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Andrea Locke and Mary Carman (Guest Editors)

Research article

Tunicate faunas of two North Atlantic-New England islands: Martha's Vineyard, Massachusetts and Block Island, Rhode Island

Mary R. Carman[1*], K. Elaine Hoagland[2], Emma Green-Beach[3] and David W. Grunden[4]
[1]*Geology and Geophysics Dept., Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA, E-mail: mcarman@whoi.edu*
[2]*National Centers for Coastal Ocean Science, National Ocean Service, NOAA, 1305 East-West Hwy, Silver Spring, MD 20910, USA, E-mail: elaine_hoagland25@hotmail.com*
[3]*Martha's Vineyard Shellfish Group, Inc., Oak Bluffs, MA 02557, USA, E-mail: emma.greenbeach@gmail.com*
[4]*Town of Oak Bluffs Shellfish Dept., Oak Bluffs, MA 02557, USA, E-mail: dgrunden@ci.oak-bluffs.ma.us*
* *Corresponding author*

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Abstract

Two unique bays, Great Salt Pond system of Block Island, Rhode Island and Lagoon Pond and adjacent portions of Vineyard Haven Harbor, Martha's Vineyard, Massachusetts, undergoing bay scallop *Argopecten irradians irradians* restoration had similar tunicate faunas. We found that Great Salt Pond and Lagoon Pond contained similar tunicate fauna dominated by invasive species, *Ascidiella aspersa*, *Botrylloides violaceus*, *Botryllus schlosseri*, *Didemnum vexillum* and *Styela clava*, along with native species *Aplidium constellatum* and *Molgula manhattensis* and cryptogenic species *Ciona intestinalis*. In both regions, most tunicate fouling was on artificial surfaces. Tunicate fouling occurred but at lower biomass on natural benthic surfaces including marine plants and algae *Ulva lactuca*, *Sargassum filipendula*, *Fucus* spp., *Zostera marina* and *Codium fragile tomentosoides* especially near docks. Tunicates were absent on rocks, free-living scallops, the sedentary snail *Crepidula fornicata* and open meadows of marine plants.

Key words: bay scallops, marine plants, invasive tunicates, epibiont fouling, scallop restoration

Introduction

Argopecten irradians irradians (Lamarck, 1819) (bay scallops) and *Crassostrea virginica* (Gmelin, 1791) (oysters) are valued coastal resources in New England (CZM 2008). *Zostera marina* (Linnaeus, 1753) (eelgrass) beds are important feeding and nursery grounds for many species of fish and shellfish (Short and Neckles 1999). Eelgrass, macroalgae, and other species of marine plants filter coastal waters, dissipate wave energy, and anchor sediments and also can serve as habitat for tunicate epibionts. Tunicates can be pests to aquaculture and can heavily foul bivalves and other sessile invertebrates (Bullard et al. 2007). Tunicate epibionts can also foul marine plants. Fell and Lewandrowski (1981) cited *Molgula manhattensis* (Dekay, 1843) as heavily colonizing healthy eelgrass in the lower Mystic Estuary, Connecticut during summer. *Didemnum* can be abundant on *Fucus serratus* Linnaeus, 1753 in Strangford Lough, Ireland (Seed et al. 1981). *Botrylloides* sp. commonly occurred on eelgrass at Tomales Bay, California, and was observed rafted on defoliated blades of eelgrass that traveled up to distances 200 times farther than larval dispersal (Worcester 1994). Locke et al. (2007) documented *Botrylloides violaceus* Okra, 1927 growing on eelgrass in southern Gulf of St. Lawrence estuaries. There is no mention in these papers of the effect of tunicates on marine plants. Colonial tunicates are capable of encapsulating a marine plant blade. While at least 7 species of tunicates have been introduced to seagrass ecosystems, the ecological effects of tunicates introduced to seagrass beds remain unassessed (Williams 2007). *Didemnum vexillum* Kott, 2002 commonly encapsulates blades of *Ascophyllum nodosum* (Linnaeus) LeJolis, 1863, *Chondrus crispus* Stackhouse, 1797 and *Fucus edentatus* Bachelot de la Pylaie, 1829 in intertidal pools at Sandwich, Massachusetts (Carman, unpub. data). The effect of blade smothering by *Didemnum* to the plant is unknown.

The epifaunas of marine macroalgae and grasses have been infrequently investigated (Seed and O'Connor 1981). Eelgrass beds are not the expected major habitat for tunicates under ordinary circumstances (e.g., when there is artificial substrate available). Tunicates have been found on blades of eelgrass in places where there is limited natural substrate for tunicate attachment (Locke et al. 2007). Eelgrass is not the only potential natural substrate for tunicates in our area; there are many other natural substrates including bivalves and other sessile invertebrates. Eelgrass is a peculiar host for tunicates, being thin bladed and flexible; not what one would expect as a substrate for tunicates. However, we were interested in eelgrass because it has been reported as hosting tunicates and it is a living host with the potential to float to new areas, so it could be significant. Also, tunicates might damage eelgrass in some way that would be negative for shellfish beds. Therefore we sought it out and examined it carefully to see if any were infested.

Not all species of macroalgae are settled upon by epifauna, and epibionts may vary from one geographical location to another (Seed and O'Connor 1981). We selected Great Salt Pond and Lagoon Pond to investigate because they are undergoing bay scallop restoration. We investigated whether tunicates were attached to bay scallops in these commercially important shellfish areas and if tunicates were attached to eelgrass and other marine plants in these same shellfish areas. Tunicates that were expected to be found in our study area were: invasive species *Ascidiella aspersa* D.F.Müller, 1776*, Botryllus schlosseri* (Pallas, 1774), *B. violaceus, D. vexillum, Diplosoma listerianum* Milne-Edwards, 1841, *Styela clava* Herdman, 1881; native species *Aplidium constellatum* (Verrill, 1871), *Aplidium stellatum* (Verrill, 1871), *Didemnum albidum* (Verrill, 1871), *M. manhattensis*; and the cryptogenic species *Ciona intestinalis* (Linnaeus, 1767) (Van Name 1945; Plough 1978; Pederson 2005; Carman et al. 2007).

Methods

Our study was conducted at two bays undergoing shellfish restoration in southern New England (Figure 1). The Great Salt Pond system is located on the northwestern end of Block Island, an island in the North Atlantic off the Rhode Island coast. This system of ponds is composed of a large embayment known as Great Salt Pond, which is open to the sea via a narrow channel, plus three smaller ponds that interconnect with Great Salt Pond, extending landward. The entire system is full salinity (30 psu). The shoreline includes several marinas, private homes, and marine-based businesses. The ponds contain large mooring fields and an outer anchorage. Great Salt Pond itself contains a large hard-clam bed (*Mercenaria mercenaria* (Linnaeus, 1758)). There have been a number of closures to clamming in recent years due to high bacteria counts. Two shellfish leases operate in the inner ponds, and there is a lease area outside the ponds along the shore for final grow-out of oysters. As of this writing, a federally funded project is growing bay scallop seed for release in the Great Salt Pond system (Block Island Shellfish Commission, June 2007 meeting).

Lagoon Pond is located on the north side of Martha's Vineyard, an island in the North Atlantic off southern Cape Cod, Massachusetts. Lagoon Pond is a north-south trending, elongate, full marine salinity embayment within Vineyard Haven Harbor, which is exposed to Vineyard Sound. Lagoon Pond is accessible by a narrow channel under Lagoon Pond Drawbridge. The shoreline of Lagoon Pond is somewhat developed with residential homes, a shipyard, and small private docks. Recreational boaters and commercial shellfish boaters frequent the pond. The Town of Oak Bluffs Shellfish Department and Martha's Vineyard Shellfish Group, Inc. are planting bay scallops in Lagoon Pond every year to keep the fishery active.

We surveyed Great Salt Pond (GSP) for tunicates on June 20, 2007. Floating platforms, docks, and aquaculture equipment and product in "Ft. Island Pond" (Station GSP-1), at Hog Pen Marina in Trim Pond (Station GSP-2), and in Trim Pond (Station GSP-3) were examined by use of a small boat. Next, we examined a water hose and aquaculture bags, cages, and shellfish for tunicates under and attached to the dock at Martha's Vineyard Shellfish Group Inc. (MVSG) in Lagoon Pond (LP) on July 6 (Station LP-1). On July 12, we used a small boat and plexiglass-bottomed viewer boxes to do an assessment survey for tunicates at randomly selected 10 m^2 areas of Lagoon Pond at water depths of about one meter. Near Sandy Point, an anchor line for aquaculture equipment, about 7 m in length, was pulled from approximately two meters' water

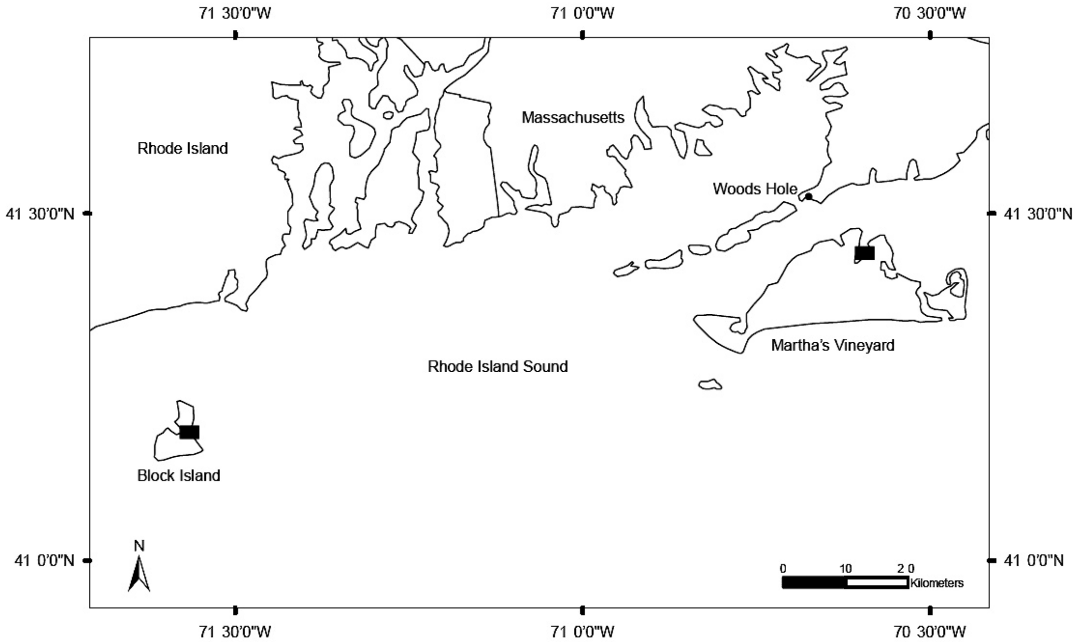

Figure 1. Map of the study areas in southern New England.

depth and examined on board. One investigatory bottom trawl using a 30″ bay scallop pan drag that lasted for about 30 seconds was taken at Sandy Point (Station LP-2). The contents of the trawl were examined on board and returned to the water.

We visually examined wood pilings abutting the Lagoon Pond Drawbridge at the entrance to Lagoon Pond, and benthic surfaces immediately outside of Lagoon Pond (Station LP-3). We examined benthic surfaces and mooring balls just inside the entrance to Lagoon Pond (Station LP-4). Our field assistant waded in haphazardly selected parts of Stations LP-2, LP-3, and LP-4 and used a viewer box to search for tunicates. On July 30, a nearshore, one meter and less than one meter water depth, 5 m^2 areas of MVSG and surrounding nearshore were surveyed by wading at low tide (Station LP-5). At all stations observations were made and, where possible, representative specimens were collected by hand, identified, numbered, preserved in isopropyl alcohol and deposited at WHOI McLean Lab.

Results

At Station GSP-1, we found *B. schlosseri, B. violaceus, D. vexillum*, *M. manhattensis*, and *S. clava* attached to the sides and bottom of a wooden floating platform (Table 1). At Station GSP-2, we found *B. schlosseri, B. violaceus, C. intestinalis, D. vexillum*, *M. manhattensis* and *S. clava* on a buoy and line. Mussels and oysters attached to the buoy and line were also fouled by *B. violaceus* and *D. vexillum* (Figure 2). At Station GSP-3, we found *B. violaceus, C. intestinalis, D. vexillum* and *S. clava* attached to aquaculture bags, to the exterior shell of live oysters and inside the shell of dead oysters.

At Station LP-1, we found *A. aspersa, A. constellatum, B. violaceus, D. vexillum*, *M. manhattensis* and *S. clava* on a water hose; *A. aspersa, B. violaceus,* and *D. vexillum* on aquaculture cages; *A. aspersa, B. violaceus, D. vexillum* and *S. clava* on a living bay scallop (Figure 3); *B. violaceus* attached to *A. nodosum* (Figure 4). At Station LP-2, we found *A. aspersa, D. vexillum* and *S. clava* on an anchor line for aquaculture equipment and *A. aspersa* and *S. clava* on *Codium fragile tomentosoides.* No tunicates were found in the trawl. At Station LP-3, we observed *B. violaceus, D. vexillum* and *S. clava* on bridge pilings. At Station LP-4, we found *B. violaceus* and *S. clava* on the bottom of a mooring ball. At Station LP-5, we found *B. violaceus* attached to *A. nodosum, C. fragile tomentosoides, Fucus* spp., *Sargassum filipendula* and *Z. marina*; *D. vexillum* attached to *C. fragile tomentosoides* (Table 1). In all cases, tunicates were attached to the stalks and blades

Figure 2. *Botrylloides violaceus* (left) and *Didemnum vexillum* (right) on living oysters *Crassostrea virginica* in aquaculture bags at Station GSP-3, Trim Pond, Block Island, Rhode Island.

Figure 3. *Ascidiella aspersa, Botrylloides violaceus,* and *Didemnum vexillum* on a living bay scallop *Argopecten irradians irradians* at Station LP-1, Martha's Vineyard Shellfish Group, Inc. dock, Lagoon Pond, Martha's Vineyard, Massachusetts.

of the plants. Reposited tunicate specimens are: (#WHOI-ML-002) *A. aspersa* on anchor line and on *C. fragile tomentosoides* from Station LP-2, (#WHOI-ML-003) *D. vexillum* on anchor line from Station LP-2, (#WHOI-ML-004) *S. clava* on anchor line and on *C. fragile tomentosoides* from Station LP-2, (#WHOI-ML-007) *B. violaceus* on blue mussel *Mytilus edulis* on mooring ball from Station LP-4, (#WHOI-ML-008) *B. violaceus* and *S. clava* on mooring ball from Station LP-4, (#WHOI-ML-009) *B. violaceus* on *A. nodosum* from Station LP-5, (#WHOI-ML-010) *B. violaceus* on *Z. marina* from Station LP-5.

Figure 4. *Botrylloides violaceus* on *Ascophyllum nodosum* collected near Station LP-1, Martha's Vineyard Shellfish Group, Inc. dock, Lagoon Pond, Martha's Vineyard, Massachusetts.

Discussion

Great Salt Pond and Lagoon Pond hosted tunicate faunas dominated by invasive species which were predominantly found on anthropogenic structures and materials. Natural surfaces and artificial surfaces were occupied by both native and invasive species of tunicates, but tunicates were not found directly on cobbles, pebbles, or on the common native sedentary gastropod *Crepidula fornicata*. Available hard substratum is often limited in marine environments. Cultured shellfish and associated gear (cages, lines, moorings) offered additional surfaces for fouling community to develop, whereas natural living surfaces such as *Crepidula* and free-living scallops are generally clean of tunicates and other biofouling. Free-living scallops are capable of moving, which may reduce fouling, compared to scallops that are restricted to aquaculture cages. It should be noted that some bivalves freely living on artificial surfaces were affected. Mussels attached to lines and buoys in Great Salt Pond were fouled by *B. violaceus* and *D. vexillum.*

The proximity of natural surfaces to infested man-made objects greatly influences the degree of fouling. Exotic tunicates on artificial substrates increase dramatically as fouling communities develop (Tyrrell and Byers 2007). Tunicates were found on bay scallops near a dock with a diverse, abundant tunicate fauna, but not on free-living bay scallops in open areas where there were no anthropogenic surfaces. *Botrylloides violaceus* was found on *Z. marina* near a permanent wooden dock with shellfish

Table 1. Locations and substrata where tunicates were found (x) in Lagoon Pond (LP), Martha's Vineyard, Massachusetts and Great Salt Pond (GSP), Block Island, Rhode Island.

Station	Location	N. latitude	W. longitude	Substrate	*Aplidium constellatum*	*Ascidiella aspersa*	*Botrylloides violaceus*	*Botryllus schlosseri*	*Ciona intestinalis*	*Didemnum vexillum*	*Molgula manhattensis*	*Styela clava*
LP-1	MVSG dock	41°26'24.7"	70°36'2.2"	water hose	x	x	x			x	x	x
				aquaculture cage		x	x			x		
				A.irradians irradians		x	x			x		x
LP-2	Sandy Pt	41°26'35.5"	70°35'25.1"	anchor line		x				x		x
				C.fragile tomentosoides		x						x
LP-3	Beach Rd bridge	41°27'28.4"	70°35'11.8"	wood piling			x			x		x
LP-4	inner pond	41°27'17.6"	70°35'23.6"	mooring ball			x					x
LP-5	MVSG shoreline	41°26'24.7"	70°36'2.2"	*A.nodosum*			x					
				C.fragile tomentosoides			x			x		
				Fucus sp.			x					
				S.filipendula			x					
				Z.marina			x					
GSP-1	"Ft. Island pond"	41°10'62"	71°34'58"	floating platform			x	x		x	x	x
GSP-2	Hog Pen Marina	41°10'46.95	71°34'18.5"	buoy and line			x	x	x	x	x	x
				M.edulis			x	x		x		
GSP-3	Trim Pond	41°10'94"	71°34'15"	aquaculture bags & *C.virginica*			x		x	x		x

aquaculture gear both encrusted with *B. violaceus* but was not found in meadows where there were no docks, no other anthropogenic surfaces, and consequently no nearby sources of *B. violaceus*. Shellfish and marine plants in close proximity to man-made structures are more vulnerable to tunicate infestation than shellfish and marine plants not in close proximity to anthropogenic substrates. Although there were many natural substrates available for tunicate attachment in the bays, only those natural substrates near man-made structures were fouled by invasive species of tunicates.

Native marine plants provide available space and marine plant invaders provide new surfaces for larval settlement. Because space on which to live is often a limited resource, the annual growth of plants provides an escape from competition. Artificial surfaces tend to be static, non-changing and present all year but marine plant surfaces are seasonal, increasing in surface availability as the plant grows during summer (Seed and O'Connor 1981). Opportunistic tunicates may take advantage of this available space. For example, *C. fragile tomentosoides* has recently become a dominant member of benthic communities in New England and is a successful invader in many disturbed habitats of the world (Chavanich et al. 2006). *Codium fragile tomentosoides* was introduced to New England in 1957, began spreading, and is expected to continue to spread (Mathieson et al. 2003). Tunicates found on *C. fragile tomentosoides* were *A. aspersa, B. violaceus, D. vexillum* and *S. clava.*

The non-indigenous species of tunicates in Lagoon Pond and Great Salt Pond were introduced to New England in the 1980's, began spreading (Carman and Roscoe 2003; Pederson 2005; Bullard et al. 2007), and may continue to spread. At present, the tunicate fauna of Lagoon Pond appears to be predominantly bio-fouling anthropogenic structures and materials. Although there is a high risk for phoresis on living biota, the marine plants and algae of Lagoon Pond appear not to be inhabited by tunicates, except near an infested dock.

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