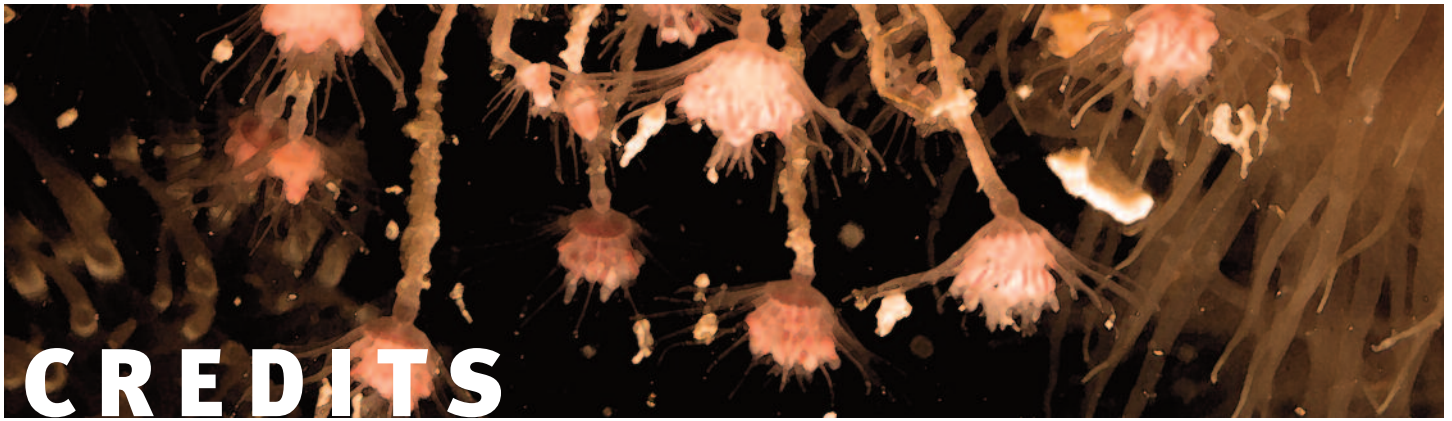




**Report on the 2010
Rapid Assessment Survey of
Marine Species at New England
Floating Docks and Rocky Shores**





This report is a publication of the Massachusetts Office of Coastal Management (CZM) pursuant to National Oceanic and Atmospheric Administration NA12NOS4190086. This publication is funded (in part) by a grant/cooperative agreement from the National Oceanic and Atmospheric Administration (NOAA). The views expressed herein are those of the author(s) and do not necessarily reflect the views of NOAA or any of its sub-agencies. This project has been financed, in part, by CZM and the Massachusetts Institute of Technology Sea Grant College Program, Massachusetts Bays Program, Casco Bay Estuary Partnership, Northeast Aquatic Nuisance Species Panel, Piscataqua Region Estuaries Partnership, Narragansett Bay Estuary Program, and Rhode Island Bays, Rivers, and Watersheds Coordination Team.

Commonwealth of Massachusetts

Deval L. Patrick, Governor

Timothy P. Murray, Lieutenant Governor

Executive Office of Energy and Environmental Affairs

Richard K. Sullivan Jr., Secretary

Massachusetts Office of Coastal Zone Management

Bruce K. Carlisle, Director

Massachusetts Office of Coastal Zone Management

251 Causeway Street, Suite 800

Boston, MA 02114-2136

(617) 626-1200

CZM Information Line: (617) 626-1212

CZM Website: www.mass.gov/czm



Photos: Arjan Gittenberger and Gretchen Lambert

Publication date: March 2013



The Massachusetts Office of Coastal Zone Management (CZM) would like to acknowledge the exceptional work of the 2010 Rapid Assessment Survey (RAS) team for their tireless efforts to collect and analyze marine invasive species data and for providing logistical support for the survey: Jessica Bryant, Jim Carlton, Kevin Cute, Jenn Dijkstra, Renee Erickson, Yvette Garner, Adriaan Gittenberger, Sara Grady, Linsey Haram, Larry Harris, Niels Hobbs, Charles Lambert, Gretchen Lambert, Walter Lambert, Antonio Marques, Arthur Mathieson, Megan McCuller, Chris McIntyre, Miranda Mickiewicz, Adrienne Pappal, Judy Pederson, Rachel Rock-Blake, Jan Smith, Cascade Sorte, Lauren Stefaniak, and Martine Wagstaff.

Major funding for the 2010 Rapid Assessment Survey was provided by the Northeast Aquatic Nuisance Species Panel, the Casco Bay Estuary Partnership, the Piscataqua Region Estuary Partnership, the Massachusetts Bays Program, the Narragansett Bay Estuary Program, and the Rhode Island Bays, Rivers, and Watersheds Coordination Team. Additional logistical support for the 2010 RAS was provided by CZM, the Massachusetts Institute of Technology Sea Grant College Program (MIT Sea Grant), the Buzzards Bay National Estuary Program, and the Rhode Island Coastal Resources Management Council. Laboratory facilities were provided by Brown University and Dr. Larry Harris of the University of New Hampshire.

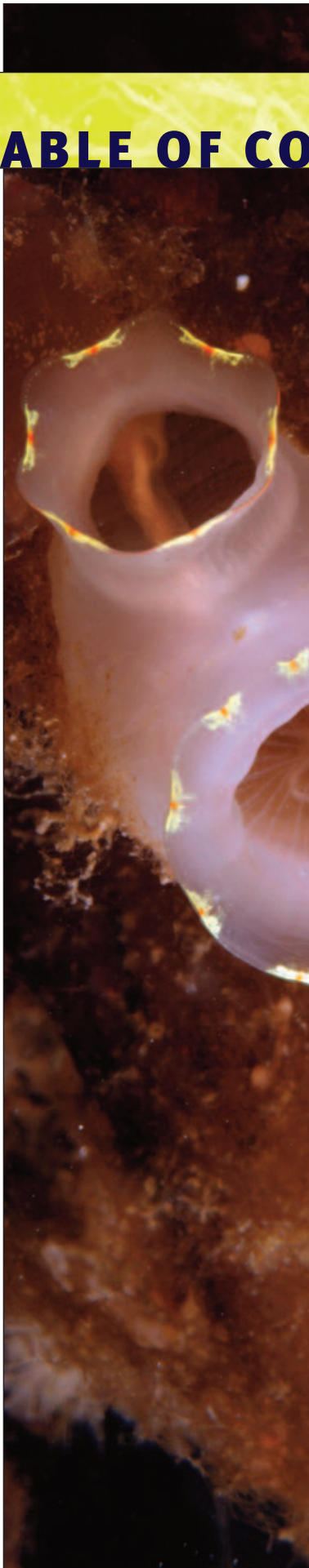
This document was prepared by Christopher McIntyre of the University of Massachusetts Boston and Adrienne Pappal of CZM, with assistance from Jan Smith of CZM and Judy Pederson of MIT Sea Grant.

CZM would also like to especially thank the many marinas and facilities who allowed access for the survey: Port Edgewood Marina, Cranston, Rhode Island; Allen Harbor Marina, North Kingston, Rhode Island; Point Judith Marina, South Kingston, Rhode Island; F.L. Tripp & Sons, Inc., Westport, Massachusetts; Fort Adams State Park, Newport, Rhode Island; Pope's Island Marina, New Bedford, Massachusetts; Massachusetts Maritime Academy, Bourne, Massachusetts; Sandwich Marina, Sandwich, Massachusetts; Brewer Plymouth Marine, Plymouth, Massachusetts; The Marina at Rowes Wharf, Boston, Massachusetts; Hampton River Marina, Hampton, New Hampshire; University of New Hampshire Coastal Marine Lab, Newcastle, New Hampshire; Hawthorne Cove Marina, Salem, Massachusetts; Jodrey State Pier, Gloucester, Massachusetts; Spring Point Marina, South Portland, Maine; Brewer South Freeport Marine, South Freeport, Maine.



TABLE OF CONTENTS

Introduction	5
Map of Sites Sampled	6
Sites and Findings	7
Summary	27
Conclusions	30
Appendix	32
References	34





Introduction

Biological invasions are largely irreversible with major, wide-ranging impacts on species diversity, native ecology, and the economy (Parker et al. 1999; Vitousek et al. 1997). Associated management costs of invasive species in the United States are estimated in the billions of dollars annually (Pimentel et al. 2005). In the marine realm, globalization and enhancements in commercial transportation have increased the rate and spread of species introductions with most new invasions detected in estuarine waters (Carlton 1985; Lodge et al. 2006; Ruiz et al. 2000). It is estimated that over 300 non-native invertebrates and algae have become established in the marine coastal waters of North America during the last 200 years, not including numerous species with as of yet unresolved origins (Ruiz et al. 2000). Surveillance of high-risk coastal habitats to detect new introductions and monitor established invaders is crucial to build scientific knowledge needed for the development of effective prevention practices and control methods. The Rapid Assessment Survey is one method currently used to monitor and detect non-native marine species.

The primary objectives of the Northeast Rapid Assessment Survey (RAS) for marine species are to: (1) identify native, non-native, and cryptogenic species, (2) expand on data collected in past surveys, (3) assess the invasion status and range extensions of documented non-native species, and (4) detect new introductions (Cohen et al. 2005; Pederson et al. 2005). The 2010 survey was the fourth of its kind to be conducted in the Northeast since the year 2000. This report presents data collected from 20 New England locations from Narragansett Bay in Rhode Island to Cape Elizabeth, Maine.

Methods

This section covers the sampling sites and sampling method used in the 2010 RAS.

Sampling Sites

The 2010 RAS targeted sampling at commercial ports and marinas and rocky intertidal sites in each of the four states within the study region. Previous surveys have concentrated exclusively on docks and piers, as it has been theorized that artificial substrates facilitate invasions and often serve as stepping stones for broad dispersal (Glasby et al. 2007). In 2010, the survey was expanded to include intertidal habitats (rocky shores) to permit comparisons of species and community assemblages between artificial and natural habitats. The survey began in North Kingston, Rhode Island, on July 25 and was completed in South Freeport, Maine, on July 31. Twenty coastal sites within five National Estuary Program (NEP) regions were surveyed in Rhode Island, Massachusetts, New Hampshire, and Maine. The following NEPs were included in the study: Narragansett Bay Estuary Program, Rhode Island; Buzzards Bay National Estuary Program, Massachusetts; Massachusetts Bays Program, Massachusetts; Piscataqua Region Estuaries Partnership, New Hampshire; and the Casco Bay Estuary Partnership, Maine.

Sampling Method

Rapid assessment is a qualitative approach of visual search within a fixed area and/or time frame, and is focused on the identification of organisms within arm's reach (Pederson et al. 2005). For the 2010 RAS, biologists and expert taxonomists were brought together as a team to observe and identify all native and non-native species (see pg. 33). Categorization of species was based on professional judgment of

RAPID ASSESSMENT SURVEY: 2010 SAMPLING SITES



RAS taxonomic team and as described by Carlton (2003) and Mathieson et al. (2008a,b). As in previous surveys, visual searches, including those conducted by a SCUBA diver, were limited to one hour per site. In addition to field identifications, collections were labeled, placed on ice, and returned to a laboratory for verification of species identification. Voucher specimens were also placed with the Harvard Museum of Comparative Zoology as applicable. Biomass samples and photographs for calculation of percent cover were collected from 16 marinas to compare non-native species to native species; however, these data are still in the process of being analyzed and are not presented in this report. Water quality measurements were taken

with a YSI 600XLM and YSI 55 at the surface and at depth for dock stations and at the surface at rocky shore sites. Secchi depth was also measured at dock stations (Table 23).

Results

Sampling locations and results are described in the following pages and are listed from north to south. Each listing includes the sampling date, time (one hour sampling per site), as well as a description of the site and listings of the non-native and cryptogenic (undefined origin) species found at each location. In all, 20 sites were sampled during the 2010 RAS, including 16 floating dock locations and four intertidal rocky shore sites.

Brewer South Freeport Marine, South Freeport, Maine

July 31, 2010, 13:30

Brewer South Freeport Marine is located on the banks of the Harraseeket River on the edge of Casco Bay. The marina provides 15 moorings and 100 boat slips with dockside depths of 14 feet. Sixty-seven species were found here during the 2010 RAS, including six non-native and 10 cryptogenic species.

Table 1a: Non-native species recorded at Brewer South Freeport Marine during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Bryozoa	<i>Membranipora membranacea</i>	Lacy Crust Bryozoan
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate

Table 1b: Cryptogenic species recorded at Brewer South Freeport Marine during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bugula simplex</i>	Fan Bugula
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Cnidaria	<i>Obelia geniculata</i>	Knotted Thread Hydroid
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid
Mollusca	<i>Cuthona gymnota</i>	Sea Slug
Mollusca	<i>Tenellia adspersa</i>	Miniature Aeolis
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-Scale Worm
Tunicata	<i>Ciona intestinalis</i>	Sea Vase

Spring Point Marina, South Portland, Maine

July 31, 2010, 10:15

Located at the entrance of Portland Harbor and the mouth of the Fore River, Spring Point Marina is Maine's largest full-service marina. Portland Harbor, like many urban waterways, has been influenced by past industrial activities including papermaking, gasworks, tanning, and metal working. Seventy-eight species were found during the 2010 RAS, including nine non-native and 12 cryptogenic species.

Table 2a: Non-native species recorded at Spring Point Marina during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Praunus flexuosus</i>	Opossum Shrimp
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Bryozoa	<i>Membranipora membranacea</i>	Lacy Crust Bryozoan
Cnidaria	<i>Diadumene lineata</i>	Orange Striped Anemone
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Tunicata	<i>Ascidella aspersa</i>	European Tunicate
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate

Table 2b: Cryptogenic species recorded at Spring Point Marina during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bowerbankia imbricata</i>	Bryozoan
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-mat
Cnidaria	<i>Dynamena pumila</i>	Sea Oak Hydroid
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Cnidaria	<i>Obelia geniculata</i>	Knotted Thread Hydroid
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-Scale Worm
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Porifera	<i>Leucosolenia botryoides</i>	Pipe Sponge
Porifera	<i>Sycon</i> sp.	Sponge
Tunicata	<i>Ciona intestinalis</i>	Sea Vase



Sheath tunicate, Botrylloides violaceus, encrusts mussels at Spring Point Marina, South Portland, Maine.

Dyer Cove, Cape Elizabeth, Maine

July 31, 2010, 08:30

Dyer Cove is a rocky intertidal inlet located along the shore of Maine’s Casco Bay. A diverse array of seaweeds were present, accounting for half of the total species count for the site, far more than any other location on the survey. One hundred species were found during the 2010 RAS in total, including 11 non-native and six cryptogenic species.

Table 3a: Non-native species recorded at Dyer Cove during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Chlorophyta	<i>Codium fragile</i> ssp. <i>fragile</i>	Green Fleece
Mollusca	<i>Littorina littorea</i>	European Periwinkle
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Bonnemaisonia hamifera</i>	Red Algae
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate
Tunicata	<i>Diplosoma listerianum</i>	Compound Tunicate

Table 3b: Cryptogenic species recorded at Dyer Cove during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bowerbankia imbricata</i>	Bryozoan
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Cnidaria	<i>Dynamena pumila</i>	Sea Oak Hydroid
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Porifera	<i>Leucosolenia</i> sp.	Pipe Sponge



The RAS survey team at Dyer Cove, Cape Elizabeth, Maine.

University of New Hampshire Marine Lab, Newcastle, New Hampshire

July 29, 2010, 13:15

Located at historic Fort Constitution in New Castle, New Hampshire, at the mouth of Portsmouth Harbor, the Coastal Marine Lab provides University of New Hampshire (UNH) faculty and students with access to the open waters of the Gulf of Maine and laboratory facilities with full-strength seawater capabilities. The lab features a new 325-foot research pier and dock that provide essential berth space for the UNH fleet of research vessels and shelter for experimental enclosures located under the fixed pier. The fouling community was composed of a mussel base supporting ascidians, barnacles, and sponges. Ninety species were found during the 2010 RAS, including 10 non-natives and 11 cryptogenic species.

Table 4a: Non-native species recorded at UNH Marine Lab during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Praunus flexuosus</i>	Opossum Shrimp
Bryozoa	<i>Membranipora membranacea</i>	Lacy Crust Bryozoan
Mollusca	<i>Littorina littorea</i>	European Periwinkle
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate

Table 4b: Cryptogenic species recorded at UNH Marine Lab during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bugula simplex</i>	Fan Bugula
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Cnidaria	<i>Obelia geniculata</i>	Knotted Thread Hydroid
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid
Cnidaria	<i>Dynamena pumila</i>	Sea Oak Hydroid
Mollusca	<i>Cuthona gymnota</i>	Sea Slug
Mollusca	<i>Tenellia adspersa</i>	Miniature Aeolis
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-Scaled Worm
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Tunicata	<i>Ciona intestinalis</i>	Vase Tunicate

Hydroids and mussels at the UNH docks in Newcastle, New Hampshire.



Odiorne Point South, Rye, New Hampshire

July 29, 2010, 08:00

This rocky shore site is located just south of Odiorne State Park on the longest stretch of undeveloped land on the New Hampshire coast. Large sheltered tide pools and adjacent salt marshes provide extensive habitat for a diverse array of marine species. Thirty-three species were found during the 2010 RAS, including eight non-native and three cryptogenic species.



Sheath tunicate, Botrylloides violaceus, on the rocks at Odiorne Point, Rye, New Hampshire.

Table 5a: Non-native species recorded at Odiorne Point South during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Mollusca	<i>Littorina littorea</i>	European Periwinkle
Rhodophyta	<i>Bonnemaisonia hamifera</i>	Filamentous Red Algae
Rhodophyta	<i>Neosiphonia harveyi</i>	Red Algae
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate

Table 5b: Cryptogenic species recorded at Odiorne Point South during the 2010 RAS.

Group	Species	Common Name/Description
Cnidaria	<i>Dynamena pumila</i>	Sea Oak Hydroid
Cnidaria	<i>Obelia geniculata</i>	Knotted Thread Hydroid
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm

Hampton River Marina, Hampton, New Hampshire

July 29, 2010, 10:00

Hampton River Marina is located within the Piscataqua River Estuary. The Marina features 144 boat slips with floating docks and wooden pilings. The fouling community was composed of mussels, barnacles, and ascidians. Eighty species were found during the 2010 RAS, including 11 non-native and 12 cryptogenic species.

Hydroids, anemones, and sheath tunicate, Botrylloides violaceus, at the Hampton River Marina, Hampton, New Hampshire.

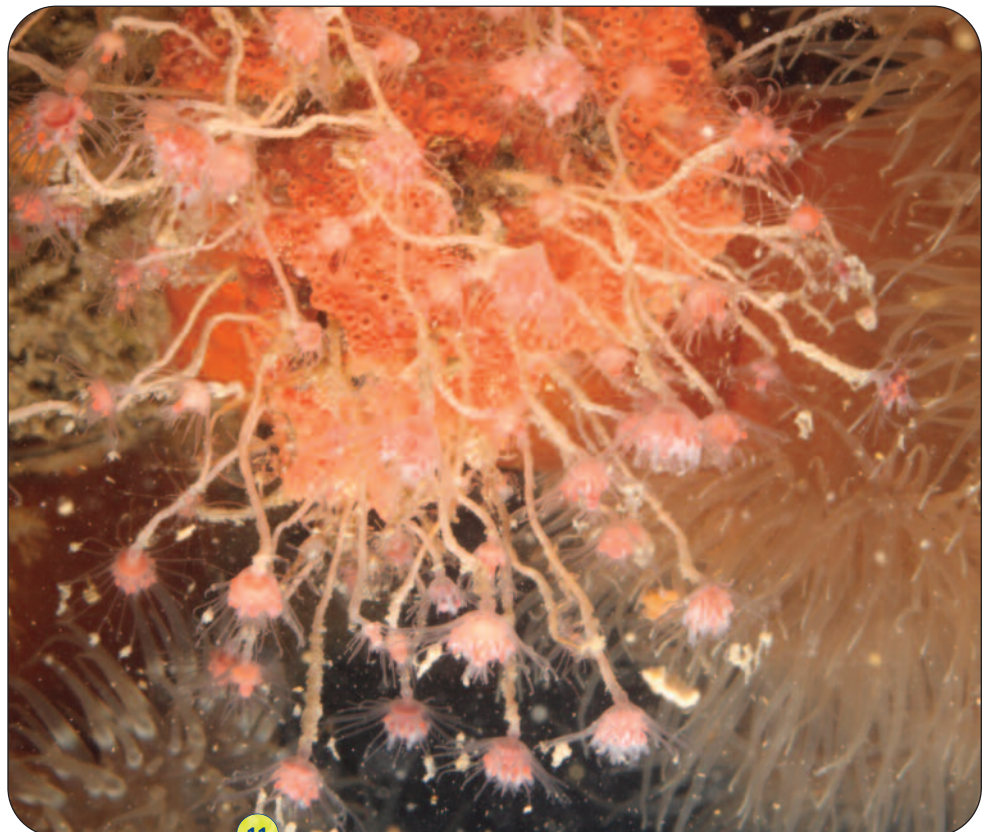


Table 6a: Non-native species recorded at Hampton River Marina during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Praunus flexuosus</i>	Opossum Shrimp
Mollusca	<i>Littorina littorea</i>	European Periwinkle
Phaeophyceae	<i>Melanosiphon intestinalis</i>	Brown Algae
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Rhodophyta	<i>Lomentaria clavellosa</i>	Red Algae
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate

Table 6b: Cryptogenic species recorded at Hampton River Marina during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bowerbankia imbricata</i>	Bryozoan
Bryozoa	<i>Bugula stolonifera</i>	Bryozoan
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Cnidaria	<i>Obelia geniculata</i>	Knotted Thread Hydroid
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid
Mollusca	<i>Cuthona gymnota</i>	Sea Slug
Mollusca	<i>Tenellia adspersa</i>	Miniature Aeolis
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-Scaled Worm
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Porifera	<i>Leucosolenia botryoides</i>	Pipe Sponge

Jodrey State Pier, Gloucester, Massachusetts

July 30, 2010, 13:15

In 1993, the Jodrey State Pier was renovated to accommodate modern fishing vessels and a new fish processing plant. Facilities at the pier include a 54-slip marina for boats up to 100 feet in length, three berths for ships up to 145 feet in length, a 5,000-square-foot office building, a 50,000-square-foot fish processing facility, and a 40,000-square-foot freezer facility. The fouling community is composed of a mussel base with rich ascidian cover. Seventy-two species were found during the 2010 RAS, including 12 non-native and 13 cryptogenic species.

Sea vase tunicates, Ciona intestinalis, were common at the Jodrey State Pier, Gloucester, Massachusetts.

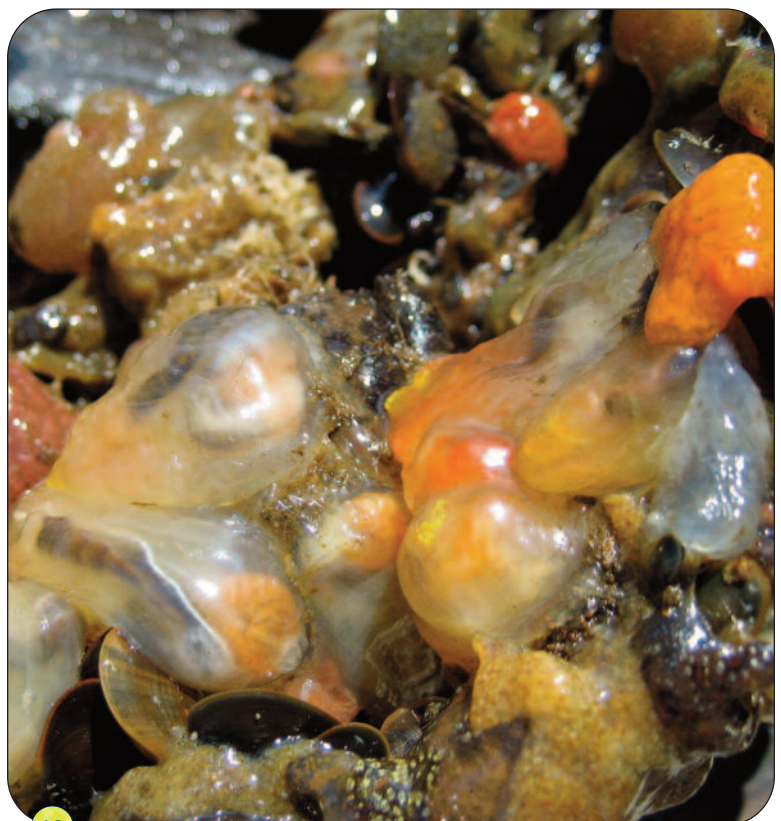


Table 7a: Non-native species recorded at Jodrey State Pier during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Bryozoa	<i>Membranipora membranacea</i>	Lacy Crust Bryozoan
Mollusca	<i>Littorina littorea</i>	European Periwinkle
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Asciidiella aspersa</i>	European Tunicate
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Diplosoma listerianum</i>	Compound Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate

Table 7b: Cryptogenic species recorded at Jodrey State Pier during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bowerbankia gracilis</i>	Bryozoan
Bryozoa	<i>Bugula simplex</i>	Fan Bugula
Bryozoa	<i>Bugula stolonifera</i>	Bryozoan
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Cnidaria	<i>Laomedea calceolifera</i>	Hydroid
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-Scaled Worm
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Porifera	<i>Leucosolenia botryoides</i>	Pipe Sponge
Porifera	<i>Sycon ciliatum</i>	Sponge
Tunicata	<i>Ciona intestinalis</i>	Sea Vase

Winter Island, Salem, Massachusetts

July 30, 2010, 08:15

Winter Island is a marine recreational park located on Salem's eastern end at the mouth of Salem Harbor. The park features a public beach and a rocky intertidal shore that looks out over the navigation channels of Salem Sound. Sixty-eight species were found during the 2010 RAS, including 11 non-native and six cryptogenic species.



The RAS survey team at Winter Island, Salem, Massachusetts.

Table 8a: Non-native species recorded at Winter Island during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Bryozoa	<i>Alcyonidium</i> sp.	Encrusting Bryozoan
Mollusca	<i>Littorina littorea</i>	European Periwinkle
Rhodophyta	<i>Bonnemaisonia hamifera</i>	Red Algae
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Asciella aspersa</i>	European Tunicate
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate

Table 8b: Cryptogenic species recorded at Winter Island during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bowerbankia imbricata</i>	Bryozoan
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Cnidaria	<i>Dynamena pumila</i>	Sea Oak Hydroid
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Tunicata	<i>Ciona intestinalis</i>	Sea Vase

Hawthorne Cove Marina, Salem, Massachusetts

July 30, 2010, 10:00

Hawthorne Cove Marina, part of the historic Salem shipping port, features a floating dock system with 100 boat slips. The fouling community includes a mussel base supporting ascidians and anemones, including the non-native *Sagartia elegans*, not recorded at any other sites during the assessment. A new non-native species, the European shrimp *Palaemon elegans*, was discovered here during this site visit. This is the first record of this species in North America. Sixty-nine species were found during the 2010 RAS, including 17 non-native and 12 cryptogenic species.



The non-native anemone, Sagartia elegans, was found at Hawthorne Cove Marina, Salem, Massachusetts.

Table 9a: Non-native species recorded at Hawthorne Cove Marina during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Palaemon elegans</i>	European Rock Pool Shrimp
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Arthropoda	<i>Praunus flexuosus</i>	Opossum Shrimp
Bryozoa	<i>Bugula neritina</i>	Bryozoan
Bryozoa	<i>Membranipora membranacea</i>	Lacy Crust Bryozoan
Chlorophyta	<i>Codium fragile</i> ssp. <i>fragile</i>	Green Fleece
Cnidaria	<i>Diadumene lineata</i>	Orange Striped Anemone
Cnidaria	<i>Sagartia elegans</i>	Purple Anemone
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Asciadiella aspersa</i>	European Tunicate
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate
Tunicata	<i>Diplosoma listerianum</i>	Compound Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate

Table 9b: Cryptogenic species recorded at Hawthorne Cove Marina during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Bryozoa	<i>Bugula stolonifera</i>	Bryozoan
Bryozoa	<i>Bugula simplex</i>	Fan Bugula
Bryozoa	<i>Bowerbankia gracilis</i>	Bryozoan
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Mollusca	<i>Placida dendritica</i>	Sea Slug
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-Scale Worm
Porifera	<i>Leucosolenia botryoides</i>	Pipe Sponge
Tunicata	<i>Ciona intestinalis</i>	Sea Vase

Rowes Wharf, Boston, Massachusetts

July 28, 2010, 11:30

The Marina at Rowes Wharf is located along the highly developed waterfront of Boston's inner harbor and is part of the Rowes Wharf luxury hotel and condominium complex. The marina features many floating docks frequented by international boaters. Water quality in Boston Harbor, monitored by the Massachusetts Water Resource Authority (MWRA), has shown improvement since the opening of a wastewater treatment plant on Deer Island. The fouling community is composed of a mussel base supporting various ascidians, bryozoans, sponges, and sea anemones. Seventy-nine different species were found during the 2010 RAS, including 13 non-native and 12 cryptogenic species.



Non-native tunicates encrust kelp blades at Rowes Wharf, Boston, Massachusetts.

Table 10a: Non-native species recorded at Rows Wharf during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Bryozoa	<i>Membranipora membranacea</i>	Lacy Crust Bryozoan
Cnidaria	<i>Diadumene lineata</i>	Orange Striped Anemone
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Grateloupia turuturu</i>	Asian Red Seaweed
Rhodophyta	<i>Lomentaria clavellosa</i>	Red Algae
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate
Tunicata	<i>Ascidella aspersa</i>	European Tunicate
Tunicata	<i>Botrylloides violaceus</i>	Orange Sheath Tunicate

Table 10b: Cryptogenic species recorded at Rows Wharf during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bowerbankia imbricata</i>	Bryozoan
Bryozoa	<i>Bugula simplex</i>	Fan Bugula
Bryozoa	<i>Bugula stolonifera</i>	Bryozoan
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Cnidaria	<i>Laomedea calceolifera</i>	Hydroid
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Cnidaria	<i>Obelia geniculata</i>	Knotted Thread Hydroid
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-Scaled Worm
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Tunicata	<i>Ciona intestinalis</i>	Sea Vase

Brewer Plymouth Marine, Plymouth, Massachusetts

July 28, 2010, 08:30

Brewer Plymouth Marine is a boatyard and marina located in the historic Plymouth Harbor behind a scenic, narrow barrier beach and a stone breakwater. The marina features concrete floats with 100 seasonal slips that can accommodate boats up to 150 feet. Discharge from Town Brook adjacent to the marina creates a lens of freshwater over the seawater, which impacts the distribution of some species near the surface. The fouling community was composed of a mixed ascidian base. Sixty species were found during the 2010 RAS, including 11 non-native and seven cryptogenic species.

Non-native tunicates foul a rope at Brewer Plymouth Marine, Plymouth, Massachusetts.



Table 11a: Non-native species recorded at Brewer Plymouth Marine during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Chlorophyta	<i>Codium fragile</i> ssp. <i>fragile</i>	Green Fleece
Cnidaria	<i>Diadumene lineata</i>	Orange Striped Anemone
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate

Table 11b: Cryptogenic species recorded at Brewer Plymouth Marine during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bowerbankia imbricata</i>	Bryozoan
Bryozoa	<i>Bugula simplex</i>	Fan Bugula
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid
Porifera	<i>Leucosolenia</i> sp.	Sponge

Sandwich Marina, Sandwich, Massachusetts

July 27, 2010, 13:15

Sandwich Marina, opened in 1989, is an important site for monitoring the northerly progression of non-native species via the Cape Cod Canal. The marina features a floating dock system, which includes 140 seasonal slips, 42 commercial slips, and 24 transient slips. The fouling community was composed primarily of solitary tunicates as well as a large population of the native anemone *Metridium senile*. Eighty-five species were found during the 2010 RAS, including 13 non-native and 12 cryptogenic species.



Floating docks at Sandwich Marina, Sandwich, Massachusetts.

Table 12a: Non-native species recorded at Sandwich Marina during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Bryozoa	<i>Membranipora membranacea</i>	Lacy Crust Bryozoan
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Grateloupia turuturu</i>	Asian Red Seaweed
Rhodophyta	<i>Lomentaria orcadensis</i>	Red Algae
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Asciidiella aspersa</i>	European Tunicate
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate

Table 12b: Cryptogenic species recorded at Sandwich Marina during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bugula simplex</i>	Fan Bugula
Bryozoa	<i>Bugula stolonifera</i>	Bryozoan
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Cnidaria	<i>Gonothyrea loveni</i>	Hydroid
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Cnidaria	<i>Obelia geniculata</i>	Knotted Thread Hydroid
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-Scaled Worm
Porifera	<i>Leucosolenia</i> sp.	Sponge
Porifera	<i>Sycon ciliatum</i>	Sponge
Tunicata	<i>Ciona intestinalis</i>	Sea Vase



European sea squirt, Asciidiella aspersa, sheath tunicate, Botrylloides violaceus, and the compound tunicate, Didemnum vexillum, grow on a milk crate (left); sea vase foul the floating docks (right) at Sandwich Marina.

**Massachusetts Maritime Academy,
Bourne, Massachusetts**

July, 27, 2010 10:00

The Massachusetts Maritime Academy is located at the southern end of the Cape Cod Canal. The academy's private docking area features one permanent floating dock of approximately 70 meters. Several vessels are docked there including the USTS Kennedy, which frequently travels around the world for training exercises. There are also seasonal floating docks for smaller vessels. The fouling community on the docks was



diverse with a base of mussels and solitary tunicates including *Styela clava*. Many different ascidian species were found here, including the native *Aplidium constellatum*, not recorded at any other sites during the assessment. Eighty-one species were found during the 2010 RAS, including 14 non-native and 11 cryptogenic species.

Table 13a: Non-native species recorded at Massachusetts Maritime Academy during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Chlorophyta	<i>Codium fragile</i> ssp. <i>fragile</i>	Green Fleece
Cnidaria	<i>Diadumene lineata</i>	Orange Striped Anemone
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Grateloupia turuturu</i>	Asian Red Seaweed
Rhodophyta	<i>Lomentaria clavellosa</i>	Red Algae
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Styela canopus</i>	Rough Tunicate
Tunicata	<i>Asciella aspersa</i>	European Tunicate
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate

Table 13b: Cryptogenic species recorded at Massachusetts Maritime Academy during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bugula simplex</i>	Fan Bugula
Bryozoa	<i>Bugula stolonifera</i>	Bryozoan
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Cnidaria	<i>Clytia hemisphaerica</i>	Hydroid
Cnidaria	<i>Laomedea calceolifera</i>	Hydroid
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-glass Hydroid
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-scaled worm
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Porifera	<i>Leucosolenia botryoides</i>	Pipe Sponge
Tunicata	<i>Ciona intestinalis</i>	Sea Vase

Pope's Island Marina, New Bedford, Massachusetts

July 27, 2010, 08:00

Pope's Island Marina is a public boat facility with 198 boat slips. The marina was opened in 1993 with assistance from the Massachusetts Department of Conservation and Recreation and is currently maintained and operated by the New Bedford Harbor Development Commission. The marina is located on the south side of Pope's Island in the upper region of New Bedford Harbor, a superfund site. The base of the fouling community was composed of encrusting bryozoans and the alcaeous tubes of the serpulid polychaete *Hydroides dianthus*.



Sixty-seven species were found during the 2010 RAS, including 10 non-native and eight cryptogenic species.

Sheath tunicate, Botrylloides violaceus, and star tunicate, Botryllus schlosseri, overgrow the native sea grape tunicate, Molgula manhattensis, at Pope's Island Marina, New Bedford, Massachusetts.

Table 14a: Non-native species recorded at Pope's Island Marina during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Chlorophyta	<i>Codium fragile</i> ssp. <i>fragile</i>	Green Fleece
Cnidaria	<i>Diadumene lineata</i>	Orange Striped Anemone
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Asciella aspersa</i>	European Tunicate
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate

Table 14b: Cryptogenic species recorded at Pope's Island Marina during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bowerbankia gracilis</i>	Bryozoan
Bryozoa	<i>Bowerbankia imbricata</i>	Bryozoan
Bryozoa	<i>Bugula simplex</i>	Fan Bugula
Bryozoa	<i>Bugula stolonifera</i>	Bryozoan
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Cnidaria	<i>Halecium halecinum</i>	Herringbone Hydroid
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid

F.L. Tripp & Sons, Westport, Massachusetts

July 26, 2010, 08:15

F.L. Tripp & Sons boatyard and marina is located on the Westport River between Rhode Island Sound and Buzzards Bay. The marina features 178 boat slips and is situated on the inland side of Horseneck Beach State Reservation. The fouling community was composed of a mussel base that supported a rich assortment of ascidians and hydroids. Eighty species were found during the 2010 RAS, including 15 non-native and eight cryptogenic species.



Table 15a: Non-native species recorded at F.L. Tripp & Sons during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Bryozoa	<i>Bugula neritina</i>	Bryozoan
Chlorophyta	<i>Codium fragile</i> ssp. <i>fragile</i>	Green Fleece
Cnidaria	<i>Diadumene lineata</i>	Orange Striped Anemone
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Grateloupia turuturu</i>	Asian Red Seaweed
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate
Tunicata	<i>Diplosoma listerianum</i>	Compound Tunicate
Tunicata	<i>Styela canopus</i>	Rough Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate

Table 15b: Cryptogenic species recorded at F.L. Tripps & Sons during the 2010 RAS.

Group	Species	Common Name/ Description
Bryozoa	<i>Amathia vidovici</i>	Bryozoan
Bryozoa	<i>Bowerbankia imbricata</i>	Bryozoan
Bryozoa	<i>Bugula stolonifera</i>	Bryozoan
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-Scaled worm
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Tunicata	<i>Ciona intestinalis</i>	Sea Vase

**Port Edgewood Marina,
Cranston, Rhode Island**

July 25, 2010, 07:35

Located in the northern region of Providence Harbor adjacent to a large industrial park, Port Edgewood is one of many areas of the Providence River that has been filled over the last century to create shipyards, highways, wharves, and naval bases. The marina includes three large wooden floats and 160 seasonal and transient boat slips. The fouling community was dominated by a mussel base with an abundance of ascidians and bryozoans. This site had the lowest average salinity (25.3 ppt) of any site sampled during the 2010 RAS. Fifty-two species were found during the 2010 RAS, including six non-native and six cryptogenic species.

Barnacles encrust a bumper and chain at Port Edgewood Marina, Cranston, Rhode Island.



Table 16a: Non-native species recorded at Port Edgewood Marina during the 2010 RAS

Group	Species	Common Name/Description
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Cnidaria	<i>Diadumene lineata</i>	Orange Striped Anemone
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate

Table 16b: Cryptogenic species recorded at Port Edgewood Marina during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bowerbankia</i> sp.	Bryozoan
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-Scaled Worm
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Porifera	<i>Leucosolenia botryoides</i>	Pipe Sponge

**Allen Harbor Marina,
North Kingston,
Rhode Island**

July 25, 2010, 09:30

Allen Harbor Marina is located on the western side of Narragansett Bay on the corner of the former Quonset-Davisville Naval Base. The marina features a wooden dock system with 80 moorings and 66 slips and is located within a semi-enclosed, 17.5-acre harbor surrounded by heavily industrialized lands. The fouling community was dominated by a barnacle base that supported anemones, sponges, and ascidians. Fifty-nine species were found during the 2010 RAS, including eight non-native and five cryptogenic species.

Native sea grape, Molgula manhattensis, at Allen Harbor Marina, North Kingston, Rhode Island.



Table 17a: Non-native species recorded at Allen Harbor Marina during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Cnidaria	<i>Diadumene lineata</i>	Orange Striped Anemone
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Grateloupia turuturu</i>	Asian Red Seaweed
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate

Table 17b: Cryptogenic species recorded at Allen Harbor Marina during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bowerbankia imbricata</i>	Bryozoan
Bryozoa	<i>Bugula simplex</i>	Fan Bugula
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Bryozoa	<i>Conopeum reticulum</i>	Encrusting Bryozoan
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid



**Fort Adams State Park,
Newport, Rhode Island**

July 26, 2010, 10:45

Fort Adams State Park is located at the mouth of Newport Harbor facing the East Passage of Narragansett Bay. Construction of the fort began in 1824 and was completed 30 years later. The fort was deeded to the state of Rhode Island in 1966 and has since become a major public access point into Narragansett Bay and a recreational attraction. The 105-acre park includes a small, semi-enclosed marina at the southern-most point. The fouling community on the wooden docks was composed of a mussel base with a covering of the non-native colonial tunicate *Didemnum vexillum*, and the cryptogenic tunicate *Ciona intestinalis*. Seventy-six species were found during the 2010 RAS, including 17 non-native and 13 cryptogenic species.

A grass shrimp, Palaemonetes sp., and tunicate, Didemnum vexillum, amongst mussels, anemones, and other tunicate species at Fort Adams State Park, Newport, Rhode Island.

Table 18a: Non-native species recorded at Fort Adams State Park during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Arthropoda	<i>Praunus flexuosus</i>	Opossum Shrimp
Bryozoa	<i>Bugula neritina</i>	Bryozoan
Bryozoa	<i>Membranipora membranacea</i>	Lacy Crust Bryozoan
Chlorophyta	<i>Codium fragile</i> ssp. <i>fragile</i>	Green Fleece
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Grateloupia turuturu</i>	Asian Red Seaweed
Rhodophyta	<i>Heterosiphonia japonica</i>	Red Algae
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Asciidiella aspersa</i>	European Tunicate
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate
Tunicata	<i>Diplosoma listerianum</i>	Compound Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate

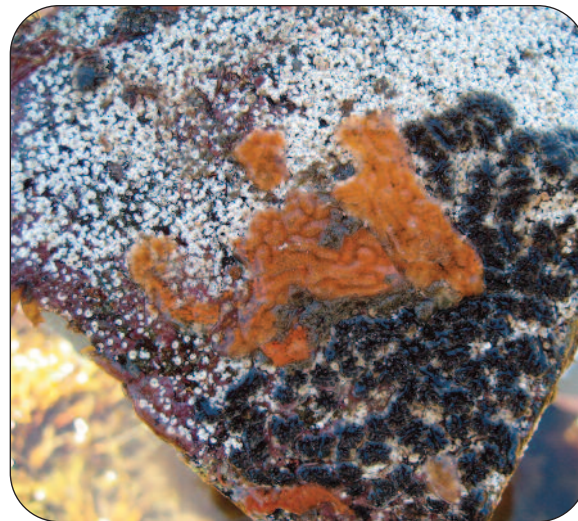
Table 18b: Cryptogenic species recorded at Fort Adams State Park during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bowerbankia gracilis</i>	Bryozoan
Bryozoa	<i>Bugula simplex</i>	Fan Bugula
Bryozoa	<i>Bugula stolonifera</i>	Bryozoan
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Cnidaria	<i>Laomedea calceolifera</i>	Hydroid
Cnidaria	<i>Obelia dichotoma</i>	Sea Thread Hydroid
Cnidaria	<i>Obelia geniculata</i>	Knotted Thread Hydroid
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-Scaled Worm
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Porifera	<i>Leucosolenia botryoides</i>	Pipe Sponge
Porifera	<i>Sycon ciliatum</i>	Sponge
Tunicata	<i>Ciona intestinalis</i>	Sea Vase

Kings Beach, Newport, Rhode Island

July 26, 2010, 13:30

This popular diving and fishing spot is located on the southern end of Newport. The rocky intertidal habitat in the western cove and sandy subtidal eastern cove support a rich diversity of fish species and a thriving eelgrass bed, commonly used as a source of eelgrass for restoration projects throughout Narragansett Bay. Sixty-five species were found during the 2010 RAS, including 13 non-native and three cryptogenic species.



Sheath tunicate, Botrylloides violaceus, star tunicate, Botryllus schlosseri, and tube-building polychaetes at Kings Beach, Newport, Rhode Island.

Table 19a: Non-native species recorded at Kings Beach during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Chthamalus fragilis</i>	Barnacle
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Chlorophyta	<i>Codium fragile</i> ssp. <i>fragile</i>	Green Fleece
Cnidaria	<i>Diadumene lineata</i>	Orange Striped Anemone
Mollusca	<i>Littorina littorea</i>	European Periwinkle
Rhodophyta	<i>Gracilaria vermiculophylla</i>	Red Algae
Rhodophyta	<i>Grateloupia turuturu</i>	Asian Red Seaweed
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate
Tunicata	<i>Diplosoma listerianum</i>	Compound Tunicate

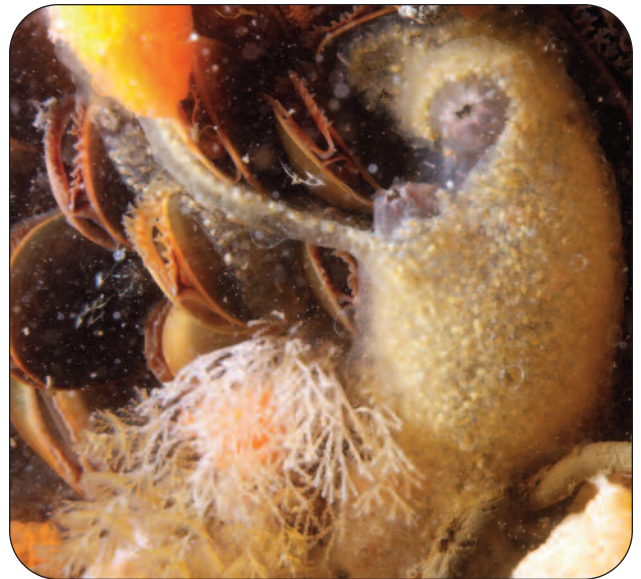
Table 19b: Cryptogenic species recorded at Kings Beach during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Bryozoa	<i>Electra pilosa</i>	Hairy Sea-Mat
Cnidaria	<i>Dynamena pumila</i>	Sea Oak Hydroid

**Point Judith Marina,
South Kingston, Rhode Island**

July 25, 2010, 13:00

The Point Judith Marina is located on the southern end of Narragansett Bay within the sheltered enclosure of Point Judith Pond. The marina features a large system of floating docks and wooden pilings. In 2008, the Rhode Island Coastal Resources Management Council designated Point Judith as Rhode Island’s second Clean Marina, a distinction that reflects the use of Best Management Practices (BMPs) and innovative pollution control strategies. The fouling community was composed of a barnacle base with an abundance of anemones and bryozoans. Seventy-three species were found during the 2010 RAS, including 15 non-native and 11 cryptogenic species.



The colonial tunicate, Diplosoma listerianum, overgrows the European tunicate, Ascidiella aspersa, amongst mussels, bryozoans, and other tunicates at Point Judith Marina, South Kingston, Rhode Island.

Table 20a: Non-native species recorded at Point Judith Marina during the 2010 RAS.

Group	Species	Common Name/Description
Arthropoda	<i>Caprella mutica</i>	Skeleton Shrimp
Arthropoda	<i>Carcinus maenas</i>	European Green Crab
Arthropoda	<i>Hemigrapsus sanguineus</i>	Asian Shore Crab
Bryozoa	<i>Bugula neritina</i>	Bryozoan
Chlorophyta	<i>Codium fragile</i> ssp. <i>fragile</i>	Green Fleece
Cnidaria	<i>Diadumene lineata</i>	Orange Striped Anemone
Porifera	<i>Halichondria bowerbanki</i>	Bread Crumb Sponge
Rhodophyta	<i>Grateloupia turuturu</i>	Asian Red Seaweed
Rhodophyta	<i>Neosiphonia harveyi</i>	Filamentous Red Algae
Tunicata	<i>Ascidiella aspersa</i>	European Tunicate
Tunicata	<i>Botrylloides violaceus</i>	Sheath Tunicate
Tunicata	<i>Botryllus schlosseri</i>	Star Tunicate
Tunicata	<i>Didemnum vexillum</i>	Colonial Tunicate
Tunicata	<i>Diplosoma listerianum</i>	Compound Tunicate
Tunicata	<i>Styela clava</i>	Club Tunicate

Table 20b: Cryptogenic species recorded at Point Judith Marina during the 2010 RAS.

Group	Species	Common Name/Description
Bryozoa	<i>Bowerbankia gracilis</i>	Bryozoan
Bryozoa	<i>Bugula simplex</i>	Fan Bugula
Bryozoa	<i>Bugula stolonifera</i>	Bryozoan
Bryozoa	<i>Cryptosula pallasiana</i>	Encrusting Bryozoan
Cnidaria	<i>Clytia hemisphaerica</i>	Hydroid
Cnidaria	<i>Obelia longissima</i>	Bushy Wine-Glass Hydroid
Mollusca	<i>Placida dendritica</i>	Sea Slug
Polychaeta	<i>Harmothoe imbricata</i>	Fifteen-Scaled worm
Polychaeta	<i>Lepidonotus squamatus</i>	Rusty Scaleworm
Porifera	<i>Leucosolenia botryoides</i>	Pipe Sponge
Tunicata	<i>Ciona intestinalis</i>	Sea Vase

Summary

In total, 314 species were documented during the survey, including 259 native, 29 non-native, and 26 cryptogenic species (Table 22a, b). The Massachusetts Bays NEP region had the highest number of non-native species detected overall with 24, followed by the Narragansett Bay NEP region with 21 non-native species (Table 22a). The number of non-native species has not increased dramatically since the first survey in 2000 (Table 21). Levels of non-native species are well below areas such as Southern California (69 species), but similar to levels found in Puget Sound and Willapa Bay on the U.S. West Coast (Cohen et al. 1998, 2001, 2005).

Table 21: Rapid assessment surveys conducted along the Northeast coast since 2000.

Year	Sites Sampled	Geographic Range of Survey	Non-Native Species
2000	34	Narragansett Bay (RI) to Gloucester (MA)	32
2003	20	Staten Island (NY) to Portland (ME)	29
2007	17	Buzzards Bay (MA) to Rockland (ME)	26
2010	20	Narragansett Bay (RI) to Cape Elizabeth (ME)	29

Tunicata and Rhodophyta were on the whole the most diverse group in the survey, each with seven species recorded. These taxa were also among the most common; the colonial tunicates *Botrylloides violaceus* and *Botryllus schlosseri* were found at all sampling locations and the red algae *Neosiphonia harveyi* was found at 95% of sites. As with prior surveys, native species were in the majority, representing 82% of the total number of species identified.

Rocky shore sites and floating dock sites had similar numbers of non-native species. Kings Beach in Rhode Island had the highest number of non-native species at a rocky shore site with 13, while Dyer Cove in Maine had the highest number of total species overall (100 species). Fort Adams in Rhode Island and Hawthorne Cove Marina in Massachusetts were tied for the highest number of non-native species with 17. Interestingly, Hawthorne Cove Marina is also where a new invader, the European shrimp *Palaemon elegans*, was discovered by the RAS taxonomic team during this survey. The Rocky Shore site at Odiorne Point South in New Hampshire had the lowest number of species detected overall with 33, while the nearby docks at the UNH Marine Lab in New Hampshire had the highest number of total species for a floating dock sites with 90 species. The number of non-native species recorded at the site, however, was similar: eight species for Odiorne Point South and 10 for the UNH Marine Lab.



Invasive species were not just restricted to the intertidal: non-native wildflowers at Dyer Cove, Cape Elizabeth, Maine.

Table 22a: List of the 29 non-native marine species identified during the 2010 Rapid Assessment Survey.

Species	NBEP	BBP	MBP	PREP	CBEP	Occurrence
Chlorophyta						
<i>Codium fragile</i> ssp. <i>fragile</i>	x	x	x		x	45%
Rhodophyta						
<i>Bonnemaisonia hamifera</i>			x	x	x	15%
<i>Gracilaria vermiculophylla</i>	x					10%
<i>Grateloupia turuturu</i>	x	x	x			30%
<i>Heterosiphonia japonica</i>	x					10%
<i>Lomentaria clavellosa</i>		x	x			15%
<i>Lomentaria orcadensis</i>			x			5%
<i>Neosiphonia harveyi</i>	x	x	x	x	x	95%
Phaeophyceae						
<i>Melanosiphon intestinalis</i>				x		5%
Porifera						
<i>Halichondria bowerbanki</i>	x	x	x	x	x	70%
Cnidaria						
<i>Diadumene lineata</i>	x	x	x		x	55%
<i>Sagartia elegans</i>			x			5%
Mollusca						
<i>Littorina littorea</i>	x		x	x	x	30%
Arthropoda:						
Amphipoda						
<i>Caprella mutica</i>	x	x	x	x	x	65%
Arthropoda:						
Sessilia						
<i>Chthamalus fragilis</i>	x					5%
Arthropoda:						
Mysida						
<i>Praunus flexuosus</i>	x		x	x	x	25%
Arthropoda:						
Decapoda						
<i>Carcinus maenas</i>	x	x	x	x	x	80%
<i>Hemigrapsus sanguineus</i>	x	x	x		x	70%
<i>Palaemon elegans</i>			x			5%
Bryozoa						
<i>Alcyonidium</i> sp.			x			5%

NATIONAL ESTUARY PROGRAM ABBREVIATIONS

Narragansett Bay Estuary Program = NBEP

Buzzards Bay National Estuary Program = BBP

Massachusetts Bays Program = MBP

Piscataqua Region Estuaries Partnership = PREP

Casco Bay Estuary Partnership = CBEP

Occurrence = number of sites where species was recorded/total number of sites.

<i>Botryllus schlosseri</i>	x	x	x	x	x	100%
<i>Styela canopus</i>		x			x	10%
<i>Styela clava</i>	x	x	x	x	x	65%
Total Species/Region	21	17	24	13	16	-

Table 22b: List of the 26 cryptogenic marine species identified during the 2010 Rapid Assessment Survey.

Species	NBEP	BBP	MBP	PREP	CBEP	Occurrence
Polychaeta						
<i>Lepidonotus squamatus</i>	x	x	x	x	x	70%
<i>Harmothoe imbricata</i>	x	x	x	x	x	75%
Bryozoa						
<i>Amathia vidovici</i>		x				10%
<i>Bowerbankia gracilis</i>	x	x	x		x	30%
<i>Bowerbankia imbricata</i>	x	x		x	x	45%
<i>Bugula stolonifera</i>	x	x	x	x		50%
<i>Bugula simplex</i>	x	x	x	x	x	60%
<i>Conopeum reticulum</i>	x					5%
<i>Electra pilosa</i>	x	x	x	x	x	70%
<i>Cryptosula pallasiana</i>	x	x	x	x	x	75%
Cnidaria						
<i>Ectopleura larynx</i>				x		5%
<i>Halecium halecinum</i>		x				5%
<i>Pennaria disticha</i>	x					5%
<i>Gonothyrea loveni</i>		x	x			10%
<i>Clytia hemisphaerica</i>	x	x				15%
<i>Laomedea calceolifera</i>	x	x	x			20%
<i>Dynamena pumila</i>			x	x	x	30%
<i>Obelia geniculata</i>	x	x	x	x	x	40%
<i>Obelia longissima</i>	x	x	x	x	x	65%
<i>Obelia dichotoma</i>	x	x	x	x	x	75%
Mollusca						
<i>Placida dendritica</i>	x		x			10%
<i>Tenellia adpersa</i>				x	x	15%
<i>Cuthona gymnota</i>				x	x	20%
Porifera						
<i>Sycon sp.</i>	x				x	20%
<i>Leucosolenia sp.</i>	x	x	x	x	x	55%
Tunicata						
<i>Ciona intestinalis</i>	x	x	x	x	x	60%
Total Species/Region	20	18	18	18	18	-

Conclusions

The value of Rapid Assessment Surveys will only increase over time as consecutive datasets come together. Multiple surveys conducted over an extended period of time support the formation of a comprehensive dataset that will provide the public and policy makers with better information concerning the status of non-native species in the region. The taxonomic team has expertise in both native and non-native species, making the data invaluable for identifying new species not previously reported. For example, new species such as the invasive tunicate *Didemnum vexillum*, the non-native isopod *Synidotea laevidorsalis*, and the shrimp *Palaemon elegans* have all been identified in the region by the RAS taxonomic teams. In addition, the survey has led to the reclassification of species formerly assumed to be native. For example, several species of marine algae, formerly thought to be native to the region, were correctly reclassified as non-native from information gathered by previous surveys (Mathieson et al. 2008a,b).

Building on these results, the research team can begin to examine trends, impacts, and management implications more closely. The addition of rocky shore sites in 2010 has enabled insights into the spread of non-native species outside of likely introduction sites (marinas and docks) to natural substrates. The similar numbers of non-native species at both types of sampling sites adds evidence to the theory of invasive species spread, but there is much to learn. Long-term regional studies like the RAS are critical to improving our understanding of invasive species dynamics and for the examination of trends in relation to climate change and continued invasion pressure.

Spotlight: Non-Native Isopoda and Gammaridean Amphipoda

During the survey, the non-native isopod *Laniropsis serricaudis* was discovered at eight survey locations. This species, native to Asia, was also likely found during the 2007 and 2003 surveys but not definitively identified until now. The amphipod *Microdeutopus gryllotalpa*, which was recorded during the 2003 survey in Buzzards Bay and Long Island Sound, was found in Narragansett Bay and as far north as Casco Bay during the 2010 survey. In addition, a number of other amphipod species collected by the survey team are still in the process of being identified. This highlights the importance of the Rapid Assessment Survey taxonomic team in tracking existing species and in the discovery of new invaders, which may be cryptic and otherwise undetectable by non-targeted surveys. Publications for the new records of *Laniropsis serricaudis*, and also the European shrimp *Palaemon elegans*, are currently in production.



RAPID ASSESSMENT SURVEY: 2010 Distribution of Non-Native Isopoda and Gammaridean Amphipoda



Appendix

Table 23: Water Quality Data was collected using compact sondes (YSI 600XLM and YSI 55) as well as a secchi disk. Measurements were collected at the surface only at rocky shore sites (RS).

SITE	Max Depth (m)	Surface Temp (°C)	Surface DO [mg/L]	Surface Salinity (ppt.)	Max Depth Temp (°C)	Max Depth DO [mg/L]	Max Depth Salinity (ppt.)	Secchi Depth (m)
Port Edgewood	3.00	25.7	8.29	25.2	25.4	6.44	25.4	0.75
Brewers S. Freeport	3.25	17.7	7.76	30.7	17.2	7.70	30.9	1.0
Spring Point Marina	3.00	17.6	8.38	29.1	15.7	7.17	30.4	2.5
Dyer Cove	n/a	15.3	10.1	30.2	n/a	n/a	n/a	n/a
UNH	5.75	17.0	8.02	30.5	15.2	8.20	30.8	3.5
Odiorne Point South	n/a	19.4	7.42	31.0	n/a	n/a	n/a	n/a
Hampton Marina	1.75	19.9	6.64	31.1	18.6	6.16	31.0	1.8
Jodrey Pier	5.25	19.3	6.64	31.2	12.3	7.72	31.2	2.8
Winter Island	n/a	18.3	7.95	30.8	n/a	n/a	n/a	n/a
Hawthorne Cove	2.00	19.7	7.66	31.3	18.6	6.64	31.3	2.0
Rowes Wharf	6.00	19.3	7.41	30.6	17.4	7.04	30.8	2.0
Brewers Plymouth	2.75	20.9	6.87	17.7	20.0	7.45	30.9	2.0
Sandwich Marina	5.00	22.0	6.98	30.3	19.3	95.4	30.6	5.0
Mass Maritime	4.00	22.5	7.16	30.6	22.5	7.24	30.6	3.0
Pope's Island	3.50	24.2	2.78	30.2	24.2	4.53	30.6	1.8
F.L. Tripp & Sons	3.10	21.6	6.90	31.3	21.6	6.59	31.4	2.0
Allen Harbor	3.75	25.8	8.78	27.8	23.8	1.89	29.8	1.5
Fort Adams	3.00	22.4	6.88	30.6	21.7	5.40	30.6	3.0
Kings Beach	n/a	21.4	12.8	31.2	n/a	n/a	n/a	n/a
Point Judith	1.50	25.5	8.64	30.3	25.1	7.92	30.4	1.5

Rapid Assessment Survey Team

The field team for the 2010 RAS included marine scientists with varying specialties.

Participant Name	Specialty/Role	Affiliation
------------------	----------------	-------------

FIELD TEAM

Charles Lambert	Tunicata Taxonomy	California State University, Fullerton
Gretchen Lambert	Tunicata Taxonomy	California State University, Fullerton
James Carlton	General Taxonomy	Williams College-Mystic Seaport
Arthur Mathieson	Algae Taxonomy	University of New Hampshire
Niels Hobbs	Arthropoda Taxonomy	Salem Sound Coastwatch
Antonio Carlos Marques	Cnidaria Taxonomy	Universidade de Sao Paulo
Adriaan Gittenberger	Underwater Photographer/ General Taxonomy	Leiden Bio Science Park
Walter Lambert	General Taxonomy	Framingham State University
Jenn Dijkstra	General Taxonomy/Biomass Collection	Wells National Estuarine Research Reserve
Judy Pederson	Co-Organizer/General Taxonomy	MIT Sea Grant
Larry Harris	General Taxonomy	University of New Hampshire
Lauren Stefaniak	Tunicata Taxonomy	University of Connecticut
Cascade Sorte	Biomass/Lab and Field Assistant	Northeastern University Marine Science Center
Adrienne Pappal	Co-Organizer, Dockmaster/Logistics	MA Office of Coastal Zone Management
Sara Grady	Water Quality, Annelida Taxonomy	Mass Bays Program
Jan Smith	Co-Organizer/Logistics	MA Office of Coastal Zone Management
Linsey Haram	Decapoda/Lab and Field Assistant	Williams College-Mystic Seaport
Miranda Mickiewicz	Decapoda/Lab and Field Assistant	Williams College-Mystic Seaport
Rachel Rock-Blake	Sessilia/Lab and Field Assistant	Williams College-Mystic Seaport
Christopher McIntyre	Lab, Field Assistant/ Data Analysis, Reporting	University of Massachusetts Boston
Martine Wagstaff	Biomass/Lab and Field Assistant	University of Massachusetts Boston
Jessica Bryant	Biomass/Lab and Field Assistant	University of New Hampshire
Yvette Garner	Biomass/Lab and Field Assistant	University of New Hampshire
Renée Eriksen	Algae/Lab and Field Assistant	University of New Hampshire
Megan McCuller	Biomass/Lab and Field Assistant	University of New Hampshire

SUPPORT TEAM

Greg Booma	Data Management	MIT Sea Grant College Program
Kevin Cute	Logistics/RI	RI Coastal Resources Management Council
Curtis Bohlen	Logistics/NH	Casco Bay Estuary Program
Beverly Bayley-Smith	Logistics/ME	Casco Bay Estuary Program
Tracy Warncke	Logistics/Buzzards Bay, MA	Buzzards Bay Estuary Program
Barbara Warren	Logistics/Salem Sound, MA	Salem Sound Coastwatch
Jay Baker	Logistics/MA	Mass Bays Program
Michele Tremblay	Logistics/Fiscal	Northeast Aquatic Nuisance Species Panel

References

- Campbell ML, Gould B, Hewitt CL. 2007. Survey evaluations to assess marine bioinvasions. *Marine Pollution Bulletin* 55:360-378.
- Carlton JT. 1985. Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. *Oceanography and Marine Biology an Annual Review* 23: 313-371.
- Carlton JT. 2003. A checklist of the introduced and cryptogenic marine and estuarine organisms from Nova Scotia to Long Island Sound. 2nd Edition. Williams College-Mystic Seaport Maritime Studies Program. Mystic, CT.
- Cohen AN, Berry H, Mills C, Milne D, Britton-Simmons K, Wonham M, Secord D, Barkas JA, Bingham B, Bookheim B, Byers J, Chapman JW, Cordell J, Dumbauld B, Fukuyama A, Harris LH, Kohn A, Li K, Mumford T, Radashevsky V, Sewell A, Welch K. 2001. Report of the Washington State exotics expedition 2000: A rapid assessment survey of exotic species in the shallow waters of Elliot Bay, Totten and Eld Inlets, and Willapa Bay. Nearshore Habitat Program, Washington State Department of Natural Resources, Olympia, WA. 47 pp.
- Cohen AN, Mills CE, Berry H, Wonham MJ, Bingham B, Bookheim B, Carlton JT, Chapman JW, Cordell JR, Harris LH, Klinger T, Kohn A, Lambert CC, Lambert G, Li K, Secord D, Toft J. 1998. Report of the Puget Sound Expedition, September 8-16, 1998: A rapid assessment survey of nonindigenous species in the shallow waters of Puget Sound. Nearshore Habitat Program, Washington State Department of Natural Resources, Olympia, WA. 37 pp.
- Cohen AN, Harris LH, Bingham BL, Carlton JT, Chapman JW, Lambert CC, Lambert G, Ljubenkov JC, Murray SN, Rao LC. 2005. Biological assessment survey for exotic organisms in Southern California Bays and Harbors, and abundance in port and non-port areas. *Biological Invasions* 7(6): 995-1002.
- Glasby TM, Connell SD, Holloway MG, Hewitt CL. 2007. Nonindigenous biota on artificial structures: could habitat creation facilitate biological invasions? *Marine Biology* 151(3): 887-895.
- Lodge DM, Williams S, MacIsaac HJ, Hayes KR, Leung B, Reichard S, Mack RN, Moyle PB, Smith M, Andow DA, Carlton JT, McMichael A. 2006. Biological invasions: Recommendations for U.S. policy and management. *Ecological Applications* 16:2035-2054.
- Mathieson AC, Pederson J, Dawes CJ. 2008a. Rapid assessment surveys of fouling and introduced seaweeds in the northeastern Atlantic. *Rhodora* 110(944): 406-478.
- Mathieson AC, Pederson JR, Neefus CD, Dawes CJ, Bray TL. 2008b. Multiple assessments of introduced seaweeds in the North Atlantic. *ICES Journal of Marine Science* 65: 730-741.
- Parker IM, Simberloff D, Lonsdale WM, Goodell K, Wonham M, Kareiva PM, Williamson MH, Van Holle B, Moyle PB, Byers JE, Goldwasser L. 1999. Impact: Toward a framework for understanding the ecological effects of invaders. *Biological Invasions* 1: 3-1.
- Pederson J, Bullock R, Carlton JT, Dijkstra J, Dobroski N, Dyrinda P, Fishers R, Harris L, Hobbs N, Lambert G, Lazo-Wasem E, Mathieson A, Miglietta M, Smith J, Smith J III, Tyrrell M. 2005. Marine invaders in the northeast: Rapid assessment survey of non-native and native marine species of floating dock communities, report of the August 3-9, 2003, survey. Publication No. 05-03. Cambridge: Massachusetts Institute of Technology, Sea Grant College Program. 40 pp.
- Pimentel D, Zuniga R, Morrison D. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics* 52: 273-288.
- Ruiz GM, Fofonoff PW, Carlton JT, Wonham MJ, Hines AH. 2000. Invasion of coastal marine communities in North America: Apparent patterns, processes, and biases. *Annual Review of Ecology and Systematics* 31: 481-531.
- Vitousek PM, Mooney HA, Lubchenco J, Melillo JM. 1997. Human domination of Earth's ecosystems. *Science* 277:494-499.



For more on
INVASIVE SPECIES
www.mass.gov/czm/invasives