

## **FINAL REPORT**

### **Regional Proposal to Test Sensors for Detecting the Sea Squirt *Didemnum* sp. A on Georges Bank**

Award No. NA07NMF4720360

Period of Performance: 11/21/08-6/30/10

Report Submitted: October 21, 2010

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## Abstract

*Didemnum vexillum*, a compound sea squirt, has been found in Georges Bank where it may cover between 50-90% of the sea floor in areas that were surveyed before 2009. The sea squirt may be impacting groundfish and scallops in the region for multiple reasons: it is not a preferred food for groundfish, restricts access of fish to polychaete worms, and prohibits bay scallops from settling on the sea squirt. To understand the scope of the impact, the challenge is to identify the spatial coverage of *D. vexillum* in its potential habitat, assess risk of spreading, and model predicted areas of coverage. High-resolution imagery has been the most reliable means of detection, but it has limitations in efficiency and areas surveyed. We are using the MIT Sea Grant College Program autonomous underwater vehicle (AUV) Odyssey IV to test sensors that will effectively and efficiently detect *D. vexillum*.

As a first step, we surveyed areas in Georges Bank, Massachusetts and Cape Cod Bays, Stellwagen Bank, and Nantucket Sound using our AUV platform. We tested an acoustic sensor that failed to provide sufficient detail to identify *D. vexillum* from the sea floor and subsequently are developing and testing a new optical sensor. Current results indicate that *D. vexillum* can die back during adverse periods and little or no *D. vexillum* were present in areas surveyed in Massachusetts Bay and Stellwagen Bank. Images of benthic organisms from the AUV deployment were recorded as well as measurements of conductivity, temperature, and depth.

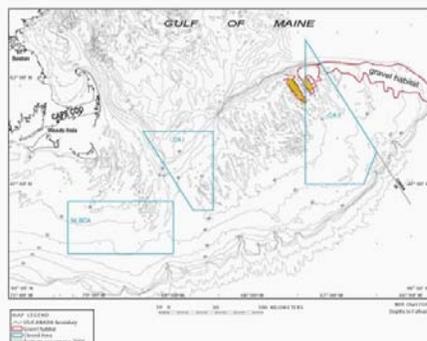
## Introduction

The sea squirt *Didemnum vexillum* (formerly referred to as *Didemnum* sp. A) is a highly successful invader and grows over many encrusting organisms, including mussels and other bivalves (Bullard et al. 2007). Although it was first observed in Georges Bank in 2003, our knowledge of the abundance of *D. vexillum* on Georges Bank is limited, in part because only some of the area has been surveyed. *Didemnum vexillum* covers 50-90% of ~240 km<sup>2</sup> and has the potential to impact groundfish and scallop productivity (Valentine et al. 2007). Large mats of *Didemnum vexillum* may limit access to infaunal prey, such as polychaetes (Valentine et al. 2007, R. Whitlatch, pers. comm., University of Connecticut 2008). *Didemnum vexillum* appears to inhibit settlement of bay scallops *Argopecten irradians irradians* on the sea squirt that has implications for offshore populations of *Placopecten magellanicus* (Morris et al. 2009).

In order to assess the impact of *D. vexillum*, we need to document its spatial coverage. This effort will explore how best to monitor the sea squirt presence throughout potential habitats (gravel beds and other hard surface areas). The current video and imaging methods are the most reliable method for detecting *D. vexillum*, but only a small area of the sea floor had been surveyed during research cruises. What is needed is a sensor that can distinguish *D. vexillum* from other species and substrate that is reliable, efficient and can quickly survey large areas. This project addresses the Northeast Consortium (NEC) research funding priority areas by cross-cutting oceanographic monitoring with novel technology to study species distribution and abundance.



A



B

Figure 1 a and b: Figure 1a is a photograph of *Didemnum* covering a scallop and gravel areas in Georges Bank and reflects the 50-90% coverage observed in areas where *Didemnum* is found. Figure 1b is a map of Georges Bank showing gravel beds (outlined in red) closed areas (outlined in blue) and areas where *Didemnum* is found (colored in yellow). Both the photo and map are from <http://woodshole.er.usgs.gov/project-pages/stellwagen/didemnum/>.

## Technologies for Surveying Large Marine Ecosystems

The use of autonomous underwater vehicles (AUVs) for ocean exploration offers an alternative platform for mobile sensors. The MIT Sea Grant College Program (MIT SG) AUV is an ideal platform for testing sensors in deeper waters. AUVs are untethered, do not require dynamic positioning, and use only minimal surface support, e.g. small research vessels can supervise more than one AUV at a time thereby increasing spatial coverage at less cost. The MIT SG Odyssey IV is a mid-sized streamlined, deep-water capable platform. In 2008, an acoustic sensor was tested and although it provided images, scientists could not distinguish cobble habitat from *D. vexillum* in these images. The purpose of this project was to test the ability of Odyssey IV and its optical sensors to detect *D. vexillum* in Georges Bank and in waters of 25-50 m depth in Massachusetts and Cape Cod Bays and Stellwagen Bank.

## Project Objectives and Scientific Hypotheses

Because marine invasions are out of sight and out of mind - especially in deeper, offshore waters such as Georges Bank, Stellwagen Bank and Massachusetts Bay - impacts to the environment and fisheries are poorly documented. *Didemnum vexillum* covers large areas of cobble habitat in Georges Bank where it may interfere with groundfish accessing infaunal prey species and prohibit settlement of scallop larvae. This project is the first phase of a longer-term effort to evaluate the risk of *D. vexillum* to fisheries and to develop models of dispersion.

This project focused on documenting the range of *D. vexillum*, a non-native tunicate in nearshore habitats and Georges Bank ecosystem where it covers more than 50% of

approximately 240 km<sup>2</sup> of the sea floor. Georges Bank is a productive groundfish and scallop fishing area. Currently, only a small area of Georges Bank has been surveyed for *D. vexillum*, which limits assessment of the risk to fisheries and understanding how quickly it can spread. We also are limited in our understanding of the extent of spatial coverage of the sea squirt in nearshore habitats. This first phase explored how best to monitor the sea squirt presence throughout potential habitats (gravel beds and other hard surface areas). The next phase of our research will focus on the impact of *D. vexillum* to fisheries, identify options to prevent its spread and mitigate these impacts, and develop models to predict its potential spread throughout the region.

The funding from the NEC was intended to address only the first phase of the project, namely to test different sensors for quickly and reliably identifying *D. vexillum* colonies throughout nearshore Georges Bank cobble and hard surface habitats. Depending on the success of the sensor testing, targeted optimal habitats for *D. vexillum* would be surveyed to expand our knowledge of its subtidal and offshore distribution. The fall-back option was to use cameras and videos to identify areas where *D. vexillum* is present and where it is absent. This project supports regional research efforts of the Northeast Sea Grant College Programs and complements NEC's ongoing research documenting species distribution and abundance. The research is part of our MIT Sea Grant College Program's (MIT SG) strategic and implementation plan.

### **Changes from the Original Proposal**

#### **Changes in Personnel and Fishing Collaborator:**

As noted in the June 24, 2009 report, there were changes in personnel and the Fishing Industry Collaborator. MIT Sea Grant engineers Seth Newburg, Ian Katz and Michael Soroka collaborated with the Fishing Industry Collaborator Captain Troy Dwyer (Dwyer Fisheries). Captain Dwyer's boat is a 90-foot fishing vessel with a large deck, crane, and other equipment necessary for safely deploying our AUV, Odyssey IV. We requested and were approved for the change in Fishing Industry Collaborator.

#### **Changes in Workplan:**

The change of Fishing Industry Collaborator was necessary to ensure the safety of the crew, autonomous underwater vehicles (AUVs), and AUV lab to be consistent with the size of the fishing vessel. Thus, nearshore surveys for *D. vexillum* are included in the workplan. The change in location identifies, among other areas, some sampling locations in Massachusetts and Cape Cod Bays and Stellwagen Bank. The change in location was reflected in our application to the National Environmental Policy Act (NEPA). The response of the NOAA NMFS is provided below and we will adhere to the requirements in the Categorical Exclusion from Requirements to Prepare and Environmental Assessment (EA) or and Environmental Impact Statement (EIS) for the University of New Hampshire, Regional Proposal to Test Sensors for Detecting the Sea Squirt, *Didemnum vexillum* on Georges Bank, Award No. NA07NMF4720360 (Appendix) for deploying the AUV and surveying for *Didemnum*. Thus, we adhered to the time restrictions for deploying in Cape Cod Bay to avoid marine mammal interference.

Because the AUV was under development during the summer of 2009, we were unable to complete our missions until the summer of 2010. Our sampling area was modified to survey for *D. vexillum* in areas closer to shore based on fishermen's and scientists input.

The purpose of this research is to identify appropriate technologies to document the spatial coverage and estimate the biomass of an invader, *Didemnum vexillum*, in large regional marine ecosystems.

The specific objectives of this project were to:

1. Adapt an autonomous underwater vehicle (AUV) for testing optical sensors for detecting *D. vexillum* quickly in offshore areas.
2. Determine the effectiveness of digital still camera technology for assessing *D. vexillum* on the sea floor.
3. Use fishermen's local knowledge to identify potential areas of *D. vexillum* infestation on the seafloor in Massachusetts and Cape Cod Bays and Stellwagen Bank.
4. Document the presence and absence of *D. vexillum* with habitat type and, where feasible, with epifaunal species.
5. Record environmental data and images of the sea floor and distribute online.

## Participants

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### **Fishing Industry Collaborator**

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### **Science Advisors**

- William Schwab, Director, Woods Hole Coastal & Marine Science Center, US Geological Survey
- Page Valentine, Ph.D., Scientist, Woods Hole Coastal & Marine Science Center, US Geological Survey
- Vincent Guida, Scientist, NOAA: Northeast Fisheries Science Center, Sandy Hook Laboratory

### **Methods**

The NEPA Categorical exclusion letter was issued in September 30, 2008 and the grant was officially awarded on November 21, 2008. At this time of the year, the water temperatures have dropped and *D. vexillum* colonies regress. Thus, field studies were not resumed until the summer of 2009. The MIT Sea Grant AUV Odyssey IV operated for a few days, but engineering problems arose and forced a postponement of the remaining surveys with the AUV. Surveys were completed during the summer of 2010.

The goals of the Odyssey IV deployments included capturing high quality images of the ocean floor in surveys for the invasive species *D. vexillum* and other biota, as well as operating the Odyssey IV at increased depths, and developing and demonstrating autonomous control behaviors using machine vision. We include photographs that document the safe deployment of the Odyssey IV (see Figure 2).



Figure 2: Photographic sequence of a routine deployment of the Odyssey IV from the F/V *Isabella & Ava* using the overhead boom crane. Field operations were conducted at Stellwagen Bank in October 2009.

We prepared the Odyssey IV and support equipment for operations in the open ocean. The vehicle was deployed from the 90 foot F/V *Isabella & Ava* piloted by Captain Troy Dwyer for a total of five days in 2009 and six days in 2010. Operational trials and seabed imaging surveys were performed in Massachusetts Bay, four miles east of Scituate, MA, and on Stellwagen Bank, and Fifteen Bank. Our cruise dates were October 5, 6, 13-15, 2009 and June 15, 16 and 22-25, 2010. Areas surveyed for *D. vexillum* include the NEC-funded survey sites in Massachusetts and Cape Cod Bays and Stellwagen Bank, along with two other projects, one in Georges Bank Closed Area II (CA II) in 2008, and another near the Nantucket Lightship and Closed Area I (CA I) in 2010 (see Figure 3).

The areas were chosen in collaboration with recommendations from Captain Dwyer based on his local ecological knowledge of the sea floor and in consultation with Scott Gallager, Woods Hole Oceanographic Institution who observed *D. vexillum* in Stellwagen Bank. The goal was to look for *D. vexillum* in hard bottom areas to see if there were patches for testing with an optical sensor (radiometer) being developed under another grant.

One of the modifications to Odyssey IV was to mount and test a new camera system for capturing high quality images of the ocean floor in surveys for the *D. vexillum* and other biota. The imaging system of the Odyssey IV was extensively tested in 2009. The

vehicle performed surveys cruising at altitudes of 1.4-2.0 m above the sea floor while at depths of up to 100 m. Images were recorded at a 3-second interval (0.33 Hz) with dual strobe illumination. The improvements to the imaging system are crucial for successful imaging processing and automated identification tasks in deep water where there is no ambient light. During some of the cruises sediments in the water column prevented clear images, nonetheless macroinvertebrates were identifiable in most of the runs.

During the 2010 summer surveys, we continued to maximize the performance of our imaging hardware, evaluating and implementing a new camera system that increases image resolution, illumination uniformity, and color fidelity. The image acquisition rate was increased to a 2-second interval (0.5 Hz) with dual strobe illumination. In addition, trials with the AUV indicated that it functioned and performed reliably and consistently. Odyssey IV continued untethered, autonomous operations and imaging tasks in the open ocean at depths of 100 m. Supervisory control has been demonstrated over a radio link on the Odyssey IV. Integration of supervisory control using acoustic modem with Odyssey IV is in progress.

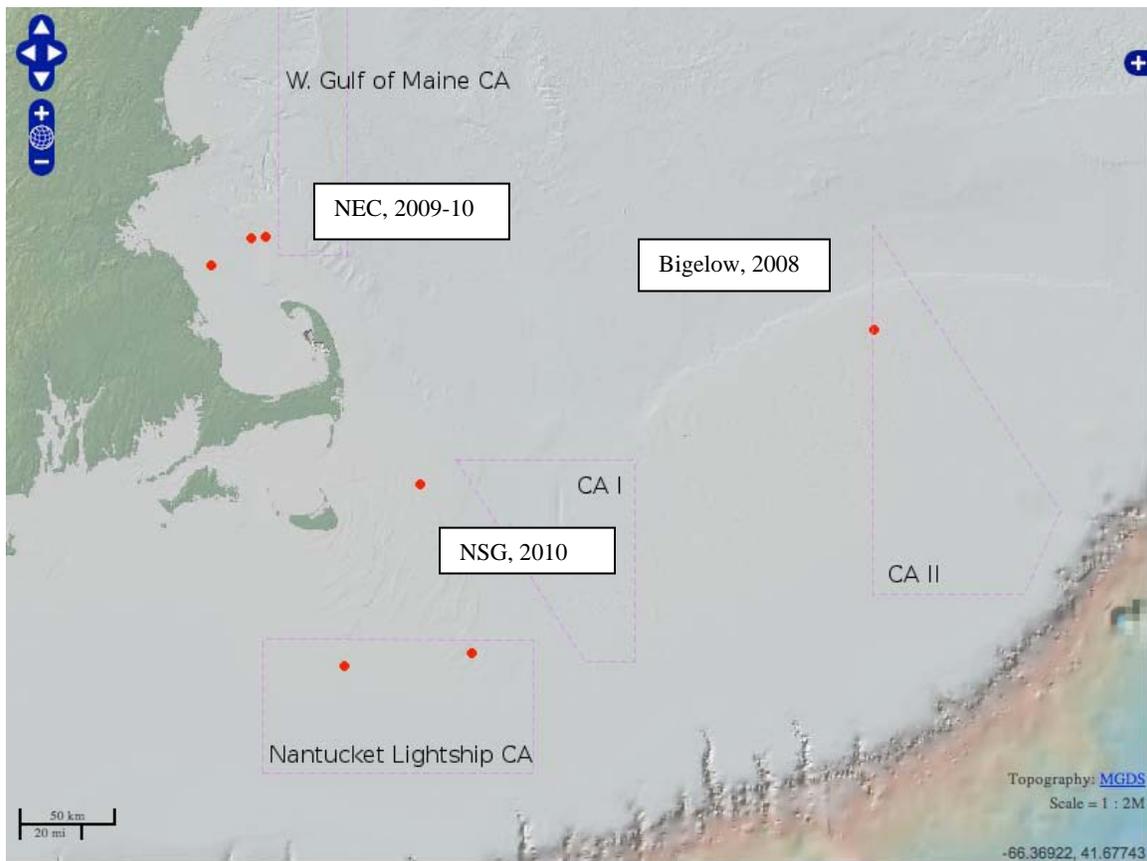


Figure 3: The red dots indicate areas of *Didemnum vexillum* surveys conducted with optical and acoustic sensors. The Northeast Consortium surveys were in the summer of 2009-2010 (NEC 2009-10), a Georges Bank cruise on the Bigelow was during the summer of 2008 (Bigelow, 2008) and a regional project funded by the Northeast Sea Grant Programs had cruises to the Nantucket Lightship area and near Closed Area I during the summer of 2010 (NSG, 2010).

## Data

Images of the sea floor and temperature, conductivity and depth data were collected along with information on altitude and other measurements necessary for operating the AUV. During the six days of surveys in 2010, no *D. vexillum* was found near the outfall in Massachusetts Bay, near Scituate, in Stellwagen Bank, and in Fifteen Bank.

With the new camera system, the images were uniformly bright and had excellent color content. An example of the images that were collected is shown in Figure 4. Many species of starfish, sponge, tunicate, and fish were identified in the photographs.

We will be completing a data report and sending data to NEC. The data will be available online and entered into the database by December 31, 2010.

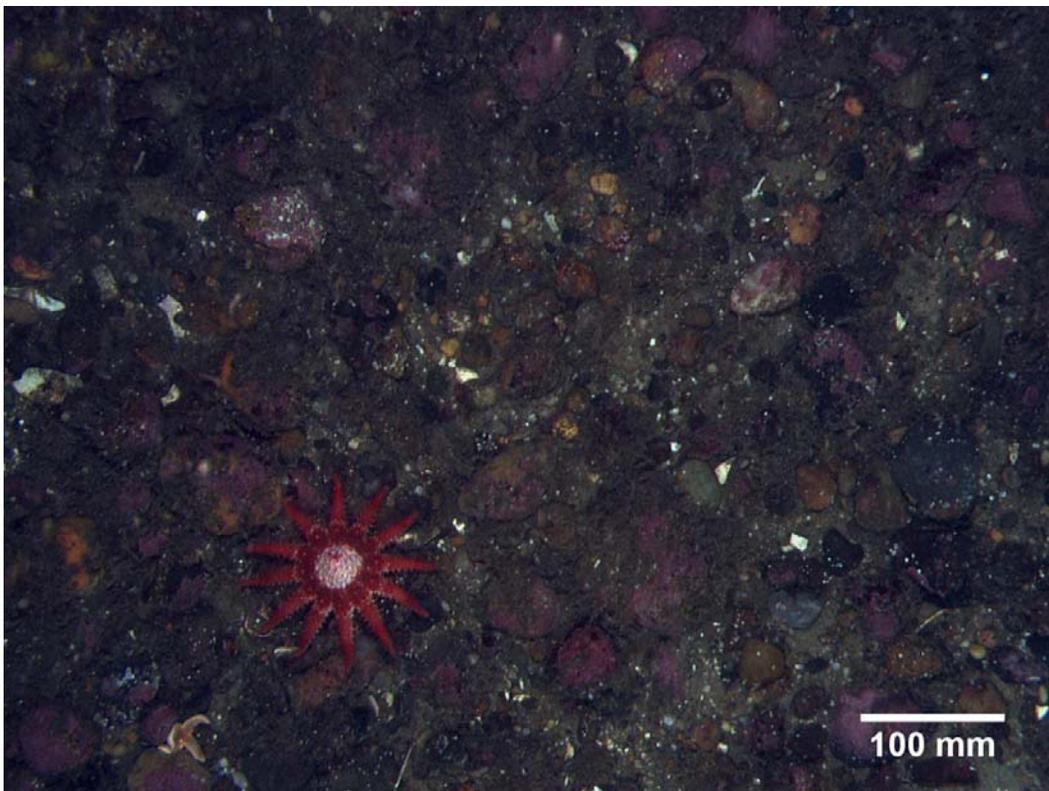


Figure 4: Photograph of the cobble substrate on Stellwagen Bank at a depth of 100 meters. Image was recorded at an altitude of 1.4 meters using the Balsler A102f scientific video camera and dual strobe illumination. Species identified in this image include *Orossaster papposus* (spiny sunstar), *Asterias vulgaris* (northern seastar), *Lithophyllum sp.* (encrusting red coralline alga), *Modiolus modiolus* (mussel), and upright bryozoans. Scale bar is 100 mm.

## Results and Conclusion

The AUV performed consistently and the imaging system provided high quality photographs of the sea floor. The good news for fisheries is the lack of *D. vexillum* in the

hard substrate areas that were surveyed. Nonetheless from earlier work in Georges Bank, *D. vexillum* can cover large areas of the sea floor and potentially impact fisheries and scallops. Because *D. vexillum* grows on piers, pontoons, and floats in most marinas and harbors, care should be taken to maintain hulls and hard surfaces to prevent accidental dispersal.

## **Partnerships**

Our primary partnership was with Captain Troy Dwyer who assisted us with identifying areas of hard bottom as we searched for *Didemnum* in Stellwagen Bank, near Scituate, near the outfall, and in Massachusetts and Cape Cod Bays. His familiarity with these areas as well as others provided us with local knowledge that was essential for our deployments. We have contacted Captains of several fishing vessels, but have not collaborated directly with them or other fishermen. During the course of our field efforts, fishermen whom we met on the docks expressed concern about *Didemnum* and supported efforts to identify where it is found and to work towards eliminating it. We used this opportunity to discuss the need for clean hulls and good fishing practices.

Scott Gallager, Amber York, and Mary Carman from Woods Hole Oceanographic Institution provided advice on locations of *D. vexillum*, and results of a survey with shellfishers. In addition Page Valentine, U.S. Geological Survey, and Vincent Guida, National Marine Fisheries Service, have provided information on the distribution of *D. vexillum* in Georges Bank and nearshore.

## **Impacts and Applications**

The technology developed has a wide range of potential applications for ocean monitoring activities. Our focus in this project was to monitor sea squirt presence throughout potential habitats along the sea floor. We anticipate that this work will be used by fisheries managers to assess the impact of *D. vexillum* on groundfish and scallops and by coastal managers who are concerned about changes to diversity and function of nearshore coastal areas. This research is relevant to the fishing industry and we hope that they will adopt best management practices to prevent *D. vexillum* infestation from gear and ship hulls. The next phase of this project will develop models to predict the potential spread of *D. vexillum* throughout the region.

## **Related Projects**

We conducted a survey of *D. vexillum* on Georges Bank in 2008 and this work adds to our initial pilot project study and preliminary data. The MIT SG's Marine Advisory Service continues to advise the public about introduced species in general and *D. vexillum* specifically (<http://nemis.mit.edu/>; <http://massbay.mit.edu>). We have met formally and informally with groundfish, scallop, and lobster fishermen as well as nearshore aquaculturists and coastal managers.

## Presentations and Abstracts

Seth Newburg presented a paper entitled "Applications for Autonomous Underwater Vehicles in Science, Industry, and Education" at the Seminar: Life Members Society, Social Implications of Technology Chapter and Hanscom Sigma Xi, The Scientific Research Society, January 13, 2010, MIT Lincoln Laboratory, Lexington, MA.

A poster entitled, "Autonomous Underwater Vehicle to Measure *Didemnum* Infestation" by Newburg, Seth O.; Chryssostomidis, Chryssostomos; Eskesen, Justin G.; Hover, Franz S.; Katz, Ian J.; Soroka, Michael G.; Pederson, Judith was part of the Poster Presentation: International Invasive Sea Squirt Conference-III, April 26-28, 2010, Woods Hole Oceanographic Institution, Woods Hole, MA.

Michael Soroka presented "The Odyssey IV Class Submersible," a Video Presentation: Monaco's Fall Energy Summit with MIT to Focus on the Future September 22-25, 2010, Oceanographic Museum of Monaco, Monaco-Ville, Monaco.

Michael Soroka, "MIT Autonomous Underwater Vehicles Laboratory Odyssey IV" as a seminar to the Swampscott Middle School, December 2009, Swampscott Middle School, Swampscott, MA.

Michael Soroka presented a paper entitled "Applications of Robotic Submarines" at the MIT Sea Perch Institute, December 5, 2009, Massachusetts Institute of Technology Cambridge, MA.

Michael Soroka presented a paper entitled "Vehicles Slide Show" at the MIT Museum, March 12, 2010, Massachusetts Institute of Technology, Cambridge, MA.

Michael Soroka presented a paper entitled, "Odyssey IV, Deep Water Submersible" at the Université Pierre et Marie Curie, May 26, 2010, Saint-Cyr-l'École, Paris, France.

Ian Katz gave a presentation entitled "Topside MOOS Utilities to Increase AUV Operator Efficiency" at the MOOS-DAWG Conference, August 24, 2010, Massachusetts Institute of Technology, Cambridge, MA.

Judith Pederson presented a paper entitled, "Seeking *Didemnum* on Georges Bank," Judith Pederson, John Blakeney, Justin Eskensen, Franz Hover, Karl McLetchie, James Morash, Dylan Owens, Michael Soroka, and Dan Walker at the Northeast Consortium Annual meeting, 2009, Portsmouth, New Hampshire.

Judith Pederson presented a paper entitled, "Towards Understanding the Impacts of *Didemnum vexillum*," Judith Pederson, Greg Booma, John Davis, Chryssostomos Chryssostomidis, Ian Katz, Seth Newburg, and Michael Soroka, MIT Sea Grant College Program, Cambridge, Massachusetts, October 12, 2010, Regional Association for Research in the Gulf of Maine, Portsmouth, NH.

## Student Participation

Nine students were supported in research related to this project in 2010.

High School Students:

- Cole Kerr - Newton North High School
- Stephanie Liu - Phillips Andover Academy
- Beth Lacarra - High Tech High - San Diego, Ca
- Jake Neighbors - High Tech High - San Diego, Ca

Undergraduate Students:

- Matt Gildner - MIT
- Jesse Thornburg - MIT
- Andrew Mcdonough - Wentworth Institute of Technology
- John "Max" Davis - Champlain College

Graduate Students:

- Eric Brege – MIT

## Published Reports and Papers

A technical report documenting this effort is in preparation.

## Future Research

We have been funded to develop an optical sensor (radiometer) to see if we can detect a signal specific to *D. vexillum*. Preliminary results suggest that there is a unique signal from other spectra and we will be testing its efficacy in early autumn 2010. In addition, other investigators are examining ecological and biological aspects of *D. vexillum* to explore its potential to spread to new areas.

## References Cited

- Bullard SG, Lambert G, Carman MR, Byrnes J, Whitlatch RB, Ruiz G, Miller RJ, Harris L, Valentine PC, Collie JS, Pederson J, McNaught DC, Cohen AN, Asch RG, Dijkstra J. 2007. Distribution and ecology of the invasive colonial ascidian *Didemnum* sp. on the east and west coasts of the United States. *Journal Marine Biology and Ecology* 342:99-108.
- Valentine PG, Collie JS, Reid RN, Asch RG, Guida VG, Blackwood DS. 2007. The occurrence of the colonial ascidian *Didemnum* sp. on Georges Bank gravel habitat — Ecological observations and potential effects on groundfish and scallop fisheries. *Journal of Experimental Marine Biology and Ecology* 342: 179–181.
- Morris, Jr. JA, Carman MR, Hoagland KE, Green-Beach EMR, and Karney RC. 2009. Impact of the invasive colonial tunicate *Didemnum vexillum* on the recruitment of the bay scallop (*Argopecten irradians irradians*) and implications for recruitment of the sea scallop (*Placopecten magellanicus*) on Georges Bank. *Aquatic Invasions* 4: 207-211.

## Appendix

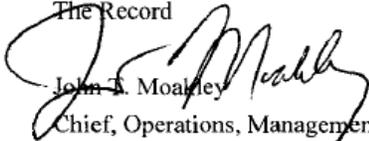


UNITED STATES DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
NATIONAL MARINE FISHERIES SERVICE  
Northeast Fisheries Science Center  
166 Water Street  
Woods Hole, MA 02543-1026

September 30, 2008

MEMORANDUM FOR: The Record

FROM:

  
John T. Moakley

Chief, Operations, Management and Information

SUBJECT:

Categorical Exclusion from Requirements to Prepare an Environmental Assessment (EA) or an Environmental Impact Statement (EIS), for the University of New Hampshire *Regional Proposal to test sensors for detecting sea squirt on Georges Bank Pederson, NA07NMF4720360*

I have reviewed the proposal for the above-referenced Federal financial assistance project NA07NMF4720360, submitted by the University of New Hampshire under the provisions for Unallied Science Projects, statute 16 U.S.C. 661. The environmental review of this proposal has been performed to address provisions of NOAA Administrative Order (NAO) 216-6, "Environmental Review Procedures for Implementing the National Environmental Policy Act" (NEPA) to determine whether the proposed action should be categorically excluded from requirements to prepare either an EIS or an EA under NEPA.

The goal of this project is to document presence or absence of the non-native, soft-bodied *Didemnum sp.* (sea squirts) in various habitats in waters off Massachusetts and Georges Bank. This project would progress in two phases. The first phase involves identifying the best method to monitor the presence of *Didemnum* in potential habitats (gravel beds and other hard surface areas). In the waters of Georges Bank, an autonomous underwater vehicle (AUV) would be deployed from F/V Lady Jane, with optical and acoustic sensors (i.e., color digital still camera and a high frequency imaging sonar). This data would be post-processed to produce seamless, geo-referenced image mosaics, which would be presented as GIS maps which may be hand-tagged to indicate the presence of *Didemnum* colonies. The second phase involves using location data collected from phase one in order for researchers to target optimal habitats. In order to verify the observations, 12 grab samples, 20 grams each will be collected by a ponar grab sampler and preserved for later work up in laboratory. A strict and specific protocol will be followed to ensure that researchers will not spread the organisms. Five cruises would be completed through mid-October of 2008, and approximately 10 additional cruises would take



place from spring 2009 through September of 2009. Study areas in the waters of Massachusetts include near shore waters off Sandwich in Cape Cod Bay, 5-15 meters (16'- 49') deep, and near the Nantucket Lightship Closed Area in approximately 30-50 meters (98'-164') of water. Offshore study areas include Georges Bank and the northern part of Closed Area II. Since researchers are not fishing, it was determined that they would not need any federal exemption permits. Researchers have necessary permits to collect in state waters.

Since all sonar devices would be pointed at the seafloor and attached to the bottom of the AUV which would be operating close to the seafloor, the high frequencies would not affect any nearby whales. In addition, researchers have agreed to mitigate any potential aggravation to whales by:

- 1) not to conducting the study in Cape Cod Bay from 2/15/2008 – 4/1/2008;
- 2) not using sonar in to Great South Channel area from 3/1/2009 – 6/30/2009; and,
- 3) visually inspecting waters for whales, prior to AUV deployment.

The minimal ponar grab sampling of the seafloor would result in impacts that are negligible and temporary. No other impacts associated with this project are expected.

This project would have only minimal effects to the human environment. As defined in Sections 5.05 and 6.03c.3 (a), of NAO 216-6, this is a research project of limited size and magnitude and for which any cumulative effects are negligible. As such, it is categorically excluded from the need to prepare an EA or an EIS.

Additionally, this project does not involve: (1) A geographic area with unique characteristics; (2) public controversy based on potential environmental consequences; (3) uncertain environmental impacts or unique or unknown risks; (4) establishment of a precedent or decision in principle about future proposals; (5) cumulatively significant impacts; or (6) adverse effects upon endangered or threatened species or their habitats. Therefore, the project does not trigger the exceptions for categorical exclusions listed in NAO 216-6, Section 5.05c.