PART I - PROJECT IDENTIFICATION INFORMATION

Investigator: Franz Hover
Institution: Massachusetts Institute of Technology
Report Submission Date: 3/11/2013 10:27:08 AM
Address: Department of Mechanical Engineering
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Primary Focus Area: Healthy Coastal Ecosystems

Project Title: Using Technology to Assess the Invasive Sea Squirt, Didemnum vexillum, Impacts on Fisheries and Ecosystems

Project Number: 2010-R/RCM-29-REG

PART II - DOCUMENTATION

Name and degree candidacy of all students:

<table>
<thead>
<tr>
<th>Name</th>
<th>Degree</th>
<th>Degree Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thomas Leeuw</td>
<td>MS</td>
<td>6/1/2014</td>
</tr>
</tbody>
</table>

Documents:

Remote identification of the invasive tunicate Didemnum vexillum using reflectance spectroscopy,

Material properties of Didemnum vexillum and prediction of tendril fragmentation

Current Matching Funds: $ [ enter value ]
Sources: [ enter sources ]
Progress Report on Gulf of Maine Regional Proposal, Using Technology to Assess the Invasive Sea Squirt, Didemnum vexillum, Impacts on Fisheries and Ecosystems, 2010, R/RCM-29

February 1, 2012 to January 31, 2013

Franz Hover, PI, Massachusetts Institute of Technology, Robert Whitlatch, Co-PI, University of Connecticut, Emmanuel Boss, Co-PI, University of Maine, and Judith Pederson, Co-PI, MIT Sea Grant college Program

Introduction and Goals
The long-term goal of this project is to refine the conceptual model of Didemnum as an ecological engineer and explore options for its management and control in the context of ecosystem-based management. This project is an integrated effort that will proceed along two paths simultaneously, modifying an optical sensor for detecting Didemnum and adapting it for use on the Reef Explore II/III hybrid underwater vehicle (UV), as well as continuing to use photography and grab samples to evaluate the impact of Didemnum in hard substrate habitats and support fisheries management to ensure a sustainable fishery. Below are the 4 objectives of the project.

1. Prototype and test an optical sensor (e.g. a hyperspectral radiometer) for rapid spatial surveys that detect Didemnum
2. Adapt the sensor for use on the Reef Explorer II/III, a hybrid UV
3. Map the spatial coverage of Didemnum using digital cameras and optical sensors
4. Examine benthic species diversity composition in the presence and absence of Didemnum mats, and develop a conceptual model of the role of Didemnum as an ecological engineer to identify critical areas for future research.

As a regional project, the investigators’ activities, while unique and identifiable as separate tasks, are integrated to address the goals and objectives of this project. To maximize the opportunity for integration, conference calls and face to face meetings were held. Three conference calls were held throughout the year to coordinate efforts. In addition, the PIs made presentations to the Gulf of Maine Regional Ocean Science Council on the progress of their work.

Below are the second year summaries of the progress of each PI’s research. During this reporting period, Dr. Robert Whitlatch was unable to complete field work during the summer of 2012 because of a chronic illness that prevented him from achieving his goal. As a result, a no-cost extension has been granted until January 31, 2014. Some aspects of the project have moved forward and these are reported here.

Spectral Sensors and the Use of Underwater Vehicles

Emmanuel Boss and his student, Thomas Leeuw continued testing the hypothesis that optical methods and algorithms can be developed for automated mapping of Didemnum
colonies. They collected additional data, presented their results in October 2011 at the AAUS conference in Portland Maine where Leeuw was awarded the best Student Paper Award. In September 2012, of 60 students presenting at the Ocean Optics conference in Glasgow, Leeuw received an honorable mention award for his presentation. The results of both presentations are in the conference proceedings. In addition, a paper entitled, Remote identification of the invasive tunicate Didemnum vexillum using reflectance spectroscopy, has been accepted to Applied Optics

Boss et al. collaborated with MIT Sea Grant AUV lab to integrate data from field reflectance spectra of Didemnum vexillum using the hybrid autonomous/remotely operated underwater vehicle, Reef Explorer II (REX II). The data support the earlier observation that D. vexillum has a unique spectral signature between 500 and 600 nm refine analysis of the data. The method is successful for the areas surveyed and should be tested on large-scale surveys.

Reef Explorer Hybrid Underwater Vehicle

The AUV Lab (Seth Newburg and Michael Soroka) collaborated with Boss on adapting the radiometer to an MIT Sea Grant Hybrid UV vehicle. Because Didemnum is abundant close to shore (which is easier for testing purposes), the radiometer was initially adapted for the Reef Explorer II (REX II), a small hybrid UV that can be deployed from a dock and is rated to a depth of 20-25m. REX III, the recent version also carries its own battery power and is managed through a tether that connects the vehicle to a small surface float with radio communication and GPS. This design creates a wireless data connection between the vehicle and operator, and gives accurate navigation information. REX III, which sits five feet below the surface can maintain an altitude of 2 m because it operates near the sea floor and receives altimetry information frequently.

The camera and lighting system was optimized for REX III and is now able to record images from the sea floor and at a 90° angle facing forward. It also has sensors for navigation (altimetry, speed, object avoidance, etc.). The radiometer was initially adapted for REX II, and now REX III. Data field testing conducted during the summer (the peak growing season of Didemnum colonies) of 2011 has been included in two publications. The system functions at the 1.5-2 m from the bottom or vertical hard surfaces. With the integrated light, camera and radiometer system, the images yielded data on reflectance of Didemnum within the limits of the light system.

Field Studies Using the Radiometer

In 2011, the AUV was deployed in a marina in Hull, Massachusetts that has Didemnum growing on pilings and pontoons through the late fall and early winter (Figure 1). For each cruise a spectalon 99% reflectance calibration plate was used to remove the spectral characteristics of the illumination sources, water color and green plankton. The identifying features for Didemnum were a low plateau between 450 and 500 nm rising to a high
plateau between 600 and 650 nm. The video from the AUV was posted on youtube and shared (for example, see http://www.youtube.com/watch?v=EM4KG1uNMXM)

Figure 1. Didemnum growing on a piling in Hull, Massachusetts (11-51-18)

Ecological studies

Robert Whitlatch and his colleagues’ working hypothesis is that Didemnum in both nearshore and offshore hard substrate habitats impacts settlement of important fisheries species (e.g. scallops) and may alter infaunal prey species availability other groundfish. In the absence of predators, Didemnum grows quickly from newly attached larvae and fragments and at optimal temperatures can form large patches that appear to persist for years.

Whitlatch is interested in propagation models for populations and dispersal potential. The fragment tendrils of Didemnum form balls that are dispersed and can reattach giving rise to a new colony. Understanding rates of fragmentation that leads to dispersal as well as larval release is needed. Data on the rate of fragmentation under specific current speeds will be used to assess spread and dispersion. A paper, entitled Material properties of Didemnum vexillum and prediction of tendril fragmentation has been published in Marine Biology describing the high tensile strength of the tendrils. Didemnum vexillum tendrils have a higher tensile strength than other tunicates and are not easily broken by wave action except in extreme cases (e.g. storms and some vessel generated waves).

Another component of Whitlatch’s work is to examine mats of Didemnum that are seen as “porous” either from predation, growing around species such as anemones that retract, etc. A few predators include the sea star Henricia sanguinolenta, Costoanachis spp. snails, winter flounder Pleuronectes americanus, and Littorina littorea (which feeds on senescent colonies). However, to date, no predator has been shown to significantly reduce Didemnum populations. Data from grab samples and images of the sea floor will provide insights into
benthic communities within and outside the mats of *Didemnum*. Digital photos will be analyzed using Image J software to assess bottom type and provide percent cover of species and substrate. From these and other data, a conceptual model will be developed. Because of storms during the summer of 2011, Dr. Whitlatch was unable to obtain data on the distribution and abundance of *Didemnum* using grabs and divers. In turn, we were unable to verify the use of the optical sensor with the field studies using divers and grab samples. These data are essential for integrating the biological surveys with the optical sensor and verifying the efficacy of the optical sensor.

In addition, the objective, examine benthic species diversity composition in the presence and absence of *Didemnum* mats, and develop a conceptual model of the role of *Didemnum* as an ecological engineer to identify critical areas for future research, will be developed using information on fragmentation, spread, and other data on distribution.

**Accomplishments:**

The AUV was deployed in a marina in Hull, Massachusetts that has *Didemnum* growing on pilings and pontoons through the late fall and early winter (Figure 1). For each cruise a spectralon 99% reflectance calibration plate was used to remove the spectral characteristics of the illumination sources, water color and green plankton. The identifying features for *Didemnum* were a low plateau between 450 and 500 nm rising to a high plateau between 600 and 650 nm. The video from the AUV was posted on YouTube and shared (for example, see [http://www.youtube.com/watch?v=EM4KG1uNMXM](http://www.youtube.com/watch?v=EM4KG1uNMXM)).

For *Didemnum vexillum* developing propagation models for populations is related to specific attributes of the sea squirt. The fragment tendrils of *Didemnum* form balls that are dispersed and can reattach giving rise to a new colony. Understanding rates of fragmentation that leads to dispersal as well as larval release is needed. Data on the rate of fragmentation under specific current speeds will be used to assess spread and dispersion. A paper, entitled Material properties of *Didemnum vexillum* and prediction of tendril fragmentation has been published in Marine Biology describing the high tensile strength of the tendrils. *Didemnum vexillum* tendrils have a higher tensile strength than other tunicates and are not easily broken by wave action except in extreme cases (e.g. storms and some vessel generated waves).

**Presentations and papers**


Thomas Leeuw, Seth O. Newburg, Emmanuel S. Boss, Wayne H. Slade, Michael G. Soroka, Judith Pederson, Chryssostomos Chryssostomidis, and Franz S. Hover (accepted 2/15/13).
Remote identification of the invasive tunicate *Didemnum vexillum* using reflectance spectroscopy, *Applied Optics* (also a presentation at Ocean Optics XXI).


Web interviews: 
http://kenai.asap.um.maine.edu/mainejournal/articles/Thomas_Leeuw.html
Ocean Optics XXI Awards notification: http://www.tos.org/oceanography/archive/25-4_student_awards.html
Update Report
Period: 2/1/2012 - 1/31/2013
Project: 2010-R/RCM-29-REG - Using Technology to Assess the Invasive Sea Squirt, Didemnum vexillum, Impacts on Fisheries and Ecosystems

:: STUDENTS SUPPORTED
Leeuw, Thomas, University of Maine, School of Marine Sciences, status:cont, field of study:Oceanography, advisor: Emmanuel Boss, degree type:MS, degree date:2014-06-01, degree completed this period:Yes
Student Project Title: none
Involvement with Sea Grant This Period: none
Post-Graduation Plans:
Was a BS student, now a master's student

:: CONFERENCES / PRESENTATIONS
Ocean Optics conference, Glasgow, public/profession presentation, 250 attendees, 2012-10-08

:: ADDITIONAL METRICS
K-12 Students Reached:
Acres of degraded ecosystems restored as a result of Sea Grant activities:
Resource Managers who use Ecosystem Based Approaches to Management:
Curricula Developed:
Volunteer Hours:
HACCP - Number of people with new certifications:
Cumulative Clean Marina Program - certifications:

:: PATENTS AND ECONOMIC BENEFITS
No Benefits Reported This Period

:: TOOLS, TECH, AND INFORMATION SERVICES
No Tools, Tech, or Information Services Reported This Period

:: HAZARD RESILIENCE IN COASTAL COMMUNITIES
No Communities Reported This Period

:: ADDITIONAL MEASURES
Safe and sustainable seafood
Number of stakeholders modifying practices
Number of fishers using new techniques
Actual (2/1/2012 - 1/31/2013):
Anticipated (2/1/2013 - 1/31/2014):

Sustainable Coastal Development
Coastal Ecosystems
Actual (2/1/2012 - 1/31/2013):
Anticipated (2/1/2013 - 1/31/2014):

:: PARTNERS
Partner Name: University of Connecticut
Partner Name: University of Maine

:: IMPACTS AND ACCOMPLISHMENTS
Title: Using Technology to Assess the Invasive Sea Squirt, Didemnum vexillum, Impacts on Fisheries and Ecosystems
Type: accomplishment
Description:
For Didemnum vexillum developing propagation models for populations is related to specific attributes of the sea squirt. The fragment tendrils of Didemnum form balls that are dispersed and can reach back giving rise to a new colony. Understanding rates of fragmentation that lead to dispersal as well as larval release is needed. Data on the rate of fragmentation under specific current speeds will be used to assess spread and dispersion. A paper, entitled Material properties of Didemnum vexillum and prediction of tendril fragmentation has been published in Marine Biology describing the high tensile strength of the tendrils. Didemnum vexillum tendrils have a higher tensile strength than other tunicates and are not easily broken by wave action except in extreme cases (e.g. storms and some vessel-generated waves).
Recap:
High tensile strength of tendrils limits breakage and affect dispersal of the non-native tunicate, Didemnum vexillum.
Comments: none
Related Partners: none
### Title: Using Technology to Assess the Invasive Sea Squirt, Didemnum vexillum, Impacts on Fisheries and Ecosystems

**Type:** accomplishment  
**Description:**

The AUV was deployed in a marina in Hull, Massachusetts that has Didemnum growing on pilings and pontoons through the late fall and early winter (Figure 1). For each cruise a spectralon 99% reflectance calibration plate was used to remove the spectral characteristics of the illumination sources, water color and green plankton. The identifying features for Didemnum were a low plateau between 450 and 500 nm rising to a high plateau between 600 and 650 nm. The video from the AUV was posted on YouTube and shared (for example, see http://www.youtube.com/watch?v=EM4KG1uN00M).

**Recap:**

Using a radiometer was attached to a hybrid autonomous underwater, reflectance specific to Didemnum was identified and promises to efficiently identify the sea squirt in the field.

**Comments:** none  
**Related Partners:** none

### :: PUBLICATIONS

#### Title: Material properties of Didemnum vexillum and prediction of tendril fragmentation

**Type:** Reprints from peer-reviewed journals, books, proceedings  
**Publication Year:** 2012  
**Uploaded File:** Reinhardt_et_al__2012.pdf, 466 kb  
**URL:** none

**Abstract:**

Abstract The colonial tunicate Didemnum vexillum has recently invaded the North American coast and has the potential to cause economic and ecological damage. One potential mechanism for adult D. vexillum colonies to disperse is fragmentation and subsequent reattachment to another substrate. To understand the life history and ecology of D. vexillum and obtain a first-order estimate of dispersal potential via fragmentation, (1) the basic material properties of D. vexillum sampled from two locations in southern New England were measured in two growth forms (i.e., encrusting and tendril forms); (2) summer calcium concentration was measured as a proxy for spicule densities; and (3) the environmental stress factor (ESF) of tendrils under various hydrodynamic circumstances (i.e., water velocities from 0.01 to 20 m s⁻¹) was determined.

Results show that D. vexillum colonies have high tensile strengths compared to other colonial tunicates. Colonies with higher calcium concentration tended to have greater elastic modulus (resistance to deformation). Calculations of ESF suggest that tidal currents are insufficient to cause fragmentation; however, wave-generated (in rare circumstances) and mechanical forces from vessels and trawl equipment may cause fragmentation.

**Citation:**


**Copyright Restrictions + Other Notes:**

unknown

**Journal Title:** Marine Biology

#### Title: Remote identification of the invasive tunicate Didemnum vexillum using reflectance spectroscopy.

**Type:** Reprints from peer-reviewed journals, books, proceedings  
**Publication Year:** 2013  
**Uploaded File:** Leewu_spectral_paper.pdf, 1518 kb  
**URL:** none

**Abstract:**

Benthic coverage of the invasive tunicate Didemnum vexillum on Georges Bank is largely unknown. Monitoring of D. vexillum coverage is vital to understanding the impact this invasive species will have on the productive fishing grounds of Georges Bank. Here we investigate using reflectance spectroscopy as a method for remote identification of D. vexillum. Using two different systems, a NightSea Dive-Spec and a combination of LED light sources with a hyperspectral radiometer, we collected in-situ measurements of reflectance from D. vexillum colonies. In comparison to reflectance spectra of other common benthic substrates, D. vexillum appears to have a unique spectral signature between 500 and 600 nm. Measuring the slope of the spectrum between these wavelengths appears to be the most robust method for spectral identification. Using derivative analysis or principal component analysis, the reflectance spectra of D. vexillum can be identified among numerous other spectra of common benthic substrates. An optical system consisting of a radiometer, light source, and camera was deployed on a remotely operated vehicle to test the feasibility of using reflectance to assess D. vexillum coverage. Preliminary results, analyzed here, prove the method to be successful for the areas we surveyed and open the way for its use on large-scale surveys.

**Citation:**


**Copyright Restrictions + Other Notes:**

Will be available on web

**Journal Title:** Applied Optics

### :: OTHER DOCUMENTS

**No Documents Reported This Period**

### :: LEVERAGED FUNDS

**Type:** influenced  
**Period:** 2012-10-08–2012-10-12  
**Amount:** $500  
**Purpose:**

Student travel to Ocean Optics XXI  
**Source:** The Oceanography Society
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