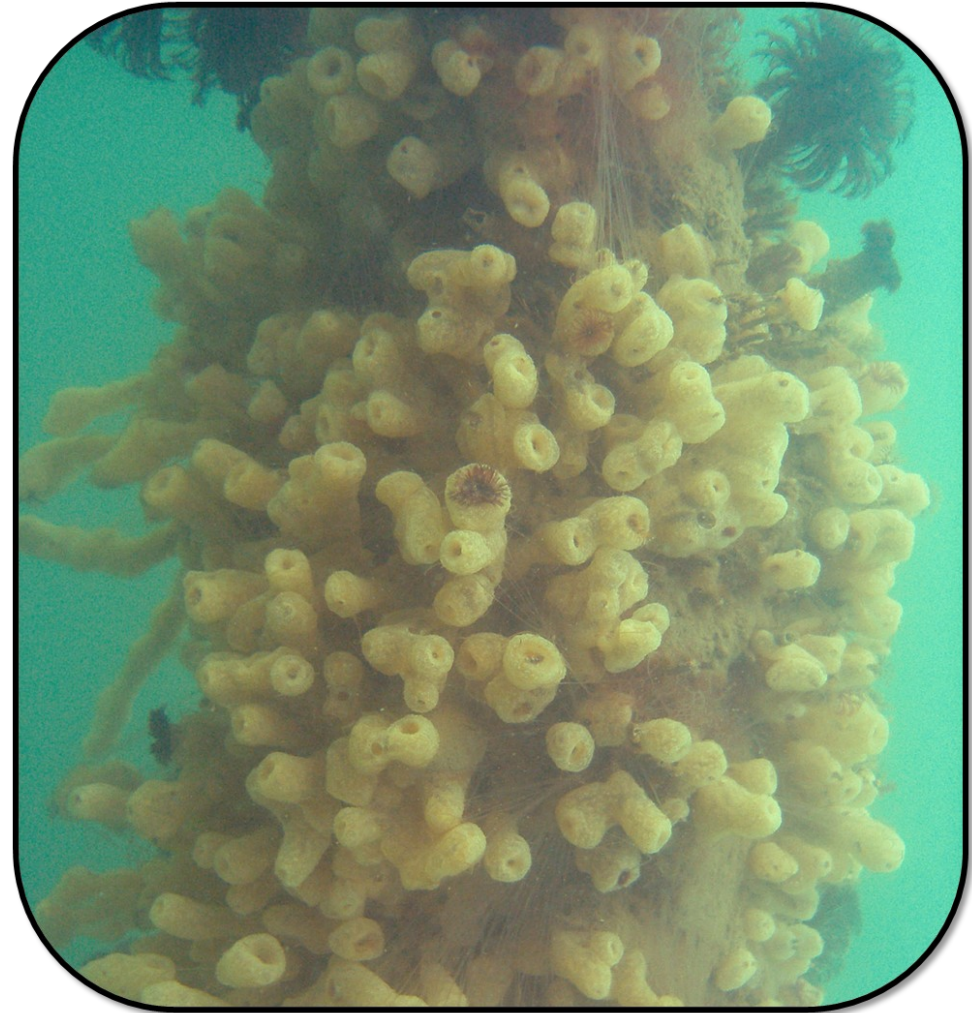




Diver Hillaire Bojonell collecting *D.vex* underwater (Aaron Macomber, USFS)

Invasive Tunicates in the Pacific Northwest



**Think you've found an invasive tunicate?
Contact the Oregon Invasive Species Council at
online at OregonInvasivesHotline.org or Oregon
Department of Agriculture at [1-866-INVADER](tel:1-866-INVADER)**

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Developed by Lorne Curran. Introduction by Samuel Chan. Layout by Jennifer Lam.
Contacts: Lorne Curran at lornecurran@gmail.com, or Samuel Chan at samuel.chan@oregonstate.edu.

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Yaquina Bay in Newport, Oregon (David Gamboa)

Purpose of the Guide

This guide is intended to enhance the early detection and rapid response (EDRR) of invasive tunicates by providing basic identification of nine of the most invasive tunicates posing a threat to the marine infrastructure, ecology, and economy of the Pacific Northwest coast. Sections on identification, similar species (those that may look similar, including natives), and ecology describe each of the nine invasive tunicates, and current distribution maps indicate areas where they've been found.

Colonial tunicates may exhibit a wide variety of morphological variants, including vast differences in coloration. For example, the colonial tunicate *Didemnum vexillum* forms long, ropey or beard-like colonies that commonly hang from hard substrates such as docks, lines, and ship hulls where water current moves slowly. Where the current is faster, the tunicate forms low, undulating mats with short appendages that encrust and drape rocky seabeds of pebbles, cobbles, boulders, and rock outcrops (Valentine 2012).

If you suspect you've found an invasive tunicate, take good-quality photos at both close and wider scales, record its location, and report it to the invasive species hotline or website (see back page), so experts can work with you on identification (which may include gathering samples for microscopic and genetic analysis) and rapid response.

Considerable resources have been invested in surveying, monitoring, and managing *Didemnum vexillum* since its discovery in estuaries of California, Washington, and British Columbia in 2004 and in Oregon and Alaska in 2010. Managing and eradicating infestations of invasive tunicates after they are established is extremely costly and has resulted in very limited success.

Cover photo: *D. vexillum* overgrowing N Feather Duster Worm on mooring line, Winchester Bay, Oregon (Lorne Curran)

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Here's what you can do if you are an outdoor recreationist (boater, angler, gardener, hiker, hunter) or you work near waterways:

Boaters and Anglers

Aquatic invasive species can very easily spread between waterways by hitching a ride on boats and trailers. Some species can even cause expensive damage to your boat. Protect Oregon's waterways and never launch a dirty boat!

- Inspect hard-to-reach spots, damp areas, and other protected places on your boat. Harmful species can survive in such places for days. Feel for small bumps, which could be attached organisms. Remove any plants and animals you find before leaving the water.
- Clean your boat and equipment with high-pressure hot water, or allow equipment and your boat to dry in sunny conditions for at least five days before entering new waters. For more information about clean boating activities, visit anstackforce.gov/campaigns.php or contact the Oregon State Marine Board at 503-378-8587.
- Drain and empty water entirely from the motor, wet well, and bilge on land, before leaving the water body.
- Remove any plants, dirt, and water from your gear and clothing.
- Dispose of bait properly. Empty your bait bucket on land in a trash container before leaving the water body. Never release live bait into the water or release aquatic animals from one water body to another.

Gardeners, Hikers, and Watershed Stewards

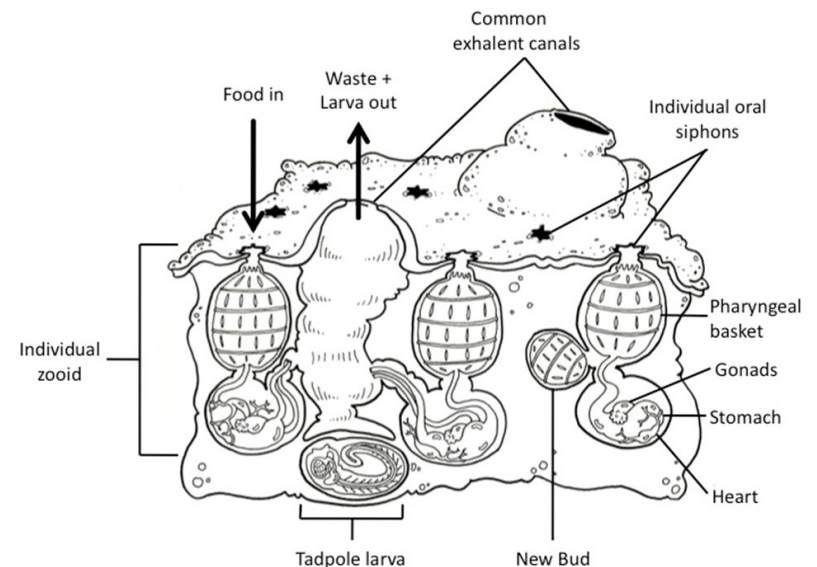
- Learn about the prominent aquatic invasive species. Do not buy or share aquatic invasives.
- Inspect and clean your equipment, tools, and clothing of seeds, soil, and plant fragments before entering and after leaving natural areas and waterways.
- Do not dump pond plants or animals into natural areas.
- Inspect, decontaminate, rinse, and remove "hitchhiking" invasive plants and animals from purchased aquatic plants before setting them in your garden.
- Remove and properly dispose of aquatic invasive plants by drying them, away from natural areas. When possible, place them in a plastic bag for disposal in the trash.

Pets and Aquariums

- Don't dump your pets. If you have a pet that you can no longer care for, contact your local pet store, humane society, veterinarian, or other expert, for guidance on appropriate and humane options.
- Don't dump your aquarium water into natural habitats. Seal aquarium plants in plastic bags and place them in the trash.
- Make responsible pet and aquarium purchases. Check to see whether they are listed as invasive species by local agencies. Many pets may live longer, grow bigger, and take more care than you realize. Before choosing a pet, do some research and be sure you're ready to care for it long-term.

Prevention, early detection, and rapid response are the most cost-effective approaches to preventing the spread of invasive tunicates and associated invasive species. Knowledge of invasive tunicates led volunteer divers to the discovery and, ultimately, the decontamination of barge hulls heavily infested with nonindigenous species (including some of the invasive tunicates described in this guide). These barges were to be used in the construction of the new NOAA Pacific Fleet Operations docks in Newport, Oregon; thus decontamination helped minimize the risk of a potentially costly infestation.

Since 1970, a new invading tunicate species has been reported about every five to six years in Atlantic or Gulf waters and every three to four years on the Pacific Coast (National Exotic Marine and Estuarine Species Information System [NEMESIS]). This guide will be updated as new species of concern emerge. It is intended for initial identification and reporting for verification by experts.



Cutaway view of tunicate (Amanda Slade)

Why Should We Be Concerned about Invasive Tunicates?

The nonindigenous tunicates listed in this guide are invasive on the west coast of North America. They spread rapidly and are easily transported by boating gear and aquaculture. They foul surfaces of boats, fishing nets, water intakes, docks, and buoys, making them costly to control, and their ability to smother shellfish beds and sensitive marine environments is a significant threat to other marine life. The fouling potential from tunicate invasions can be severe, given tunicates' ability to reproduce asexually by budding, or breaking off as fragments, and through sexual reproduction where tadpoles emerge and attach themselves to surfaces to form new colonies. Under cooler and shaded conditions, the majority of tunicates can survive for 48 hours out of water. Their ability to survive this long out of water indicates that they may be transported inadvertently by normal boating activities (Darbyson et al. 2009).

Tunicates colonize primarily hard surfaces, as epibionts (organisms that live on the surface of other organisms), and increasingly on human-made infrastructure such as docks, pilings, jetties, aquaculture facilities, nets, lines, boats, and water intakes. Though individual tunicates (zooids) are small, they are efficient suspension filter-feeders of plankton, bacteria, and other fine particulate organic materials, often filtering hundreds of liters of seawater per day through their gill sacs. Unlike bivalves (mussels and clams), tunicates efficiently capture the suspended food on the mucous layer lining the branchial basket. Since tunicates are often epibenthic (growing over other organisms), they may have an additional competitive advantage over the aquaculture bivalves they foul.

Not all nonindigenous tunicates become invasive. Environmental factors such as water conditions, substrate, food web dynamics, climate, radiation, benthic diversity, and pressure from human introductions via maritime activities can contribute to the spread, establishment, and growth of an infestation. Until we gain a better understanding of these interactions, prevention and EDRR will continue the principal management emphasis.

Controlling Invasive Species: Let's Work Together



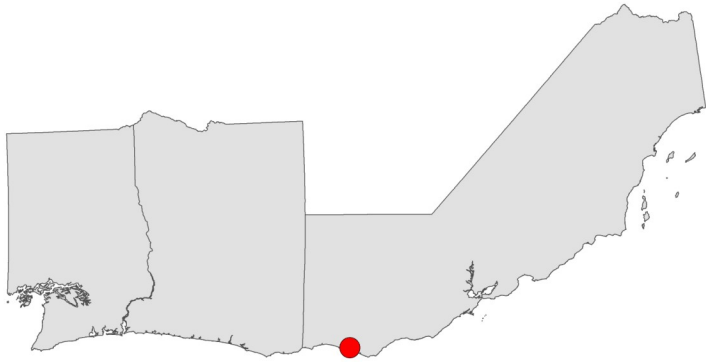
The Triangle at Winchester Bay, Oregon (Sam Chan)

The Pacific Northwest is renowned for its natural environment. Diverse plant and animal communities thrive in our ecosystems. Unfortunately, these natural communities and systems are increasingly threatened by aquatic invasive species, a form of biological water pollution. Harmful nonnative plants and animals are moving into our coasts, waterways, and wetlands, degrading habitats, displacing desirable species, damaging infrastructure, contaminating water resources, and necessitating expensive control treatments.

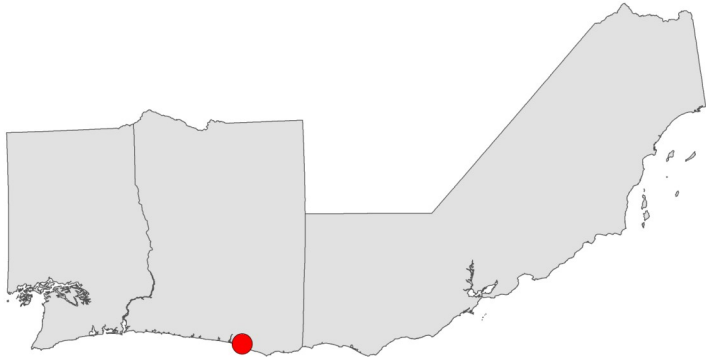
Once established, invasive species spread relentlessly, each generation taking over more territory. Unlike other forms of water pollution such as oil spills, however, invasive species don't dissipate with time and they will permanently alter the environment. Awareness and early detection help us contain these threats and keep them from spreading and causing further damage to the environment and our quality of life.

This guide is an introduction to some of the more prominent and harmful tunicates in our region. It is not too late to stop the spread and establishment of these species. You can make a difference in your community and watershed by

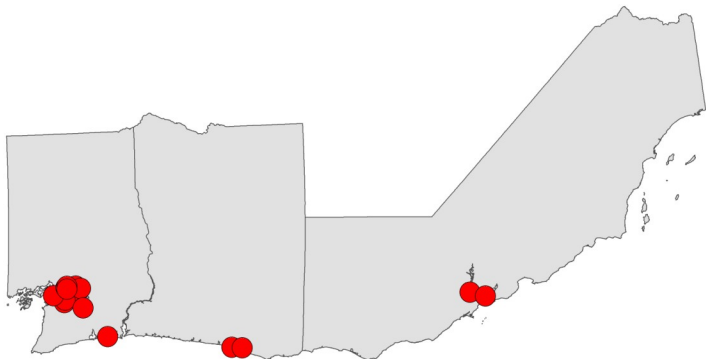
- staying informed and “connected.” Learn about the species listed in this guide. Visit OregonInvasivesHotline.org, oregoninvasivespecies.com or anstaskforce.gov/campaigns.php for more information on invasive species and access to other resources available on the Web. Contact experts listed on the back of this publication.
- detecting and reporting these invasive species. Be vigilant, and report sightings by calling **1-866-INVADER** or going to **OregonInvasivesHotline.org**.



a colonial tunicate
Perophora japonica



a colonial tunicate
Diplosoma listerianum



Golden star tunicate
Botryllus schlosseri

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Social Ascidian

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Current Invasion Maps 26–28



Tunicate colonies of *Didemnum vexillum* encrusting mussel cages. Okeover Inlet, Malaspina Peninsula, BC (Gordon King, Taylor Shellfish Farms, Inc.)

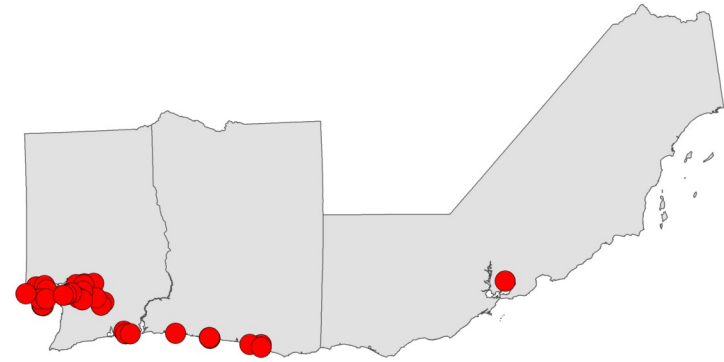
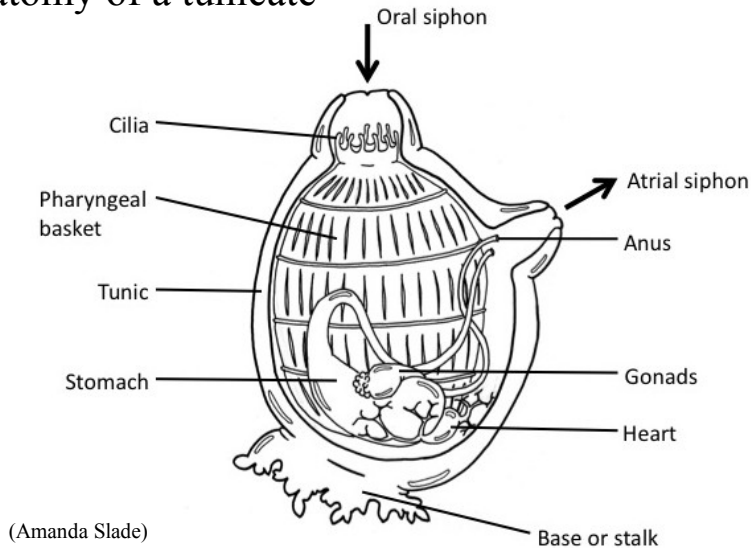
The Solitary Tunicates

Scientific name	PNW sites found	Regional organizations tracking
<i>Styela clava</i>	Coos Bay, 3+ sites WA	OISC/ODFW, WDFW (priority), REEF
<i>Ciona savignyi</i>	19+ sites WA	OISC/ODFW, WDFW (priority), REEF
<i>Ciona intestinalis</i>	3+ sites WA	WDFW (secondary)
<i>Molgula manhattensis</i>	Coos Bay, 6+ sites WA, 2010 occurrence in Yaquina Bay, OR, but not established	WDFW (secondary)

(OISC = Oregon Invasive Species Council; ODFW = Oregon Department of Fish and Wildlife; REEF = Reef Environmental Education Foundation; WDFW = Washington Department of Fish and Wildlife)

We begin with the solitary tunicates, which anchor to the substrate at their base or tether themselves with a stalk. They have an outer skin, called a tunic, and two apertures—most often at the end of tube-shaped siphons—at the distal, or free end, of the body. Beating cilia move water through the oral siphon and into the pharyngeal basket, filtering out oxygen and feeding on plankton and other suspended organics, then pump the water as waste out through the atrial siphon. The siphons retract when the animal is disturbed. Though we call them “solitary” tunicates, by virtue of each discrete body being an individual organism, they can form dense aggregations that aggressively compete with many other organisms. We consider *Styela clava* and *Ciona savignyi* particularly threatening to our local ecosystems.

Anatomy of a tunicate



Orange tunicate
Botrylloides violaceus



a colonial tunicate
Didemnum vexillum

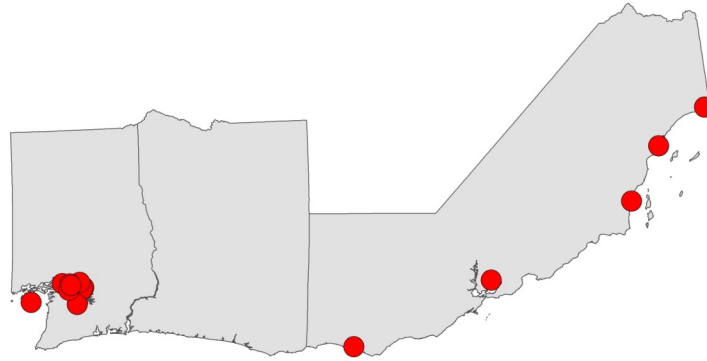


Common sea grape
Molgula manhattensis

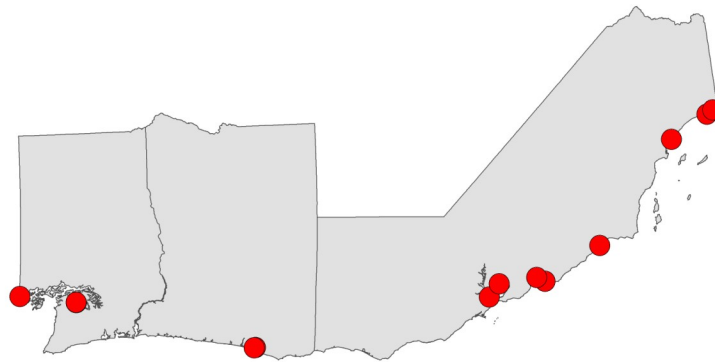
Current Invasion Maps



Sea vase
Ciona intestinalis



Pacific transparent sea squirt
Ciona savignyi



Club tunicate
Styela clava

The Solitary Tunicates



Ciona savignyi (California Academy of Sciences: SFBay:2K)



Ciona intestinalis (Keith Hiscock)



Styela clava overgrown (Lorne Curran)



Molgula manhattensis (Lorne Curran)

Styela clava

Solitary Tunicate

Identification

1. Tunic shows conspicuous bumps (think warty), often wrinkled swellings at the siphon end of body, and irregular longitudinal ridges on the bottom portion. **2.** Commonly called Club Tunicate, *S. clava* may gradually taper but more often makes an abrupt transition to the stalk, which comprises up to one half of its body length. **3.** Siphons are smooth, with alternating dark and light bands around the edges.

Its tough, leathery tunic may be yellowish-gray to reddish-brown. Besides the signature tubercles (think warts again), *Styela* will exhibit fine, longitudinal ridges. *Styela* is often covered with other organisms, such as sponges, hydroids, bryozoans, and other tunicates. Siphons project with a slight curve at the distal end of the body. Young specimens, 1–3 cm, have no stalk; the base of the cylindrical body attaches directly to the substrate.

Ecology

Styela will attach to rock, wood, and shells but prefers artificial structures in protected waters such as pilings, floats, docks, mooring lines, aquaculture gear, and boat hulls. It occurs in the low intertidal to shallow subtidal, rarely to 25 m depth. On our coast, it has been collected in water temperatures of 11–27°C and salinities of 22–36. Adults die in salinities of less than 10. It arrived here from Japan via Europe. It is eaten in Korea.

Similar Species

Four natives, two exotics. Only the native *Styela montereyensis* presents any real confusion with adult *S. clava*. *S. montereyensis* most often occurs on rocky outer shores and other environments with strong water flow. Resembling *S. clava* in that it attaches to the substrate by a stalk, it grows longer and more slender, merging gradually with its stalk. The oral siphon has a more pronounced curve than *S. clava*'s. Regular and coarse ridges and furrows run along the tunic's length. Small specimens of *S. montereyensis* may be found in protected waters and may be difficult to distinguish from *S. clava*. Approach slowly to avoid startling the animal, and observe the curve of the siphon.

S. gibbsii reaches a length of 4 cm and attaches to the substrate without a stalk and is also primarily found on outer rocky shores. It has a uniform trunk width and no banding around siphons. *Boltenia villosa* also attaches with a stalk and has bands alternating around the siphons, but it has hairs and is shaped like a heart. *S. truncata* can be common on floats and protected coastal rocks, but the orange to brown body is squat and oval, usually less than 3 cm high.

Exotic *S. plicata* grows to 9 cm and is ovoid and stalkless, with a whitish to light-brown tunic covered in lumps. *S. canopus* runs to 3 cm long and is ovoid to glandular, stalkless, smooth-skinned, and reddish-brown. To date, investigators have found these two invasives only in southern California.

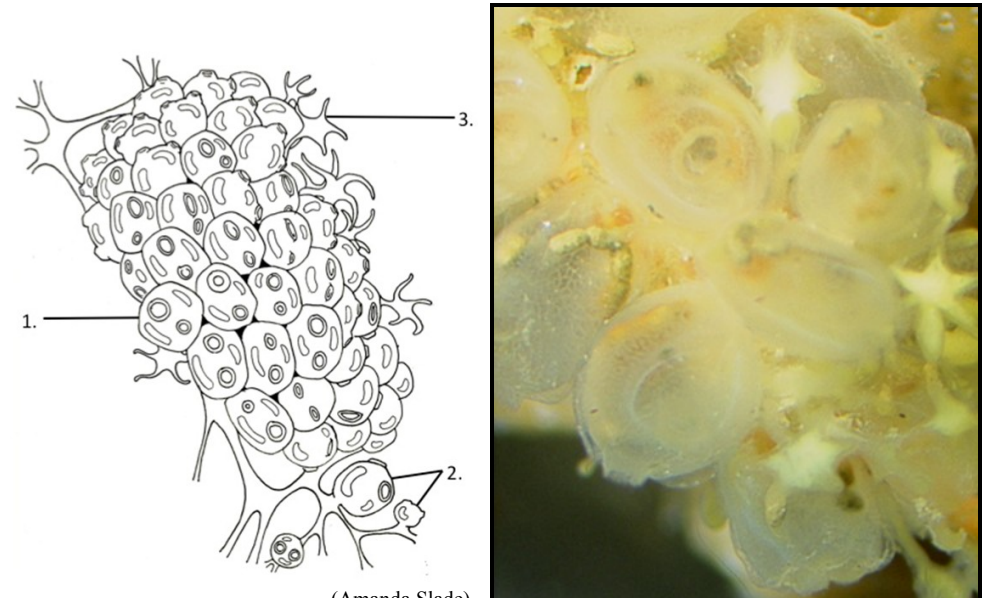
Diplosoma listerianum

Colonial Tunicate



(Dann Blackwood)

Perophora japonica



(Amanda Slade)

(Dorothea Sommerfeldt/Marine Biological Association of the United Kingdom)

Diplosoma listerianum

Colonial Tunicate

Identification

D. listerianum grows in thin, flat, soft, gelatinous sheets up to 20 cm across. It has a milky, translucent appearance, often with granules of bluish-white or yellow pigment. Brown spots appearing on it are fecal matter. Zooids are colorless and grouped around large, exhalant openings.

Ecology

It grows on seaweed, eelgrass, and most hard substrates, including docks. It thrives in mostly shallow water, to 80 m.

Similar Species

Other *Diplosoma* are not yet known on the Pacific coast. Its appearance is similar to that of fish and invertebrate eggs. *D. vex* grows more thickly and with mostly solid coloration.

A Social Ascidian

The tunicates covered by this guide are members of the class Ascidiacea. They may be more precisely called sessile tunicates, ascidians, or sea squirts. Social ascidians fall between the solitary and colonial ascidians in appearance and form. Like the solitaries, individuals grow in aggregation, each ensconced in its own tunic and with projecting incurrent and excurrent siphons. More like the colonials, socials bud from and are interconnected with stolons, or a thin, vascularized sheet of tunic, at their bases.

Perophora japonica

Identification

1. *P. japonica*'s 4–6 mm translucent zooids bud from stolons, densely packed. 2. The zooids attach to the stolon by a broad part of the tunic. 3. Stolons may have bright yellow terminal buds, angular in form, even star-shaped.

Colonies range from yellow in the younger parts to greenish-yellow. Documenting the terminal buds is key to confirming identification.

Ecology

P. japonica overgrows macro-algae; other benthic organisms such as tunicates, sponge, and oysters; and human-made structures. The only North American record thus far comes from Humboldt Bay, California, in 2003. It is native to Japan and Korea.

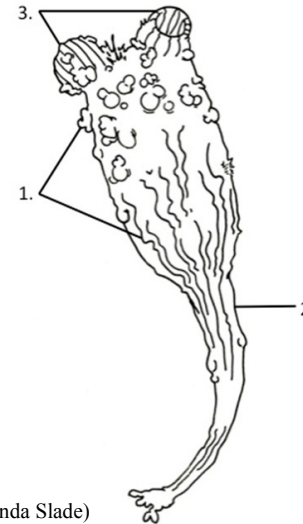
Similar Species

The Pacific coast native *Perophora annectens* lacks terminal buds. Its zooids run 2.5–3.5 mm in length and attach to the stolon by a narrow stalk.

Styela clava

Solitary Tunicate

Size: Adults 5–15 cm long, max 20 cm.



(Amanda Slade)



Styela clava

(all photos this page by Janna Nichols)



Styela montereyensis



Left: *Styela gibbsii*



Right: *Boltenia villosa*

Ciona savignyi

Solitary Tunicate

Identification

1. *Ciona* is tube-shaped, with two siphons of unequal length that are slightly scalloped at the openings. 2. It has yellow or white flecks on the body wall. 3. There is no red spot at the end of the sperm duct.

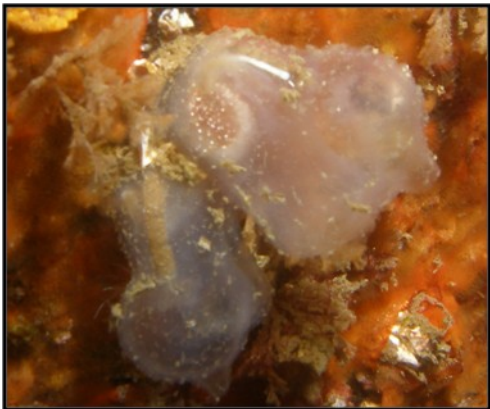
Ciona's tunic is smooth, thin, and easily damaged. Its color may be white or yellowish-green, but the tunic can be so translucent that internal organs can be seen. Its siphons are well separated at the distal end of the body. It has light, longitudinal lines of pigment at the siphon openings, often with orange dots on the rim.

Ecology

It is usually found in depths 12 to 25 m, but it can also grow under docks and on pilings and boat hulls. It can survive in water temperatures of 11 to 27°C. It is tolerant of salinities 22 to 36 and may be found in estuaries. It is native to Japan.

Similar Species

See in particular *Ciona intestinalis*. Several native tunicates have translucent bodies. Almost completely transparent, *Corella willmeriana* grows to only 7.5 cm with stubby siphons, the atrial siphon pointing to one side. It typically grows at subtidal depths of up to 75 m. *Corella inflata*, native to Washington but an introduced species in Oregon, has a still-more cubic shape and a maximum height of 5 cm. Apertures may appear to be emanating directly from the body if the short siphons are retracted. Common on floats and under docks, it likely will be found to only 20 m. *Ascidia paratropa*'s tunic bears numerous fleshy protuberances.



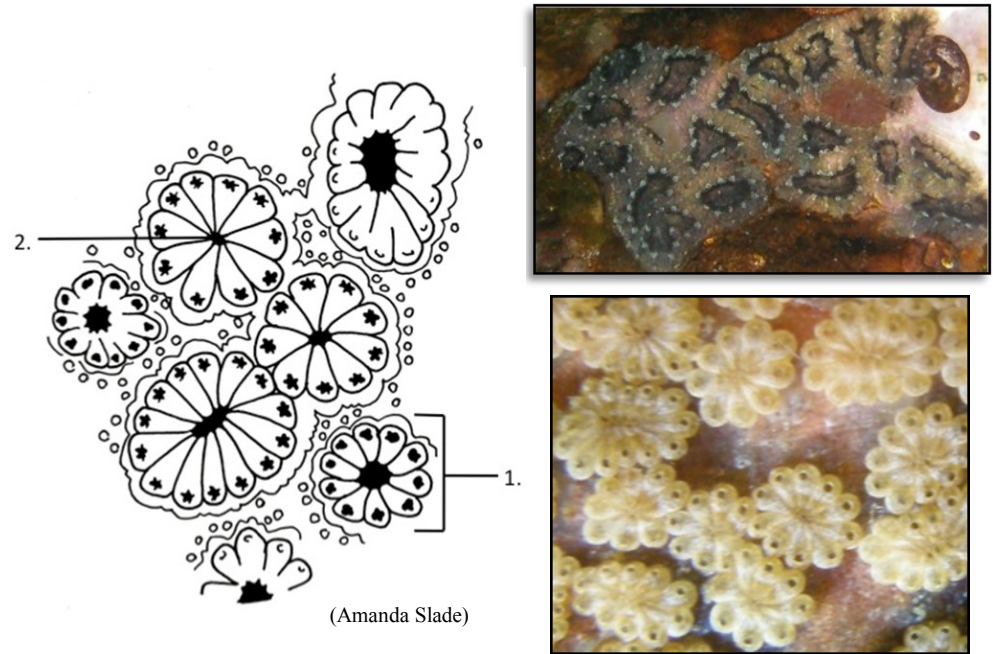
Corella inflata (Lorne Curran)



Corella willmeriana (Janna Nichols)

Botryllus schlosseri

Colonial Tunicate



(Amanda Slade)



(all photos on this page by Lorne Curran)

The Triangle at Winchester Bay, Oregon

Botryllus schlosseri

Colonial Tunicate

Identification

1. Individual zooids are organized into flower-shaped clusters (commonly called Golden Star Tunicate). 2. The narrow ends of the teardrop-shaped zooids point to the excurrent opening at the center of the cluster.

Colonies begin as soft, flat patches and may mature into loose rolls and lobes when overgrowing seaweed. They encrust substrates in sheets 3–4 mm thick and at least 10 cm wide. They can be orange, yellow, red, white, gray-green, purple, dark gray, black, or some combination of these colors, although all zooids of a colony are the same color.

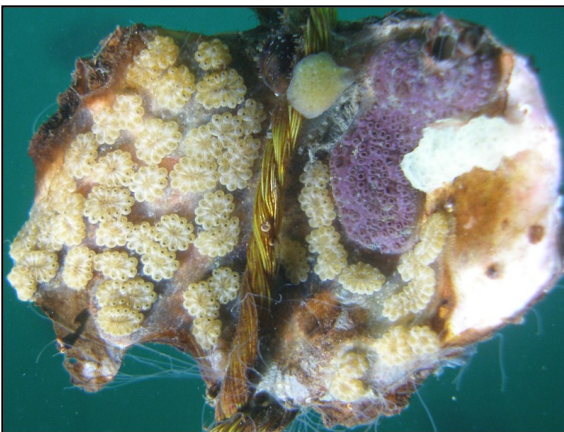
Ecology

B. schlosseri can be found on docks, piers, boat hulls, ropes, aquaculture gear, rocks, gravel sea floor, and shells; and on seaweed, eelgrass, solitary tunicates, and mussels. It is subtidal to 200 m and survive in temperatures of 3+°C and salinity of 16 to 44. It is possibly an East Coast native, or it may have been introduced there from Europe.

Similar Species

Botrylloides systems grow in elongated shapes, most commonly in meandering double rows. Sometimes the matrix between *Botrylloides* systems has an oval appearance reminiscent of *Botryllus* clusters, but in *Botryllus* the zooids clearly point toward the center. Young systems of *Botrylloides* at the edge of a colony may begin in an oval pattern, with the teardrop shape of the young zooid still evident. At times, the ends of blood vessels show up as pigmented blobs in the oval spaces of *Botrylloides* specimens, further indicating that the oval is matrix and not cluster.

The rarely seen *B. tuberatus* has 1 mm zooids, versus *B. schlosseri*'s 2 mm zooids; and waste exits through a spout-like excurrent opening rather than a simple large hole, as with *B. schlosseri*.

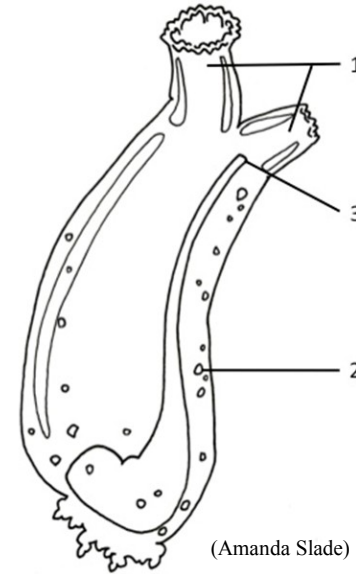


Botryllus schlosseri on oyster (Lorne Curran)

Ciona savignyi

Solitary Tunicate

Size: 6–8 cm, but can grow up to 15 cm.



(Amanda Slade)



(Janna Nichols)



(California Academy of Sciences: SFBay:2K)

Ciona intestinalis

Solitary Tunicate

Identification

1. Sexually mature specimens have a red spot at the end of the sperm duct, visible through the tunic or atrial siphon. 2. Two siphons *may* bear bright-yellow margins with small, red to orange spots, the longer oral siphon having eight lobes and the shorter atrial six. 3. Siphons are close together, in comparison to *C. savignyi*.

In shape and color it is strikingly similar to *C. savignyi*; however, its differences make positive identification possible in the field. Its body is translucent to nearly transparent, greenish to yellow, with or without orange bars. Five longitudinal muscle bands are visible along the length of the tunic.

Ecology

Like *C. savignyi*, it grows on bedrock and boulders but also fouls artificial substrates such as pilings, floats, and ship hulls and over other organisms. It prefers low wave exposure and some water flow. It is common in both marine and brackish water, at the low tide line to 550 m. It is native to the North Atlantic.

Similar Species

As with *C. savignyi* it has ghostly white, elongated cylinders; squid eggs can be mistaken for the *Cionas*, but are tightly clustered with no siphons.



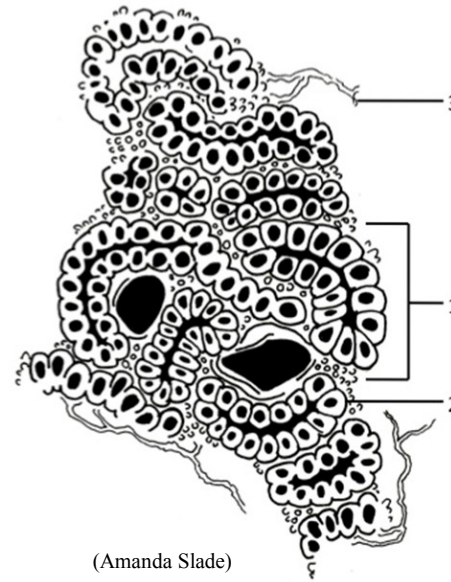
Ascidia paratropa has that cactus look
(Janna Nichols)



Squid eggs are tightly clustered, no siphons (Janna Nichols)

Botrylloides violaceus

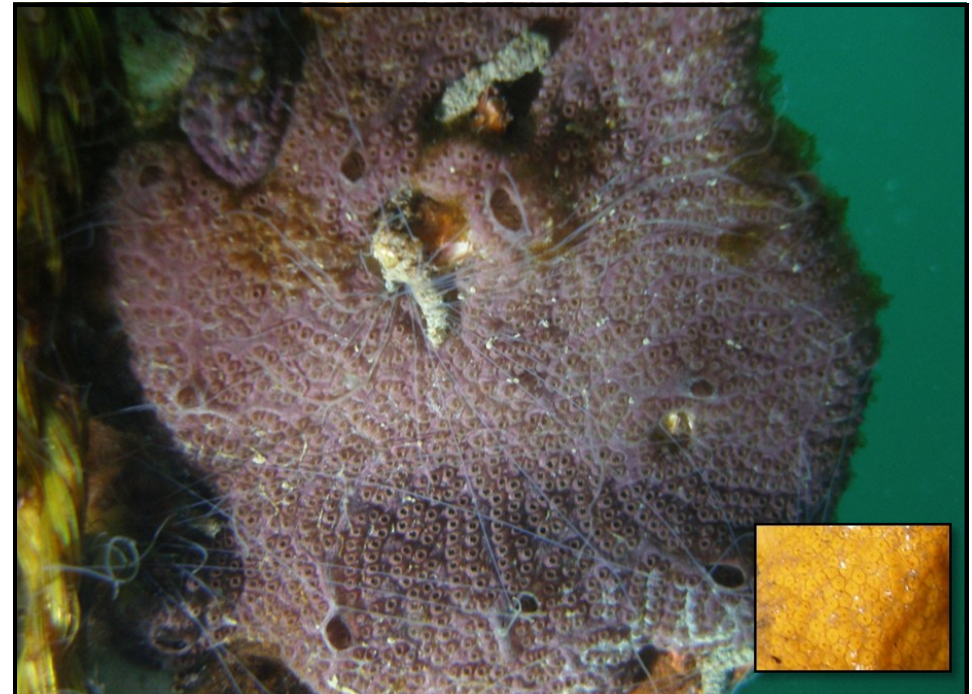
Colonial Tunicate



(Amanda Slade)



(all photos on this page by Lorne Curran)



Botrylloides violaceus

Colonial Tunicate

Identification

1. Colonies consist of zooids 1–2 mm long, arranged in elongated clusters (called “systems”) within a clear, firm matrix. 2. In mature systems, zooids appear rounded and well-defined. 3. Stringy, white bodies at the edges of the colonies may be apparent; they serve as part of the botryllid’s vascular system.

Commonly called Chain Tunicate, these systems take the shape of long ovals, meandering double rows, or chains, discharging their wastes through shared spaces and out the larger excurrent openings. They form flat sheets on hard substrates up to a third of a meter in diameter. They can develop into lobate forms. All the zooids of a colony are the same color, usually orange, yellow, red, purple (also called Violet Tunicate), or tan, and occasionally brown or lavender. Networks of blood vessels running through the matrix have numerous dead ends, visible as small pigmented blobs the same color as the zooids showing up in the clear matrix. In older colonies, the matrix may be dark.

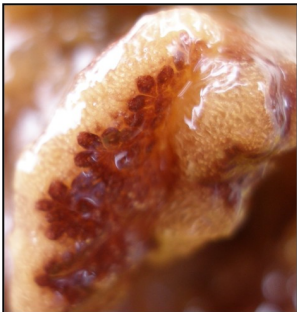
Ecology

Botrylloides grow on docks, boat hulls, buoys, ropes, pilings, the undersides of rocks, eelgrass, seaweeds, aquaculture gear, and shellfish. They occur in the intertidal to 50 m and can be on structures several feet in the air at low tide. They can survive in temperatures ranging from 8 to 25°C and salinity of 26 to 34, but can still flourish in an estuary’s variable salinity. Originally from Japan.

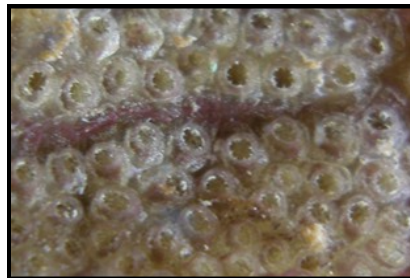
Similar Species

In contrast to *D. vex*’s small, randomly located zooids and dark channels, *B. violaceus* has well-defined zooids organized in linear fashion, often forming circles or half-loops, and the matrix between zooid systems does not connect zooids to any excurrent openings.

In *B. diegensis*, reported as far north as San Francisco Bay, each zooid has two colors with a white, yellow, orange, or greenish ring around the oral aperture, contrasting with the zooids’ overall darker color. Farther south, *B. perspicum* has a thicker matrix, with ridges that separate the systems of zooids.



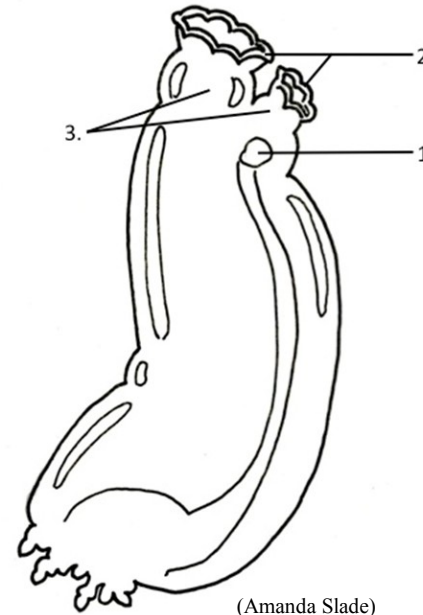
Botrylloides violaceus
(Lorne Curran)



Ciona intestinalis

Solitary Tunicate

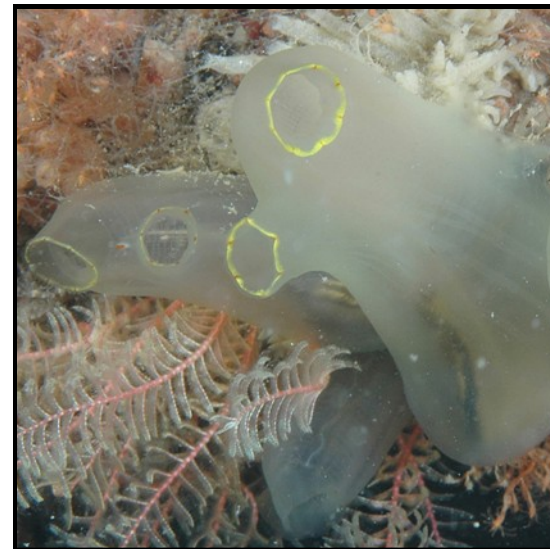
Size: 6–8 cm, but can grow up to 15 cm.



(Amanda Slade)



(Keith Hiscock)



C. intestinalis has siphons with yellow margins versus *C. savignyi*’s yellow speckles (Keith Hiscock)

Molgula manhattensis

Solitary Tunicate

Identification

1. *Molgula* is more or less spherical (common name: Sea Grapes). 2. Its body is covered in fibrils that collect debris, giving the tunic a muddy look. 3. It has distinct siphons, even when retracted.

Molgula's tunic is soft but tough, yellow-gray to gray-green, even translucent in clean specimens. It is stemless; it has a broad-based attachment to substrate.

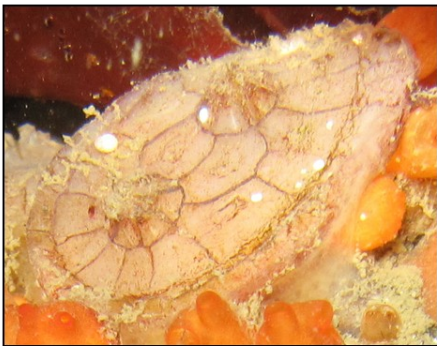
Ecology

Molgula thrives on softer substrates than other invasives and can be found attached to bedrock, boulders, shells, seaweeds, and sandy or soft bottoms. It can be found in the low intertidal, to 90 m. It is tolerant of a wide range of temperature, salinity, and pollution. It is native to the northeastern Atlantic and the Gulf of Mexico.

Similar Species

Several tunicates have a globular body form. *Corella inflata*, already discussed in comparison to the *Cionas*, can be common on floats and under docks, but its lesser siphons and enlarged atrial chamber give it an altogether different look. *Chelyosoma productum* is more barrel-shaped, with top flattened and covered in horny plates. The apertures are simple holes in the top, distinctly different from *Molgula*'s prominent siphons. *Pyura mirabilis* has siphons but they are well separated and facing in opposite directions. As its name indicates, the Shiny Orange Sea Squirt, *Cnemidocarpa finmarkiensis*, is smooth, orange, and shiny.

Native *M. pacifica* has orange siphons. Expert help may be necessary to differentiate other *Molgula*. It is native to the Atlantic; only two recorded sightings of *M. citrina* have been made in the Pacific Ocean—in Alaska, and in the Triangle at the mouth of the Umpqua River, Oregon.



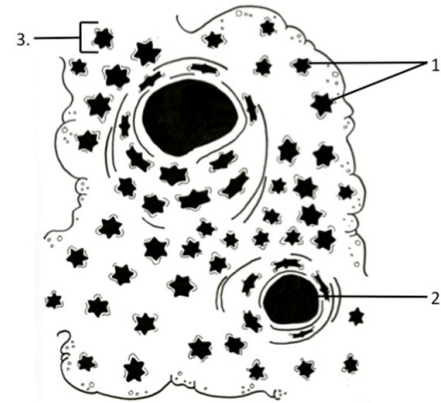
C. productum (Richard Zade)



M. pacifica (Marine Life of the Pacific Northwest)

Didemnum vexillum

Colonial Tunicate



(Amanda Slade)



Winchester Bay (Lorne Curran)



Shilshole Bay, Seattle (Janna Nichols)

Didemnum vexillum

Colonial Tunicate

Identification

The appearance of *D. vex* can vary widely. In calmer waters, it develops thick masses that hang from hard substrates in irregular lobes. In high current, colonies encrust substrates with only small finger-like lobes projecting.

1. Zooids are less well-defined than those of *B. violaceus* and are randomly distributed in a tan, cream, or yellow to orange matrix. Some appear as open holes; other zooids with closed openings appear as white dots. 2. Dark channels run from groups of zooids to common excurrent openings. 3. Close examination reveals that the zooids have six-sided openings.

Ecology

Found on many hard, artificial substrates, rock, and gravel seabeds, *D. vex* will overgrow other organisms such as seaweed and shellfish. It occurs in the low intertidal to 80 m. When salinity falls below 20, infestations may die back, only to later recolonize from colonies deeper in the water column. Its origin is most likely Japan.

Similar Species

See *B. violaceus* and *D. listerianum*. Sponges and bryozoans lack the dark channels of *D. vex*. Like other native didemnids found on the open coast, *Didemnum carnulentum* encrusts substrate and will overgrow other organisms, but it never achieves the lobate form of *D. vex*. Colors are limited to a uniform white to gray with tinges of pink.



Halichondria sp. Sponge (Lorne Curran)

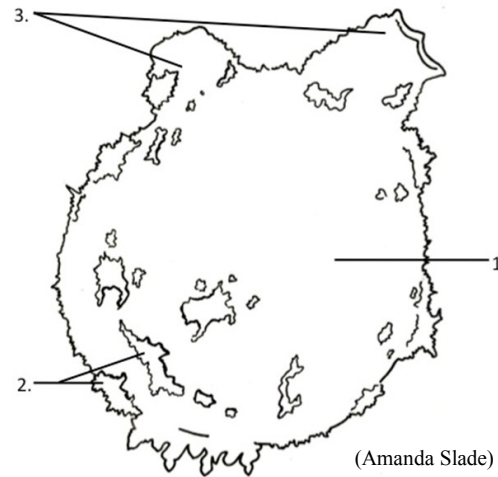


Didemnum carnulentum (Lorne Curran)

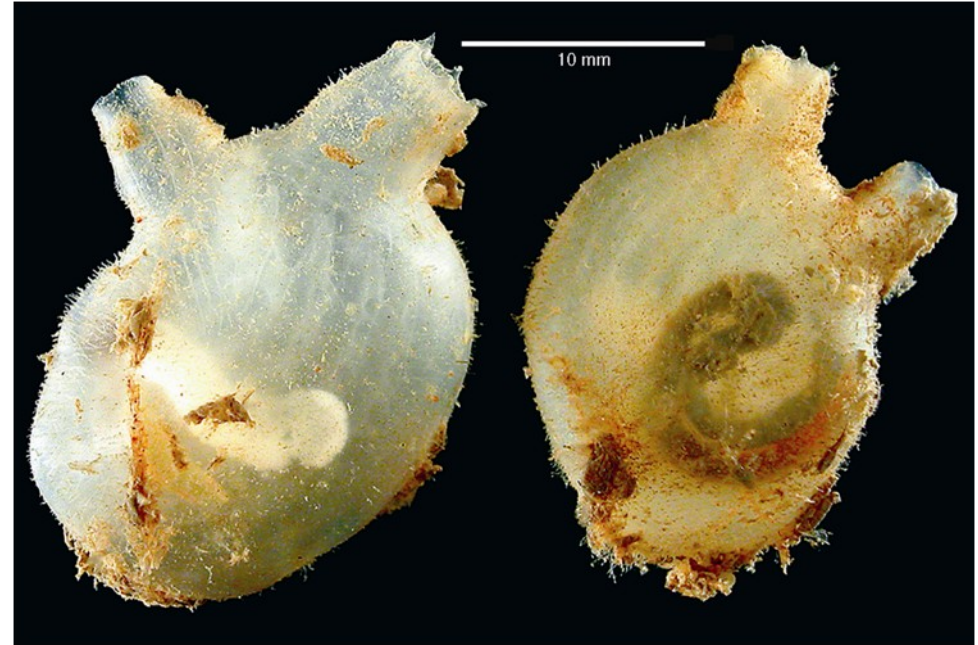
Molgula manhattensis

Solitary Tunicate

Size: 2–3 cm, but can grow up to 5 cm.



M. manhattensis on bottom of barge (Lorne Curran)



(California Academy of Sciences: SFBay:2K)

The Colonial Tunicate

Scientific name	PNW sites found	Regional organizations tracking
<i>Didemnum vexillum</i>	Coos and Winchester Bays, OR; 12+ sites WA	OISC/ODFW, WDFW (priority), REEF
<i>Botrylloides violaceus</i>	Coos, Winchester, Netarts, and Yaquina Bays, OR, and presumed elsewhere; 26+ sites WA	WDFW (secondary)
<i>Botryllus schlosseri</i>	Coos and Winchester Bays, OR; 11+ sites WA	WDFW (secondary)
<i>Diplosoma listerianum</i>	Coos and Netarts Bays, OR; also WA. Offshore occurrences as well, on natural reef	

Appearing as an encrusting organism, colonial tunicate colonies consist of many small individuals, called zooids, encased within a common tunic. Each zooid pumps water in through its own oral siphon, filtering oxygen and plankton. The zooid's atrial siphon discharges the waste water into a space shared within a system of other zooids, where the waste exits through the larger, readily apparent openings. Unlike the invasive solitary tunicates described above, colonials brood their larvae within the colony's matrix before releasing them. Larvae may survive in the planktonic stage for only a day before attaching to substrate, but colonials also reproduce asexually from fragments of the colony, spreading after a colony is disturbed—drifting in ocean currents for months or traveling in ships' ballast water.

Most often discovered in bays and harbors, *D. vex* has also been found covering much of 230 square kilometers of the Georges Bank, prime fishing grounds in the Gulf of Maine. The botryllids (*B. violaceus* and *B. schlosseri*) form smaller colonies but have greatly increased their distribution on the West Coast over the past 40 years. *D. listerianum* has also been documented as an aggressive invader.



Didemnum vexillum (Lorne Curran)

The Colonial Tunicates



Botrylloides violaceus (Lorne Curran)



D. vexillum with *D. listerianum* (Dann Blackwood)



Botryllus schlosseri (Lorne Curran)



Diplosoma listerianum (Steve Trehwella)