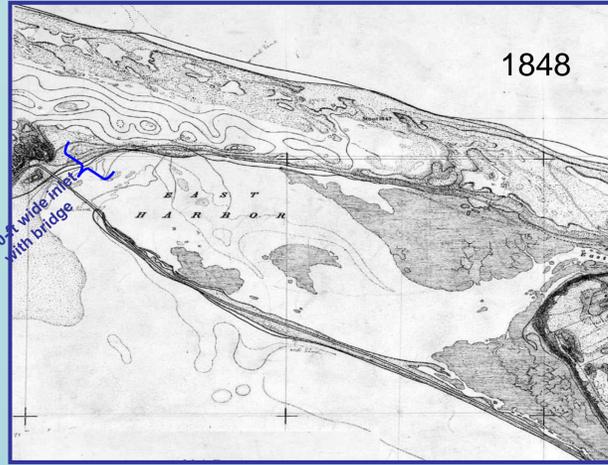


# Ecological Response of the East Harbor Estuary to Partial Tidal Restoration

Cape Cod National Seashore

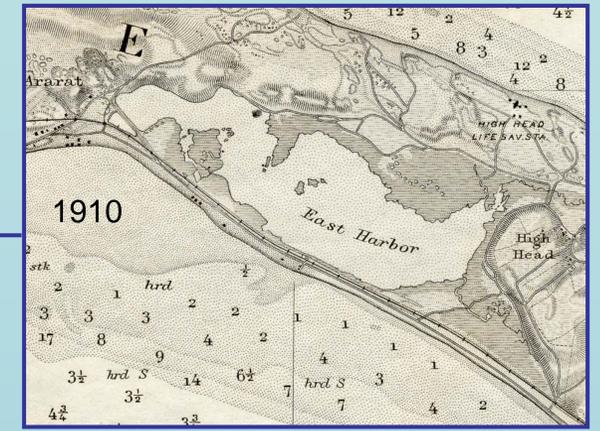


In 2002, the Town of Truro and Cape Cod National Seashore began to restore tides to the 720-acre East Harbor estuary, diked off from Cape Cod Bay since 1868. Although the objectives were simply to increase tidal flushing, improve water quality and avert chronic dissolved oxygen depletions and fish kills by opening valves in the system's only connection to Cape Cod Bay (a four-foot diameter, 700-foot long pipe), the resurgence of marine plants and animals has been remarkable.



1848

Thousands of years ago, sand eroded from Atlantic and Cape Cod Bay sea cliffs eroded into the sea and was carried by shoreline currents to form barrier beaches and enclose the East Harbor back-barrier lagoon and salt-marsh estuary. Daily tides flowed in and out of the lagoon through a 1000-foot-wide inlet.



1910

This early 20<sup>th</sup> century map shows the inlet closed, for railway construction in 1868, cutting off both tidal seawater and marine animals. By 1910 the lagoon, renamed "Pilgrim Lake", featured nuisance midges, non-native carp and blue-green "algae" (cyanobacteria), chronically clouding the water and likely causing summer oxygen depletions and fish kills.



Even more remarkable has been the reestablishment of marine animals in the East Harbor ecosystem. All (but birds) entered on their own through the culvert from Cape Cod Bay.

### A partial list of marine animals re-established in East Harbor since 2002

- |                        |                        |
|------------------------|------------------------|
| Mummichog              | Atlantic silverside    |
| Winter flounder        | Hogchoker              |
| Pipe fish              | Sand shrimp            |
| Shore shrimp           | Green crab             |
| Nine-spine stickleback | Four-spine stickleback |
| Sand eel               | Soft-shell clam        |
| Hard clam              | Blue mussel            |
| Horseshoe crab         | Bay scallop            |

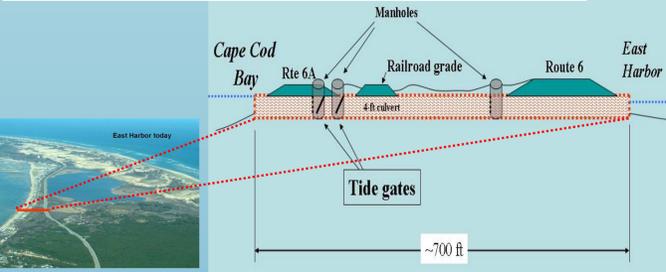


Setting of softshell clams (above), hard clams and mussels, and their rapid growth, has followed the partial restoration of tidal flow and salinity in East Harbor.

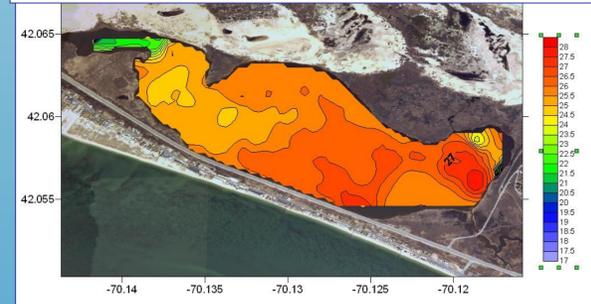


Because, after 136 years of diking, no salt-marsh plants could be found anywhere in the East harbor estuary, the Seashore collected cord grass seed from nearby Hatches Harbor and broadcast it in areas where invasive cattails had been salt-killed. Vigorous stands of salt-marsh cord grass have resulted, easily observed along High Head Road.

Tidal exchange was partially restored in 2002 by opening tide gates in the 4-foot diameter, 700-foot-long culvert connecting East Harbor to Cape Cod Bay near Noons Landing.



Although this culvert opening provides less than 1% of the tidal volume that entered East Harbor prior to diking in 1868, the resulting salinity increase, from less than 4 parts per thousand (ppt) to now 20-28 ppt (below) has been remarkable. [Note that the salinity of ocean water is about 32 ppt].

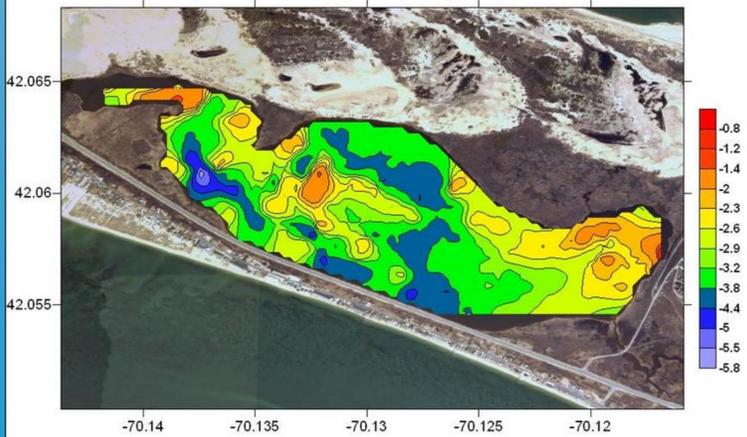


**Wintering waterfowl**  
Fourteen species of wintering sea and bay ducks, many of which had never been seen in the lagoon in living memory, now regularly feed on bottom-dwelling marine worms, shellfish and other invertebrates throughout the ice-free portions of the winter, and in flocks numbering in the hundreds.

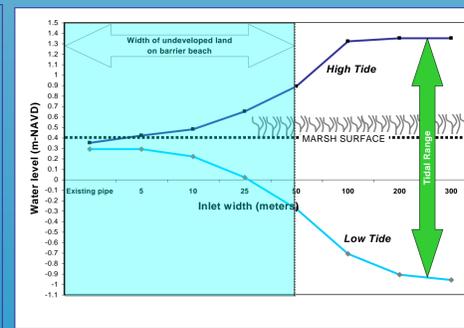
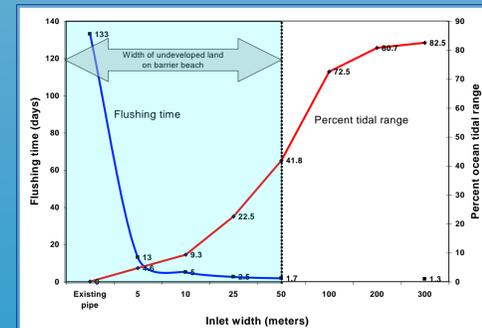


Like marine animals, marine plants like this widgeon grass have reestablished in the lagoon on their own, probably benefiting from clearer and more saline water. This plant is an important waterfowl food and nursery habitat for fish and crustaceans.

### Depth Sounding, Feet East Harbor, North Truro, MA, Aug 17, 2007



•Modeling indicates that the maximum degree of tidal restoration that is possible, given available undeveloped land for culverts under Beach Point, will produce a modest area of exposed sand flats at low tide, indicated by in orange and red shades in the above map.  
•Intertidal flats promote the natural setting of shellfish beds.



The above graphs show model-predicted increases in the harbor's flushing rate and tidal range with the existing 4-ft diameter pipe and, alternatively, with inlets of various widths connecting the estuary to Cape Cod Bay. The blue-shaded area marks the width of remaining undeveloped land, possibly available for new culverts, on Beach Point at Noons Landing.

- Flushing time decreases, and flushing rate increases, greatly with only a 5-meter wide inlet.
- Flushing time decreases little for inlets greater than 50 meters.
- Tidal range increases exponentially with increasing inlet width, reaching 41% of cape Cod Bay tides at 50 meters.
- There is little tide in the fringing wetlands with inlet widths less than 25 meters.

### Social effects

Although the long-term effects of tidal restoration on the local human community and visitors are expected to be positive, with improved water quality and increased marine resources (e.g. finfish, clams, etc.), continuing limits on tidal flushing have produced short-term problems, including macroalgae blooms and odors in the summers of 2005 and 2006.

Cape Cod National Seashore is studying these problems and, in collaboration with the Town of Truro, seeking funds and technical help from other federal and state agencies for more complete habitat restoration.



Macroalgae bloom, 2006

After six years of partial tidal restoration, the ecology of East Harbor continues to evolve with the re-establishment of more and more marine and estuarine species.

