Biology and Ecological Impacts of the European Green Crab, *Carcinus maenas*, on the Pacific Coast of Canada

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Green Crab (*Carcinus maenas*)

- Arrived in San Francisco Bay in 1989 (packing material)
- Slowly expanded northward into Pacific Northwest
- Arrived in BC through larval transport during 1998/99 El Nino
- Relatively few public reports after 1999
- No surveys until 2006
Data Sources

- Public records 1999-present
- Exploratory trap surveys 2006-2008
- Directed studies in Pipestem Inlet 2007-2008
Traps

• Fukui folding fish traps
  – 63 x 46 x 23 cm frame, 1.6 cm mesh
  – Standard Scotty plastic bait jar, top of trap
  – Frozen herring bait

• Traps set in strings of 6 or more on groundlines
  – Generally set from shallow to deep across intertidal into subtidal zone in exploratory work
  – Occasionally set along contours for tagging work
Sites

- Site selection through examination of charts
  - Tied to intertidal surveys
  - Incorporated local knowledge when available
- Developed “search image” to target specific micro-habitats
  - Adjacent to or in stream or tidal channels
  - Adjacent to cover (rocks, eelgrass)
- Some directed sampling in Georgia and Queen Charlotte Straits
  - Targeted wet storage sites for WCVI shellfish
  - Response to public reports
Data Collection

- Catches recorded by trap (target species and bycatch)
- Crab carapace width measured (nearest mm)
  - Both notch and point width recorded
- Sex determined
  - Male, female, ovigerous female, spent female
- Shell condition
- Injuries
  - Missing or regenerating limbs, torn abdomen, shell damage
Tagging

- Tagging study at Pipestem Inlet
  - Applied 3” and ¾” Floy anchor tags
  - Inserted into right gill chamber along suture line
- Final day catches used to produce population estimate
- Subsequent recoveries to estimate moult increment
Tagging
Results
Historical Records

• First reports from Barkley Sound and Esquimalt in 1999
• Subsequent records from further north 2000-2003
• Surveys begun in 2006
Historical Records
### Green Crab Catch Rates 2006-08

<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th># traps</th>
<th>Carcinus /trap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quatsino Sound</td>
<td>2007</td>
<td>108</td>
<td>0.3</td>
</tr>
<tr>
<td>Winter Harbour</td>
<td>2007</td>
<td>96</td>
<td>12.5</td>
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<tr>
<td>Klaskino Inlet</td>
<td>2007</td>
<td>35</td>
<td>1.8</td>
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<tr>
<td>Kyuquot Sound</td>
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<td>37</td>
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<tr>
<td>Mary Basin</td>
<td>2007</td>
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<td>Nootka/Esperanza</td>
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<tr>
<td>Tlupana Inlet</td>
<td>2007</td>
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<tr>
<td>Clayoquot Sound</td>
<td>2006</td>
<td>205</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Sydney Inlet</strong></td>
<td><strong>2006</strong></td>
<td><strong>12</strong></td>
<td><strong>1.4</strong></td>
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<tr>
<td><strong>Sydney Inlet</strong></td>
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<td><strong>42</strong></td>
<td><strong>1.5</strong></td>
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<tr>
<td>Barkley Sound</td>
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<td>162</td>
<td>1.7</td>
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<tr>
<td>Pipestem Inlet</td>
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<td>180</td>
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# Green Crab Catch Rates 2006-08

<table>
<thead>
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<th>Year</th>
<th># traps</th>
<th>Carcinus/trap</th>
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<tr>
<td>QC Strait</td>
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<td>Baynes Sound</td>
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<tr>
<td>Saanich Inlet</td>
<td>2006</td>
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# Green Crab Catch Rates 2006-08

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<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th># traps</th>
<th>Carcinus/Trap</th>
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<tbody>
<tr>
<td>Lewis Passage</td>
<td>2008</td>
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<tr>
<td>Gardiner Canal</td>
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<td>Devastation Channel</td>
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<td>Whale Channel</td>
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<td>Douglas Channel</td>
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<tr>
<td>Laredo Inlet</td>
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<tr>
<td>Port Blackney</td>
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<td>Fisher Channel</td>
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<td>Spider Anchorage</td>
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<tr>
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<tr>
<td>Rivers Inlet</td>
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<tr>
<td>Smith Sound</td>
<td>2007</td>
<td>47</td>
<td>0.0</td>
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### WCVI Catches (crabs/trap)

<table>
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<tr>
<th>Site</th>
<th>1999</th>
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<th>2002</th>
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<td></td>
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<tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>12.54</td>
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<tr>
<td>Klaskino</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.83*</td>
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<tr>
<td>Kyuquot</td>
<td>P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P</td>
<td>0.53</td>
<td>0.38*</td>
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<td>Esperanza</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td></td>
<td></td>
<td></td>
<td>5*</td>
<td>0.46</td>
<td>0.33*</td>
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<tr>
<td>Nootka</td>
<td>P</td>
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<td></td>
<td></td>
<td></td>
<td>0.03</td>
<td>0.03*</td>
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<tr>
<td>Clayoquot</td>
<td>P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.2</td>
<td>1.50*</td>
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<tr>
<td>Barkley</td>
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<td></td>
<td></td>
<td>P</td>
<td>1.72</td>
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<td>Esquimalt</td>
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</table>

Note: P = presence confirmed (non-survey), * = < 50 traps set
Tagging

- Large Floy tags not suitable
  - High incidence of tag loss
  - Crabs pulling tags out leaving large holes in gill chamber

- To date 349 crabs recovered with tags
  - 165 recovered within days of initial tagging
  - 57/184 (~30%) moulted
  - Longest liberty without moult 407 days

- Population estimates not yet calculated
  - Perhaps compare tag recovery estimate to depletion estimate?

- 2008 tagging used ¾” Floy anchor tags
Discussion
Geographic Distribution

- Green crabs distributed throughout the west coast of Vancouver Island
  - High density sites at both northern and southern limits
    - Winter Harbour and Pipestem Inlet, respectively
  - Some evidence of increased abundance (inferred from catch rates) from 2006 to 2008, particularly in Pipestem Inlet
- High catch rates correlated with decreased salinity
- No green crabs from inside or mainland waters
Evidence of Regular Recruitment

- 2006 survey indicated strong 2005 year class
  - Most male crabs 50-70 mm CW
- 2007 survey showed strong 2005 and 2006 year classes
  - 2005 mode roughly centered around 70 mm CW
  - 2006 mode roughly centered around 50 mm CW
2006 Male Size Frequency
2007 Male Size Frequency

Frequency

2007 2006 2005

CW PP (mm)
2008 Male Size Frequency

Frequency

CW PP (mm)

2007 2006 2005
Evidence of Local Reproduction

- Mating pairs collected in summer
  - Pre-mating embrace; male clasps female with walking leg, leaving chelae free for foraging or aggression
- Ovigerous and spent females collected in spring
Moult Increments

\[ y = 1.0529x + 10.518 \]

\[ R^2 = 0.9562 \]
Conclusions

• Standardized survey protocols allow determination of distribution and allow inference regarding relative abundance based on catch rates
• Biological data collected used to infer age frequency and recruitment (from size data and size-age key), timing of moult and reproductive activities
• Tagging data provide population estimates and moult increment information
• Directed studies provide information on environmental and ecological tolerances
Green Crab Issues

• Bivalve shellfish products as potential vector
  – WCVI clam harvests and oyster shipments wet stored in Baynes Sound
  – ITC issued advisory that practice was not recommended
  – WCVI harvesters questioning requirement, beginning dialogue on mitigation

• WCVI populations can serve as larval pool
  – Potential for dispersal into northern BC and Alaska
Future Projects

- Experimental depletion of green crab population
  - Compare tagging and depletion estimates of population size
  - Assess effectiveness of regular trapping to decrease abundance
Future Projects

- Selective removal of female green crabs
  - Use pheromone baits in early summer to attract females to traps
  - Use habitat traps in winter to collect ovigerous females
  - Potentially reduce larval production
Future Projects

• Comparison of bycatch from areas with and without green crab
  – Could provide insight into ecological impacts of green crab
Acknowledgements

• Sylvia Behrens Yamada, Jim Boutillier, Claudio DiBacco, Jason Dunham, Gavin Hanke, Jonathan Hupman, Debbie Paltzat, Chris Payne, Antan Phillips, Anna Russell, Dennis Rutherford

• Funding provided by Fisheries and Oceans Canada Aquatic Invasive Species Program