EXPERIENCE
YOUR
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October 7, 2024
Cape Cod National Seashore Advisory Commission

Superintendent Presentation: Climate Change & Coastal Resilience

EXPERIENCE
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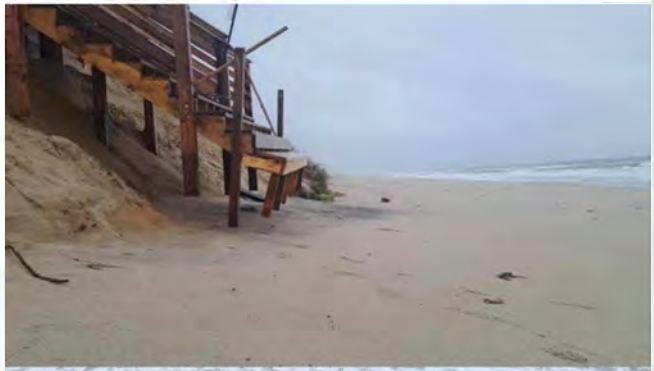
Marconi Stairs

Friday, September 20th 8:00 am



Friday, September 20th 4:00 pm

EXPERIENCE
YOUR
AMERICA

Marconi Stairs

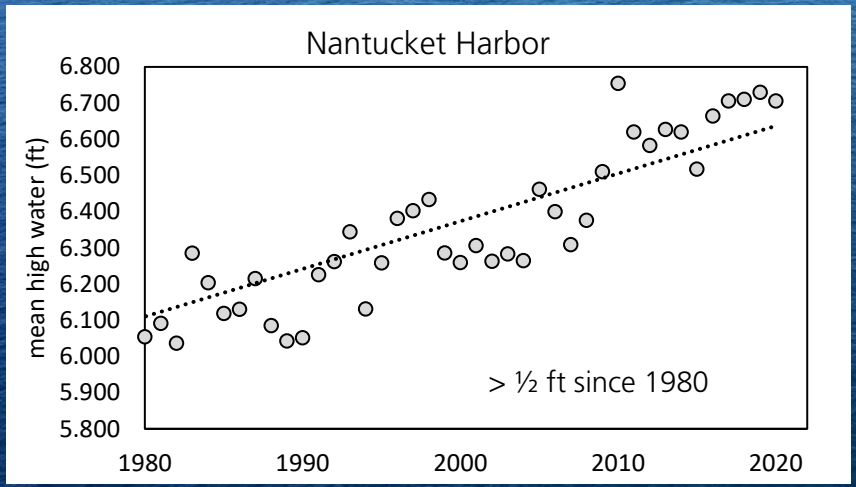
Monday, September 23rd

Wednesday, September 25th

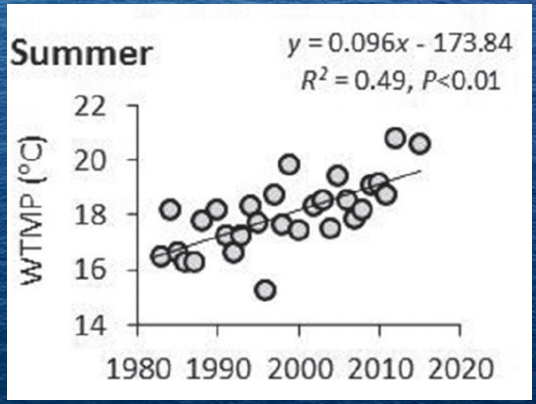
Coastal Resiliency

Climate change is driving changes in ecosystem conditions

sea level rise



water temperature

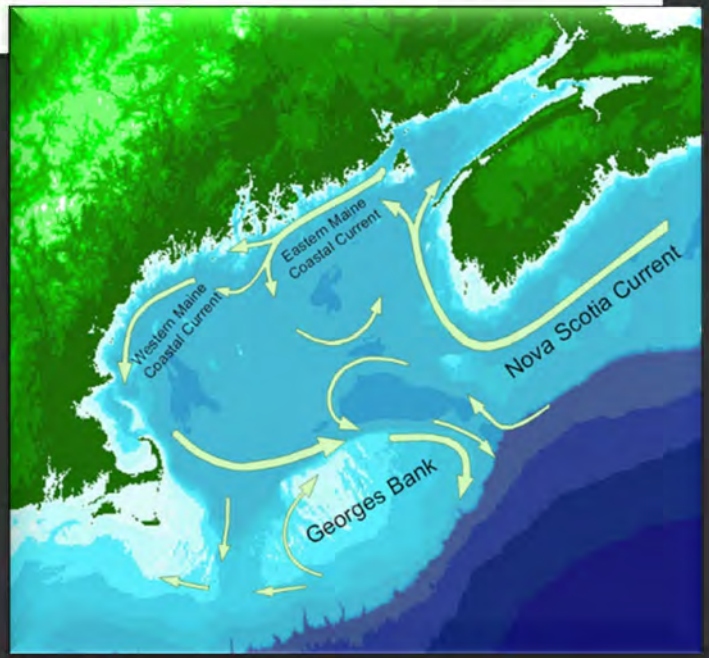


Eos

ABOUT SECTIONS TOPICS PROJECTS NEWSLETTER SUBMIT TO *EOS*

Why Is the Gulf of Maine Warming Faster Than 99% of the Ocean?

The Gulf of Maine's location at the meeting point of two major currents, as well as its shallow depth and shape, makes it especially susceptible to warming.



Coastal Geomorphology Monitoring at Cape Cod National Seashore

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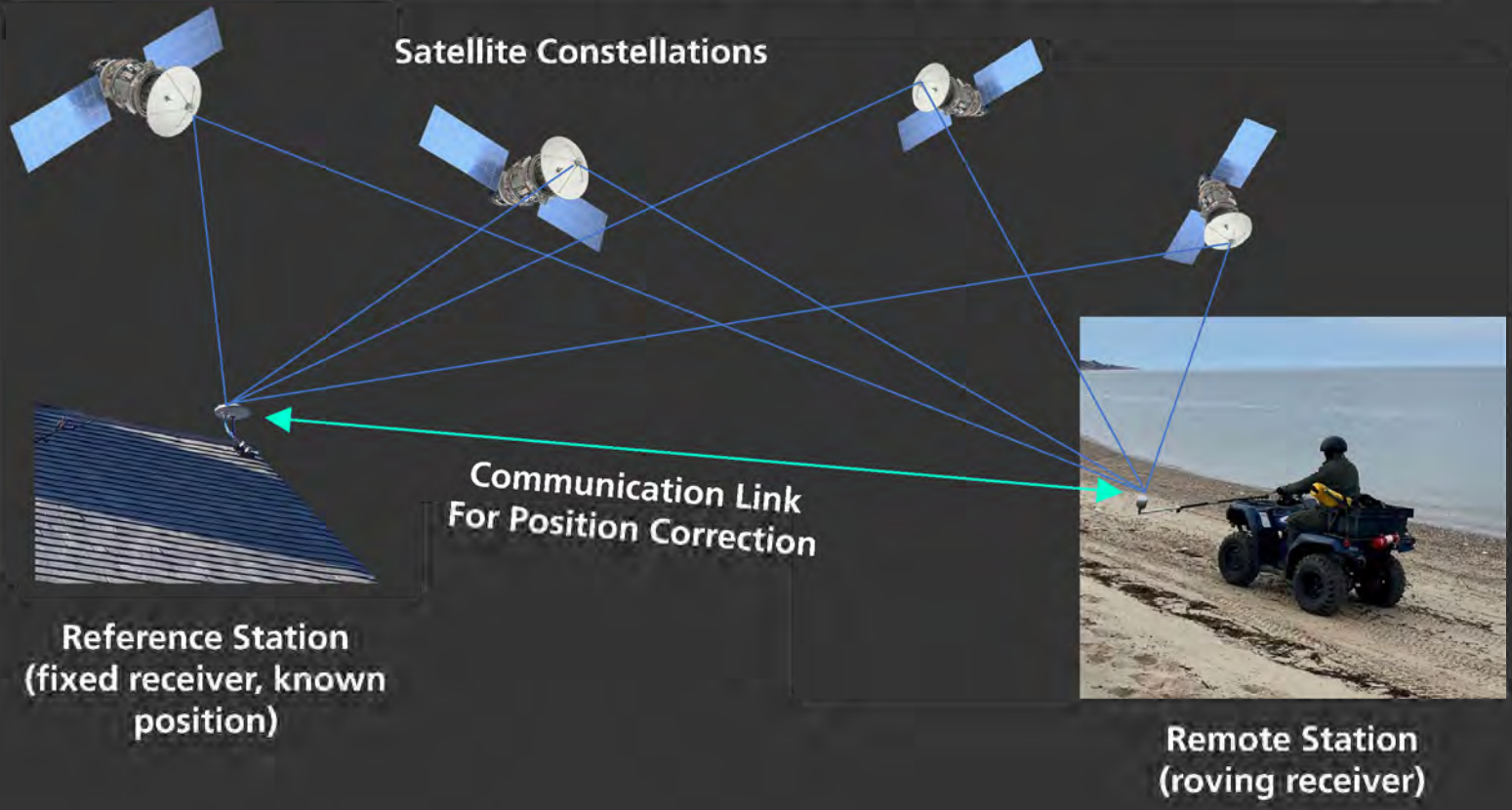
- Ocean Shoreline Position (1D)
- Coastal Topography (2D)
- Coastal Landform Elevation Models (3D)

Ocean Shoreline Position

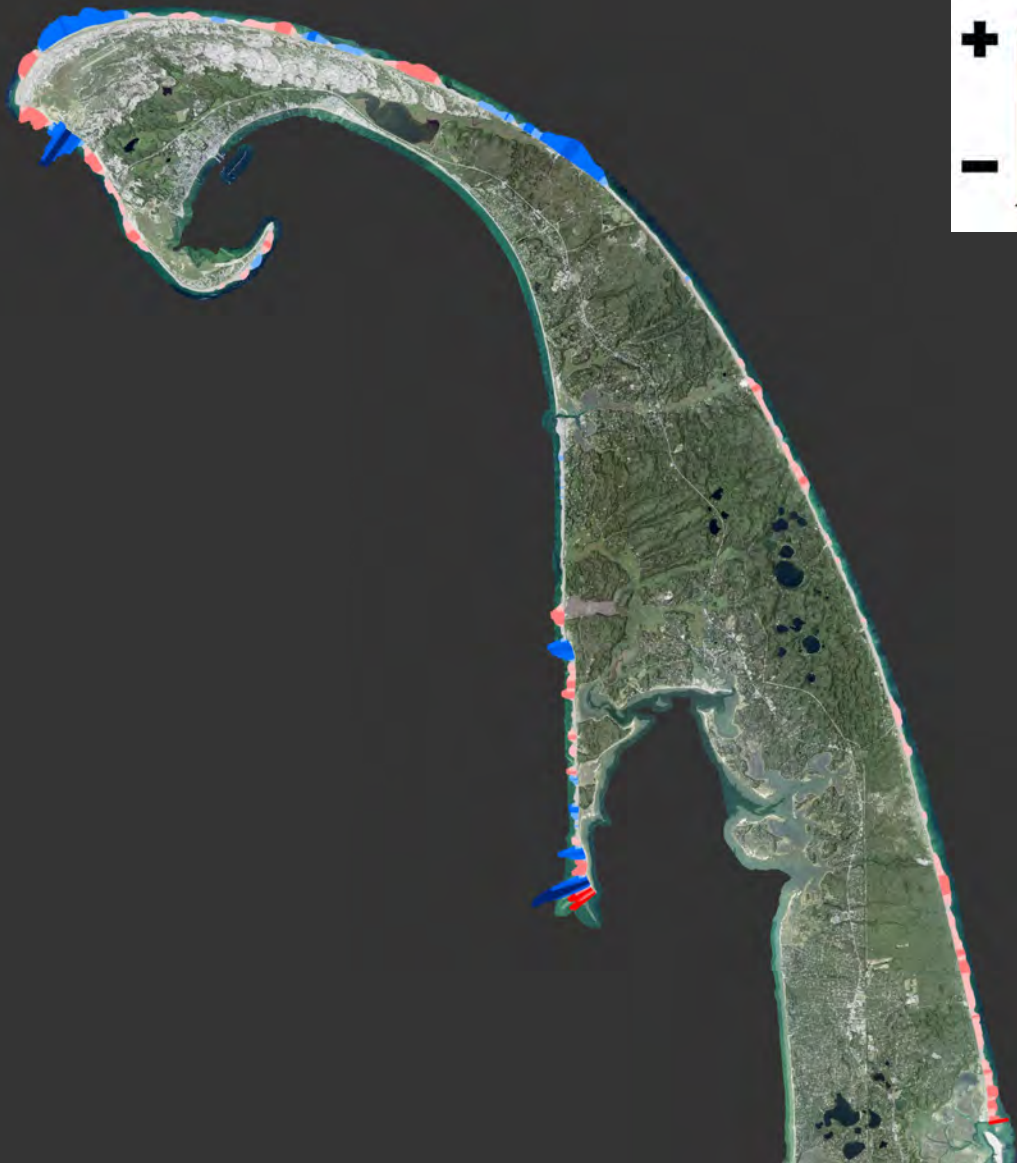
RTK-GNSS

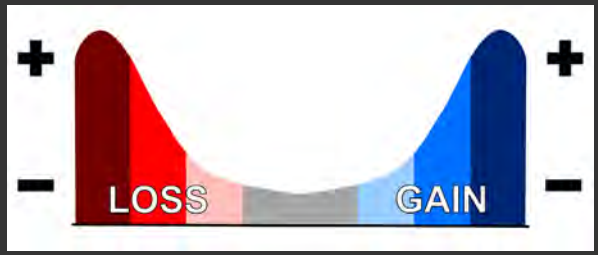
Real-Time Kinematic-
Global Navigation Satellite System



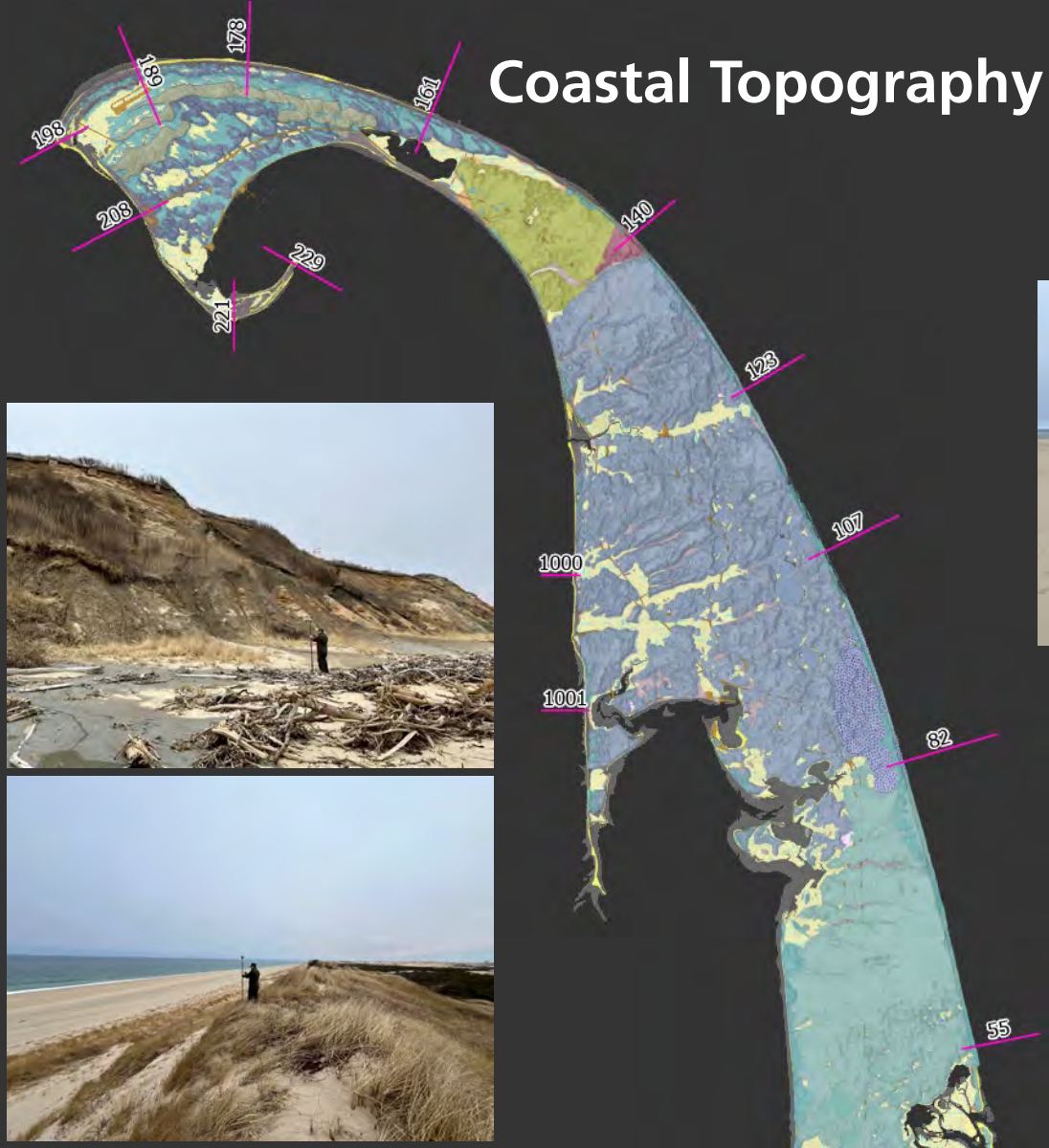
Corrected Points
with Baselines

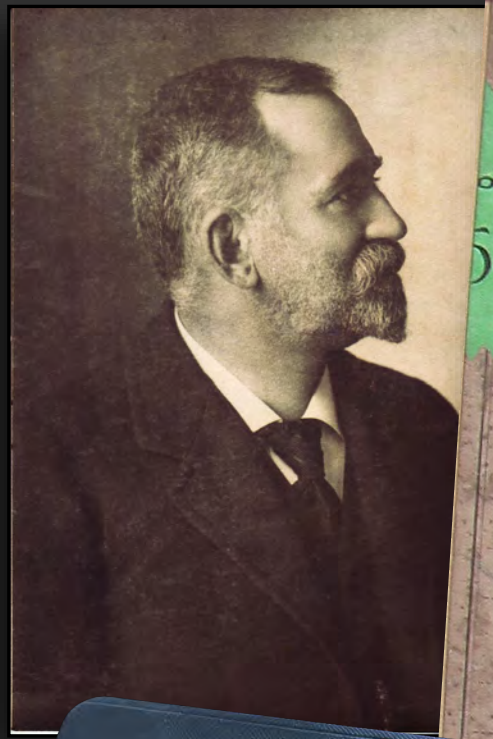
Race Point Beach shorelines




+
+
−
−
LOSS
GAIN

Coastal Topography





Duplicate

U. S. COAST AND GEODETIC SURVEY.

T. C. Mendenhall, Superintendent.

When the original record is returned to the archives, this duplicate is to be destroyed.

ox.

State: Mass.

6 1/2

OBSERVATIONS

OF

HORIZONTAL ANGLES.

LOCALITY

Near Provincetown
Cape Cod, Mass.

INSTRUMENT

Theodolite No 67

Duplicate

1889. JUN 8 - 1904

Acc. No

CHIEF OF PARTY

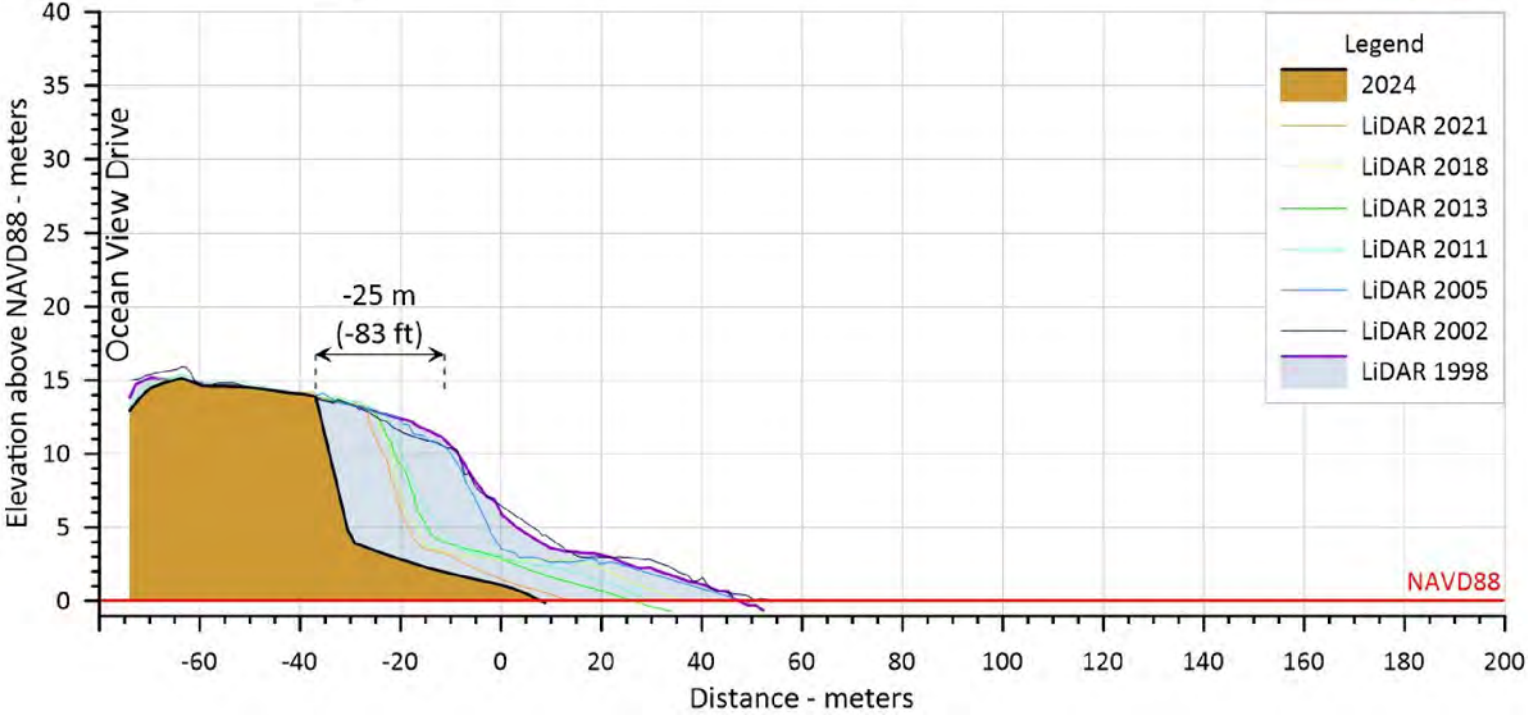
Henry L Marindin

1 Vols. When the original record is returned to the archives, this duplicate is to be destroyed. Vol. 1

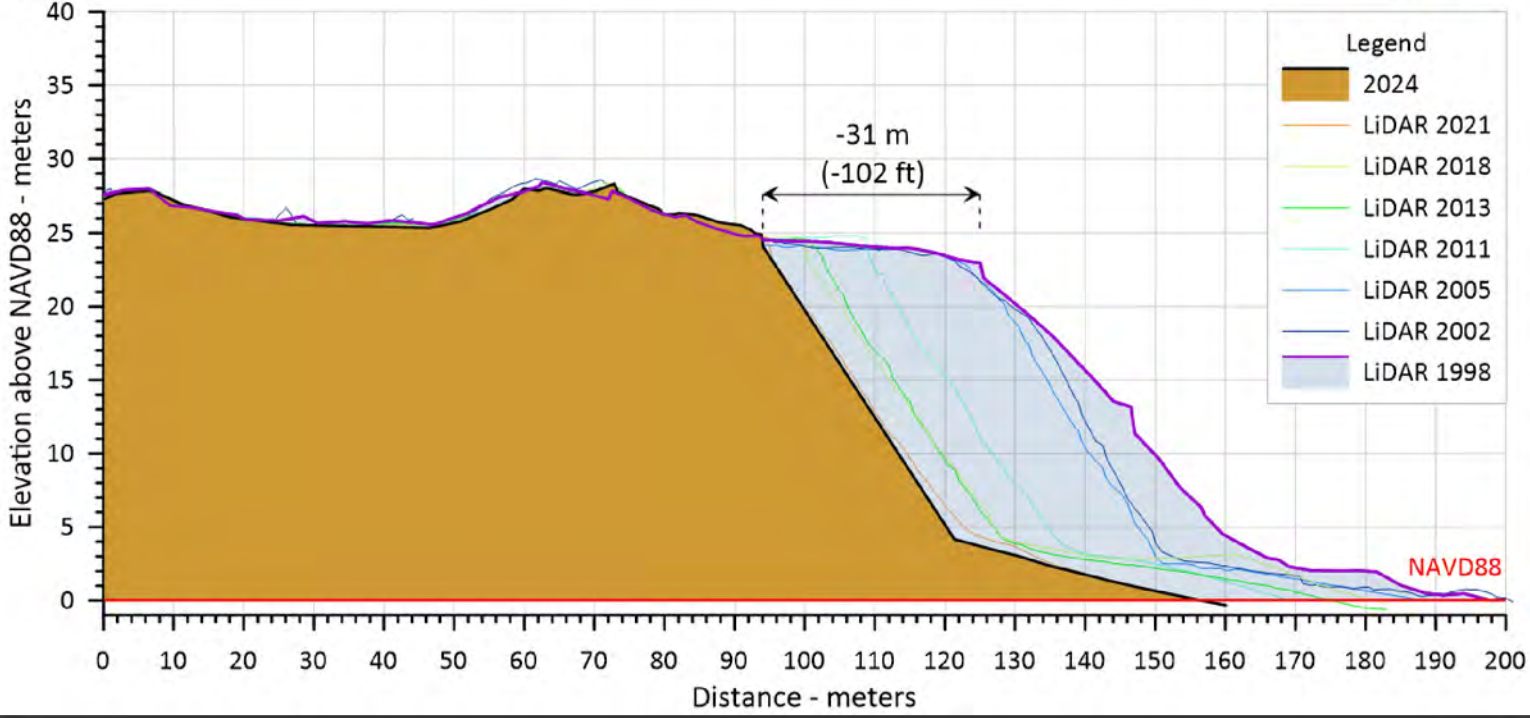
2—188

Marindin Profile 189 - Race Point Parking Lot

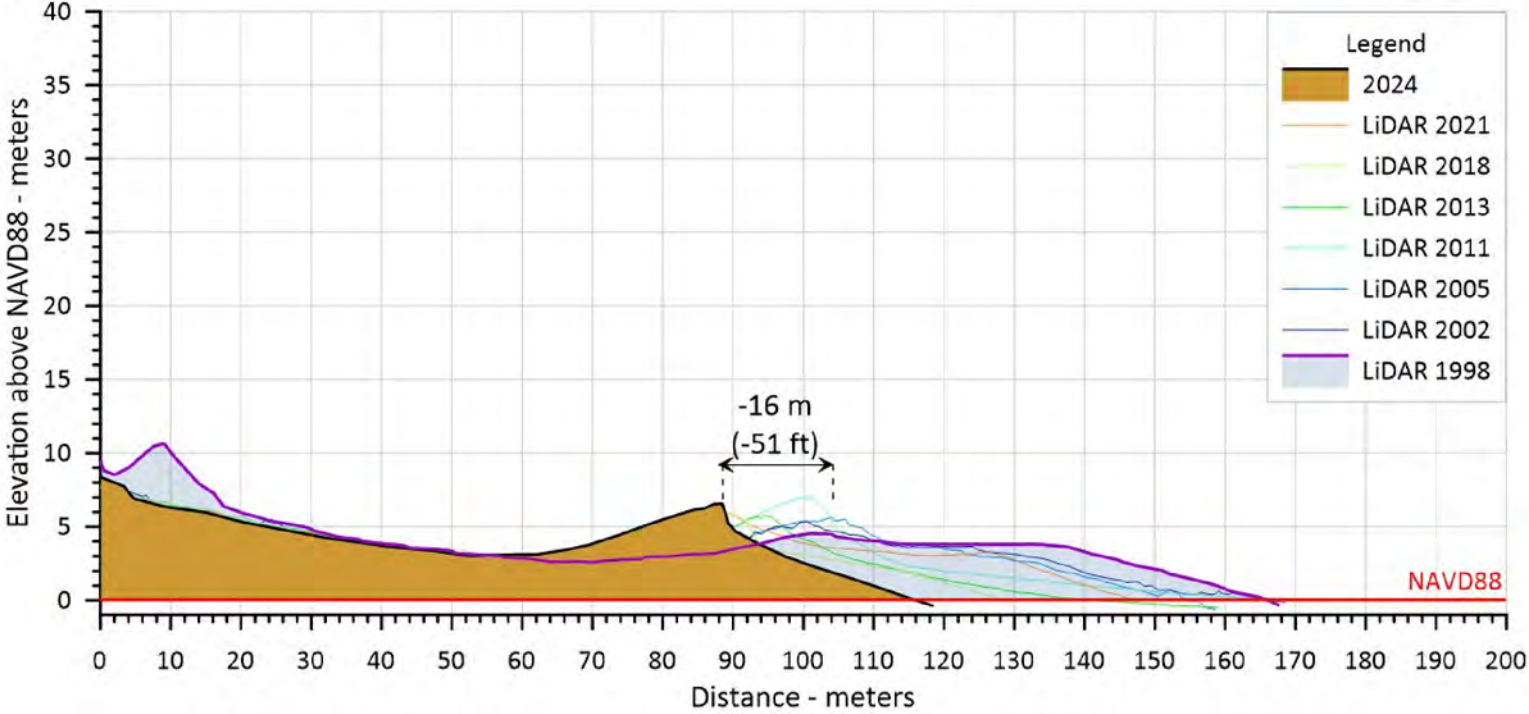
Marindin Profile 55 - Bartlett Property



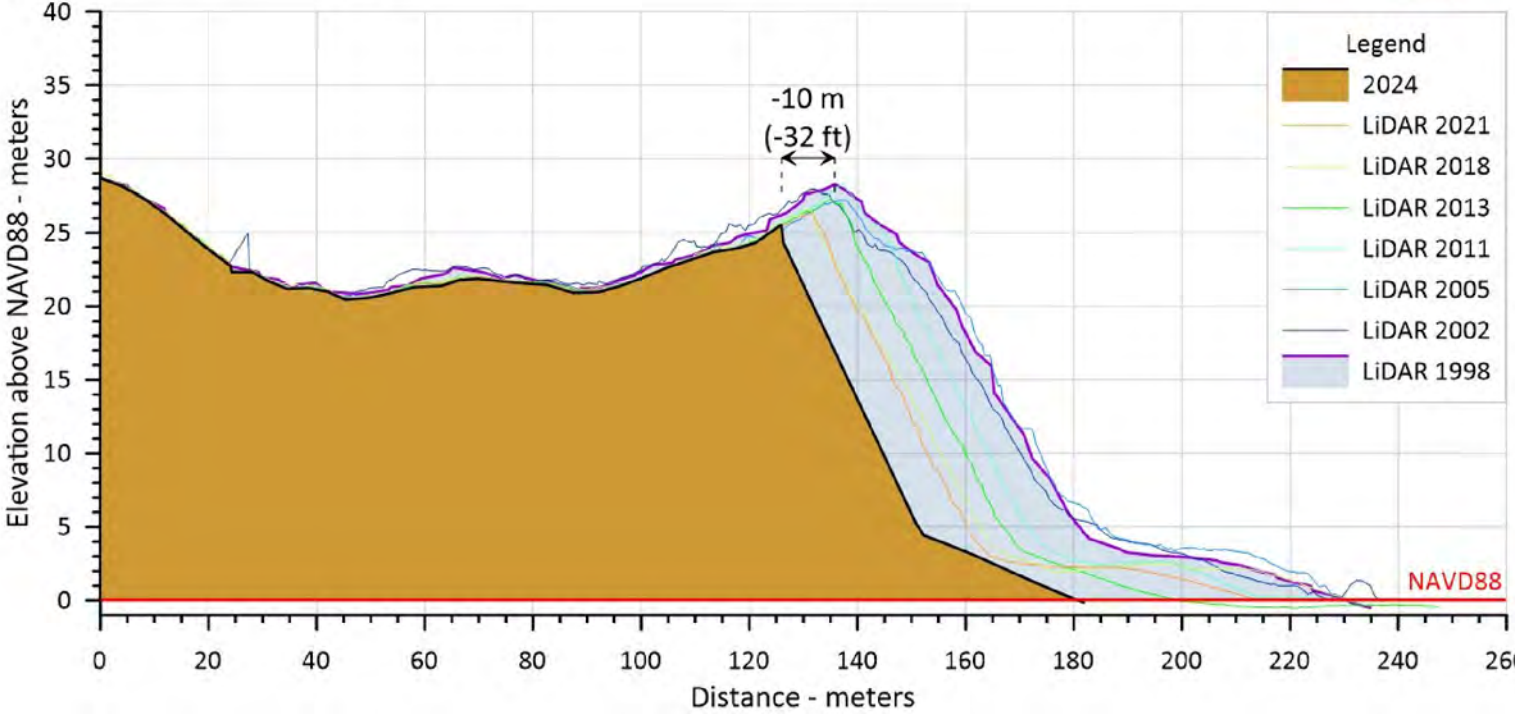
Marindin Profile 82 - Marconi Site



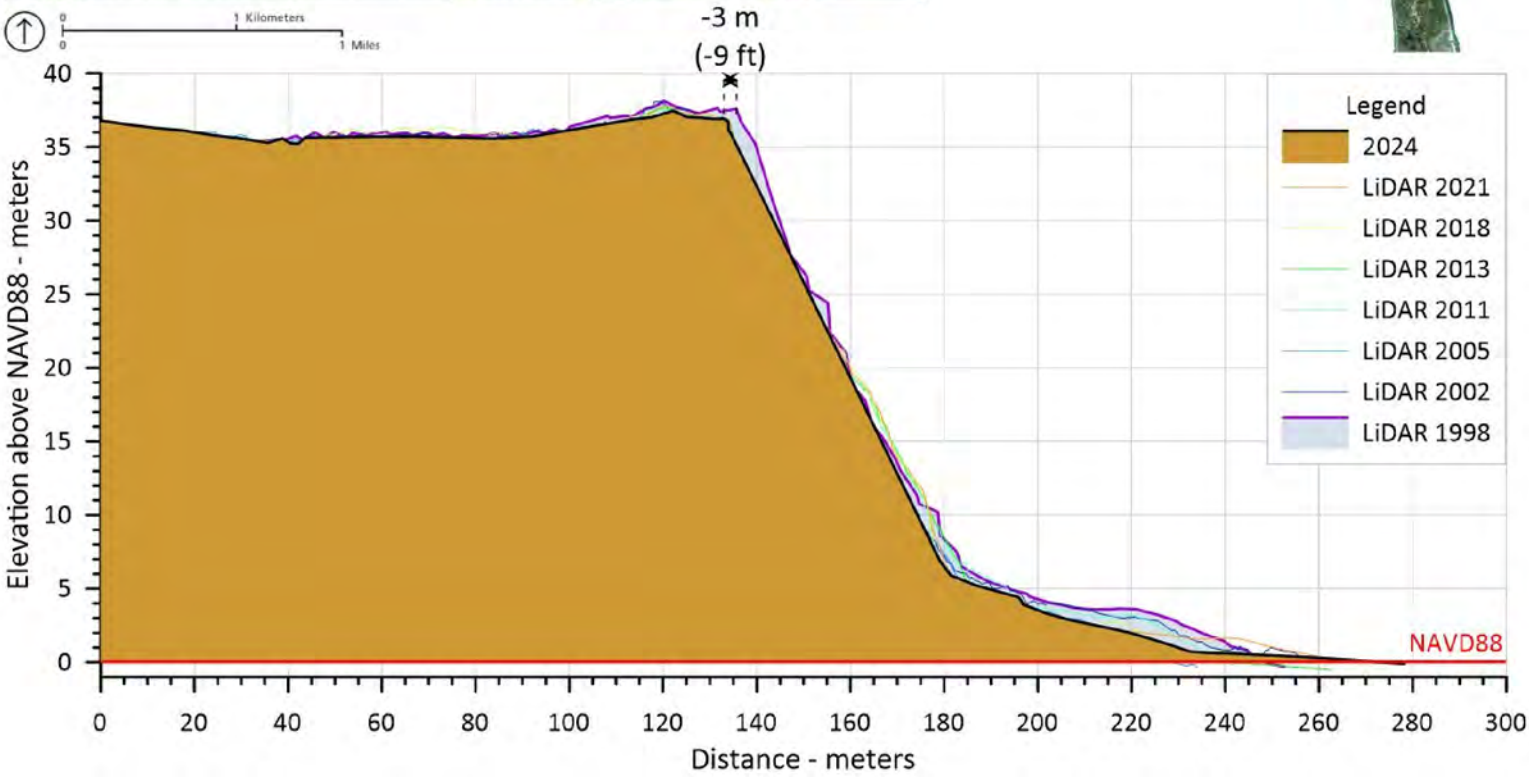
Marindin Profile 107 - Newcomb Hollow

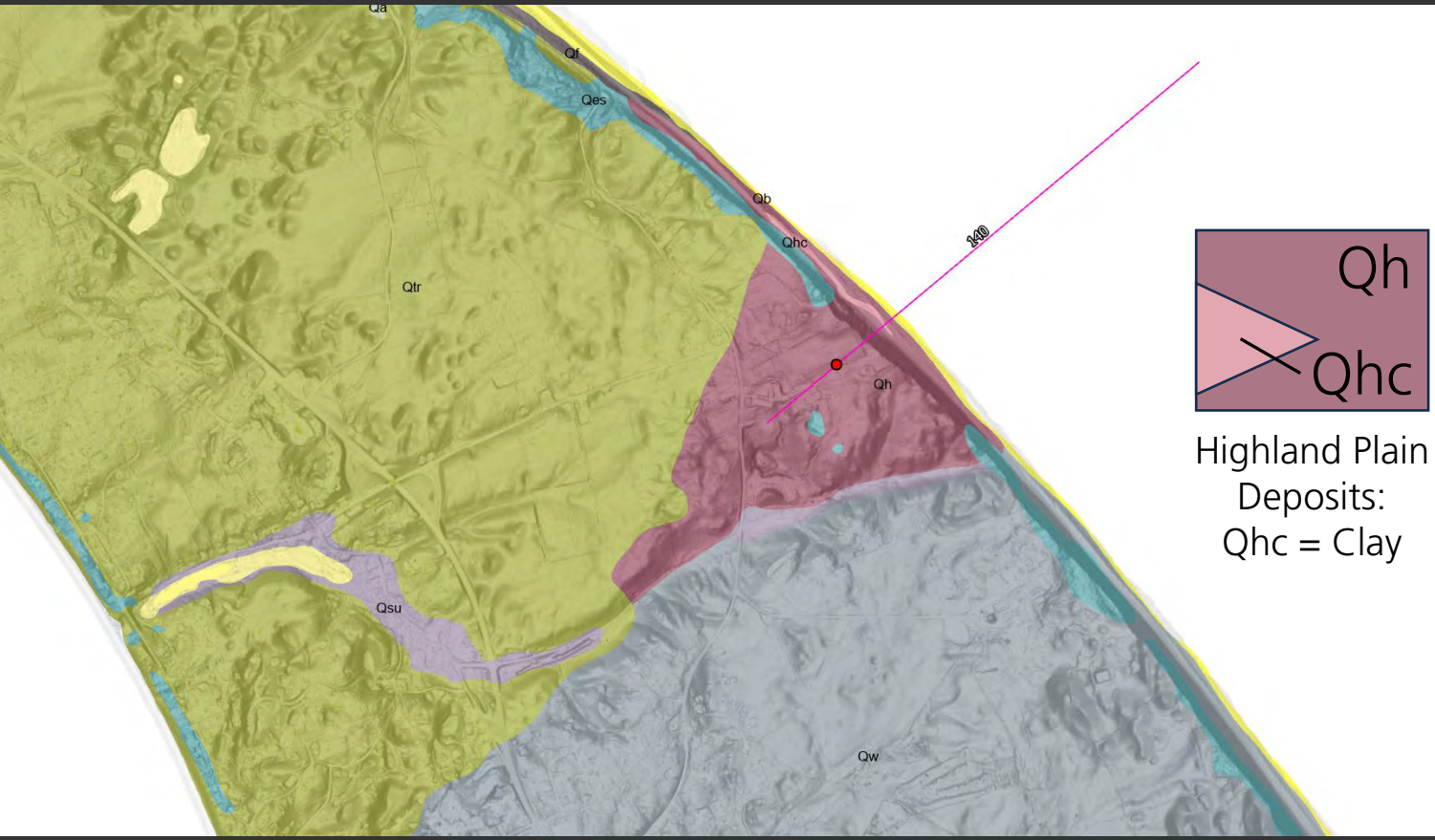


Marindin Profile 123 - Pamet Area



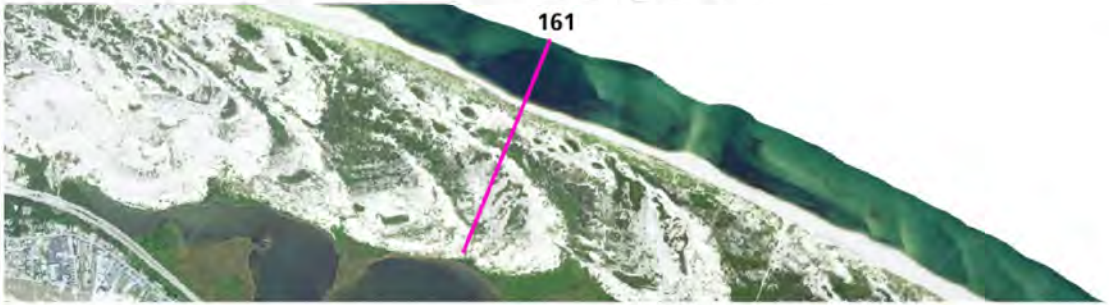
Marindin Profile 140 - Highland Light

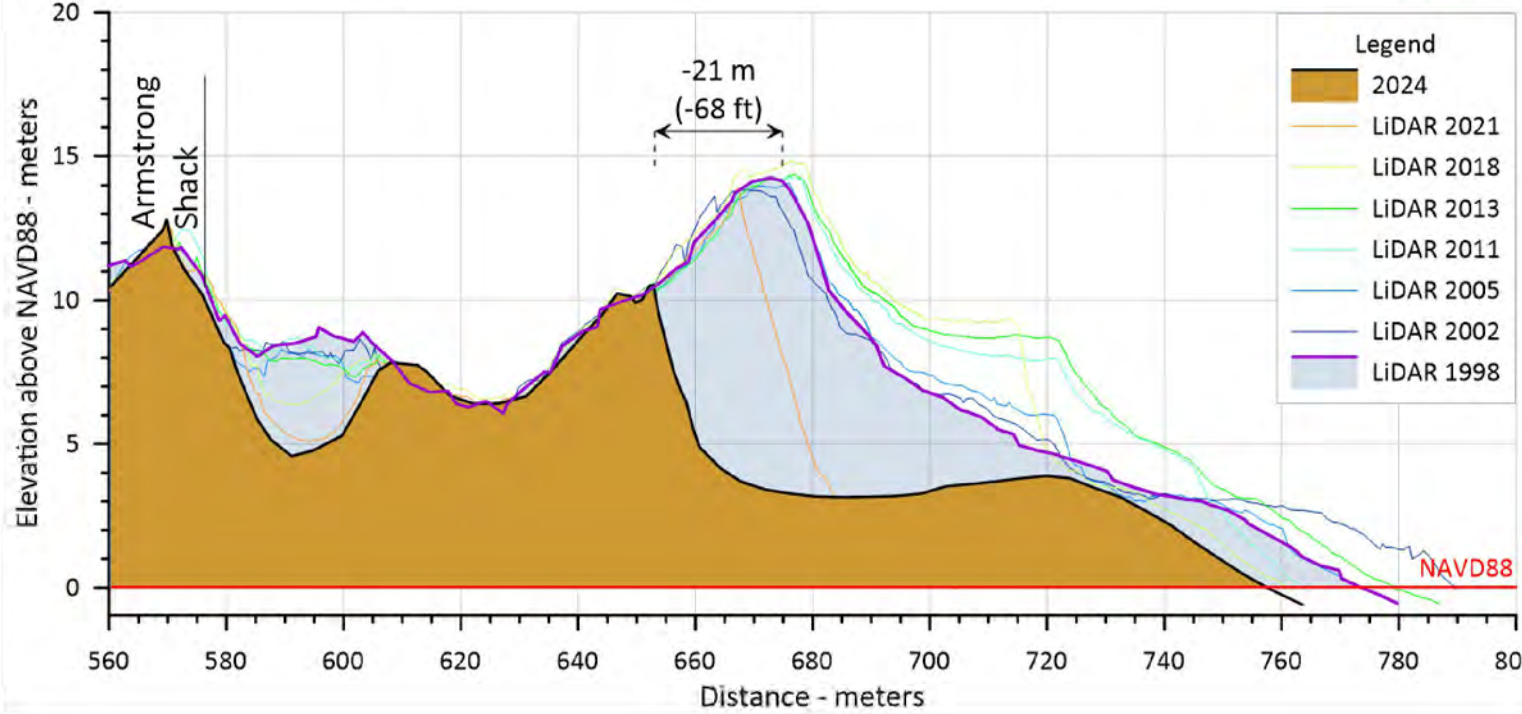




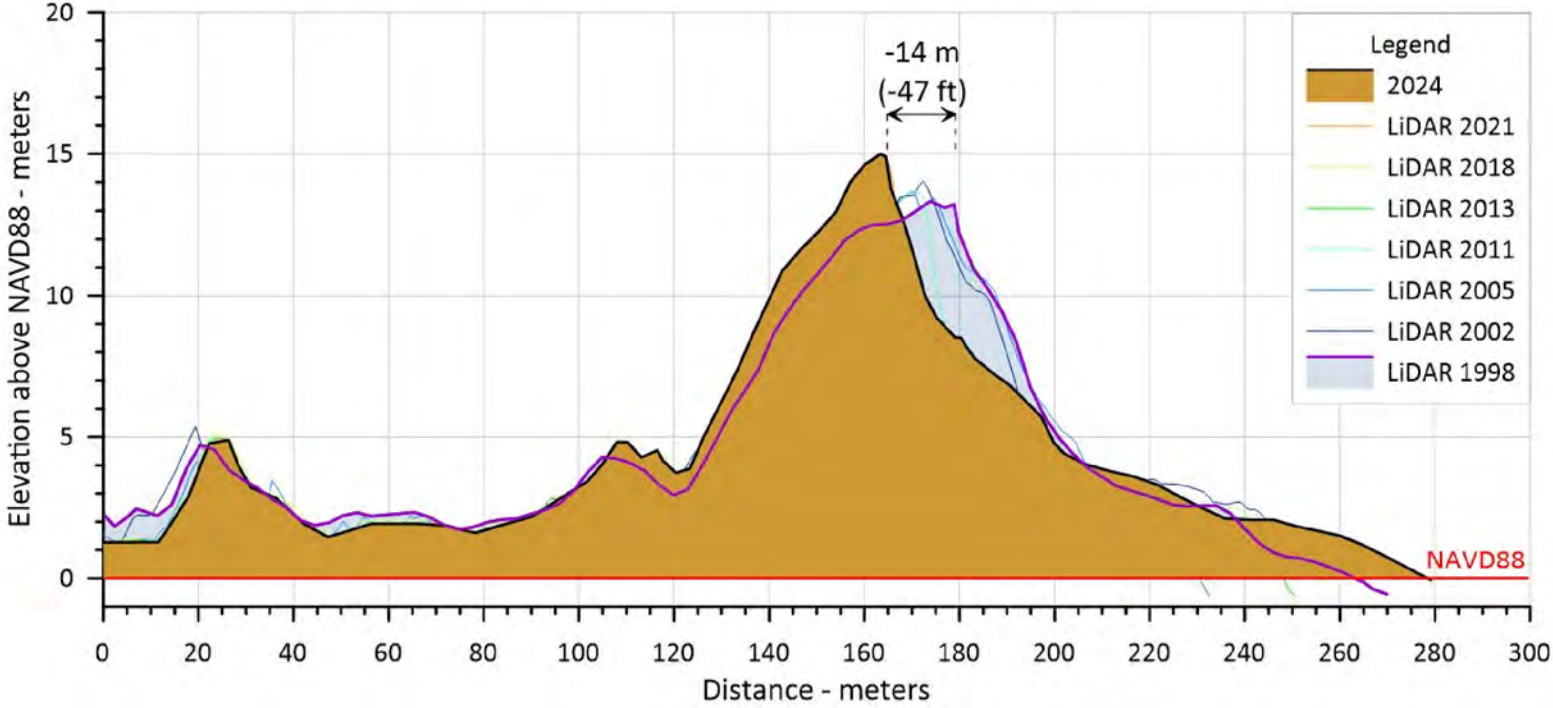
Highland Plain Deposits:
Qhc = Clay

Marindin Profile 161 - Armstrong Shack

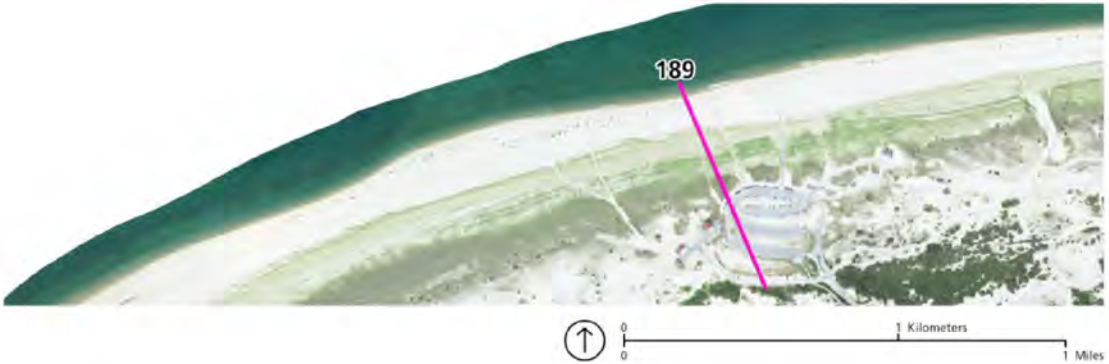


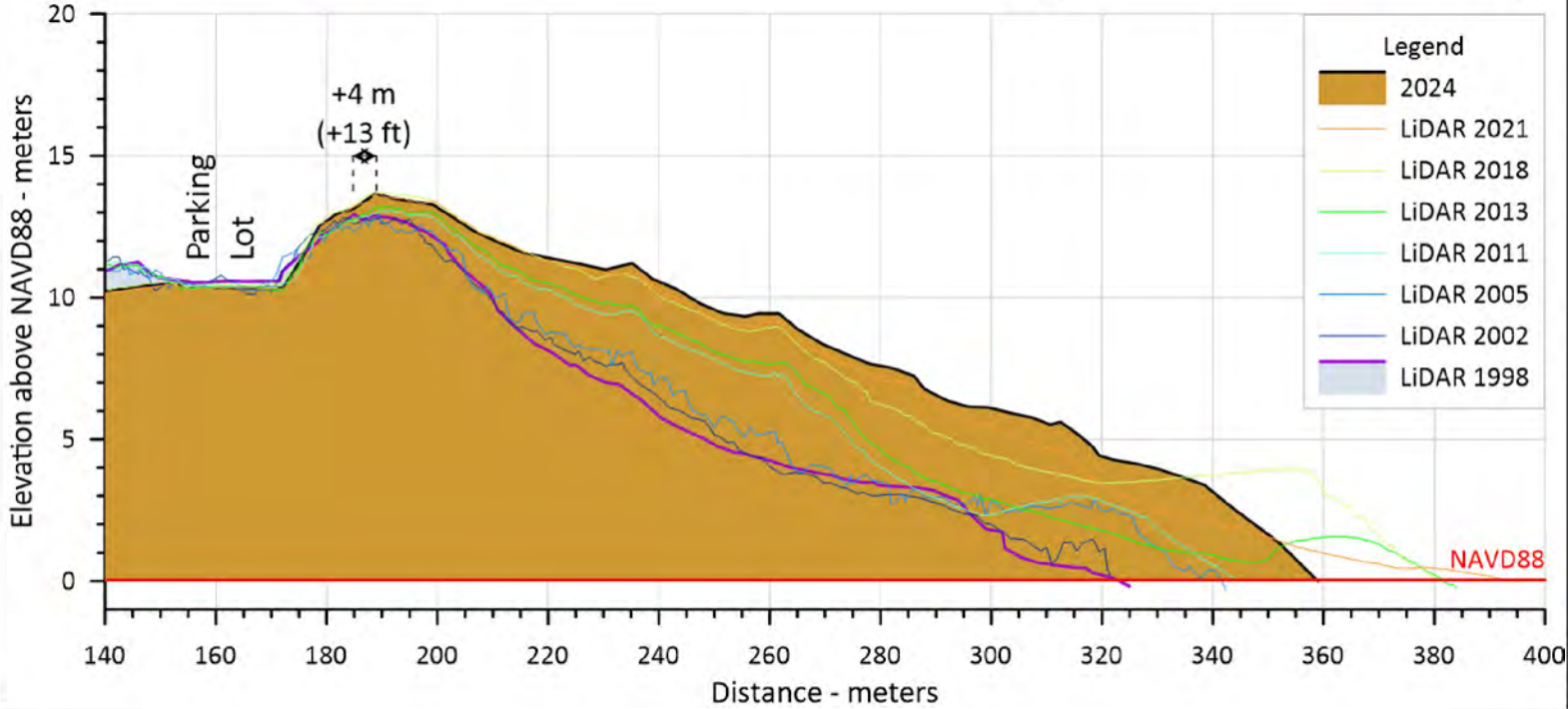


Marindin Profile 178 - Race Point South Beach

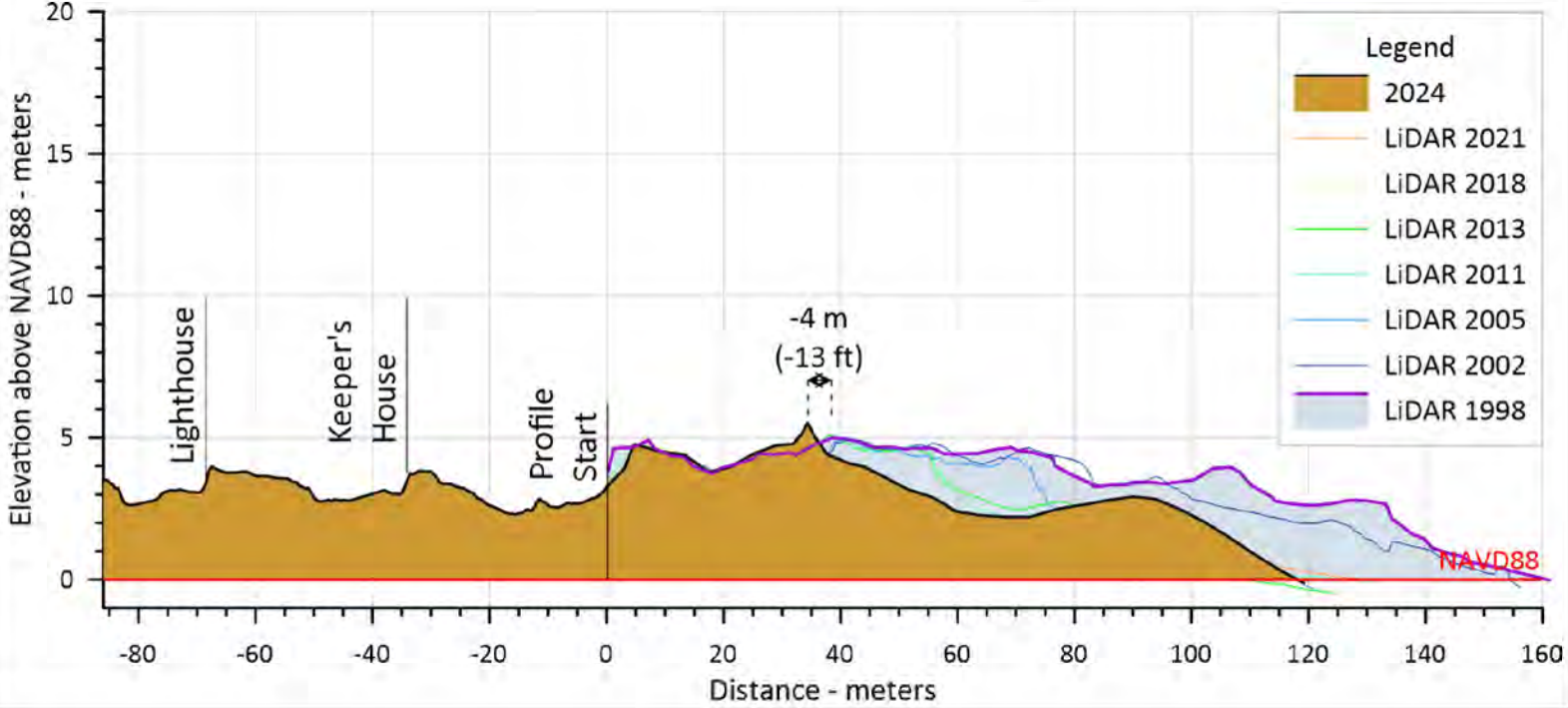


Marindin Profile 189 - Race Point Parking Lot

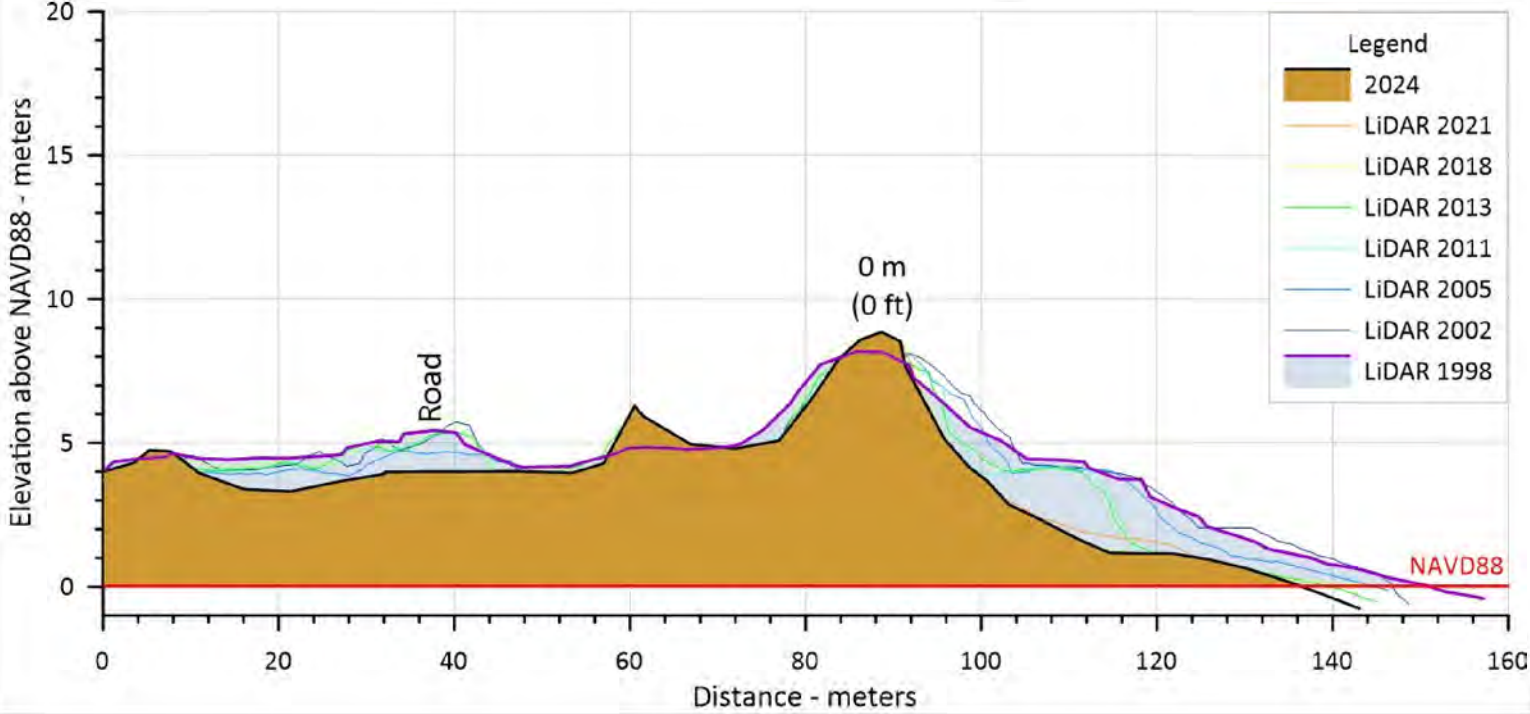




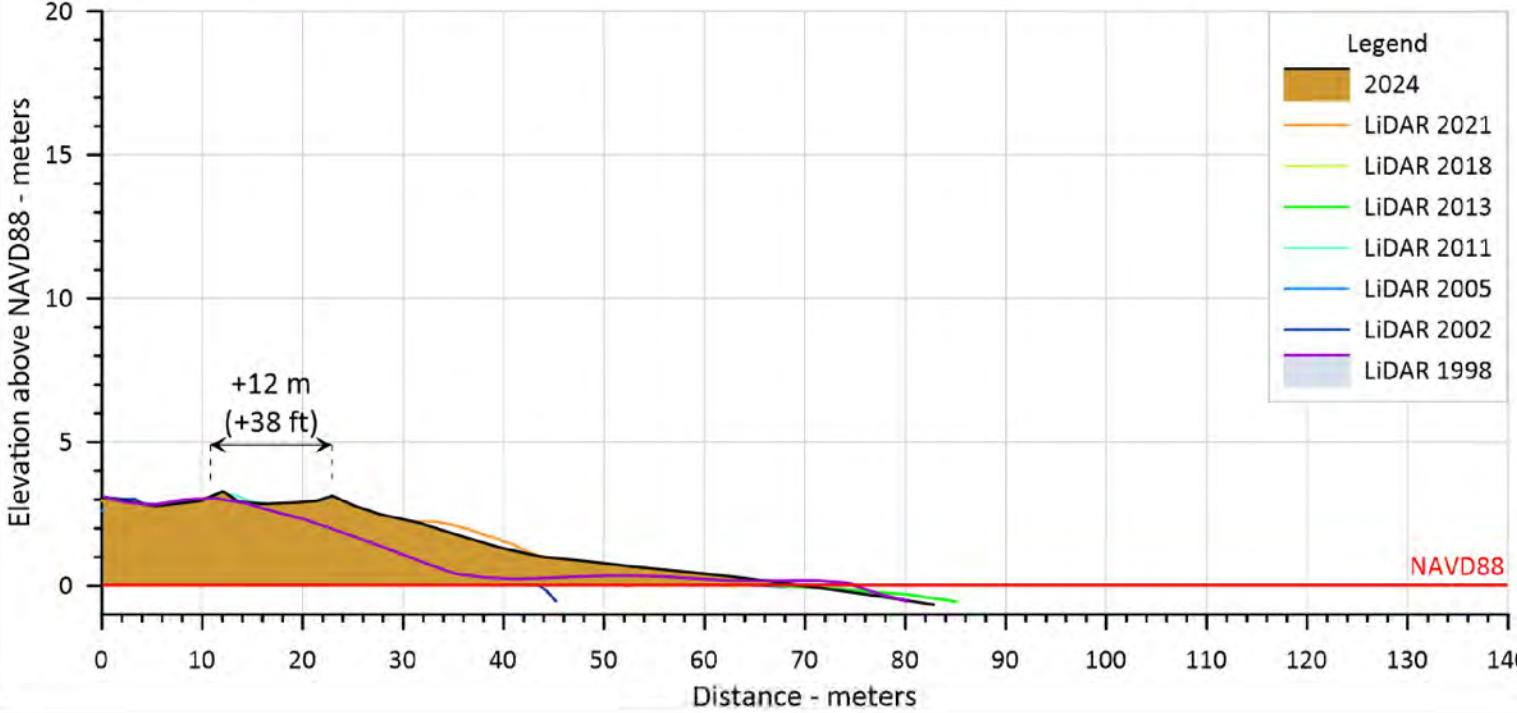
Marindin Profile 198 - Race Point Light



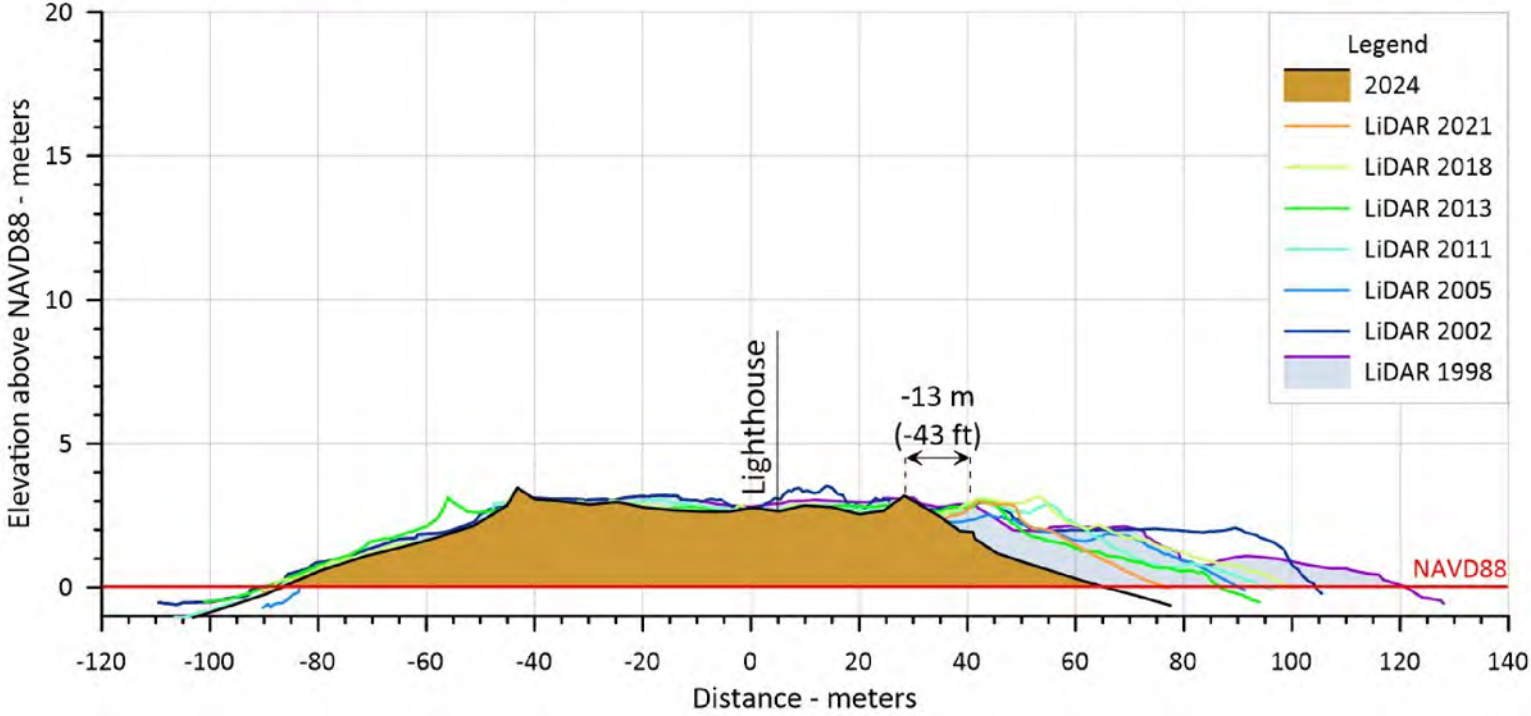
Marindin Profile 208 - Herring Cove Beach



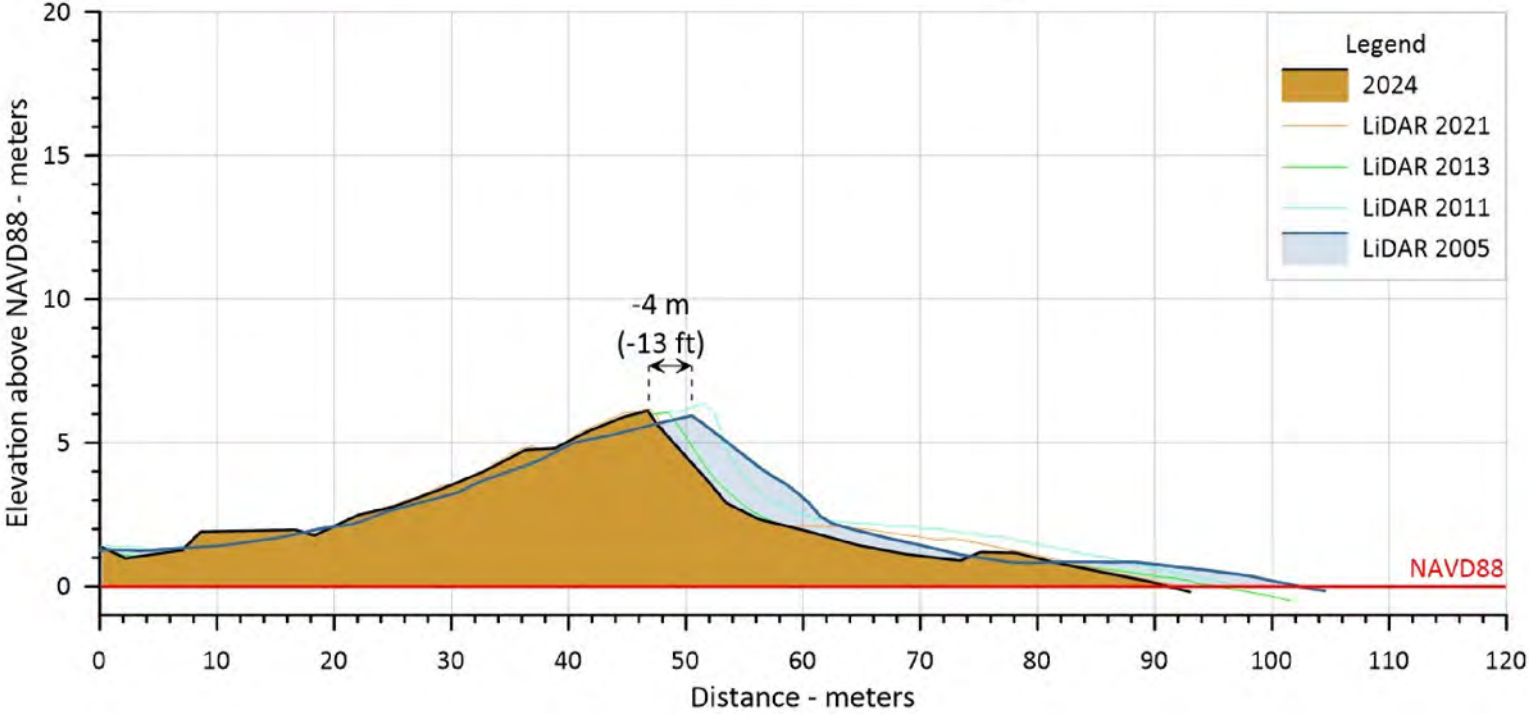
Marindin Profile 221 - Wood End



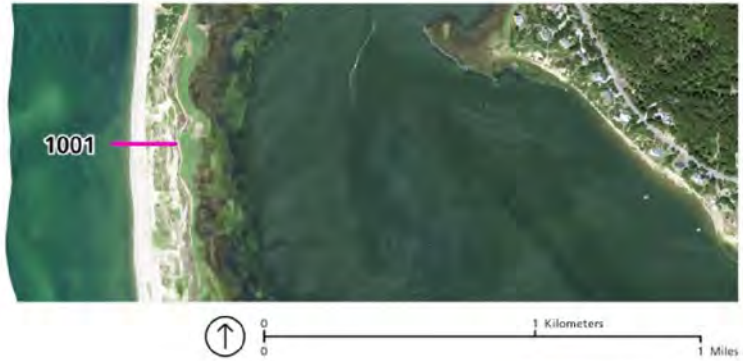
Marindin Profile 229 - Long Point Light

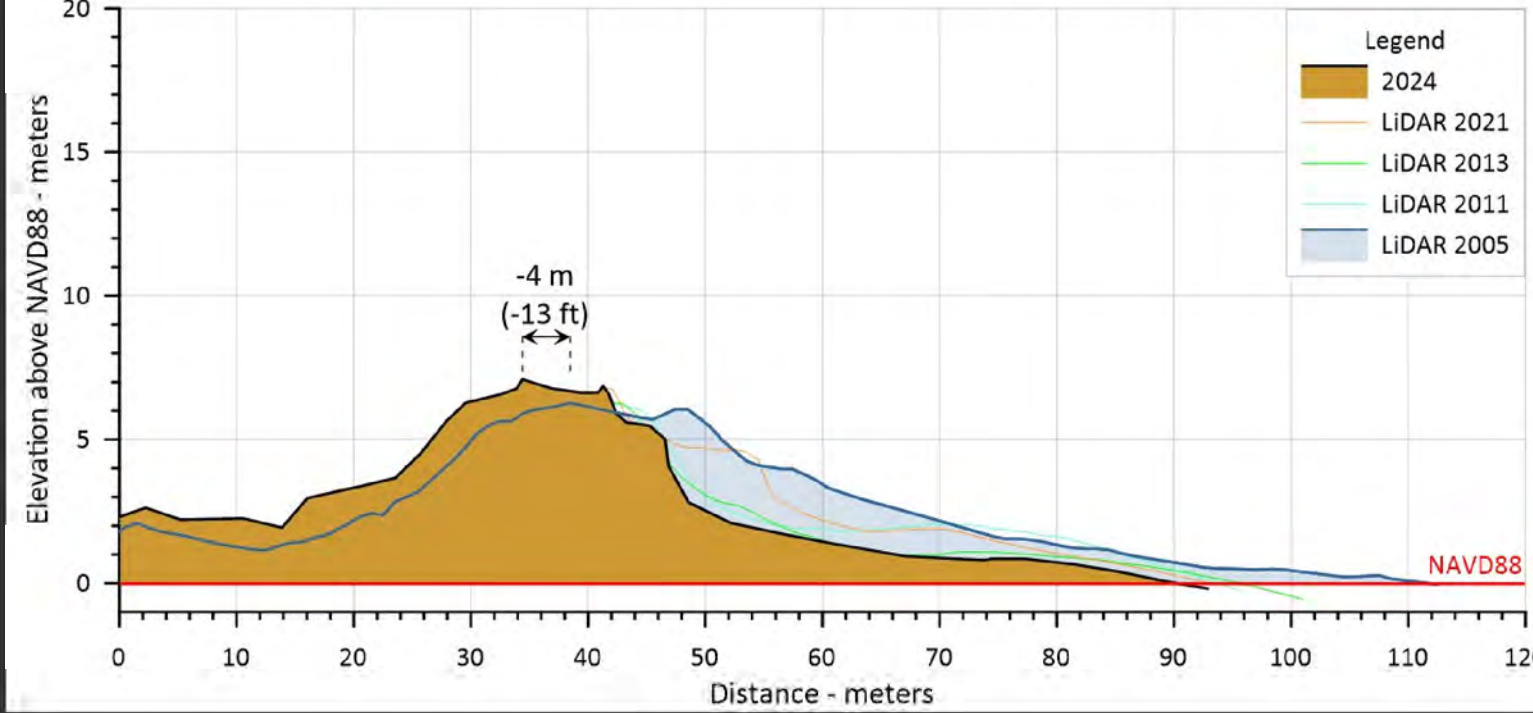


Profile 1000 - Ryder Beach



Profile 1001 - The Gut

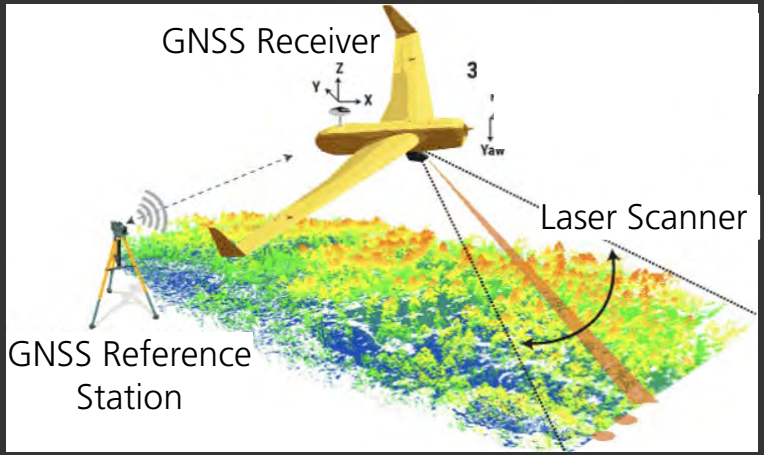




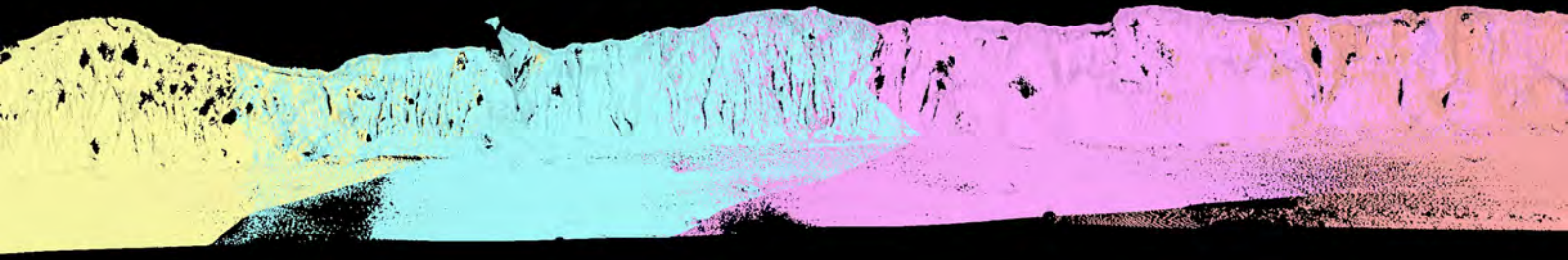
Coastal Landform Elevation Models

Light Detection And Ranging

- Light is emitted from a rapidly firing laser.
- Light travels to the ground and reflects off objects like dunes and tree branches.
- A LiDAR system measures the time it takes for the light to travel to the object and back.
- Time used to calculate Distance.
- Distance converted to Elevation.

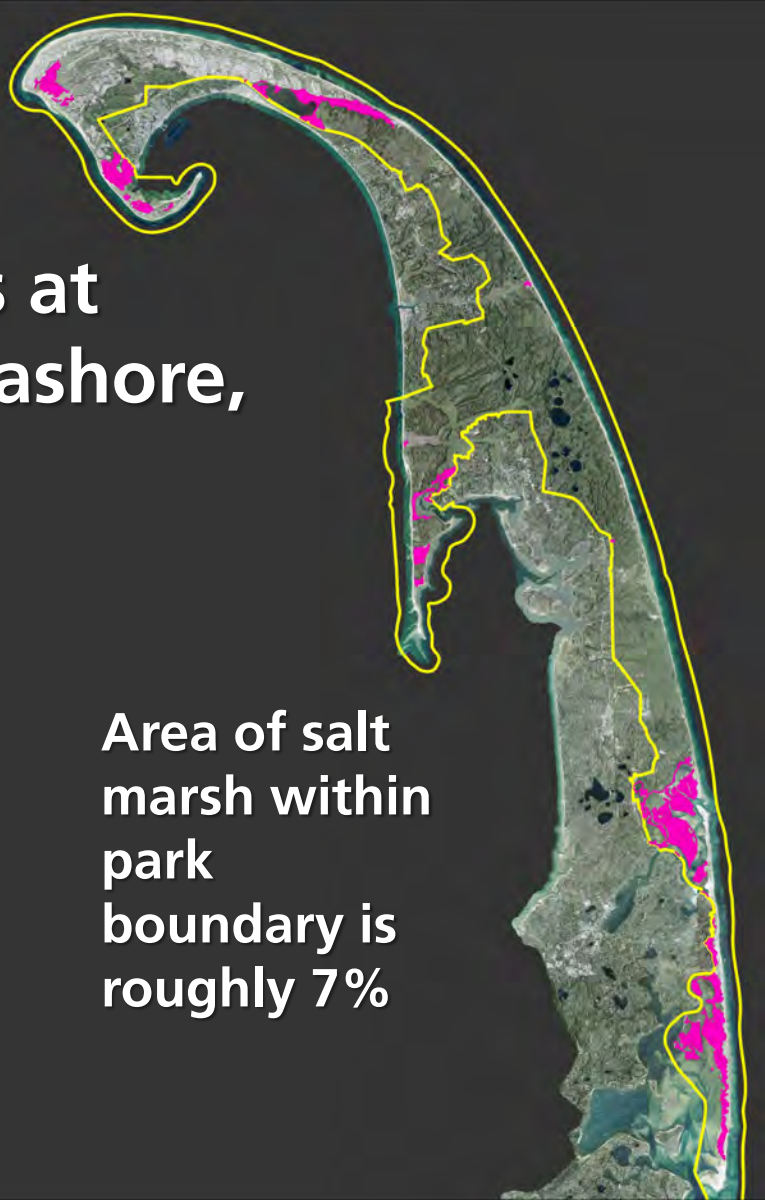


Scan Color



True Color

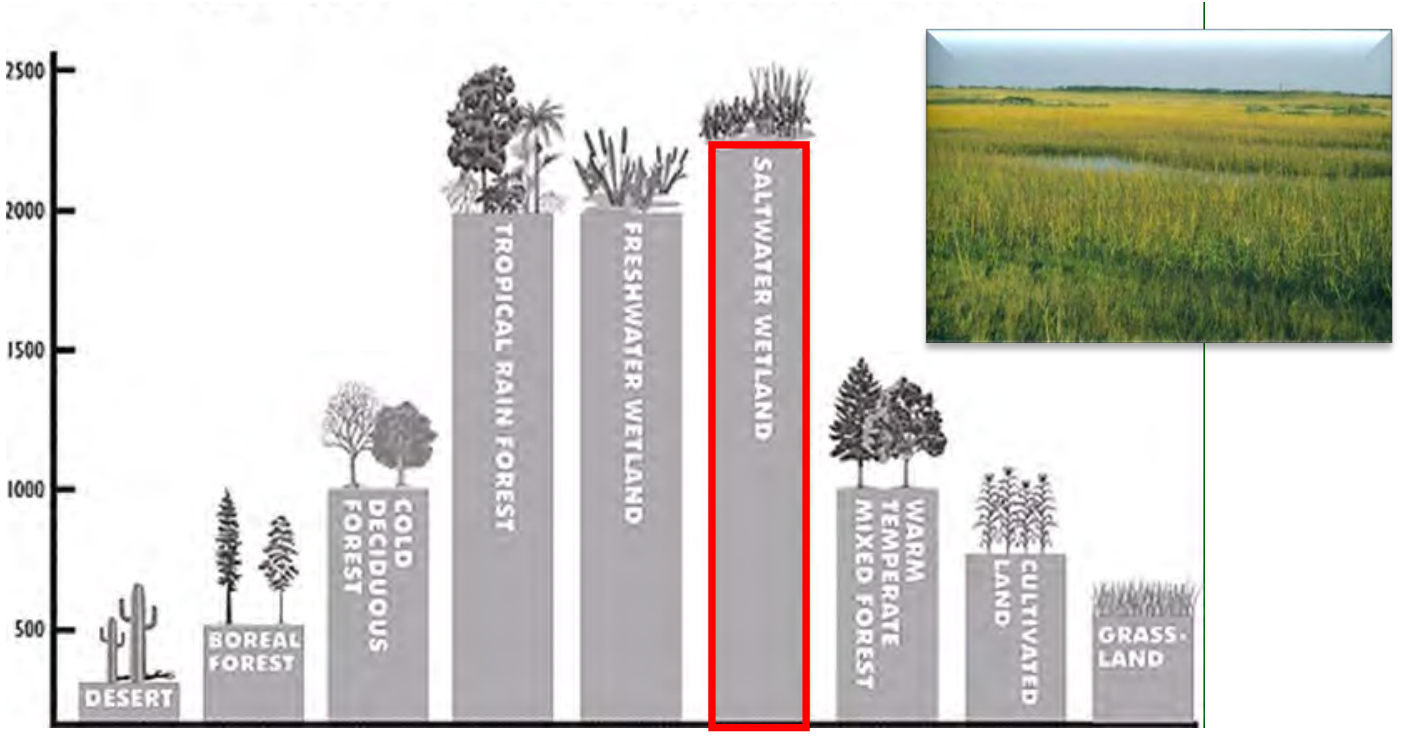
Status of salt marshes at Cape Cod National Seashore, 2024



Area of salt marsh within park boundary is roughly 7%

Net Primary Productivity of Selected Ecosystems

(g/m^2/year – amount of photosynthesis



*** Very important in biogeochemical cycling of elements and energy**

Salt Marsh Fauna – many permanent & part time residents

Invertebrates

American Oyster
Amphipods and Isopods
Atlantic Horseshoe Crab
Black-fingered Mud Crab
Blue Crab
Common Periwinkle
Common Slipper Shell
Fiddler Crab
Grass Shrimp
Green Crab
Hermit Crab
New England Dog Whelk
Northern Rock Barnacle
Razor Clam
Red-beard Sponge
Ribbed Mussel
Soft-shelled Clam
Zooplankton

Fish

American Eel
Atlantic Menhaden
Atlantic Silverside
Bluefish
Fourspine Stickleback
Killifish
Naked Goby
River Herring
Sheepshead Minnow
Squeteague
Striped Bass

Birds

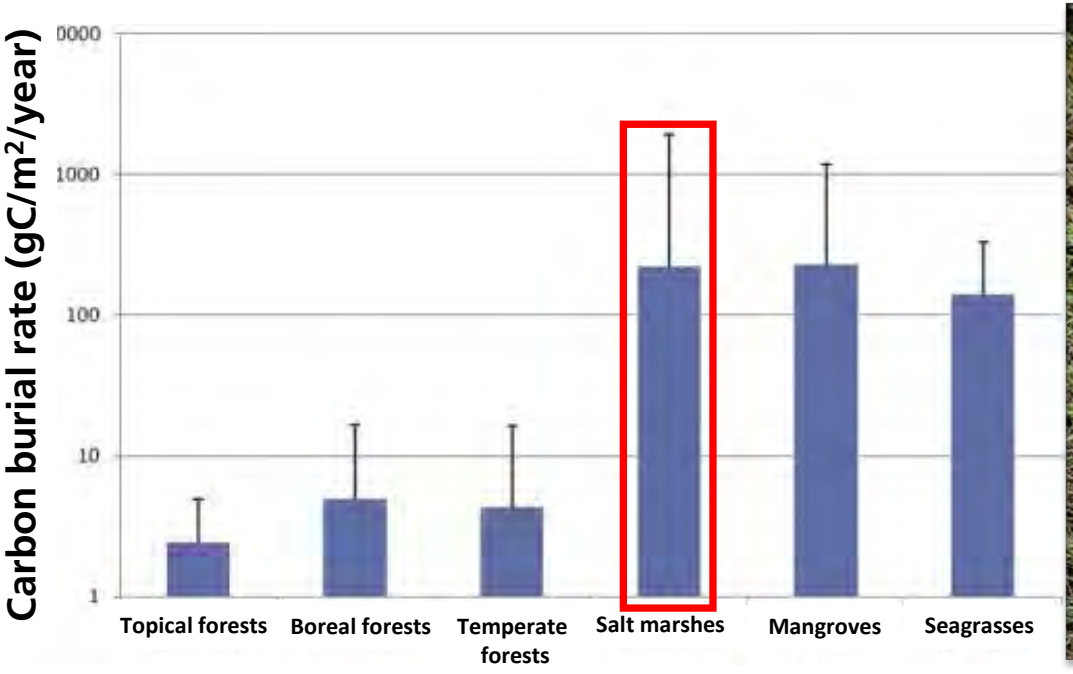
American Black Duck
American Wigeon
Belted Kingfisher
Black-crowned Night Heron
Brant
Bufflehead
Canada Goose
Common Goldeneye
Common Loon
Glossy Ibis
Great Blue Heron
Great Egret
Greater Yellowlegs
Least Tern
Mallard
Mute Swan
Osprey
Red-breasted Merganser
Small Sandpipers
Snowy Egret

Ecosystem Services:

- **Two-thirds of commercial shellfish and finfish landed in the U.S. depend on coastal wetlands for nursery and breeding habitat or on forage fish that breed there**
- **Recreational fishing, hunting, wildlife watching, and boating in coastal wetlands also contribute significant economic value**

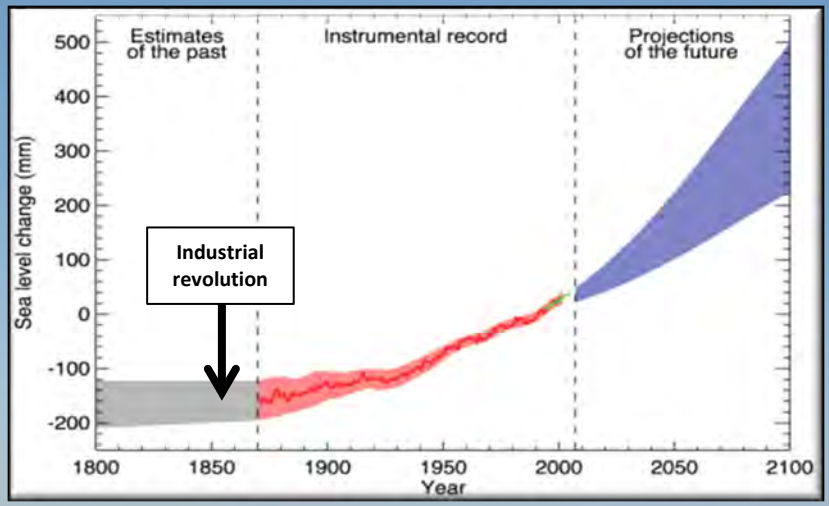
Erosion control – both the plants and marsh (peat) platform itself greatly dampen wave energy

Long term carbon sequestration in peat

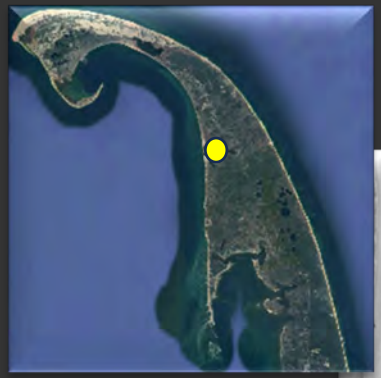


* ameliorate (bury) atmospheric CO_2 (greenhouse gas)

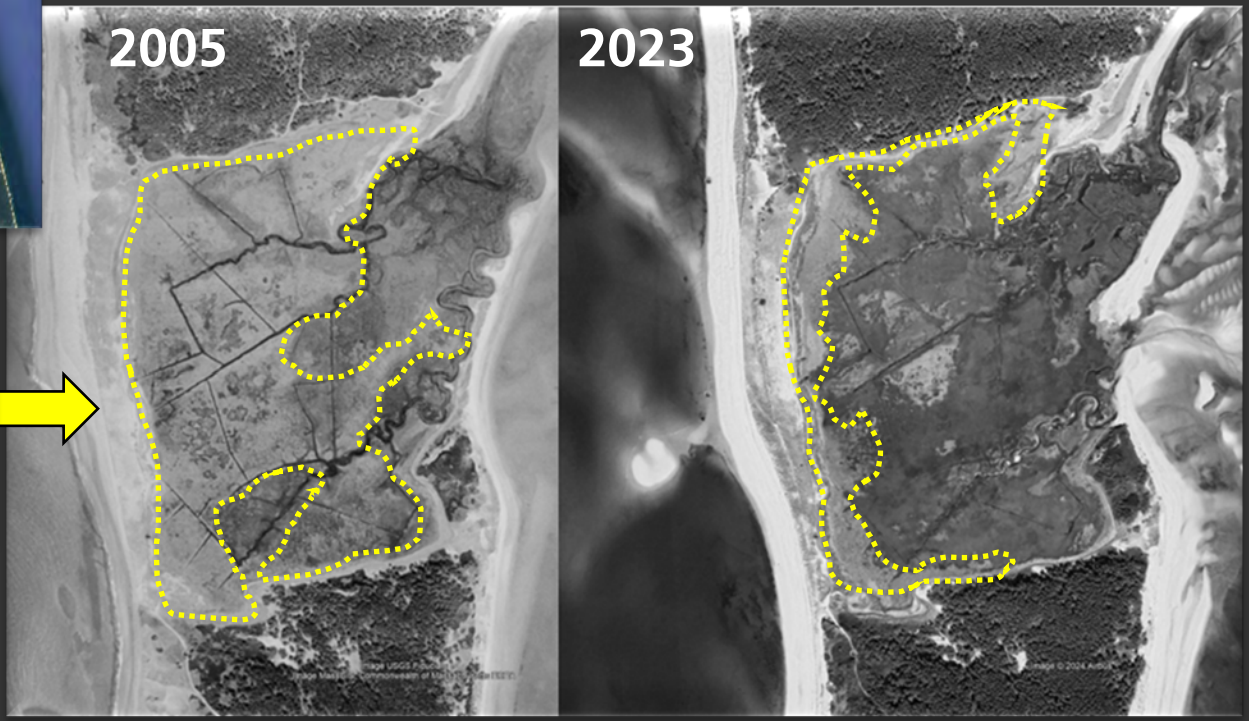
Sea level rise

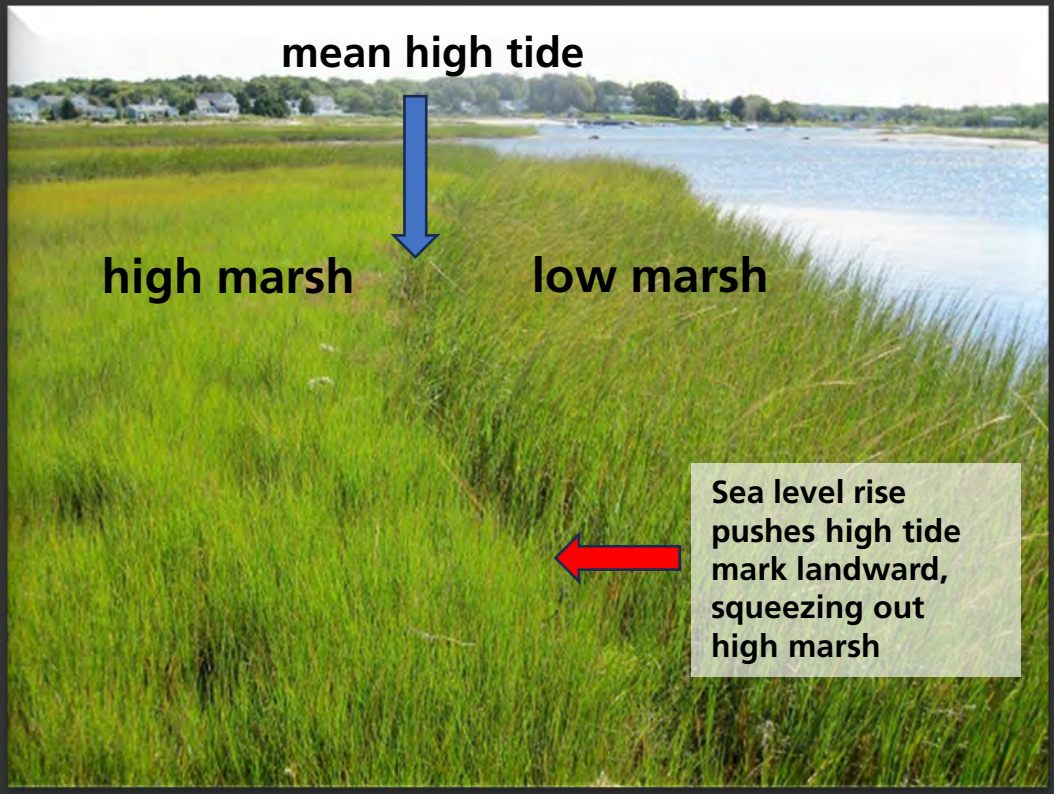


SLR effects are evident in shifting species composition of CCNS salt marshes (below: middle Meadow, Great Island)

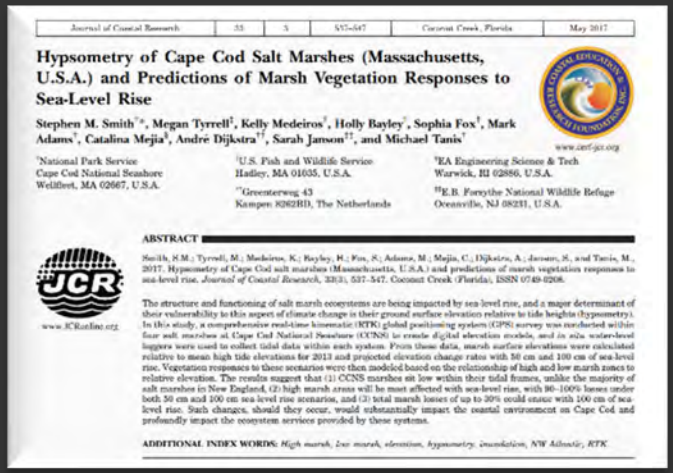


- Low marsh (cordgrass – dark areas) has replaced large amounts of high marsh (salt hay- light areas)




mean high tide
high marsh
low marsh
Sea level rise pushes high tide mark landward, squeezing out high marsh

Projections of SLR effects: lower edge losses and interior ponding will occur as well



Journal of Coastal Research | 33 | 5 | 537–547 | Coconut Creek, Florida | May 2017

Hypsometry of Cape Cod Salt Marshes (Massachusetts, U.S.A.) and Predictions of Marsh Vegetation Responses to Sea-Level Rise

Stephen M. Smith[†*], Megan Tyrrell[‡], Kelly Medeiros[‡], Holly Bayley[‡], Sophia Fox[†], Mark Adams[†], Catalina Mejia[§], André Dijkstra[††], Sarah Janson[‡‡], and Michael Tanis[†]

[†]National Park Service
Cape Cod National Seashore
Wellfleet, MA 02667, U.S.A.

[‡]U.S. Fish and Wildlife Service
Hadley, MA 01035, U.S.A.

[††]Greenterweg 43
Kampen 8262RD, The Netherlands

[§]EA Engineering Science & Tech
Warwick, RI 02886, U.S.A.

[‡‡]E.B. Forsythe National Wildlife Refuge
Oceanville, NJ 08231, U.S.A.

www.cerf-jcr.org

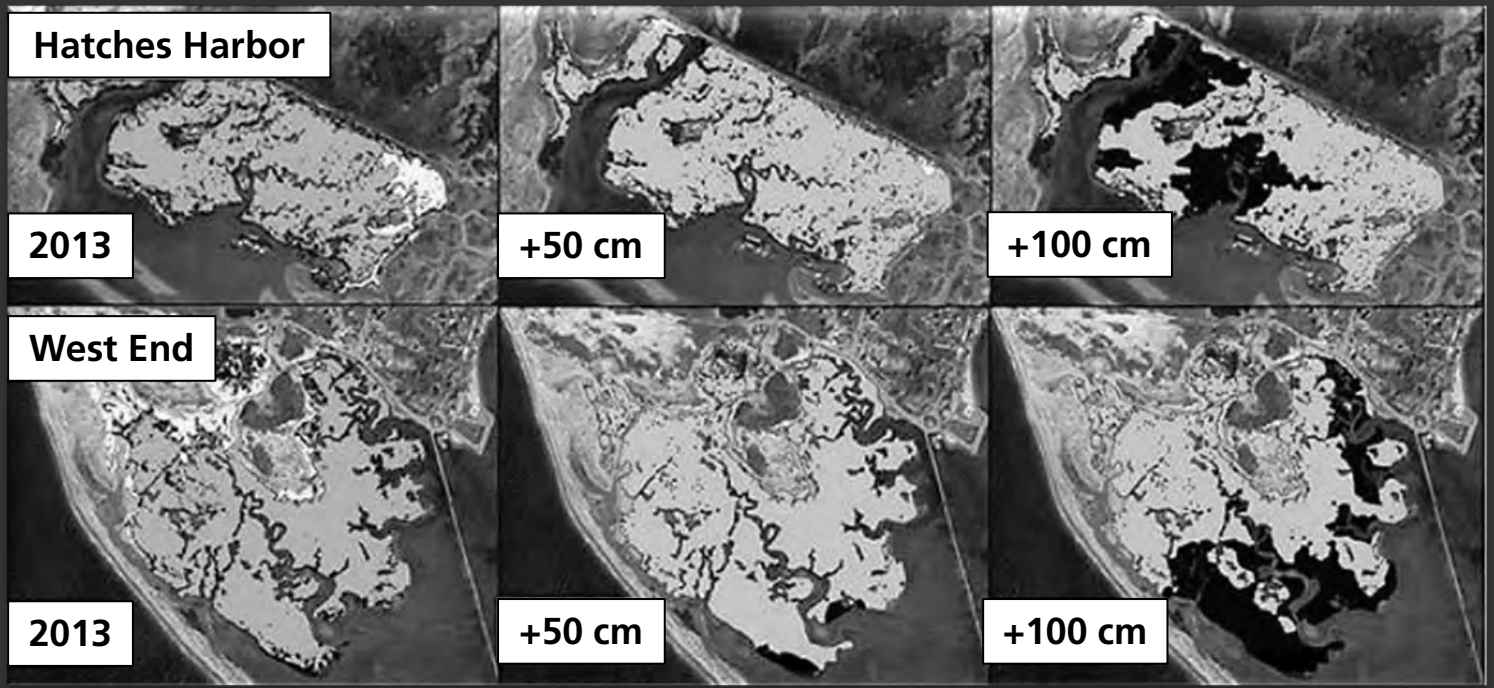
JCR
www.JCRonline.org

ABSTRACT

Smith, S.M.; Tyrrell, M.; Medeiros, K.; Bayley, H.; Fox, S.; Adams, M.; Mejia, C.; Dijkstra, A.; Janson, S., and Tanis, M., 2017. Hypsometry of Cape Cod salt marshes (Massachusetts, U.S.A.) and predictions of marsh vegetation responses to sea-level rise. *Journal of Coastal Research*, 33(3), 537–547. Coconut Creek (Florida), ISSN 0749-0208.

The structure and functioning of salt marsh ecosystems are being impacted by sea-level rise, and a major determinant of their vulnerability to this aspect of climate change is their ground surface elevation relative to tide heights (hypsometry). In this study, a comprehensive real-time kinematic (RTK) global positioning system (GPS) survey was conducted within four salt marshes at Cape Cod National Seashore (CCNS) to create digital elevation models, and in situ water-level loggers were used to collect tidal data within each system. From these data, marsh surface elevations were calculated relative to mean high tide elevations for 2013 and projected elevation change rates with 50 cm and 100 cm of sea-level rise. Vegetation responses to these scenarios were then modeled based on the relationship of high and low marsh zones to relative elevation. The results suggest that (1) CCNS marshes sit low within their tidal frames, unlike the majority of salt marshes in New England, (2) high marsh areas will be most affected with sea-level rise, with 90–100% losses under both 50 cm and 100 cm sea-level rise scenarios, and (3) total marsh losses of up to 30% could ensue with 100 cm of sea-level rise. Such changes, should they occur, would substantially impact the coastal environment on Cape Cod and profoundly impact the ecosystem services provided by these systems.

ADDITIONAL INDEX WORDS: *High marsh, low marsh, elevation, hypsometry, inundation, NW Atlantic, RTK*



Sesarma reticulatum, purple marsh crab

Conceptual Model of *Sesarma*-driven dieoff:

- *Sesarma* populations have greatly increased over the last several decades due to the loss of a predator(s) or expansion of *Sesarma* range northward faster than predators (e.g., blue crabs)

RESEARCH ARTICLE | BIOLOGICAL SCIENCES

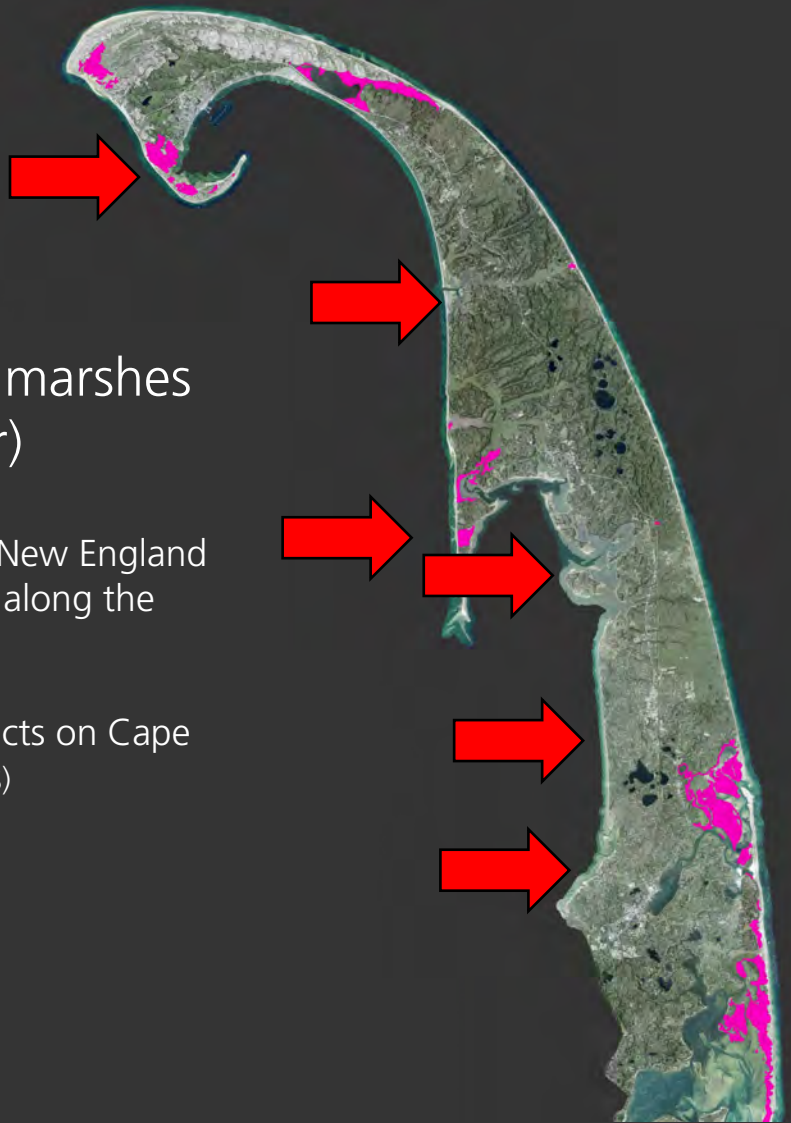
Sea-level rise and the emergence of a keystone grazer alter the geomorphic evolution and ecology of southeast US salt marshes

Sinéad M. Crotty, Collin Ortals, Thomas M. Pettengill, +8, and Christine Angelini Authors Info & Affiliations

Edited by Mary E. Power, University of California, Berkeley, CA, and approved June 9, 2020 (received for review October 15, 2019)

July 13, 2020 | 117 (30) 17891-17902 | https://doi.org/10.1073/pnas.1917869117

West End marsh (Provincetown)



Sesarma-impacted marshes (bayside only so far)

- All along south coast of New England and NY, and many spots along the Atlantic coast
- Earliest evidence of impacts on Cape Cod 1987 (photographs)

Sesarma-driven alterations in marsh morphology and hydrology

2010

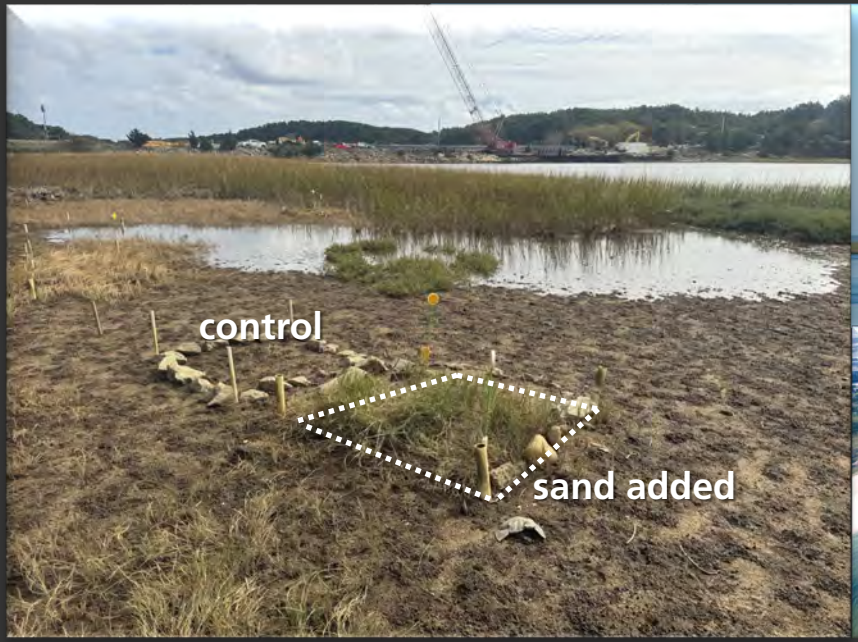
2021

Continental Shelf Research

The effects of *Sesarma reticulanum* (L.) herbivory and sea level rise on creek expansion in Cape Cod salt marshes

Stephen Smith

Dramatic creek widening where Sesarma has denuded edge vegetation



- **CCNS staff are conducting studies on elevation augmentation/substrate manipulations to control *Sesarma* and recover vegetation**
- **Addition of sand promotes enhanced growth by reducing flooding stress and render sediments unsuitable for *Sesarma* burrow construction and maintenance**

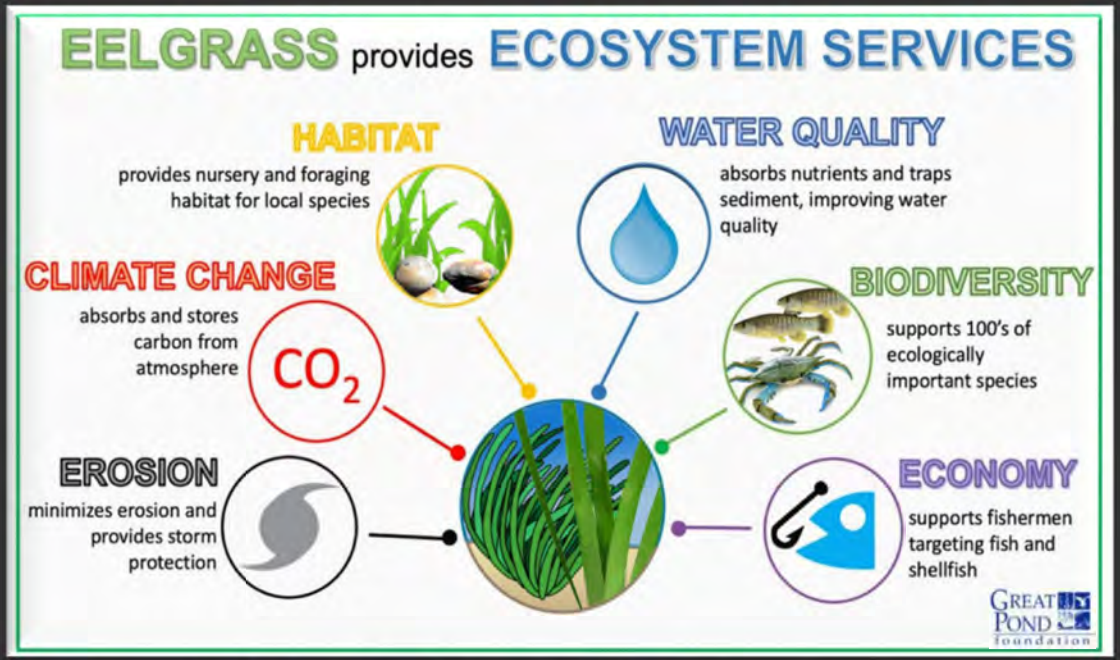
Gains in salt marsh habitat – very few opportunities to migrate inland due to development, or steep slopes, or island morphology – except in the Province Lands

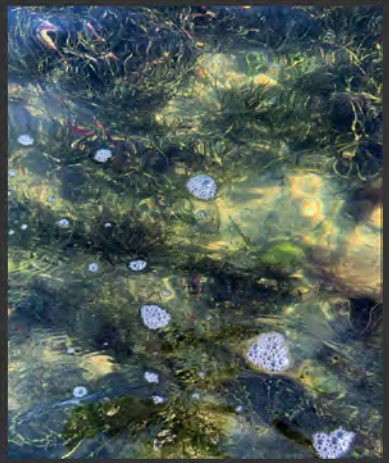
Best opportunity for new marsh development is through the Province Lands (already occurring)

Seawater intrusion into peripheral freshwater wetlands (esp. Hatches Harbor) – how can we effectively manage migration?

Salt Marsh Restoration

- Herring River – restore up to roughly 900 acres of salt marsh to the Herring River system.
- Hatches Harbor – Restored roughly 80 acres of salt marsh in the tidally restricted portion.
- East Harbor - ~ 10 acres

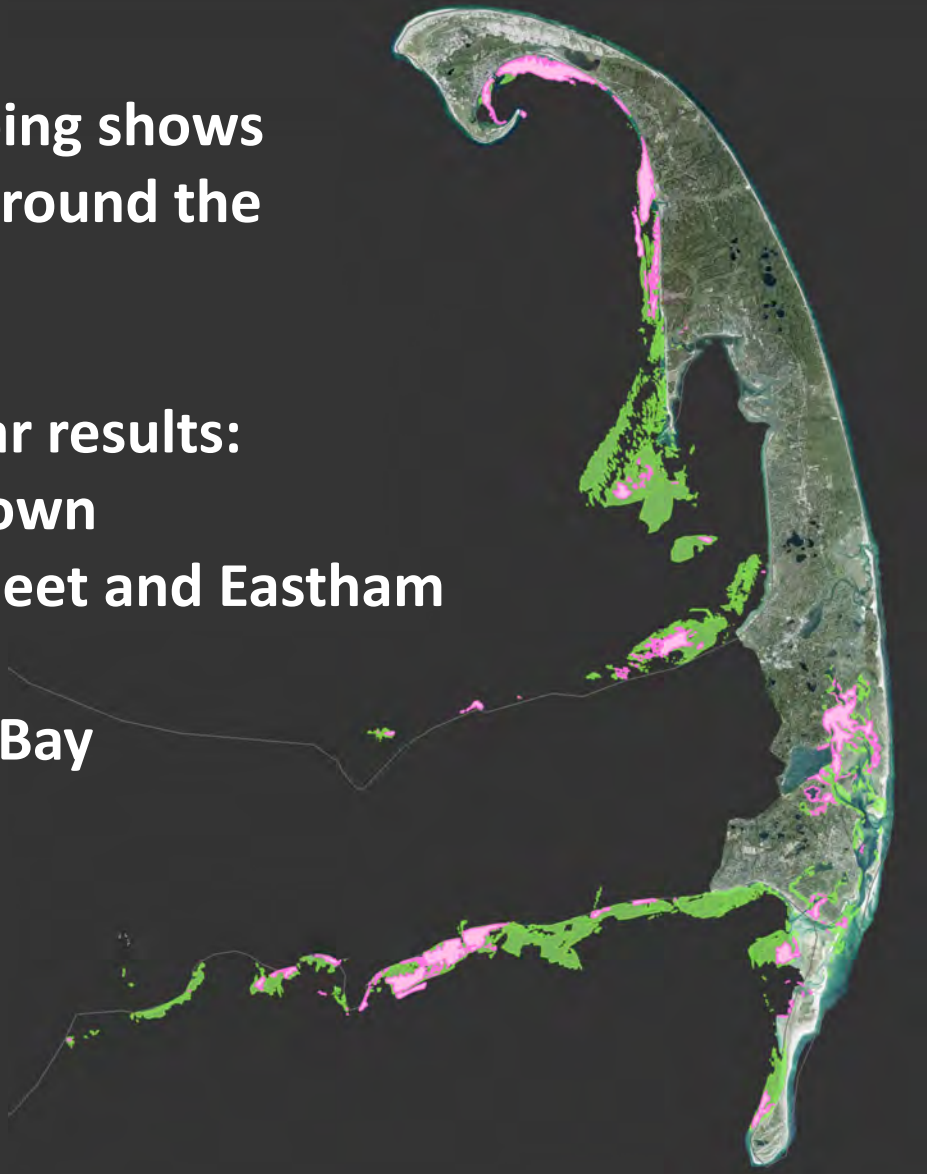

EELGRASS provides ECOSYSTEM SERVICES
HABITAT
provides nursery and foraging habitat for local species
WATER QUALITY
absorbs nutrients and traps sediment, improving water quality
CLIMATE CHANGE
absorbs and stores carbon from atmosphere
CO_2
BIODIVERSITY
supports 100's of ecologically important species
EROSION
minimizes erosion and provides storm protection
ECONOMY
supports fishermen targeting fish and shellfish
GREAT POND foundation



MassDEP eelgrass mapping shows extensive loss of beds around the peninsula

NPS surveys show similar results:

- **Stability in Provincetown**
- **Major losses in Wellfleet and Eastham (Nauset)**
- **Recovery in Pleasant Bay**



historic

current

Losses are due to many factors, including:

climate

Warming sea surface temperatures fuel summer epidemics of eelgrass wasting disease

Marine Ecology Progress Series

By: Maya Groner , Morgan E. Eisenlord, Reyn M. Yoshioka, Evan A. Fiorenza, Phoebe D. Dawkins, Olivia J. Graham, Miranda Winninghan Burge, Brendan Rappazzo, Carla P. Gomes, and C. Drew Harvell

https://doi.org/10.3354/meps13902

eutrophication

physical disturbance

Rescuing Eelgrass Beds: Researchers Plan Restoration In Pleasant Bay

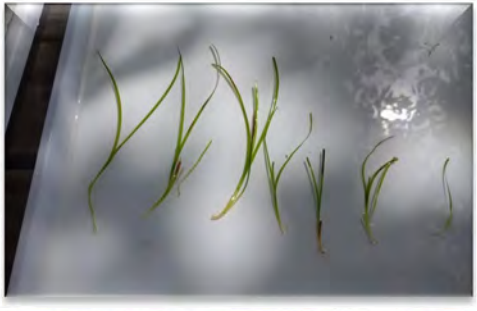
by Alan Pollock

March 28, 2024

Eelgrass provides key habitat for juvenile fish and shellfish like scallops. COURTESY BOB ORTH

PLEASANT BAY – If you can remember large, lush beds of eelgrass rippling just under the surface of waterways like Pleasant Bay, you've probably been around awhile. Since 1951, more than half of the eelgrass in Massachusetts waters has vanished — taking with it important fish and shellfish habitat, a buffer against erosion, and a vitally important mechanism for capturing carbon.

- CCNS
- Center for Coastal Studies
- MassDEP
- EPA Region 1
- Boston University

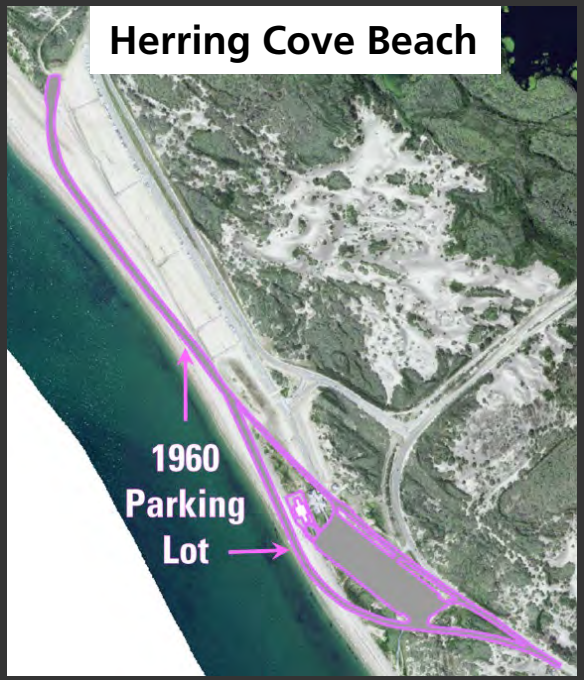


Partners

- We can't do this without the help and expertise of our partners
  - NPS Partners
    - Climate Change Response Program
    - Inventory and Monitoring Program
    - Water Resources Division
  - USGS
  - Center for Coastal Studies
  - University partners
  - Friends of Cape Cod National Seashore
  - Friends of Herring River
  - National Park Foundation

From lighthouses to beach parking lots, CCNS has a long history of relocating resources out of harm's way.

Today, we are actively monitoring our shoreline, bluffs, and dunes to help make data-driven decisions and continue to safely offer public access to these resources.



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