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INVASION NOTE

An Atlantic infaunal engineer is established in the Northeast Pacific: *Clymenella torquata* (Polychaeta: Maldanidae) on the British Columbia and Washington Coasts

Megan E. Mach · Colin D. Levings · P. Sean McDonald · Kai M. A. Chan

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Abstract The Northwest Atlantic bamboo worm *Clymenella torquata*, believed to have been imported with commercial oyster culture, was last formally reported from the American Pacific coast more than 30 years ago from a single location. We report here that it is broadly distributed in British Columbia and is now established in Washington. In Samish Bay, Washington, this tubiculous infaunal worm creates a spongy, porous substrate that has proved detrimental to commercial oyster farms by causing the oysters to sink into the sediment and suffocate. Little is known about the ecological or economic impacts of this invasion in the Pacific Northwest.

Keywords *Clymenella torquata* · British Columbia · Washington · Invasive marine polychaete

M. E. Mach (✉) · K. M. A. Chan
Institute for Resources, Environment and Sustainability, Resource Management and Environmental Sustainability, University of British Columbia, 429-2202 Main Mall, Vancouver, BC V6T 1Z4, Canada
e-mail: mach5@interchange.ubc.ca

C. D. Levings
Fisheries and Oceans Canada, Science Branch, West Vancouver Laboratory, 4160 Marine Drive, West Vancouver, BC V7V 1N6, Canada

P. S. McDonald
School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98195, USA

Introduction

The introduction of non-native species may pose a serious economic and ecological impact to coastal ecosystems (Hoagland and Jin 2006; Pimentel et al. 2000). While many marine invertebrate invasions have been documented, the introduction of marine polychaete worms have received less attention compared to other groups (Eno et al. 1997; Ruiz et al. 2000). We document here the expansion in the Northeast Pacific of a well-known North Atlantic polychaete, last formally reported more than three decades ago.

Clymenella torquata Leidy, 1855 (hereafter *Clymenella*, Fig. 1) commonly known as the bamboo worm, a member of the family Maldanidae, is native along the Atlantic and Gulf coasts of North America (Fauchald et al. 2009; Mangum 1964). The bamboo worm is a filter feeding polychaete which constructs a cylindrical tube about 20 cm long perpendicular to the surface (Mangum 1964). In its native range these tubes can be extremely numerous, occurring in densities up to 675/m^2 on intertidal sandy mud flats (Mangum 1964), and on rare occasion in much higher numbers (150,000 m^2; Sanders et al. 1962), creating a "spongy" effect on the sediment (Sanders et al. 1962). Like all bamboo worms, *Clymenella* are aptly named for their truncate ends and long, cylindrical segments giving them a jointed appearance. Within the family, the genus *Clymenella* is distinguished by the deep

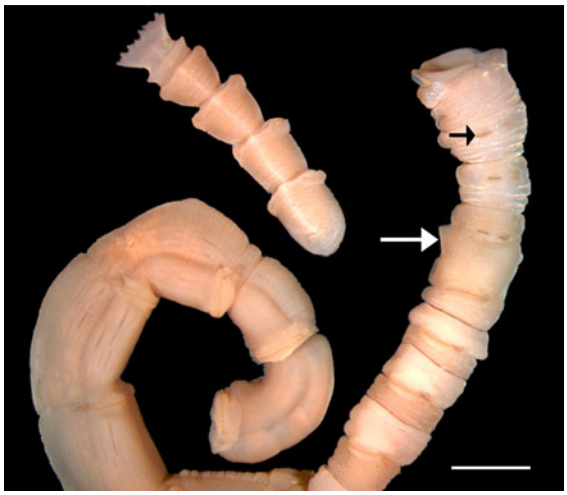

Fig. 1 *Clymenella* from Roberts Bank, BC, collected in 2008. *Clymenella* has a membranous collar on the anterior margin of setiger four which extends over part of setiger three (*white arrow*) and rostrate hooks on setiger one (*black arrow*). *Scale bar* = 2 mm (Photo: T. Goodman)

membranous collar on the anterior margin of setiger (segment) four that extends up over part of setiger three. *Clymenella* differs from its west coast congeners by lacking acicular spines in the anterior neuropodia, and by possessing a total of 18 rather than 21+ setigers (Banse 1981; R. E. Ruff, personal communication).

Non-native populations of *Clymenella* have been previously reported outside North America only in England (Eno et al. 1997; Newell 1949), its introduction a consequence of the American oyster trade between 1870 and 1936 (Eno et al. 1997; Wolff and Reise 2002). Past studies have described the British *Clymenella* as unusually large (maximum length 15 cm) when compared to American populations (11 cm) (Mangum 1964; Pilgrim 1965), however, samples from Massachusetts suggest American *Clymenella* are capable of surpassing this length (19.5 cm) (Rankin 1946).

Clymenella in the Pacific Northwest

Clymenella was last formally recorded on the Northeast Pacific coast in Boundary Bay, British Columbia (Fig. 1) based upon specimens collected in 1980 in eelgrass (*Zostera marina*) beds (Banse 1981). Banse reported densities averaging 416/m^2 and ranging from 16 to 1680/m^2 and suggested the species had been introduced in the 1930s with importations of the Atlantic oyster *Crassostrea virginica* from the North American Atlantic coast. There have been no subsequent reports of *Clymenella* in British Columbia.

In the mid-2000s *Clymenella* was reported in Samish Bay, Washington (Fig. 1), about 75 km south of Boundary Bay (Fig. 1; Eissinger 2008, as "Puget Sound", but sample identified from Samish Bay, A. Eissinger, personal communication, 2011; Hancock et al. 2008; P. Blau of Blau Oyster (Samish Bay), personal communication), but these records have not benefited from formal publication. *Clymenella* is now abundant in Samish Bay (P.A. Dinnel, R.E. Rogers, W. Dooey, and R.E. Ruff, personal communications). Samish Bay mudflats support aquaculture of the non-native Pacific oyster *Crassostrea gigas*. Around 2006, the first populations of *Clymenella* were found on the northeast side of Samish Island on lands leased to Blau Oyster. The worms are reported to have since spread patchily throughout Samish Bay, negatively affecting many farmed tidelands. Oysters in this area are typically grown using "on-bottom" culture methods; thus when *Clymenella* densities are high, the oysters sink into the porous sediment and suffocate (Rogers 2007; P. Dinnel, personal communication). The decline in sediment firmness associated with high worm densities is similar to what has been reported within its native range (unpublished data; Sanders et al. 1962).

Present study

We investigated the expanded range of *Clymenella* north into the Strait of Georgia, British Columbia, and south into Puget Sound, Washington. As part of a baseline study of native and exotic species in seagrass beds, infaunal samples were collected at 9 sites along the British Columbia coast during the summer of 2008 (Fig. 2, black circles and points 3, 4). At each site, 6 sediment cores (10 cm diameter × 17 cm depth) spaced 25 m apart along two 50-meter transects were collected in *Zostera marina* eelgrass beds. Cores were sieved at 1 mm and specimens preserved in 95% ethanol for identification. In Puget Sound, haphazard sampling was done at 9 sites between 2008 and 2011 (open circles and point 2); all Puget Sound sampling targeted preferred habitat of *Clymenella* (i.e., substrate

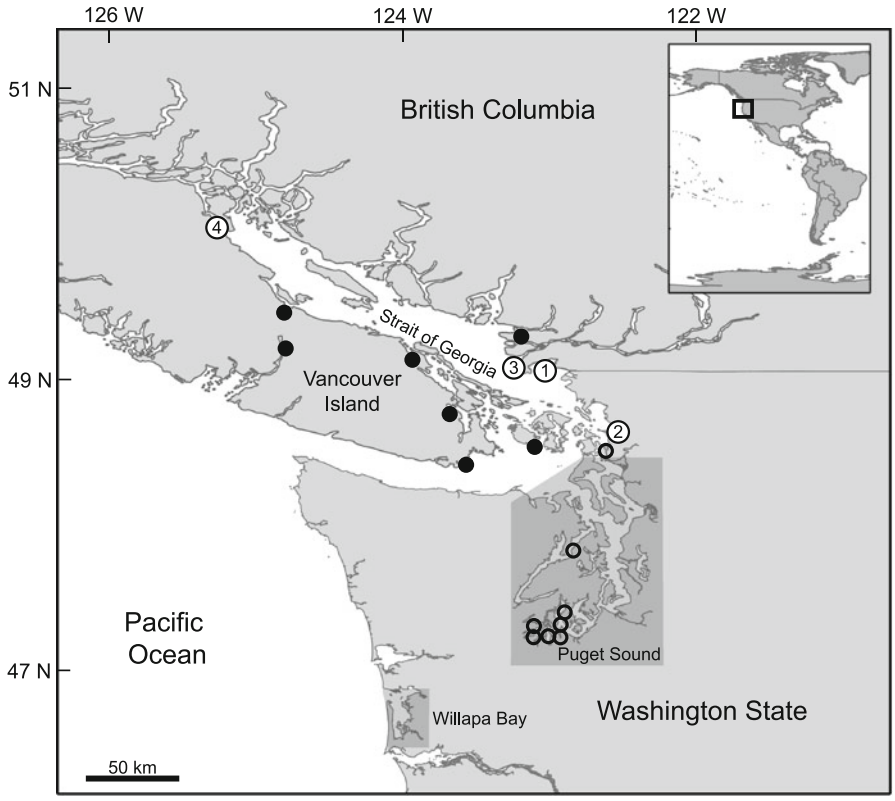

Fig. 2 Known distribution of *Clymenella* in the Northeast Pacific. Site number and year of record: *1* Boundary Bay, BC (1980); *2* Samish Bay, WA (2007); *3* Roberts Bank (2008); *4* Campbell River (2008). *Black circles* and *open circles* are sites where infaunal cores were taken but no *Clymenella* found

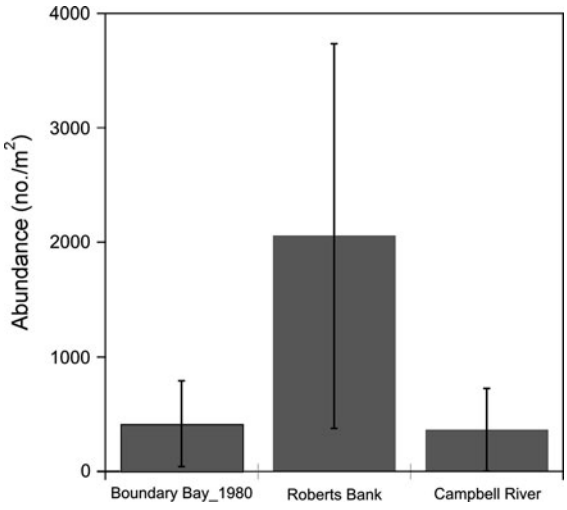

Fig. 3 Abundances (and standard deviations) of *Clymenella* in Boundary Bay in 1980 (Banse 1981) and Roberts Bank and Campbell River in 2008, as estimated through sediment cores

types and tidal elevations; unpublished data) in areas currently or historically used for oyster aquaculture.

We found *Clymenella* at 2 of our 9 sampling sites in British Columbia: Roberts Bank (N 49.018° lat, W 123.119° long) and Campbell River, mid-Vancouver Island (N 50.057° lat, W 125.262° long; Fig. 1). Roberts Bank and Campbell River are 20 and 240 km, respectively, northwest of Boundary Bay, yet *Clymenella* was not found at sampling sites located between these sites. Abundance of *Clymenella* at Campbell River (367/m^2, SD ±367, sampled in 3 of 6 cores) was almost the same as that measured in 1980 in Boundary Bay, while *Clymenella* at Roberts Bank were more than four times as dense (2056/m^2, SD ±1681, sampled in 6 of 6 cores; Fig. 3). Identification of *Clymenella* was confirmed by R. Eugene Ruff (Ruff Systematics, Puyallup, WA) and reference specimens have been deposited in the collections of the University of British Columbia's Beaty Biodiversity Museum and digitized on the Marine Biodiversity of British Columbia LifeDesks webpage (Nelson and Goodman 2010).

No *Clymenella* were found at Puget Sound sampling sites outside of Samish Bay (Site 2, Figure 1), including Padilla Bay (1 site), Thorndyke Bay (1 site), Case Inlet (3 sites), Hartstene Island (1 site), Eld Inlet (1), and Totten Inlet (1 site). As of 2011, *Clymenella*

has not been reported in central or southern Puget Sound (personal observation; M. Dethier, personal communication) nor has the species been found in coastal embayments of Washington State, such as Willapa Bay (personal observation; S. Booth, personal communication).

Dispersal in the Pacific Northwest

Clymenella is believed to have a benthic larval phase (Newell 1951), presumably not amenable to ballast water transport or long distance dispersal in ocean currents. Although first reported in Boundary Bay, where large numbers of Atlantic oysters were transplanted in the 1930s, the site of initial introduction in the Pacific Northwest is not known, nor do we know if there were multiple separate introductions with different oyster importations in Washington and British Columbia. Oyster farmers in the Samish Bay region believe *Clymenella* arrived on the hull of a barge from north of Samish Bay, possibly from Boundary Bay (Paul Blau, personal communication). As *Clymenella* is not a fouling organism, it more likely moved south, if it was not historically present in low numbers in Samish Bay (the species had been overlooked in Boundary Bay for nearly 50 years if it was originally introduced with Atlantic oysters), by other means, such as the movement of oysters and aquaculture equipment. Similar oyster translocations may explain its presence far to the north in Campbell River assuming the population present at this location is not due to an early but long-undetected introduction.

Monitoring and management

In Samish Bay various control strategies for *Clymenella* have been tested (Paul Dinnel, unpublished data); physical methods, including tilling (using rotating blades to break up the sediment and worms) and application of shell pavement, significantly decreased worm biomass and number of worm tubes, while increasing sediment firmness, in experimental plots (Hancock et al. 2008). Oyster farms in Samish Bay are attempting to employ these methods at a local level while adapting their practices to limit further spread of *Clymenella* in the area (Bill Dewey, personal communication). In some cases, growers have discontinued operations where density of *Clymenella* is high (Paul Blau, personal communication). Given the importance of Puget Sound and the Strait of Georgia to oyster aquaculture (PSAT 2003) and the potential for continued and increasing economic costs of *Clymenella*'s impact on oyster farms, it will be critical to monitor populations of *Clymenella* and further explore control methods. Data on habitat selection and modification, reproduction, and species interactions will also be important for predicting the relative impact of this invasion should it spread further south into Puget Sound or increase its range in the Strait of Georgia.

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