Ecological Impacts of the European Green Crab

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Green Crab Impacts

- Green crabs have had substantial impacts on both Atlantic and Pacific coasts
- GC are listed in the top 100 worst species by IUCN
- Significant economic impacts (see later talk)
- Significant ecological impacts on both coasts
Tracking Impacts in California

- Since 1994, green crab populations monitored at least once at >15 sites along the California coast,
- Part of cooperative monitoring program that includes seven OR sites, three WA sites, six B.C. sites and four AK sites
- In CA, since 1999, nine sites have been monitored irregularly
- Since 2002, monitored sites annually
  - Humboldt Bay
  - Bodega Harbor
  - Tomales Bay
  - San Francisco Bay
  - Elkhorn Slough
  - Morro Bay
Tracking Impacts in California

• Research on green crabs impacts has focused primarily on sites in central California
  – San Francisco
  – Tomales Bay
  – Bodega Bay

• These studies have focused on several topics including impacts on benthic communities, interactions with other invasive species, and consequences for native oyster restoration
Direct Effects of Green Crab Invasion

- Green crabs reduced densities of small native clams (*Nutricola tantilla* and *N. confusa*) by 90%.
- Green crabs reduced densities of native shore crabs (*Hemigrapsus oregonensis*) by 95%.
- Significantly reduced overall biomass of infaunal invertebrates.
- Shifted resource base available to migratory shorebirds.

Indirect Effects of Green Crab Invasion

- *Gemma gemma*, native to eastern U.S., introduced to Bodega Harbor with oysters
- For >40 years found at only one site Bodega Harbor
- Green crabs reduced densities of native *Nutricola confusa* and *N. tantilla* >90%
- Density and distribution of *Gemma gemma* rapidly increased throughout Bodega Harbor
Small Clams in Bodega Harbor

- Eastern Gem Clam (*Gemma gemma*)
- Native Clam (*Nutricola confusa*)
- Native Clam (*Nutricola tantilla*)
Bodega Harbor, California, USA
Life History

• Green crabs selectively prey on larger individuals among these small clams
• Native *Nutricola* are significantly larger than the invasive *Gemma*
• Green clams disproportionately prey on native *Nutricola*
Green Crab Predation Species Preferences

Number Remaining (# of 25)

<table>
<thead>
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<th>Treatment</th>
<th>Nutricola</th>
<th>Gemma</th>
<th>Control</th>
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<tr>
<td></td>
<td>0</td>
<td>15</td>
<td>25</td>
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Size Dependent Predation by Green Crabs
Life History

• Within species, green crabs consume largest in population
• Invasive Gemma are diecious
  – Large individuals are male and female
  – Green crabs consume both equally
• Native Nutricola are protandrous hermaphrodites
  – Largest individual are reproductive females
  – Green crabs selectively consume large females
  – Demographic impact of green crab predation greater on Nutricola
Historical Densities vs. Current Densities

• Hypothesis: competition with native *Nutricola* historically restricted distribution of *Gemma*

• We tested competition between *Nutricola* and *Gemma* under two conditions
  – Pre-green crab densities of *Nutricola* (up to 10,000 per m²)
  – Post-green crab densities of *Nutricola* (1,000 to 2,000 per m²)
Relative Densities of *Carcinus, Gemma, and Nutricola*

Gemma Abundance vs. Nutricola Abundance

Current Densities

Gemma Growth (%)

Treatment

Historic Densities

Gemma Growth (%)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Gemma Growth (%)</th>
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<tbody>
<tr>
<td>40G</td>
<td>6</td>
</tr>
<tr>
<td>80G</td>
<td>4</td>
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<td>40G 40N</td>
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p<0.0005  **

Positive Indirect Effects

- Introduced *Gemma gemma* was benign invasion with restricted distribution for >40 years
- Direct effects of green crab predation
  - Density of native *Nutricola* by >90%
- Indirect effects of green crab predation
  - Invasion of *Gemma* rapidly accelerated throughout Bodega Harbor
- Demonstrated a new mechanism that could result in rapid ecosystem degradation or “invasional meltdown”
Risk to Coastal Systems

- Hundreds of species have accumulated in coastal waters worldwide
- Currently most are benign invasions with little impact
- We have not seen evidence of invasional meltdown in coastal systems
- New invasions could accelerate these older introductions
- Positive feedback among invasions could result in extensive degradation and possible meltdown
Lessons for Management

• Identify high priority species
  – Problem species introduced many times around the world
  – Focus on functional groups likely to cause problems
    • Predators
    • Ecosystem engineers (alter/remove habitats)
    • Suspension feeders (move water column productivity to benthos)
Broad range of impacts to native shore crabs

Goal: Identify long-term impacts of green crabs on Hairy shore crab, *Hemigrapsus oregonensis*

– Abundance
– Demography
– Habitat use
**Hemigrapsus oregonensis**, Hairy shore crab

- Small, native crab
- Habitat & range overlap with green crabs

Photo credit: Gregory Jensen
Impacts methods

- Catherine deRivera and Greg Ruiz
- Data from Bodega Harbor, CA
- 13 yr (1993-2005), spring tides
- 12 pitfall traps/yr, from 4 littoral transects (+.1, .4, .7, 1.2 m MLLW)
- Counted, measured all crabs
- Summed counts
Reciprocal abundance

Y = 290.15 - 4.04 X; $r^2 = 0.4$; n = 13
Spearman rank correlation: rho = -0.64, p = 0.026
Numerical recovery?

# Hairy shore crabs

# Green crabs

![Graph showing numerical recovery of hairy and green crabs over years.](image)
Decrease in size

Median hairy shore crab carapace width (mm)

Year

Y = 506.8 - 0.25 X; r² = 0.28; n = 13
Spearman rank: rho = -.59, p = 0.036
excluding recruits rho = -.56, p = 0.054
Consequence of reduced size

• Invertebrate fecundity increases as a function of body size
• Decrease in size could limit the reproductive capacity of the native population
Change in intertidal distribution

Proportion of hairy shore crabs in highest transect

Similar change for both sexes

Y = -38.72 + 0.02 X; r² = 0.4; n = 13
Spearman rank: rho = 0.59, p = 0.033;
excluding recruits rho = 0.74, p = 0.004
Consequences of habitat shift

• Shift to higher intertidal:
  – Increases exposure time to air
  – Increases time under shelter (lowers desiccation, predation risks)
  – Decreases foraging time

• Behavioral changes due to threat of predation may surpass direct impacts of predation
Changes due to green crabs

• Green crab abundance was not correlated with size or microhabitat use

• Don’t expect it to be if: time lag, functional response…

• Green crabs prey on shore crabs

• Shore crabs always moved up in tanks with green crabs but not in controls
Changes not caused by other factors

• A San Diego population of hairy shore crabs did not change size over time
• Rainfall, air & sea temps not correlated with abundance, size, or microhabitat use
• Changes not due to 3rd-most-abundant crab.
Effects of red rock crabs

 rho = -0.69, n = 12, p = 0.0213;

 rho = 0.11, n = 12, p = 0.7063

 rho = 0.63, n = 12, p = 0.0374

If partial out effects of Carcinus:
 rho = -0.69, n = 12, p = 0.0213;

 rho = 0.11, n = 12, p = 0.7063

http://dnr.metrokc.gov
Impacts summary

- Decreased native abundance while invader abundance high
- Lagging behind temporary numeric recovery
  - Decreased size
  - Shift to higher intertidal distribution
Impacts conclusions

• Long-term consequences of the green crab invasion
• These changes may reduce ability to recover from future perturbations
• Important to examine multiple types of & long term impacts
Effects of Green Crab Parasites on Other Taxa

- Trematode and Acanthocephala can affect other host species like shorebirds or diving ducks
- *Polymorphus* sp. (Acanthocephala)
- *Microphallus* sp. (Platyhelminthes)
- Potential host for sacculinid barnacle parasites if introduced
Additional Impacts in Eastern North America

- Crabs can reduce grazing pressure on algae by consuming littorine snails in NE (Menge 1983, Trussell et al. 2004)
- GC can significantly reduce abundances of eel grass seedlings in NE (Davis et al. 1998)
- Large effects on commercial bivalves (soft-shell clams, mussels, scallops) in maritime Canada (Miron et al. 2002, 2005, Floyd and Williams 2004)
- Older records of large impact on soft-shell clams in NE (MacPhail et al. 1953, Glude 1955)
- Recent data on impacts on scallops (Tettlebach 1986) and hardshell clams (Walton 2003)
- Consume significant quantities of juvenile winter flounder (Taylor 2005)
Additional Impacts in Western North America

- Additional evidence for impacts on native shorecrabs (*H. oregonensis*) (McDonald et al. 2001)
- Possible impacts on YOY Dungeness crabs (McDonald et al. 2001)
- Impacts on cultured Manila clams (Grosholz et al. 2001)
Impacts acknowledgments

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