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Northern Range Expansion and Coastal Occurrences of the New Zealand Mud Snail Potamopyrgus Antipodarum (Gray, 1843) in the Northeast Pacific

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Northern range expansion and coastal occurrences of the New Zealand mud snail Potamopyrgus antipodarum (Gray, 1843) in the northeast Pacific

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Abstract

The New Zealand mud snail Potamopyrgus antipodarum (Gray, 1843) is a common invasive species in fresh and brackish water ecosystems in Europe, Australia, Japan, and North America. In some invaded habitats, P. antipodarum can reach high densities (over 500,000 snails m⁻²) and dominate the biomass of the benthos, leading to detrimental impacts to native biota and changes in ecosystem dynamics. We report the previously unpublished occurrence of P. antipodarum in thirteen fresh and brackish water systems adjacent to the Pacific coast of North America including a new northern range for P. antipodarum: Port Alberni, Vancouver Island, British Columbia, Canada (49.2479º, -124.8395º). We hypothesize the snail was spread from the Columbia River Estuary to Port Alberni via recreational watercraft or infected fishing equipment. Its discovery in Port Alberni reveals the potential for other aquatic nuisance species in the lower Columbia River to spread to British Columbia. Resource managers on the Pacific coast should remain vigilant and educate the public to prevent the further spread of the P. antipodarum as well as other aquatic invaders.

Key words: brackish gastropods, British Columbia, New Zealand mud snail, Port Alberni, Potamopyrgus antipodarum, range expansion, Vancouver Island
subtidally or intertidally on or under rocks and debris in fresh or brackish waters. *Potamopyrgus antipodarum* can be spread anthropogenically through movement of gear such as waders, boots, angling equipment, and boats or by the translocation of aquaculture materials (live fish or eggs; Bowler 1991; Haynes et al. 1985; Hosea and Finlayson 2005). Secondary introductions may occur on birds that carry the snails among their feathers or by fish that consume but are unable to digest snails (Bondesen and Kaiser 1949; Haynes et al. 1985).

In some invaded freshwater systems, *P. antipodarum* has become the most prevalent and numerically abundant species (Ponder 1988; Hall et al. 2006) reaching densities over 500,000 snails m$^{-2}$ in vegetative and muddy substrates, and constituting between 65-92% of total invertebrate productivity (Hall et al. 2006). These herbivorous and detritivorous snails can also dominate carbon and nitrogen fluxes (Hall et al. 2003). The high densities achieved by *P. antipodarum* in invaded systems suggest that it may compete with native species for resources (Brown et al. 2008). However, the field evidence for a negative competitive effect is mixed, with some negative (Kerans et al. 2005), non-significant (Cada 2004) and positive (Schreiber 2002) correlations between densities of *P. antipodarum* and native fauna. *Potamopyrgus antipodarum* may also reduce the colonization rate of some macroinvertebrates (Kerans et al. 2005) and affect the survivorship of fish that consume them (Vinson and Baker 2008). The interactions with different trophic levels coupled with the high densities observed in many systems may lead to substantial changes in trophic dynamics and nutrient cycling in aquatic ecosystems (Bronmark 1989; Hall et al. 2003; Hall et al. 2006).

While *P. antipodarum* is usually described as a freshwater invader in North America, this species is being increasingly found in brackish estuarine environments and adjacent aquatic habitats (Bersine et al. 2008). We report occurrences of this invasive snail from a series of qualitative surveys and verified sightings in coastal aquatic systems of the northeast Pacific. Our surveys revealed several new invasions of brackish and freshwater environments by *P. antipodarum* including a new northern limit on the northeast Pacific coast for the invasive mud snail. *Potamopyrgus antipodarum* was discovered in Port Alberni Inlet (5 salinity), Vancouver Island, British Columbia during surveys conducted in July 2007. The snails occur in low densities amongst intertidal woody debris in areas adjacent (<1 km) to the primary marina and boat ramp for the town of Port Alberni. We also report twelve occurrences in the brackish and fresh water environments of Oregon and Washington, USA (Figure 1, Annex 1).

We hypothesize that the well-established population of *P. antipodarum* in the Columbia River Estuary is the source of the snails found in Port Alberni. This hypothesis is supported by four main lines of evidence. 1) *P. antipodarum* occurs in very high densities (over 200,000 snails/m$^2$; Litton 2000) in the Columbia River Estuary and has been there at least since 1996 (Bersine et al. 2008). 2) The lower Columbia River Estuary hosts many recreational sport fisheries and boaters, which are likely vectors for *P. antipodarum* (Bowler 1991; Haynes et al. 1985; Hosea and Finlayson 2005). 3) Port Alberni is also a popular destination for recreational fishers and boaters (G. Gillespie, pers. obs.). 4) *P. antipodarum* is highly tolerant to desiccation and can survive over 50 days on a...
controlling there appear to be few (if any) feasible options in desiccation, and parthenogenetic reproduction, invaders across international borders. In preventing and reporting the spread of aquatic dates the importance of international cooperation (Wasson et al. 2001). This invasion also eluci-

... in Port Alberni from the populations in Long Beach, Washington or other Oregon sites since many of these sites harbor lower densities of P. antipodarum (unpublished data) and are utilized by fewer recreational fishers and boaters compared to the Columbia River Estuary. The invasion of the Columbia River Estuary by P. antipodarum is thought to be a secondary intro-
duction from the interior of the western USA since both populations exhibit the same clonal lineage (Dybdahl and Kane 2005). Thus, genetic analysis of the Port Alberni populations would reveal if this population is a new clone (new invasion from New Zealand or Australia) or of the same clonal lineage (secondary introduction). Potamopyrgus antipodarum could also invade locations north of Port Alberni. Using Genetic Algorithm for Rule-set Production (GARP), Loo et al. (2007) predicted P. antipodarum might be distributed in areas many kilometers north of Port Alberni due to its wide range of temperature and salinity tolerance.

The discovery of P. antipodarum in Port Alberni reveals the potential for further invasions of the numerous other non-native aquatic species present in the lower Columbia River, if this new population is sourced from there. The lower Columbia River receives a large volume of international and regional ship traffic and hosts over 54 non-native species (Sytsma et al. 2004) including several that could be transported similarly and can drastically alter aquatic habitats (e.g. Eurasian watermilfoil Myriophyllum spicatum [Linnaeus, 1753] and common reed Phragmites australis [Cav.] Trin. ex Steud). Thus, it is important to recognize the role of intraregional traffic (such as recreational boaters) in spreading invasive species initially introduced through commercial shipping (Wasson et al. 2001). This invasion also eluci-
dates the importance of international cooperation in preventing and reporting the spread of aquatic invaders across international borders.

Due to their small size, resistance to desiccation, and parthenogenetic reproduction, there appear to be few (if any) feasible options in controlling P. antipodarum populations once they become established (New Zealand Mudsnail Management and Control Plan Working Group 2007). Resource managers, however, are employing several options to prevent the future spread of P. antipodarum such as posting signs at boat ramps, distributing informational media (pamphlets, brochures, websites; pers. obs.), and by establishing permanent and mobile washing stations at boat ramps (New Zealand Mudsnail Management and Control Plan Working Group 2007). Another option is to treat infected equip-

... employing several options to prevent the future spread of P. antipodarum through infected equipment: 1) freezing for several hours or 2) drying infected equipment at 30ºC for at least 24 hours or at 40ºC for 2 hours. There are also several chemical options to decontaminate infected equipment including copper sulfate (252 mg/L Cu), Formula 409® Disinfectant (50% dilution), and benzethonium chloride compounds (1,940 mg/L; Hosea and Finlayson 2005). These types of chemical treatments only require five minutes of submergence to be effective and do not appear to damage neoprene and rubber wading gear, although care must be taken to dispose of those chemicals properly (Hosea and Finlayson 2005). While chemical options are effective in preventing the spread of P. antipodarum, knowledge of infested sites coupled with rigorous gear cleaning (scrubbing, draining, and drying) at these sites and elsewhere are cost effective means of limiting further transport of P. antipodarum and other aquatic invasive species. We urge resource managers to remain vigilant and aware of the threat P. antipodarum may hold for aquatic systems and to educate the public in order to prevent the further spread of P. antipodarum on the Pacific coast of North America.

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### Annex 1

**Occurrences of *Potamopyrgus antipodarum* in the coastal region of the northeast Pacific**

<table>
<thead>
<tr>
<th>Location</th>
<th>Record coordinates</th>
<th>Date of record</th>
<th>Collector and affiliation or Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port Alberni</td>
<td>49.2479  -124.8395</td>
<td>5.07.2007</td>
<td>Timothy M Davidson, Portland State University</td>
</tr>
<tr>
<td>Long Beach, Surfside drainage canal&lt;sup&gt;1&lt;/sup&gt;</td>
<td>46.5343  -124.0547</td>
<td>Spring 2002</td>
<td>Washington Department of Fish and Wildlife</td>
</tr>
<tr>
<td>Columbia River, Youngs Bay</td>
<td>46.1643  -123.8388</td>
<td>Mar-1996</td>
<td>Clatsop Economic Development Council Fisheries Project, Oregon</td>
</tr>
<tr>
<td>Tillamook Bay</td>
<td>45.4709  -123.8610</td>
<td>29.10.2007</td>
<td>Sarah Miller, Oregon Department of Environmental Quality</td>
</tr>
<tr>
<td>Devils Lake</td>
<td>44.9707  -123.9989</td>
<td>23.08.2003</td>
<td>John W Chapman, Oregon State University</td>
</tr>
<tr>
<td>Yaquina Bay</td>
<td>44.6040  -123.9024</td>
<td>2.06.2008</td>
<td>James T Carlton, Williams College</td>
</tr>
<tr>
<td>Alsea Bay&lt;sup&gt;1&lt;/sup&gt;</td>
<td>44.4288  -124.0443</td>
<td>Oct-2007</td>
<td>John W Chapman, Oregon State University</td>
</tr>
<tr>
<td>Umpqua River</td>
<td>43.7155  -124.0937</td>
<td>6.09.2005</td>
<td>Timothy M Davidson, Portland State University</td>
</tr>
<tr>
<td>Coos Bay</td>
<td>43.3733  -124.0989</td>
<td>24.12.2006</td>
<td>Timothy M Davidson, Portland State University</td>
</tr>
<tr>
<td>Hanson Slough</td>
<td>42.9206  -124.5239</td>
<td>29.06.2006</td>
<td>Erin Minster, South Coast Watershed Council</td>
</tr>
<tr>
<td>Garrison Lake</td>
<td>42.7510  -124.4996</td>
<td>2.07.2002</td>
<td>Alice Pfand, Volunteer for Portland State University</td>
</tr>
<tr>
<td>Rogue River</td>
<td>42.4325  -124.4114</td>
<td>31.08.1999</td>
<td>Larry Caton, Oregon Department of Environmental Quality</td>
</tr>
</tbody>
</table>

<sup>1</sup>Latitude and Longitude are approximations, exact record coordinates are unavailable