Distribution of Non-indigenous Intertidal Species on the Pacific Coast of Canada

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Introduction

• Non-indigenous species (NIS) are of concern globally
  – PICES WG on NIS
  – Canadian government programs to collect, synthesize and distribute data on NIS
  – Survey work to determine distribution and abundance of intertidal NIS
    • Strait of Georgia (Jamieson, Thériault)
    • Other areas of British Columbia
Objectives

- Provide updated information on distribution of intertidal NIS on the Pacific Coast of Canada

- Synthesize information on distribution, source and pathway
Legend and Data Sources

• White circles ◯ are survey locations
• Yellow circles ● are collection records from:
  – Other survey databases (limited species)
  – Literature and public records
• Red circles ● are collection records from:
  – Exploratory intertidal clam surveys 1990-present
  – Exploratory NIS surveys 2006
Boundary Bay

- Sole location for:
  - *Crassostrea virginica*
  - *Crepidula convexa*
  - *Nassarius fraterculus*
  - *Nassarius obsoletus*
  - *Petricolaria pholadiformis*
  - *Spartina anglica*

- Primary location for:
  - *Urosalpinx cinerea*
    (Ladysmith)
  - *Neotrapezium liratum*
    (Ladysmith)
  - *Crepidula fornicata*
    (Victoria)
  - *Cecina manchurica*
    (Nanaimo)
Intertidal NIS in BC – Plants / Algae

- Wireweed, *Sargassum muticum*
- Cordgrass, *Spartina alterniflora, S. anglica* and *S. patens*
- Dwarf eelgrass, *Zostera japonica*
Wireweed (*Sargassum muticum*)
Sargassum muticum

- Arrived with Pacific oyster seed
- Common in all South Coast areas
- Continuing to spread in North Coast
Cordgrass (*Spartina* sp.)

- Few records, possibly dispersal, possibly human mediated
  - Smooth cordgrass, *Spartina alterniflora*
    - Comox, Strait of Georgia
  - English cordgrass, *Spartina anglica*
    - Boundary Bay
  - Saltmeadow cordgrass, *Spartina patens*
    - Baynes Sound, Strait of Georgia
Dwarf Eelgrass (*Zostera japonica*)
Zostera japonica

- Arrived with Pacific oyster seed
- Dispersed from aquaculture locations
- Primarily Strait of Georgia, specific locations on WCVI and in Johnstone Strait
Dwarf Eelgrass
Zostera japonica
Intertidal NIS in BC – Gastropods I

- Japanese false cerith, *Batillaria attramentaria*
- Manchurian cecina, *Cecina manchurica*
- Convex slippersnail, *Crepidula convexa*
- Atlantic slippersnail, *Crepidula fornicata*
- Mouse-ear snail, *Myosotella myosotis*
Intertidal NIS in BC – Gastropods II

- Japanese nassa, *Nassarius fraterculus*
- Eastern mudsnail, *Nassarius obsoletus*
- Japanese oyster drill, *Ocinebrina inornata*
- Atlantic oyster drill, *Urosalpinx cinerea*
False Cerith (*Batillaria attramentaria*)
Batillaria attramentaria

- Arrived with Pacific oyster seed
- Relatively few locations in Strait of Georgia, associated with oyster culture
- Dispersal limited by life history (benthic larvae)
- Collected in Pendrell Sound and Okeover Inlet in 2006
Japanese False Cerith
Batillaria attramentaria
Japanese Oyster Drill (*Ocinebrina inornata*)
Ocinebrina inornata

- Arrived with Pacific oyster seed
- Few locations, associated with oyster culture
- Drill Zone regulations in place to prevent spread
- Dispersal limited by life history (benthic larvae)
- Collected in Barkley Sound in 2006
Japanese Oyster Drill
Ocinebrina inornata
Mouse-ear Snail (*Myosotella myosotis*)
Myosotella myosotis

- Possibly arrived with Atlantic oysters
- Known from Boundary Bay
- Recent records from Nanaimo
- Dispersal limited by life history (benthic larvae)
- Collected in Barkley Sound in 2006
Mouse-eared Snail
Myosotella myosotis
Intertidal NIS in BC – Bivalves I

- Pacific oyster, *Crassostrea gigas*
- Eastern oyster, *Crassostrea virginica*
- European flat oyster, *Ostrea edulis*
- Green mussel, *Musculista senhousia*
- Blue mussel, *Mytilus edulis*
- Mediterranean mussel, *Mytilus galloprovincialis*
Intertidal NIS in BC – Bivalves II

- Softshell, *Mya arenaria*
- Quadrate trapezium, *Neotrapezuim liratum*
- Varnish clam, *Nuttallia obscurata*
- False angelwing, *Petricolaria pholadiformis*
- Manila clam, *Venerupis philippinarum*
- Naval shipworm, *Teredo navalis*
Pacific Oyster (*Crassostrea gigas*)
**Crassostrea gigas**

- Imported since 1920s for aquaculture to Strait of Georgia and WCVI
- Successful reproduction in Ladysmith Harbour, 1936
- Dispersed throughout Strait of Georgia and on WCVI north to Brooks Peninsula
- Dispersal limited by temperature
Pacific Oyster
Crassostrea gigas
European Flat Oyster (*Ostrea edulis*)
Ostrea edulis

- Imported for aquaculture in Strait of Georgia and WCVI
- Limited successful reproduction in Barkley Sound
- Deliberate introduction to several sites in Esperanza Inlet
European Flat Oyster
Ostrea edulis
Green Mussel (*Musculista senhousia*)
Musculista senhousia

- Known from Puget Sound since 1940s, arrived with Pacific oysters, no dispersal
- Collected in Strait of Georgia in 1990s
- Collected in Desolation Sound and Barkley Sound in 2006
Green Mussel
Musculista senhousia
Blue Mussels, *Mytilus* sp.
**Mytilus edulis** and **Mytilus galloprovincialis**

- Cannot be definitively distinguished from each other or native **Mytilus trossulus** in field
- Samples collected from each location for genetic analyses (pending funding)
Softshell (*Mya arenaria*)
Mya arenaria

- Brought to San Francisco Bay with Atlantic oysters
- Dispersed north, some deliberate introductions (e.g., Willapa Bay, Washington)
- Dispersed through BC to Alaska, then south to Queen Charlotte Islands
Varnish Clam (*Nuttallia obscurata*)
Nuttallia obscurata

- Arrived late 1980s, ballast water introduction
- Nearly simultaneous appearance in Strait of Georgia and southern WCVI
- Dispersed north to tip of Vancouver Island
  - One record from North Coast
- Dispersal not complete
Manila Clam (Venerupis philippinarum)
Venerupis philippinarum

- Came with Pacific oyster seed
- Found in Ladysmith Harbour in 1936
- Spread quickly, now basis of commercial fishery and aquaculture
- Dispersed into North Coast
- Dispersal limited by temperature
Manila Clam
Venerupis philippinarum
Intertidal NIS in BC - Others

- Violet tunicate, *Botrylloides violaceus*
- European green crab, *Carcinus maenas*
Violet Tunicate (*Botrylloides violaceus*)
Botrylloides violaceus

- May have been introduced with oysters or through hull fouling
- Found from Mexico to Alaska
- Cryptogenic, known in BC since at least 1990s
- Collected at low tide line or in oyster shell in 2006 surveys
Green Crab (*Carcinus maenas*)
Carcnius maenas

- Arrived in San Francisco Bay in 1980s, likely ballast water introduction
- Dispersed north during strong El Nino episode in 1998
- Found on WCVI in 1999 (one year-olds)
- First survey in 2006
  - Collected on WCVI; not Johnstone Strait
## Green Crab Catch Rates by Sound

<table>
<thead>
<tr>
<th>Sound</th>
<th>No. of Traps Set</th>
<th>Crabs/Trap-day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barkley</td>
<td>162</td>
<td>1.72</td>
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<tr>
<td>Clayoquot</td>
<td>205</td>
<td>0.20</td>
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<tr>
<td>Nootka</td>
<td>30</td>
<td>0.03</td>
</tr>
<tr>
<td>Esperanza</td>
<td>118</td>
<td>0.46</td>
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<tr>
<td>Kyuquot</td>
<td>17</td>
<td>0.53</td>
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</table>
Intertidal NIS in BC – Not Established

- Topsnail, *Clanculus ater*
- Japanese rock-shell, *Purpura clavigera*
- Hoofsnail, *Sabia conica*

- Takenoshima shipworm, *Lyrodus takenoshimensis*
- Northern quahog, *Mercenaria mercenaria*
Number of NIS by Area

- Strait of Georgia: 26
- West Coast Vancouver Island: 14
- Johnstone Strait: 6
- North Coast: 4
- Queen Charlotte Islands: 1

Total Possible: 28
<table>
<thead>
<tr>
<th>Origin</th>
<th>Number</th>
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<tbody>
<tr>
<td>NW Pacific</td>
<td>13</td>
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<tr>
<td>North Atlantic</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
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### Number of NIS by Area and Source

<table>
<thead>
<tr>
<th>Area</th>
<th>Atlantic</th>
<th>Pacific</th>
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</thead>
<tbody>
<tr>
<td>Strait of Georgia</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>West Coast Vancouver Island</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Johnstone Strait</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>North Coast</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Queen Charlotte Islands</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total Possible</strong></td>
<td><strong>15</strong></td>
<td><strong>13</strong></td>
</tr>
</tbody>
</table>
### Number of NIS by Pathway

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Count</th>
</tr>
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<tbody>
<tr>
<td>Aquaculture (Hitch-hiker)</td>
<td>13</td>
</tr>
<tr>
<td>Natural Dispersal</td>
<td>5</td>
</tr>
<tr>
<td>Aquaculture (Intentional)</td>
<td>4</td>
</tr>
<tr>
<td>Fouling/Boring</td>
<td>4</td>
</tr>
<tr>
<td>Ballast Water</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
</tr>
</tbody>
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Deliberate Dispersal Within BC

- Species transferred to previously uninhabited areas for aquaculture

  Pacific oyster, *Crassostrea gigas*
  Kumamoto oyster, *Crassostrea sikamea*
  European flat oyster, *Ostrea edulis*
  Mediterranean mussel, *Mytilus galloprovincialis*
  Manila clam, *Venerupis philippinarum*
  Japanese scallop, *Mizuhopecten yessoensis* hybrids
Conclusions

• NIS found throughout BC
  – Diversity greatest in Strait of Georgia
    • Highest density of aquaculture
    • Only aquaculture of Atlantic oysters
  – Diversity decreases with increasing latitude
    • Some species limited by temperature requirements
    • Aquaculture expanding into North Coast and QCI
Conclusions

• Most important pathway historically was aquaculture (intentional and unintentional)
  – Strict legislation in place to ensure that unintentional introductions prevented
  – However, still allow deliberate transfers to areas where not currently established

• Ship vectors currently of more concern
Other Considerations

• Where dispersal limited by life history, control of human vectors can limit spread
• Where dispersal limited by temperature requirements, projected climate change will allow broader distribution, particularly northward
• BC larval sources for green crab could allow dispersal through northern BC into Alaska in years of strong northward coastal currents