Invasive European Green Crab Impacts on Salt Marshes in Maine – Sudden Increase in Erosion Potential

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Abstract

INVASIVE GREEN CRAB IMPACTS ON SALT MARSHES IN MAINE - SUDDEN INCREASE IN EROSION POTENTIAL

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The Maine coast is experiencing an explosive population growth of the invasive European Green Crab (*Carcinus maenus*), similar to an outbreak in the mid 1950's. Green crabs are implicated in the widespread destruction of juvenile clams, eelgrass beds, and possible impacts on mussels and lobsters, with critical consequences for seafood industries as well as ecosystem health. In 2013 we noticed severe dieback of low salt marshes in the Damariscotta River Estuary. In addition, we observed green crab molts in much greater density than we have observed over decades at this marsh. Neckles (2013) is studying eelgrass dieback in southern Maine also attributed to green crabs. Salt-marsh dieback in Cape Cod (e.g., Johnson, 2010; Hight, 2013) is thought to be caused by a different crab, the purple marsh crab (*Sesarma reticulatum*), which is not (yet) found in the northern Gulf of Maine. We hypothesize that green crabs could be causing the widespread clipping of *Spartina alterniflora* low-marsh grass, resulting in denudation of the surface and increased surficial erosion. Subsequent discussions with researchers and stakeholders, including at a Maine Sea Grant sponsored summit in December, proved widespread effects are already underway, including a massive population of green crabs burrowing like termites into marshes in the Brunswick region, causing lateral and internal erosion. The cause of the population explosion is unknown: hypotheses include warmer winters and/or a population shift caused by more recent invasions by northern European populations that are more aggressive and cool temperature adapted. Beyond the biological and ecological importance of these environments, salt marshes are critical in the bluff erosion/stability cycle in Maine (Kelley and Hay, 1986; Kelley et al., 1989; Kelley and Dickson, 2000). Rapid dieback and consequent marsh erosion could lead to greater extents of bare bluff exposed to wave and ice erosion, resulting in accelerated land loss.

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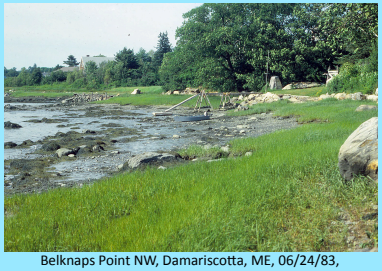
The Problem

Days Cove, Damariscotta, ME, 05/27/2012

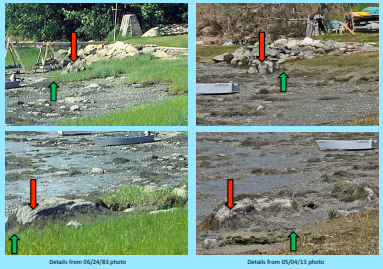
Days Cove, Damariscotta, ME, 09/15/2013

Long observation of salt-marsh shorelines in the Damariscotta River, Maine between 1970 and 2013 revealed cyclical colonization and expansion of *Spartina alterniflora* low marsh in spring and summer, followed by erosion and retreat due to ice block erosion in the winter. However, during the spring and summer of 2013 almost no healthy low marsh grass was found, with stalks clipped off as if mowed raggedly. Disease was an early concern, but then we correlated the dieoff with explosive expansion of invasive green crabs, as noted by Neckles (2013) was happening in eelgrass (*Zostera marina*) beds elsewhere on the Maine coast.



Belknaps Point NW, Damariscotta, ME, 06/24/83,
Mid-Tide, View N. D.F. Belknap

Belknaps Point NW, Damariscotta, ME, 05/04/13,
Mid-Low Tide, View N. D.F. Belknap



Details from 06/24/83 photo | Details from 05/04/13 photo

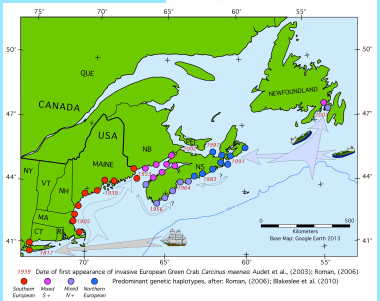
The comparison of photos taken at the same marsh and tidal flat site over an interval of 30 years is not proof of a continuous rate of erosion, but they do document the difference between a healthy marsh in 1983 and the distressed marsh in 2013. Scarping of the marsh and complete removal of above-ground portions of the *Spartina alterniflora* are evident. The prominent crack displayed in the 2013 photo is not completely unusual for ice-block erosion, but it is larger than most seen at this site.

Concerns for long-term continuation of this erosion include:

1. Destabilization of shoreline. Salt marshes protect the toe of the bluff of till and glaciomarine mud from wave and ice erosion. Loss of the marsh would accelerate land loss, both here and at many similar sites on the Maine coast.
2. Loss of salt marsh habitat. Salt marshes have extremely high productivity, providing particulate organic matter of great importance to the estuarine and marine food web. In addition, many juvenile fish and shellfish use the salt marsh as nursery habitat. Birds and mammals are also dependent on these resources.
3. Reduction in ecosystem viability. Salt marshes are important filters of pollutants, traps of turbidity, and sinks for CO_2. Loss of marshes will result in degradation of coastal and regional environment.

The Culprit: *Carcinus maenas*

L. 1758 Invasive European Green Crab



?1939 Date of first appearance of invasive European Green Crab *Carcinus maenas*: Audet et al., (2003); Roman, (2006)
Southern European | Mixed S + | Mixed N + | Northern European — Predominant genetic haplotypes, after: Roman, (2006); Blakeslee et al. (2010)

Native to much of the coast of Europe, European Green Crabs *Carcinus maenus* (L.) are generally nocturnal, euryhaline, shallow to intertidal, and tolerate temperatures from 0 to 30°C. They were first recognized in New York in 1817, and gradually invaded the Gulf of Maine and the Bay of Fundy over the next 150 years (Roman, 2006). They were thought to have been brought in on ships' ballast stones. Acceleration in invasion of the Nova Scotia coast and into the Gulf of St. Lawrence was noticed between 1956 and 2002. They were found in Placentia Bay in Newfoundland in 2007 (Blakeslee et al, 2010). Green crabs are also invasive in California, and recently in Australia, South Africa and other coasts worldwide.

The northeastward progression in the eastern US and Canada has been linked to seawater warming trends. However, Roman (2006) and Blakeslee et al. (2010) document genetic differences of the northern populations from the southern, and suggest that they are a later wave of invasives, brought from northern Europe in the ballast water of tankers as plankton. The northern clades may be more adapted to colder sea water, and they demonstrate greater aggressiveness than the southern clade.

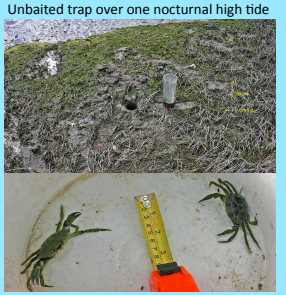
The primary concern over the invasive crabs is their severe impact on juvenile soft-shell clams (*Mya arenaria*) and other commercial shellfish. Some clam beds in southern coastal Maine have no discernable clams less than 3-5 years old, as the crabs have completely removed the juveniles.

Days Cove, Damariscotta, ME, 09/15/2013

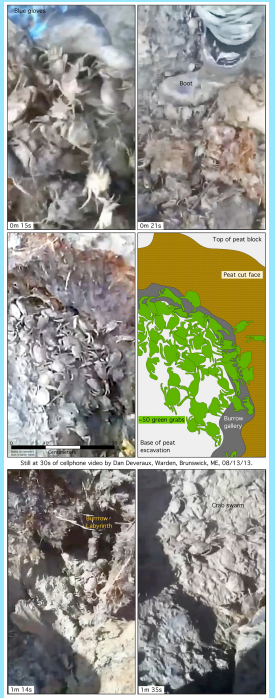
By September, 2013 it became obvious that the surface of the marsh was being eroded rapidly by tidal and freshwater runoff, with development of rills and gullies. Consultation with biologists and wardens from the central and southern Maine coast confirmed that this was not just a local problem, but is did vary from severe impacts in inner estuaries (warmer?) such as the Damariscotta River and Harpswell Cove, in Brunswick, as opposed to outer coastal sites such as Wells.

The panels to the right are stills from a cell-phone movie taken by Brunswick warden Dan Deveraux at the Harpswell Cove site on August 13, 2013,, which show completely unexpected concentrations of extremely active crabs burrowing laterally into the salt marsh. This is the first documentation of such behavior, and the original movie conveys the impression of a horror movie as the swarms of crabs are exposed in their labyrinthic burrows and gallaries.

Unbaited trap over one nocturnal high tide



Days Cove, Damariscotta, ME, 10/15/2013

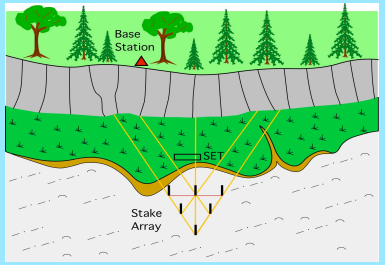


Still at 30s of cellphone video by Dan Deveraux, Warden, Brunswick, ME, 08/15/13.

The Plan

Consultation with USGS, Maine Department of Marine Resources, Casco Bay Estuary Partners, and other marine scientists led us to submit a small Program Development Proposal to Maine Sea Grant for rapid response monitoring of sites in Wells, Casco Bay, and the Damariscotta estuary. This project was funded, and received additional support from the Casco Bay Estuary Partners. In addition, we have submitted a small proposal for CT (Computed Tomography) scanning of cores, to the Maine Outdoor Heritage Fund, which is pending. We will apply several techniques in each area:

1. In the Damariscotta estuary we measured stake and plate arrays to determine rates of erosion of bluffs and marsh scarps, and accumulation on mudflats, starting in 1985, for several years. The surveyed locations and mapped marsh edges will be reoccupied in Damariscotta and Walpole. We will establish triangular grids of stakes from which to measure short-term rates of marsh erosion (or colonization) over seasonal time scales (see cartoon below). The stakes provide a 3-fold replicate, and we will install multiple arrays at each site. New stations will be established in the Webhannet Marsh, Wells, and in Casco Bay at Maquoit Bay and Harpswell Cove.
2. We will construct SET (Surface Elevation Transect) stations at each of the localities, to determine short-term rates of marsh vertical accretion or erosion.
3. We will remap the marsh edge at the Damariscotta 1985-1987 sites, and newly map marsh edges at the other localities, with our Total Station. The 30-year remapping will provide a longer comparison to the short-term, but probably accelerated erosion already observed qualitatively.
4. We will collect Dutch cores (Eijkelkamp half-cylinder gouge auger) in marshes to visually compare standard peat columns in lightly affected sites with heavily burrowed locations. Selected cores will be imaged with CT X-ray imagery to quantitatively assess void spaces, volume of roots, rhizomes, and perhaps crabs, as well as the 3-D geometry of burrows (e.g., Blum and Davey, 2013; Davey et al., 2011).
5. We will continue to collaborate with biologists studying green crab genetics and the crabs' impacts on shellfish, eel grass, and estuarine ecosystems in general, through the auspices of Maine Sea Grant and our informal Green Grab working group (UMaine, Wells Reserve, USGS Patuxent Wildlife Research, Casco Bay Estuary Partners).



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Maine Sea Grant
Marine Science for Maine People

Northeast Section, Geological Society of America,
Lancaster, PA, March 24, 2014.
Abstract 55-9: Marine/Coastal Science, Booth 31.