Aquatic Invasive Species of the Pacific Northwest

*Didemnum vexillum*

Colonial tunicate; ascidian; sea squirt

Dejah L. Sanchez

Aquatic Invasion Ecology: Julian Olden

Autumn 2014

Figure 1. *Didemnum vexillum* growing on mussels in New Zealand, the originating location as described by P. Kott in 2002. (Photo US Geological Survey).
Classification
Order: Aplousobranchia
Family: Didemnidae
Genus: Didemnum
Species: vexillum

Identification Key

Per the Kott 2002 description, the colony color is yellowish cream with a range of thin to thick shaped colonies. These extensive colonies can be either encrusting or lobed and have spicule-free dark bands between zooid groups. The spicule density is sparse and mostly limited to the surface. Spicule shape stellate, with 9-11 conical rays in the optical transverse section, and can be up to 58 μm (averaging 30 μm per photo). Hypo abdominal lacunae are absent. May be confused with encrusting sponges at times.

Figure 2. Close up view of spicules. Scale bar is 0.1 mm. (Kott 2002).

Figure 3. Encrusting colony seen in Massachusetts. (Photo US Geological Survey).

The zooids are about 1mm overall, the abdomen about twice the size of the contracted thorax. The branchial syphon is short with six small pointed projections around the rim of the aperture. A large spherical clump of crowded spicules from the lateral organ projects from the test each side of the posterior end of the large sessile atrial aperture, which exposes most of the branchial sac directly to the common cloacal cavity. Eight or nine stigmata are in the anterior row of the branchial sac. A short retractor muscle projects from halfway down the moderately long oesophageal neck (about the same length as the thorax). Oesophageal buds are developing. The post pyloric part of the gut loop is long and flexed ventrally forming a double loop. It has the usual divisions and cylindrical
duodenal part, short posterior stomach and long rectum. Nine coils of the vas deferens surround the spherical to oval testis which, with a single egg ovary, lie against the dorsal side of the flexed part of the gut loop, i.e. almost behind it. Both testes and ovary appear to be mature in the examined specimens, but although some embryos are being incubated in the basal test or in the central test (of surface protuberances), only few are well advanced. The larval trunk is 0.6 mm long with the tail wound almost halfway around it (barely to its anterior end). Six long ectodermal ampullae are each side of the three antero-median adhesive organs. A large, yellow yolk mass is beneath the oozooid in less mature larvae.

Although Kott formally described *Didemnum vexillum* in 2002, the taxonomy remains a little muddled still. The presence of colonial tunicates has been observed in numerous locations around the globe since the 1970s, although officially documented on the east coast of the United States in 1988, however due to incomplete descriptions or poorly preserved samples, it is difficult to determine the exact species (Bullard et al. 2007). The species *Didemnum vestum* may be relegated to a junior synonym of *Didemnum vexillum* based on the close morphological and genetic similarities (Lambert 2009). Kott describes the species to be endemic to New Zealand (Kott 2002, 2004), although Lambert disputes saying *Didemnum vexillum* is probably native to Japan with the earliest worldwide record in 1926 from Mutsu Bay, where it is still commonly found (Lambert 2009). The possibility does exist that it might have been introduced to Japan by boat traffic from elsewhere long ago, but is widespread and common in Japan, especially as a fouler of cultured bivalves, net cages, and various other artificial structures, though it can be found on natural benthic surfaces such as the rocky low intertidal of Ise Bay (Lambert 2009). A much larger scale study, involving the collection and DNA sequencing of hundreds of samples from Japan and elsewhere around the world, will be necessary to determine the haplotype variability, enabling a more definite decision about the origin of the species.

**Life History and Reproduction**

Like all sea squirts, *Didemnum vexillum* is a hermaphrodite, meaning it contains male and female reproductive organs. Internally fertilized eggs are brooded and develop into larvae (sometimes called tadpoles because of their small tails) before they are released. Most larvae remain in the water for 2-6 hours before settling on hard structures, but larvae have the potential to survive for up to 36 hours before settling. This sea squirt is also capable of asexual
reproduction, whereby small pieces can break off and re-attach to suitable substrates to form new colonies. It grows extremely rapidly, sometimes covering areas up to hundreds of square meters (Lambert 2009). On suspended mussel lines, floating docks, boat hulls and other structures in quiet waters it quickly forms long fingerlike lobes that break off easily, float away, and are capable of reattachment and growth (Bullard et al. 2007; Coutts and Forrest 2007). These fragments may likely contain brooded larvae capable of being released either during dispersal or after reattachment.

Figure 4. Didemnum vexillum overgrowing scallops in Washington state waters. (Photo US Geological Survey).

**History of invasiveness within the Pacific Northwest**

**Washington**

Although first misidentified, the first verified record in Washington State was October 1998, found attached to the end of a long rope hanging from floating docks in the west central region of Puget Sound at Poulsbo Yacht Club (Lambert 2009). The next record is May 2000, as a common fouler of mussel strings and rafts at Taylor Shellfish Co. in Totten Inlet, in South Puget Sound (Cohen et al. 2001), where it had apparently been present for an indeterminate number of years but was not a new arrival (Lambert 2009). It was documented there again in November 2004. It was found on a sunken wooden boat at an underwater park in Edmonds just north of Seattle in November 2003. Between its discovery and its removal in October 2004 the colony or colonies had increased from ~1 m to ~3.3 m in diameter (Lambert 2009.). A single small colony was found in November 2004 at Des Moines marina just south of Seattle after a thorough search (Bullard et al. 2007). Since then it has become much more abundant and widespread throughout the marina, and has been documented at a number of other sites in Puget Sound (Lambert 2006).
The first documented record in British Columbia is in 2003, heavily fouling mussel cages in Okeover Inlet, Malaspina Peninsula (49°58.8′N, 124°41.4′W). Numerous locations have been documented since then, all at or near oyster farms (Crassostrea gigas, originally imported from Japan) including sightings by recreational divers in subtidal areas where it had not previously been seen, indicating that it is spreading rapidly and in some cases covering many square meters (Bullard et al. 2007). Most of the known localities so far, with photos, are posted on the US Geological Survey website.

Figure 6. Heavily fouled caged in British Columbia. (Photo US Geological Survey).

**Invasion process**

The five vectors with the highest potential for future dispersal of *Didemnum vexillum* are slow-moving vessels, aquaculture, fishing vessels, small vessels, and commercial vessels (Herborg 2009). It is unlikely that *Didemnum vexillum* gained a foothold on the stock until the various aquaculture methods involving complete submersion such as rack and tray and longline became common (Lambert 2009).
In British Columbia a great deal of movement of oyster strings continues, especially from Pendrell Sound, the center for oyster spawning in B.C., to numerous grow-out areas in the province. Movement of cultured oyster and mussel lines is also common in Washington State. *Didemnum vexillum* has been a common fouler of these cultured bivalves in southern Puget Sound for many years, and movement of mussel strings from southern Puget Sound to grow-out at the north end of Hood Canal may be the reason *Didemnum vexillum* fouls mussels and gear at the Hood Canal location (Lambert 2009).

**Management strategies and control methods**

There are a few different removal methods that have been experimented with. Encapsulating or wrapping in plastic (Forrest & Hopkins 2013) has proven effective in instances with moorings or other structures (Pannell and Coutts 2007), but is not conducive in treating shellfish racks or seawalls. Eco-friendly bio-controls have been tested using acetic acid, hydrated lime, and sodium hypochlorite (Piola, Dunmore, and Forrest 2009). Single-spray treatments of 5% acetic acid (Fig. 7 & 8) reduced cover of the species by up to 100% depending on the exposure duration, while repeat-spraying ensured that even short exposure times (1 min) achieved ~99% mortality (Piola, Dunmore, and Forrest 2009). This method is applicable for many different substrates. In attempts to reduce aquaculture practices as a potential vector, sodium hypochlorite was found to cause 100% mortality of *Didemnum vexillum* fouling on mussel seed-stock following 20-second immersions in 5000 g m⁻³ sodium hypochlorite solution (Denny 2008). Economically, aquaculture within the shellfish industry takes a hit if this species establishes but the ecological impacts within the ecosystem can also see negative effects.

![Figure 7. Mean change in the percentage cover (±1SE, n = 3) recorded for *D. vexillum* colonies treated with single- and repeat-sprays of (a, b) seawater (Control); and (c, d) 5% acetic acid, over exposure periods of 1, 10 and 30 min.](image-url)
Figure 8. A series of photographs showing *D. vexillum* plates sprayed with seawater (control: a–c), and 5% acetic acid single (d–f) and repeat spray (g–i) treatments, with an exposure period of 1 min. The photographs are sequential and show individual colonies: pre-spray at Day 0 (top row); at Day 7 (middle row); and at Day 14 (bottom row). Note partial mortality of *Didemnum* on 5% treatments on day 7, with recovery (single spray) and complete eradication (repeat spray) on Day 14 (Piola, Dunmore, and Forrest 2009).
Literature Cited


Other Key Sources

A Snail’s Odyssey: A journey through the research done on west coast marine invertebrates: http://www.asnailsodyssey.com/LEARNABOUT/TUNICATE/tunInva.php


**Regional Contacts**

Washington Sea Grant Kitsap County

Jeff Adams

Marine Water Quality Specialist

345 Sixth St., Suite 550
Bremerton, WA 98337-1874

Phone 360.337.4619; FAX 360.337.4864
jaws@u.washington.edu

Washington Department of Fish and Wildlife

Larry LeClair

[Larry.leclair@dfw.wa.gov](mailto:Larry.leclair@dfw.wa.gov)

360-902-2767