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

Grosholz et al. 2000. *Ecology* 81-1206-1224

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

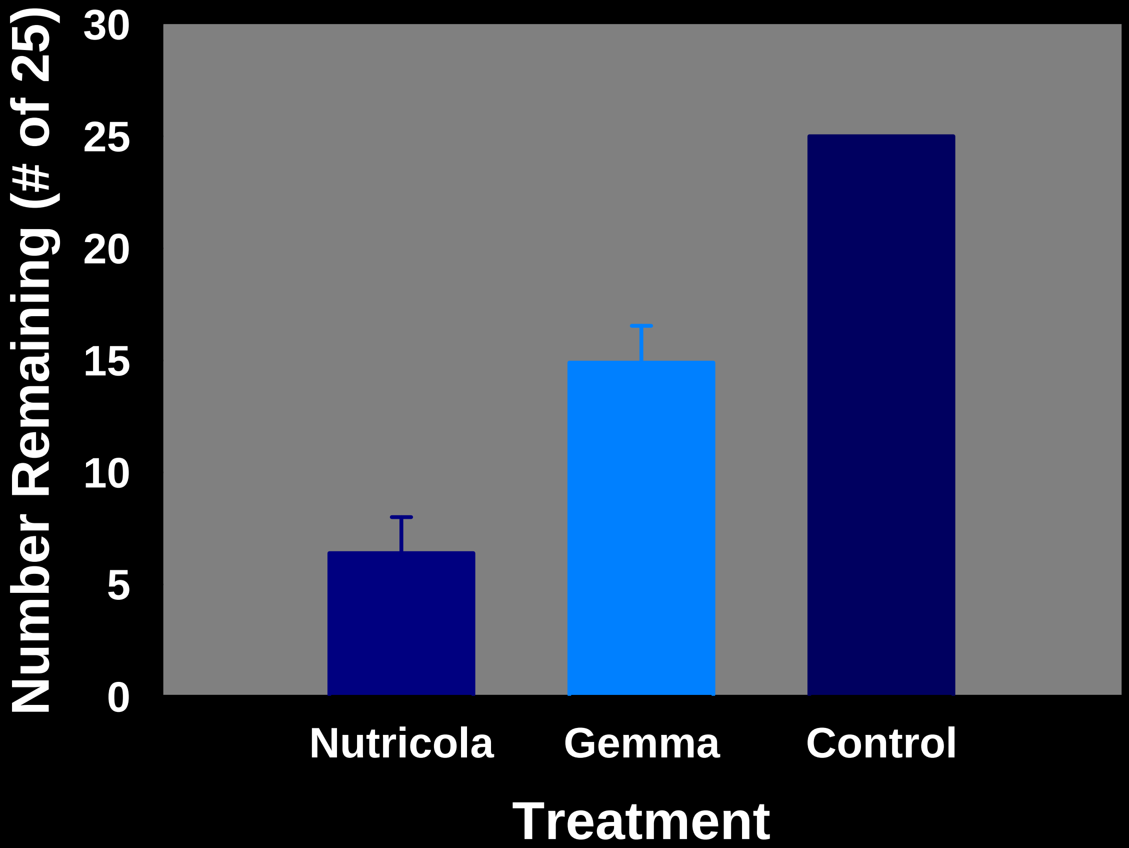

Small Clams in Bodega Harbor
Eastern Gem Clam
(*Gemma gemma*)
Native Clam
(Nutricola confusa)
Native Clam
(Nutricola tantilla)

Bodega Harbor, California, USA

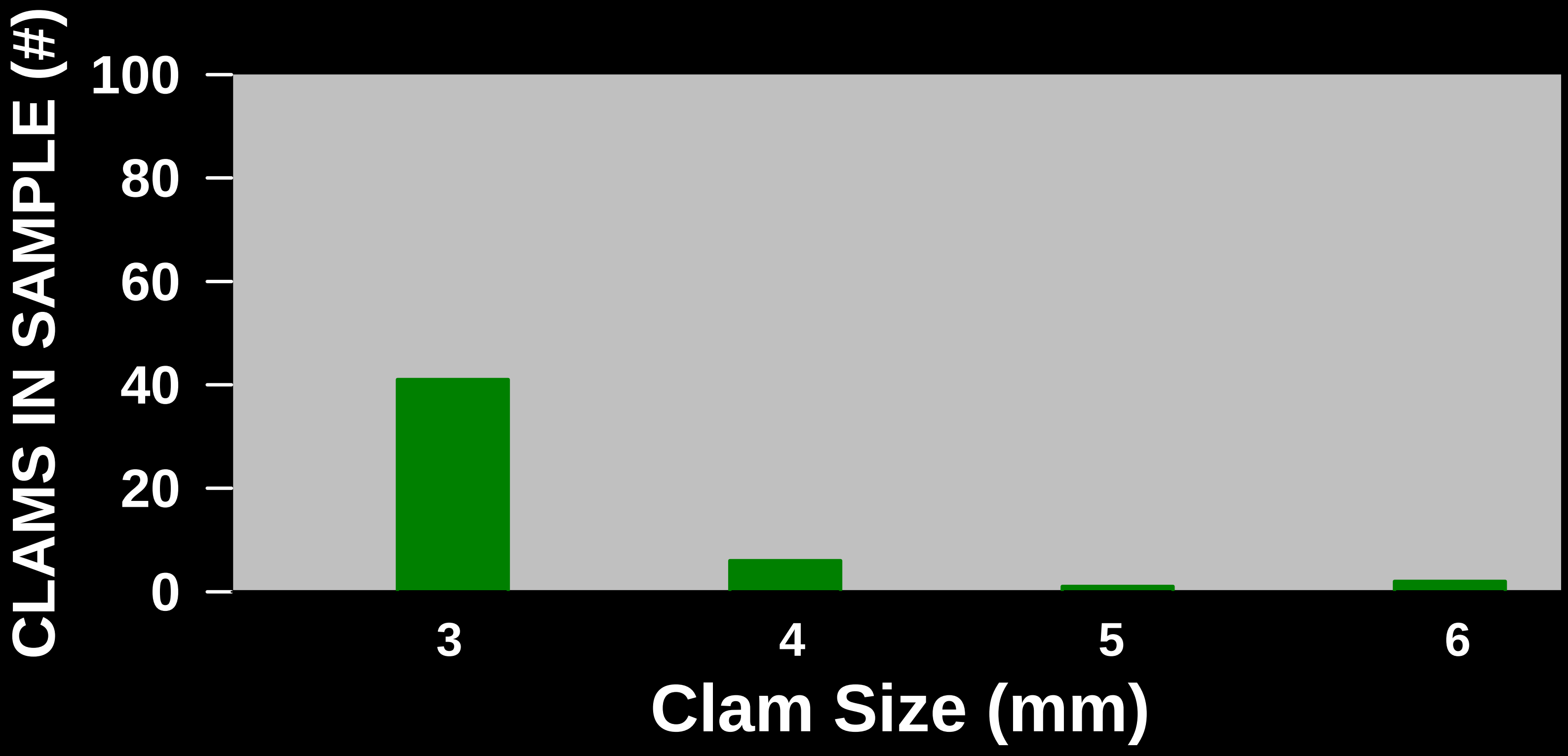
Life History

- 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



Size Dependent Predation by Green Crabs

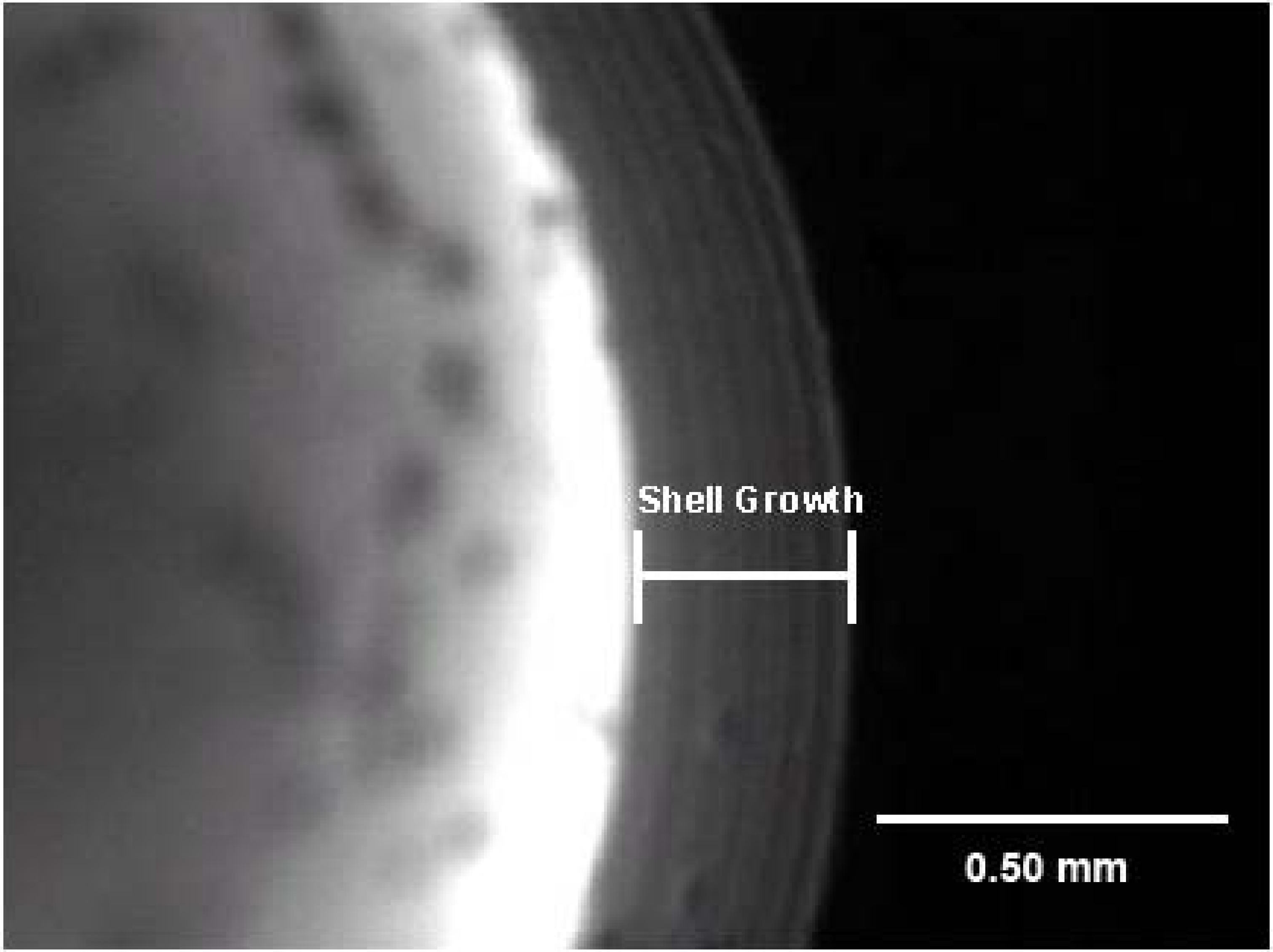


Life History

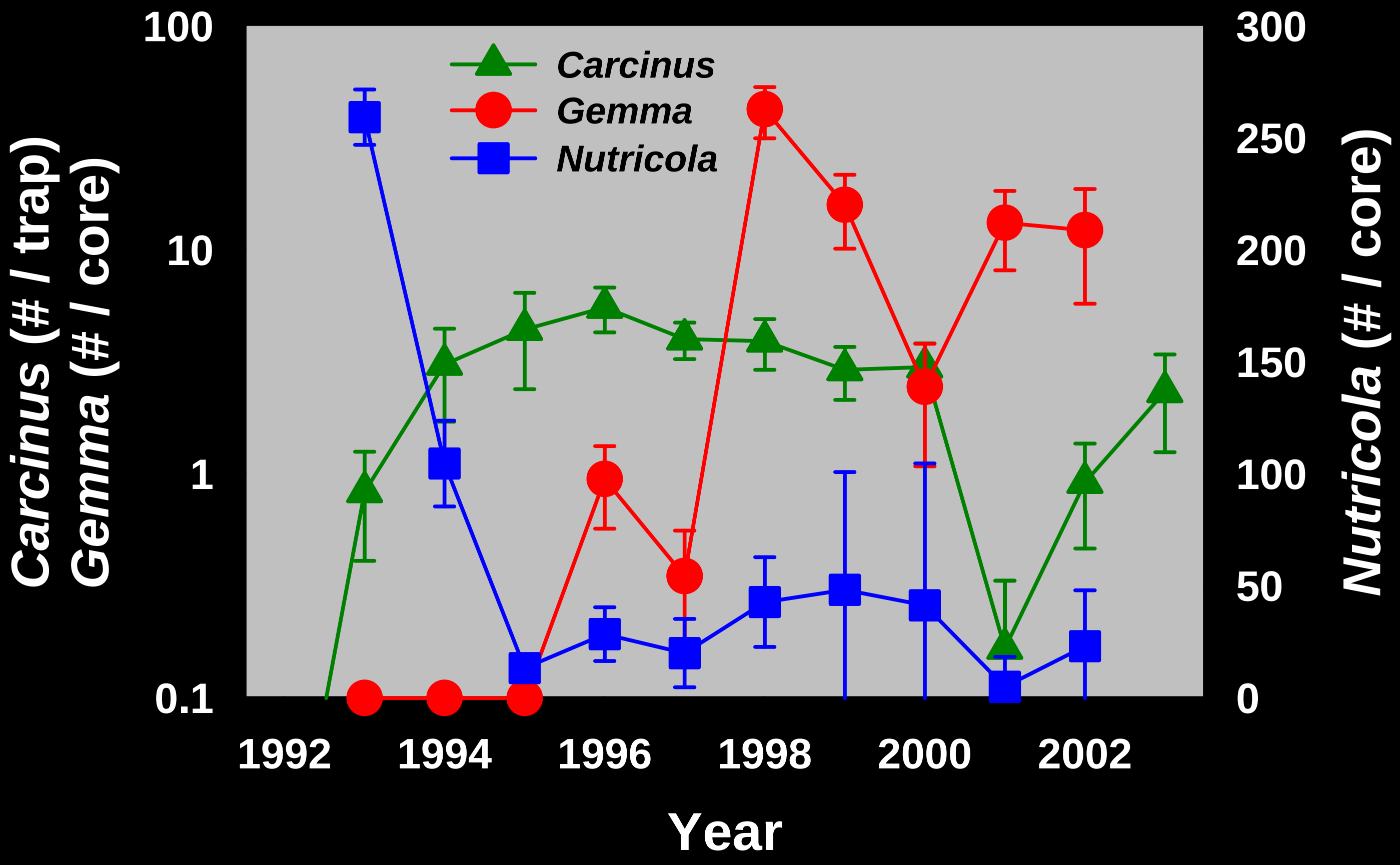
- Within species, green crabs consume largest in population
- Invasive *Gemma* are diecious
  - Large individuals are male and female
  - Green crabs consume both equally
- Native *Nutricola* are protandrous hermaphrodites
  - Largest individual are reproductive females
  - Green crabs selectively consume 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 m^2)
  - Post-green crab densities of *Nutricola* (1,000 to 2,000 per m^2)

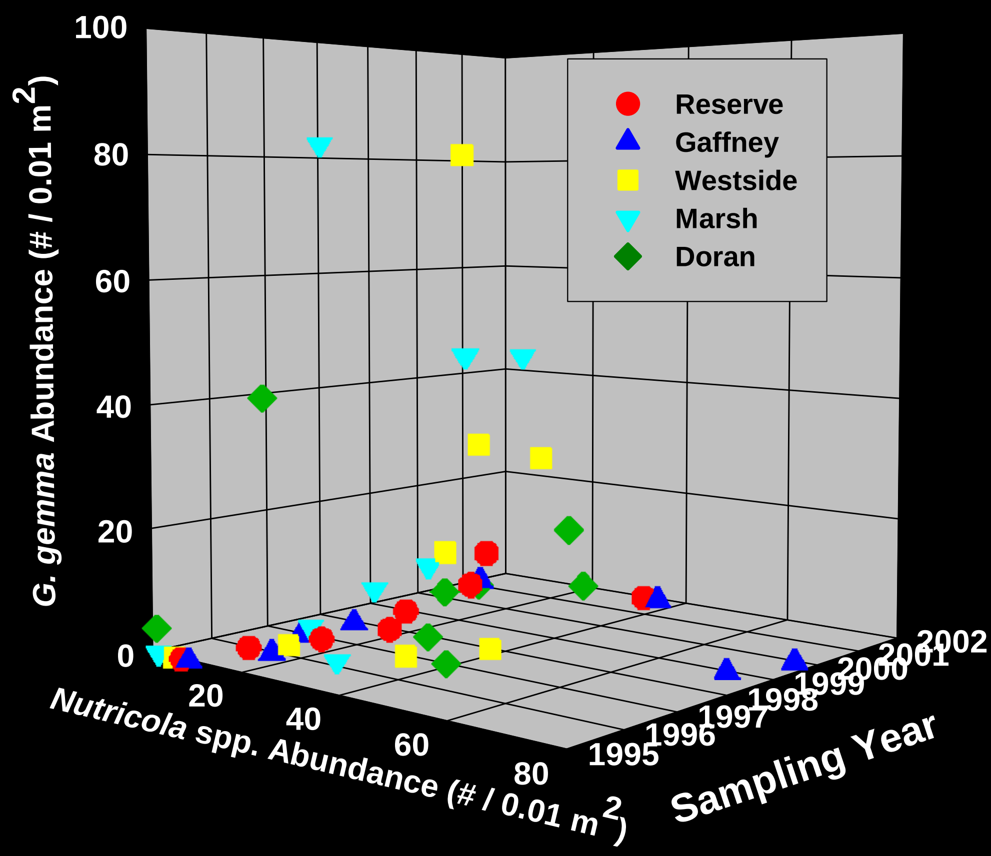

Shell Growth
0.50 mm

Relative Densities of *Carcinus, Gemma,* and *Nutricola*



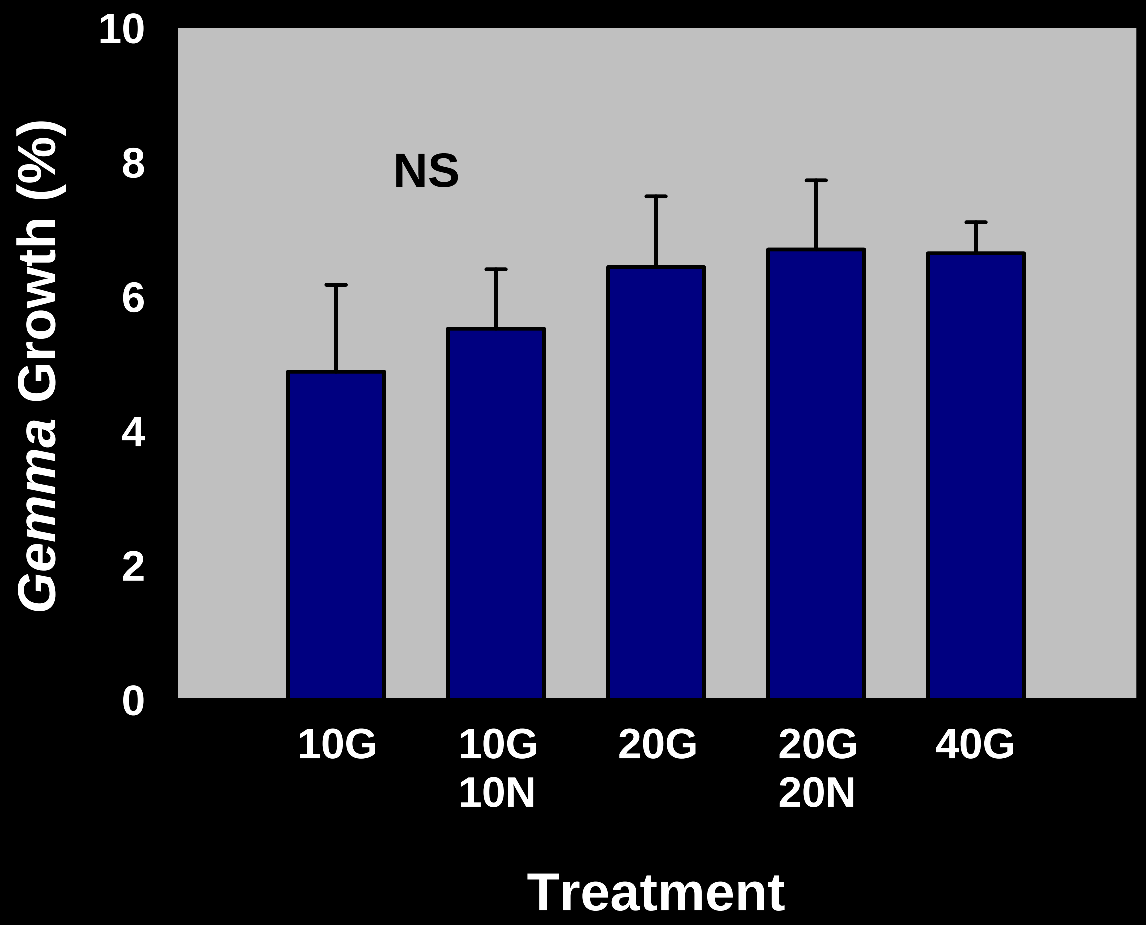
Grosholz. 2005. Proc. Nat. Acad. Sci.

Gemma Abundance vs. *Nutricola* Abundance



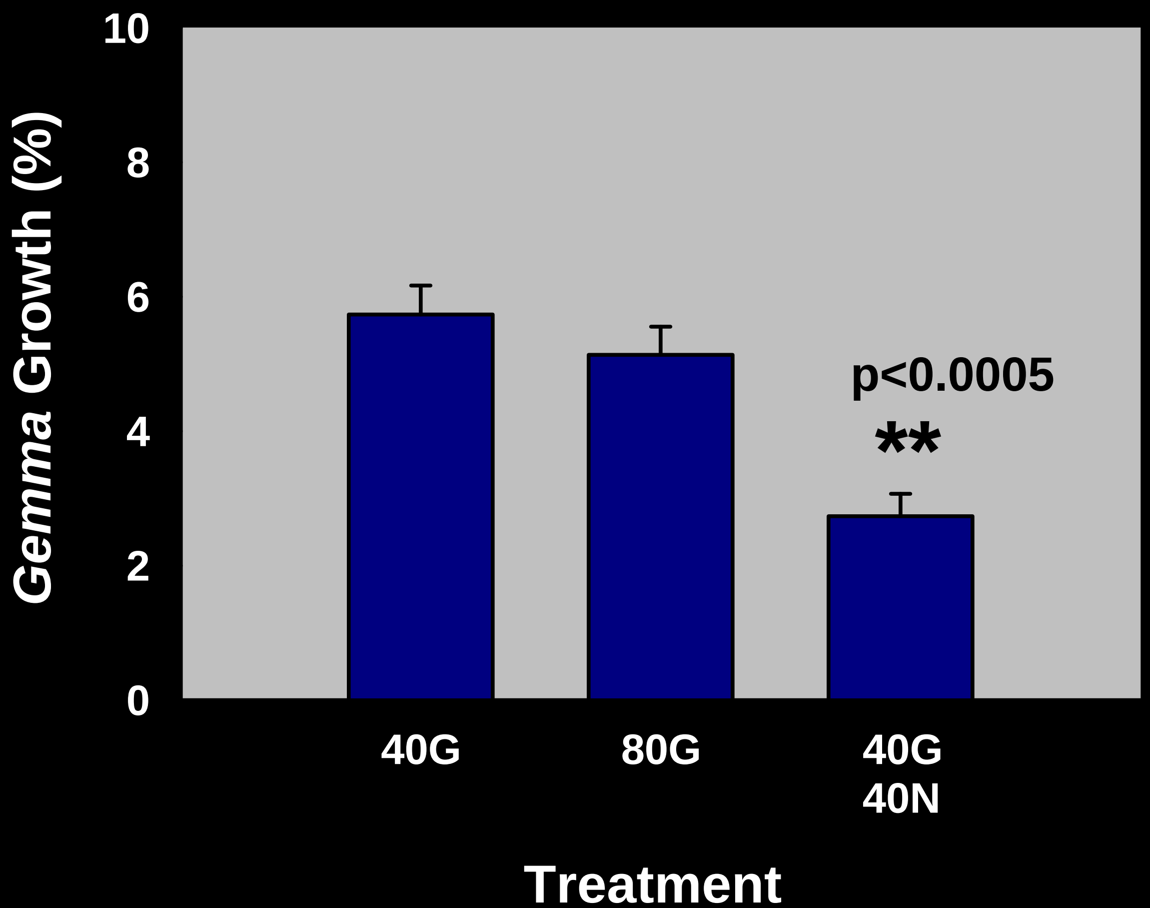
Grosholz. 2005. Proc. Nat. Acad. Sci.

Current Densities



Grosholz. 2005. Proc. Nat. Acad. Sci.

Historic Densities



Grosholz. 2005. Proc. Nat. Acad. Sci.

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

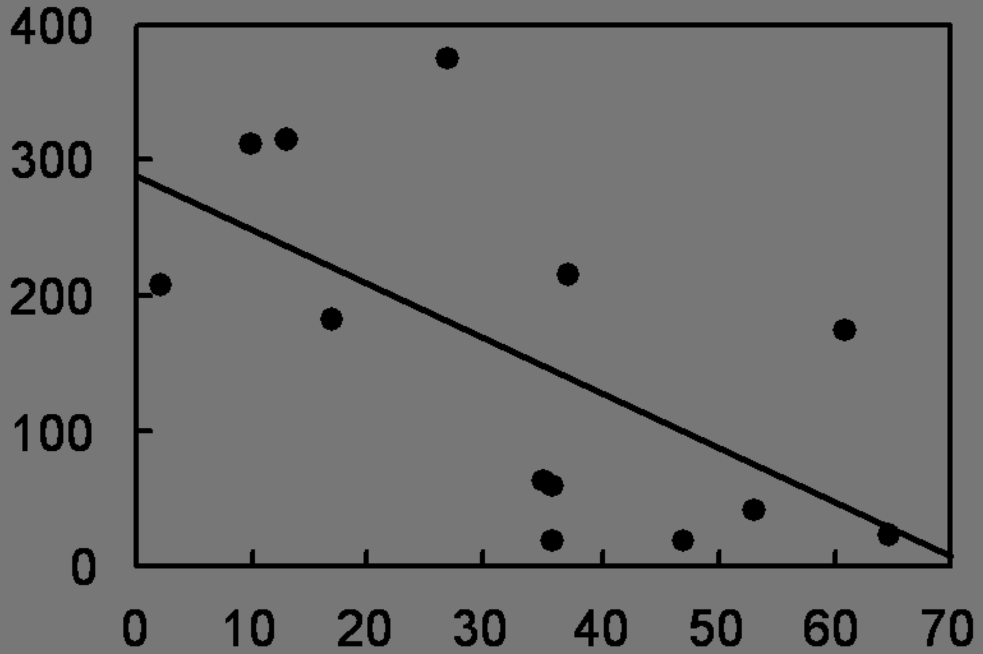
- Small, native crab
- Habitat & range overlap with green crabs

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



Hairy shore crabs

Green crabs

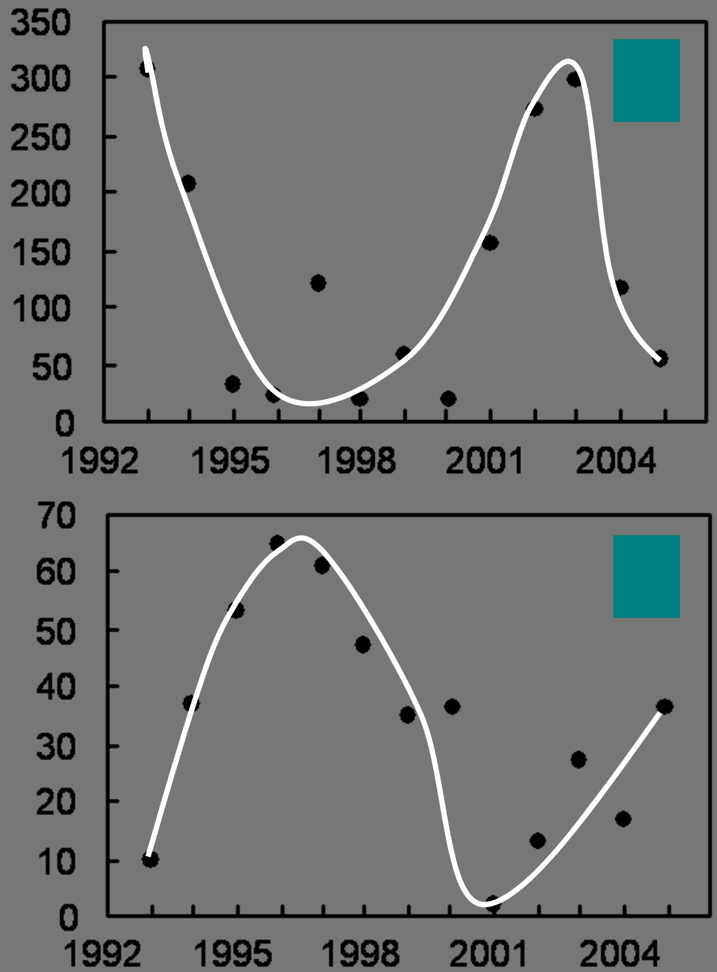
$Y = 290.15 - 4.04 X$; $r^2 = 0.4$; $n = 13$

Spearman rank correlation: rho = -0.64, $p = 0.026$

Numerical recovery?

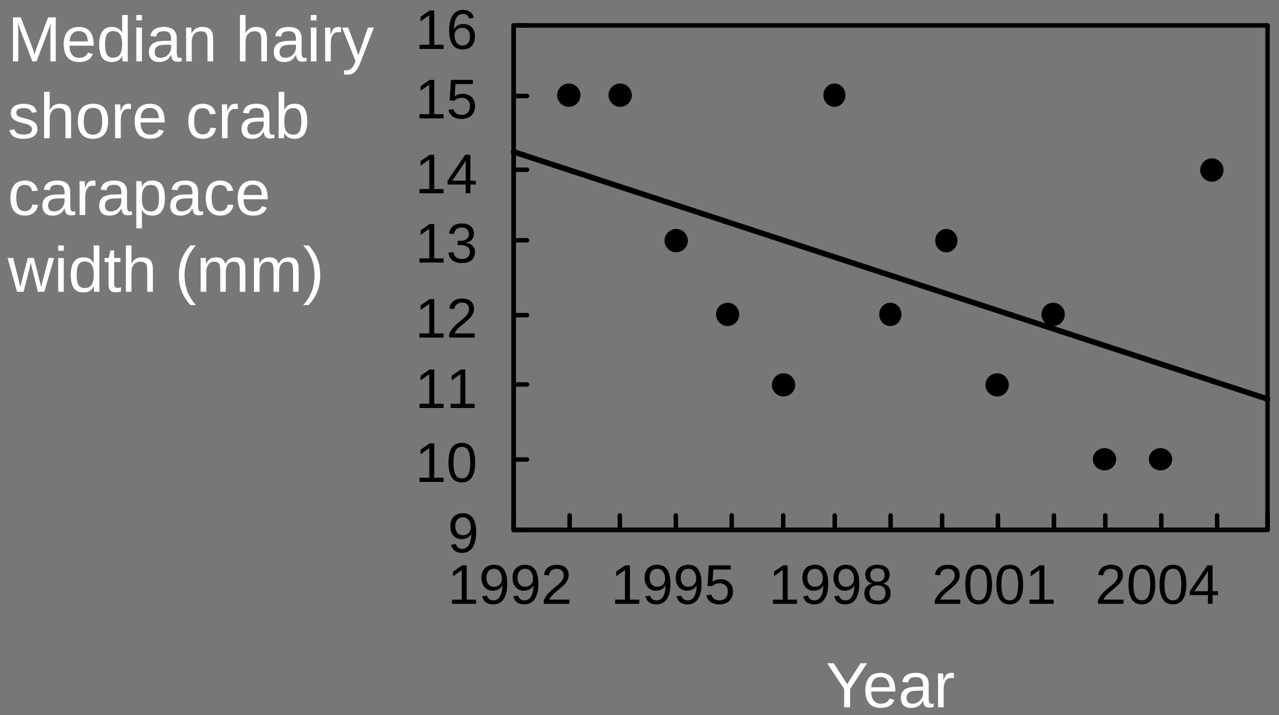
Hairy shore crabs

Green crabs



Year

Decrease in size



$Y = 506.8 - 0.25 X$; $r^2 = 0.28$; $n = 13$

Spearman rank: rho = -.59, p = 0.036

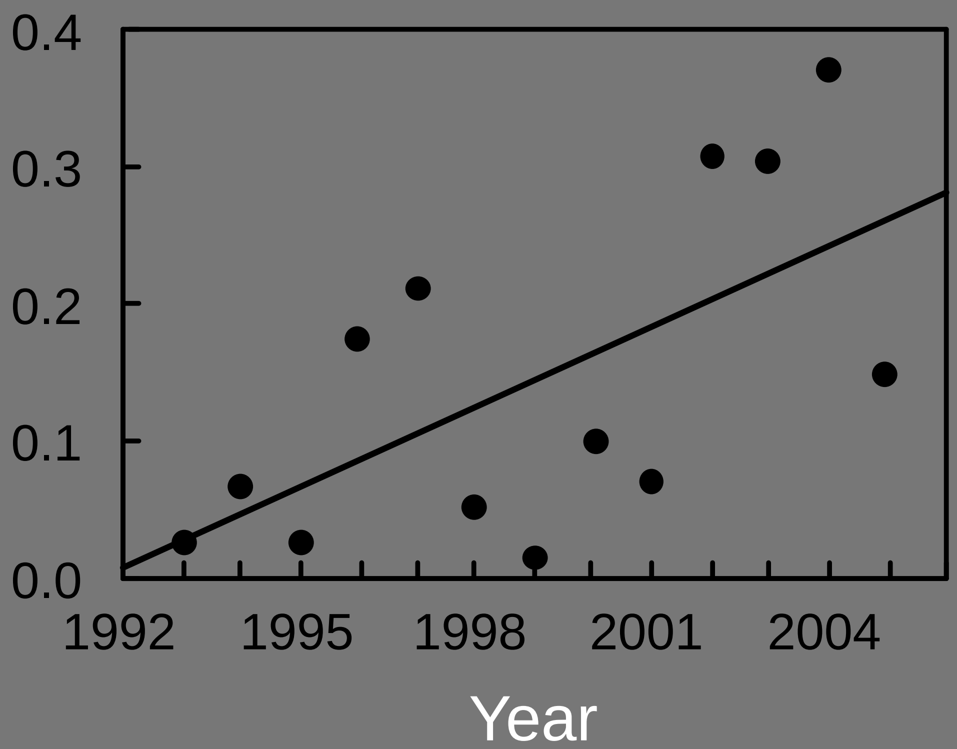
excluding recruits rho = -.56, p = 0.054

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; $r^2 = 0.4$; 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

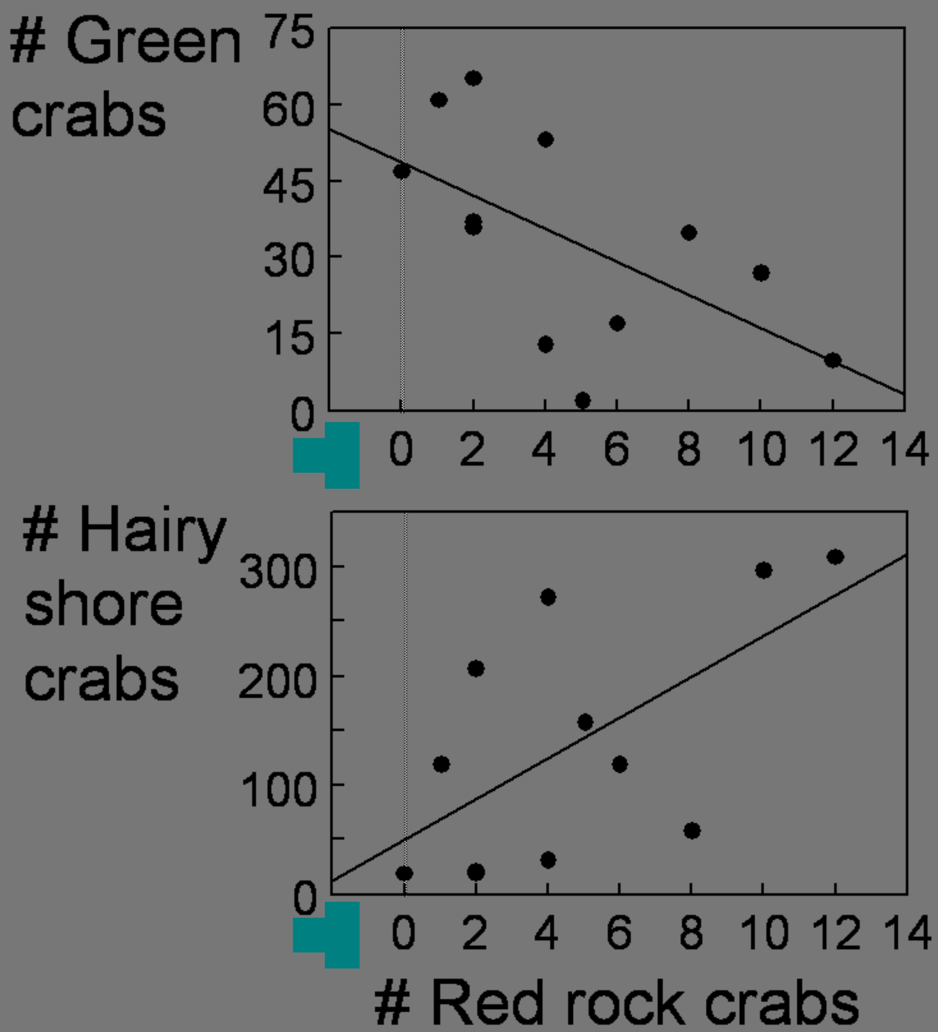
Changes due to green crabs

- 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



http://dnr.metrokc.gov

rho = 0.63, n = 12, p = 0.0374

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

If partial out effects of *Carcinus*:
rho = 0.11, n = 12, p = 0.7063

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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