

# Narragansett Bay Expedition:

## The 2000 Rapid Assessment Survey of Non-Indigenous Aquatic Nuisance Species in Narragansett Bay, Rhode Island

August 12-18, 2000



This report presents the results of the Narragansett Bay Rapid Assessment Survey 2000:

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# The Narragansett Bay Rapid Assessment Survey, August 2000

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## **DEDICATION**

This report is dedicated to the memory of Dr. Gary J. Brusca. His brilliance as Professor of Invertebrate Zoology at Humboldt State University imparted a world of knowledge to those fortunate enough to be his students. But his love and respect for Northern California's coastal marine habitats and the myriad creatures found within imparted a different gift. Dr. Brusca bequeathed a world of wonder to those who learned to see it through his eyes.

## Acknowledgements

The authors wish to extend heartfelt thanks to the following individuals without whom this study would not have been possible:

- Those who granted permission to use their facilities as sampling stations;
- The Narragansett Bay Rapid Assessment Survey research team:
  - Dr. James T. Carlton, Williams College/Mystic Seaport Maritime Studies
  - Dr. Robert Bullock, University of Rhode Island
  - Dr. Dale Calder, Royal Ontario Museum
  - Dr. John Chapman, Oregon State University
  - Dr. Larry Harris, University of New Hampshire
  - Dr. Charles Lambert, Professor Emeritus, Cal. State Fullerton; Univ. of Washington, Friday Harbor Laboratories
  - Gretchen Lambert, University of Washington, Friday Harbor Laboratories
  - Dr. Seth Tyler, University of Maine at Orono
  - Evangelina Schwindt, Williams College/Mystic Seaport Maritime Studies
  - Niels-Viggo Hobbs, University of Rhode Island;
- Grover J. Fugate, Rhode Island Coastal Resources Management Council, project approval and providing staff for project planning and management;
- Ames Colt, Rhode Island Sea Grant, grant funding to cover direct project costs;
- Jan Reitsma, Rhode Island Department of Environmental Management, administrative support and providing staff for project planning and management;
- Richard Ribb and Dr. Chris Deacutis, Narragansett Bay Estuary Program, financial support, scientific expertise, sampling equipment, and logistical support;
- Roger Greene, Narragansett Bay National Estuarine Research Reserve, providing laboratory facilities, lodging, and research vessel services;
- Lisa Gould, Rhode Island Natural History Survey, administrative support;
- Dr. Kenneth Hinga, URI Graduate School of Oceanography, logistical support and laboratory equipment;
- Walter Berry, EPA National Health and Environmental Effects Research Lab, providing glassware and other field and lab equipment;
- Dr. Harlan Dean, Museum of Comparative Zoology, Harvard University, and Dr. Judith Winston, Virginia Museum of Natural History, for additional species identifications.

## Overview

The first Narragansett Bay Rapid Assessment Survey (RAS) of invasive non-indigenous species (August 12-18, 2000) was modeled after the seminal RAS expeditions led by Dr. James Carlton on the West Coast of the United States. The overall research methodology developed by Drs. Andrew Cohen and James Carlton for Puget Sound and San Francisco Bay RAS expeditions was applied to defining the study area, selecting sampling stations, sample collection techniques, and analytical methods.

The interest in conducting a RAS in Rhode Island's coastal marine waters was based on three factors: 1) the growing scientific evidence that invasive non-indigenous species are a significant potential threat to coastal marine ecosystems and the economic activities they support; 2) the lack of scientific research that specifically addresses non-indigenous species in Rhode Island; and, 3) the lack of a regulatory/management framework to address the problem of invasions by non-indigenous species. The government agencies and academic programs<sup>1</sup> that organized and managed the Narragansett Bay RAS supported this research project because of its potential to produce data on the current status of non-indigenous species, provide a basis for creating a comprehensive database of non-indigenous species in Rhode Island's coastal waters.

Narragansett Bay was chosen as the study area, as it is a discrete coastal embayment that represents a unique marine ecosystem. Due to time constraints related to the availability of the research team, it was estimated that a representative survey of Narragansett Bay could be conducted by sampling thirteen stations (Figure 1) over a four-day period (14-17 August, 2000). These stations were chosen to collectively represent:

- Potential historic and contemporary introduction sites
- Diverse natural habitats and engineered structures
- Diverse adjacent land uses
- Structures capable of accommodating 12 to 15 researchers and support personnel
- A broad spatial distribution
- Temperature and salinity ranges

The presence of floating docks was a primary criterion for selecting each sampling station. As demonstrated during prior RAS expeditions, floating docks are ideal sampling stations as they have several favorable characteristics:

- Accommodate communication among researchers while sampling
- Epiphytic flora and fauna communities are common and abundant
- Non-indigenous species often present
- Accessibility regardless of tide cycle
- Numerous and broadly distributed in many coastal embayments
- First point of arrival for many species from fouled boat hulls and ballast water

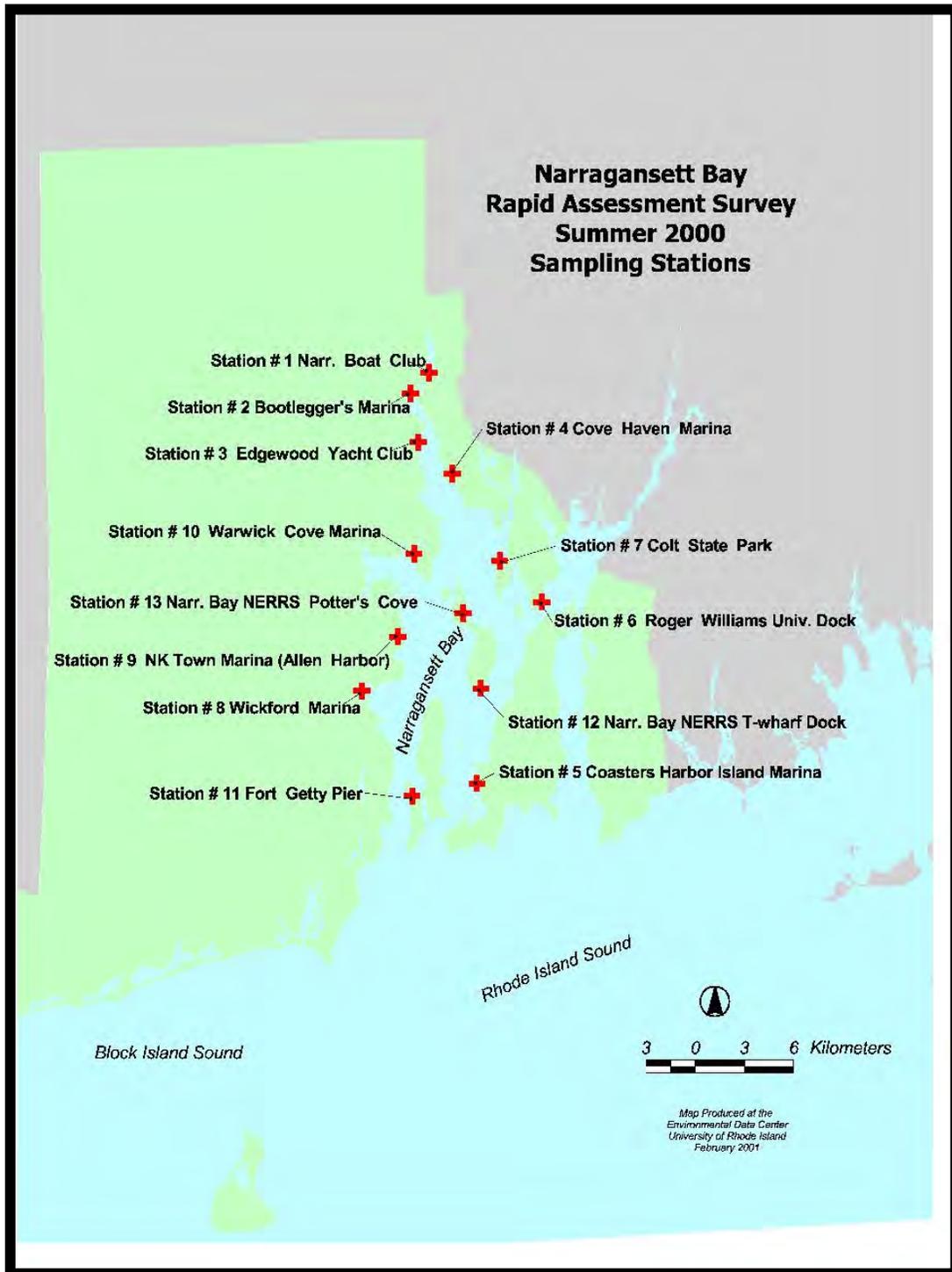
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<sup>1</sup> RI Coastal Resources Management Council, University of Rhode Island (RI Sea Grant College Program and the RI Natural History Survey), RI Department of Environmental Management (Narragansett Bay Estuary Program and the Narragansett Bay National Estuarine Reserve).

However, it is important to note the inherent limitations of using floating docks exclusively as sampling stations. While numerous and widespread throughout Narragansett Bay, they do not necessarily represent an appropriate basis for quantitative research methods. In addition, they are not natural habitats, nor do they represent all habitats and as such, do not necessarily include niches that may support certain introduced species. Floating docks also represent a small area of the bay relative to its natural habitats.

The team used simple hand tools such as scrapers and sieves to sample each station. Researchers examined collected specimens and identified them as indigenous or non-indigenous species. Similar visual analysis of specimens was later conducted in the laboratory at the end of each day's field sampling.

**Figure 1. Sampling Stations**



Station numbers indicate sampling order  
*GIS map courtesy of Dr. Peter August, Director, Coastal Institute, University of Rhode Island*

## Methods

### *Sample Collection Techniques*

The Narragansett Bay RAS adapted the non-quantitative sampling methods developed during the previous West Coast RAS expeditions in San Francisco Bay and Puget Sound (Cohen et al, 1998). The team used simple manual techniques to collect samples, generally by scraping encrusting biota from various surfaces of floating docks using paint scrapers. Other tools for directly sampling dock surfaces included sieves, steel mesh and nylon mesh nets, in some cases attached to wooden poles. Some researchers used a 0.05m<sup>2</sup> Ekman grab sampler to take samples from the nearby benthos. We sampled the surrounding water column with plankton nets of various mesh sizes and used an YSI meter to record temperature and salinity data at each station (**Table 2**). The team also collected voucher samples at each station.

### *Analytical Techniques*

The expertise of the taxonomic specialists that constituted the RAS research team ensured a level of quality control in regard to data analysis such as species identification. Because of this, the chief analytical technique to verify the presence of non-indigenous species from samples collected at each station was visual examination and dichotomous keying performed by each individual expert. The research team performed field identification of non-indigenous, cryptogenic<sup>2</sup>, and indigenous species at each station, with any follow-up analysis being performed in the laboratory at the close of each day. Each individual researcher was responsible for identifying specimens within his or her taxonomic expertise. However, consultation and cross-referencing was common among all members of the research team both at the sampling sites and also in the laboratory. In this manner, identifications and classifications were verified.

The team identified species primarily by direct visual examination, and by using magnifying glasses, and dissecting and compound microscopes when necessary, to examine finer characteristics of individual specimens to ensure accuracy. Species that were more difficult to identify were preserved for further analysis subsequent to the survey.

In summary, some advantages of RAS research include:

- The habitat is easily sampled at low cost and with simple equipment.
- It can be sampled without regard to the tide level.
- There is easy and quick access to a large selection of suitable sites.
- Most sites accommodate a sizeable team of experts that can sample simultaneously and maintain verbal contact.
- Harbors are the first point of arrival for most non-indigenous species, thus providing an area of “first warning” for new invasions.
- Dock fouling communities often include a significant non-indigenous component.

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<sup>2</sup> Cryptogenic refers to species whose status as non-indigenous or native organisms is unknown (Carlton, 1996; Cohen, et. al., 1998). It is important to note however, that recent advances in molecular identification techniques are making this term increasingly obsolete and leading invasion biologists including Dr. Carlton have abandoned its use.

In addition, the findings produce a comprehensive inventory of the biotic communities at each sampling station, and an inventory of the non-indigenous and cryptogenic species at each sampling station.

**Table 1.**  
**Physical Descriptions of Sampling Stations, Narragansett Bay Rapid Assessment Survey, 2000**

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**Station 1: Narragansett Boat Club, Seekonk River, Providence**

The Narragansett Boat Club is located in the Seekonk River in Providence, and is the northernmost sampling station of the Narragansett Bay RAS. It is also the least saline environment that was encountered during the RAS expedition (salinity 17.7 ‰). A single floating dock, used by Club members to launch sculls, is present year round. The shore immediately adjacent to the dock, on the Providence side of the river, is characterized by scattered clusters of marsh habitat. The dominant adjacent land use is residential property. Several old wharfs extend from about mid-river to the opposite shore in East Providence, which is characterized by several old industrial sites. The commercial shipping related to these sites ceased several years ago, but the infrastructure, including the wharfs mentioned above, and various other shore side facilities remain. Non-motorized recreational boating is the dominant water based activity at this section of the river. The RI Department of Environmental Management has imposed a year-round shell fishing ban at this site due to the presence of polluted shellfish grounds.

**Station 2: Bootleggers Marina, India Point, Providence**

A large marina is located at this site which primarily accommodates seasonal recreational boats. It is located on India Point, at Providence harbor, near the confluence of the Providence and Seekonk rivers. The volume of commercial shipping in the harbor has declined significantly over the past few decades as silting in the commercial shipping channel has reduced the water depth. However, lightering of petroleum in small barges is a common activity and other larger oceangoing vessels regularly tie up at the large bulkhead just south of the marina. India Point itself is an important historic shipping center. India Point was regularly visited by sailing vessels from India and other far-flung locations during and after colonial times as part of the trade of the East India Company and other maritime trade companies. The harbor contains some old wooden wrecks, abandoned wooden pilings, and is marked by some small salt marshes. A commercial tugboat company is located nearby, its boats are used extensively throughout Narragansett Bay and nearby Mt. Hope Bay, to transport fuel barges, and assist oceangoing vessels with docking operations. The RI Department of Environmental Management has imposed a year-round shell fishing ban at this site due to the presence of polluted shellfish grounds.

**Station 3: Edgewood Yacht Club, Warwick**

The Edgewood Yacht Club has a large recreational marina that includes docks and a mooring field that are used for recreational boating. It is located just south of Providence Harbor, in the upper arm of Narragansett Bay. Some relatively large marshes are located at this site, and mud flats are exposed daily at low tide. Land uses include another large marina just to the north, and extensive residential neighborhoods in the immediate vicinity. The RI Department of Environmental Management has imposed a year-round shell fishing ban at this site due to the presence of polluted shellfish grounds.

**Station 4: Cove Haven Marina, Barrington**

Cove Haven Marina is a very large recreational boating facility located in Bullocks Cove, a relatively sheltered embayment on the eastern shore of upper Narragansett Bay. Other marinas are located in the cove, and extensive mooring fields also characterize this site. Recreational boating is the dominant water use in the cove. Some relatively extensive salt marshes are found at this site, and mudflats are exposed at low tide. The RI Department of Environmental Management has imposed a year-round shell fishing ban at this site due to the presence of polluted shellfish grounds. Land uses include residential neighborhoods, limited industrial/commercial activity, and a state park. The RI Department of Environmental Management has imposed a year-round shell fishing ban at this site due to the presence of polluted shellfish grounds.

**Station 5: Coasters Harbor Island Marina, Newport**

This large recreational marina is located on the property of the Newport Naval War College, a U.S. Department of Defense facility. A large stone breakwater separates the marina's floating docks from the open waters of Narragansett Bay's East Passage. This is the southernmost station on the east shore of the Bay, and the oceanic waters of Rhode Island Sound are nearby. The adjacent land use is dominated by the buildings and other facilities of the Naval War College. While military vessels are no longer stationed at the Naval War College, several large WW II vintage ships are mothballed a few miles to the north at Coddington Cove in Middletown. In addition, large cruise ships regularly visit Newport Harbor just to the south, and often lay anchor in the East Passage. The RI Department of Environmental Management has imposed a year-round shell fishing ban at this site due to the presence of polluted shellfish grounds.

**Station 6: Roger Williams University Learning Platform, Bristol**

This station is located in Mt. Hope Bay, where it joins with Narragansett Bay. A small floating learning platform is present, which is used to support the University's research activities, including shellfish aquaculture research projects. A pump house is located on a pier attached to the dock, and an intake line attached to the pier is used to transport salt water to the University's land-based lab facilities, where phytoplankton, shellfish, and other species are cultured. A nearby anchored float is used to store small sailboats. Cobble beaches characterize the shoreline and some scattered patches of salt marsh are present. The University campus is the dominant adjacent land. The shoreline is otherwise undeveloped, and recreational anglers regularly use a public access point just to the south at the Mt. Hope Bridge. The RI Department of Environmental Management has imposed a conditional shell fishing ban at this site due to pollution associated with rainfall events.

**Station 7: Colt State Park, Bristol**

This station is not located in a sheltered embayment; it is a relatively exposed site on the eastern shore of Narragansett Bay. A wooden pier extends a short distance from the shore at this site to a small wooden float that is regularly used by recreational anglers. The float is not primarily intended for use as a recreational boat dock, but small boats do occasionally tie up to it for short periods of time. A very extensive salt marsh is located a few hundred feet away in a protected cove with a narrow connection to the Bay. The dominant land use is Colt State Park, a large state park that is used by the public for recreation. There are no marinas or other water dependent developments nearby.

**Station 8: Wickford Marina, Wickford**

This station is located in Wickford Harbor, along the southwestern shore of Narragansett Bay. The site is somewhat similar to Station 4 at Bullocks Cove, which is located along the Bay's northeastern shore. Both are sheltered embayments that are characterized by large recreational marinas, mooring fields, and extensive salt marshes. The RI Department of Environmental Management has a marine fisheries field station adjacent to Wickford Marina, where small research vessels that regularly conduct finfish field surveys of Narragansett Bay and coastal salt ponds are berthed. Residential property and some small businesses are also in the vicinity. The RI Department of Environmental Management has imposed a year-round shell-fishing ban at this site due to the presence of polluted shellfish grounds.

**Station 9: North Kingstown Town Marina, N. Kingstown**

This station is located in Allen Harbor, just north of Station 8. Several vestiges of the decommissioned US Navy base at Quonset Point/Davisville are present at the harbor. A WW II era wooden pier is located near the Town Marina docks. Farther up the harbor is a restored Superfund site that the Navy had used as a dump for toxic materials. The landfill has been capped, and an adjacent degraded salt marsh was restored as a mitigation measure. The bulkhead, wharves, and piers of the former military base, which also includes an airport used by the RI Air National Guard, are located on Narragansett Bay, to the immediate south of the mouth of Allen Cove. Large oceangoing container ships from Europe and Asia are the major source of commercial shipping at Quonset Point. Several thousand new automobiles are offloaded annually at the bulkhead. Allen Cove contains some scattered patches of salt marsh. Recreational boats and some small commercial boats (i.e. quahog skiffs) represent the primary water use in the harbor. There is no residential property in the vicinity of the harbor. The decommissioned Navy base has been redeveloped as a commercial park. The RI Department of Environmental Management has imposed a year-round shell fishing ban at this site due to the presence of polluted shellfish grounds.

**Station 10: Warwick Cove Marina, E. Greenwich**

Warwick Cove is a small tributary-like extension of Greenwich Bay, which connects to the western reach of Narragansett Bay. Warwick Cove is characterized by marinas, mooring fields, and private docks associated with residential property. Both recreational and commercial boating is supported by the many boating facilities present, including wholesale shellfish businesses where commercial shellfishers unload their daily catch. The RI Department of Environmental Management has imposed a year-round shell-fishing ban at this site due to the presence of polluted shellfish grounds.

**Station 11: Fort Getty Pier, Jamestown**

Ft. Getty Pier is the only station sampled by the expedition that does not have a floating dock. This station was chosen as it represented an opportunity to sample some mid-bay waters. The pier was constructed as part of a military installation around the turn of the 20<sup>th</sup> century. The partially dilapidated pier is now part of a public park owned by the Town of Jamestown, which itself is a large island at the mouth of Narragansett Bay. The pier is a popular fishing spot, several small recreational and commercial (i.e. quahog skiffs) boats are tied up nearby, and RV camping is a popular seasonal activity at the park. An extensive salt marsh is located at a small sheltered cove near the pier. A cobble beach also characterizes the site. The RI Department of Environmental Management has imposed a seasonal shell fishing ban (generally from Memorial Day to Columbus Day) at a portion of this site.

**Station 12: Narragansett Bay National Estuarine Research Reserve System/T-wharf Dock, Prudence Island**

The small floating dock at the NERRS T-wharf is another mid-bay sampling station. The dock is located at the southern end of Prudence Island on NERRS property. The dock is a relatively recent addition to the T-wharf that was heavily used by military ships during WW II. The adjacent shoreline is characterized by a sand and cobble beach, which is bounded by coastal scrub habitat. The immediate upland area is undeveloped, and the NERRS laboratory and other facilities that are located about a mile from the T-wharf, are part of a former US Navy base.

**Station 13: Narragansett Bay National Estuarine Research Reserve System/Potter's Cove, Prudence Island**

Potter's Cove is a relatively sheltered embayment adjacent to NERRS property on the northwest shore of Prudence Island. In recent years, recreational boaters have been increasingly using the cove as an anchorage during the summer. A small wooden float at this site is used by NERRS researchers for regular monitoring of physical characteristics such as water temperature and salinity. Extensive salt marshes are present in the vicinity, and the adjacent upland is undeveloped. The RI Department of Environmental Management has imposed a seasonal shell fishing ban (generally from Memorial Day to Columbus Day) at this site.

**Table 2.**  
**Sampling Station Surface Temperature and Salinity Data<sup>1</sup>** (see digital map at: <http://chartis.mit.edu/>)

| Sampling Station              | Latitude - Longitude      | Date    | Time<br>(24 hr.) | Temp.<br>(C°) | Salinity<br>(‰) |
|-------------------------------|---------------------------|---------|------------------|---------------|-----------------|
| Narragansett Boat Club        | 41.49.941 N - 71.22.675 W | 8/14/00 | 9:28             | 20.9          | 17.7            |
| Bootleggers Dock, India Point | 41.48.954 N - 71.23.852 W | 8/14/00 | 10:21            | 21.0          | 25.4            |
| Edgewood Yacht Club           | 41.46.606 N - 71.23.355 W | 8/14/00 | 12:09            | 20.9          | 25.6            |
| Cove Haven Marina             | 41.45.111 N - 71.21.164 W | 8/14/00 | 13:32            | 21.7          | 27.0            |
| Coasters Harbor Island        | 41.30.275 N - 71.19.572 W | 8/15/00 | ---              | ---           | ---             |
| Roger Williams Univ.          | 41.38.975 N - 71.15.363 W | 8/15/00 | 10:55            | 21.2          | 29.5            |
| Colt State Park               | 41.40.949 N - 71.18.077 W | 8/15/00 | 12:52            | 20.9          | 30.2            |
| Wickford Marina               | 41.34.678 N - 71.27.032 W | 8/16/00 | 8:51             | 21.7          | 28.4            |
| N.K. Town Marina              | 41.37.297 N - 71.24.689 W | 8/16/00 | 10:17            | 21.7          | 28.0            |
| Warwick Cove Marina           | 41.41.284 N - 71.23.636 W | 8/16/00 | 11:46            | 22.0          | 29.3            |
| Ft. Getty Fishing Pier        | 41.29.671 N - 71.23.789 W | 8/16/00 | 14:04            | 21.5          | 30.7            |
| NBNERRS <sup>2</sup> T-Wharf  | 41.34.731 N - 71.19.287 W | 8/17/00 |                  | 20            | 32              |
| NBNERRS Potters Cove          | 41.38.435 N - 71.20.467 W | 8/17/00 |                  | 21.5          | 32              |

<sup>1</sup> Temperature and salinity data collected at depth range of 0.1- 0.3 meters

<sup>2</sup> NBNERRS: Narragansett Bay National Estuarine Research Reserve System (Prudence Island)

**Table 3.**

**Biotic Descriptions of Sampling Stations, Narragansett Bay Rapid Assessment Survey, 2000**

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**Station 1: Narragansett Boat Club, Seekonk River, Providence**

This site, composed of floating docks, is depauperate in both richness and diversity, largely as a result of its low salinity environment. The community present can be described as being dominated by Balanid barnacles and *Bowerbankia* hydroids. Other species found included the non-native hydroid *Cordylophora caspia* (a low salinity indicator species), the mussel *Geukensia demissa*, and numerous species of flatworms.

**Station 2: Bootleggers Marina, India Point, Providence**

This fouling community, found on floating docks, is depauperate in both richness and diversity. Predominate species found are the non-native anemone *Diadumene lineata*, the tunicate *Molgula manhattensis*, small-sized *Mytilus edulis* mussels, red filamentous algae, *Ulva lactuca* and some brown filamentous algae, all on a thin bed of Balanid barnacles. Among this fouling are numerous other commonly associated species such as various polychaete worms, the crab *Carcinus maenas*, Palaemonid shrimp and various flatworms.

**Station 3: Edgewood Yacht Club, Warwick**

A relatively diverse fouling community on floating docks. It consists of a thick mat of the mussel *Mytilus edulis* with small numbers of barnacles, hydroids, sponges, nereid worms, amphipods, crabs, tunicates (mostly *Molgula manhattensis*) and *Crepidula* snails.

**Station 4: Cove Haven Marina, Barrington**

This diverse community is heavily fouled on the sides of several floating docks. On a thick base of the mussel *Mytilus edulis* are found several species in very great abundance, including the snail *Crepidula fornicata*, the tunicate *Molgula manhattensis*, the bryozoan *Bowerbankia* sp. and the anemone *Diadumene lineata*, with numerous other typical fouling species associated.

**Station 5: Coasters Harbor Island Marina, Newport**

A densely encrusted and diverse community on numerous long floating docks. Predominant species include several species of tunicates (*Styela clava*, *Diplosoma listerianum*, *Botrylloides violaceus*, *Ascidia aspersa*, *Ciona intestinalis* and *Didemnum vexillum*), algae, bryozoa (*Bugula* spp.), hydrozoa, amphipods (particularly *Caprella mutica*) and several decapod crab species living among mats of *Mytilus edulis* mussels.

**Station 6: Roger Williams University Learning Platform, Bristol**

This moderately diverse community is found on small floating docks and is chiefly populated by *Mytilus edulis* mussels, *Crepidula* snails, *Ulva lactuca* algae and barnacles. Other common species at the site include various hydroids and associated amphipods, the snail *Urosalpinx cinerea*, the tunicate *Botrylloides violaceus*, and the crabs *Carcinus maenas* and *Libinia emarginata*.

**Station 7: Colt State Park, Bristol**

This small and moderately diverse fouling community encrusts a small floating dock and associated pilings. The primary composition includes mats of the mussel *Mytilus edulis*, the tunicate *Ascidia aspersa* and *Crepidula* snails. Other common species include the algae *Ulva lactuca*, nereid polychaete worms, *Haliclona* sponges and the snail *Littorina littorea* with *Semibalanus balanoides* and *Cthamalus fragilis* barnacles on the pilings.

**Station 8: Wickford Marina, Wickford**

This diverse fouling community found on floating docks is composed primarily of the mussel *Mytilus edulis*, forming the typical living substrate for the community. Other predominate species are *Molgula manhattensis* and small *Styela clava* tunicates, the algae *Ulva lactuca*, the anemone *Diadumene lineata*, the snail *Crepidula fornicata*, the tunicate *Botrylloides violaceus* and the sponge *Haliclona loosanoffi*.

The rest of the community consists of numerous species common to such complex fouling habitats; nereid polychaete worms, various bryozoa, hydrozoa & associated amphipods and decapod crabs.

**Station 9: North Kingstown Town Marina, N. Kingstown**

This fouling community on floating docks is relatively diverse despite an apparently high amount of water pollution associated with the local boat traffic. Major species found include abundant amounts of the anemone *Diadumene lineata*, the mussel *Mytilus edulis*, and the tunicate *Molgula manhattensis*. Other common organisms include hydrozoa, a few other tunicate spp., nereid polychaete worms and *Crepidula* spp. snails as well as some *Asterias forbesi* seastars.

**Station 10: Warwick Cove Marina, E. Greenwich**

This diverse fouling community is found encrusted on the sides of floating docks. Most common among those species found are several spp. of tunicates (primarily *Molgula manhattensis*, *Styela* spp., & *Botryllus schlosseri*), various bryozoa, hydrozoa and decapod crabs.

**Station 11: Fort Getty Pier, Jamestown**

This community, found on dock pilings subject to tidal fluctuations, is not particularly diverse. Predominant are various species of algae and barnacles, hydrozoa & associated amphipod crustacea, bryozoa, *Crepidula* spp., *Botrylloides violaceus*, *Styela clava*, several decapod crustacea spp. and several polychaete spp.

**Station 12: Narragansett Bay National Estuarine Research Reserve System/ T-wharf Dock, Prudence Island**

This fairly diverse community is sited on a small floating dock and associated pilings at the end of a long wharf. The dominant species is *Mytilus edulis*, which provides a base for the many other species found. Most common are the tunicate *Botrylloides violaceus*, the barnacle *Semibalanus balanoides*, and various small Xanthid mud crabs as well as the various fouling organisms typically found in the *M. edulis* matrix.

**Station 13: Narragansett Bay National Estuarine Research Reserve System/ Potter's Cove, Prudence Island**

This community, though a smaller, more sheltered, floating dock than at the other Prudence Island site, is comparable in biotic composition, being again comprised of a *Mytilus edulis*-based complex substrate.

## Results

One hundred and forty-nine species were catalogued during the four-day RAS expedition survey (**Appendices 1 & 2**). Of those, twenty-two species in seven phyla were identified as non-indigenous, most of them being common at the sites visited (**Table 4**). In addition to the species conservatively labeled as non-indigenous, another sixteen species in four phyla presently classified as cryptogenic were recorded (**Table 4 & Appendix 1**). Our knowledge of the native range of these species is not complete enough to accurately classify them as locally native or otherwise, and therefore may constitute a larger number of non-indigenous species sampled during the survey.

**Table 4** contains a complete listing of each non-indigenous species found, including the date first recorded in northeastern U.S. waters, the native range and the vector for introduction, and the results of the RAS including the observed distribution and abundance at our sampled sites and the possible impact the species may have. This information was determined by a literature review of the historic record and consultations with researchers with expert knowledge of introduced species, in particular Dr. James T. Carlton who developed and provided the primary sources. **Table 5** contains detailed descriptions and images of the non-native species.

One interesting result was that nearly all the Ascidians (tunicates) recorded were non-indigenous. A total of nine Ascidian species were found, only one of which, *Molgula manhattensis*, is native. *Botryllus schlosseri*, *Ciona intestinalis*, and *Styela canopus*, are three non-native species that have been here for well over a century, leading to a common misconception that they are native. The remaining non-native species, mostly highly successful invaders, were introduced over the past few decades.

Phylum Arthropoda was also well represented in the RAS findings, with six non-native species, as well as two cryptogenic species reported. Some of these species, in particular the Asian shore crab, *Hemigrapsus sanguineus*, and the European green crab, *Carcinus maenas*, afford some of the best opportunities for acquiring a complete picture of the impact these introduced species have on their new habitats. Thus far, research has shown that they have a significant and generally negative impact (Jensen et al, 2002; Lohrer & Whitlatch, 2002). *Hemigrapsus sanguineus*, in particular, has come under much scrutiny and has been shown to have so completely out-competed the native crabs, such as the rock crab *Cancer irroratus*, that *H. sanguineus* is now essentially the sole crab species found in most Narragansett Bay rocky intertidal habitats, and in very high densities (Lohrer, 2001).

## Discussion

A rapid assessment survey (RAS), by its very nature, cannot be viewed as a complete and comprehensive survey of the biota of Narragansett Bay or any other ecosystem. A RAS study should be seen as an important preliminary tool for the analysis of biotic diversity, particularly when trying to identify non-indigenous species (Mooney & Hobbs, 2000).

Essentially, it is the vanguard of an arsenal of investigative tools at the disposal of researchers and managers. The results of the Narragansett Bay RAS are an invaluable first step toward gaining a thorough understanding of newly introduced marine species in Narragansett Bay, as well as an all-encompassing, and hitherto lacking, description of the biotic diversity of the bay.

The distributions recorded by the Narragansett Bay RAS for the non-indigenous species, likely do not represent the total distribution of any of these species in the bay. This study focused on collecting specimens on easy to access floating docks, a particularly unnatural habitat, as there is no exposure to true tidal cycles, and thus may present a somewhat skewed picture of true species distribution and abundance. And the skewing may not be in one direction. Species for which floating docks provide significant ecological advantages throughout their life-cycles are typically present if not abundant, and are readily observed. Those that require different habitats during various developmental stages may not be as readily observed. Non-sessile species may also simply fall off or otherwise exit a floating dock and not be counted despite their presence nearby. Also, due to the qualitative nature of recording species abundance during the survey, it is important to view species abundance and distribution as an indicator of general occurrence, lacking the exactness of a more detailed, in depth follow-up study. Two non-indigenous examples illustrate this; both the algae *Grateloupia turuturu* and the snail *Littorina littorea* have widespread distribution in Narragansett bay and are generally found in high abundances, yet the RAS found them at only one and two sites respectively, and in relatively low abundances (**Table 4**).

Almost all of the species identified as non-indigenous by the expedition have been previously reported as present in Narragansett Bay, with the few exceptions being the isopod *Ianiropsis* sp. (NB: recent work has shown this is likely *I. serricaudis*, a native of the northwestern Pacific) and some of the other species for which specimens were unclear or where further analysis hasn't been conducted such as many of the Platyhelminthe and Nemertine worms. Such gaps in the record of the 2000 Narragansett Bay RAS underscore the problem of a lack of qualified taxonomists.

The literature related to marine organisms in New England coastal waters indicates that two of the non-indigenous species identified by the survey were present as early as 1838 (**Table 4**). Of the twenty-two non-indigenous species identified for which origin and date of first appearance can be generally determined, nine are identified as 19<sup>th</sup> Century, or earlier, introductions. Of that number, six are identified as having a native range in European coastal waters or nearby central Atlantic waters, and the other two species are reported native to the Pacific. Three 20<sup>th</sup> Century introductions are reported in the 1950s; two in the 1970s, three in the 1980s and four since 1990; the most recent introductions being within the past few years. As illustrated in **Figure 2**, it is worth noting that the rate of introductions increased after the 1970s (half the introduced species found by the RAS were introduced post-1970). Furthermore, it is interesting to note an increase in introductions from Pacific waters since the mid-20<sup>th</sup> Century. Of the twelve species introduced since 1950, nine are reported as native to Pacific waters, though some were first observed in Europe prior to arriving in the Northeastern United States.

This increase in non-indigenous species over the past few decades correlates well with the increase in global trade, particularly modern sea traffic (and practices, i.e. ballast water), one of the most significant vectors of introduction repeatedly linked to marine non-indigenous species introductions. The large spike in the single decade of the 1950s is also observed in other such studies (Coles et al, 1999), and is generally thought to be the result of the massive global traffic that occurred as a result of World War II and the subsequent increase in global commerce. Though many of these introductions may be range extensions from nearby regional introductions, it is no surprise that Narragansett Bay would see its share of marine introductions during the war, as Rhode Island was a major naval hub during the war and in the decades that followed. Another factor to consider in the recent increase in the reporting of new introductions is the increase in the number of scientists studying non-indigenous species as their myriad impacts and the need for solutions has become more evident. Several of these recorded species may have been making their home in Narragansett Bay for longer than we realize, as a result of a lack of focus and expertise on this subject.

### **Future Research**

Bearing in mind the limitations of rapid assessment surveys, the majority of future research needs entail the placement of this study in the full and proper framework of a complete analysis of Narragansett Bay biodiversity. This includes the development of a comprehensive bibliography of existing research and merging preexisting data sets with the RAS findings. For example, different departments in the University of Rhode Island (the Graduate School of Oceanography, Biological Sciences, Fisheries, to name a few) have been conducting survey studies; some of them, such as the Jeffries Fish Trawl Survey, have been running for several decades. These may be focused on one or a few species, yet still offer tremendous complementary value. Individual researchers at URI as well as other academic and research centers also have data sets that would be of great value. Hopefully, an effort can be made to attempt to compile and synthesize these various resources toward the final goal. Further effort should be put into filling in those gaps that remain, especially in more natural habitats.

The largest research need in the growing field of invasive/non-indigenous research is a tremendous increase in financial support and basic development of taxonomic resources. The field of taxonomy, central to the study of diversity and the impact of non-indigenous species, is a dwindling field that made this study much more laborious than necessary. There are few experts on the vast array of taxa found in our seas, and these researchers are often too overworked to be easily available to take part in important endeavors such as this RAS. Much of the data from specimens incorporated into this report took well over eighteen months to finalize. The large numbers of species labeled cryptogenic in this report particularly point to the lack of a proper body of literature to turn to for a thorough analysis of biota. Without this framework of knowledge, even the most comprehensive field survey will not provide the necessary information to researchers and managers.

**Table 4.** Non-indigenous species identified by Narragansett Bay RAS Expedition, 2000. This table includes date of first report in Northeastern U.S. waters, native origin, vector of introduction, RAS observed distribution in Narragansett Bay with overall abundance at found sites, and possible impact. See appendices 1 and 2 for further information.

| <i>Species</i>   | Date of introduction, Origin<br>Distribution (# sites)- Abundance | Vector of introduction<br>Possible impact   |
|--|---|---|
| <b>Algae</b>   |   |   |
| <i>Codium fragile tomentosoides</i> (Suringar, 1867)   | 1957, NW.Pacific<br>Central/lower bay (3 sites)- Uncommon         | Probably ship fouling or aquaculture importation<br>Appears to be an aggressive competitor                |
| <i>Grateloupia turuturu</i> Yamada, 1941   | 1996, W.Pacific<br>Lower bay (1 site)- Uncommon                   | Probably ship fouling, aquaculture importation or ballast water<br>Appears to be an aggressive competitor |
| <b>Porifera</b>  |   |   |
| <i>Halichondria bowerbanki</i> Burton, 1930  | 1958, Europe<br>Throughout bay (8 sites)- Common                  | Probably ship fouling<br>Unknown impact   |
| <b>Cnidaria</b>  |   |   |
| <i>Cordylophora caspia</i> (Pallas, 1771)  | 1860, E.Europe<br>Upper bay (1 site)- Rare                        | Probably ballast water or ship fouling<br>Probable habitat change, competition                            |
| <i>Garveia franciscana</i> (Torrey, 1902)  | 1950, E. Pacific<br>Upper bay (1 site)- Rare                      | Probably ballast water or ship fouling<br>Probable competition, predation and habitat change              |
| <i>Diadumene lineata</i> Merrill, 1870   | 1892, W. Pacific<br>Throughout bay (7 sites)- Common              | Ship fouling<br>Probable competition, predation and habitat change;<br>Nuisance as a fouling organism     |
| Eight probable cryptogenic species in the following genera:<br><i>Laomedea, Clytia, Obelia, Gonothyraea, Halecium, Dynamena.</i> |   |   |
| <b>Lophophorates (bryozoa, ectoprocta, etc.)</b>   |   |   |
| <i>Bugula neritina</i> (Linnaeus, 1758)  | 1993, Pacific<br>Lower bay (1 site)- Uncommon                     | Probably ship fouling<br>A highly competitive nuisance fouling organism                                   |
| <i>Barentsia benedeni</i> (Foettinger, 1887)   | Early 20thC, Europe<br>Upper bay (1 site)- Rare                   | Probably ship fouling<br>Unknown  |
| Six probable cryptogenic species in the following genera:<br><i>Aeverillia, Bowerbankia, Bugula and Cryptosula</i>               |   |   |
| <b>Mollusca</b>  |   |   |
| <i>Littorina littorea</i> (Linnaeus, 1758)   | 1840, Europe<br>Central bay (2 sites)- Uncommon                   | Probably ship fouling   |

## Arthropoda

|   |  |
|---|--|
| <i>Chthamalus fragilis</i> Darwin, 1854<br>1898, Central Atlantic<br>Central bay (1 site)- Uncommon             | Probably ship fouling or ballast water<br>Probable competition, predation and habitat change |
| <i>Caprella mutica</i> Schurin, 1935<br>1990's, Japan<br>Central & lower bay (6 sites)- Common                  | Probably ballast water or aquaculture importation<br>Probable competition and predation      |
| <i>Carcinus maenas</i> (Linnaeus, 1758)<br>1841, Europe<br>Throughout bay (6 sites)- Common                     | Probably ship fouling or boring communities  |
| <i>Hemigrapsus sanguineus</i> (de Haan, 1835)<br>1988, W. Pacific<br><br>Central & lower bay (8 sites)- Common. | Probably introduced by ballast water or ship fouling;  |

|  |  |
|--|--|
| Janirid isopod (likely <i>Ianiropsis serricaudis</i> )<br>Recent, Unknown<br>Central & lower bay (2 sites)- Uncommon | Unknown, probably ship fouling<br>Probable competition and predation |
| Two probable cryptogenic species: <i>Jassa staudei</i> and <i>Paracaprella tenuis</i>                                |  |

## Asciidiacea

|   |  |
|---|--|
| <i>Asciidiella aspersa</i> (Muller, 1776)<br>1983, Europe<br>Central & lower bay (6 sites)- Common                                | Probably ship fouling or ballast water<br>Possible habitat change, competition                       |
| <i>Botrylloides violaceus</i> Oka, 1927<br>1972, W.Pacific<br>Throughout bay (8 sites)- Common                                    | Probably ship fouling or aquaculture importation<br>An abundant, highly competitive fouling organism |
| <i>Botryllus schlosseri</i> (Pallas, 1774)<br>1838, poss. Europe<br>Throughout bay (7 sites)- Common                              | Probably ship fouling or aquaculture importation<br>Possible habitat change, competition             |
| <i>Ciona intestinalis</i> (Linnaeus, 1767)<br>Unk. introduction date, Northern Europe<br>Central and lower bay (2 sites) – Common |  |
| <i>Didemnum vexillum</i> Hartmeyer, 1909<br>~1990s, W. Pacific<br>Lower bay (1 site)- Uncommon                                    |  |
| <i>Diplosoma listerianum</i> (Milne-Edwards, 1841)<br>1981, poss. Europe<br>Lower bay (1 site)- Rare                              | Probably ship fouling or aquaculture importation<br>Possible habitat change, competition             |
| <i>Styela canopus</i> (Savigny, 1816)<br>1852, W. Pacific<br>Central bay (2 sites)- Rare  | Possible habitat change, competition   |
| <i>Styela clava</i> Herdman, 1881<br>1970, Pacific<br>Central & lower bay (6 sites)- Common                                       | Possible habitat change, competition; known nuisance species   |

**Table 5.** Descriptions and images of non-indigenous species identified by Narragansett Bay RAS

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**Algae**

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*Codium fragile tomentosoides* (Suringar, 1867)

Green alga with a dichotomously branching bushy shape (generally less than .5m tall) comprised of sponge-like, dark green cylindrical branches.



(image credit: MIT Sea Grant)

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*Grateloupia turuturu* (Yamada, 1941)

(= *G. doryphora*)

Red alga with a variable, foliose body plan. The slippery blades can vary in shape and color. Can be up to 2m in length, generally less than half that.



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**Porifera**

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*Halichondria bowerbanki* (Burton, 1930)

An encrusting sponge with extremely variable color and form. Generally a yellow to greenish colored thin crust with several prominent pores and a bread-crumbs like texture. Can be 30 cm wide and 5 cm thick.



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**Cnidaria**

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*Cordylophora caspia* (Pallas, 1771)

A tall, erect colonial hydroid, generally growing up to 10 cm high, branching occasionally from alternate sides, each branching having a terminal polyp ringed at the base and holding up to 3 pear-shaped reproductive bodies on short stalks. The polyps are brownish-white to pale pink with 12-16 tentacles.



(image credit: Horia Galea)

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*Garveia franciscana* (Torrey, 1902)

A highly branched colonial athecate hydroid with bright orange feeding and reproductive polyps. Each feeding polyp is on the end of a short stem that consists of many contiguous rings stacked on top of each other.



(image credit: Leslie Harris, NHMLAC)

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*Diadumene lineata* Merrill, 1870 (=Haliplanella luciae)

Anemone with a dark olive or ruddy brown body and orange, yellow, red or white vertical lines on the base of the body, with numerous pale colored tentacles up to 2 cm tall, 5 mm wide.



(image credit: Robert Buchsbaum)

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### **Lophophorates (bryozoa, entoprocta, etc.)**

*Bugula neritina* (Linnaeus, 1758)

A tall, erect bryozoan forming red-brown colonial tufts. Large zooids that alternate biserially on branches, with individual zooids tapering at the base. It differs from other species in this genus in that it possesses no avicularia and no spines, instead having sharp points in the distal corners of the zooids.



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*Barentsia benedeni* (Foettinger, 1887)

Small (less than 2mm in length) branching colonial entoproct, generally white or pale yellow in color. A circle of tentacles surround their cup-like upper portion. The zooids have a clear circle of tentacles on the top and a stalk lacking in spines.



(credit: Gregory M. Ruiz, SERC)

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## Mollusca

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*Littorina littorea* (Linnaeus, 1758)

A common snail that is up to 3 cm in spire length and generally brown black or grey. Spire is generally very pointy, especially when young. Older individuals have smooth shells with more rounded, worn spires.



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## Arthropoda

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*Chthamalus fragilis* (Darwin, 1854)

A small barnacle, usually up to 1 cm in diameter at the base with a grey, beige or brown color. Two plates on either end are similarly sized and overlapped by four larger side plates.



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*Caprella mutica* (Schurin, 1935)

Reddish brown translucent Caprellid amphipod (commonly called a skeleton shrimp) with long and slender body shape. Have distinctive small spines along the backs of main body segments, and very long antennae and pronounced claws. Males can be upwards of 5cm in length with females usually half that length.



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*Carcinus maenas* (Linnaeus, 1758)

Dark to medium green crabs with yellow or brown blotches, occasionally with orangish-red underside. The carapace is up to 8 cm in width and relatively oval-shaped. **Five** teeth along each side of the carapace, behind the eye and three teeth in between each eye.



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*Hemigrapsus sanguineus* (de Haan, 1835)

Small crabs with mottled olive green- to brownish carapace up to 3.5 cm across with brown and white bands on legs. Have **three** teeth behind each eye on either side of the carapace, and a small hard bulge of tissue in between the pincers on the claws.



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*Ianiropsis* sp. (probably *I. serricaudis* Gurjanova, 1936)

Samples for description are based on specimens of *I. serricaudis* collected post survey (and now common at most sites), as no survey specimens are available for identification. Small isopod with very long secondary antennae, roughly equal to main body length. Very large mandibles. Generally four distinct serrations on the lateral margins of each side of the pleotelson.



(image is of preserved and stained *I. serricaudis* collected in 2010)

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**Asciacea**

*Botrylloides violaceus* Oka, 1927 (previously misidentified as *B. diegensis*)

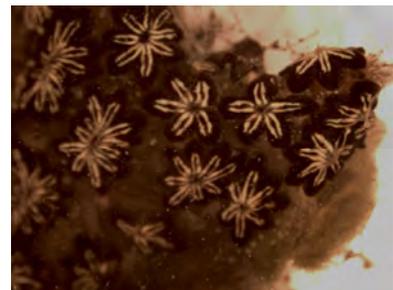
An encrusting colonial tunicate, generally bright orange but can vary from deep red to white. Colonies can be well over 10 cm in width with very obvious zooids sometimes in serpentine twisting rows.



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*Botryllus schlosseri* (Pallas, 1774)

Dark brown, green, or purple-ish colored encrusting colonial tunicate with gold-highlighted zooids. Colony can be up to 7.5 cm in width.



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*Didemnum vexillum* (Hartmeyer, 1909)

Cream or pale yellow colored colonial tunicate with very small individual zooids. Can reach over 30 cm across, with long rubbery lobes draping down.

Note: after some initial debate over the specific identity, morphological and molecular study have confirmed this is *D. vexillum*, and recent molecular work identifies its origin as the northwestern Pacific.



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*Diplosoma listerianum* (Milne-Edwards, 1841)

A gelatinous, encrusting colonial tunicate that is generally a translucent greyish or off-white in color. The colony is made up of very small zooids that are difficult to see, often clustered around several excurrent openings that are more generally mounded.



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*Asciidiella aspersa* (Muller, 1776)

This species is solitary but commonly found in dense unfused aggregations. The body is ovoid in shape, up to 130 mm long and usually attached to the substratum by the left side. The tunic that encloses the often pinkish red body is firm to touch, thick, rough and gristly, and is translucent white or grey in color, often with attached detritus.



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*Ciona intestinalis* (Linnaeus, 1767)

A solitary sea squirt that is nearly transparent in color with pronounced gold rings around both the incurrent and excurrent openings, often with small red dots at each notch. Commonly reaching over 10 cm in length.



(photo credit: Arjan Gittenberger)

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*Styela clava* (Herdman, 1881)

A solitary sea squirt, up to 15 cm in length with a notable stalk that attaches to substrate. Generally brown or yellow in color with a rough, and wrinkled surface.



(credit: Melissa Frey, Royal BC Museum, Canada)

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*Styela canopus* (Savigny, 1816) (= *S. partita*)

A solitary sea squirt, up to 2 cm in length. Similar to *S. clava* in general appearance but is generally much smaller and lacks a stalk; it attaches directly to the substrate.



(credit: Rosana M. Rocha, Universidade Federal do Paraná, Brasil)

**Figure 2: Native origin and Initial record of RAS 2000 non-native species**

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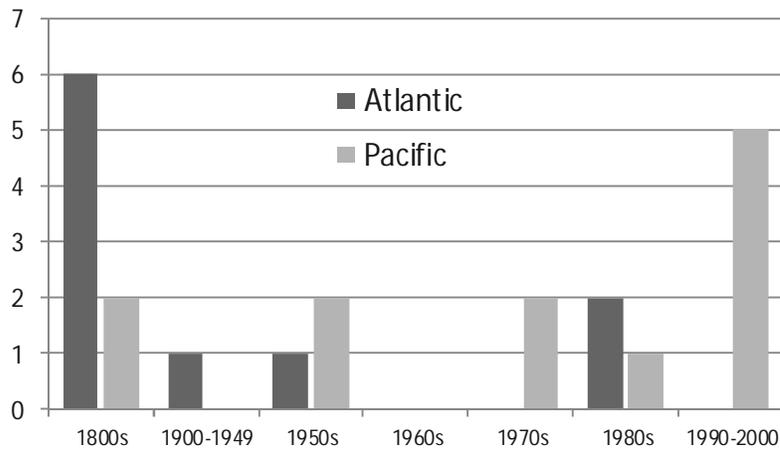


Figure 2 shows the native oceanic origin, and the general time of first record in New England, of 22 non-indigenous species found during the Narragansett Bay Rapid Assessment Survey, August 2000. For ease of presentation, species considered indigenous to the Atlantic (primarily European species) are grouped together, as are species indigenous to the Pacific. The isopod *Ianiropsis* sp., is categorized as a recent arrival from the Pacific, given the tentative species identification of *I. serricaudis*, a native of the Sea of Japan.

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**Appendix 1:** Comprehensive species list by taxa catalogued by the Narragansett Bay RAS expedition (2000), with status as introduced or cryptogenic and introduction date and origin.

| <u>Taxa</u>               | <u>Number</u> | <u>Genus</u>                     | <u>species</u>       | <u>Introduced?</u>              |
|---------------------------|---------------|----------------------------------|----------------------|---------------------------------|
|                           | 1.00          | Cyanobacteria                    | unk.                 | unk.                            |
| <b>K.Protista-ciliate</b> |               |                                  |                      |                                 |
|                           | 2.00          | <i>Zoothamnium</i>               | sp.                  | unk.                            |
| <b>K.Protista- algae</b>  |               |                                  |                      |                                 |
|                           | 2.10          | <i>Codium</i>                    | <i>fragile</i>       | yes (1957, NW Pacific)          |
|                           | 2.10          | <i>Bryopsis</i>                  | sp.                  | no                              |
|                           | 2.10          | <i>Enteromorpha</i> <sup>3</sup> | sp.                  | no                              |
|                           | 2.10          | <i>Ulva</i>                      | <i>lactuca</i>       | no                              |
|                           | 2.20          | <i>Fucus</i>                     | spp.                 | no                              |
|                           | 2.20          | Phaeophyta-filamentous           | unk.                 | unk.                            |
|                           | 2.30          | <i>Agardhiella</i>               | sp.                  | no                              |
|                           | 2.30          | <i>Chaetomorpha</i>              | sp.                  | no                              |
|                           | 2.30          | <i>Champia</i>                   | <i>parvula</i>       | no                              |
|                           | 2.30          | <i>Grateloupia</i>               | <i>turuturu</i>      | yes (1996, W.Pacific)           |
|                           | 2.30          | <i>Polysiphonia</i>              | spp.?                | no                              |
| <b>Porifera</b>           |               |                                  |                      |                                 |
|                           | 4.00          | <i>Cliona</i>                    | sp.                  | none                            |
|                           | 4.00          | <i>Halichondria</i>              | <i>bowerbankia</i>   | yes (1958, Europe)              |
|                           | 4.00          | <i>Haliclona</i>                 | sp.                  | none known                      |
|                           | 4.00          | <i>Leucosolenia</i>              | <i>botryoides</i>    | no                              |
|                           | 4.00          | <i>Microciona</i>                | <i>prolifera</i>     | no                              |
|                           | 4.00          | <i>Scypha</i>                    | <i>ciliata</i>       | no                              |
| <b>Cnidaria</b>           |               |                                  |                      |                                 |
|                           | 5.10          | <i>Laomedea</i>                  | <i>calciolifera</i>  | cryptogenic (1875, NE Atlantic) |
|                           | 5.10          | <i>Clytia</i>                    | <i>hemisphaerica</i> | cryptogenic (1859)              |
|                           | 5.10          | <i>Cordylophora</i>              | <i>caspia</i>        | yes (1860, E.Europe)            |
|                           | 5.10          | <i>Ectopleura</i>                | <i>crocea</i>        | no                              |

<sup>3</sup> The genus *Enteromorpha* is obsolete and all species formerly classified under this genus are now classified under the genus *Ulva*.

|  |                      |                    |   |
|--|----------------------|--------------------|---|
| 5.10                                     | <i>Eudendrium</i>    | <i>carneum</i>     | no  |
| 5.10                                     | <i>Hydractinea</i>   | <i>echinata</i>    | no  |
| 5.10                                     | <i>Hydractinea</i>   | <i>polyclina</i>   | no  |
| 5.10                                     | <i>Obelia</i>        | <i>articulata</i>  | probably cryptogenic                                      |
| 5.10                                     | <i>Obelia</i>        | <i>bidentata</i>   | probably cryptogenic                                      |
| 5.10                                     | <i>Obelia</i>        | <i>longissima</i>  | probably cryptogenic                                      |
| 5.10                                     | <i>Zanclaea</i>      | <i>gemmosa</i>     | no  |
| 5.10                                     | <i>Garveia</i>       | <i>franciscana</i> | yes, (~1950, E. Pacific)<br>cryptogenic (1874, N. Europe) |
| 5.10                                     | <i>Gonothyraea</i>   | <i>loveni</i>      | cryptogenic (1863)  |
| 5.10                                     | <i>Halecium</i>      | <i>halecinum</i>   | cryptogenic (1858)  |
| 5.10                                     | <i>Dynamena</i>      | <i>pumila</i>      | cryptogenic (1858)  |
| 5.30                                     | <i>Aurelia</i>       | <i>aurita</i>      | no  |
| 5.40                                     | <i>Diadumene</i>     | <i>leucolena</i>   | no  |
| 5.40                                     | <i>Diadumene</i>     | <i>lineata</i>     | Yes (1892, probably Asia)                                 |
| 5.40                                     | <i>Metridium</i>     | <i>senile</i>      | no  |
| <b>Ctenophora</b>                        |                      |                    |   |
| 6.00                                     | <i>Mnemiopsis</i>    | <i>leidyi</i>      | no  |
| <b>Platyhelminthes &amp; Nemertinea*</b> |                      |                    |   |
| 7.00                                     | <i>Cylindrostoma</i> | sp.                | unk.  |
| 7.00                                     | Dalyellioid          | #1                 | unk.  |
| 7.00                                     | Dolichomacrostomid   | (immature)         | unk.  |
| 7.00                                     | <i>Euplana</i>       | <i>gracilis</i>    | no  |
| 7.00                                     | Kytorhynchid         | unk.               | unk.  |
| 7.00                                     | <i>Macrostomum</i>   | sp.                | unk.  |
| 7.00                                     | <i>Pentacoelum</i>   | <i>punctatum</i>   | no  |
| 7.00                                     | <i>Plagiostomum</i>  | #1                 | unk.  |
| 7.00                                     | <i>Plagiostomum</i>  | #3                 | unk.  |
| 7.00                                     | <i>Plicastoma</i>    | sp.                | unk.  |
| 7.00                                     | <i>Promesostoma</i>  | #1                 | unk.  |
| 7.00                                     | <i>Promesostoma</i>  | #3                 | unk.  |
| 7.00                                     | <i>Stylochus</i>     | <i>ellipticus</i>  | no  |
| 7.00                                     | <i>Tetrastemma</i>   | sp.                | unk.  |
| 7.00                                     | Typhloplanoid        | (juvenile)         | unk.  |

7.00 Aceol unk. unk  
 \*Complete analysis is in progress, but preliminary data indicates no non-native spp.

**Lophophorates (Bryozoans, Ectoprocts, etc.)**

|      |                      |                    |                           |
|------|----------------------|--------------------|---------------------------|
| 8.00 | <i>Aeverillia</i>    | <i>armata</i>      | cryptogenic               |
| 8.00 | <i>Bowerbankia</i>   | <i>gracilis</i>    | cryptogenic               |
| 8.00 | <i>Bowerbankia</i>   | <i>imbricata</i>   | cryptogenic               |
| 8.00 | <i>Bowerbankia</i>   | sp. 3              | no                        |
| 8.00 | <i>Bugula</i>        | <i>neritina</i>    | yes (1993, Pacific)       |
| 8.00 | <i>Bugula</i>        | <i>simplex</i>     | cryptogenic               |
| 8.00 | <i>Bugula</i>        | <i>stolonifera</i> | cryptogenic               |
| 8.00 | <i>Conopeum</i>      | <i>tenuissimum</i> | no                        |
| 8.00 | <i>Cryptosula</i>    | <i>pallasiana</i>  | cryptogenic               |
| 8.00 | <i>Electra</i>       | <i>pilosa</i>      | no                        |
| 8.00 | <i>Schyzoporella</i> | <i>variabilis</i>  | no                        |
| 8.10 | <i>Barentsia</i>     | <i>benedeni</i>    | yes (Early 20thC, Europe) |

**Annelida**

|      |                    |                  |      |
|------|--------------------|------------------|------|
| 9.10 | <i>Capitella</i>   | sp.              | no   |
| 9.10 | <i>Harmothoe</i>   | <i>imbricata</i> | no   |
| 9.10 | <i>Hydroides</i>   | <i>dianthus</i>  | no   |
| 9.10 | <i>Lepidonotus</i> | <i>squamatus</i> | no   |
| 9.10 | <i>Nereis</i>      | <i>succinea</i>  | no   |
| 9.10 | <i>Nereis</i>      | <i>pelagica</i>  | no   |
| 9.10 | <i>Polydora</i>    | <i>cornuta</i>   | no   |
| 9.10 | <i>Spio</i>        | sp.              | no   |
| 9.20 | Oligochaeta        | unk.             | unk. |

**Mollusca**

|       |                    |                    |                      |
|-------|--------------------|--------------------|----------------------|
| 12.20 | <i>Anachis</i>     | <i>translirata</i> | no                   |
| 12.20 | <i>Bittium</i>     | <i>alternatum</i>  | no                   |
| 12.20 | <i>Eubbranchus</i> | <i>exiguus</i>     | no                   |
| 12.20 | <i>Littorina</i>   | <i>littorea</i>    | yes** (1840, Europe) |
| 12.20 | <i>Ilyanassa</i>   | <i>obsoleta</i>    | no                   |
| 12.20 | <i>Lacuna</i>      | <i>vincta</i>      | no                   |
| 12.20 | <i>Astyris</i>     | <i>lunata</i>      | no                   |

|       |                    |                    |    |
|-------|--------------------|--------------------|----|
| 12.20 | <i>Odostomia</i>   | <i>bisuturalis</i> | no |
| 12.20 | <i>Urosalpinx</i>  | <i>cinerea</i>     | no |
| 12.50 | <i>Crassostrea</i> | <i>virginica</i>   | no |
| 12.50 | <i>Crepidula</i>   | <i>fornicata</i>   | no |
| 12.50 | <i>Crepidula</i>   | <i>plana</i>       | no |
| 12.50 | <i>Geukensia</i>   | <i>demissa</i>     | no |
| 12.50 | <i>Hiatella</i>    | <i>arctica</i>     | no |
| 12.50 | <i>Mya</i>         | <i>arenaria</i>    | no |
| 12.50 | <i>Mytilus</i>     | <i>edulis</i>      | no |
| 12.60 | <i>Polycerella</i> | <i>emertoni</i>    | no |
| 12.60 | <i>Tenellia</i>    | <i>adspera</i>     | no |
| 12.70 | <i>Omalogyra</i>   | <i>atomus</i>      | no |

### Arthropoda

|       |                     |                                 |                                 |
|-------|---------------------|---------------------------------|---------------------------------|
| 13.22 | <i>Balanus</i>      | <i>crenatus</i>                 | no                              |
| 13.22 | <i>Balanus</i>      | <i>eburneus</i>                 | no                              |
| 13.22 | <i>Balanus</i>      | <i>Improvises</i>               | no                              |
| 13.22 | <i>Chthamalus</i>   | <i>Fragilis</i>                 | yes (1898 Pacific)              |
| 13.22 | <i>Semibalanus</i>  | <i>Balanoides</i>               | No                              |
| 13.23 | <i>Palaemonetes</i> | <i>Pugio</i>                    | no                              |
| 13.23 | <i>Palaemonetes</i> | <i>Vulgaris</i>                 | no                              |
| 13.26 | <i>Erichsonella</i> | <i>Filiformis</i>               | no                              |
| 13.26 | <i>Ianiropsis</i>   | sp. (prob. <i>serricaudis</i> ) | yes (unknown, prob. W. Pacific) |
| 13.26 | <i>Idotea</i>       | <i>Baltica</i>                  | No                              |
| 13.27 | <i>Ampithoe</i>     | <i>Longimana</i>                | no                              |
| 13.27 | <i>Ampithoe</i>     | <i>Valida</i>                   | no                              |
| 13.27 | <i>Hyale</i>        | <i>Plumulosa</i>                | no                              |
| 13.27 | <i>Corophium</i>    | <i>Acutum</i>                   | no                              |
| 13.27 | <i>Corophium</i>    | <i>ascherusicum</i>             | no                              |
| 13.27 | <i>Corophium</i>    | <i>Insidiosum</i>               | no                              |
| 13.27 | <i>Elasmopus</i>    | <i>Levis</i>                    | no                              |
| 13.27 | <i>Eobrolgus</i>    | <i>Spinusus</i>                 | no                              |
| 13.27 | <i>Gammarus</i>     | <i>mucronatus</i>               | no                              |
| 13.27 | <i>Gammarus</i>     | <i>Oceanicus</i>                | no                              |

|       |                        |                    |                        |
|-------|------------------------|--------------------|------------------------|
| 13.27 | <i>Jassa</i>           | <i>Marmorata</i>   | no                     |
| 13.27 | <i>Jassa</i>           | <i>Staudei</i>     | cryptogenic            |
| 13.27 | <i>Lysianopsis</i>     | <i>Alba</i>        | No                     |
| 13.27 | <i>Melita</i>          | <i>Nitida</i>      | no                     |
| 13.27 | <i>Microdeutopus</i>   | <i>Anomalus</i>    | no                     |
| 13.27 | <i>Microdeutopus</i>   | <i>gryllotalpa</i> | no                     |
| 13.27 | <i>Caprella</i>        | <i>Mutica</i>      | yes (1990s, Japan)     |
| 13.27 | <i>Caprella</i>        | <i>Penantis</i>    | No                     |
| 13.27 | <i>Paracaprella</i>    | <i>Tenuis</i>      | cryptogenic            |
| 13.28 | <i>Carcinus</i>        | <i>Maenas</i>      | yes (1841, Europe)     |
| 13.28 | <i>Callinectes</i>     | <i>Sapidus</i>     | No                     |
| 13.28 | <i>Dyspanopeus</i>     | <i>Sayi</i>        | No                     |
| 13.28 | <i>Eurypanopeus</i>    | <i>Depressus</i>   | No                     |
| 13.28 | <i>Hemigrapsus</i>     | <i>sanguineus</i>  | yes (1988, W. Pacific) |
| 13.28 | <i>Libinia</i>         | <i>emarginata</i>  | No                     |
| 13.28 | <i>Panopeus</i>        | <i>Herbstii</i>    | No                     |
| 13.28 | <i>Pinnotheres</i>     | <i>Maculatus</i>   | No                     |
| 13.28 | <i>Rhithropanopeus</i> | <i>Harrisi</i>     | No                     |

### Echinodermata

|       |                 |                |    |
|-------|-----------------|----------------|----|
| 18.10 | <i>Asterias</i> | <i>forbesi</i> | No |
|-------|-----------------|----------------|----|

### Asciacea

|       |                     |                     |                            |
|-------|---------------------|---------------------|----------------------------|
| 21.10 | <i>Ascidiella</i>   | <i>aspersa</i>      | yes (1983, Europe)         |
| 21.10 | <i>Botrylloides</i> | <i>violaceus</i>    | yes (1972, W.Pacific)      |
| 21.10 | <i>Botryllus</i>    | <i>schlosseri</i>   | yes (1838, Europe?)        |
| 21.10 | <i>Ciona</i>        | <i>intestinalis</i> | yes (unk, Northern Europe) |
| 21.10 | <i>Didemnum</i>     | <i>vexillum</i>     | yes (1990s, W. Pacific?)   |
| 21.10 | <i>Diplosoma</i>    | <i>listerianum</i>  | yes (1981, uncertain)      |
| 21.10 | <i>Molgula</i>      | <i>manhattensis</i> | No                         |
| 21.10 | <i>Styela</i>       | <i>clava</i>        | yes (1970, Pacific)        |
| 21.10 | <i>Styela</i>       | <i>canopus</i>      | yes (1852, W. Pacific)     |

**Appendix 2:** Comprehensive Listing of Species Identified by Narragansett Bay RAS Expedition, 2000 (**Note: Non-Indigenous Species Indicated in Bold Print**)

| Taxa#        | Genus                      | species                  | Date and Site Number/Abbreviation |                   |                   |                   |                   |                   |                   |                      |                   |                       |                    |                       |                       |
|--------------|----------------------------|--------------------------|-----------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|----------------------|-------------------|-----------------------|--------------------|-----------------------|-----------------------|
|              |                            |                          | 8.14.00<br>#1 nbc                 | 8.14.00<br>#2 ipt | 8.14.00<br>#3 eyc | 8.14.00<br>#4 chm | 8.15.00<br>#5 chi | 8.15.00<br>#6 rwu | 8.15.00<br>#7 csp | 8.16.00<br>#8<br>wkm | 8.16.00<br>#9 ahm | 8.16.00<br>#10<br>wwc | 8.16.00<br>#11 ftg | 8.17.00<br>#12<br>twh | 8.17.00<br>#13<br>pot |
| 7.00         | Aceol                      | unk.                     | .                                 | .                 | .                 | .                 | .                 | .                 | .                 | st                   | .                 | .                     | .                  | .                     |                       |
| 8.00         | <i>Aeверrillia</i>         | <i>armata</i>            | .                                 | .                 | .                 | .                 | .                 | jew               | .                 | .                    | .                 | .                     | .                  | lh/gl                 |                       |
| 2.30         | <i>Agardhiella</i>         | sp.                      | .                                 | .                 | .                 | .                 | .                 | .                 | .                 | .                    | .                 | jtc                   | .                  | .                     |                       |
| 13.27        | <i>Ampithoe</i>            | <i>longimana</i>         | .                                 | .                 | .                 | .                 | .                 | .                 | .                 | .                    | jc                | .                     | .                  | .                     |                       |
| 13.27        | <i>Ampithoe</i>            | <i>valida</i>            | jc                                | jc/jtc            | jc                | jtc               | jtc               | jc                | jc/jtc            | jc                   | .                 | jc                    | Jc                 | lh/nh                 |                       |
| 12.20        | <i>Anachis</i>             | <i>translirata</i>       | .                                 | .                 | .                 | .                 | rb                | rb                | .                 | .                    | .                 | Rb                    | .                  | .                     |                       |
| <b>21.10</b> | <b><i>Ascidiella</i></b>   | <b><i>aspersa</i></b>    | .                                 | .                 | .                 | .                 | <b>gl</b>         | <b>gl</b>         | <b>gl</b>         | <b>jtc</b>           | <b>jtc</b>        | .                     | .                  | <b>gl</b>             |                       |
| 18.10        | <i>Asterias</i>            | <i>forbesi</i>           | .                                 | .                 | .                 | .                 | .                 | lh                | jtc/lh            | lh                   | jtc               | .                     | .                  | .                     |                       |
| 12.20        | <i>Astyris</i>             | <i>lunata</i>            | .                                 | .                 | .                 | .                 | rb                | rb                | .                 | .                    | .                 | rb                    | .                  | .                     |                       |
| 5.30         | <i>Aurelia</i>             | <i>aurita</i>            | .                                 | .                 | .                 | .                 | .                 | .                 | .                 | lh                   | .                 | .                     | .                  | .                     |                       |
| <b>8.10</b>  | <b><i>Barentsia</i></b>    | <b><i>benedeni</i></b>   | <b>jtc</b>                        | .                 | .                 | .                 | .                 | .                 | .                 | .                    | .                 | .                     | .                  | .                     |                       |
| 13.22        | <i>Balanus</i>             | <i>crenatus</i>          | .                                 | jtc               | .                 | .                 | jtc               | jtc               | .                 | jtc                  | jtc               | .                     | jtc                | .                     |                       |
| 13.22        | <i>Balanus</i>             | <i>eburneus</i>          | jtc                               | jtc               | jtc               | .                 | .                 | .                 | jtc               | jtc                  | .                 | jtc                   | .                  | nh                    |                       |
| 13.22        | <i>Balanus</i>             | <i>improvisus</i>        | jtc                               | jtc               | .                 | jtc               | .                 | .                 | jtc               | .                    | jtc               | .                     | .                  | .                     |                       |
| 12.20        | <i>Bittium</i>             | <i>alternatum</i>        | .                                 | .                 | .                 | .                 | rb                | .                 | .                 | .                    | .                 | .                     | .                  | .                     |                       |
| <b>21.10</b> | <b><i>Botrylloides</i></b> | <b><i>violaceus</i></b>  | .                                 | .                 | <b>gl</b>         | <b>gl</b>         | <b>gl</b>         | <b>gl</b>         | .                 | <b>gl</b>            | <b>gl</b>         | <b>gl</b>             | <b>G1</b>          | <b>gl</b>             |                       |
| <b>21.10</b> | <b><i>Botryllus</i></b>    | <b><i>schlosseri</i></b> | .                                 | .                 | <b>gl</b>         | <b>gl</b>         | .                 | <b>lh</b>         | <b>gl</b>         | <b>gl</b>            | <b>lh/jtc</b>     | <b>gl</b>             | .                  | .                     |                       |
| 8.00         | <i>Bowerbankia</i>         | <i>gracilis</i>          | jtc/jew                           | jew/lh            | jew               | .                 | jtc               | .                 | .                 | jew/jtc              | jew/jtc           | jew/jtc               | .                  | lh                    |                       |
| 8.00         | <i>Bowerbankia</i>         | <i>imbricata</i>         | .                                 | .                 | lh                | lh                | .                 | .                 | .                 | lh                   | lh                | .                     | .                  | .                     |                       |
| 8.00         | <i>Bowerbankia</i>         | sp.3                     | .                                 | .                 | jew               | .                 | .                 | .                 | .                 | .                    | .                 | .                     | .                  | .                     |                       |
| 2.10         | <i>Bryopsis</i>            | sp.                      | .                                 | .                 | .                 | .                 | .                 | .                 | .                 | .                    | .                 | .                     | lh/gl              | .                     |                       |
| <b>8.00</b>  | <b><i>Bugula</i></b>       | <b><i>neritina</i></b>   | .                                 | .                 | .                 | .                 | <b>jtc/lh</b>     | .                 | .                 | .                    | .                 | .                     | .                  | .                     |                       |
| 8.00         | <i>Bugula</i>              | <i>simplex</i>           | .                                 | .                 | .                 | .                 | jtc/lh            | .                 | .                 | jtc                  | jtc               | .                     | .                  | .                     |                       |
| 8.00         | <i>Bugula</i>              | <i>stolonifera</i>       | .                                 | lh                | .                 | .                 | jtc/lh            | .                 | .                 | jew                  | jew               | .                     | .                  | lh/nh                 |                       |
| 13.28        | <i>Callinectes</i>         | <i>sapidus</i>           | .                                 | .                 | lh                | lh                | .                 | .                 | .                 | lh                   | .                 | .                     | .                  | .                     |                       |
| 9.10         | <i>Capitella</i>           | sp.                      | .                                 | .                 | .                 | .                 | hd/jtc            | .                 | .                 | .                    | .                 | .                     | .                  | .                     |                       |
| <b>13.27</b> | <b><i>Caprella</i></b>     | <b><i>mutica</i></b>     | .                                 | .                 | .                 | .                 | <b>jtc</b>        | <b>jc/jtc</b>     | <b>jc/jtc</b>     | <b>jc</b>            | .                 | .                     | <b>jc/jtc</b>      | <b>lh/nh</b>          |                       |
| 13.27        | <i>Caprella</i>            | <i>penantis</i>          | .                                 | .                 | .                 | .                 | .                 | .                 | jc/jtc            | jc                   | .                 | .                     | .                  | .                     |                       |
| <b>13.28</b> | <b><i>Carcinus</i></b>     | <b><i>maenas</i></b>     | .                                 | <b>jtc</b>        | .                 | .                 | <b>jtc</b>        | <b>lh/jtc</b>     | .                 | <b>jtc/lh</b>        | <b>jc</b>         | <b>jc</b>             | <b>lh/jtc</b>      | <b>lh/nh</b>          |                       |

|              |                                  |                            |              |               |           |               |            |            |        |               |               |            |            |           |    |
|--------------|----------------------------------|----------------------------|--------------|---------------|-----------|---------------|------------|------------|--------|---------------|---------------|------------|------------|-----------|----|
| 2.30         | <i>Chaetomorpha</i>              | sp.                        | .            | .             | .         | .             | .          | .          | .      | .             | .             | .          | .          | lh/nh     | .  |
| 2.30         | <i>Champia</i>                   | <i>parvula</i>             | .            | .             | .         | .             | .          | .          | .      | .             | .             | .          | jtc        | .         | .  |
| <b>13.22</b> | <b><i>Chthamalus</i></b>         | <b><i>fragilis</i></b>     | .            | .             | .         | .             | .          | <b>jtc</b> | .      | .             | .             | .          | .          | .         | .  |
| <b>21.10</b> | <b><i>Ciona</i></b>              | <b><i>intestinalis</i></b> | .            | .             | .         | .             | <b>gl</b>  | .          | .      | .             | .             | .          | .          | <b>gl</b> | .  |
| 4.00         | <i>Cliona</i>                    | sp.                        | .            | .             | .         | .             | .          | .          | .      | .             | .             | jtc        | .          | .         | .  |
| 5.10         | <i>Clytia</i>                    | <i>hemispherica</i>        | .            | .             | .         | dc            | .          | dc         | .      | dc            | dc            | dc         | Dc         | .         | lh |
| <b>2.10</b>  | <b><i>Codium</i></b>             | <b><i>fragile</i></b>      | .            | .             | .         | .             | <b>jtc</b> | .          | .      | .             | .             | <b>jtc</b> | <b>jtc</b> | .         | .  |
| 8.00         | <i>Conopeum</i>                  | <i>tenuissimum</i>         | jew          | jew/lh        | jew       | .             | .          | .          | .      | jew           | jew           | jew        | .          | .         | .  |
| 13.21        | Copepoda                         | unk.                       | .            | .             | .         | .             | jtc        | .          | .      | .             | .             | .          | .          | .         | .  |
| <b>5.10</b>  | <b><i>Cordylophora</i></b>       | <b><i>caspia</i></b>       | <b>dc/lh</b> | .             | .         | .             | .          | .          | .      | .             | .             | .          | .          | .         | .  |
| 13.27        | <i>Corophium</i>                 | <i>acutum</i>              | jc           | .             | .         | .             | jc         | jc         | jc     | jc            | jc            | jc         | Jc         | .         | .  |
| 13.27        | <i>Corophium</i>                 | <i>acherusicum</i>         | jc           | .             | .         | .             | .          | .          | .      | .             | .             | .          | Jc         | .         | .  |
| 13.27        | <i>Corophium</i>                 | <i>insidiosum</i>          | .            | jc            | jc        | jc            | jc         | .          | .      | jc            | jc            | jc         | .          | .         | .  |
| 12.50        | <i>Crassostrea</i>               | <i>virginica</i>           | .            | jtc           | lh/rb     | jtc           | .          | .          | .      | .             | lh            | .          | .          | .         | .  |
| 12.50        | <i>Crepidula</i>                 | <i>fornicata</i>           | .            | jtc/lh        | rb/lh     | rb/jtc        | lh         | rb/jtc     | jtc/lh | rb/jtc        | rb/jtc        | rb/jtc     | rb/jtc     | lh        | lh |
| 12.50        | <i>Crepidula</i>                 | <i>plana</i>               | .            | jtc/rb        | rb/lh     | rb/lh         | .          | lh         | lh/jtc | rb/jtc        | rb            | .          | rb/jtc     | .         | .  |
| 8.00         | <i>Cryptosula</i>                | <i>pallasiana</i>          | .            | .             | .         | .             | lh         | .          | .      | lh            | lh            | .          | .          | .         | .  |
| 1.00         | Cyanobacteria                    | unk.                       | jtc          | .             | .         | .             | .          | .          | .      | .             | .             | .          | .          | .         | .  |
| 7.00         | <i>Cylindrostoma</i>             | sp.                        | .            | .             | .         | .             | st         | .          | .      | .             | .             | .          | .          | lh/gl     | .  |
| 7.00         | Dalyellioid                      | #1                         | st           | .             | .         | .             | .          | .          | .      | .             | .             | .          | .          | .         | .  |
| 5.40         | <i>Diadumene</i>                 | <i>leucolena</i>           | .            | .             | .         | lh            | jtc        | .          | .      | jtc/lh        | lh            | .          | .          | .         | .  |
| <b>5.40</b>  | <b><i>Diadumene</i></b>          | <b><i>lineata</i></b>      | .            | <b>jtc/lh</b> | <b>lh</b> | <b>lh/jtc</b> | <b>jtc</b> | .          | .      | <b>lh/jtc</b> | <b>lh/jtc</b> | <b>jtc</b> | .          | .         | .  |
| <b>21.10</b> | <b><i>Didemnum</i></b>           | <b><i>vexillum</i></b>     | .            | .             | .         | .             | <b>gl</b>  | .          | .      | .             | .             | .          | .          | .         | .  |
| <b>21.10</b> | <b><i>Diplosoma</i></b>          | <b><i>listerianum</i></b>  | .            | .             | .         | .             | <b>gl</b>  | .          | .      | .             | .             | .          | .          | .         | .  |
| 7.00         | Dolichomacrostom                 | (immature)                 | .            | .             | .         | .             | .          | st         | .      | .             | .             | .          | .          | .         | .  |
| 5.10         | <i>Dynamena</i>                  | <i>pumila</i>              | .            | .             | .         | .             | .          | dc         | .      | .             | .             | .          | .          | .         | .  |
| 13.28        | <i>Dyspanopeus</i>               | <i>sayi</i>                | .            | .             | .         | .             | jtc        | jtc        | jtc    | .             | .             | jtc        | jtc        | .         | nh |
| 5.10         | <i>Ectopleura</i>                | <i>crocea</i>              | .            | dc            | .         | .             | .          | .          | .      | .             | .             | .          | .          | .         | .  |
| 13.27        | <i>Elasmopus</i>                 | <i>levis</i>               | .            | .             | .         | jc            | .          | jc         | jc     | jc            | jc            | jc         | Jc         | .         | .  |
| 8.00         | <i>Electra</i>                   | <i>pilosa</i>              | .            | .             | .         | .             | .          | .          | .      | .             | .             | .          | lh         | .         | .  |
| 2.10         | <i>Enteromorpha</i> <sup>4</sup> | sp.                        | jtc          | .             | .         | .             | jtc        | .          | .      | .             | .             | .          | jtc        | .         | nh |
| 13.27        | <i>Eobrolgus</i>                 | <i>spinosus</i>            | .            | .             | .         | .             | .          | .          | .      | .             | .             | .          | jc         | .         | .  |
| 13.26        | <i>Erichsonella</i>              | <i>filiiformis</i>         | .            | .             | .         | .             | .          | .          | .      | .             | .             | .          | Jc         | .         | .  |

<sup>4</sup> The genus *Enteromorpha* is obsolete and all species formerly classified under this genus are now classified under the genus *Ulva*.

|              |                            |                           |     |        |        |            |              |        |               |            |            |            |               |           |           |
|--------------|----------------------------|---------------------------|-----|--------|--------|------------|--------------|--------|---------------|------------|------------|------------|---------------|-----------|-----------|
| 12.20        | <i>Eubranchus</i>          | <i>exiguus</i>            | .   | .      | .      | .          | lh           | .      | .             | .          | .          | .          | .             | .         | .         |
| 5.10         | <i>Eudendrium</i>          | <i>carneum</i>            | .   | .      | .      | .          | .            | .      | .             | .          | .          | dc         | .             | .         |           |
| 7.00         | <i>Euplana</i>             | <i>gracilis</i>           | .   | st     | st     | st         | .            | .      | .             | st         | .          | st         | St            | .         | .         |
| 13.28        | <i>Eurypanopeus</i>        | <i>depressus</i>          | jtc | .      | jc/jtc | .          | .            | .      | .             | .          | .          | .          | .             | .         | .         |
| 2.20         | <i>Fucus</i>               | spp.                      | .   | .      | .      | .          | jtc          | .      | .             | .          | .          | .          | .             | .         | .         |
| 13.27        | <i>Gammarus</i>            | <i>mucronatus</i>         | jc  | .      | jc     | jc         | .            | .      | .             | jc         | .          | jc         | .             | .         | .         |
| 13.27        | <i>Gammarus</i>            | <i>oceanicus</i>          | jc  | .      | .      | .          | jc           | .      | .             | .          | .          | .          | .             | .         | .         |
| <b>5.10</b>  | <b><i>Garveia</i></b>      | <b><i>franciscana</i></b> | .   | lh/dc  | .      | .          | .            | .      | .             | .          | .          | .          | .             | .         | .         |
| 12.50        | <i>Geukensia</i>           | <i>demissa</i>            | rb  | .      | jtc    | .          | .            | .      | .             | rb         | lh         | rb         | .             | .         | .         |
| 5.10         | <i>Gonothyraea</i>         | <i>loveni</i>             | .   | dc     | .      | .          | dc           | .      | .             | .          | .          | .          | .             | .         | .         |
| <b>2.30</b>  | <b><i>Grateloupia</i></b>  | <b><i>turuturu</i></b>    | .   | .      | .      | .          | <b>jtc</b>   | .      | .             | .          | .          | .          | .             | .         | .         |
| 5.10         | <i>Halecium</i>            | <i>halecinum</i>          | .   | .      | .      | .          | .            | dc     | .             | dc         | .          | .          | dc            | .         | .         |
| <b>4.00</b>  | <b><i>Halichondria</i></b> | <b><i>bowerbanki</i></b>  | .   | .      | lh     | lh         | lh           | lh     | jtc           | jtc/lh     | lh         | .          | .             | lh        | .         |
| 4.00         | <i>Haliclona</i>           | sp.                       | .   | jtc/lh | jtc    | jtc        | .            | jtc    | jtc/lh        | lh/jtc     | lh/jtc     | jtc        | .             | .         | .         |
| 9.10         | <i>Harmothoe</i>           | <i>imbricata</i>          | .   | .      | .      | .          | hd           | .      | .             | .          | .          | .          | hd            | .         | .         |
| <b>13.28</b> | <b><i>Hemigrapsus</i></b>  | <b><i>sanguineus</i></b>  | .   | .      | .      | <b>jtc</b> | <b>jc/lh</b> | .      | <b>jtc/lh</b> | <b>jtc</b> | <b>jtc</b> | <b>jtc</b> | <b>lh/jtc</b> | <b>lh</b> | <b>nh</b> |
| 12.50        | <i>Hiatella</i>            | <i>arctica</i>            | .   | .      | lh     | .          | .            | .      | .             | .          | .          | .          | rb            | .         | .         |
| 13.27        | <i>Hyale</i>               | <i>plumulosa</i>          | .   | .      | .      | .          | jc           | jc     | jc/jtc        | .          | jc         | jc         | jc            | .         | .         |
| 5.10         | <i>Hydractinea</i>         | <i>echinata</i>           | .   | .      | .      | .          | .            | .      | *             | .          | .          | .          | dc            | .         | .         |
| 5.10         | <i>Hydractinea</i>         | <i>polyclina</i>          | .   | .      | .      | .          | .            | .      | .             | .          | .          | .          | .             | .         | .         |
| 9.10         | <i>Hydroides</i>           | <i>dianthus</i>           | .   | .      | .      | .          | .            | .      | .             | .          | jtc        | hd         | .             | .         | .         |
| <b>13.26</b> | <b><i>Ianiropsis</i></b>   | <b>sp.</b>                | .   | .      | .      | .          | <b>jc</b>    | .      | .             | .          | .          | .          | <b>jc</b>     | .         | .         |
| 13.26        | <i>Idotea</i>              | <i>baltica</i>            | .   | .      | .      | .          | jtc/jc       | .      | .             | .          | .          | .          | jc            | .         | .         |
| 12.20        | <i>Ilyanassa</i>           | <i>obsoleta</i>           | .   | jtc    | rb     | .          | .            | .      | .             | .          | .          | rb         | .             | .         | .         |
| 13.26        | <i>Jaera</i>               | <i>marina</i>             | .   | .      | .      | .          | .            | jc     | .             | .          | .          | .          | .             | .         | .         |
| 13.26        | <i>Janira</i>              | sp.                       | .   | .      | .      | .          | jtc          | .      | .             | .          | .          | .          | jtc           | .         | .         |
| 13.27        | <i>Jassa</i>               | <i>marmorata</i>          | .   | .      | .      | .          | .            | jc/jtc | jc/jtc        | jc         | .          | jc         | jc            | lh/nh     | .         |
| 13.27        | <i>Jassa</i>               | <i>staudei</i>            | .   | .      | .      | .          | jc           | .      | jc            | .          | .          | .          | .             | .         | .         |
| 7.00         | Kytorhynchid               | unk.                      | .   | .      | .      | .          | .            | .      | .             | .          | .          | .          | st            | .         | .         |
| 12.20        | <i>Lacuna</i>              | <i>vincta</i>             | .   | .      | .      | .          | rb           | .      | .             | .          | .          | .          | rb            | .         | .         |
| 5.10         | <i>Laomedea</i>            | <i>calciolifera</i>       | .   | .      | .      | .          | dc           | .      | .             | .          | dc         | dc         | .             | .         | .         |
| 9.10         | <i>Lepidonotus</i>         | <i>squamata</i>           | .   | .      | .      | .          | .            | .      | .             | .          | hd         | .          | hd/lh         | lh        | .         |
| 4.00         | <i>Leucosolenia</i>        | <i>botryoides</i>         | .   | lh     | .      | .          | lh           | .      | .             | .          | .          | .          | .             | .         | .         |
| 13.28        | <i>Libinia</i>             | <i>emarginata</i>         | .   | .      | .      | .          | .            | lh     | .             | .          | .          | .          | lh/jtc        | .         | .         |
| <b>12.20</b> | <b><i>Littorina</i></b>    | <b><i>littorea</i></b>    | .   | .      | .      | .          | .            | .      | <b>jtc</b>    | .          | .          | .          | <b>rb</b>     | .         | .         |

|       |                      |                                  |        |        |        |        |        |        |        |        |        |        |        |       |       |
|-------|----------------------|----------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|
| 12.20 | <i>Littorina</i>     | <i>saxatilis</i>                 | .      | .      | .      | .      | .      | .      | .      | .      | .      | .      | Rb     | .     | .     |
| 13.27 | <i>Lysianopsis</i>   | <i>alba</i>                      | .      | .      | .      | .      | .      | jc     | .      | .      | .      | .      | .      | .     | .     |
| 7.00  | <i>Macrostomum</i>   | Sp.                              | .      | .      | st     | .      | .      | .      | .      | .      | .      | .      | .      | .     | .     |
| 13.27 | <i>Melita</i>        | <i>nitida</i>                    | jc     | jc/jtc | jc     | jc/jtc | .      | jc     | jc     | jc     | jc     | .      | .      | .     | .     |
| 5.40  | <i>Metridium</i>     | <i>senile</i>                    | .      | jtc    | .      | lh     | jtc/lh | .      | .      | .      | jtc/lh | .      | .      | .     | lh    |
| 4.00  | <i>Microciona</i>    | <i>prolifera</i>                 | .      | .      | .      | .      | .      | .      | lh     | .      | lh/jtc | .      | .      | .     | lh    |
| 13.27 | <i>Microdeutopus</i> | <i>anomalus</i>                  | .      | .      | .      | .      | jc     | .      | .      | .      | .      | .      | .      | .     | .     |
| 13.27 | <i>Microdeutopus</i> | <i>gryllotalpa</i>               | jc     | jc     | .      | jc     | jc/jtc | .      | jc     | jc     | jc     | jc     | Jc     | .     | .     |
| 6.00  | <i>Mnemeiopsis</i>   | <i>leidy</i>                     | .      | .      | .      | .      | .      | .      | jtc    | jtc    | .      | jtc    | .      | .     | nh    |
| 21.10 | <i>Molgula</i>       | <i>manhattensis</i> <sup>5</sup> | .      | gl     | gl     | gl     | .      | .      | gl     | gl     | gl     | gl     | .      | lh    | gl    |
| 12.50 | <i>Mya</i>           | <i>arenaria</i>                  | .      | jtc    | rb/jtc | jtc    | .      | rb     | .      | .      | rb     | rb     | .      | .     | .     |
| 12.50 | <i>Mytilus</i>       | <i>edulis</i>                    | jtc    | rb/jtc | rb/lh  | rb/jtc | rb/jtc | rb/jtc | jtc/lh | rb/jtc | rb/jtc | jtc    | rb/jtc | lh    | lh    |
| 9.10  | <i>Nereis</i>        | <i>succinea</i>                  | hd/jtc | hd/jtc | hd/jtc | jtc    | hd     | hd     | hd jtc | hd/jtc | hd jtc | hd/jtc | hd/jtc | lh    | nh    |
| 9.10  | <i>Nereis</i>        | <i>pelagica</i>                  | .      | .      | .      | .      | hd     | .      | .      | .      | .      | .      | lh     | .     | .     |
| 5.10  | <i>Obelia</i>        | <i>articulata</i>                | .      | dc/lh  | dc/lh  | .      | lh     | .      | lh     | .      | lh     | .      | .      | .     | .     |
| 5.10  | <i>Obelia</i>        | <i>bidentata</i>                 | .      | .      | dc/lh  | dc     | lh     | .      | lh     | dc     | lh     | dc     | .      | lh    | .     |
| 5.10  | <i>Obelia</i>        | <i>longissima</i>                | .      | dc/lh  | dc/lh  | .      | lh     | dc     | dc     | dc     | lh     | dc     | dc     | lh    | lh/nh |
| 12.20 | <i>Odostomia</i>     | <i>bisuturalis</i>               | .      | .      | rb     | .      | .      | .      | .      | .      | .      | .      | .      | .     | .     |
| 9.20  | <i>Oligochaeta</i>   | unk.                             | jtc/rb | .      | .      | .      | .      | .      | .      | .      | .      | .      | jtc    | .     | .     |
| 12.70 | <i>Omalogyra</i>     | <i>atomus</i>                    | .      | .      | .      | .      | rb     | .      | .      | .      | .      | .      | .      | .     | .     |
| 13.23 | <i>Palaemonetes</i>  | <i>pugio</i>                     | lh     | jtc    | .      | jtc/jc | .      | .      | .      | jtc    | lh     | jc     | .      | lh/nh | lh/nh |
| 13.23 | <i>Palaemonetes</i>  | <i>vulgaris</i>                  | jc     | jc     | jc/jtc | .      | .      | .      | .      | jc     | jc     | jtc    | .      | .     | .     |
| 13.28 | <i>Panopeus</i>      | <i>herbstii</i>                  | .      | .      | jtc    | .      | .      | .      | .      | .      | .      | .      | .      | .     | .     |
| 13.27 | <i>Paracaprella</i>  | <i>tenuis</i>                    | .      | .      | .      | .      | .      | .      | .      | .      | .      | .      | jc     | .     | .     |
| 7.00  | <i>Pentacoelum</i>   | <i>punctatum</i>                 | st     | st     | .      | .      | .      | .      | .      | .      | .      | .      | .      | .     | .     |
| 2.20  | Phaeophyta           | unk.                             | .      | jtc    | .      | .      | .      | .      | .      | .      | .      | .      | .      | .     | .     |
| 13.28 | <i>Pinnotheres</i>   | <i>maculatus</i>                 | .      | .      | .      | .      | jtc    | .      | .      | .      | .      | .      | .      | .     | .     |
| 7.00  | <i>Plagiostomum</i>  | #1                               | .      | st     | .      | .      | .      | .      | .      | st     | .      | st     | st     | .     | .     |
| 7.00  | <i>Plagiostomum</i>  | #3                               | .      | .      | .      | .      | st     | .      | .      | .      | .      | .      | .      | .     | .     |
| 7.00  | <i>Plicastoma</i>    | sp.                              | .      | .      | .      | .      | st     | .      | .      | st     | st     | st     | st     | .     | .     |
| 12.60 | <i>Polycerella</i>   | <i>emertoni</i>                  | .      | .      | jtc    | .      | lh     | .      | .      | lh/jtc | lh     | .      | .      | .     | .     |
| 9.10  | <i>Polydora</i>      | <i>cornuta</i>                   | .      | hd     | jtc    | .      | .      | .      | .      | .      | .      | .      | .      | .     | .     |
| 2.30  | <i>Polysiphonia</i>  | sp.                              | .      | jtc    | .      | jtc    | .      | .      | .      | jtc    | jtc    | jtc    | .      | lh/nh | nh    |

<sup>5</sup> *Molgula manhattensis* was determined to not be an invasive species in Rhode Island subsequent to this study.

|       |                        |                   |        |     |     |     |     |        |     |     |         |     |        |       |    |
|-------|------------------------|-------------------|--------|-----|-----|-----|-----|--------|-----|-----|---------|-----|--------|-------|----|
| 7.00  | <i>Promesostoma</i>    | #1                | st     | .   | .   | .   | .   | .      | .   | .   | .       | .   | .      | .     | .  |
| 7.00  | <i>Promesostoma</i>    | #3                | .      | .   | .   | .   | st  | .      | .   | .   | .       | st  | St     | .     | .  |
| 13.28 | <i>Rhithropanopeus</i> | <i>harrisi</i>    | jc/jtc | jc  | .   | .   | .   | .      | jc  | .   | .       | .   | .      | .     | .  |
| 8.00  | <i>Schyzoporella</i>   | <i>variabilis</i> | .      | .   | .   | .   | .   | .      | jtc | lh  | jew/jtc | jtc | jew/lh | .     | .  |
| 4.00  | <i>Scypha</i>          | <i>ciliata</i>    | .      | .   | .   | .   | lh  | .      | .   | .   | .       | .   | .      | .     | .  |
| 13.22 | <i>Semibalanus</i>     | <i>balanoides</i> | .      | .   | .   | .   | .   | jtc    | jtc | .   | jtc     | jtc | jtc    | lh/nh | nh |
| 9.10  | <i>Spio</i>            | sp.               | .      | jtc | .   | .   | .   | .      | .   | .   | .       | .   | .      | .     | .  |
| 21.10 | <i>Styela</i>          | <i>clava</i>      | .      | .   | .   | .   | gl  | .      | gl  | gl  | gl      | gl  | gl     | .     | .  |
| 21.10 | <i>Styela</i>          | <i>canopus</i>    | .      | .   | .   | .   | .   | .      | .   | .   | lh      | gl  | .      | .     | .  |
| 7.00  | <i>Stylochus</i>       | <i>ellipticus</i> | st     | .   | st  | .   | .   | .      | st  | .   | .       | .   | .      | .     | .  |
| 13.27 | <i>Tanais</i>          | <i>cavolini</i>   | .      | .   | .   | .   | jc  | .      | .   | .   | .       | .   | .      | .     | .  |
| 12.20 | <i>Tenellia</i>        | <i>adspera</i>    | .      | lh  | lh  | .   | .   | .      | lh  | lh  | .       | .   | .      | lh    | lh |
| 7.00  | <i>Tetrastemma</i>     | sp.               | .      | .   | st  | .   | .   | .      | .   | .   | .       | st  | .      | .     | .  |
| 7.00  | Typhloplanoid          | (juvenile)        | .      | .   | .   | .   | .   | st     | .   | .   | .       | .   | .      | .     | .  |
| 2.10  | <i>Ulva</i>            | <i>lactuca</i>    | .      | jtc | jtc | jtc | jtc | jtc    | jtc | jtc | .       | .   | jtc    | lh/nh | nh |
| 12.20 | <i>Urosalpinx</i>      | <i>cinerea</i>    | .      | .   | .   | .   | .   | rb/jtc | .   | .   | .       | .   | rb/jtc | .     | .  |
| 13.28 | Xanthid crab           | unk.              | .      | lh  | lh  | lh  | lh  | lh     | .   | .   | lh      | .   | .      | nh    | .  |
| 5.10  | <i>Zanclaea</i>        | <i>gemmosa</i>    | .      | .   | .   | .   | .   | .      | .   | .   | .       | .   | dc     | .     | .  |
| 2.00  | <i>Zoothamnium</i>     | sp.               | .      | .   | rb  | .   | .   | .      | .   | .   | .       | .   | .      | .     | .  |

**Note:** For #s 12 &13 not all surveyers took part.

### Key:

Letters are initials of primary identifying surveyor:

jtc= James T. Carlton, lh= Larry Harris, jc= John Chapman, gl= Gretchen Lambert, st= Seth Tyler, dc= Dale Calder, rb= Robert Bullock,  
jew= Judith E. Winston, hd= Harlan Dean, nh= Niels Hobbs

Primary Numbers code for major taxonomic groupings with decimals denoting subgroups:

2= Protista (incl. algae and ciliates), 4= Porifera, 5= Cnidaria, 6= Ctenophora, 7= Platyhelminthes & Nemertinea,  
8= Lophophorates (incl. Bryozoa & Ectoprocta), 9= Annelida, 12= Mollusca, 13= Arthropoda, 18= Echinodermata, 21= Ascidiacea

### Locations:

#1 NBC = Narragansett Boat Club, Seekonk River, Providence; #2 IPT = Bootleggers Marina, India Point, Providence; #3 EYC = Edgewood Yacht Club, Warwick; #4 CHM = Cove Haven Marina, Barrington; #5 CHI = Coasters Harbor Island Marina, Newport; #6 RWU = Roger Williams University Learning Platform, Bristol; #7 CSP = Colt State Park Dock, Bristol; #8 WKM = Wickford Town Marina, Wickford; #9 AHM = Allen Harbor Marina, North Kingstown; #10 WWC = Warwick Cove Marina, East Greenwich; #11 FTG = Fort Getty Pier, Jamestown; #12 TWH = Narragansett Bay NEERS T-wharf Dock, Prudence Island; #13 POT = Narragansett Bay NEERS Potters Cove, Prudence Island

### **Appendix 3. Sites Visited for Potential as Sampling Stations**

The following were identified as potential sampling stations by preliminary selection from a list of marinas and other shore side facilities known to have floating docks, wharfs, piers, seawalls, rip-rap, adjacent salt marshes and other unique coastal habitats. Site visits were conducted at each location to determine whether safe and accessible conditions existed to accommodate the research team. Individuals responsible for the management of each site were contacted to obtain permission to access each site.

- 1) Seekonk River: Narragansett Boat Club
- 2) Seekonk River: Brown University Boathouse
- 3) Providence River: Community Boating Center
- 4) Providence River: Hot Club Marina
- 5) Providence River: Sprague Energy Bulkhead
- 6) Providence River: Promet Marine Services Corporation Bulkhead
- 7) Providence River: Motiva Bulkhead
- 8) Providence River: Hudson Terminal Corporation Bulkhead
- 9) Providence River: George Mann & Company Bulkhead
- 10) Port Edgewood Marina
- 11) Edgewood Yacht Club
- 12) Bullocks Cove: Cove Haven (Brewers) Marina
- 13) Bristol Harbor Marina
- 14) Poppasquash Point (Private dock at southern end)
- 15) Roger Williams University Learning Platform
- 16) Providence-Newport Ferry Terminal (Portsmouth)
- 17) Melville Marina District: New England Boatworks
- 18) Quonset Point/Davisville
- 19) Allen Harbor: Old Navy dock
- 20) Allen Harbor: North Kingstown Marina
- 21) Greenwich Bay: Brewers Marina
- 22) Stillwater Basin: Naval Station Newport
- 23) Coasters Harbor Island: US Navy Marina
- 24) Fort Adams: Alifson North Pier
- 25) Goat Island: American Shipyard
- 26) Fort Wetherill Marina
- 27) Fort Getty State Park: Public Dock
- 28) University of Rhode Island Graduate School of Oceanography Dock
- 29) Wickford Marina
- 30) Narragansett Bay NERRS T-wharf Dock (Prudence Island)