European Green Crab

Carcinus maenas (Linnaeus, 1758)
Northward Advance on West Coast of the USA & Canada

See 2007, M.S. Thesis
European Green Crab Native Range

Carlton & Cohen 2003
European Green Crab Invasion

Carlton & Cohen 2003
Who Cares?

- Coastal Northwest Atlantic
  - Implicated in decline of the soft-shell clam (*Mya arenaria*) industry in Maine, USA (Glude 1955)
  - Reported to negatively impact scallops, quahogs and other bivalves on the east coast of the USA (Grosholz and Ruiz 2002)
  - May outcompete native rock crab *Cancer irroratus* (Miron et al. 2005)
Who Cares?

• Coastal Northeast Pacific
  – Could have severe impacts on native bivalves and native crabs
  – Associated with enormous declines in abundance of native clams (*Nutricola tantilla* and *N. confusa*), as well as native shore crab (*Hemigrapsus oregonensis*), in Bodega Bay, California (Grosholz et al. 2000)
  – Preference for Olympia oyster (*Ostrea conchaphila*) compared with other bivalve species (Palacios and Ferraro 2003)
NON-INDIGENOUS AQUATIC SPECIES OF CONCERN
FOR ALASKA

Fact Sheet 1

BIOLOGY & PHYSIOLOGY

Physical Description: The Green Crab is a small shore crab. Adults measure about 3 inches across. The color of the dorsal (top side) of the shell is a mottled, dark brown to dark green with small yellow patches. Its ventral surface (underside) can display colors of green, yellow, red, and orange. Some studies have indicated that the color of the shell may be due to the amount of time the crab spends between molting stages. A distinguishing feature that can set green crabs apart from native crabs is the array of five evenly spaced triangular spines on either side of the eyes, on the front end of the shell. The three rounded lobes between its eyes may also be used to help identify the Green Crab.

Nutrition Requirements: The Green Crab is an omnivore, meaning that it can consume many different species of plants and animals. Its prey includes mussels, clams, snails, polychaetes, crabs, isopods, barnacles and algae. In both field observations and laboratory experiments, the Green Crab has been observed to eat an enormous variety of prey items from at least 104 families and 158 genera in 5 plant and protist and 14 animal phyla.
Ecological Niche Modeling

“can provide a powerful tool to assess the likelihood of nonindigenous species establishing in an area, once it has been transported to a region via anthropogenic or natural dispersal (Peterson & Vieglais 2001, Peterson 2003)”
Predicting the northward range expansion of non-indigenous European green crab (*Carcinus maenas*) along the west coast of North America

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Objectives

- Explore the dynamics of larval dispersal in coastal waters of the northeastern Pacific Ocean
- Predict future range expansion
Questions

• What was the source population for newly established green crab on Vancouver Island, British Columbia?
• Is larval transport augmented during oceanographic anomalies (e.g., El Niño)?
• Can larvae be transported to estuaries and embayments north of Vancouver Island?
Approach

• Develop an individual based model (IBM) of larval green crab dispersal
• Employ existing ocean circulation models to predict larval dispersal and incorporate the effects of temperature on larval development
Regional Ocean Modeling System (ROMS)

- Budgell 2005
- Di Lorenzo 2003
- Dinniman et al. 2003
- Haidvogel et al. 2000
- Marchesiello et al. 2003
- Moore et al. 2004
- Peliz et al. 2003
- Shchepetkin & McWilliams 2003
- Shchepetkin & McWilliams 2005
- Warner et al. 2005
- Wilkin et al. 2005
Life Cycle

- Eggs

- Zoea

- Megalopa

- Juvenile

- Adult
Model Scenarios

• 1997-2003
• Release in fall, winter & spring
• Release from San Francisco Bay & Humboldt Bay
• Temperature controls development
• Current control movement
Season, Location & Circulation Anomalies

See 2007, M.S. Thesis
• Protected and semi-protected wave exposures
• Mud or sand flats
• Eelgrass beds
• Fringing coastal salt marsh vegetation
Conclusions

- San Francisco is an unlikely source population for green crab on Vancouver Island, BC
- Larval transport is augmented during El Niño events and in the fall
- It is possible that larvae could be transported to estuaries and embayments north of Vancouver Island
- When coupled with existing habitat suitability mapping projects can be used to assist with early detection
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  – David Armstrong (University of Washington)
  – P. Sean McDonald (University of Washington)
Regional Ocean Modeling System (ROMS)

• “A free-surface, terrain-following, primitive equations ocean model widely used by the scientific community for a diverse range of applications” (e.g., Haidvogel et al. 2000; Marchesiello et al. 2003; Peliz et al. 2003; Di Lorenzo 2003; Dinniman et al. 2003; Budgell 2005; Warner et al. 2005; Wilkin et al. 2005)

• Computational nonlinear kernel algorithms (Shchepetkin and McWilliams 2003, 2005)

• Tangent linear and adjoint kernels and platforms (Moore et al. 2004)

http://www.myroms.org/
Potential Future Range

de Rivera et al. 2007
Green Crab Life History

Release Locations (estuaries)

Larvae are released from estuaries and ride the outgoing tide into the ocean.

Horizontal advection and diurnal migration occurs during this period, which lasts 1 – 3 months.

Mixed Layer (0-50m)

When competent, larvae ride an incoming tide into an estuary and settle.

Settlement Locations (estuaries)

See 2007, M.S. Thesis
Growth Functions

• 1\textsuperscript{st} zoeal: 44.40 – 13.04 * \ln X
• 2\textsuperscript{nd} zoeal: 23.64 – 6.31 * \ln X
• 3\textsuperscript{rd} zoeal: 20.65 – 5.34 * \ln X
• 4\textsuperscript{th} zoeal: 25.51 – 6.69 * \ln X
• All zoeal: 122.96 – 34.47 * \ln X
• Megalopal: 77.76 – 21.72 * \ln X

X = temperature

De Rivera 2007