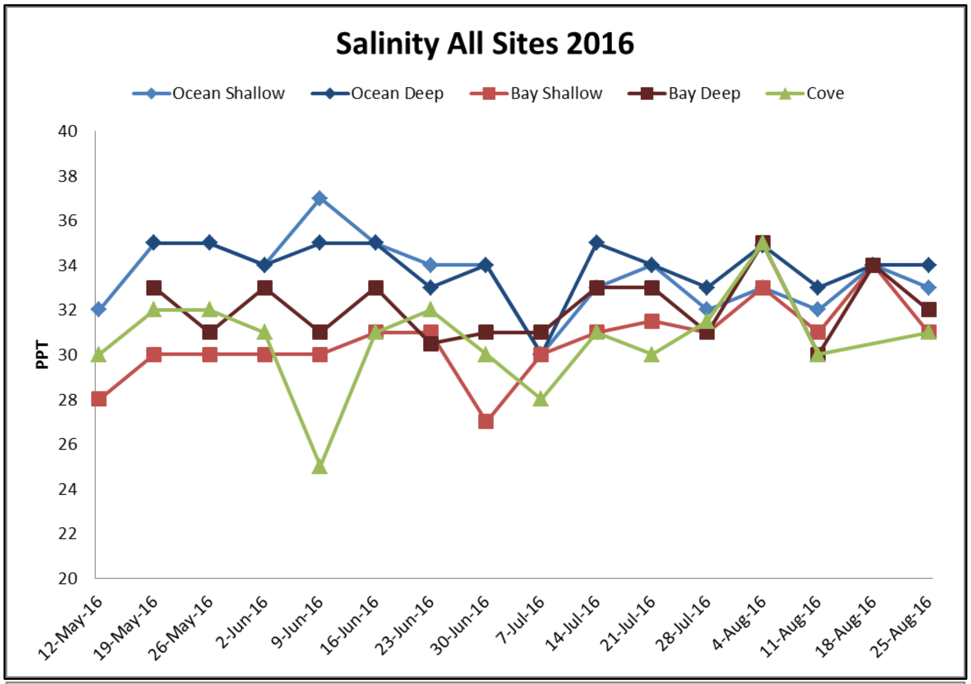


Figure 7. Temperature (C⁰) at shallow and deep depths, 2016 and 2015.

Salinity

Since all three sites are saline environments, the overall salinity content of the water remained relatively high throughout the sampling period. All sites experienced a degree of variability in salinity week to week (Figure 7). This is a product of tidal flushing, as well as the volume of fresh water discharged by the Pawcatuck River into the Little Narragansett Bay estuary, as driven by rainfall events.



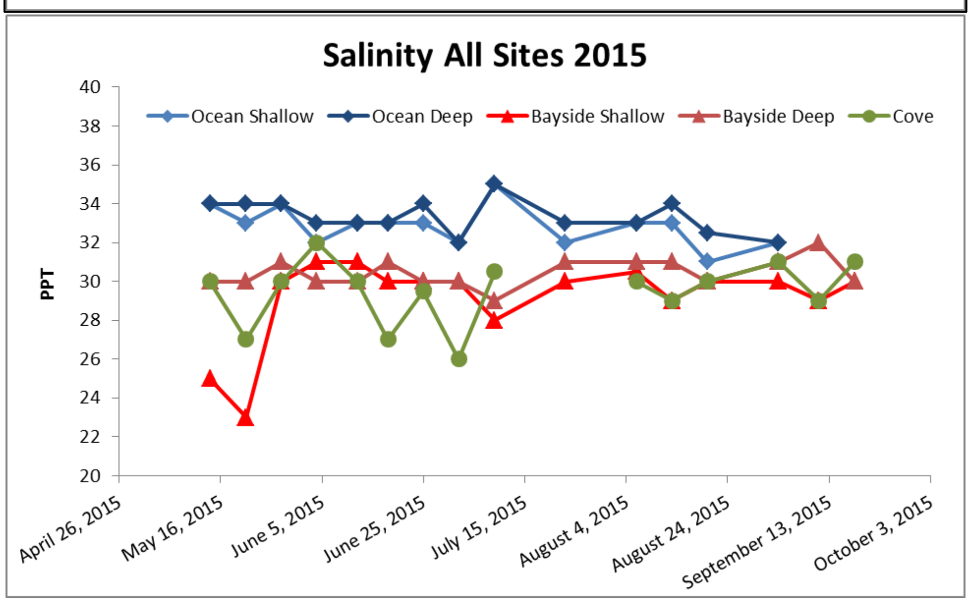


Figure 8. Salinity at shallow and deep depths, units are in parts per thousand.

Little Narragansett Bay (including tidal Pawcatuck River) and Napatree Point

Watershed code	MONITORING LOCATION	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	GEOMEAN
		- - Most Probable Number of Fecal coliform per 100 mL - -						
WD	STB - P'tuck North of WWTF	<10	Lab error	305	809	457	-	103
WD	STB - P'tuck South of WWTF	31	Lab error	52	74	305	-	78
LN	STB - Mouth of P'tuck	10	Lab error	10	<10	52	-	<10
LN	STB - Watch Hill Harbor	10	Lab error	<10	Weather	75	-	<10
LN	STB - Lil NB, North Sandy Pt	10	Lab error	20	Weather	110	-	28
LN	STB - Lil NB, S Barn Is. Ramp	<10	Lab error	<10	Weather	10	-	<10
LN	Napatree Point - Cove	<10	<10	<10	<10	-	-	<10
LN	Napatree Point - Bayside	10	<10	<10	<10	-	-	<10
CW	Napatree Point - Oceanside	<10	<10	<10	<10	-	-	<10

RI Department of Environmental Management and Connecticut Department of Environmental Protection fecal coliform standards:
Shellfish Waters - Geometric mean not to exceed 14 fecal coliform per 100 mL.

Watershed code	MONITORING LOCATION	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	GEOMEAN
		- - - - Most Probable Number of Enterococci per 100 mL - - - -						
WD	STB - P'tuck North of WWTF	10	85	10	75	20	-	26
WD	STB - P'tuck South of WWTF	64	272	<10	<10	<10	-	<10
LN	STB - Mouth of P'tuck	20	<10	<10	10	<10	-	<10
LN	STB - Watch Hill Harbor	10	<10	<10	Weather	<10	-	<10
LN	STB - Lil NB, North Sandy Pt	<10	10	<10	Weather	<10	-	<10
LN	STB - Lil NB, S Barn Is. Ramp	<10	10	<10	Weather	<10	-	<10
LN	Napatree Point - Cove	<10	10	<10	<10	-	-	<10
LN	Napatree Point - Bayside	<10	<10	<10	<10	-	-	<10
CW	Napatree Point - Oceanside	<10	<10	<10	<10	-	-	<10

Little Narragansett Bay (including tidal Pawcatuck River) and Napatree Point

Watershed code	MONITORING LOCATION	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	GEOMEAN
		- - Most Probable Number of Fecal coliform per 100 mL - -						
WD	STB - P'tuck North of WWTF	10	64	<10	842	31	<10	16
WD	STB - P'tuck South of WWTF	64	87	31	441	42	<10	38
LN	STB - Mouth of P'tuck	10	20	20	64	10	<10	12
LN	STB - Watch Hill Harbor	<10	20	<10	20	<10	<10	<10
LN	STB - Lil NB, North Sandy Pt	<10	<10	<10	53	<10	10	<10
LN	STB - Lil NB, S Barn Is. Ramp	<10	<10	<10	<10	<10	10	<10
LN	Napatree Point - Cove	<10	31	20	-	<10	<10	<10
LN	Napatree Point - Bayside	<10	20	20	-	10	<10	<10
CW	Napatree Point - Oceanside	<10	10	<10	-	too foggy	<10	<10

RI Department of Environmental Management and Connecticut Department of Environmental Protection fecal coliform standards:
Shellfish Waters - Geometric mean not to exceed 14 fecal coliform per 100 mL.

Watershed code	MONITORING LOCATION	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	GEOMEAN
		- - - - Most Probable Number of Enterococci per 100 mL - - - -						
WD	STB - P'tuck North of WWTF	10	10	10	10	<10	10	10
WD	STB - P'tuck South of WWTF	64	10	31	<10	<10	20	<10
LN	STB - Mouth of P'tuck	10	<10	<10	<10	<10	<10	<10
LN	STB - Watch Hill Harbor	<10	<10	10	<10	<10	<10	<10
LN	STB - Lil NB, North Sandy Pt	<10	<10	10	<10	<10	10	<10
LN	STB - Lil NB, S Barn Is. Ramp	<10	<10	<10	<10	<10	<10	<10
LN	Napatree Point - Cove	10	20	<10	-	<10	20	<10
LN	Napatree Point - Bayside	<10	<10	<10	-	<10	<10	<10
CW	Napatree Point - Oceanside	<10	<10	<10	-	too foggy	<10	<10

Table 1. Bacteria levels of sites within Little Narragansett Bay (data table from URI Watershed Watch). 2016 data on top, followed by 2015 data on bottom. Numbers in red exceed bacteria levels for shellfish (fecal coliform) and for recreation contact (Enterococci) established by RIDEM and CT DEEP. Note that while Bay and Cove coliform levels exceed standards in June and July of 2015, this year's bacteria counts are all within acceptable levels.

Bacteria

Last year, the samples in June and July yielded higher than acceptable counts for Fecal coliform at both the Bayside and Cove, as seen in Table 1. This represented an increase in both count and frequency from 2014[4] and could have resulted from some new input of bacteria to the system.

This year, however, bacteria counts at all sampling locations for all months were within the acceptable standards for both states, indicating that bacterial input is once again minimal.

CONCLUSIONS: The waters surrounding Napatree Point play an integral part of this barrier beach ecosystem. Overall, the water samples collected during the 2016 field season were suggestive of a healthy marine environment. Very few changes in water quality were observed since last summer, and those that were (increased overall DO, decreased chlorophyll concentrations, and lower bacterial levels) all indicated positive trends in the health of the system.

ACKNOWLEDGEMENTS: This project would be impossible without the continued help of many individuals and organizations. Specifically, we would like to thank the URI Watershed Watch team for providing training, sampling equipment used each week, and processing of samples in their lab. We thank the Watch Hill Memorial Library for the use of their space each week for sample analysis. We thank the Watch Hill Yacht Club for the kind use of their launch and dock space when our usual research vessel was out of commission. And we also thank Bruce Anderson for his services and flexibility as guest Captain on several occasions.

[4] *Cressman & Simmons, 2013, 2014, State of Napatree Reports*

Piping Plover Monitoring at Napatree Point Conservation Area: 2016

Kevin Rogers
Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

Photo credit: C. S. Spencer

Piping Plover Monitoring at Napatree Point Conservation Area: 2016

Kevin Rogers
Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

INTRODUCTION: Piping Plovers (*Charadrius melodus*) are small shorebirds that nest in open, sandy areas along the Atlantic coast and Great Lakes region. They were common in the 19th century but they face many threats and are now listed as threatened under the Endangered Species Act. Until the Migratory Bird Treaty Act of 1918, Piping Plovers were a common victim of the millinery trade and the development of coastal areas has destroyed large portions of their habitat. Because Piping Plovers lay their eggs in open beach areas, they are very susceptible to nest predators and weather events such as high surf and extreme tides. In addition, Piping Plovers are negatively impacted by human disturbance, especially dog-walkers which are perceived to be canine predators.

Napatree Point Conservation Area (NTPCA) provides a large area of nesting habitat for Piping Plovers making it an important site for the recovery of the Atlantic coast population. The US Fish & Wildlife Service (FWS) has monitored Piping Plovers on Napatree since 2001. The Watch Hill Conservancy, Watch Hill Fire District, and the FWS work together to manage land use as recommended by the Piping Plover Recovery Plan.

METHODS: In early April, staff from the NTPCA and FWS erect symbolic fencing around predicted nesting areas which are based on past nesting locations and the expertise of FWS biologists. For the third year in a row, several classes from East Greenwich High School volunteered to help install the poles, rope and signs. The fencing consists of 8-foot galvanized U-poles driven into the sand with a strand of rope running between each pole. A sign requesting that beach-goers stay out of closed areas is attached to every other pole.

The monitoring methods used at Napatree follow FWS protocols. Once Piping Plovers start arriving from their wintering grounds, Napatree is surveyed three times a week by FWS staff. A survey is a standardized search for breeding activity. All areas with plover tracks and scrapes are noted to designate territories and all Piping Plovers encountered are tallied. Once eggs are laid, the geographic coordinates of each nest are obtained by GPS and the nest is monitored from a distance. If no birds are found to be incubating a known nest, it is checked for failure. If the nest has failed, monitors attempt to determine the cause. Once the eggs in a nest have hatched, the chicks are monitored every other day until they have fledged.

In most years, eligible nests have exclosures constructed around them. In order for nests to be exclosed, they must have a full 360-degree view, not be on a steep slope, and be high enough on the beach that it is not likely to be flooded during an extreme tide.

RESULTS: This year, the first Piping Plover nest was initiated on April 28. Eight pairs established territories on Napatree, which is an increase from the five pairs that nested in 2015. However, the number of nesting pairs has significantly decreased since 2011 (Figure 1). Piping Plovers initiated ten nests (two pairs re-nested) with a total of 34 eggs laid and 21 hatched (62%). Three pairs hatched all four of their eggs. We are confident in our estimate of eight nesting pairs of Piping Plovers based on nest site locations and the timing of the initiation of new nests following nest failures. However, since only one Piping Plover was banded at Napatree we cannot be absolutely certain that eight pairs nested.

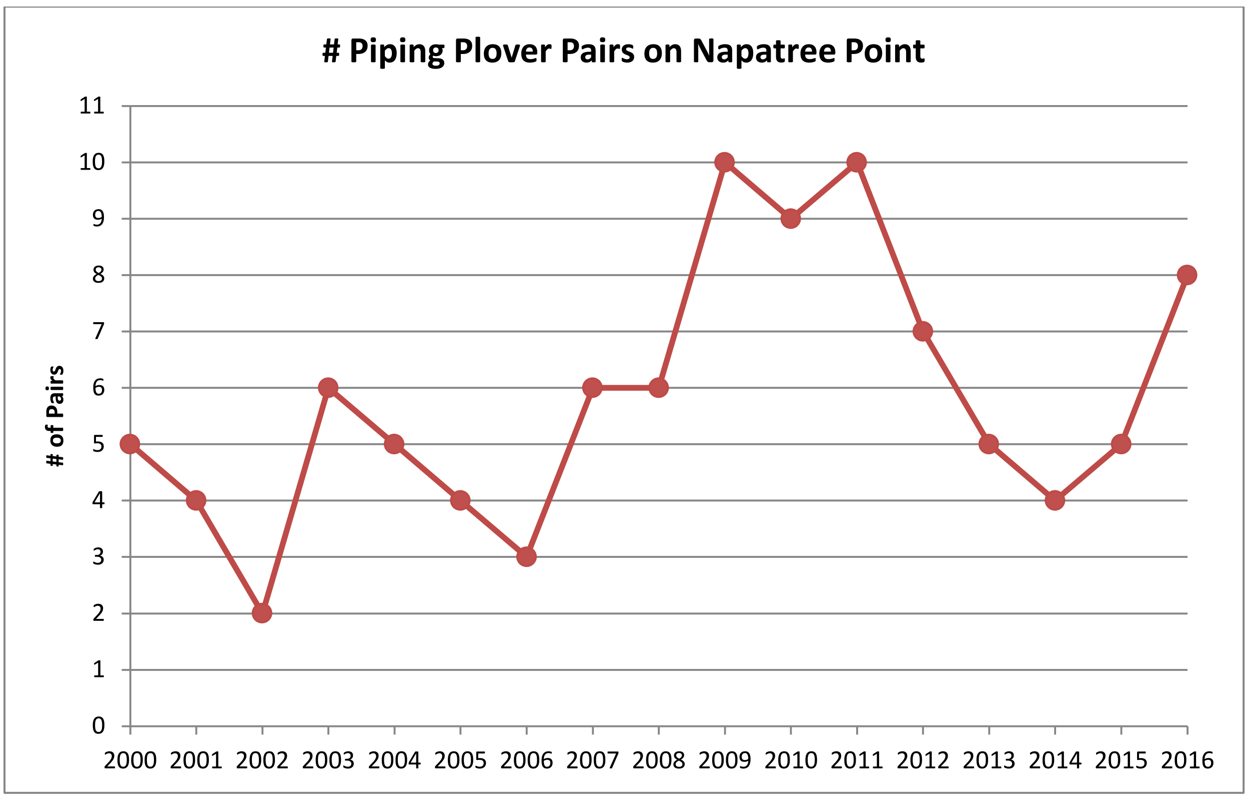


Figure 1. Piping Plover nesting history at Napatree Point

Out of ten nests, six hatched at least one egg, two were overwashed by exceptionally high tides and two failed for unknown reasons. The cause of the unknown failure was likely depredation, but no evidence was found to confirm that. There were no nests that were abandoned this year. This year two nests were exclosed and they both produced hatchlings.

Seven chicks fledging (33% of chicks hatched, 21% of eggs laid) from eight pairs gave Napatree 0.88 fledgling per pair (productivity), which is an increase in productivity from last year (Figure 2). In order to sustain the Piping Plover population at least 1.25 chicks per pair must be fledged according to the FWS Piping Plover Recovery Plan.

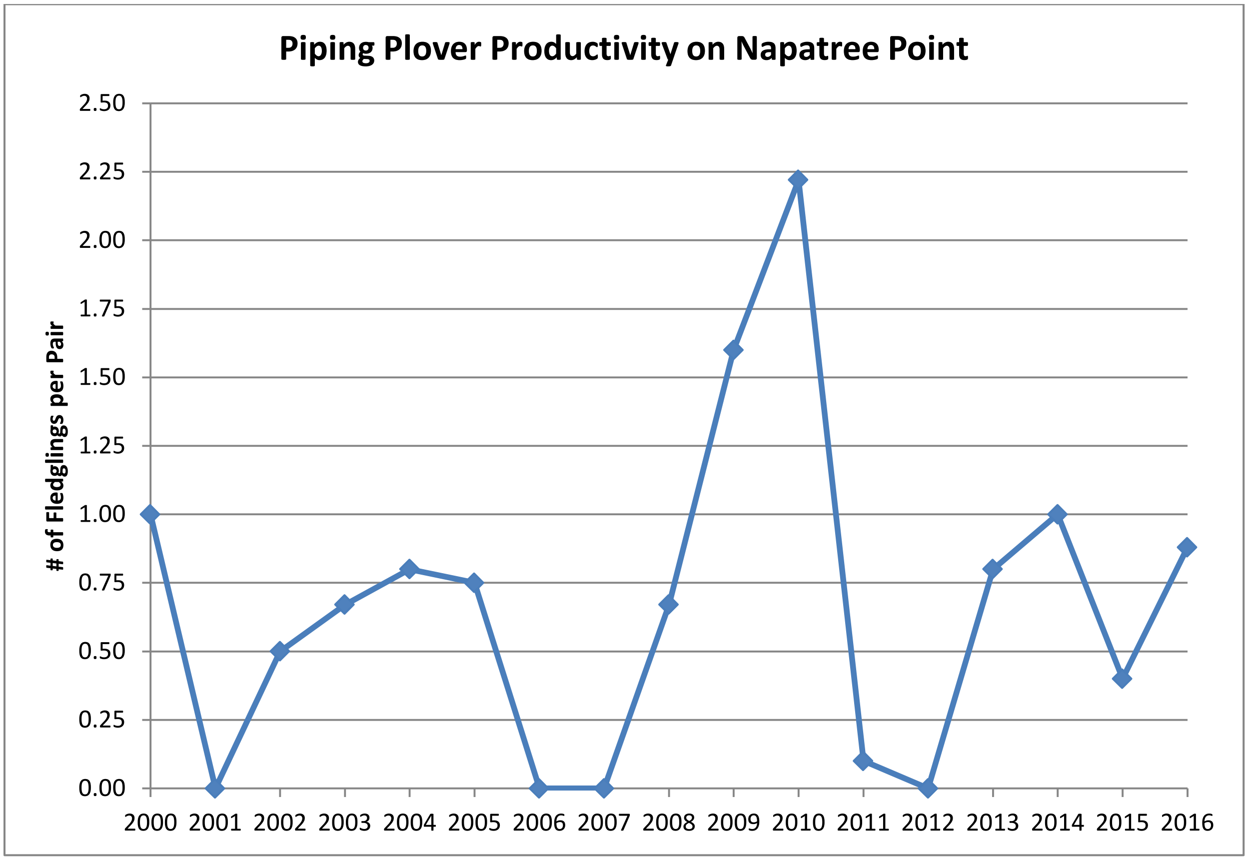


Figure 2. Piping Plover nesting productivity at Napatree Point

CONCLUSIONS: The number of nesting pairs (Figure 1) and productivity (Figure 2) continued to increase. For the third year in a row, the "Far Spit" west of the lagoon mouth was a popular spot for plovers to nest. Five nests were initiated but unfortunately two nests were overwashed and only two chicks survived to fledge there. In recent years, all nests initiated away from the lagoon were located on the Oceanside. This year only one nest was initiated on the oceanside and two were located on bayside well east of the lagoon. Also of note, a pair of American Oystercatchers, a pair of Common Terns, and several pairs of Least Terns attempted to nest on

Napatree this year but none were successful. At least one pair of Least Terns hatched two chicks but neither survived. Nesting Spotted Sandpipers were also particularly abundant this year.

ACKNOWLEDGEMENTS: We'd like to thank everyone who aided in the Piping Plover conservation efforts in 2015. This especially includes Ryan Kleinert, FWS Piping Plover Coordinator and his staff, the East Greenwich High School science students and their teachers: Mr. David King, Mr. Christopher Wren, and Mr. Nicholas Rath. Thanks to their assistance, seven new Piping Plovers were able to fledge at Napatree Point Conservation Area this year.

Project *Limulus* on Napatree Point: Horseshoe Crab Surveys in 2016

Laura Craver-Rogers & Kevin Rogers
Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

Photo credit: Janice Sassi

**Project *Limulus* on Napatree Point:
Horseshoe Crab Surveys in 2016**

Laura Craver-Rogers & Kevin Rogers
Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

INTRODUCTION: Horseshoe crabs (*Limulus polyphemus*) are an ecologically and medically important species which have existed for over 300 million years on the muddy bottoms of bays and estuaries, feeding on clams, small crustaceans, and worms. Horseshoe crabs deposit eggs beneath the wet sand along shorelines during a critical time of shorebird migration and nesting, thus providing a necessary nutrient source to many threatened and endangered shorebirds. Additionally, their "blue blood" is used to help detect contaminants in intravenous drugs.

Horseshoe crabs live along the Atlantic coast of the United States and must spawn in the intertidal zones of protected, sandy beaches. Often, this means coming into the shallow waters of coves and bays, such as Little Narragansett Bay, which borders Napatree Point to the north. Napatree provides excellent breeding habitat that allows horseshoe crabs to spawn without being flipped over by large waves. Horseshoe crabs come to shore during the extreme high tides nearest to the full and new moons during May, June, and into July. It is during these spawning periods that horseshoe crabs are the easiest to count.

The Watch Hill Conservancy (WHC) and the Watch Hill Fire District (WHFD) have partnered with Sacred Heart University's Project *Limulus* (PL) to monitor the horseshoe crabs that use Napatree Point. Started in 1998, in collaboration with the US Fish & Wildlife Service (FWS), PL relies on citizen volunteers to contribute valuable data to this scientific research. This information helps PL to estimate and monitor the population size, identify the most important spawning and nursery areas, and help answer other research questions that may be critical for the conservation of this species.

METHODS: There are four separate parts to this project: spawning surveys, tagging adults, reporting previously tagged adults, and juvenile surveys.

Spawning surveys occur during the high tides surrounding the full and new moons during May, June, and July when spawning is most likely to occur. The surveys are conducted the day of the new/full moon as well as two days prior and after, resulting in six total surveys per moon phase. The survey route in the Napatree Point Conservation Area (NTPCA) runs along the northern shore from the rock jetty adjacent to Watch Hill Harbor westward into the lagoon and ending at the active osprey nesting pole. All horseshoe crabs within 3 meters of the shoreline are counted, sexed (male or female), and recorded whether they are paired or alone. This year (2016) we broke the survey route into five zones to assess which stretches of beach were preferred by Horseshoe Crabs.

The tagging of adults can occur at any time, but typically occurs during the return trip after the spawning survey. Sex, shell (carapace) width, and shell condition are recorded when animals are tagged. Tags are attached by creating a small hole in the shell of the horseshoe crab and then inserting a small, plastic tag into the hole. These round white tags are imprinted with a unique FWS Federal ID number and a telephone number to call to report locating a tagged animal.

During horseshoe crab surveys, tagged individuals are frequently located. They are carefully captured long enough to record the tag number along with the sex, shell width, and condition. These recapture data are integral in estimating population size and determining whether an animal returns to the same beaches to spawn. Data from tagged horseshoe crabs located outside survey times are also submitted.

Juvenile surveys take place in the lagoon and are a count of the number of juveniles found anywhere in that vicinity. The juveniles are measured to determine the distribution of the cohorts using this nursery area. Project *Limulus* has established size classes for juvenile horseshoe crabs based on the carapace width (mm). For example, class 8 juveniles are animals between 18-22 mm carapace width, class 9 is 23-29 mm, class 10 is 30-36 mm, class 11 is 37-41 mm, and class 12 is 42-53 mm.

RESULTS: In 20 surveys, Napatree Naturalists and volunteers counted 4,759 spawning horseshoe crabs with most being paired (Figure 1). Single males outnumbered single females. The areas that were most used by horseshoe crabs were the western sections but not in the lagoon (Figure 2). Of the 4,759 horseshoe crabs found during the surveys, 85 were previously tagged. Out of the recaptured horseshoe crabs, there were more males than females (Table 1). From June to August 2016 the team tagged 50 horseshoe crabs; of these we tagged more males than females (Table 1).

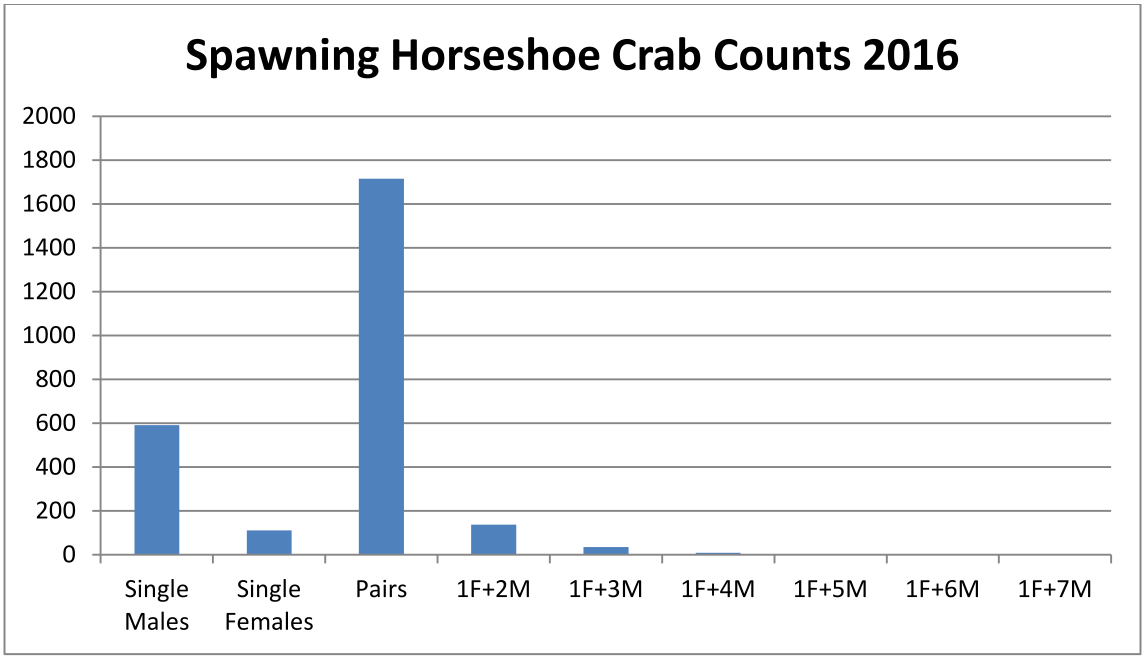


Figure 1. Total number of horseshoe crabs by class for the 2016 season.

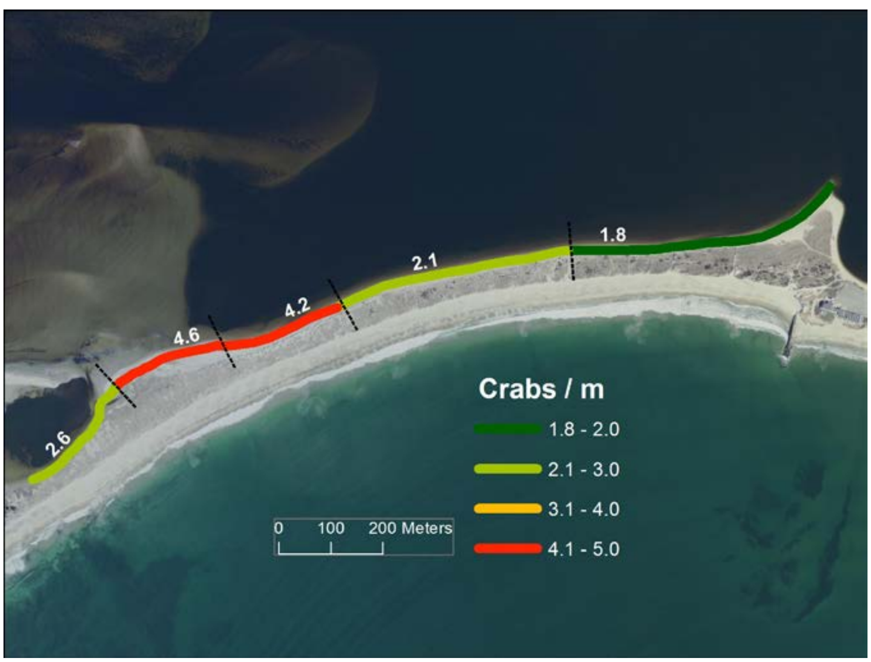


Figure 2. Number of horseshoe crabs per meter counted within each zone during the 2016 season.

	Male	Female	Total
# Tagged	39	11	50
# Recaptured	76	9	85

Table 1. Number of horseshoe crabs tagged and recaptured during the 2016 season.

There seemed to be a large increase in the number of horseshoe crabs surveyed from 2015 to 2016, topping our previous record during the 2013 season (Table 2). In 2015 there was an average of 115 horseshoe crabs per survey but in 2016 there was an average of 238 horseshoe crabs per survey. The greatest increase from 2015 to 2016 was in horseshoe crab pairs with an increase of an average of fifty four pairs per survey (Figure 3). Through all four survey seasons, single males seem to be steadily increasing, but single females seemed to be decreasing until they increased in 2016 (Figure 3). Four surveys of juveniles were conducted in 2016 in the Napatree lagoon and 56 were observed. Last year no live juveniles were found in the lagoon. In 2014, 73 juveniles were counted in five surveys, and in 2013 650 juveniles were counted in six surveys (Figure 4).

Year	# Surveys	# HSC	# HSC/ Survey
2013	13	1685	130
2014	23	2070	90
2015	16	1837	115
2016	20	4759	238

Table 2. Number of surveys conducted each season and the total number of horseshoe crabs (HSC) counted each season.

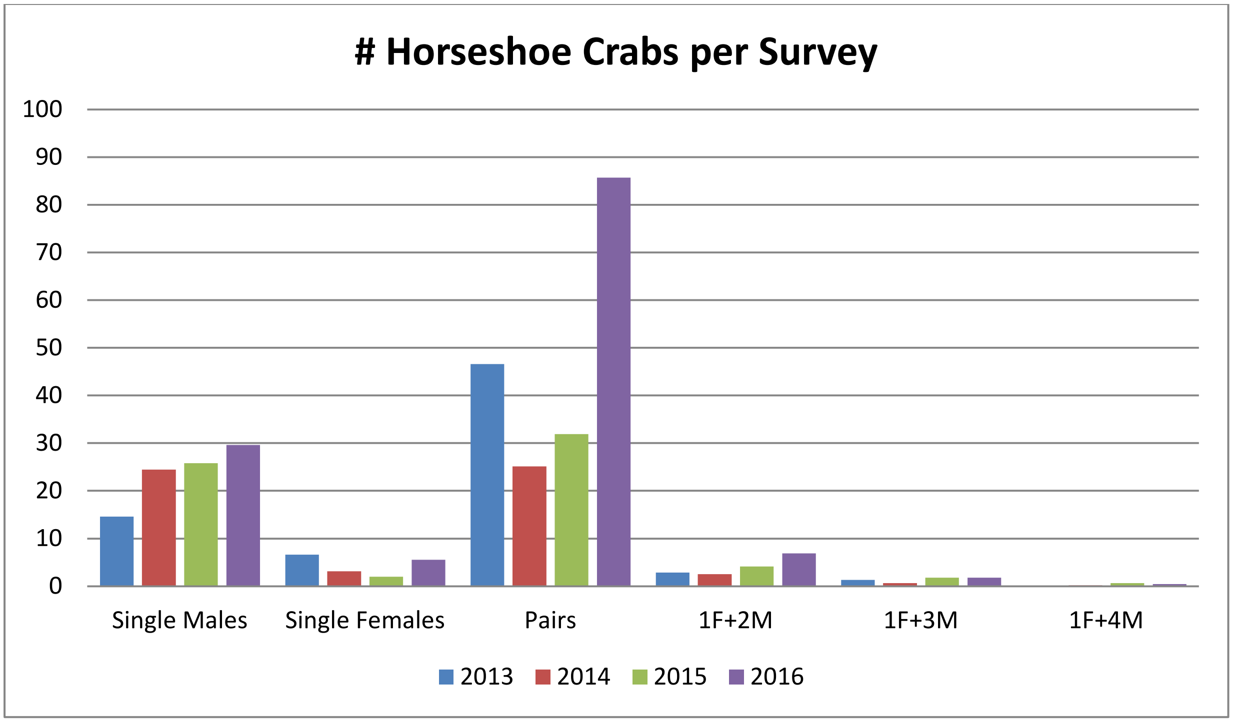


Figure 3. Number of horseshoe crabs of each class per survey for the 2013- 2016 seasons

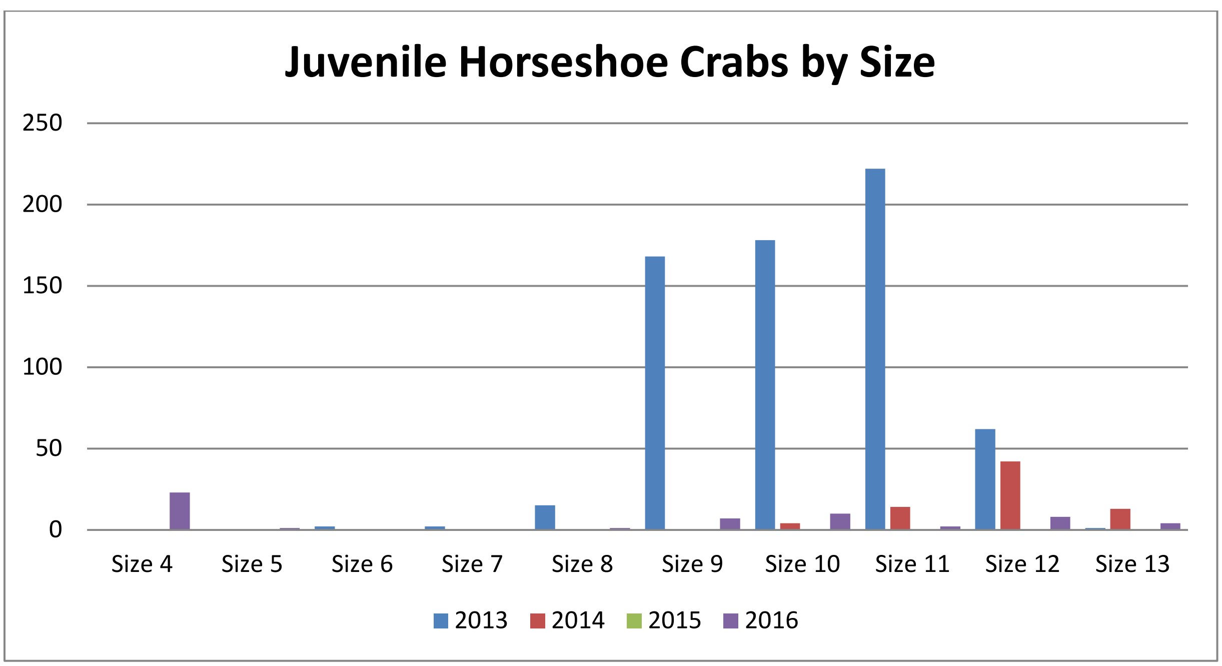


Figure 4. Juvenile horseshoe crabs surveyed, 2013-2014 seasons.

CONCLUSIONS: Horseshoe crabs are an important part of the Napatree Point ecosystem and should continue to be monitored. Their eggs provide a source of fat and protein to most of the shorebirds that stop at Napatree during migration, as well as for many aquatic predators including fish. Horseshoe crab shells also provide habitat for several species of ocean-dwelling invertebrates and plants, including common whelk, blue mussels, barnacles and a variety of seaweeds. Since horseshoe crabs have been harvested for bait and medical research, the population has declined sharply in recent years, making it even more important that this species is conserved on Napatree Point. In 2017 we should make a special effort to continue to conduct juvenile surveys in the lagoon in order to document the apparent increase in juveniles that we have observed this year after an apparent decline from 2013-2015.

Horseshoe crabs play an important role in the education and outreach activities in the Napatree Point Conservation Area. The Investigators summer education program for children have lessons on horseshoe crab ecology for the participants (see Chapter 6 (page 24) by Brown et al. in this State of Napatree Report). Visitors to Napatree frequently ask the beach Naturalists about the horseshoe crabs they find, thus creating an opportunity to educate the public about this ecologically important species. Finally, the volunteer-based horseshoe crab surveys in the summer are a valuable way to engage the public in scientific data collection to support conservation and resource management. Along with Piping Plovers, Oystercatchers, and Ospreys, horseshoe crabs are one of several iconic species occurring on Napatree Point.

The University of Rhode Island communications division created a beautiful video documentary of one of our night-time surveys. A link to the video can be found at: www.napatreepoint.info

DATA MANAGEMENT: Data sheets are submitted to Project Limulus at Sacred Heart University

ACKNOWLEDGEMENTS: The following individuals assisted Napatree Naturalists in our horseshoe crab surveys: Nicole Rohr, Caitlin Chaffee, Barbara Harvey, and Jeannie Pinzon.

Visitor Activity on Napatree: 2016

Kevin Rogers
Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

Photo credit: Janice Sassi

Visitor Activity on Napatree: 2016

Kevin Rogers
Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

INTRODUCTION: Historically, visitor use of the Napatree Point Conservation Area (NTPCA) was inconsistently documented and measuring changes in visitor use of the conservation area was difficult. Beginning in 2013, a standardized data sheet was used to record the number of visitors and dogs on NTPCA as well as boats anchored along the shore or pulled up onto the beach. We have continued use of the standardized data sheet through 2016 and this allows us to compare trends in visitor activity over the years.

METHODS: From May through September 2016, visitor use data were collected on every weekend day by the NTPCA Naturalists on duty. In many cases, visitor use data were collected by a Naturalist working the morning shift (typically 9 AM to 1 PM) and again by a Naturalist working the afternoon shift (typically 1 AM to 5 PM). When two sets of data were obtained on the same day, the count documenting the highest visitor and boat totals was used whereas the counts of dogs on Napatree were summed. Data collection on weekdays was done opportunistically whenever a Naturalist was present.

Using the standardized data sheet, Naturalists tallied the number of visitors which included individuals on boats anchored along the beach that were likely to come ashore. Those boats, as well as kayaks and dinghies on the beach were counted. The number of dogs on NTPCA in violation of the Town of Westerly ordinance prohibiting dogs from May 2 to the day after Labor Day was recorded, also noting whether they were leashed and whether they violated roped areas. Lastly, positive and negative interactions between Naturalists and visitors were documented. Due to a lack of guidelines for classifying interactions, this information was sporadically noted and is not formally summarized in this report.

In addition to data recorded by Naturalists working on Napatree, Tom Pappadia counted visitors entering the conservation area from the parking lot (i.e., “gate”). To avoid double counting boaters who walked into town and returned through the gate, the total was reduced by 25 percent. The number of dogs turned away was also recorded.

On August 14, 2016 NTPCA science advisor Peter August and Napatree intern Emily Bodell sampled dune crossing behavior of beach visitors. The purpose of the study was to determine how many people traverse the dunes using the approved trails marked by orange or white poles (Appendix 1) compared to individuals who chose to cross the dunes on unmarked or closed (roped off) social trails. August and Bodell stationed themselves on the ocean side of the dune and counted the number of people and number of groups of people crossing the dunes (Figure 1).

Sampling commenced at 10:00 AM and ended at 1:00 PM. When a person, or group of persons, was seen crossing the dune, the following data were recorded: time, number of people in the group, direction (north to south, south to north), load (0= nothing; 1=light load (e.g., a chair or umbrella), 2= heavy load (e.g., a cooler or cart)). In addition, the type of trail used was recorded (marked or unmarked) and for marked trails, the number of the trail was noted.

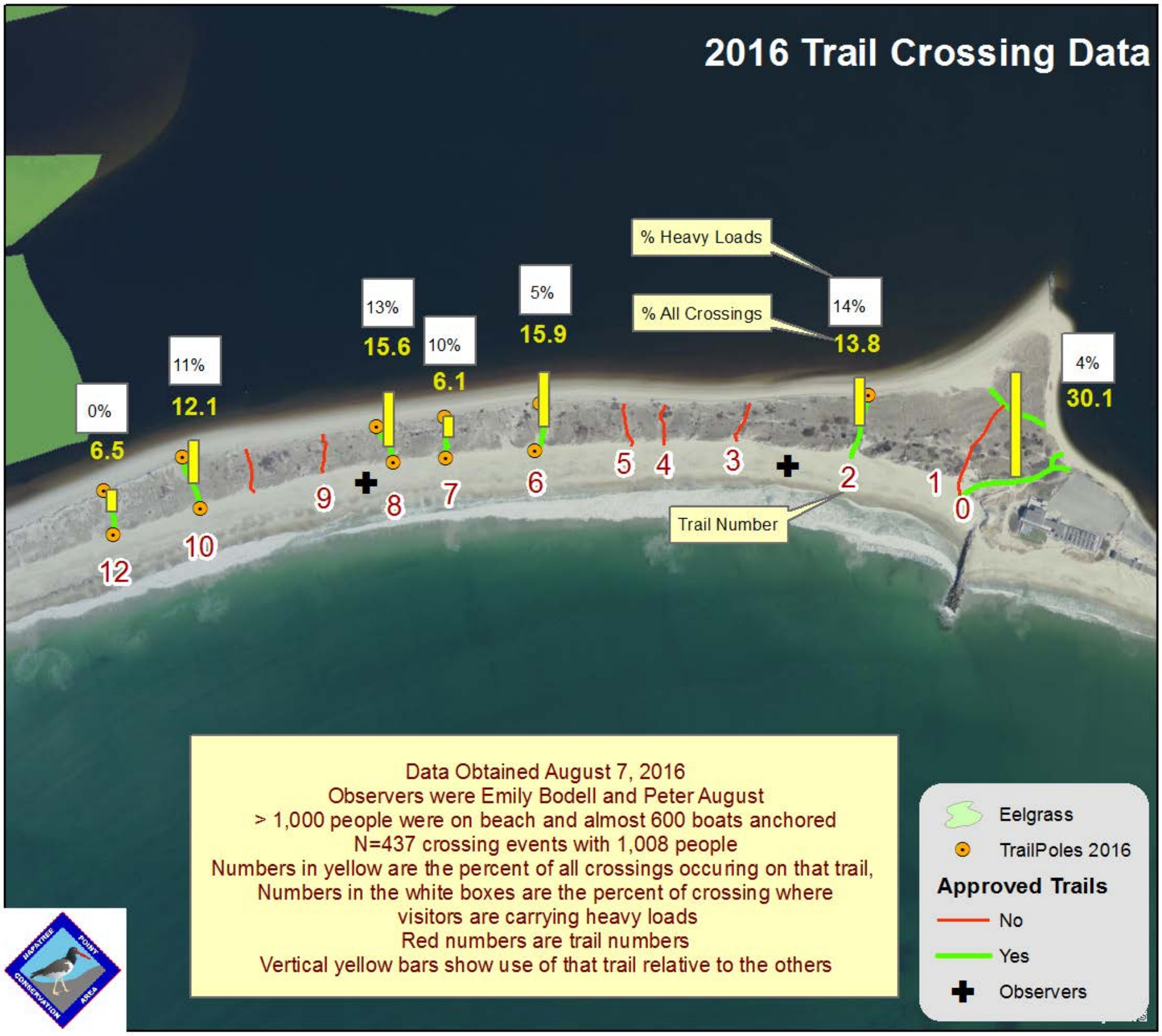


Figure 1. Location of marked paths crossing the dunes and trail use patterns in 2016

RESULTS:

Naturalist Data – A total of 46 data sheets were filled out between 21 May and 5 September 2016. The total number of visitors on Napatree for these 46 days was 18,300. Of these, 13,253 visitors were observed on weekends (average daily number of visitors was 778) and 5,047 on weekdays (average daily number of visitors was 398, Figure 2). The highest use occurred in the month of July, with an average of 711 visitors on each weekend day count and 282 on each weekday (Figure 2).

We tallied the number of boats present at NTPCA every day for the 46 days sampled. Overall, 5,899 boats were observed between May and September 2016, with 4,739 observed on weekends and 1160 observed on weekdays. The highest boat count was recorded on July 3, with a total of 526 boats observed. Overall, weekend counts averaged 215 boats per day, whereas weekdays averaged 48 boats per day (Figure 2).

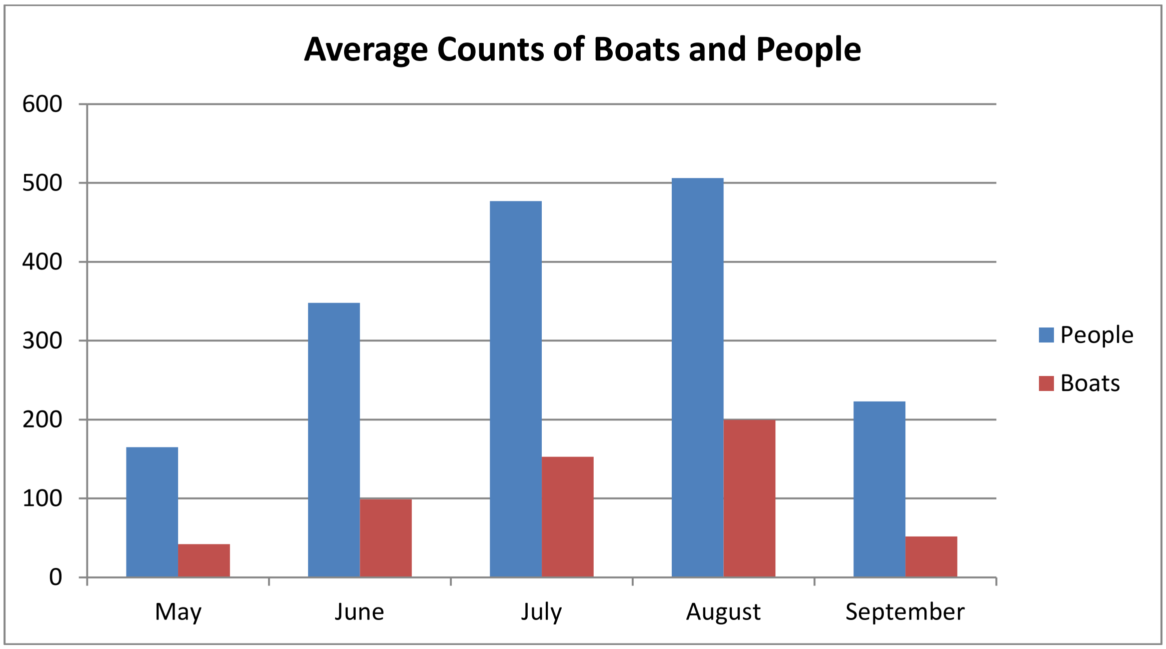


Figure 2. Average number of people and boats observed per day during counts on NTPCA from May through September 2016

A total of 38 dogs were observed on NTPCA between May and September 2016. Of the 38 dogs observed, a majority (61%) were in compliance with the leash law, with 23 dogs on leashes and 15 off leash (Figure 3). Furthermore, no dogs were observed in the roped areas during the summer of 2016.

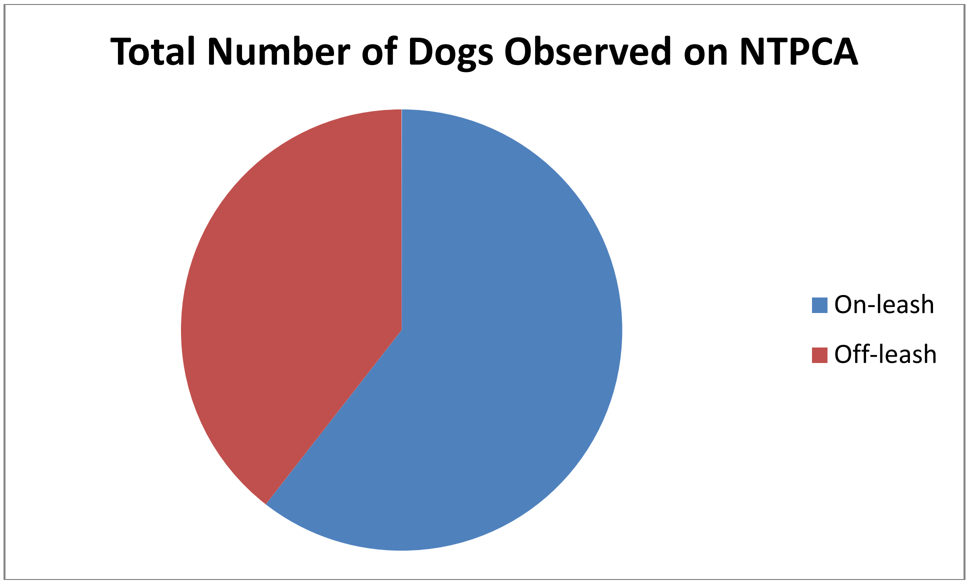


Figure 3. Breakdown of dogs observed on NTPCA and compliance with Town of Westerly leash laws during the period May through September 2016

<u>Gate Data</u> -- Tom Pappadia recorded data on visitors passing the entrance gate on 57 days between 24 April and 11 September, 2016. Of the 57 days, 39 were weekends and holidays and 18 were weekdays. Over the course of 57 days, Tom recorded 15,136 visitors passing through the entrance gate (Figure 4). August was the busiest month for visitors with an average of 462 individuals entering each day. Tom turned away 194 dog walkers attempting to access the beach during the prohibited times between 8:00 AM and 6:00 PM, with an average of 5.3 dogs per day between May and September (Figure 5). Napatree personnel generally work between 8:00 AM and 6:00 PM.

During the weekends of April 23/24 as well as April 30 and May1, prior to the start of the dog ordinance, 132 dogs came through the gate.

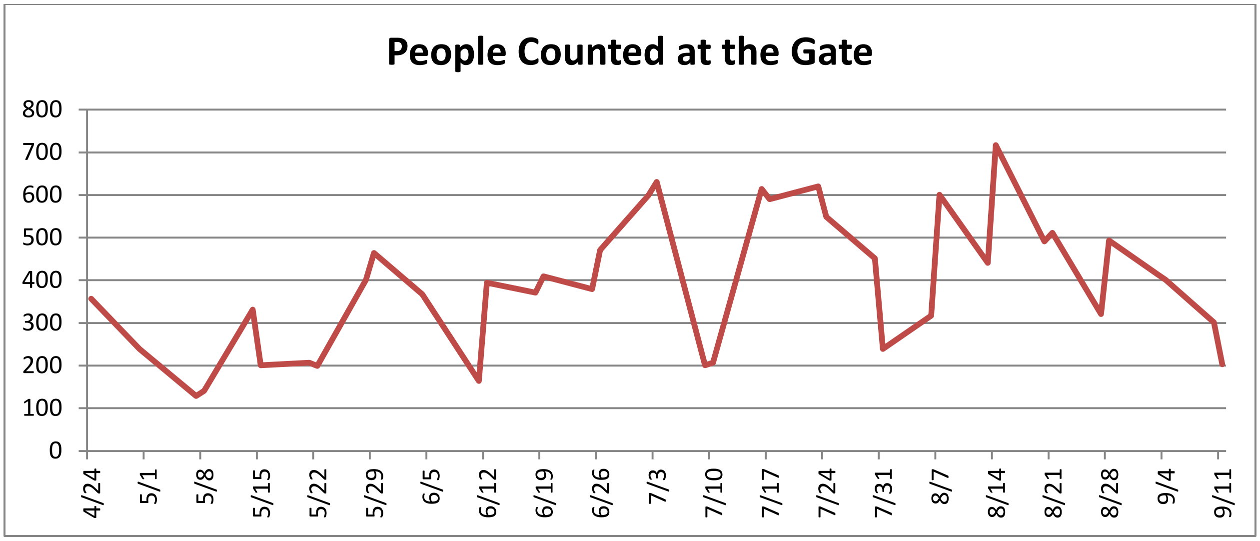


Figure 4. The number of visitors per day accessing NTPCA through the gate between April and September 2016.

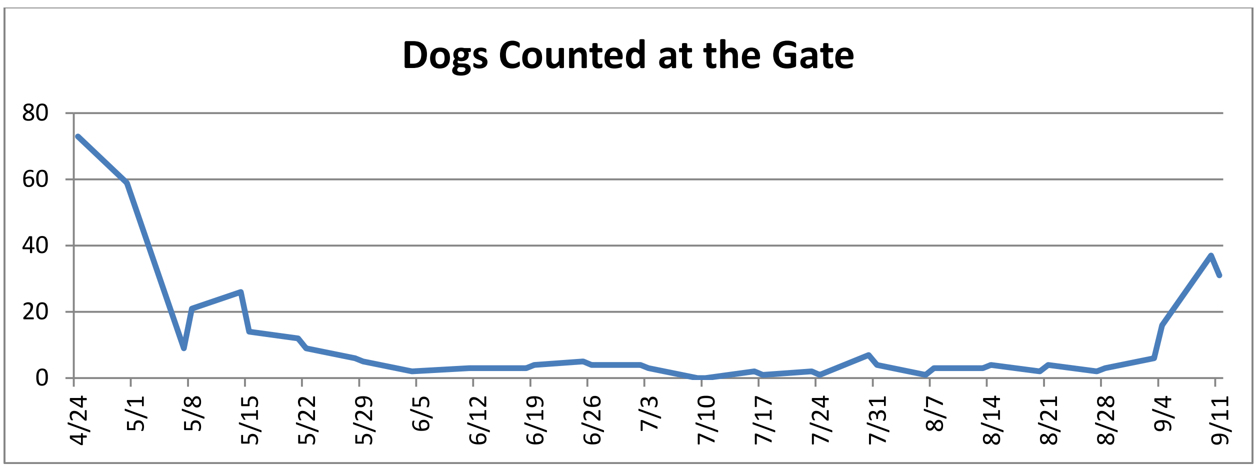


Figure 5. The number of dogs counted per day at the gate between April and September 2016.

<u>Trail Crossing Behavior</u> -- The number of people that were observed crossing the dune and the frequency with which they used the marked paths and unmarked or closed social paths are shown in Table 1. All crossings occurred on marked paths (Table 1). The popularity of the different marked paths can be seen in Figure 1. The eastern-most dune crossing (path 0) was the most heavily used path. This trail captures most of the walk-in visitors to Napatree who are headed to the beach. The paths in the middle of Napatree were also heavily used by visitors, especially those arriving by boat. Trails 2, 6, 8, and 10 were the most popular crossing points. It is not surprising that visitors with heavy loads of gear were travelling from north (bayside) to the south (ocean) since our sampling period captured people arriving to the beach (Table 2). Visitors using

the eastern-most trail rarely brought heavy loads (Figure 1), presumably because they had a long walk in from Watch Hill. Visitors to the beach that arrived via boat tended to have heavier loads on the trails that they used (Figure 1).

	Crossings on Marked Paths	**Crossings on Unmarked or Closed Paths**	**Total**
Number of Crossing Events	437 (100 %)	0 (0 %)	437 (100 %)
Number of People Crossing	1,008 (100 %)	0 (0 %)	1,008 (100 %)

Table 1. Frequency with which people crossed the dunes on marked (tall orange or white poles) approved paths and unmarked social trails. A crossing event is one person or a group of people (e.g., a family or parent and child) crossing at one time. Thus, a crossing event might include many individuals.

Load	**Direction (% all Crossings for the Load Class)**	
	To North (Bay) From South (Ocean)	**To South (Ocean) From North (Bay)**
Load None (score = 0)	56 %	44 %
Load Light (score = 1)	18 %	82 %
Load Heavy (score = 2)	11 %	89 %

Table 2. Directional differences in loads that visitors carry when traversing the dune.

DISCUSSION: Visitor use of NTPCA from May through September 2016 was 507 individuals per day on weekends and 398 individuals per day on weekdays. August was the busiest month in 2016 averaging 506 visitors per day. The next busiest month in 2016 was July, which averaged 477 visitors per day. This trend is also seen in the boat data where the average number of boats per day in 2016 was 199 in July and 153 in August. July and August have been the busiest months at NPCA since 2013 when counts were formalized.

Data collected at the gate showed a similar trend in monthly visitor activity. Gate data showed the highest foot traffic occurred during August when an average of 462 visitors per day accessed Napatree by foot. In 2015, July was the busiest month. However, data from 2013 and 2014 showed that August had the highest foot traffic with an average of 466 people per day in 2014, a decrease from approximately 675 people per weekend day in 2013. Modest increases in average daily visitors to NTPCA suggest continued high use indicative of the attraction that Napatree

Point has for both Rhode Island and Connecticut residents as well as visitors from afar. Continued presence of NTPCA Naturalists working to ensure a safe and enjoyable visit is likely to enhance a visitor's experience and increase visitation in future years.

Compliance with the Town of Westerly dog ordinance was relatively high averaging less than 1 dog recorded on NTPCA during prohibited times (8 AM to 6 PM) each day (46 total observations). Of those in violation of the no dogs on the beach ordinance, 65% were in compliance with the town's leash law. Data collected at the gate reflected an increase in the number of dogs turned away in 2016 from 2015. In 2016, an average of just over five dogs per day were turned away at the gate. However, days prior to May 2 and after Labor Day averaged 50 dogs per day. Despite a modest increase from 2015, the overall low violation rate of the dog ordinance is likely the result of continued outreach and presence of NTPCA Naturalists on the beach. With continued education, enforcement and outreach the number of violations is likely to continue to decrease in the future.

100% of all dune crossing we observed in this year's sampling were on proper paths. This is an improvement from last year when 1% of the crossings were on closed social paths and 6% of crossings in 2014 were on closed paths. Visitors to Napatree appear to understand that the orange trail poles indicate appropriate paths to the beach or bay. This gives NTPCA managers a powerful tool to control where people do and do not go. It would be interesting to determine if boaters preferentially anchor near path poles to reduce the amount of walking they have to do to get to the ocean. If so, NTPCA managers might consider closing trails 10 and 12 to draw boaters away from the eelgrass bed. Boats anchoring in the eelgrass can damage this important habitat.

ACKNOWLEDGEMENTS: The information reported here was collected by Naturalists Kevin Rogers, Josh Beuth, Laura Craver-Rogers, Hugh Markey, Steve Brown, Ryan Kleinert, Alyssa Petersen, and Christian Fox. NTPCA manager Janice Sassi, gate-keeper Tom Pappadia, NTPCA science advisor Peter August, and NTPCA intern Emily Bodell also spent significant amounts of time collecting the data included in this report.

Appendix 1. Pole marking an approved path across the dunes.

Camera Trap Reconnaissance of Wildlife in the Napatree Point Conservation Area: 2015-2016 Sampling

Peter August [1], Janice Sassi [2], Laura Craver-Rogers [2], Ryan Kleinert [3] & Emily Bodell [4]
[1] Department of Natural Resources Science, University of Rhode Island
[2] Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District
[3] United States Fish and Wildlife Service
[4] Departments of Biology and Public Policy, Wheaton College

Photo credit: Janice Sassi

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INTRODUCTION: The western end of Napatree Point consists of a variety of ecological communities – maritime shrubland, salt scrub, maritime shrub dune, high marsh, maritime herbaceous dunes, rocky shore, and maritime beach. Previous years of camera trapping have shown that the mammal fauna of this section of Napatree is surprisingly diverse. The mammals of Napatree play an important role in the ecosystem and serve as predators, prey, plant consumers, and seed dispersers. The overall purpose of our camera trap survey is to assess the diversity and relative abundance of mammals (and occasionally birds) in the different habitats in the Napatree Point Conservation Area (NTPCA), Watch Hill, RI. This is the fourth year we have been camera trapping at Napatree and each year we strive to monitor different habitats in the Conservation Area. These data will contribute to the overall ecological knowledge of the NTPCA, serve as a baseline inventory for the species at the site, and provide objective data on the relative abundance of potential predators of shorebirds in the area. With these baseline data on predator populations, we are beginning to discern trends in the relative abundance of various species on Napatree

For the past few years we have limited our camera trapping reconnaissance to periods of the year when visitor traffic was low, typically October to April. This year, we broke that tradition and deployed camera traps in peak visitor traffic (July - September). In one site ("Plover") we carved out a pine tree log to house our camera and deployed it in an open site behind (inside) the roped-off area that was off-limits to visitors because of breeding Piping Plovers (Cover, Figure 1). Our intention was to document the frequency of unleashed dog forays through the roped-off zone.

Ms. Emily Bodell, a college student intern from Wheaton College, conducted a study of the differences in deer activity between spring and summer seasons at the salt scrub location. We had a sample of animal activity at that location in the spring of 2014 and she wanted to compare activity levels in the summer season in 2016. Her results are presented here.

METHODS: We deployed camera traps (Reconyx Rapid Fire) in multiple locations in the Napatree Point to monitor animal activity (Figure 1). Four locations were sampled in the

2015/2016 monitoring season and are described in Table 1. At each site, the camera was mounted approximately 1 m off the ground on a tripod, affixed to a stout shrub branch, or set inside an old log that had been carved out to hide the camera (see cover of this chapter). The SD card containing photographs was retrieved on a 2-8 week interval. The camera ran continuously during the period of deployment and was set to record five consecutive photographs every time the motion sensor beam was broken. Each photo was stamped with the date, time, temperature, moon phase, and which shot in the five-photo sequence it was. Photos taken in the day were color and photos taken at night were black and white and were illuminated by an infrared flash. For data analysis, an animal that was continuously present for a string of consecutive photos was recorded as a single occurrence (visit). When photo sequences were more than 5 minutes apart they were counted as separate animal visits.

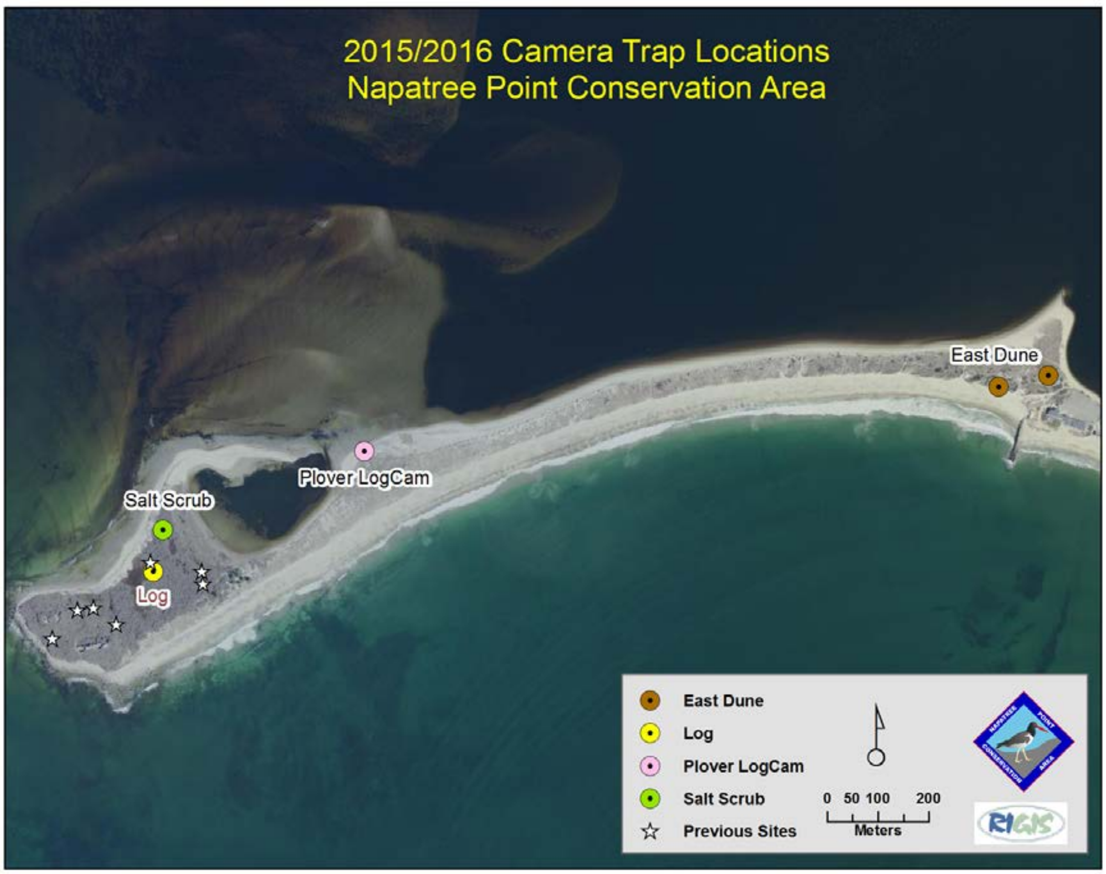

Figure 1. Location of 2015/2016 camera trap sets on Napatree Point.

Site	Sampling Period	Total Days of Camera Sampling	Habitat
East Dune	12 Oct 2015 – 17 Dec 2015	61	Among bayberry and *Rosa* shrub stands amidst dune grass
Log	20 Dec 2015 – 26 March 2016	92	Along a large fallen log on the edge of a bayberry shrub patch and large patch of *Phragmites*
Plover	6 June 2016 – 27 July 2016	50	Open sandy area where Piping Plovers were nesting near lagoon
Salt Scrub	14 July 2016 – 18 August 2016	35	Salt marsh site on western end of lagoon on shrub land fringe

Table 1. Camera trap sampling locations in 2015-2016.

RESULTS: All nine species of wild mammals (excluding humans and domestic dogs) known to occur on Napatree were recorded this year in 88 different occurrences over 238 days of camera trapping (Table 2). As observed last year, the log site was a very productive camera trap location and resulted in the highest diversity of species recorded of all the areas monitored. Coyote abundance was comparable to 2015 but fox visits were substantially lower in 2016 compared to the previous year (Table 3). Whereas fox were common and ubiquitous in all sites that we camera trapped in previous years, they were much less so in 2016. Mink visits at the log were markedly higher in 2016 compared to 2015 (Table 3). Since we do not know if we are photographing one or many individuals, it is impossible to accurately discern if numbers of mink are increasing on Napatree. We added a new species to the Napatree list this year, a raccoon (*Procyon lotor*) was photographed at the East Dune site.

Animals use the log site as a travel path and many of the photos are blurred from their rapid passing along the log. As an experiment to slow their movement across the log, we affixed a diversionary object on the log that would hopefully pique their curiosity and they would stop to investigate. The object was a bright green tennis ball tied to a yellow nylon rope which was nailed to the log. Our logic was simple -- what canid does not find a tennis ball an irresistible object to play with? The tennis ball was set in place on 2 March 2016 at 16:00. It was discovered by a coyote on 5 March 2016 at 17:32. The coyote played with the ball for the next three minutes. In two minutes, it had broken the ¼ inch nylon rope with its carnassial shearing teeth. On 22 March at 03:53 AM, two coyotes returned to the site to investigate the tennis ball. Representative photos in the series are in Appendix 1.

The Plover LogCam (cover photo) was deployed in an area that was actively used by nesting Piping Plovers. We obtained many photos of Plovers, as well as Gulls and unidentified birds. We had multiple photographs of humans walking through the area and engaging in a variety of activities including beer-drinking, urinating, and bird watching. We did not record any photos of unleashed dogs in the area and this was reassuring.

We redeployed a camera trap at the Salt Scrub site that was originally monitored in the spring of 2014. This site was heavily visited by deer in our original monitoring. The purpose of this year's redeployment was to determine if deer activity varied by season (spring versus summer). Deer activity in the summer months was one fourth what it was in 2014 (Table 3). Just as we found in 2014, many of the photos obtained this year were of does and their fawns (Appendix 1).

Representative photos obtained with the camera trap are shown in Appendix 1.

		Location **Total # Visits Recorded** **(Visits/100 Days Sampling Effort)**			
Species	**Common Name**	**East Dune**	**Plover Logcam**	**Log**	**Salt Scrub**
Didelphis virginiana	Virginia Opossum			4 (4.3)	
Homo sapiens	Human		5 (10.0)		
Sylvilagus floridanus	Eastern Cottontail Rabbit			17 (18.5)	
Peromyscus sp.	Deer Mouse			1 (1.1)	
Canis latrans	Coyote		2 (4.0)	10 (10.9)	
Canis familiaris	Domestic Dog	1 (1.6)			
Vulpes vulpes	Red Fox	1 (1.6)		2 (2.2)	

Procyon lotor	Raccoon	1 (1.6)			
Neovison vison	Mink			9 (9.8)	
Mephitus mephitus	Striped Skunk		2 (4.0)	4 (4.3)	
Odocoileus virginianus	White-tailed Deer		11 (22.0)	4 (4.3)	20 (57.1)
Charadrius melodus	Piping Plover		12 (24.0)		
Larus sp.	Gull		8 (16.0)		
	Unknown Birds		21 (42.0)	7 (7.6)	

Table 2. Species recorded in the 2015/2016 sampling period. The total number of visits per species and the rate of visitation in visits/100 camera trap days are provided.

Species	Log Site (Visits per 100 Days)		Salt Scrub Site (Visits per 100 Days)	
	2015	2016	2014	2016
Virginia Opossum	0	4.3		
Rabbit	22.6	18.5		
Deer Mouse	0	1.1		
Coyote	8.1	10.9		
Red Fox	16.1	2.2		
Mink	1.6	9.8		
Skunk	0	4.3		
Deer	0	4.3	193.7	57.1

Table 3. Comparison of 2016 data with previous years at the Log and Salt Scrub sampling sites.

CONCLUSIONS: Our annual camera trapping monitoring is allowing us to determine habitat associations for wildlife on Napatree. Deer are common in many of the habitats and are especially common in the Salt Scrub habitat west of the lagoon. Coyote have become common in the past few years and occur in a variety of habitats. Fox might be declining. Camera trapping in 2016/2017 will help us determine if this trend continues. Mink are common at the Log site but have been recorded in other locations on Napatree. Deer, mice, skunks, rabbits and opossum appear to be habitat generalists and are found in a variety of habitats as long as cover is present. The dune grass and shrub habitats on the eastern end of Napatree had very low abundance of mid-size mammals in this year’s camera trapping.

DATA MANAGEMENT: Photographs are stored in a DropBox folder. Annual tallies are stored in NP_Data/Biological/Photos/CameraTrap

ACKNOWLEDGEMENTS: This project was supported by the University of Rhode Island Coastal Institute, the USDA Renewable Resources Extension Act, the URI College of the Environment and Life Science Extension Program in Natural Resource Conservation and Management, and the United States Fish and Wildlife Service.

Appendix 1. Representative photos from the 2015/2016 camera trapping season

Striped Skunk

Virginia Opossum

Deer Mouse

Red Fox

Coyote

Doe and Fawn

Gull at Log Cam

Walker Inside Plover Nesting Area

Unleashed Dog in East Dunes

Bat Activity on Napatree Point:
A Preliminary Assessment

Peter August [1], Emily Bodell [2], Ryan Kleinert [3], Christian Fox [4], Alyssa Peterson [4] & Laura Craver-Rogers [4]

[1] Department of Natural Resources Science, University of Rhode Island
[2] Departments of Biology and Public Policy, Wheaton College
[3] United States Fish and Wildlife Service
[4] Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District

Photo credit: Peter August

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INTRODUCTION: To our knowledge, bat activity in the Napatree Point Conservation Area has never been systematically evaluated. It is conceivable that habitat conditions on Napatree would be conducive to supporting summertime bat populations and possibly even wintering populations. The subterranean chambers of abandoned coastal canon batteries, such as Fort Mansfield on Napatree, are known to provide roosting habitats for bats in Rhode Island in both summer and winter seasons (Charles Brown, RIDEM, pers. comm.). Judging by the abundance of insectivorous birds on Napatree, for example swallows, it is possible that food abundance is sufficiently plentiful to sustain foraging bats at night.

The purpose of this survey was to gather baseline data on the relative abundance and diversity of bats during the summer months in the Napatree Point Conservation Area, Watch Hill, RI.

METHODS: We used a Wildlife Acoustics (Maynard, MA) Echo Meter Touch bat detector system for our surveys. This consists of an omnidirectional FG ultrasonic microphone that connects to an iPad computer tablet. The microphone can detect ultrasounds between 8 kHz – 125 kHz. Our subjective sense is the microphone can detect bats passing within 15-20 m (50-65 ft) of the microphone. We filtered out any sounds less than 20 kHz. The iPad tablet runs the Echo Meter Touch app software and processes the signals captured by the microphone. The app provides real-time display of a power versus time curve and frequency versus time spectrograms of the calls (Figure 1). In addition, the application provides real-time audible (to humans) playback of the ultrasound. The device uses the Kaleidoscope Pro classifier algorithms to suggest a most-likely identification of the species of bat producing the call. The classifier uses the acoustic properties of the sound to make a statistical determination of the species likely producing the vocalization. Finally, a recording of each bat call is recorded to the iPad and can be transferred to a cloud repository for downloading onto a desktop computer for storage and further analysis.

Figure 1. Echo Meter Plus iPad app screen. The top graph is signal strength (Y axis) versus time (X axis). This tells you how strong a bat call signal you have. The bottom graph shows sound frequency (pitch) versus time. This is used to tell one species of bat from another.

The unit of analysis in our assessment is bat passes per hour. It is impossible to know if sequential bat passes are of the same individual bat or different individuals. Rarely could bats be seen, especially in complete darkness, but their presence was clear from the output of the bat detector. All bat identifications were based on the determination made by the Kaleidoscope Pro classifier. Since the same classifier was used for all sites, any biases would be the same and they should be comparable in a relative sense.

Three locations on Napatree were monitored for three or four nights each. Monitoring began at dusk and ended at 2200 (10:00 PM) and lasted approximately 60-90 minutes. The three locations were the top platform of the southern battery on Fort Mansfield, the Pines (near the southwest corner of the lagoon) and the shrub thicket at the first dune crossing on the eastern end of Napatree (Figure 2). For each survey, we noted the number of species recorded and the number of individual bat passes per species. We relied exclusively on the identifications provided by the Kaleidoscope Pro classification utility. Wildlife Acoustics has published confusion matrices for the identifications their software provides (http://tinyurl.com/jg3d7s5). For the species we recorded, high quality recordings yielded correct classification rates that exceed 90%.

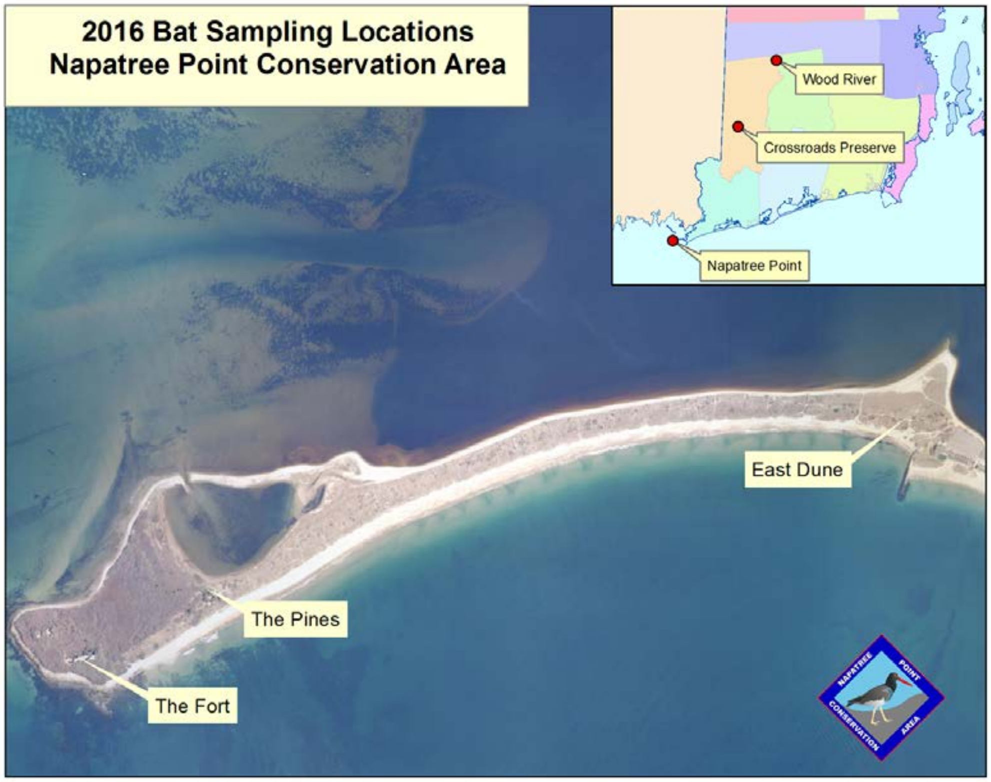

Figure 2. Bat sampling locations in 2016. The inset map shows the locations of our control sites in Rhode Island.

A site of high quality bat habitat was monitored using the same methods over the summer of 2016 and this provided a basis of comparison for the results on Napatree. The site was located on the bank of the Wood River just south of Frying Pan Pond in Richmond, RI. The area abuts the 14,000 acre (5,665 hectare) Arcadia Management Area and is one of RI’s most pristine riparian corridors. Because of its insect abundance, proximity to open water, abundant forest cover and potential roosting sites, and tall canopy along the river corridor it is prime habitat for bats. In addition, a forested upland habitat location was chosen as another control site. It was the venue for the 2016 RI Natural History Survey BioBlitz event (June 10, 2016) at the Crossroads Preserve (Hopkinton RI Land Trust, Figure 2).

RESULTS: In the Napatree Point Conservation Area, five species of bats (Appendix 1) were detected in 85 passes recorded in 15.5 hours of sampling (5.5 bat passes/hour sampled) over 13 evenings (Table 1). Six species of bats were detected 884 times in 8 hours of monitoring (110.5 bat passes/hour sampled) at the two control sites (Wood River and Crossroads Preserve, Table 2). Figure 3 shows the relative proportion of the different species of bats detected at Napatree and the two control sites.

All of the bat monitoring conducted on Napatree was done from sunset to approximately 22:00 (10:00 PM). There was one exception: we conducted a 1.5 hour acoustic survey at the Pines site commencing at 3:20 AM (03:20) on 21 July 2016. In that survey we recorded 1 big brown bat pass and 4 red bat passes.

Species		**Total Number of Passes**
Latin Name	**Common Name**	
Eptesicus fuscus	Big Brown Bat	9
Myotis lucifugus	Little Brown Bat	1
Lasionycteris noctivagans	Silver-haired Bat	29
Lasiurus cinereus	Hoary Bat	10
Lasiurus borealis	Eastern Red Bat	36

Table 1. Number of bat passes recorded for species detected in the Napatree Point Conservation Area.

			Species and Bat Passes/Hour					
Location	**Total Evenings Sampled**	**Total Hours Sampled**	**Big Brown Bats**	**Little Brown Bats**	**Silver-haired Bats**	**Hoary Bats**	**Red Bats**	**Long-eared Myotis**
Napatree								
Fort Mansfield, NTPCA	4	5	0	0	3.0	0	0	0
The Pines, NTPCA	3	4.5	1.56	0.22	2.67	0.22	0.44	0
East Dune, NTPCA	3	5	0.4	0	0.4	1.8	6	0
Control Sites								
Wood River	6	6.5	73.7	1.7	46.9	2.2	4.8	0.2
Crossroads Preserve	1	1.5	10.7	0.7	6.7	10.0	13.3	0

Table 2. Number of bat passes recorded for species detected in the Napatree Point Conservation Area and two control sites.

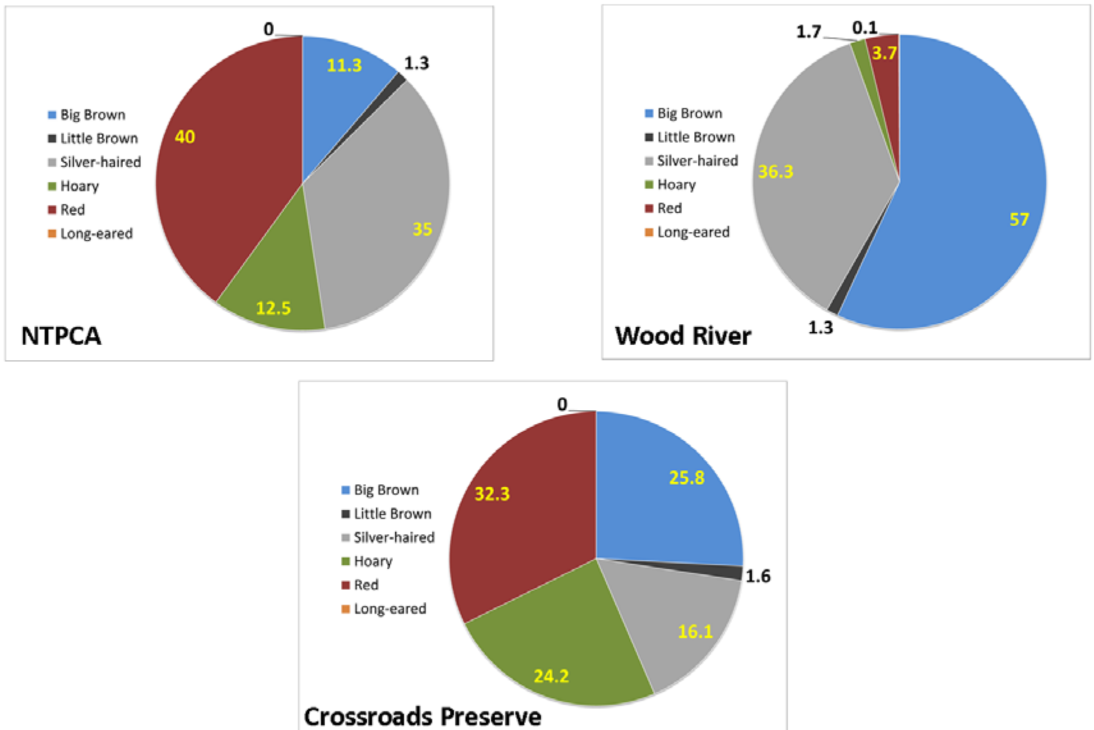

Figure 3. Relative proportion of bat passes per species at Napatree and the two control sites. The values in each pie are the percent of the total bat passes at that location for each species.

CONCLUSIONS: Bat activity on Napatree Point during the summer of 2016 was low compared to high quality bat habitats in our control sites. The diversity of bats was comparable to our control sites but the number of bat passes was much lower. As we expect due to the recent catastrophic mortality from white-nose syndrome, little brown bats were infrequently detected on all sites. In the summer, female big brown and little brown bats roost in colonies (e.g., attics, barns, hollow trees, caves, mines) of tens to hundreds of bats. Males are solitary roosters. Red, hoary, and silver-haired bats are tree-roosting species and typically roost by themselves in the summer. It is interesting to note that colonially-nesting big brown bats were uncommon on Napatree and were much more common on the mainland. Except for the bunkers in Fort Mansfield, roosting sites for big brown bat maternity colonies are not present on Napatree. Janice Sassi and Peter August made a thorough examination of all the underground bunkers in the southern battery (Battery Wooster) of Fort Mansfield on 9 March 2016. Ambient temperatures were still cold then and if bats were using the bunkers as hibernacula, we should have seen them. No bats were observed. In 2013 Sassi and August explored the bunkers of the northern battery (Battery Crawford) in the winter and no bats were found on that survey as well.

Bat passes were highest at the Pines location and lowest in Fort Mansfield. The Eastern Dunes site had intermediate levels of bat activity. Further sampling next summer (2017) should be conducted to see if these geographic patterns of bat activity are consistent. Based on our early morning sample at the Pines in July, bat activity occurs at least at dusk and dawn. We might consider establishing a continually running acoustic bat detector on Napatree for the whole summer and Fall. It would be interesting to see if there is a surge in bat activity in the Fall as tree bats migrating south pass through the area.

DATA MANAGEMENT: The data reported here are located in the DropBox folder NP_Data\Biological\Tabular\Bats\2016Surveys

ACKNOWLEDGEMENTS: This project was supported by the University of Rhode Island Coastal Institute, the USDA Renewable Resources Extension Act, and the URI College of the Environment and Life Science Extension Program in Natural Resource Conservation and Management, the Watch Hill Conservancy, and the Watch Hill Fire District. Thanks to the Rhode Island Natural History Survey for, once again, hosting a magnificent BioBlitz event where we were able to monitor bats at a control site to compare to Napatree Point.

APPENDIX 1: Bat species recorded in the Napatree Point Conservation Area. All photos from USFWS or USGS.

Big Brown Bat
Eptesicus fuscus

Little Brown Bat
Myotis lucifugus

Silver-haired Bat
Lasionycteris noctivagans

Hoary Bat
Lasiurus cinereus

Red Bat
Lasiurus borealis

Native Vegetation Restoration and Invasive Plant Control in the Napatree Point Conservation Area 2016

Hope Leeson [1], Peter August [2] & Janice Sassi [3]

[1] Rhode Island Natural History Survey
[2] University of Rhode Island, Department of Natural Resources Science
[3] Napatree Point Conservation Area, Watch Hill Conservancy and Watch Hill Fire District

Photo credit: Peter August

Native Vegetation Restoration and Invasive Plant Control in the Napatree Point Conservation Area 2016

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INTRODUCTION: Management of the numerous social trails traversing the dune has formed a focal point for the re-vegetation projects implemented within the dune system at Napatree Point. Social trails represent potential areas of degradation during storm events, and efforts have been made to limit the number of trails crossing the dune. Re-vegetation projects carried out in 2014 and 2015 have focused on closing excess trail systems, while increasing vegetation biodiversity to provide a variety of food resources for pollinator and bird species. Management efforts since 2014 have also involved the control of invasive plant species, with a focus on the less-infested area at the eastern end of the dune system. Our work in 2016 focused on monitoring the growth and survival of plants installed in Phases I (2014) and II (2015) of the re-vegetation program (Figure 1A). Invasive species management was limited to the continued control of one species (tree of heaven).

Monitoring the results and consequences of management efforts within an ecological system are essential to determining successes and failures, and can lead to a greater understanding of the whole system. In any natural area, biotic as well as abiotic elements play a role in determining what a system looks like and which organisms populate it. Our monitoring efforts in 2016 lead us to the realization that the balance between carnivores and herbivores plays a large role in determining the success or failure of plant species at Napatree Point. An apparent reduction in the red fox population (carnivore) seems to have favored that of meadow voles (herbivore), which has led to greater herbivory on selected vegetation (Figures 1B & 2A). At the outset of the re-vegetation projects at Napatree Point, we selected a broad range of species that can be found in coastal dune systems throughout Rhode Island. Monitoring their introduction to the Napatree dune system has shown us which species are suitable for Napatree at the present time.

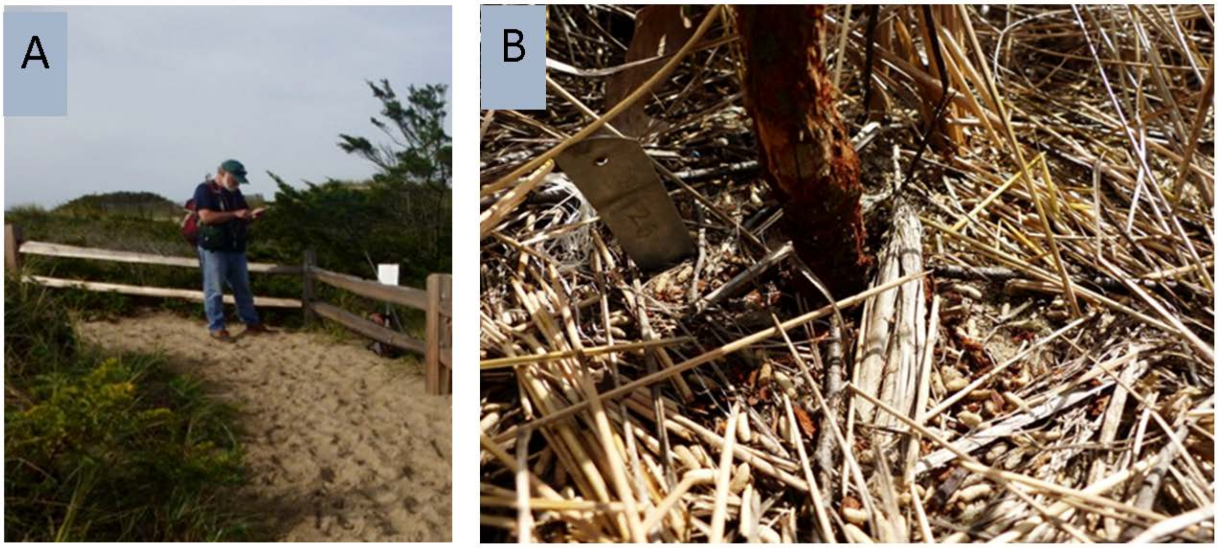


Figure 1. (A) Collecting monitoring data in an east dune closed social trail marked by split rail fencing. (B) Beach plum and American beachgrass showing evidence of browse by meadow voles.

METHODS:

Monitoring and Management: Phase I

The 2014 dune protection planting included a mix of tree, shrub (8 species), and perennial wildflower, vine, and grass species (10 species). In 2015 a subset of plants, within each species group installed in Phase I, were given a number, and an identifying tag, to enable relocation of individual plants from year to year to track their progress. For each of these plants in 2016, survival and growth data were recorded. The overall height of each plant was measured, the density and proximity of surrounding vegetation, as well as impacts to the leaves and stems by herbivores. Root and underground stem growth was assessed by quantifying the number of stems (ramets) growing off of the root system.

Monitoring and Management: Phase II

In the fall of 2015, 425 plants were placed into three additional social trails that traversed the dune system. The species mix included a total of eight species, comprised of three shrub, one grass, two vines, and two herbaceous perennial species. The total number of each species placed into each trail was recorded at the time of planting. In 2016, as with the Phase I planting, a selection of each woody species was monitored on each trail, with individual plants designated numerically and given an identifying tag. The total number of perennial grass, herbaceous, and vine species re-located on each trail were recorded. As with the species in the Phase I planting, survival and growth data were collected. The overall height of each plant was measured, the density and proximity of surrounding vegetation, as well as impacts to the leaves and stems by herbivores. Root, and underground stem growth was assessed by quantifying the number of stems (ramets) growing off of the root system (Figure 2B).

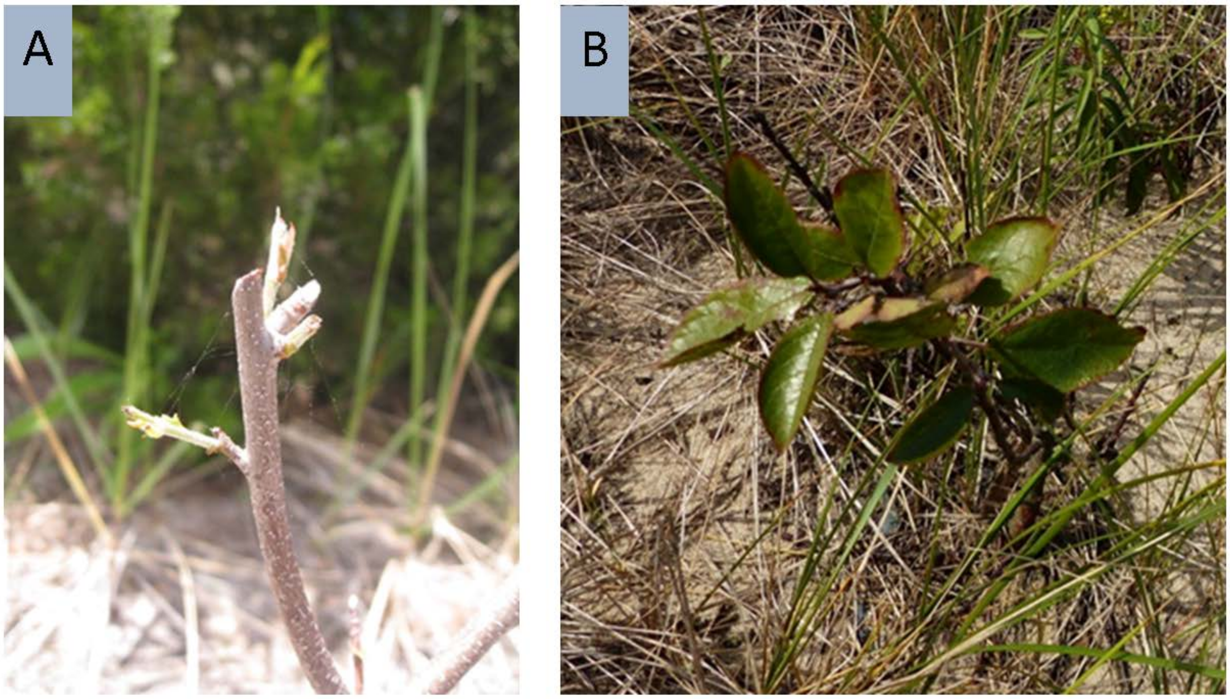


Figure 2. (A) Aronia arbutifolia *and browse impacts. (B)* Aronia arbutifolia *with re-sprouted leaves.*

<u>Invasive Species Management</u>

Invasive species management is an effort that often involves multiple years of treatment and monitoring in order to successfully eradicate the species' population. Since 2014, management of invasive species within the dune system at Napatree Point involved a combination of mechanical and chemical controls. In all cases, mechanical control has been the first method applied. This has served in many cases to eliminate populations, and for others has reduced the overall biomass of populations requiring chemical herbicide to control growth. In 2016 all invasive species populations that were treated in 2014 and 2015 were monitored to determine the extent of survival and need for continued management. Treatment of persisting populations of invasive species was limited to a single population of tree of heaven *(Ailanthus altissima)* located in the eastern-most portion of the dune (Figure 3). All above ground stems were cut and left to dry on the dune. A glyphosate-based herbicide was then applied directly to the cut stem surface.

Figure 3. Tree of heaven in the eastern end of the dune.

RESULTS AND DISCUSSION:

<u>Monitoring and Management: Phases I and II</u>

Species selection for all plantings at Napatree was based on a knowledge of plant species which a) are already present on Napatree Point, b) exist in dune and coastal lagoon systems elsewhere in Rhode Island, and c) are adapted to disturbance regimes and readily re-sprout when above ground vegetation is compromised. The survival and health of the species planted are the focal point of the monitoring efforts carried out annually since 2014. Losses over time are inevitable, as environmental factors place stress on plants and as a result, select for more tolerant individuals. Plants lost over the two-year time period have been due to a combination of factors, including changes in salinity on the salt marsh, drought, trampling, removal of plants by humans, and being eaten and pulled up by herbivores such as rabbits, deer, meadow voles, and insects. When evaluating the survival of the planted species relative to the impacts of herbivory by mammals and insects, it is interesting to note that the species exhibiting the least amount of impact are species which are already present at Napatree. As illustrated in Figure 4, greater than 50% of the individual plants of the following species have lost *less than* 10% of their total biomass due to herbivory.

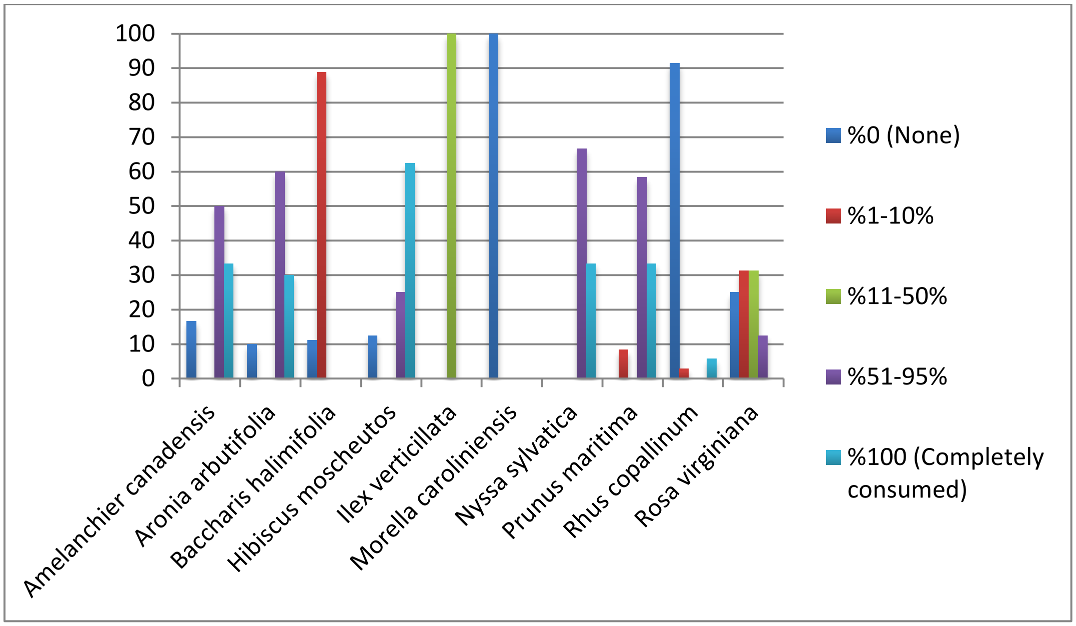


Figure 4. Herbivory to planted woody vegetation at Napatree Point Conservation Area in 2016. The Y axis is the percentage of herbivory to the different species of plants.

Examples of native species planted in this study:

> *Baccharis halimifolia*, groundsel tree (naturally present in salt marsh)
> *Morella caroliniensis,* bayberry (naturally present in dune and saltmarsh)
> *Rhus copallinum,* winged sumac (naturally present in shrub habitat on the 'Nap')
> *Rosa virginiana,* Virginia rose (naturally present in dune, and shrub habitat on the 'Nap')

Foliage health can be an indicator of herbivory, fungal pathogens, or stress from nutrient deficiencies, or drought. Figure 5 shows that in the case of the shrubs planted at Napatree Point, species that were already present prior to the planting were observed to be in better health than species which occur in dune systems elsewhere. Three exceptions to this are reflected in the foliage data: chokeberry *(Aronia arbutifolia),* winterberry *(Ilex verticillata)*, and beach plum *(Prunus maritima)*. However, when compared with Figure 4, only the winterberry is really performing well. Both beach plum and chokeberry have sustained high degrees of browsing; each with 60% of individuals having greater than 50% of their total mass eaten, and 30% of all individuals having been completely eaten. Foliage health (Figure 5) is a reflection of the leaves, which had re-sprouted from browsed stems, which at the time of our monitoring were healthy. The plants are performing according to the third criteria for which they were selected: being adapted to disturbance regimes, they have the ability to re-sprout from stems and root systems in response to the stress of top kill by salt spray or overwash during storm events. Re-sprouting in response to browse is functionally the same response. Over time, the ability of the plants to re-generate leaves and stems will require the plants to allocate an increased amount of energy; a response they may not be able to sustain if they cannot grow beyond the reach of the herbivores faster than they are cropped back.

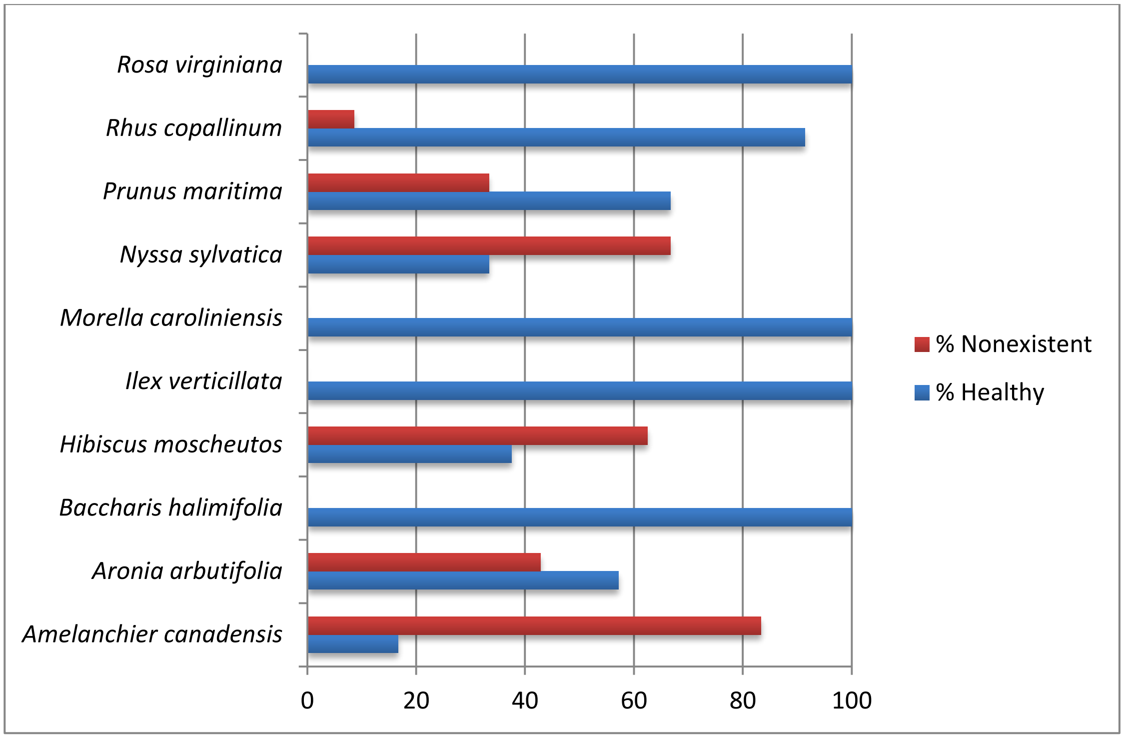


Figure 5. Foliage health of planted woody vegetation at Napatree Point Conservation Area in 2016.

Browsing preferences by herbivores are generally based on familiarity with a species, either from a positive (it tastes good and doesn't make me sick) or negative (it tastes terrible) perspective. The sap of winged sumac *(Rhus copallinum)* contains a sticky latex which may taste bitter, Virginia rose *(Rosa virginiana)* has thorns, and bayberry *(Morella caroliniensis)* and groundsel tree *(Baccharis halimifolia)* have bitter resins in the leaves. These species being already present on Napatree Point, may owe their success to herbivore familiarity with negative consequences experienced. The success of winterberry *(Ilex verticillata)*, on the other hand, may be temporarily due to complete unfamiliarity with the species by the herbivores residing on Napatree Point. While the species can be found on dune systems elsewhere in the state it is relatively uncommon, and is primarily a shrub of forested wetlands. In forest situations it can often be a preferred browse species by deer. The species is in the holly family and may also have a smell associated with bitter taste or toxins and is therefore avoided. Species at Napatree that are being heavily browsed are shad *(Amelanchier canadensis)*, chokeberry *(Aronia arbutifolia)*, and beach plum *(Prunus maritima)*, all in the rose family, and black gum *(Nyssa sylvatica)*, which is in the dogwood family. These two families are often favored by herbivores in many habitats and may have sweet smelling leaves or bark, making them more desirable relative to the other species available.

Growth (plant height) is another indicator of plant health, and in the case of the woody plants at Napatree, is also an indicator of the impact of browsing by herbivores. Figure 6 shows the average height measured for each species during three different monitoring sessions. All woody species, except beach plum (*Prunus maritima*) planted at Napatree Point showed an increase in height over the course of the 2015-growing season. However, due to the impacts of browsing in 2016, only groundsel tree (*Baccharis halimifolia*) grew taller on average. Another limiting factor for overall growth in height is the degree to which the top portion of stems are damaged by winter cold. Although winged sumac (*Rhus copallinum*, Figure 8B) and Virginia rose (*Rosa virginiana*) performed relatively well in 2016 based on other data collected, it is apparent that even for these species, overall growth in height was limited, which was attributed to winter damage. As plants become better established growth of additional stems will replace those with dead tips.

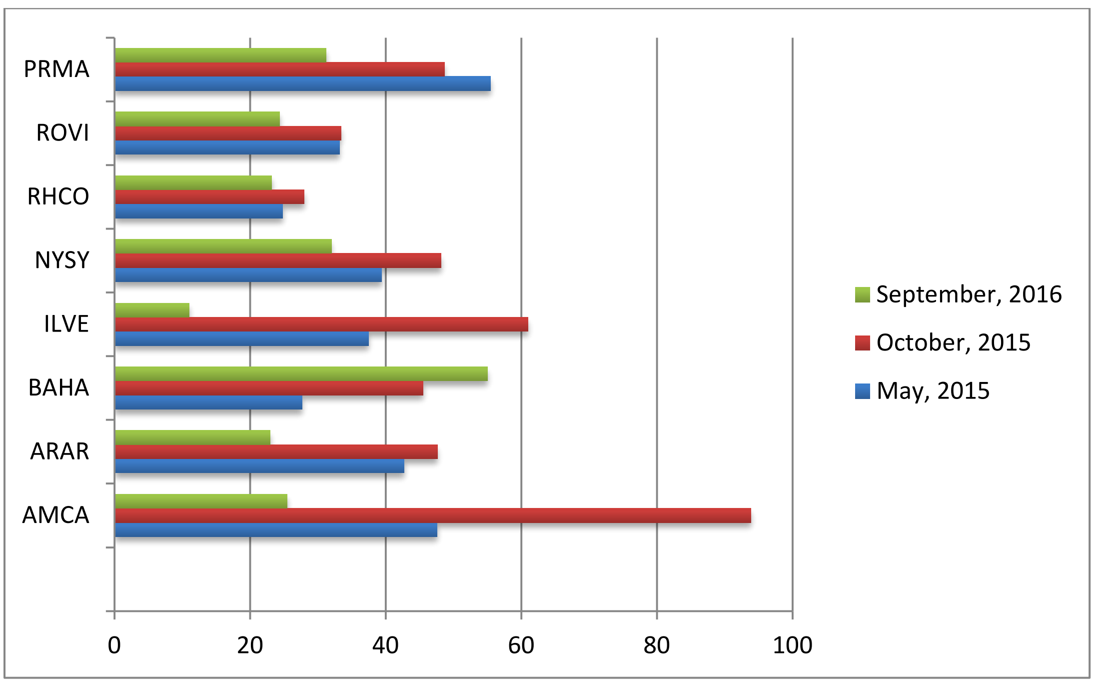
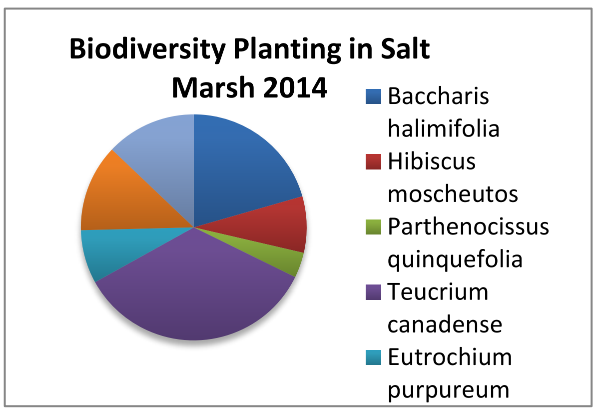


Figure 6. Growth height (centimeters) of Phase I woody vegetation at Napatree Pt. Conservation Area. Species abbreviations are: PRMA - Prunus maritima, *ROVI* - Rosa virginiana, *RHCO* - Rhus copallinum, *NYSY* - Nyssa sylvatica, *ILVE* - Ilex verticillata, *BAHA* - Baccharis halimifolia , *ARAR* - Aronia arbutifolia, *and AMCA* - Amelanchier canadensis.

The data gathered over the past two years has provided us with important information regarding which plants we should focus on in the future. At present a limited number of the total number of native dune species introduced has been successful in augmenting species biodiversity on the dune. The following pie-charts depict the diversity of species planted and their relative abundance, for each of the three areas at Napatree Point, and compares survivorship conditions in 2016. The charts depict that successful species in each planted area, increasingly occupy larger proportions of the whole when compared year-to-year.

The July 2014 salt marsh planting was made up of a total of seven species, four of which represented introductions of native salt and brackish marsh species to Napatree Point. Of the total, three species were surviving in 2016, one of which was a new introduction to the flora of Napatree (Figure 7). When comparing abundance among the surviving species in 2016, however it is clear that of the three species, it is *Baccharis halimifolia* that is thriving. One measure of success for plant species is the ability to reproduce. In 2016 groundsel tree began flowering and producing seed (Figure 8A).



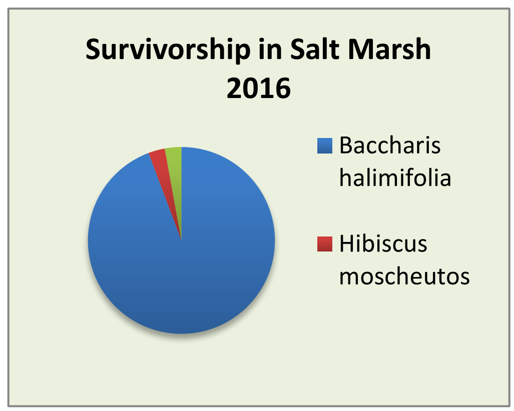


Figure 7. Relative abundance of the seven species planted in the salt marsh in 2014 (left panel) and 2016 (right panel)

Lack of survival among four of the species - Joe-Pye weed *(Eutrochium purpureum)*, salt marsh fleabane *(Pluchea odorata)*, saltmarsh aster *(Symphiotrichum tenuifolium)*, and germander *(Teucrium canadense)* - was due to the abiotic stresses of drought and salinity resulting from changes in environmental factors occurring between the date of planting in July of 2014 and fall of 2016.

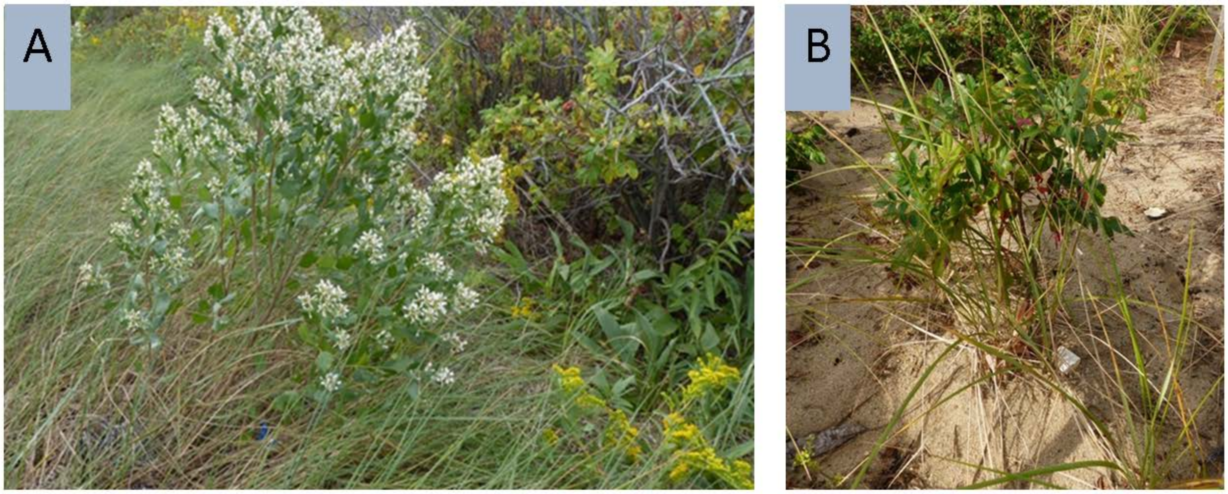
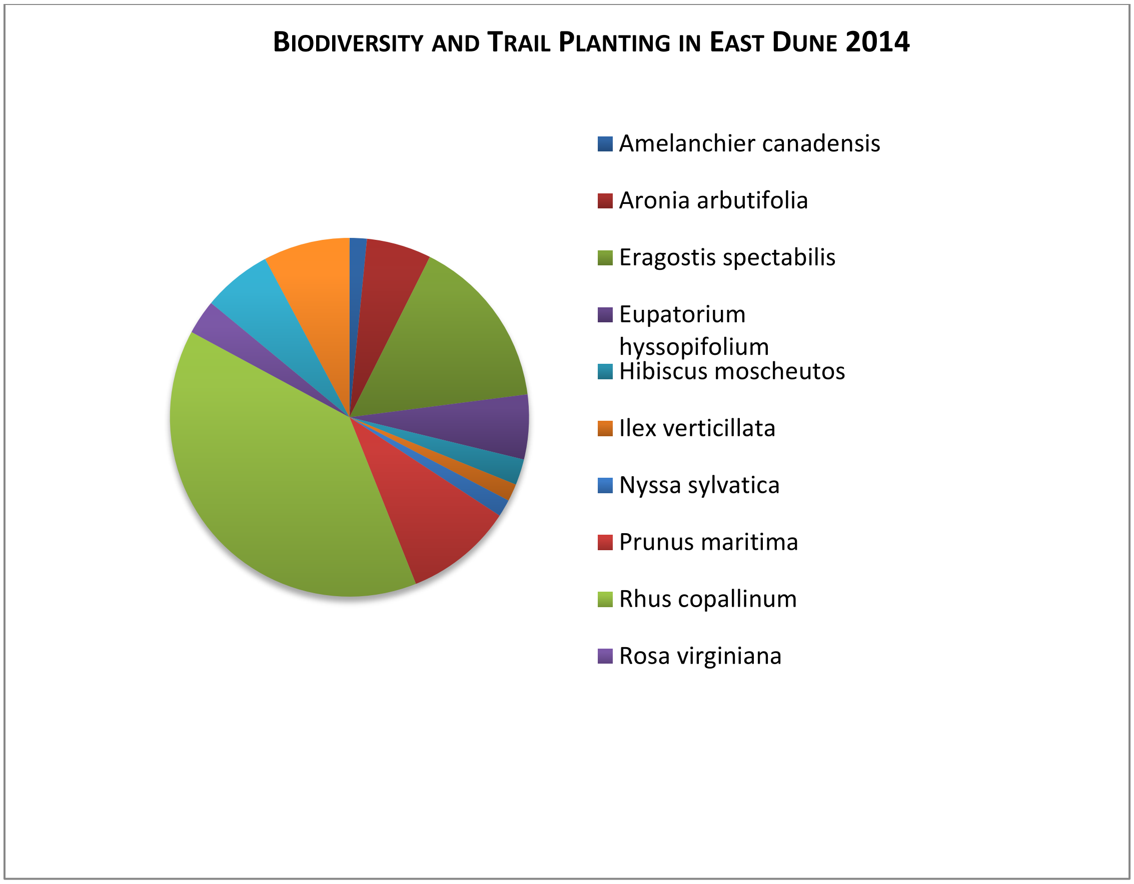


Figure 8. (A) Planted Baccharis halimifolia *in fruit along the lagoon.(B)* Rhus copallinum *with healthy growth in east dune*

The September 2014 planting at the east end of the dune at Napatree Point consisted of a mix of 12 species. Of these, 12 were dune species found elsewhere in Rhode Island, but not previously at Napatree Point. Two species were pre-existing in some portion of the Napatree dune system. Our monitoring of the planting showed two of the pre-existing species had been lost, and all others survived in various degrees of health (Figure 9). The species lost, gray goldenrod *(Solidago nemoralis)* and swamp milkweed *(Asclepias incarnata),* failed to survive due to a combination of drought and trampling stresses where they were planted along old social trails. Two pre-existing species, winged sumac and Virginia rose are doing well in proportion to the other species. In addition, two introduced species, hyssop-leaved boneset *(Eupatorium hyssopifolium*, Figure 10B*)* and purple lovegrass (*Eragrostis spectabilis*) are doing well and produced flowers and fruits in 2016.

When the data for the two areas planted in 2014 are combined, they show that 66% of all species survived into 2016, with four species out of six of the pre-existing species planted surviving, and eight species out of 12 of the introduced species surviving (Figure 9). It is interesting to note that while a substaintial number of introduced species are surviving in some quantities, survival represents only one aspect of a species' sustainability over the long term. For example, species such as beach plum (Figure 10A), were determined to be alive in the Fall of 2016, however just under 60% had greater than 50% of their foliage browsed and another 30% of the plants had been completely consumed. The survival of this dune species, while well suited for the habitat, may be tenuous in light of impacts by the herbivore populations present on Napatree Point.



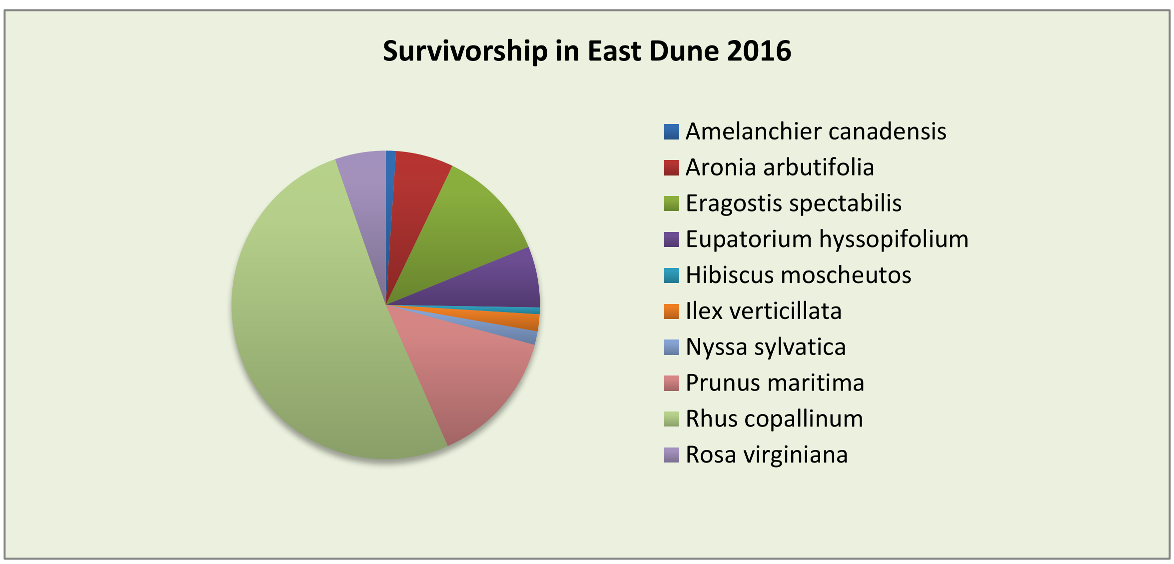


Figure 9. Relative abundance of the 10 surviving species planted into East Dune in 2014 (top) and 2016 (bottom).

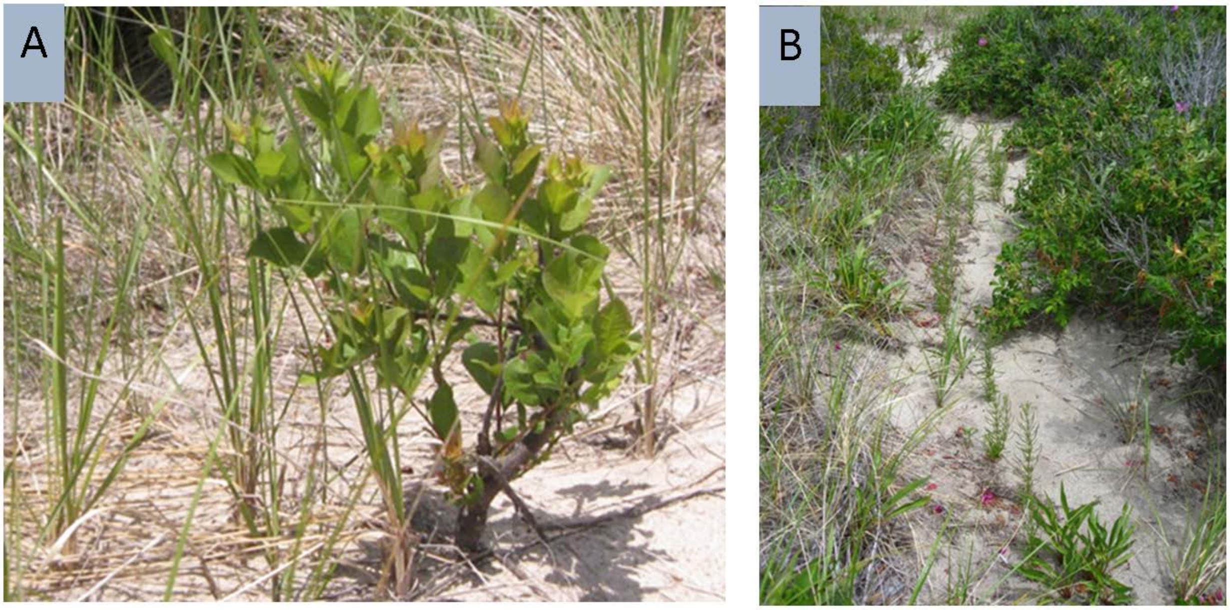
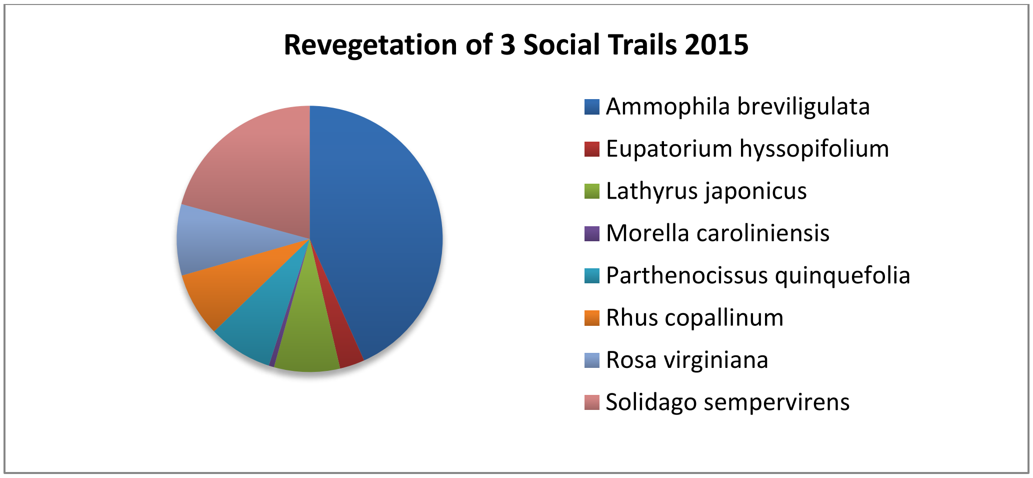


Figure 10. (A) Beach plum showing healthy growth in spring 2016. (B) Hyssop-leaved boneset and seaside goldenrod planted into social trail.

Plant selection in 2015 within the three social trails, was made based on successes observed for pre-existing plants placed into the previous two areas, and included a mix of seven pre-existing and one new species which had performed well in the Phase I planting (Figure 11). Added to the mix were four pre-existing species not previously utilized - American beachgrass *(Ammophila breviligulata)*, beach pea *(Lathyrus japonicus)*, bayberry *(Morella caroliniensis)*, and seaside goldenrod *(Solidago sempervirens)* - but more specifically appropriate for the section of dune. The species added are typically dune-building plants that withstand burial by blown and storm-driven sand. The species also serve to cool sand temperatures through the shade of their leaves. Of the eight species planted, all eight survived into 2016 (Figure 11). Losses occurred to some species due to trampling by people continuing to utilize the social trails, and some plants were actually pulled up out of the ground.



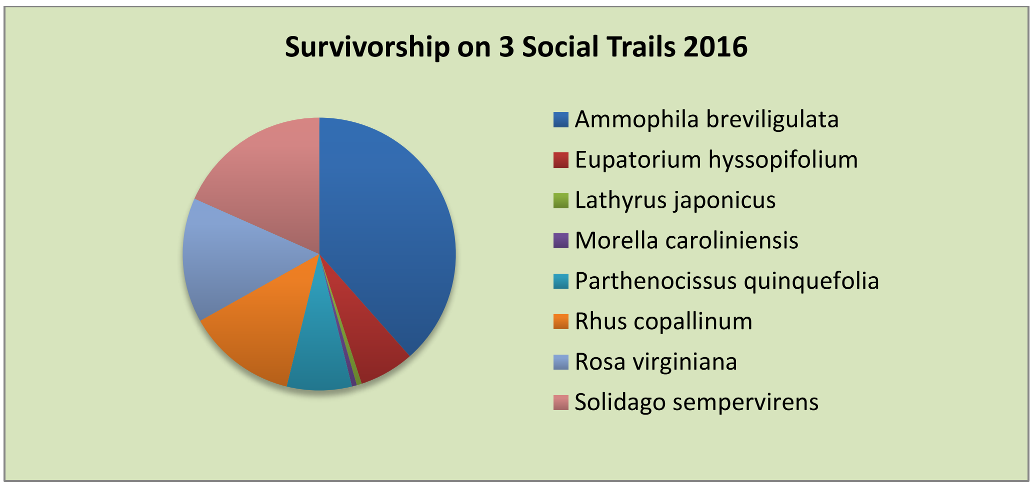


Figure 11.Relative abundance of species planted into the dune along social trails in 2015 (top) and 2016 (bottom).

Invasive Species Management

While several species continue to be present in the eastern part of the dune system, their overall numbers are diminishing. Three of the eight species targeted for treatment have been controlled and showed no regrowth in 2016 (Table 1). This includes a population of Japanese knotweed *(Fallopia japonica)*, which although a single stem sprouted in June of 2016, it had died back completely by July and no other stems appeared. The single plant of Morrow's honeysuckle *(Lonicera morrowii)* treated in 2014 has not re-sprouted, nor has a population of porcelain berry *(Ampelopsis brevipedunculata)*. The single large glossy buckthorn *(Frangula alnus)* continues to re-sprout from the root system and will require treatment in 2017 to keep its growth under control. Treatment should be similar to that applied to tree of heaven. The single population of black swallowwort *(Cynanchum louiseae)* has been managed by hand-pulling the stems and roots; an activity that should continue annually to prevent it from becoming more widespread. Seedpods, which are dispersed by the wind, should be picked off before they mature to prevent further spread of the species in the east dune. Populations of Asiatic bittersweet *(Celastrus orbiculatus)* will also need to be monitored and managed either through hand pulling or by cutting stems and applying a glyphosate-based herbicide. Horned poppy *(Glaucium flavum)*, an annual species with seeds that are buoyant and salt tolerant, will likely continue to wash ashore and germinate, and so should be looked for as a part of regular beach patrols.

Species Name	**Common Name**	**# of Populations 2014**	**# of Populations 2015**	**# of Populations 2016**
Ailanthus altissima	Tree of heaven	5	2	2
Celastrus orbiculatus	Asiatic bittersweet	8	5	3
Cynanchum louiseae	Black swallowwort	1	1	1
Glaucium flavum	Horned poppy	3	1	1
Lonicera morrowii	Morrow's honeysuckle	1	0	0
Fallopia japonica	Japanese knotweed	1	0	0
Frangula alnus	Glossy buckthorn	4	2	1
Ampelopsis brevipedunculata	Porcelain berry	0	1	0

Table 1. Invasive plant species managed within the eastern dune and western beach communities of Napatree Point Conservation Area in 2014 - 2016.

CONCLUSION: This year's monitoring efforts proved to be a demonstrable example of the importance of monitoring to inform and provide feedback on the success and failures of restoration and stewardship efforts. The set of data gathered revealed that while the majority of plants selected for introduction into the dune system to enhance biodiversity are capable of surviving in the harsh habitat of the dune and marsh systems at Napatree Point, many are subject to intense browsing by herbivores. The pressures of this factor will determine the ultimate success or failure of each species. The experiences gained over the last two years regarding plant selection and the degree of management required to allow certain desirable species to mature beyond the reach of herbivores, will determine which plants we select for future plantings.

The experiences gained through this work has also proven to be of interest to organizations, such as the Natural Resources Conservation Service, United States Fish and Wildlife, Rhode Island Department of Environmental Management Division of Fish and Wildlife, University of Rhode Island Coastal Institute, and the Rhode Island Wild Plant Society. Three tours of the planted areas were given over the course of the summer in 2016. Over time, it is hoped that we will be able to share further knowledge gained through the restoration of social trails on the Napatree Point dune system.

DATA MANAGEMENT: Plant monitoring data are stored in the NP-Data folder on DropBox under Biological/Tabular/Restoration

ACKNOWLEDGMENTS: Field work for the monitoring of the vegetation management at Napatree Point in 2016 was supported through a combination of funds and assistance provided by the University of Rhode Island Coastal Institute, the University of Rhode Island Cooperative Extension, the USDA Renewable Resources Extension Act (RREA), the Watch Hill Fire District, and the Watch Hill Conservancy. Staff of the Napatree Point Conservation Area provided field assistance, as well as assistance for each of the site tours given in 2016. We are grateful for the administrative support that has been generously provided by Grant Simmons (NTPCA) and Deb Bourassa (URI).

An Ecological Reconnaissance of the Napatree Lagoon:
Fish and Water Quality 2016

Nicole Rohr [1], *Peter August* [2], *Christian Fox* [3], *Emily Bodell* [4] *& Janice Sassi* [3]
[1] Coastal Institute, University of Rhode Island
[2] Department of Natural Resources Science, University of Rhode Island
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[4] Departments of Biology and Public Policy, Wheaton College

Photo credit: Janice Sassi

An Ecological Reconnaissance of the Napatree Lagoon: Fish and Water Quality 2016

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INTRODUCTION: The 9.9 acre lagoon on the western end of Napatree Point is critical habitat for shorebirds, horseshoe crabs, and presumably marine organisms. Until 2014, to our knowledge, there had been no systematic study of the biology of the lagoon. Over the past three years, we have investigated the physical and biological characteristics of the lagoon. These parameters, when taken together, begin to form a picture of habitat structure and species interactions within the lagoon itself, and how the lagoon supports associated species. In the first year, we mapped the bathymetry of the lagoon (State of Napatree (SoN) report 2014); in the second year, we began a biological inventory of the lagoon with a focus on fish and algae (SoN report 2015); and this year we continued the biological inventory to examine annual variability. The goal of the study was to determine what fish species occurred in the lagoon, and the spatial and temporal variability in species composition and mean total length from May through September. Furthermore, we measured water quality parameters in the lagoon over the summers of 2015 and 2016. See Chapter 15 (Green et al.) on algae surveys of the lagoon that were done concurrently with the nekton surveys.

These data will add to the baseline of the ecology of the Napatree lagoon, and allow us to monitor changes in the fish community and water quality of the lagoon, which have larger ecological ramifications for shorebirds that feed and nest along the shores. The lagoon is sensitive to changes in tidal flushing as large storms change the breach in the lagoon. When future storms hit Napatree, and if the breach is altered, we will be able to determine the impacts of increased or decreased tidal flushing of this system.

METHODS: From May through September 2016, subtidal monthly seine surveys were conducted and physical water quality parameters were recorded at four sites in the Napatree lagoon (hereafter referred to as NE, NW, SE, and SW; see Figure 1) during low tide. Sampling dates were: 4 May, 3 June, 1 July, 1 August, and 1 September. On each sampling date at each site, a 20 foot 1/8-in mesh Douglas Net Minnow seine was pulled from the interior of the lagoon perpendicular to the shore for 40 feet, ending on the beach. The maximum depth at the start of each seine pass was never more than 1 m (waist deep). All fish were identified to the species level and the total length (cm) was recorded. In seine hauls where large numbers of fish were collected, a minimum of 30 individuals of each species were measured and all remaining fish were counted and recorded as adult (≥2 cm) or small juvenile (<2 cm). In addition to fish, all crabs were identified to the species level and carapace width measured (cm), except hermit crabs, which were identified to the genus level and counted only. All snails were identified to the species level and counted. All organisms were released alive once data recording was completed.

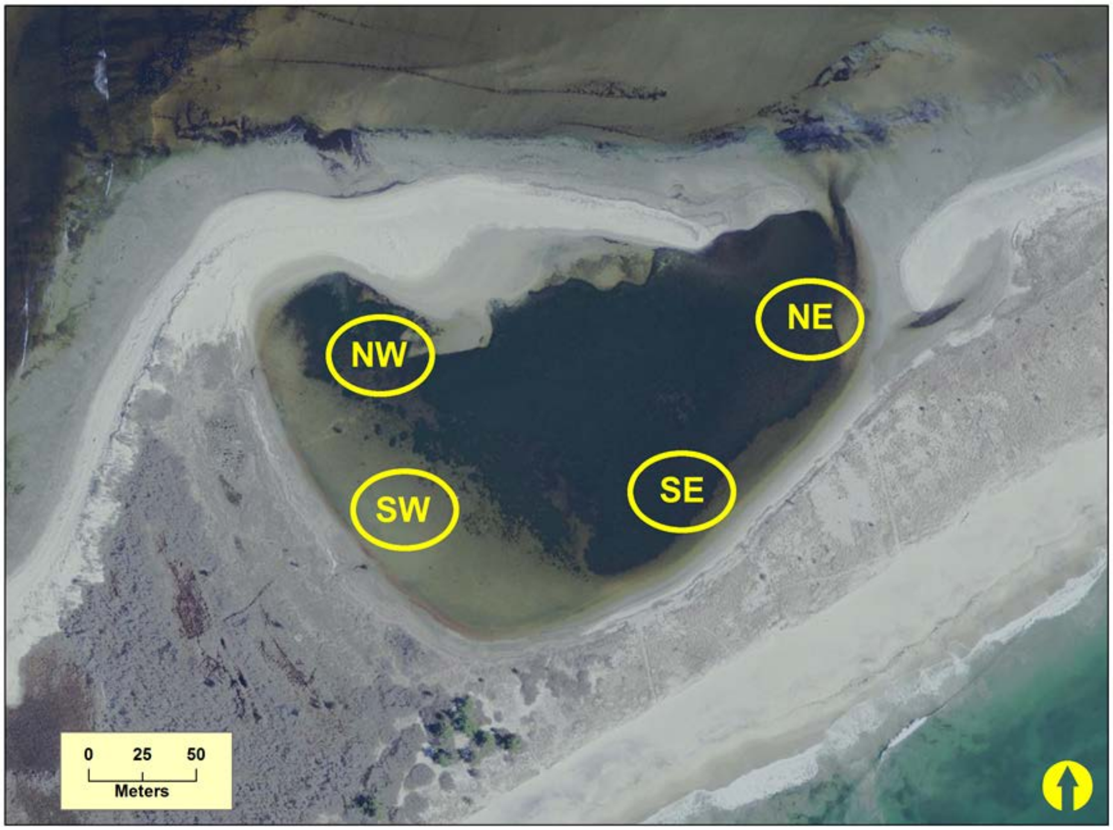


Figure 1. Sampling regions in the Napatree Lagoon for fish, algae, and water quality monitoring

Physical water quality parameters were recorded on each sampling date and at each sampling site from the bottom of the water column at the start of the seine haul 40 feet from shore using a YSI Pro2030 DO/Salinity water quality meter equipped with a YSI 2003 Polargraphic DO sensor. The instrument was maintained and calibrated by the URI Watershed Hydrology Laboratory. The following parameters were measured during water quality assessments: dissolved oxygen (mg/L; hereafter DO), salinity (parts per thousand, PPT), and temperature (^{o}C). Unlike in 2015, no Secchi depth was measured due to the shallowness of the lagoon and high clarity of the water that typically results in visibility to the bottom. Water quality data were logged into an iPad in the field using a data entry form developed with Fulcrum software. Data records were immediately uploaded into a cloud-based database.

Between monthly seine samples of the lagoon we measured water quality at hourly intervals over a full tidal cycle, from low tide to high. Sampling dates for the tidal DO measurements were: 11 May, 14 June, 21 July, and 22 August. The purpose of the DO sampling was to determine if tidal flushing influenced DO levels in the lagoon. All tidal cycle DO samples were conducted in the SE region in the lagoon and two measurement samples were taken in the SW as well. Measurements were taken hourly using the YSI instrument described above and consisted of: depth (cm) at the sampling station (marked by a floating buoy for the duration of the sample), dissolved oxygen (mg/L), salinity (parts per thousand, PPT), and temperature (^{o}C).

Comparison of group means was done using T tests for pairwise comparisons and ANOVA when three or more groups were compared. JMP software was used for all statistical analyses.

RESULTS:

Fish and Invertebrates

Species composition and abundance varied spatially and temporally in Napatree lagoon in 2016, but the variation was not statistically significant (spatially, p=0.65; temporally, P=0.09). In general, total abundances (mean number ± SD) across all sites were lowest in May (4.25±1.50) and June (20.75±24.96), mid-range in July (142.25±189.95) and September (264.00±174.02), and highest in August (1,254.00±1,471.54). Fish abundance was lowest in May with only 17 individuals found at all four sites combined (Figure 2), and abundance peaked in August at the NW site with 3,442 individuals, the majority of which were small juveniles < 2cm total length. When combined over all five months, mean total abundance was similar at the NE, SE, and SW sites (291.00±326.11, 171.20±225.77, and 160.4±200.92, respectively) and higher at the NW site (725.60±1,518.80), again driven by the August sample with nearly 3,500 individuals (Table 2).

Furthermore, total abundance was not significantly different between 2015 and 2016 (p=0.18) nor was there a significant difference in abundance between years at each site (p=0.09). While more total fish were found in 2016 than in 2015 (6,741 and 2,554 individuals, respectively), there was high variability each year among seine hauls. Fish abundance was notably lower when DO levels were below 3.0 mg/L and classified as hypoxic, with the exception of the August NE seine haul with 424 individuals and 2.4 mg/L DO (Table 3; see *Water Quality* below).

A total of nine different fish species were found in 2016, with the most prevalent species being *Fundulus majalis*, *F. heteroclitus*, and *Menidia menidia* (Table 1). This is an increase from six total species found in 2015, but the most prevalent species remained the same both years (SoN 2015). A total of four invertebrate species were found in Napatree lagoon in 2016, with *Carcinus maenas*, *Ilyanasa obsolete*, and *Pagurus* spp. consistently found (Table 1). This is two fewer species than were found in 2015, with the absence of *Calinectes sapidus* and *Limulus polphemus*;

however, both of these species are regularly seen in the lagoon, but are fast-moving and not easily captured in the seine net, and only one individual of each species caught in 2015.

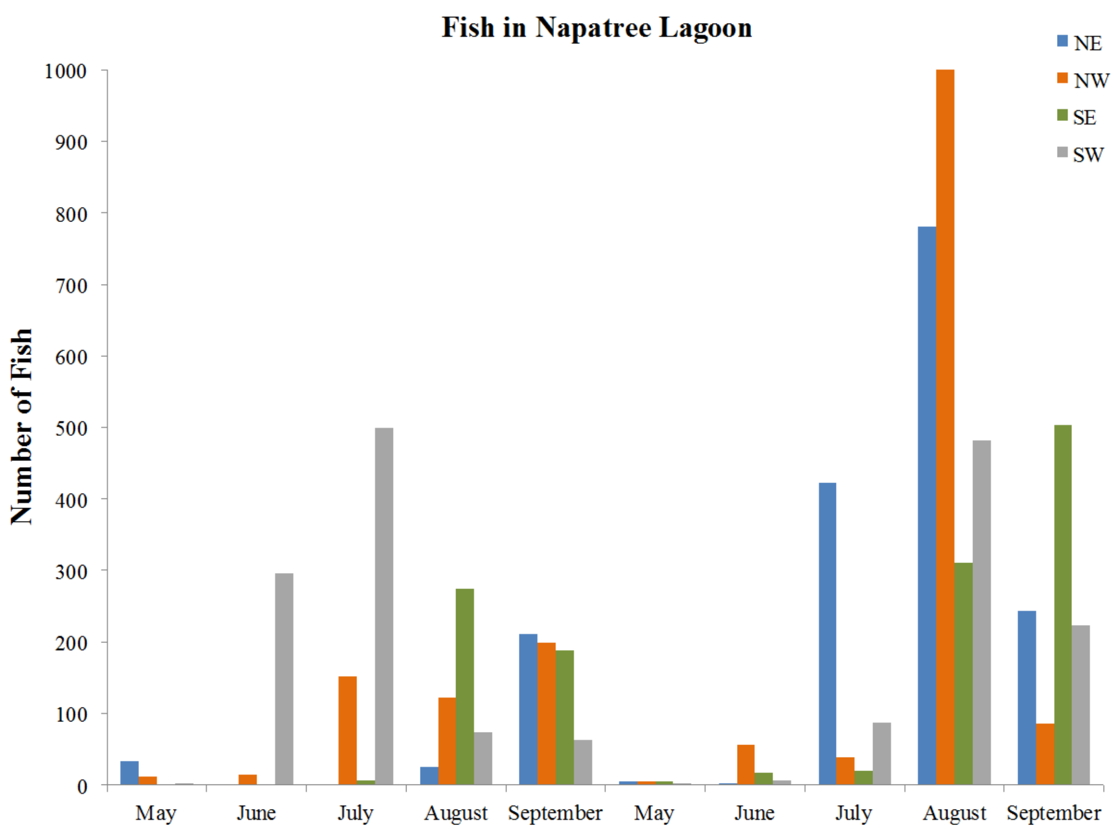


Figure 2. Numbers of fish captured at each sampling location during each sampling month in 2015 and 2016, respectively.

The mean total length of fish varied significantly among months ($p<0.001$), were slightly different among transects ($p=0.06$), but not between years ($p=0.72$). There were highly significant interaction terms among years, transects, and months ($p<0.001$). The mean total length was smallest in May and June, was significantly larger in July and August, and then smaller again in September (Figure 4, three most common species). While there was no significant difference among sites, the mean total length was generally higher at the SE site than all other sites. Mean total length (cm $\pm$ SD) over all months for fish >2 cm ranged from 4.22$\pm$0.96 to 5.75$\pm$0.92 for *F. heteroclitus*, 3.32$\pm$1.07 to 3.80$\pm$1.67 for *F. majalis*, and 2.93$\pm$0.58 to 4.49$\pm$3.10 for *M. menidia* (Figure 4).

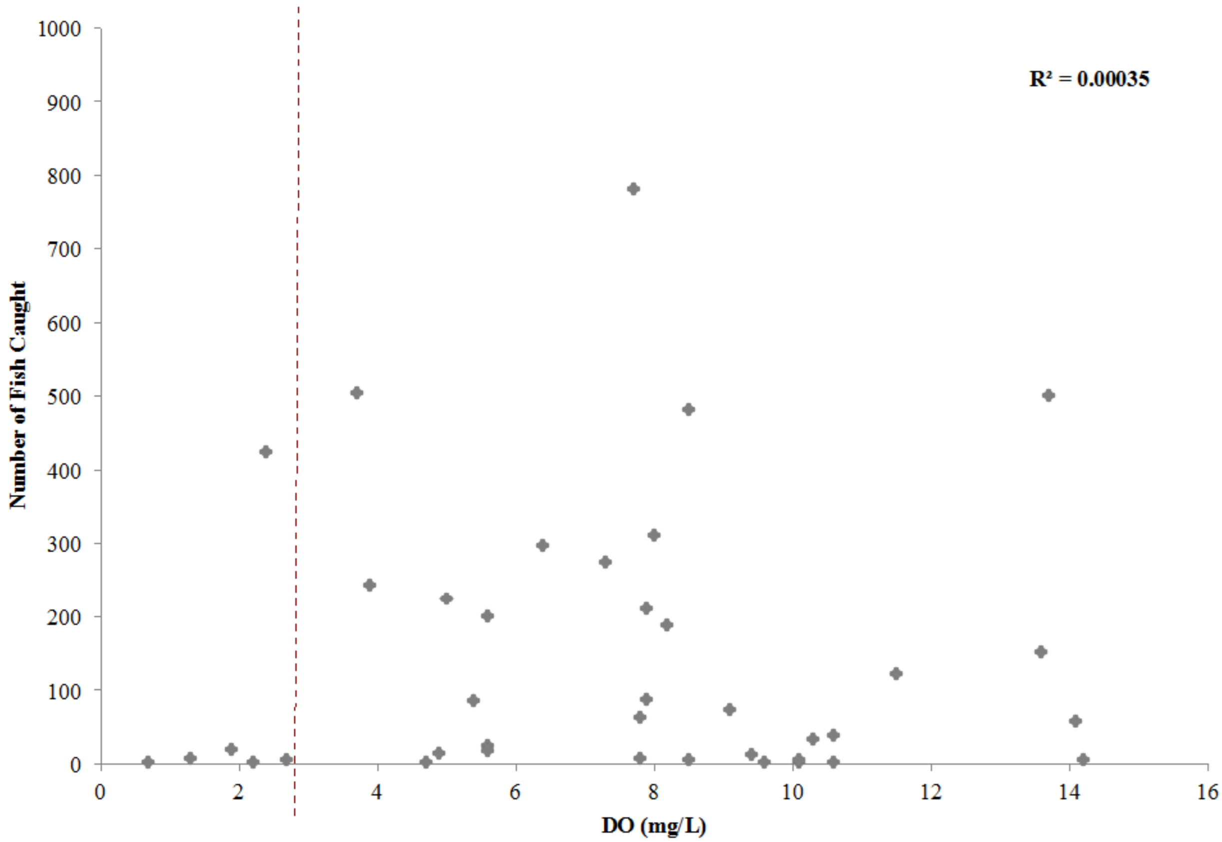


Figure 3. Numbers of fish captured at each sampling location relative to the amount of dissolved oxygen (DO) at the sampling site. Red line represents 3.0 mg/L, below which waters are hypoxic.

Water Quality

DO levels significantly varied among transects (p=0.01), but did not significantly vary between years (p=0.98) or among months (p=0.06) with no interaction (p=0.86). In general, the eastern side of the lagoon had lower DO levels than the western side; the NE site had significantly lower DO (mg/L±SD) than the NW site (5.34±3.96 and 9.00±3.74, respectively).

Bottom DO was very low in June and July, with the lowest recorded DO at the July SE site (1.9 mg/L). As expected, the temperature of the lagoon increased as summer progressed, peaked in August at the NW site (28.1 Cº), then decreased slightly in September (Table 3). In general, DO decreased as temperature increased; the relationship is approaching statistical significance (p=0.08). Salinity values were relatively consistent and uniform among months and sites.

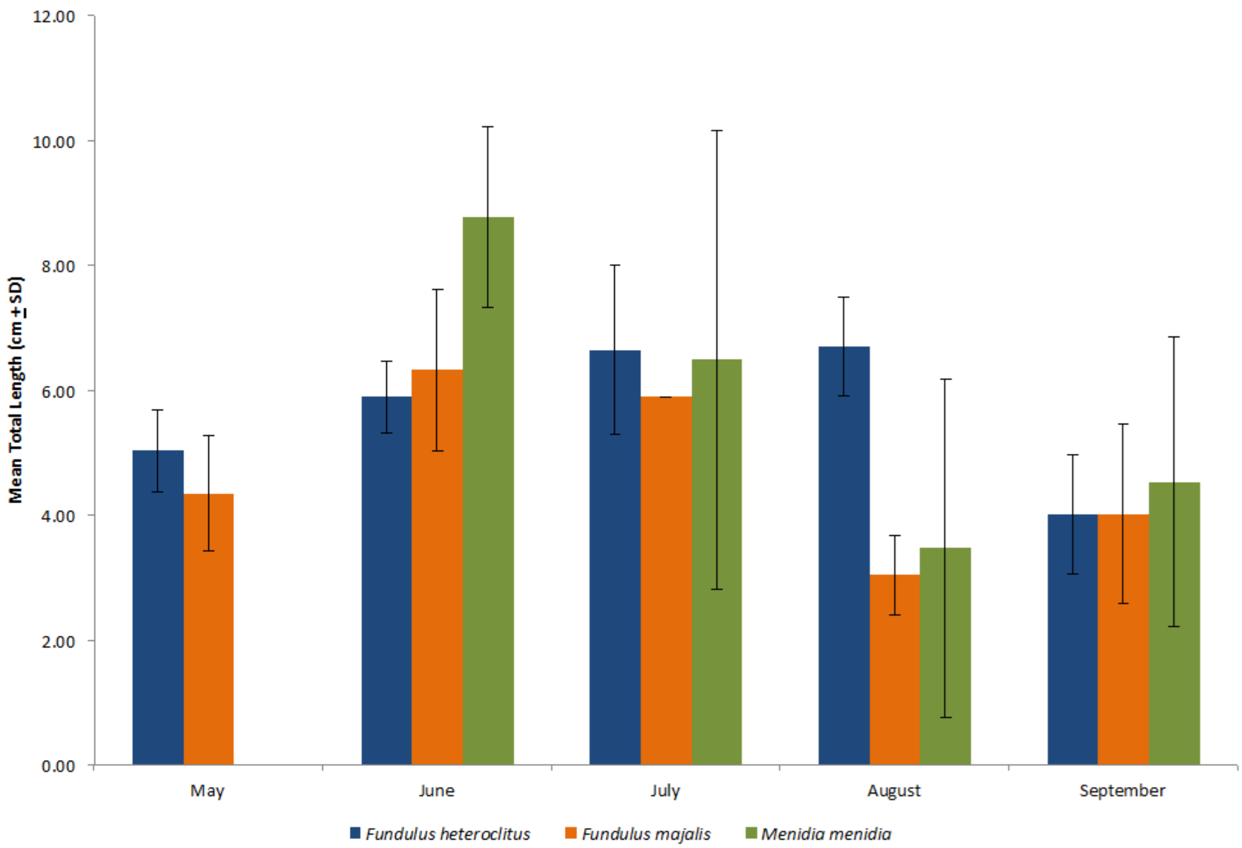


Figure 4. Mean (+ SD in cm) total length of all Fundulus *spp. >2 cm across all sites each month in 2016*

X – Present in 2015	**May**				**June**				**July**				**August**				**September**			
Y – Present in 2016	NE	SE	NW	SW	NE	SE	NW	SW	NE	SE	NW	SW	NE	SE	NW	SW	NE	SE	NW	SW
FISH SPECIES																				
Apeltes quadracus (fourspine stickleback)			XY	Y	X	XY	XY													
Brevoortia tyrannus (Atlantic menhaden)														X			Y	Y	XY	XY
Cyprinodon variegatus (sheepshead minnow)											X		Y	Y	Y	Y				
Fundulus spp. (striped killifish / mummichogs)	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fundulus heteroclitus (mummichogs)			Y	Y			Y	Y	Y	Y	Y	Y	Y			Y	Y	Y	Y	Y
Fundulus majalis (striped killifish)	Y				Y		Y	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y
Menidia menidia (Atlantic silverside)	X		X	X			X	Y		XY	Y	Y	XY	XY	XY	XY	XY	XY	XY	XY
Microgadus tomcod (Atlantic tomcod)			X																	
Pseudopleuronectes americanus (winter flounder)														Y						
Syngnathus spp. (pipefish)														Y						

INVERTEBRATES																				
Calinectes sapidus (blue crab)																				X
Carcinus maenas (European green crab)	XY	XY	X		X	XY	XY	Y	XY	Y	XY	X	Y	XY	XY	XY	Y	Y	XY	
Hemigrapsus sanguineus (Asian shore crab)											Y		X			X				
Ilyanasa obsoleta (Eastern mud snail)	Y	Y	Y	XY	XY	XY	X	XY	XY	XY	X	XY		Y		XY		Y		XY
Limulus polyphemus (Atlantic horseshoe crab)														X						
Pagurus spp. (hermit crab)					X	X	Y	XY	XY	Y		Y	Y	Y		Y	X	XY	Y	XY

Table 1. Fish and invertebrate species observed during subtidal seine surveys conducted at low tide in Napatree lagoon, Rhode Island, in 2016. X indicates 2015 sample results, while Y indicates 2016 results.

2016 – Fish Abundance and Size						
	NE	**SE**	**SW**	**NW**	***Mean***	***SD***
Number of Fish						
May	5.00	5.00	2.00	5.00	*4.25*	*1.50*
June	2.00	17.00	7.00	57.00	*20.75*	*24.96*
July	424.00	20.00	80.00	38.00	*142.25*	*189.95*
August	781.00	311.00	482.00	3442.00	*1254.00*	*1471.54*
September	243.00	503.00	224.00	86.00	*264.00*	*174.02*
Mean	*291.00*	*171.20*	*160.40*	*725.60*		
SD	*326.11*	*225.77*	*200.92*	*1518.80*		
Size, Mummichog (Mean (SD) cm)						
May		4.80 (0.57)		5.15 (0.76)	*5.03*	*0.67*
June			6.10 (--)	5.89 (0.59)	*5.89*	*0.58*
July			7.05 (1.34)	6.25 (1.77)	*6.65*	*1.36*
August		6.48 (0.64)		7.8 (--)	*6.70*	*0.79*
September	4.22 (0.96)	4.10 (1.70)	3.95 (0.46)	3.20 (1.11)	*4.02*	*0.95*
Mean	*4.22*	*5.21*	*4.44*	*5.75*		
SD	*0.96*	*1.60*	*1.23*	*0.92*		
Size, Killifish (Mean (SD) cm)						
May	4.35 (0.92)				*4.35*	*0.92*
June	5.85 (0.64)		6.9 (1.67)	5.85 (0.86)	*6.33*	*1.30*
July			5.9 (--)		*5.90*	*(--)*
August	3.01 (0.67)	2.91 (0.63)	3.00 (0.61)	3.20 (0.61)	*3.04*	*0.64*
September	4.84 (2.05)	3.77 (1.27)	3.85 (1.09)	3.57 (0.38)	*4.03*	*1.44*
Mean	*3.80*	*3.32*	*3.61*	*3.44*		
SD	*1.67*	*1.07*	*1.27*	*0.73*		

Size, Silversides (Mean (SD) cm)						
May						
June	8.78 (1.44)				*8.78*	*1.44*
July		1.5 (--)	2.35 (0.32)	9.43 (1.16)	*6.49*	*3.68*
August	4.14 (3.85)	7.25 (3.09)	2.63 (0.44)	2.54 (0.43)	*3.47*	*2.71*
Sept	4.26 (1.13)	6.20 (3.08)	3.29 (0.48)	3.84 (1.28)	*4.53*	*2.32*
Mean	*4.17*	*4.49*	*2.93*	*4.08*		
SD	*3.37*	*3.10*	*0.58*	*2.64*		

Table 2. Fish abundance and size for the Napatree lagoon during summer 2016. Means and standard deviations (SD) are provided for monthly and site samples.

2016 – Water Quality Parameters							
		NE	**SE**	**SW**	**NW**	***Mean***	***SD***
Bottom DO (mg/L)	May	8.50	10.10	10.60	14.20	*10.85*	*2.41*
	June	4.70	5.60	7.80	14.10	*8.05*	*4.24*
	July	2.40	1.90	7.90	10.60	*5.70*	*4.25*
	August	7.70	8.00	8.50	6.90	*7.78*	*0.67*
	September	3.90	3.70	5.00	5.40	*4.50*	*0.83*
	Mean	*5.44*	*5.86*	*7.96*	*10.24*		
	SD	*2.58*	*3.28*	*2.00*	*4.04*		
Temperature (ºC)	May	10.30	10.40	10.60	10.70	*10.50*	*0.18*
	June	18.40	18.60	19.70	20.80	*19.38*	*1.11*
	July	21.60	21.10	24.50	24.70	*22.98*	*1.89*
	August	24.00	24.90	26.00	28.10	*25.75*	*1.77*
	September	22.80	23.00	24.00	23.80	*23.40*	*0.59*
	Mean	*19.42*	*19.60*	*20.96*	*21.62*		
	SD	*5.51*	*5.65*	*6.25*	*6.64*		
Salinity (PPT)	May	26.90	28.30	28.30	28.80	*28.08*	*0.82*
	June	29.90	31.20	23.10	31.20	*28.85*	*3.88*
	July	30.80	32.00	31.40	31.60	*31.45*	*0.50*
	August	31.60	32.10	31.90	32.10	*31.93*	*0.24*
	September	31.80	32.00	32.00	31.80	*31.90*	*0.12*
	Mean	*30.20*	*31.12*	*29.34*	*31.10*		
	SD	*1.99*	*1.62*	*3.80*	*1.33*		

Table 3. Water quality parameters for the Napatree lagoon during summer 2016. Means and standard deviations (SD) are provided for monthly and site samples.

CONCLUSIONS: The fish fauna of the lagoon is typical for this habitat; *Menidia menidia* (silversides), *Fundulus heteroclitus* (mummichogs), and *Fundulus majalis* (striped killifish) tend to be most common in shallow lagoons in Rhode Island. The abundance and total length of fish varied over the summer, but clear patterns are not discernable because of the high variability among sites within a given month. Future sampling efforts should consider hauling multiple seines per site per month to allow for more advanced statistical analyses that better examine spatial and temporal patterns in combination; however, this should be balanced against the small ecosystem being sampled and perhaps limited to one western and one eastern site.

The abundance and mean total length of fish did not vary between 2015 and 2016, and the same species were found both years with the exception of single individuals of rarer species, such as the seaweed pipefish and winter flounder collected in 2016.

Consistent with 2015, the lowest DO levels were in the eastern lagoon, and higher DO levels were on the western side. These DO levels are inversely related with algal abundance: algae washes into the lagoon with the incoming tide, settles out of the water column on the eastern shore, and decomposes, a process that consumes oxygen from the surrounding water (see SoN chapter 15 by Green et al.). In 2015 during the hot summer months there was a milky, sulfurous plume of water overlaying areas of very low DO that corresponded to areas with high algal biomass (eastern edge of the lagoon). There were smaller, less conspicuous milky plumes this year, and the DO did not plummet to the near-zero levels that were present in 2015.

Figure 5. Fish kill in NE corner of Napatree lagoon, July 6, 2016. Photo: Laura Craver-Rogers.

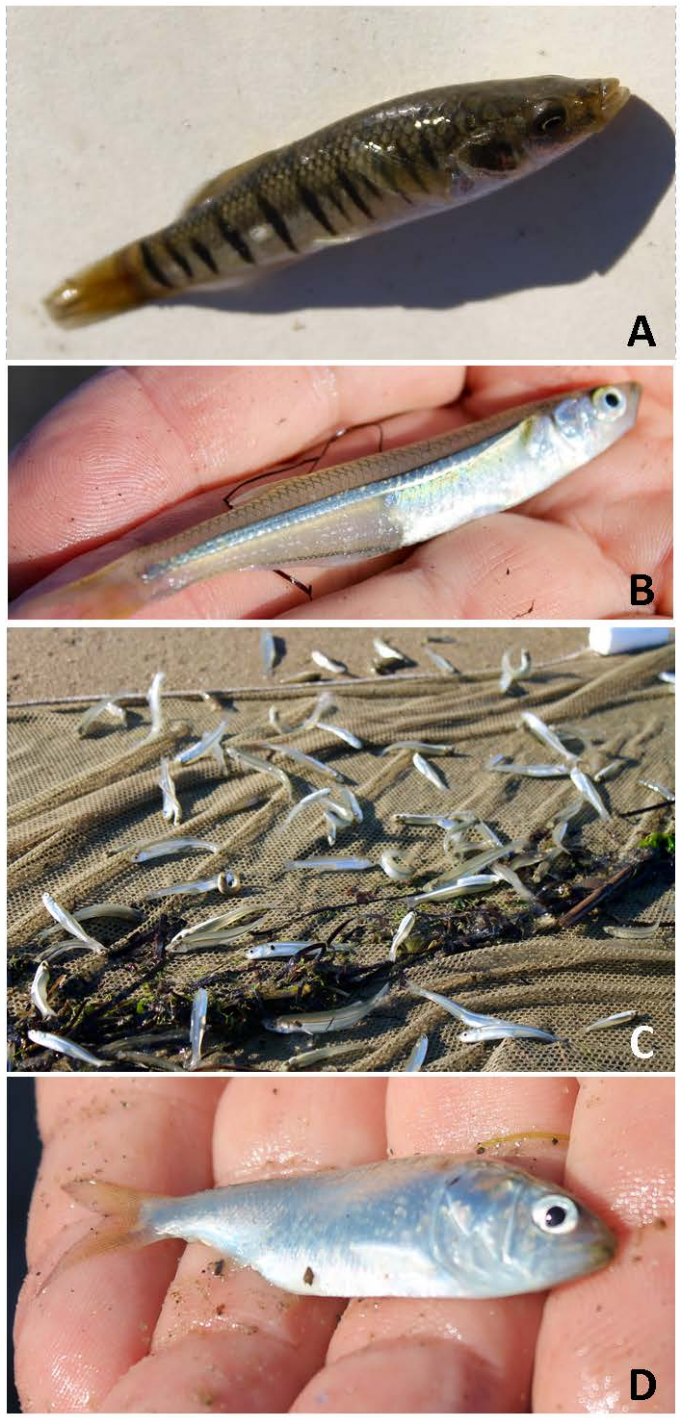
The lagoon experienced at least one localized fish kill this year on July 6, 2016, close to the NE site. In this corner, there is a tidal inlet that fills with oxygenated water during high tide, but as the tide goes out, water in the inlet is cut off from the rest of the lagoon. Observational evidence led us to develop two possible explanations: 1) fish were trapped in the inlet as water levels dropped and then depleted the limited oxygen, or 2) because it seems as fish could have easily swam out of the inlet, they may have been caught up in the abundant drift algae that was also found in the inlet (Figure 5).

The relationship between fish abundance and DO has interesting management implications. Should the lagoon ever close to Little Narragansett Bay, DO levels would likely drop to very low levels and this would negatively impact fish abundance. If the lagoon had significantly fewer, or even an absence of fish, then this would restrict the ability of shorebirds to feed from the protected lagoon.

DATA MANAGEMENT: All data collected in this project are stored in the NP_Data cloud-based database on DropBox.

ACKNOWLEDGEMENTS: This project was supported by a Grant-in-Aid from the University of Rhode Island Coastal Institute and a grant from the Sounds Conservancy of the Quebec Labrador Foundation Atlantic Center for the Environment. Dr. Charles Roman assisted us in seining and provided considerable practical advice in nekton sampling. Kelly Addy and Dr. Art Gold at the University of Rhode Island loaned us the YSI water quality monitoring instrument.

Appendix 1. Photographs of some of the fish species captured. A – Striped killifish (*Fundulus majalis*); B – Atlantic silversides (*Menidia menidia*); C – Silversides in the seine; D – Atlantic menhaden (*Brevoortia tyrannus*). Photo credit: Janice Sassi.



Monitoring Seaweed Abundance and Species Composition at Napatree Lagoon: 2016

Lindsay Green, Ivy Burns, Fiona MacKechnie, Marguerite Kinsella, Hannah Madison & Carol Thornber

College of Environment and Life Sciences, University of Rhode Island

Photo credit: Lindsay Green

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INTRODUCTION: Seaweeds are critical to the health of coastal ecosystems. There are three major groups of seaweeds, known as the greens (Chlorophyta), reds (Rhodophyta), and browns (Phaeophyceae). In addition to serving as a primary food source, seaweeds also create a three dimensional structure that provides a habitat to countless marine organisms. Seaweed communities are sensitive to changes in the nitrogen concentration of the coastal environment. Nitrogen is generally the limiting nutrient in coastal systems (Howarth and Marino, 2006) and elevated levels can lead to a disruption in the balance of natural ecosystems.

Napatree Lagoon is connected to Little Narragansett Bay through an inlet near the Northeast corner. Little Narragansett Bay is largely influenced by the Pawcatuck River watershed and is one of the most heavily nitrogen loaded estuaries in the Atlantic coast (Fulweiler and Nixon, 2005). In shallow, low wave energy environments influenced by nitrogen loading seaweed blooms can form (Valiela et al., 1997). These dense mats of drifting seaweeds can have negative consequences on the environment and can cause the decline of seagrass (Valiela et al., 1997) and overall community diversity (Worm and Lotze, 2006). Furthermore, once seaweed blooms begin to decay, oxygen levels are depleted, which can lead to fish kills. In 2003, a fish kill occurred in Greenwich Bay (Warwick, RI) as the result of a phytoplankton bloom encouraged by nitrogen loading (Rhode Island Department of Environmental Management, 2003).

In 2015, researchers at the University of Rhode Island, along with undergraduate research fellows, began conducting monthly surveys at four sites within Napatree Lagoon (Northeast, Northwest, Southeast, and Southwest; hereafter referred to as NE, NW, SE, and SW; see Figure 1 in chapter by Rohr et al.). The objective of these surveys was to determine the species composition and biomass of seaweeds at each Napatree Lagoon location from May through September 2015. We continued these surveys in 2016 in order to determine how the seaweed community changes over time.

METHODS: Intertidal and subtidal monthly surveys were conducted from May through September at four sites in Napatree Lagoon. Subtidal surveys were not conducted at the NW site due to the sinking soil conditions. Following our pre-established protocols, on each sampling date in the intertidal, a 10m transect line was laid down parallel to shore at the water's edge. At every other meter along each transect line (n=5 samples/transect), a 0.25 m^2 quadrat was placed on the substrata and the percent cover of all live seaweed species was recorded. We then collected all of the seaweed biomass in each quadrat and returned it to the lab for processing where we determined the biomass of seaweed and counted all associated invertebrates. It is important to note that we often encountered large mats of seaweed that were partially decayed (Figure 1A). When surveying these areas, we only measured live seaweed biomass and species composition, not decaying detritus.

The subtidal zone at each site was surveyed on the same day, by walking a 10 m transect perpendicular to the shoreline, starting at the water's edge. At every 3.3 m (for a total of 3 samples/site), a 0.35 m wide net was dragged along 0.5 m of seafloor to collect all seaweed and invertebrates (Figure 1B). Although most biomass was typically near the seafloor, any seaweed floating in the water column above the net drag area was also collected. The depth of the water was recorded to calculate the volume of water sampled at each point. All collected material was brought back to the laboratory for processing. In the lab we identified all species of seaweeds, determined the biomass, and counted all invertebrates (Guidone and Thornber, 2013).

Figure 1. A) Large decaying mat of seaweed, approximately 10 cm deep, at the Northeast site in Napatree in August 2016. B) I. Burns and F. MacKechnie sample the subtidal for seaweed and invertebrates. Photo credits: Lindsay Green

RESULTS: Overall, there was wide variability in the seaweed composition in Napatree Lagoon between sites, months, and years. In 2015, we recorded several species of seaweed that we did not encounter in 2016. In the intertidal samples we found the red algae *Aglaothamnion* spp., *Callithamnion* spp., *Grinellia americana*, *Phyllophora* spp., and *Spermothamnion repens* and the brown algae *Chordaria flagelliformis* and *Halosiphon tomentosus* in 2015, but not in 2016 (Table 1). In 2016, we found two previously undocumented red algae in Napatree Lagoon, the native *Cystoclonium purpureum* and the invasive *Grateloupia turuturu.*

The difference in species composition of the subtidal samples was even more striking. There were a total of 10 seaweed species that we collected in the subtidal in 2015 that were not collected in 2016 (*Aglaothamnion* spp., *Ascophyllum nodosum, Callithamnion* spp., *Codium fragile* ssp. *fragile*, *Desmerestia* spp., *Fucus vesiculosus, Halosiphon tomentosus, Palmaria palmata*, *Pyropia* spp., and *Saccharina latissima*). It is important to note, however, that six of these species were collected in the intertidal in 2016. Interestingly, we document five seaweeds in the subtidal in 2016 that were not collected in 2015. These seaweeds were all red algae and included the invasive red alga *Grateloupia turuturu,* which was also documented in the intertidal of Napatree Lagoon for the first time in 2016.

We also recorded differences in the abundance of seaweed between 2015 in 2016. In the intertidal zone, we found that seaweed abundance in May was generally higher in 2016 than in 2015 (Figure 2). In June, the pattern was highly site specific. At the NE and SW sites, we recorded higher seaweed biomass in 2015. However, the highest amount of seaweed ever recorded in Napatree Lagoon was documented in June 2016 at the SE site (over 1200 g/m^2). Intertidal seaweed biomass in July was similar between 2015 and 2016, while August biomass was generally higher in 2015. Finally, the pattern reversed in September, which had higher biomass in 2016 than in 2015 (Figure 2). In both years, the highest intertidal biomass was recorded during June and July.

	May				June				July				August				September			
	NE	SE	NW	SW	NE	SE	NW	SW	NE	SE	NW	SW	NE	SE	NW	SW	NE	SE	NW	SW
Aglaothamnion spp.[R]								5					5							
Ascophyllum nodosum[P]	5								5,6											
Callithamnion spp.[R]							5							5						
Ceramium spp.[R]	5	6		5									5	5	5	6	6	6	6	
Chaetomorpha spp.[C]	5	6		6					5,6	6		6	5,6	5, 6		5	5,6	6	5,6	6
Champia parvula[R]														5				6	6	
Chondrus crispus[R]	5,6				5,6	5, 6	5,6	5	5,6	6	5		5,6				5,6			
Chordaria flagelliformis[P]													5							
Cladophora spp.[C]														5, 6	6				6	6
Codium fragile ssp. *fragile*[C]					5												6	6		
Cystoclonium																			6	

purpureum [R]																				
Dasysiphonia japonica[R]	5	6	6	6	6	6	6	6	5,6	6			5				6	6	6	
Desmarestia aculeata[P]							6		5	5	5		5							
Ectocarpus spp.[P]	5	5, 6	6	5										6			5			
Fucus vesiculosus[P]					5,6				5				5				6			
Gracilaria spp.[R]	6					6			5	6	6		5	5, 6			6			
Grateloupia turuturu [R]		6							6				6							
Grinnellia americana[R]														5						
Halosiphon tomentosus[P]	5																			
Palmaria palmata[R]									5	6										
Petalonia/Punctaria spp.[P]	5,6	6		5,6	6	6	6	6	5,6	5, 6							6			

Phyllophora spp.^{R}									5	5										
Polyides rotunda^{R}					5				5,6				5				5,6			
Polysiphonia spp.^{R}	5,6	6	6		6	6	6		5,6	6	6	6					6	6	6	
Saccharina latissima^{P}					5				5				5					6		
Scytosiphon spp.^{P}	5	5							6											
Spermothamnion repens^{R}																	5			
Ulva blades^{C}	5,6	6	5,6	5,6	5,6	5, 6	5,6	5,6	5,6	5, 6	5,6	5,6	5,6	5, 6	5,6	5	5,6	5	6	5
Ulva tubes^{C}	5,6	5, 6	5,6	5,6	5,6	5, 6	5,6	5,6	5,6	5, 6	5,6	5,6	5,6	5, 6	5,6	5,6	5,6	5	6	5

Table 1. Taxa observed during intertidal field surveys at Napatree Lagoon in 2015 (5) and 2016 (6). Abbreviations next to taxon names indicate the seaweed group C: Chlorophyta, R: Rhodophyta, and P: Phaeophyceae

	May			**June**			**July**			**August**			**September**		
	NE	SE	SW	NE	SE	SW	NE	SE	SW	NE	SE	SW	NE	SE	SW
Agardhiella subulata [R]															6
Aglaothamnion spp.[R]				5											
Ascophyllum nodosum[P]				5											
Callithamnion spp.[R]				5											
Ceramium spp.[R]	5,6	6		5	5	6								5	
Chaetomorpha spp.[C]		5								6	6				6
Champia parvula[R]														6	6
Chondria spp. [R]															6
Chondrus crispus[R]	5	5,6		5	5,6		5	5					6		
Cladophora spp.[C]	5			5	5		5				6	6	5,6	5,6	6
Codium fragile ssp. *fragile*[C]				5											

Cystoclonium purpureum[R]	5,6	5		5											
Dasysiphonia japonica[R]	5,6	5,6	5	5,6	5,6	6	5,6	6	5,6					6	
Desmarestia spp.[P]				5			5	5							
Ectocarpus spp.[P]	5,6	5	6												
Fucus vesiculosus[P]		5		5	5		5								
Gracilaria spp.[R]	5			5,6					6	6		6			
Grateloupia turuturu[R]		6													
Grinellia americana						6									6
Halosiphon tomentosus[P]	5	5													
Palmaria palmata[R]	5														
Petalonia/Punctaria spp.[P]	5,6	5,6		5,6	5,6										
Polyides rotunda[R]				5			5,6			6					

Polysiphonia spp.[R]	5,6	5,6		5,6	5,6	6	5,6	6	6	6					6
Pyropia spp.	5														
Saccharina latissima[P]							5								
Spermothamnion repens[R]							5	5					5,6	5,6	6
Ulva blades[C]	6	5	6	5,6	5,6	6	5,6	5,6	5,6	5,6	5	5,6	6		6
Ulva tubes[C]	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5,6	5	5,6	5,6	5	6

Table 2. Taxa observed during subtidal field surveys at Napatree Lagoon in 2015 (5) and 2016 (6). Abbreviations next to taxon names indicate the seaweed group C: Chlorophyta, R: Rhodophyta, and Phaeophyceae

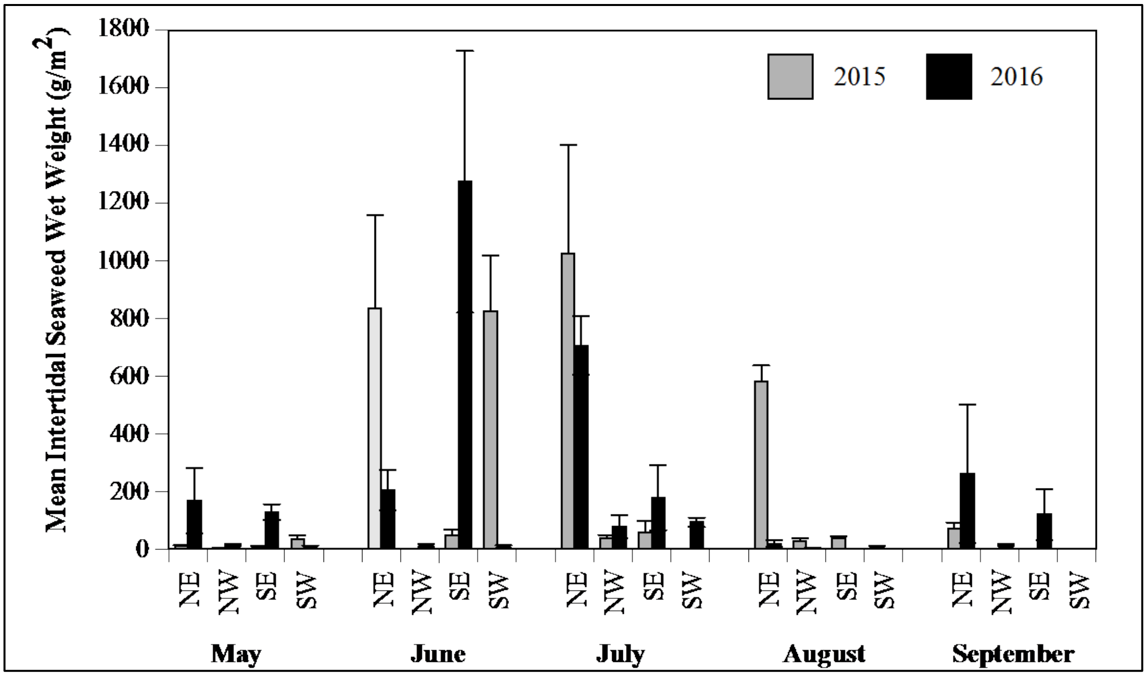

Figure 2. Mean intertidal seaweed wet weight (g/m^2) at all four study sites in Napatree Lagoon over the period of May-September 2015 and 2016 (mean ± 1 SE).

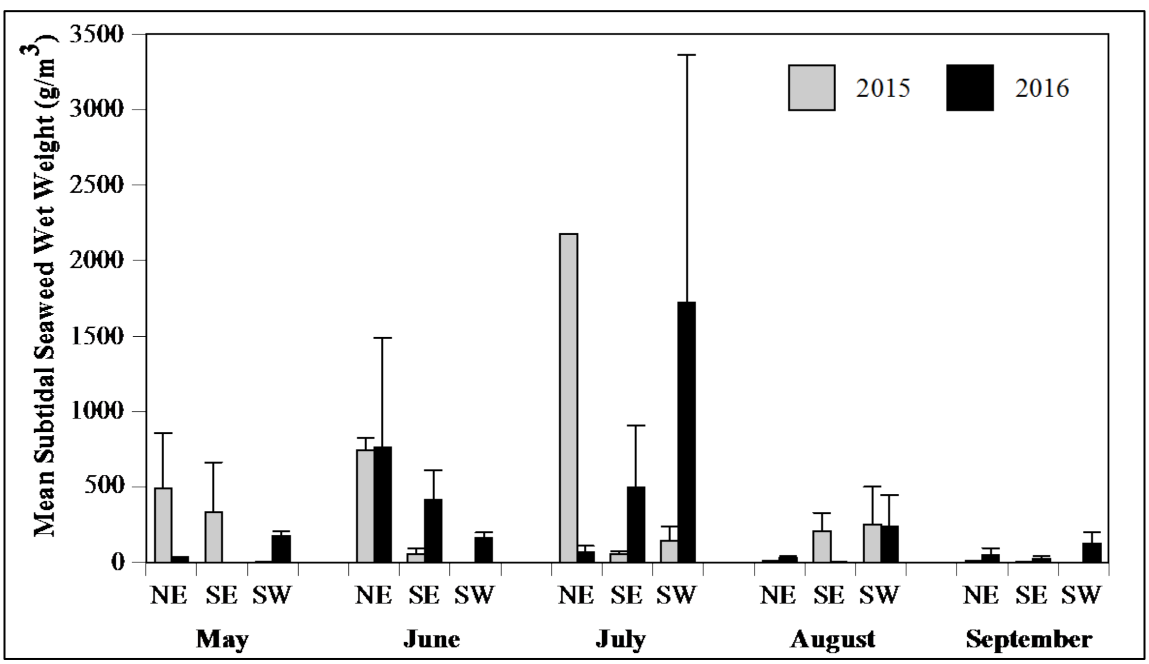

Figure 3. Mean subtidal seaweed wet weight (g/m^3) at all four study sites in Napatree Lagoon over the period of May-September 2015 and 2016 (mean ± 1 SE).

In the subtidal zone, the differences between the years were less dramatic, but highly site specific (Figure 3). At the NE and SE sites, subtidal seaweed biomass was higher in 2015 than in 2016. This differed at the SW site, which had higher seaweed biomass in 2016. Subtidal biomass was similar between the two years in June and August. In September, we recorded higher subtidal seaweed biomass in 2016. The highest subtidal seaweed biomass was recorded in July of both years (Figure 3).

CONCLUSIONS: We found high variability in species composition and abundance within Napatree Lagoon between sites, sampling months (May-September), and sampling years (2015-2016). Species of seaweeds from all of the three major groups were found throughout each sampling year. The highest intertidal biomass of seaweed was recorded in June-July and subtidal biomass was highest in July. Over the course of sampling in 2015 and 2016 we documented 32 different species of seaweed in the Napatree Lagoon. This is higher than the amount of seaweed species present in other coastal ponds in Rhode Island during the summer months (Thornber, *unpublished data*). The green bloom-forming *Ulva* blades and tubes were the most commonly seen seaweeds at Napatree Lagoon, both in the intertidal and subtidal surveys (Tables 1 & 2). We documented the invasive red alga *Grateloupia turuturu* in Napatree Lagoon for the first time in 2016, although this alga has been present in Rhode Island since the 1990s (Villalard-Bohnsack and Harlin, 1997).

Seaweed blooms are generally formed in shallow, low-wave energy environments as a result of nutrient loading (Valiela et al., 1997). The decay of seaweed mats can lead to low oxygen concentrations in the surrounding water column (Gray et al., 2002), which can negatively impact animal life. On July 6th, 2016, there was a fish kill in Napatree Lagoon (Figure 4). Both intertidal and subtidal seaweed biomass were highest at this time period, and the decay of seaweed mats likely contributed to this event by: a) physically trapping the fish on a receding tide; b) depleting the oxygen in the water column below the required level for the fish; or c) through a combination of both. These events highlight the importance of monitoring seaweed abundance and measuring environmental variables such as nitrogen concentrations and dissolved oxygen concentration to determine the health of the ecosystem.

Figure 5: Dead fish trapped in a seaweed mat at Napatree Lagoon during July 2016. Photo credit: Laura Craver-Rogers

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Assessing Shrubland Dynamics on Napatree Point, Watch Hill, RI: 2016

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Photo credit: Peter August

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INTRODUCTION: The coastal barrier shrubland of Napatree Point, Watch Hill, RI is a popular stopover site for migratory songbirds due to the numerous shrub patches that provide both food and shelter during their autumn migration. Coastal stopover sites which contain a variety of fruit-bearing shrubs, are critical to the survival of songbird populations. Annual mortality rates are 15 times higher during migration than during the breeding and wintering seasons (Sillett and Holmes, 2002). Many birds that are primarily insectivores during the breeding season switch their diet to fruit during migration (Smith et al., 2007). Since songbirds readily rely on high quality stopover habitat, the conservation and management of these areas is important to maintain the resources needed for these populations.

Currently, the shrubland habitat present on Napatree Point contains a variety of native fruit-bearing species such as Northern bayberry (*Morella pensylvanica*), Eastern juniper (*Juniperus virginiana*), groundsel tree (*Baccharis halimifolia*), Virginia creeper (*Parthenocissus quinifolia),* and poision ivy (*Toxicodendron radicans*). However, the suitability of shrubland habitat is at risk due to the spread of the invasive shrub Japanese rose (*Rosa rugosa*). Originally introduced to the United States from East Asia in 1899, Japanese rose has become fully naturalized in New England. Because of similarities in the habitat of its native range, Japanese rose can thrive in high saline soils and is tolerant of annual burying by wind-blown sand. In areas where it has been able to colonize, Japanese rose forms dense, monospecific stands (Bruun, 2005).

Due to its highly competitive growth strategy, Japanese rose poses a great threat to the biodiversity of shrubland habitat on Napatree Point. The purpose of this study is to provide baseline data on the current distribution, species composition and growth dynamics of shrubland patches. Specific objectives were to establish long-term plots to monitor: 1) expansion rates of shrub patches, 2) chronology of species establishment, and 3) changes in percent cover of shrub species within each plot.

METHODS:

Establishment of Long-term Monitoring Plots

In 2014, long-term monitoring plots were established by randomly selecting 20 Northern bayberry, 20 Japanese rose, and 15 mixed species shrub patches (Figure1). Individual plots were defined as containing at least one of the two target species and were separated by at least 0.3 m from another shrub species. In order to determine patch expansion rates, one-half inch (1.3 cm) diameter steel reinforcing rod (rebar) stakes were used to mark the boundaries of each plot. One 0.6 m long rebar stake was placed at the farthest extent of the patch in each of the four cardinal directions. Depending on the size of the plot, a measuring tape or laser range finder (Nikon Co.) was used to measure the north-south and east-west axes of the patch. The area of each plot was determined by using the equation for the area of an ellipse. Each plot was given a unique number and marked with an aluminum tag attached to the northern piece of rebar. The overall height of each patch was recorded. To determine chronology of species establishment, a stem sample, taken no greater than 5 cm from the ground, was cut from each of the species present in the plot. The individual plant having the thickest stem was selected for each shrub species. In plots that contained Eastern juniper or groundsel-tree, a tree corer was used for aging. Using this method, an age can be determined without killing the plant. In some cases, a Northern bayberry sample was not taken if cutting the plant would have resulted in significant changes in the percent cover of the plot. For each stem sample taken, the height of the plant and circumference of the stem were measured. The age of the sample was determined using a microscope and counting the growth rings. Percent cover was visually estimated for each shrub species present in the plot. The total percentage of shrub coverage did not exceed 100%.

Monitoring of Plots

On July 14, 2016, plots were revisited in order to assess changes in expansion rates and species composition. Expansion rates were determined by locating the rebar stake in each cardinal direction and measuring the extent of growth. Growth was recorded in meters as either a positive (expansion) or negative (contraction) number. Overall plot height was measured by selecting an individual shrub to represent the mean height of the patch. In plots where more than one species occurred, percent cover was visually estimated.

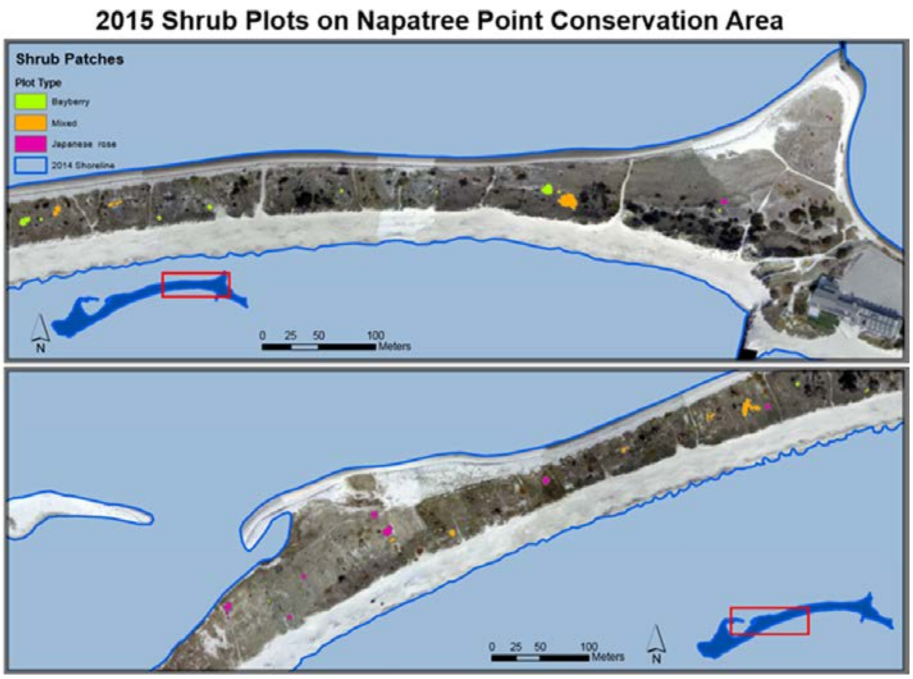

Figure 1. Shrub patches in the Napatree Point Conservation Area. Imagery obtained from low altitude aerial photography obtained on November, 2014. Shoreline data are from RIGIS.

RESULTS:

2015 Assessment

In 2015, our initial analysis showed that mixed plots had a greater average area than single species plots and overall were taller than single species plots. Northern bayberry plots were taller than Japanese rose plots. In plots containing Eastern juniper, juniper was found to be the oldest species in the plot, followed by Northern bayberry and Japanese rose.

2016 Assessment

Out of the initial 55 plots established in 2014, 54 were recovered and resampled in 2016. Due to the encroachment of other species, a total of six plots changed from single species to mixed species plots. Four Northern bayberry plots became mixed species plots with the addition of Japanese rose to the patch, and two Japanese rose plots became mixed species plots with the additional of Northern bayberry to the patch.

The overall growth pattern showed that bayberry plots are growing the greater (as seen in the average growth and the max growth) than any other plot type in all directions (Table 1). Differences in growth among plot types was greater in the North and South directions than the

East or West (Table 2). Of the three plot types, Northern bayberry expanded the most in area and height (Table 1).

	Avg (m)	Max (m)	Area (m²)	Height (m)
Northern bayberry	0.36 ± 0.34 (n=16)	0.57 ± 0.54 (n=16)	3.64 ± 4.19 (n=14)	0.25 ± 0.29 (n=16)
Northern bayberry--> Mixed	0.24 ± 0.10 (n=4)	0.42 ± 0.29 (n=4)		
Mixed	0.16 ± 0.14 (n=14)	0.32 ± 0.30 (n=14)	1.77 ± 3.30 (n=18)	0.10 ± 0.22 (n=20)
Japanese rose	0.11 ± 0.12 (n=15)	0.30 ± 0.19 (n=15)	1.13 ± 1.41 (n=17)	0.18 ± 0.10 (n=18)
Japanese rose --> Mixed	0.07 ± 0.14 (n=2)	0.18 ± 0.13 (n=2)		
Kruskal-Wallis	13.88, p < 0.01	11.27, p < 0.05	6.32, p < 0.05	5.11, p < 0.05

Table 1. Average linear expansion in all four cardinal directions, maximum linear expansion in all four cardinal directions, expansion in patch area, and increase in maximum patch height. For each plot type presented, the median and inter quartile range (IQR) are reported. A Kruskal-Wallis Test was used to determine if mean values were equal; ns = not significant (p > 0.05).

	North (m)	East (m)	South (m)	West (m)
Northern bayberry	0.23 ± 0.36 (n=16)	0.22 ± 0.17 (n=14)	0.43 ± 0.34 (n=15)	0.28 ± 0.23 (n=14)
Northern bayberry--> Mixed	0.34 ± 0.34 (n=4)	0.13 ± 0.23 (n=3)	0.20 ± 0.08 (n=4)	0.15 ± 0.29 (n=4)
Mixed	0.01 ± 0.17 (n=14)	0.13 ± 0.18 (n=13)	0.18 ± 0.23 (n=14)	0.20 ± 0.14 (n=14)
Japanese rose	0.10 ± 0.14 (n=15)	0.11 ± 0.23 (n=14)	0.08 ± 0.13 (n=15)	0.13 ± 0.22 (n=15)
Japanese rose --> Mixed	0.00 ± 0.23 (n=2)	0.11 ± 0.06 (n=2)	0.01 ± 0.09 (n=2)	0.14 ± 0.17 (n=2)
Kruskal-Wallis	13.87, p < 0.01	4.07, ns	12.5, p < 0.05	2.87, ns

Table 2. Growth for each plot type to the North, East, South and West. For each plot type presented, the median and IQR are reported. A Kruskal-Wallis Test was used to determine if plot types exhibited the same amount of growth; ns = not significant (p > 0.05).

Changes in percent cover were analyzed in both mixed species plots and single species plots that contained Eastern juniper. Between 2014 and 2016, Eastern bayberry increased in average percent cover by 5% and Japanese rose has contracted by 5% (Table 3).

	Median	IQR	N
Northern bayberry	5	14.5	18
Japanese rose	-5	17.5	14

Table 3. Differences in the change in percent cover of Japanese rose and Northern bayberry between 2014 and 2016 in mixed species shrub plots. The change in Bayberry is significantly different from the change in Rosa (Kruskal-Wallis Test, Chi Square 5.1, P < 0.05)

CONCLUSIONS: The initial two-year analysis of growth rates and changes in species composition amongst shrub patches on Napatree shows that Northern bayberry is expanding the most of all the shrub species monitored. These results are contrary to what was initially hypothesized; that Japanese rose is outcompeting native shrubs on Napatree. However, more data are needed to determine if this pattern will hold in future years. If the shrub patches continue to grow at their current average expansion rates, the barrier dunes of Napatree could become one large maritime shrubland by 2060. This assumes expansion at the rates we measured over the past two years. We suspect that we will see shrub die-back from salt spray after our next large storm. Understanding the conditions that promote or retard shrub expansion is a fundamental goal of this project.

MANAGEMENT CONSIDERATIONS: Managers at Napatree Point should continue to maintain a heterogeneous landscape that provides a variety fruit-bearing shrub species in order to provide high quality stopover habitat. By increasing the number of native fruiting species, densities of frugivorous migrants should increase (Buler et al., 2007). By selecting a variety of species with varying fruiting phenology, fruits will be available throughout the migration season. Although many studies have shown the Japanese rose is a readily consumed fruit by migratory songbirds due to its high concentration of carbohydrates and ability to persist throughout the winter (Drummond, 2005), its occurrence on Napatree threatens the biodiversity of the natural landscape.

Continual monitoring of these plots will help assess changes in species composition and expansion rates to further determine if Japanese rose is posing a threat to native plant diversity.

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Tidal Characteristics of the Napatree Lagoon

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Image credit: RIGIS, 2016

Tidal Characteristics of the Napatree Lagoon

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INTRODUCTION: A basic element necessary for understanding the physical dynamics of the Napatree Lagoon is an accurate measure of present tidal datums with respect to a fixed vertical orthometric datum (e.g., NAVD88) that is used as the reference for vertical elevation data on land. Due to spatial variability in the oceanic tidal response and in non-tidal currents, the vertical height of a particular tidal datum (e.g., Mean Sea Level (MSL) or Mean High Water (MHW)) relative to an orthometric datum is generally not spatially uniform. To address this, a temporary tide gauge was deployed in the Napatree Lagoon from March 24, 2016 – October 22, 2016. Field methods and results of that deployment are presented here.

This work is a continuation of a long-term assessment of the physical properties of the Napatree Lagoon beginning in 2014. Previously, the bathymetry of the lagoon was mapped and depths relative to MHW and MLW were calculated (Rohr et al., 2014) based on NOAA tidal parameters of Watch Hill Point; analysis period August 1-31, 1962. A longer and current record of water elevations inside the lagoon will improve depth calculations as well as better predicting the timing and extent of tides.

METHODS: A Hobo U20-001-04 water level logger was used to record water levels in the Napatree Lagoon. The Hobo model measures pressure and converts to water height via HOBOware-Pro software package to within a typical accuracy of 0.3 cm (Onset, 2016). The meaning of *accuracy*, as it applies to these sensors, is that the indicated pressure will conform to true pressure to within ± *maximum error* (expressed as equivalent depth) throughout the sensor's operating range. The logger was calibrated by the manufacturer and manually tested in an office setting prior to deployment. Measurement bursts were programmed to record the water height above the sensor every 15 minutes.

In order to account for atmospheric pressure, a second Hobo device (U20L-04) was deployed in a nearby tree. Measurement bursts of the atmospheric logger were programmed to begin at the same time and frequency as the water level logger. At 15 minute measurement intervals, the internal memory for these devices has capacity to store data for at least 6 months.

Real Time Kinematic (RTK) GPS measurements were performed to establish a geodetic relationship to tidal datums. This method of surveying can provide 2-5 cm of accuracy by using a reference station (base receiver) which sends position corrections to the rover receiver in real time. The corrections are of satellite signals which can be distorted from atmospheric interferences. A base receiver was set up on a nearby brass disc benchmark (NAP5) which in turn was surveyed for 4+ hrs. A second benchmark (NAP4) was used as a "Check-In" which is used to validate the accuracy of the survey (Figure 1). All elevations were recorded in NAVD88 feet and referenced to RI State Plane NAD83 coordinates.

Figure 1. Top: location of water level logger, atmospheric pressure logger, RTK-GPS base receiver, and survey check-in location. Blue lines represent RTK baselines from the base receiver to the rover receiver. Bottom left: RTK-GPS base station set-up. Bottom right: Hobo survey.

The Hobo was placed in a PVC container which was mounted to a 55 lb cinder block with two stainless steel rods driven into the lagoon bottom. A survey target was affixed to the PVC housing cap so repeated surveys could be performed on the same location in relationship to the logger sensor (Figure 2). The Hobo is attached to the end of the housing cap with galvanized steel wire. This method provides easy access to the Hobo for downloading data without disturbing the submerged mount system. The distance from the target face to the end of the Hobo was measured to 8.46 in (Figure 2). The pressure sensor is located 0.81 in from the outer shell of the Hobo; therefore, -7.65 in are added to the RTK-GPS measurement to derive the sensor elevation. Water heights above the sensor are manually checked at the time of deployment to serve as an accuracy check and to account for movement and pressure sensor drift. Additional water heights were performed periodically throughout the deployment period.

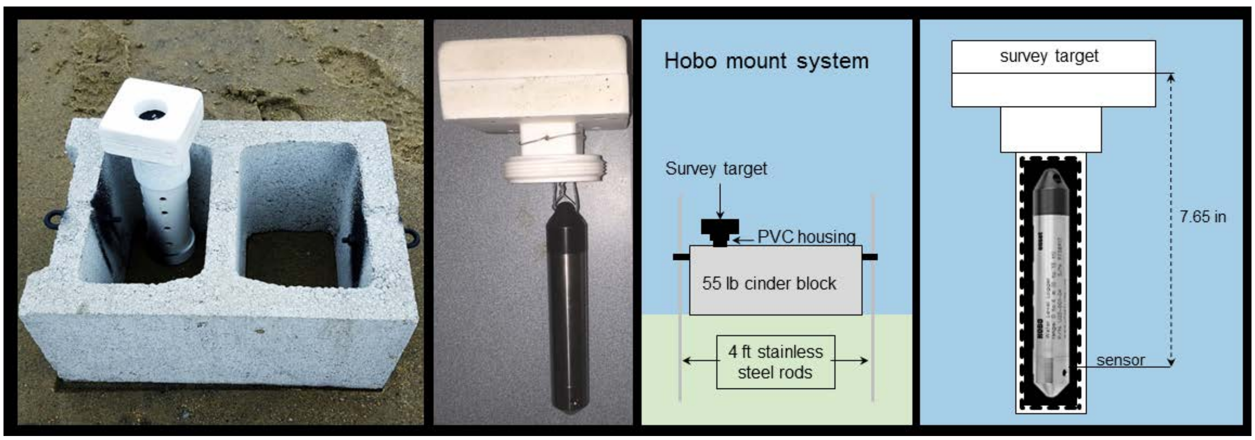

Figure 2. Mount system for water level logger.

The Hobo data were downloaded on October 23, 2016; the Hobo logger was then redeployed for an additional 6 months. Water depths were exported to a Microsoft Excel document via the HOBOware-Pro software package. Tidal datums such as MHW and MLW for the deployment period were extracted by an Excel command and manually verified as defined by National Ocean Service (NOS, 2003). Values were converted to NAVD88 based on averaging RTK-GPS measurements performed on the mount target at the times of deployment and retrieval. Final tidal datum calculations used in this report are "stand alone," they represent conditions from the time of logger deployment and have not been tied into a long term control station.

RESULTS: Comparisons of the Napatree Lagoon to that of the NOS station 8510560 at Montauk, NY during the deployment period show similar tidal patterns (Figure 3). The extent of high tide elevations are nearly identical while low water levels are restricted from the narrow width and elevation of the sill of the tidal inlet connecting the lagoon to Little Narragansett Bay. The basin cannot completely drain before the overpowering tide floods the lagoon. This restriction also delays the timing of high and low tide with respect to outside the lagoon. The average delay of MHW and MLW for the entire deployment period was one hour later than the Montauk tide gauge and 55 minutes later than at Watch Hill Point.

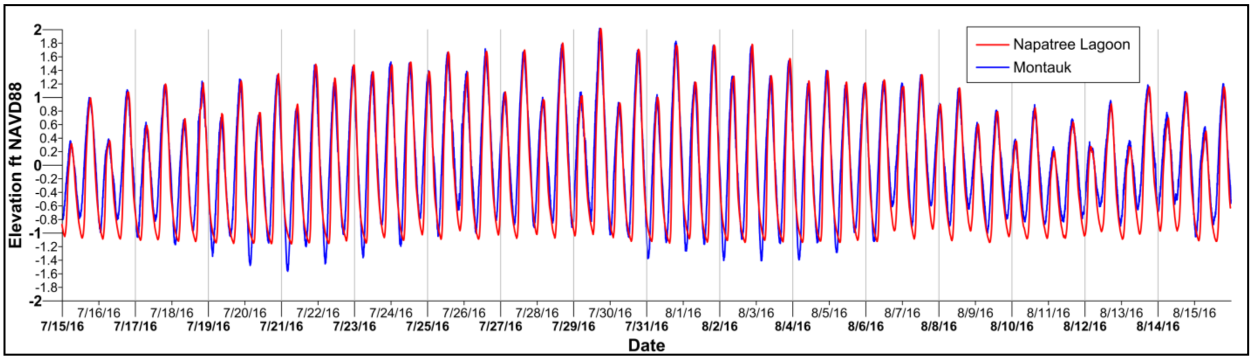

Figure 3. Concurrent tide graph sample from Napatree Lagoon and Montauk, NY.

The Great Diurnal Range (GT) of the lagoon was 2.5 ft while Montauk's GT was 2.6 ft, nearly identical. Based on the lagoon tidal datums and previous bathmetry work, the greatest depth of the lagoon is approximately 3.1 ft deep relative to MSL. At MLW, the maximum depth is 2.1 ft and at MHW it is 4.6 ft deep (Figure 4)

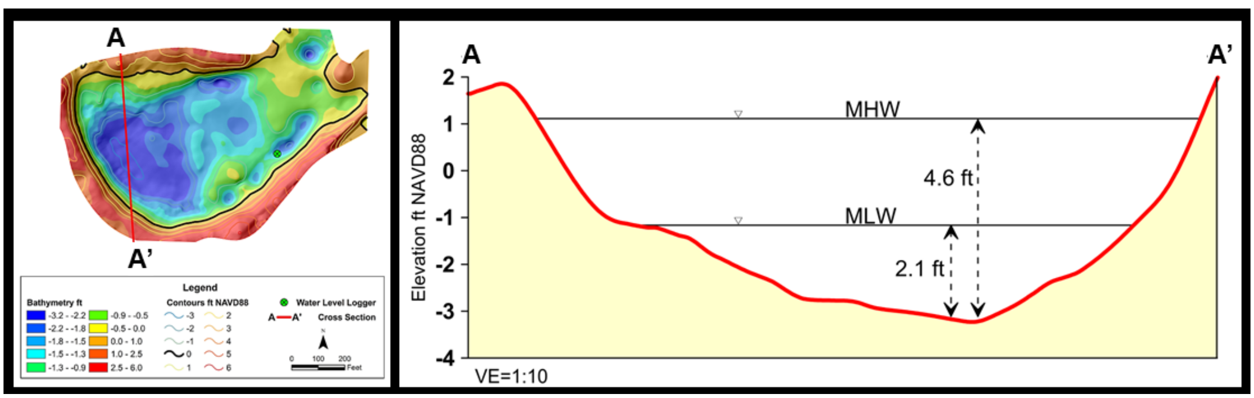

Figure 4. Left: bathymetry of Napatree Lagoon (adapted from Rohr et al. State of Napatree Report 2014). Right: cross section of deepest area of Napatree Lagoon derived from bathymetric data collected in 2014. MHW and MLW values based on water level logger deployment period.

DISCUSSION: Observations at short-term deployments are not sufficient for a precise, independent determination of tidal datums. More accurate results can be obtained by comparison with simultaneous observations at a suitable control tide station such as Montauk (NOS, 2003). At long-term NOAA NWLON (National Water Level Observation Network) stations, where the required 19-year dataset is available, datums are computed directly by averaging monthly mean values over the entire National Tidal Datum Epoch (NTDE). To derive datum elevations at a location with a shorter data record, monthly mean values from a shorter record location are compared with values from a nearby long-term control station. Published datum elevations at the control station are used as baseline elevations. Computed datum elevation differences between the deployment period and control station, over the time period of the short term observations, are used with the accepted datum elevations at the control site to determine datum elevations at the short-term site.

Water levels in estuaries and lagoons can be affected by restrictive channels and dominant wind directions, and therefore, caution should be used when tying to a control station that falls outside this zone (NOS, 2014). To see the effect of wind on the Napatree Lagoon, wind data (speed and direction) from a USGS weather station located in Watch Hill Cove were downloaded for the deployment period and compared to concurrent tidal data from the Napatree Lagoon and Montauk. Strong NW winds can create a regional setdown (lower observed tides than predicted) for the coast and keep the water from entering Little Narragansett Bay and therefore limiting the water supply to enter the lagoon (Figure 5). The April 4, 2016 wind event produced a low high tide due to the lack of water supply but low tide levels remained the same as compared to the extreme low tide at Montauk. The lowest tide levels in the lagoon remain consistent due to the sill/depth of the lagoon tidal inlet. In this case, the amount of sediment in the mouth of the inlet will cut off tidal flow between the bay and lagoon during low tide.

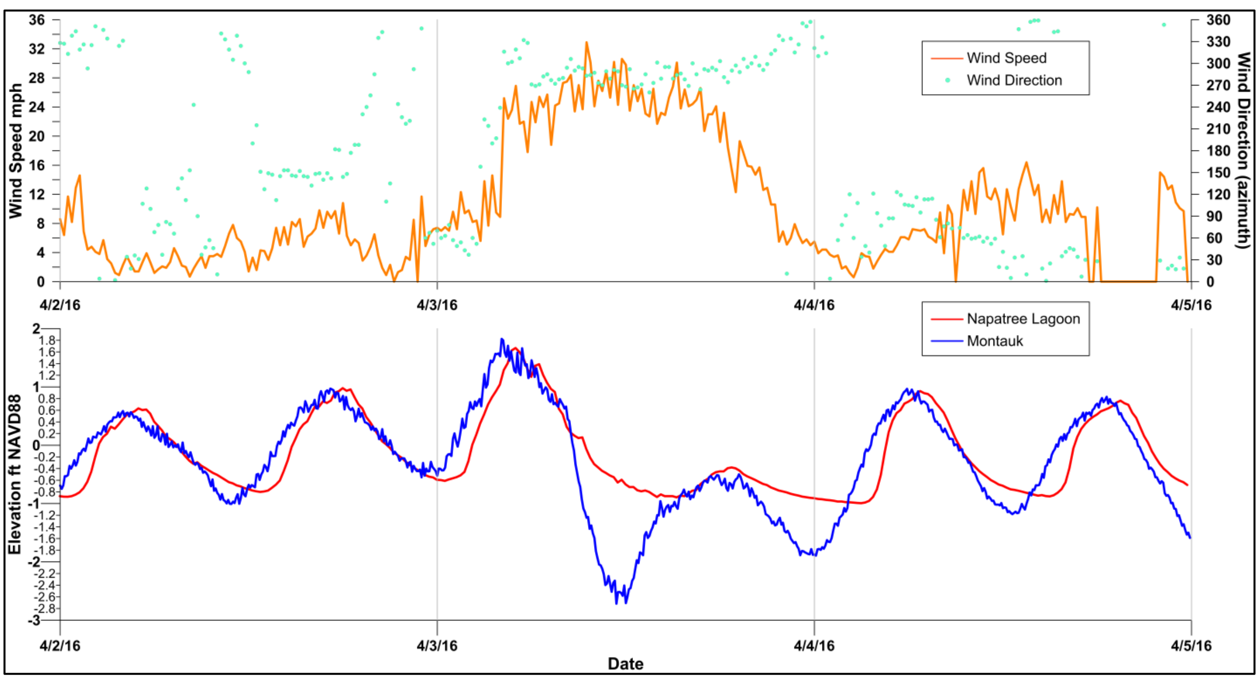

Figure 5. Simultaneous comparison of tide levels from the Napatree Lagoon and Montauk, NY combined with wind speed and direction from a local (Watch Hill Cove) USGS weather station.

Tools such as NOAA's VDatum can be used to calculate tidal datums in areas that do not possess a long-term control station. However, consideration of a variety of factors should be made over the accuracy of these calculations, including variations in tidal range, bathymetric and coastal features, the density and proximity of nearby geodetic and tide stations used in the corrections (NOAA 2012). NOAA (2012) further states that larger errors in the calculations are more likely to appear in upstream river environments and marshes.

CONCLUSIONS: The calculated average tidal datum elevations and great diurnal range of the Napatree Lagoon and the Montauk, NY gauge were remarkably similar for the deployment period March to October, 2016 (Figure 6). Therefore, tidal extents and timing from the Montauk gauge is an adequate proxy for those in the lagoon when a one hour delay offset is applied to Napatree Lagoon tidal conditions.

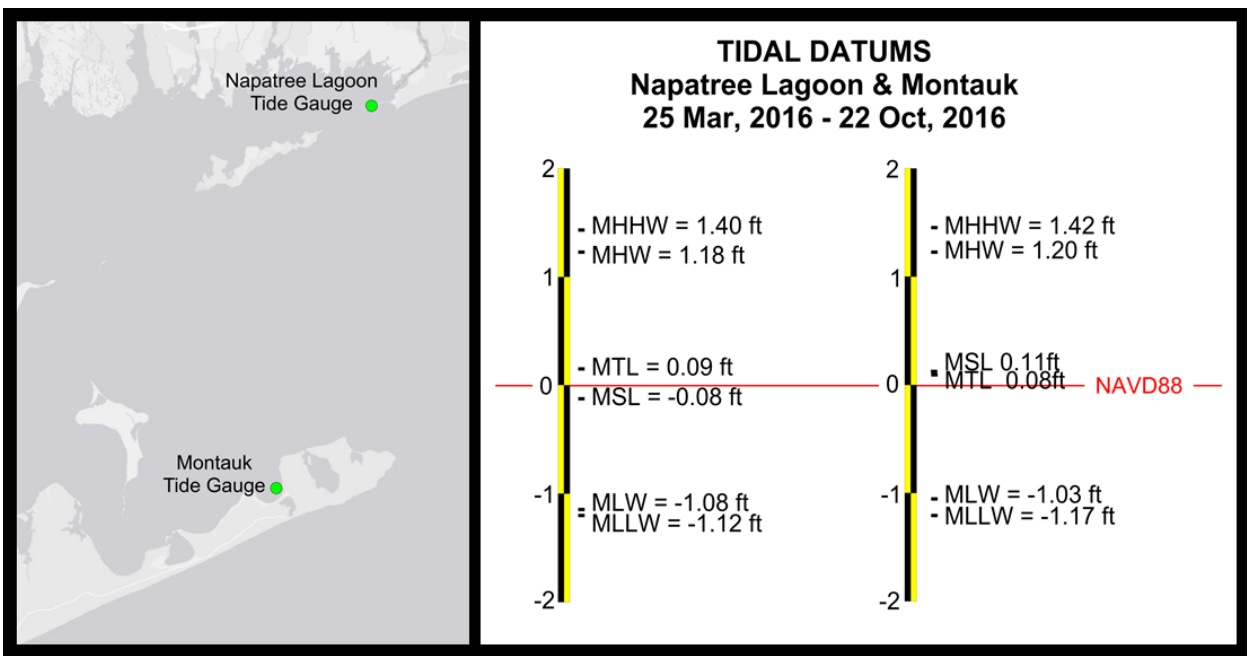

Figure 6. Locations and tide staffs for Napatree Lagoon (left) and Montauk, NY (right).

This short-term deployment is not tied into a long-term control station and is necessary to note that average values are only indicative of the short-term deployment and may or may not represent that from a full year or tidal epoch. Mean sea levels can be influenced by regular fluctuations in coastal temperatures, salinities, winds, atmospheric pressures, and ocean currents (NOS, 2016) (Figure 7). It is for this reason the Hobo logger was redeployed for an additional six months to capture a full year of data and account for seasonal variability.

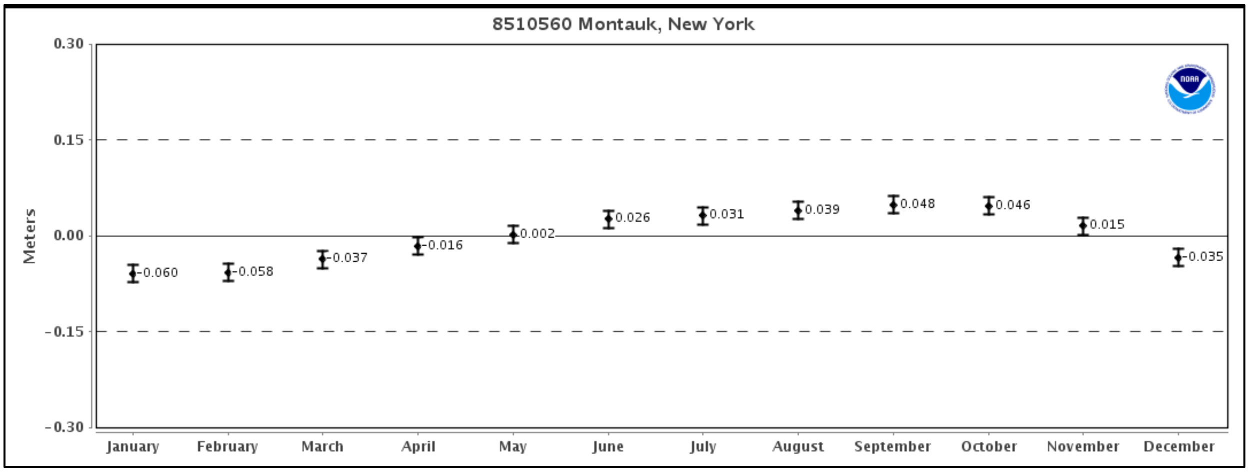

Figure 7. The average seasonal cycle of mean sea level at Montauk is ~10 cm.

DATA MANAGEMENT: Water level data and shapefiles reported here are stored in the NP_Data Dropbox repository under Physical\GIS\Lagoon.

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Notable News and Sightings of Fauna and Flora at Napatree Point in 2016

Janice Sassi [1] & Peter August [2]

[1] Napatree Point Conservation Area, Watch Hill Conservancy & Watch Hill Fire District
[2] Department of Natural Resources Science, University of Rhode Island

Photo credit: Janice Sassi

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Napatree Point Conservation Area Web Resource Portal

As studies, videos, and reports become available on work done in the Napatree Point Conservation Area (NTPCA), many are ending up in web-accessible Internet sites. Keeping track of all the URL's to get to the web sites is no small job! The NTPCA management team has created a portal page to get you to important sites. The URL is simple, it is: *www.napatreepoint.info*

NTPCA - A Learning Destination

Napatree is an extremely popular site for field trips, demonstrations, and classes. This year we hosted visits from: The USDA Natural Resources Conservation Service, the EPA Narragansett Bay Estuary Program, Block Island Maritime Institute, URI classes in Environmental Economics and Ornithology, Save the Bay, Washington Trust Bank, the Wild Plant Society, Osher Lifelong Learning Institute, a local high school class of student volunteers, and Senior Fellows of the URI Coastal Institute.

Tough Summer for Napatree Osprey

Our resident Osprey pair abandoned their nesting attempt this summer. It is always great fun to watch the hatchlings grow and ultimately fledge. Hopefully, they will have better success in 2017.

NTPCA Designated Climate Response Demonstration Site by URI Coastal Institute

The URI Coastal Institute has established three climate response demonstration sites in Rhode Island that exemplify best management practices to enhance ecosystem and community resilience to the effects of climate change. The Napatree Point Conservation Area has been designated the “natural areas” demonstration site because of the innovative and comprehensive stewardship, monitoring, management, and education programs that carried out by Napatree staff and collaborators.

Telemetry Tower

Dr. Pamela Loring continues her studies of bird movement patterns on the eastern seaboard. The telemetry tower on the western end of Napatree logged passes by over 100 individual radio-tagged birds including Roseate Terns, Commons Terns, Piping Plovers, Red Knots, and a Woodcock. Some of the birds were tagged as far away as Arctic Canada, the Great Lakes, and Virginia. Dr. Loring and her colleague (and Napatree Science Advisor) Dr. Peter Paton

have their hands full analyzing the huge volume of data this study produces. The results will be used by the Bureau of Ocean Energy Management to ensure that future offshore windfarms are not situated in important coastal flyways for shorebirds.

Diamondback Terrapin

On June 26, one of the Napatree Naturalists found a dead diamondback terrapin on the ocean side of the western end of Napatree. It is not clear what the cause of mortality was. It was disappointing to learn that this individual did not survive but we are heartened to know that diamondback terrapins continue to be found on Napatree.

Snowy Owl Sightings in 2016

One or more Snowy Owls were observed on Napatree in 2016. Although sightings were not as frequent as in 2015, local birdwatchers enjoyed their presence last winter.

Napatree Part of the U. S. Fish and Wildlife Service John H. Chafee Coastal Barrier Resources System (CBRS)

As a “System Unit” in the CBRS network, Napatree is afforded an important level of protection. With System Unit status, federal funds can not be used to develop or damage the environmental quality of Napatree. Federal funds can, however, be used to support certain conservation and recreation projects in the NTPCA.