02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.C.a. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Jarrett Byrnes

Gender: ☐ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
☐ American Indian or Alaska Native
☐ Asian
☐ Black or African American
☐ Native Hawaiian or Other Pacific Islander
☒ White

Disability Status: (Select one or more)
☐ Hearing Impairment
☐ Visual Impairment
☐ Mobility/Orthopedic Impairment
☐ Other
☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☐

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

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List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:

Michael H. Graham
Robert Steneck
Ladd Johnson
David Duggins

REVIEWERS NOT TO INCLUDE:

Not Listed

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 13-1

NSF 13-505 **01/14/13**

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NSF PROPOSAL NUMBER

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

OCE - OCE Research Initiation Grant

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				808008122	

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

043167352

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NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

University of Massachusetts Boston

AWARDEE ORGANIZATION CODE (IF KNOWN)

0022228000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

University of Massachusetts Boston
100 Morrissey Boulevard
Dorchester, MA. 021253300

NAME OF PRIMARY PLACE OF PERF

University of Massachusetts, Boston

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE

University of Massachusetts, Boston
100 Morrissey Blvd
Boston ,MA ,021253300 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **OCE-RIG:Interactions Between Climate Change and Invasions in the New England Subtidal**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **100,000**	**24** months	**07/01/13**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☒ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____

☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____

PI/PD DEPARTMENT
Biology Department

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PI/PD FAX NUMBER
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NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Email Address
PI/PD NAME **Jarrett Byrnes**	**PhD**	**2008**	**401-529-4104**	**byrnes@nceas.ucsb.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative (or Equivalent) or Individual Applicant

By electronically signing and submitting this proposal, the Authorized Organizational Representative (AOR) or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding conflict of interest (when applicable), drug-free workplace, debarment and suspension, lobbying activities (see below), nondiscrimination, flood hazard insurance (when applicable), responsible conduct of research, organizational support, Federal tax obligations, unpaid Federal tax liability, and criminal convictions as set forth in the NSF Proposal & Award Policies & Procedures Guide,Part I: the Grant Proposal Guide (GPG). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U.S. Code, Title 18, Section 1001).

Conflict of Interest Certification

When the proposing organization employs more than fifty persons, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Conflict of Interest:
By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the organization has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Section IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the organization's expenditure of any funds under the award, in accordance with the organization's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent), is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:
(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.
(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:
(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:
(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR)
(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the Certification Pages, the Authorized Organizational Representative is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
The AOR shall require that the language of this certification be included in any award documents for all subawards at all tiers.

CERTIFICATION PAGE - CONTINUED

Certification Regarding Organizational Support

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that there is organizational support for the proposal as required by Section 526 of the America COMPETES Reauthorization Act of 2010. This support extends to the portion of the proposal developed to satisfy the Broader Impacts Review Criterion as well as the Intellectual Merit Review Criterion, and any additional review criteria specified in the solicitation. Organizational support will be made available, as described in the proposal, in order to address the broader impacts and intellectual merit activities to be undertaken.

Certification Regarding Federal Tax Obligations

When the proposal exceeds $5,000,000, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal tax obligations. By electronically signing the Certification pages, the Authorized Organizational Representative is certifying that, to the best of their knowledge and belief, the proposing organization:
(1) has filed all Federal tax returns required during the three years preceding this certification;
(2) has not been convicted of a criminal offense under the Internal Revenue Code of 1986; and
(3) has not, more than 90 days prior to this certification, been notified of any unpaid Federal tax assessment for which the liability remains unsatisfied, unless the assessment is the subject of an installment agreement or offer in compromise that has been approved by the Internal Revenue Service and is not in default, or the assessment is the subject of a non-frivolous administrative or judicial proceeding.

Certification Regarding Unpaid Federal Tax Liability

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal Tax Liability:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has no unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

Certification Regarding Criminal Convictions

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Criminal Convictions:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has not been convicted of a felony criminal violation under any Federal law within the 24 months preceding the date on which the certification is signed.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME		

TELEPHONE NUMBER	EMAIL ADDRESS	FAX NUMBER

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

PROJECT SUMMARY

OCE-RIG Proposal: Interactions Between Climate Change and Invasions in the New England Subtidal

Summary

In this project, the principle investigator will examine the effects of climate change on subtidal nearshore ecosystems by removing either dominant native or invasive foundation species.

Intellectual Merit
Many of climate change's most dramatic impacts on ocean ecosystems will be via indirect effects. While changes in temperature, storms, and acidification will affect all organisms in an ecosystem, impacts on species that structure the entire ecosystem can have cascading consequences. In many systems, native dominant species have been replaced by invasive foundation species, often already shifting an ecosystem. This project will investigate whether the consequences of climate driven foundation species removal differ depending on whether the foundation species in question is native or not.

The subtidal of the Northwest Atlantic is dominated by kelps - brown algae of the order Laminariales. These kelps provide a wide variety of goods and services for these ecosystems and serve as a foundation species. In many areas, however, kelps have been outcompeted and replaced by the non-native *Codium fragile* subsp. *tomentosoides*. This project will 1) evaluate whether climate change will further alter the balance of competition by further shrinking the range of kelp, 2) model the relationship between climate impacts, kelp and *Codium* abundance, and how they influence the structure of Northwest Atlantic communities, and 3) experimentally evaluate the consequences of losing kelps, *Codium*, or both for subtidal community structure. Range limit and monitoring data sets created by this project will serve as a foundational data set for the principle investigator and will be maintained well beyond the extent of this grant

Broader Impacts
To facilitate the training of underrepresented groups in my lab, this project will tap a pool of culturally and ethnically diverse students at an urban campus. Not only will students be trained and mentored in the lab, but students will be sent to a field station for certification as scientific divers. A female graduate student will also be trained and mentored as part of the underwater research team. To facilitate outreach outside of the lab and strengthen skills in science writing for a broad audience, students will all take part in a lab blog that reports on discoveries within the project. Students will also crowdfund an additional portion of their work in the #SciFund Challenge, of which the principle investigator is a co-founder, to receive further training in outreach communication techniques.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.B.2.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

PROJECT DESCRIPTION

OCE-RIG Proposal: Interactions Between Climate Change and Invasions in the New England Subtidal

Introduction

Among the strongest impacts of human activities in marine ecosystems is the wholesale removal or replacement of habitat forming foundation species. Foundation species – those whose high abundance and biogenic structure influence physical environments, resource provision, and habitat availability (Dayton 1972) – directly and indirectly determine the structure and function of the ecosystems around them (Ellison et al. 2005). In many ecosystems, we have witnessed the replacement of native foundation species with non-natives (Mathieson et al. 2003). Both native and non-native foundation species will be affected by climate change, however. ***Here I seek to ask how community-wide climate impacts mediated by foundation species differ in systems dominated by native versus non-native foundation species.***

How the native or non-native status of a foundation species will moderate the impact of climate change is unclear and suggests several hypotheses. Given the co-evolutionary history of native species with the local ecosystem, their loss due to climate change could have larger impacts than the loss of non-natives. In contrast, if non-native species have already altered an ecosystem, their loss may provide some room for system recovery. It is also possible that non-native species may prove more resistant and resilient co climate change, providing function that would otherwise be lost due to climate impacts on native species. *We do not currently know how climate change impacts will interact with pre-existing species invasions to alter marine ecosystems.*

To evaluate the potential impact of climate change on systems that have landscapes dominated by patches of native and non-native species, I propose to work in the shallow subtidal of the Northwest Atlantic. This area is dominated by native kelps (order Laminariales) and non-native algae (*Codium fragile* subsp. *tomentosoides*) (Chapman 1998) – both of which are likely to respond negatively to projected changes in the temperature and wave energy environment caused by climate change (see below). I propose three goals that will both provide short-term answers to basic questions regarding the consequences of change in foundation species abundance driven by climate change in the Northwest Atlantic and begin long-term datasets that will fuel work in my lab for the next few decades.

1) I will establish baseline southern range limits for kelps in the Northwest Atlantic to evaluate whether temperature is potentially causing its loss where it is most vulnerable to temperature effects.
2) I will create a network of long-term survey sites here in Massachusetts across a physical gradient in order to model the influence of wave energy on community structure as mediated by native and non-native foundation species abundance (e.g., Byrnes et al. 2011).
3) I will run a factorial experiment to evalute the potential impact of increased disturbances in clearing kelp, non-native *Codium fragile*, and both to evaluate the causal consequences of annual losses for each foundation species.

Study System & Projected Climate Impacts

The Northeast Atlantic has historically been dominated by kelps from the order Laminariales (e.g, *Saccharina latissima*, *S. longicrus*, *Laminaria digitata, Alaria esculenta*). These kelps extend down to the northeastern shore of Long Island (Egan and Yarish 1988). Since the late 1950's, the Northwest Atlantic has also been subjected to an invasion by the Asian *Codium fragile* subspecies *tomentosoides* that spread and expanded greatly in the 1980s (Mathieson et al. 2003). The synergistic effects of *Codium,* the invasive bryozoan *Membranipora membranacea* that weakens kelp fronds, and periodic events of high urchin abundances throughout the Gulf has led to the replacement of kelps in many wave protected areas by *Codium* (Levin et al. 2002). *Codium* is not tolerant of high wave energy environments (Trowbridge 1998, D'Amours and Scheibling 2007), and thus many areas have become a patchwork of kelp and *Codium* dominated areas. The community level impact of *Codium*, however, is unclear. Its effects seem to be few, and it even appears to be equally good habitat for a variety of species (Levin et al. 2002), although its nutritional value to some grazers is lower (Lyons and Scheibling 2007).

Climate change is projected to have two impacts that will affect both kelps and *Codium*: warming water and a change in the wave environment (on Climate Change 2007). Warming waters negatively affect kelps as high temperatures 1) can lead to die-offs due to kelp physiology (Wernberg et al. 2012) cause dissolved nutrients to drop below required levels for kelp growth and survival (Tegner and Dayton 1987) and 3) can stimulate grazing activities by altering grazer physiology or lowering their available food supply and causing a behavioral shift (Harrold and Reed 1985). Indeed, in other areas around the globe kelps are dying back due to direct effects of warming waters (Wernberg et al. 2012). In New Hampshire, for example, long-term monitoring has shown a decrease in kelp abundances, even in areas where *Codium* has only been sporadically absent (Figure 1, Normandeau Associates 2012). *Codium* will have less of a problem with warmer waters – it currently has an invasive range extending to North Carolina (Searles et al. 1994). It may benefit from warmer waters, as the combination of warm water and heavy epibiont loads in areas within the Atlantic have led to kelp deforestation (Scheibling and

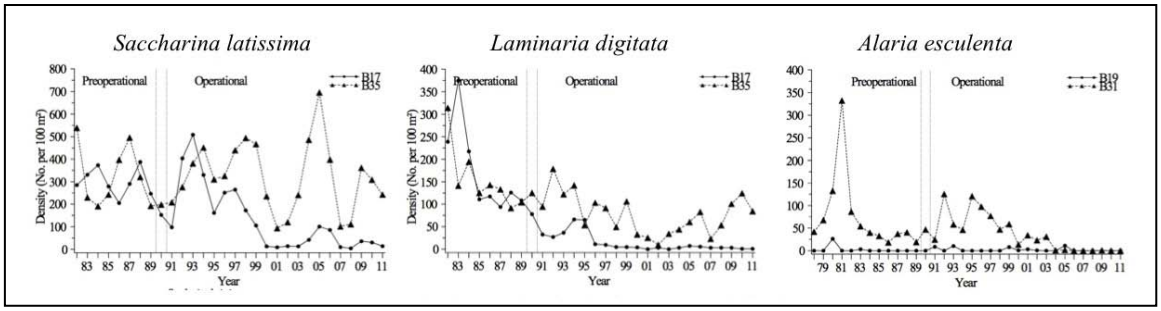

Figure 1: Abundances of three species of kelp at sites in New Hampshire. These measurements have been ongoing since the 1980's as part of a power plant impact assessment project. Controls are the lower number in each plot. All kelps at all sites show decreases in density, save *Saccharina latissima* which is still highly variable at the control site. Figure provided by Normandeau Associates.

Gagnon 2009).

Changes in wave intensity from projected shifts in maximum storm intensity might also affect the Northwest Atlantic. The largest storm of the year in the Gulf of Maine, for example, has been getting larger over the last hundred years (Balch et al. 2012), suggesting a concomitant

increase in wave intensity. Similarly, hurricanes have been moving closer to the coast over the last 30 years as surface waters warm (Scheibling and Lauzon-Guay 2010). Given *Codium*'s tolerance for high wave conditions, this increase should lead to a gradual removal of *Codium* from many areas that it currently exists. Thus, it is possible that the Northwest Atlantic will see a decline in two current dominant foundation species groups – kelps and *Codium* – a native and a non-native. ***The long-term consequences of losing each, or both together are unknown, as there is little work on foundation species loss in the area not linked to urchin overgrazing.***

Goal 1: Establish a Baseline for the mixed kelp-*Codium* Assemblage Southern Range Limit

Figure 2: Sites of proposed surveys. Red dots are sites that will be sampled to assess kelp southern range limits (Goal 1). Orange triangles are sites for surveys of climate, foundation species abundance, and subtidal community structure (Goal 2).

If temperature is going to affect the abundance of foundation species in subtidal assemblages, then we should observe the southern range limit of a species move north. The previously southern range limit of kelps in the Northwest Atlantic is the eastern edge of Long Island (Egan and Yarish 1988). While there is ongoing kelp aquaculture in Long Island Sound currently (Van Patten 2012), whether natural populations exist in that area or further south is not known. *Codium*, in contrast, is reported as far south as North Carolina (Searles et al. 1994). Thus, its range will always overlap with kelps.

To assess the southern range limit of this assemblage, I will resurvey the southernmost sampled sites of *S. latissima, S. digitata, and L. longicrus* as noted by Egan and Yarrish (1988). The furthest point south will be the wreck of Texas Tower 4 off of New Jersey. I will survey four nearby wrecks, as those are the primary source of hard bottom in the area. If kelp is noted, I will also survey four shallow wreck sites to evaluate whether deeper waters may be providing a thermal buffer. . I will also sample three sites around the Northern tip of Long Island (e.g., Cape Neck Point) where the southern range limits of other kelps have been noted by Egan and Yarrish. As kelps may be moving more north already, or will shortly in the future, I will also establish three sites around the mouth of the Narraganset where I have previously noted kelp in the early 2000s – Fort Wetherhill, King's Beach, and The Dumplings.

Rather than merely establish a range limit for several species, I want to also note whether they are forming functional kelp bed communities, or if these are remnant populations – potentially sinks kept occupied by propagules from other areas. To quantify the availability of kelp and *Codium* habitat at these sites, I will survey their percent cover and abundance in ten 0.5 m^2 quadrats placed uniformly along a 10m transect at each site. I will also roughly quantify areal extent of kelp or *Codium* habitat by running a transect line from along the longest edge of the largest observed patch, and along the perpendicular edge, roughly assessing area as a rectangle. Both measurements will be truncated at 100m.

To verify that the absence of kelp is not by chance, I will resurvey these sites one year later. Furthermore, beyond this grant, I will attempt to resurvey any sites that do have kelp, or have no

kelp but high urchin abundances, every other year until no kelp has been cited for five consecutive samplings.

In addition to noting the potential movement of the southern range limit of kelps in the Northwest Atlantic, I will compare the sampled abundances to other sites sampled in the Gulf of Maine (see below). I will compare both cover and abundance using generalized linear models with the appropriate link and error distributions (O'Hara and Kotze 2009) to ask 1) are kelp abundances lower in Southern sites , 2) do kelp abundances at these sites exhibit similar trends to those in the north and 3) are abundances at these sites declining over time . These measurements along with the rough assessment of areal extent will tell me not only how far south these communities exist, but whether they are truly 'kelp beds' further south, or whether those communities only start further to the north.

Goal 2: Model the Effects of Wave Exposure and Foundation Species Identity on Community Structure in the Subtidal

To evaluate the relationship between environmental variables, foundation species abundance – whether kelp or *Codium* – and community structure, I will begin a long-term survey of subtidal rocky reefs in the Gulf of Maine. I will use this data to tease apart potential direct and indirect effects of environmental variables on community structure and foundation species abundance using Structural Equation Modeling (Grace et al. 2010). This work will parallel my own previous efforts in California (Byrnes et al. 2011) and will serve as a useful comparison to ongoing work at the Santa Barbara Coastal Long Term Ecological Research Site.

Field Sampling

In order to parameterize the models discussed below, I will need to create a long-term subtidal monitoring program here in the Gulf of Maine. I have selected 15 sites within the Southern end of the Gulf. I will setup half of these sites in year one, and the second half in year two. Two sites – Dive Beach and Shag Rock - are near Nahant, MA close to the Northeastern University Marine Science Center, and have been surveyed by Ken Sebens since 1978 (Sebens 1986). Further north is another site that has been actively surveyed since 1978 by Sebens, Halfway Rock in Marblehead. Additionally, around Nahant, I will add Canoe Beach and Egg Rock, also sampled irregularly by Sebens and Jon Witman. These sites all have historical data on urchin, fish, crab, and lobster abundances, as well as some data for temperature and wave heights. Last in Massachusetts, I will add two other sites in Marblehead to more completely cover the area around Cape Ann.

In year two, I will add to these sites three control sites that have been sampled since 1983 by Normandeau Associates, LLC, as control sites for a power plant impact assessment project. Last, I will add five sites around the Shoals Marine Lab on Appledore Island that will be paired with an ongoing intertidal monitoring effort. These sites will vary in wave exposure, summer warmest temperature, larval and nutrient availability, and more. All are between 7-12m of water. I am currently talking with SML about the possibility of working with interns from the Underwater Research course to conduct the surveys at those sites.

PROJECT DESCRIPTION

At each site, I will install three permanent 40m transects as references for long-term surveys. Each transect will be marked at the 0 and 50m points with rebar stakes secured in the substrate. Every 5m, I will install eyebolts marked with flagging tape. Sites will cleaned and maintained annually the week before sampling. At either end of each transect, I will attach a Tidbit™ temperature sampler. I will also deploy a wave pressure sensor at each site for one month for 3-4 weeks in order to calibrate local wave heights at a site with those at nearby NOAA buoys.

Along each transect, my lab will use a modified version of the Santa Barbara Coastal LTER's rocky reef monitoring protocol (Byrnes et al. 2011) to assess community structure of all organisms to the lowest identifiable taxonomic level in the field. Each transect will be sampled with 1 video transect to quantify fish, 8 $1m^2$ quadrats to quantify the density (# stipes per m^2) of each kelp species, all small invertebrates, and demersal fish. 8 additional $1m^2$ quadrats will be used to sample the percent cover of kelps and *Codium*. Within these 8 quadrats, we will take 10 random point counts and quantify every species under each random point as well as the substrate type under each point. We will also measure test diameters of the first 50 urchins we encounter in order to estimate transect level urchin biomass.

During year 1, I will create a photographic library of all species – invertebrates, vertebrates, and algae – that we sample. In my lab, we will turn this library into a public photographic ID guide for the subtidal of the southern Gulf of Maine. A pdf and html version will be made public for other interested divers or research groups in the area.

After surveys in year one, I will re-evaluate sampling techniques. I will conduct a power analysis to evaluate whether our sample size and sampling techniques are adequate for each species. Briefly, I will use field data to construct population distributions of each organism and each site, and then simulate sampled from those populations to see if sample size is accurate. I will also note after year 1 which species appeared rarely in quadrats, and yet were large enough to be conspicuous to divers. During year two, I will add 4 1x20 m band transects to the survey in order to quantify abundances of these species.

Quantifying Food Web Structure

There are a wide variety of potential analyses that one could do with this data. To aggregate many properties into a small suite of metrics, I will quantify the network topology of sampled subtidal food webs (Byrnes et al. 2011). In order to quantify site level food web structure, I will first need to know all of the feeding relationships between species in the Gulf of Maine. Working with my students, we will survey the extant literature on feeding relationships in the Gulf of Maine and input all results into a modified version of the California Kelp Forest Food Web database (http://kelpforest.ucsc.edu/). This database will be made available to the public, so that other researchers can use the information for their own work on network topology and food web structure. Using this database and field data, I will be able to assess food web richness, connectance, omnivory, trophic height, and more (Dunne et al. 2002).

Model and Analysis

To understand the direct effects of changes in climate variables versus the indirect changes due to altering foundation species abundance (Figure 3), I will model the data from surveys using Structural Equation Modeling (Grace et al. 2011). Rather than use a covariance based approach,

because many relationships are likely to be nonlinear with non-normal error distributions, and because transect will be nested within site, I will evaluate models for goodness of fit and parameter estimates using a network based approach to SEM (Grace et al. 2012).

I use a general model where environmental variables may affect kelp and *Codium* abundance either directly or by altering urchin abundances, as both waves and indirect effects of warmer temperatures can decrease urchin populations (Siddon and Witman 2003, Scheibling and Lauzon-Guay 2010). I will first evaluate models without food web structure, and if I find not relationship between environmental variables and urchin abundance, I will drop them from future models. I will then evaluate several models with different aspects of food web structure as the ultimate response variable: species richness, connectance, trophic height, omnivory, abundance of algae and sessile invertebrates, fish abundance, and crustacean abundance. After two years, I will not yet have a sufficient sample size to evaluate the relationships between those different aspects of food web structure, but, this first analysis should allow me to begin to understand when climate has a direct effect versus when it has an indirect effect mediated by foundation species abundance.

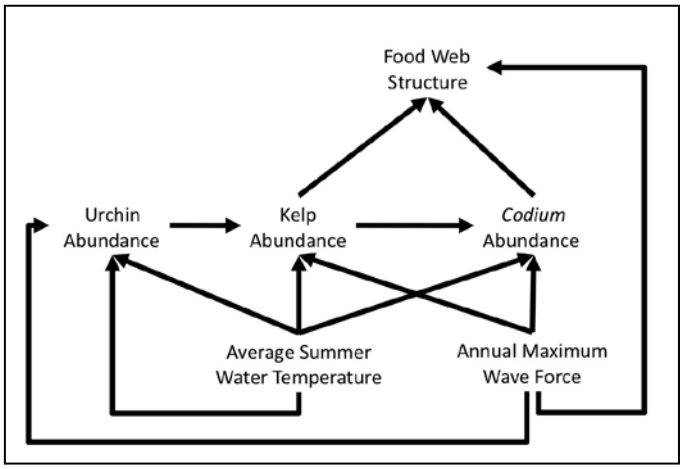

Figure 3: Path diagram for SEM analysis. All variables will be taken from field measurements. Note, different models will have different variables for different aspects of food web structure.

Goal 3: Evaluate the Effects of Loss of Native and Non-Native Foundation Species on Community Structure

To evaluate the potential effects climate driven disturbances and extreme events on removing native or non-native foundation species abundance, I will perform a factorial removal experiment spread across my five sites in Massachusetts during the late summer (i.e., the start of hurricane season) to mimic potential climate driven disturbance from large storms. I will then evaluate changes in different removal plots relative to control plots. I will select a site that has a mixed kelp/*Codium* assemblage. I will select 60 plots, 2m in diameter. 15 plots will have kelp removed. 15 plots will have *Codium* removed. 15 plots will have both removed, and 15 will remain as controls. Each site will have 3 plots of each type. I will survey $1m^2$ area in the center of each plot and quantify the percent cover of algae and invertebrates using point counts, the abundance of demersal fish, and the abundance of invertebrates. This removal is not large enough to allow the evaluation of loss on mobile fish, but it serves as a useful entry point to understand community change in the system due to removal of each species.

To assess community change, I will sample the plots immediately after removal, one month after removal, and one year after removal. I will then examine change in total algal and sessile invertebrate cover and the abundance of each species of herbivore with generalized linear models

using initial abundance and status of the adjacent community as a covariate. By repeating the experiment at the five sites, I will be able to use the condition of the site as a covariate to evaluate community change. For example, how will foundation species removed interact with initial kelp, *Codium*, and urchin abundance in an area to affect community change? Additionally, I will conduct a simple test of mediation in a Structural Equation Modeling framework (Grace et al. 2011) to evaluate whether changes in sessile invertebrate abundance are due to direct effect of kelp loss or indirect effects due to altered competitive regimes with other algae (Arkema et al. 2009).

This experiment will allow me to evaluate in more detail whether patterns noted in goal 2 above relate causally to the loss of foundation species. It will also allow me to tease apart the role of native kelps versus non-native *Codium* in altering the abundance of a wide variety of species in the community. In order to begin evaluating long-term consequences of removal, I will repeat the experiment in the same plots in year two of the grant.

How This Research Contributes to My Long-Term Goals

The focus of my lab is the investigation of the causes and consequences of changes in community structure due to human activities. Here I propose to begin this research evaluating the consequences of climate change and foundation species loss. ***The research I am proposing will setup two long-term sampling programs that will serve as the backbone data for many activities within my lab in the future.*** The monitoring program I set up in goal 2 will be a tremendous resource for my lab for the foreseeable future. The data will be used as a reference point for any future experimental work done in my lab. I plan to maintain this program through any future subtidal grant. Additionally, students coming through my lab will help with its maintenance. Thus, it will also be an important source of training – students will need to learn species IDs, sampling techniques, etc., when they participate. It will be the cornerstone of my research program investigating future change in the ocean, and will only grow and expand across the Gulf in the future.

Second, the manipulative experiments that I propose here will serve as a jumping off point for future grants and experiments. It will reveal important information about the role of different foundation species in the subtidal Gulf of Maine that my students and I will use in the design of future experiments. One cannot manipulate whole communities easily in the subtidal. If I can show that changes in the composition of foundation species can effectively alter community structure, this will provide a useful tool for future experiments. Similarly, this work is a stepping stone for conducting larger-scale manipulations. I will evaluate what organisms showed a change in abundance at this scale of manipulation, and scale up future experiment accordingly.

Broadening Participation of Women and Minorities in Ocean Science

To advance the role of women and minorities in marine science, I will employ and train students from the University of Massachusetts Boston for this work. UMB is an urban university with (as of 2010) 55% female and 44% minority enrollment. 50% are first generation college students, and 30-40% come from non-English speaking homes. ***Thus, UMB does not have a typical population of students that have grown up with the socio-cultural trappings that shape so many of the students and faculty in the marine and ecological sciences.*** It is the perfect

university in which to draw in students and open their eyes to the wonder of the ocean and provide them with opportunities they would not have otherwise considered in the ocean sciences.

As a part of this grant, I will bring students from these groups into my lab to participate in our research activities. Furthermore, subtidal research is a field that is often difficult to become involved in due to the time and finances required to become an active research diver. I plan to select one student and use funds from this grant to fully train them as a field research diver, thus enabling them to pursue unique opportunities that would have been previously unavailable. This student will function as an active part of my field research team as we pursue our three goals, gaining a wide range of valuable skills.

Graduate Mentoring and Training
I currently have four outstanding applicants who wish to work in my lab as doctoral students doing subtidal research. All four are women. This project will provide exceptional training opportunities for the student I select to be part of my lab. The selected student will help create our long-term dataset and conduct field experiments. This initial work will be the fuel for them to shape their dissertation project, and provide them with a dataset that they will be able to ground truth their work against in the future. Thus, they will not only be active participants in this work, but will be expected to use it as a piece of their own future work.

Undergraduate Mentoring and Training
I plan to hire two undergraduate interns for this project from the diverse mix of students at UMB. Hired students will initially work analyzing fish transect data and culling data from primary literature to add to the food web database. Students will also be given opportunities to come out to the field for surface support when appropriate. Depending on their interest and abilities, one student will be selected and funded to go to the Underwater Research course at the Shoals Marine Laboratory to gain their certification in the American Academy of Underwater Sciences. If necessary, we will financially support their initial basic diving certification as well and supply equipment from our lab's field supplies. This student will then be hired on as a fully participating field assistant for their duration at UMB.

General Training
I will conduct a one-week workshop at UMass Boston during its winter term in Structural Equation Modeling for Field Biologists. I have conducted this workshop at many field stations and universities around the globe over the past 3 years, and look forward to bringing it to my home institution. Enrollment will be open to any student that wishes to take it - from graduate to professor.

Outreach
As part of the outreach to broader audiences strategy of my lab, all graduate and undergraduate students will be required to participate in our lab blog. I have been blogging about science since 2001 and running the outreach and crowdfunding effort #SciFund (http://scifundchallenge.org) for the last year. Beginning next fall, my lab will launch a blog in which all members will post weekly about their work in the lab. We will work together to attempt to crowdfund parts of our lab's activities (Wheat et al. 2012), and in so doing, bring our work to a broader audience.

PROJECT DESCRIPTION

Timeline and Feasibility

This work will commence in the summer of 2013. During year 1, I will sample southern range limits in the early summer (June). During July and August, I will setup monitoring sites around Nahant and Marblehead. At the end of August, I will initiate the kelp manipulations adjacent to sampled transects. Transects will be resampled one month later.

During the fall and winter of 2013-2014, I will bring undergraduates into the lab in order to work on data entry, the food web database, and analyzing fish video transects. They will also participate in weekly lab meetings. By spring of 2014, I will select one student to attend the subtidal research course at SML.

During the summer of 2014, I will resample range limit sites in June as necessary. I will then resample the Nahant sites in July. I will use August to setup new transects at SML with the help of our now trained undergraduate. I will then resample foundation species removal plots at the end of August, and repeat the removal, sampling again in September.

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Wheat, R. E., Y. Wang, J. E. Byrnes, and J. Ranganathan. 2012. Raising money for scientific research through crowdfunding. Trends in Ecology & Evolution.

BIOGRAPHICAL SKETCH

Jarrett E. K. Byrnes

Professional Preparation & Appointments
1997-2001, Brown University, Bachelor of Science in Biology.
2002-2008, UC Davis, Population Biology, M.S. 2003, Ph.D. 2008

Professional Appointments
2012-Present, University of Massachusetts Boston, Assistant Professor

PUBLICATIONS (MOST CLOSELY RELATED)

Byrnes, J.E.K., Cardinale, B.J., and Reed, D.R. In Press. Sea urchin grazing increases with prey diversity on temperate rocky reefs. *Ecology*.

Byrnes, J.E., Reed, D.C., Cardinale, B.J., Cavanaugh, K.C., Holbrook, S.J., and Schmitt, R.J. 2011. Climate driven increases in storm frequency simplify kelp forest food webs. *Global Change Biology*. 17: 2513-2524. [doi]

Byrnes, J.E. and Stachowicz, J.J. 2009. The consequences of consumer diversity loss: different answers from different designs. *Ecology*. 90: 2879-2888. [doi]

Byrnes, J.E., Reynolds, P.L., Stachowicz, J.J. 2007. Invasions and extinctions reshape coastal marine food webs. *PLoS One*. 2: e295. [doi]

Byrnes, J.E., Stachowicz, J.J., Hultgren, K.M., Hughes, A.R., Olyarnik, S.V., Thornber, C. 2006. Predator diversity enhances trophic cascades in kelp forests by modifying herbivore behavior. *Ecology Letters*. 9: 61-71. [doi]

PUBLICATIONS (OTHER SIGNIFICANT)

Hooper, D.U., Adair, E.C., Cardinale, B.J., Byrnes, J.E.K., Hungate, B.A., Matulich, KL., Gonzalez, A., Duffy, J.E., Gamfeldt, L., O'Connor, M.I. 2012. Biodiversity loss ranks as a major driver of ecosystem change. *Nature*.

Fox, J., Byrnes, J., Boker, S., and Neale, M. 2012. Structural equation modeling in R with the sem and OpenMX packages. In *Handbook of Structural Equation Modeling*. Rock H. Hole, David Kaplan, George Marcoulides, and Steve West, eds. pg. 325-340.

SYNERGISTIC ACTIVITIES

- Organizer, Global Impacts of Climate Change on Kelp Forests. National Center for Ecological Analysis and Synthesis working group.
- Co-Creator of The #SciFund Challenge. A large-scale effort for scientists to crowdfund their research. http://scifund.rockethub.com for projects and http://scifund.wordpress.com for the project blog.
- Author of I'm a chordata! Urochordata! http://www.imachordata.com/. A science blog discussing ecology, marine biology, and the culture of science in the modern age.
- Contributing Developer for Lavaan - Analysis of latent variable structural equation models in R. http://lavaan.org

- Participant in Biodiversity and the functioning of ecosystems: translating results from model experiments to functional reality. National Center for Ecological Analysis and Synthesis working group.
- Participant in Dissertation Initiative for the advancement of Climate Change ReSearch (DISCCRS) participant. Interdisciplinary workshop in climate change communication.

COLLABORATORS AND OTHER AFFILIATIONS

Collaborators and Co-Editors

Patricia Balvanera (UNAM)
Kyle Cavanaugh (University of California Santa Barbara)
J. Emmett Duffy (Virginia Institute of Marine Sciences)
Kyle Edwards (University of Michigan)
Lars Gamfeldt (University of Gothenburg, Sweden)
Andrew Gonzalez (McGill University)
Sally Holbrook (University of California Santa Barbara)
David Hooper (Western Washington University)
Forest Isbell (University of Minnesota)
Mary O'Connor (University of British Columbia)
Pamela Reynolds (Virginia Institute of Marine Sciences)
Schmitt Schmitt (University of California Santa Barbara)
Peter Roopnarine (California Academy of Sciences)
Matt Ferner (San Francisco State University)

Graduate and Postdoctoral Advisors: Stachowicz J.J. (UC Davis), Cardinale B (University of Michigan), Reed D (UCSB)

Thesis Advisor and Postgraduate-Scholar Sponsor: Witman, J.D.

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Massachusetts Boston

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jarrett Byrnes

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1.	0.00	0.00	0.00		
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**1**) GRADUATE STUDENTS				**7,500**	
4. (**2**) UNDERGRADUATE STUDENTS				**10,000**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**17,500**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**97**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**17,597**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**3,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**6,241**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**8,285**	
TOTAL OTHER DIRECT COSTS				**14,526**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**35,123**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 52.5000, Base: 28338)**					
TOTAL INDIRECT COSTS (F&A)				**14,877**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**50,000**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**50,000**	

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jarrett Byrnes

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Massachusetts Boston

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jarrett Byrnes

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1.	0.00	0.00	0.00		
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**1**) GRADUATE STUDENTS				**7,500**	
4. (**2**) UNDERGRADUATE STUDENTS				**10,000**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**17,500**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**97**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**17,597**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**4,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**9,690**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**1,500**	
TOTAL OTHER DIRECT COSTS				**11,190**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**32,787**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 52.5000, Base: 32787)**					
TOTAL INDIRECT COSTS (F&A)				**17,213**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**50,000**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**50,000**	

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jarrett Byrnes

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Massachusetts Boston

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jarrett Byrnes

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1.	0.00	0.00	0.00		
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**0**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**2**) GRADUATE STUDENTS				**15,000**	
4. (**4**) UNDERGRADUATE STUDENTS				**20,000**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**35,000**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**194**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**35,194**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**7,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**15,931**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**9,785**	
TOTAL OTHER DIRECT COSTS				**25,716**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**67,910**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**32,090**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**100,000**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**100,000**	

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jarrett Byrnes

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

BUDGET JUSTIFICATION

A. Senior Personnel:
PI: Will oversee all activities associated with the project.
No funds are requested or allowed in this program for senior personnel.

B. Other Personnel:
One Graduates student: support funds requested for one graduate student during the summer months in Year 1 $7500: and in Year 2 $7500. Total requested $15,000.

Two Undergraduates: support funds requested for two undergraduate students during the calendar year: Year 1 $10,000 and Year 2 $10,000. Total requested $20,000.

C. Fringe Benefit: $97.00 per year will incur during the summer months associate with graduate student support: total fringe $194.00.

D. Equipment: No equipment is requested in this project.

E. Travel: Travel is requested for domestic travel to coverage the cost of commuting (mileage) to and from research sites for PI and students. Funds will also be used to cover cost of per diem for PI; and dive charter to offshore sites such as Nahant Ma and New Jersey ~$1320 in Year 1 and ~$2320 in Year 2. Lodging in New Jersey x 4 days x $120/day = $480 and 4 Days in New Jersey x 3 divers x $100/day = $1200 in Years 1 & 2. Lodging in Long Island and RI accounted for. Total Travel requested Year 1 $3000; Year 2 $4000

F. Participant Support Cost: n/a

G. Other Direct Cost:
a. Materials and Supplies: Funds requested for
Year 1 $6241 and Year 2 $9690
Funds will go towards cost of site marker materials, site maintenance, boat registration, nautical supplies, cost of fuel for boat and maintenance. Boat itself is part of PI startup.

b. Operational Cost: $1500 is request each year for two year for Lab space rental at the research site; total requested $3000. Fees are standard for Northeastern Marine Science Center.

c. Tuition and fees: Funds requested in Year 1 only to support two student's course certification total funds requested $6785, as listed at the SML website.

H. Total Direct Costs: Year 1 $35,123 and Year 2 $32,787

I. Indirect Costs: Year 1 $14,877 and Year 2 $17,213

J. Total Direct and Indirect Costs: Year 1 $50,000 and Year 2 $50,000

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Jarrett Byrnes	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: OCE-RIG: Interactions Between Climate Change and Invasions in the Northwest Atlantic

Source of Support: NSF

Total Award Amount: $ 100,000 Total Award Period Covered: 07/01/13 - 06/30/15

Location of Project: Boston, MA

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: CIF21 DIBBS: The Living Paper: Re-envisioning scientific publication at Internet scale

Source of Support: NSF with UCSB

Total Award Amount: $ 271,784 Total Award Period Covered: 09/01/13 - 08/31/18

Location of Project: Boston, MA

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 1.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

FACILITIES, EQUIPMENT AND OTHER RESOURCES

Facilities & Resources for OCE-RIG Proposal: Interactions Between Climate Change and Invasions in the New England Subtidal

UMB Laboratory:
On the UMB campus, students will be placed in the PI's fully equipped research laboratory in the Biology Department. The 600 sq. ft. lab is fully supplied with computers, a fume hood for sample processing, and sample freezer. With startup funds, the PI is currently acquiring a full range of shop tools, drying ovens, Metler scales, and other equipment for lab work. A new building, the Integrated Sciences Complex, where the PI and lab will move, is scheduled to open in September 2013.

UMB Computer:
UMass Boston has extensive computer resources for this project. Each research lab has an array of internet- connected Macs and PCs. UMB has 10 computer labs with over 250 PCs and printers available for student use, as well as specialty computer facilities and computer teaching laboratories. The PI will provide computer facilities in his lab for student work.

UMB Office Support:
The Program Coordinator has dedicated office space with computer equipment as well as access to a full array of support equipment such as copy and fax machines. The Directors and all participating faculty have appropriate office space. The offices of the Biology Department and the Dean of the College of Science and Mathematics have staff and supplies that support this project.

PI Field Equipment:
The PI is currently in the process of building his lab's supply of gear for field work using his startup. Purchases in progress include a Boston Whaler with trailer and vehicle, wet and dry suits for lab personnel, full sets of dive gear - including BCDs, regulators, mask, fins, and weights – and a full suite of field sampling gear (PVC quadrats, transect tapes, etc). The lab will also have several underwater digital still and video cameras for sampling sites and recording identifying photographs of organisms.

Northeastern University Marine Science Center:
The Northeastern MSC is a 1,310 square feet research facility with an ocean engineering lab, a molecular/analytical chemistry lab, a shared molecular resources lab, and a wet prep lab, and full SCUBA diving facilities. In addition, the MSC houses a flow-through seawater system with multiple sea tables with a flow through rate of 415 gallons per minute and a seawater storage capacity currently being increased of 40,000 gallons.

Data Management Plan for OCE-RIG Proposal: Interactions Between Climate Change and Invasions in the New England Subtidal

1. Types of data

Data will be collected by divers on SCUBA. Data will consist of quadrat, transect, and point count data of species abundances from both surveys and experiments. In general, data sheet formats will include identifying information for individual quadrat or transect, taxon name being sampled, and the abundance recorded of the relevant taxon. Units of data (% or count) will be set by sampling method and taxon and unique to each survey. All data sheets will be scanned before being entered by undergraduate research assistants into excel spreadsheets. Data will be Quality Assured by interns reading back data from sheets to check for consistency. Data will be spot checked by lab technicians as a final QA step.

The final data will comprise a collection of comma separated files that will include entries for site, time, project name, taxon, measurement type, and measurement value. R scripts used to create derived data sets for analysis will be archived separately and have their workflows documented. Derived data files will be stored in a separate directory from the original data. Further R scripts for analyses will be archived separately from data processing scripts.

2. Data and metadata standards

All data files will have metadata stored in accompanying text files. Text files will fully document the spatial and temporal information regarding each data set. Text files will include a full description of the methodology used to collect data, and a description of the measurements contained in each column.

A second meta-data table will the full taxonomy of each taxon sampled in the data as well as a brief description.

Analysis scripts will be commented extensively, and the workflow for each analysis will be documented in an accompanying text file.

3. Policies for access and sharing

All derived and raw data will be made publicly available via the Knowledge Network for Biocomoplexity (KNB). The PI has previously participated in depositing data sets at KNB while a postdoctoral fellow at NCEAS. All metadata will be supplied with data sets, as will scripts for creating derived data sets. Scripts for analysis will be made public as appendices to published papers. When appropriate, data will also accompany published paper as appendices (e.g., for PLoS One). Data will be fully open access with the only requirement being citation to the data product.

4. Policies and provisions for re-use, re-distribution

Survey data will be made available as soon as it is quality assured via KNB with the requirement

that it be cited properly for use. Experimental data will be made available upon publication of the first paper using the data with the requirement that the data product and paper be properly cited. While future authors will be encouraged to contact the PI and co-authors with questions about the data, not requirements or restrictions will be placed on the use of the data.

5. Plans for archiving and preservation of access

Short-term

In the short-term, data and scripts will be stored on laboratory Macintosh computers and backed up nightly to a hard drive. Additionally, the lab will use the Dropbox service (https://www.dropbox.com/) to persistently backup the data as it is entered.

Long-term

Long-term archiving will be via KNB as described in the policies for access and sharing. If KNB should fail, we will move data to another member node of the Data One project to ensure that it is fully searchable and accessible to the general public.

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January 7, 2013

Dear Madam or Sir,

As Chair of the Biology Department here at the University of Massachusetts, Boston (UMB), I write to give my strong support for the OCE-RIG proposal being submitted by Dr. Jarrett Byrnes from our department. Dr. Byrnes is a new, tenure-track member of the Department of Biology. Dr. Byrnes' proposed research and educational activities parallel and are extremely well integrated into the educational and research missions of the Department and University. The Department is committed to supporting Dr. Byrnes' professional development. Dr. Byrnes' proposal directly links his University mandated research, teaching and service responsibilities to each other and the Department is taking an active role to mentor Dr. Byrnes and to ensure that he is balancing his efforts appropriately to remain on track for his tenure evaluation in the future. I will elaborate on all of these items below and hopefully demonstrate the strong institutional commitment that we have for Dr. Byrnes and the success of his program.

Though Dr. Byrnes has only been here since September of 2012, he has already had a huge impact on the research atmosphere within our department. He is collaborating with several members of the faculty in Biology as well as members in the Environmental, Earth and Ocean Sciences department and scientists in other institutions. He is bringing new and innovative ideas and tools to the campus. His expertise will benefit both our Environmental Biology and the Marine Sciences PhD programs. This past fall semester Dr. Byrnes taught a very interactive course entitled "**An Introduction to Computational Data Analysis for Biological Sciences"** for graduate and advanced undergraduate students. It was inspiring to watch this course develop and to witness Dr. Byrnes working individually and in groups with the students. The comments from students for this course were uniform in their appreciation of the course and respect for the instructor: "incredibly challenging, but incredibly valuable... Jarrett was awesome.." "some of the most important skills (that) I'll need throughout my career." and "I was very impressed by how well organized and informative this course was…" These students work in many different labs at UMB and clearly Dr. Byrnes has provided them with valuable skills that will begin to permeate through our programs.

As you can see, Dr. Byrnes he has already established a reputation as a strong research scientist and innovative teacher. As an ecologist, he has the necessary aptitude to be a team player, able to bring together collaborators from different disciplines to focus on environmental issues. This

will be a strength in developing his research program. Students are beginning to contact him anxious to participate in his research work. Dr. Byrnes is already consulting with graduate students on their research projects and has developed several projects that will be perfect Honors projects for undergraduates. His proposal will allow him to build on these activities, extend his influence in our programs, expand his outreach activities and expose more students to ecological and marine research possibilities and opportunities. UMB has high proportion of students from under-represented minority groups and first generation college students. Dr. Byrnes has made interacting with these groups of individuals a priority for his research program and the Department vigorously applauds this initiative.

The Biology Department is absolutely committed to supporting the continued development of Dr. Byrnes and his research program. We are providing a technician or post-doctoral support, graduate student support for several years and start-up funding to his program. We also have several undergraduate training programs and will give Dr. Byrnes priority in selecting students for these programs.

Dr. Byrnes has already demonstrated that this support has been well worth the input. He is delivering on all fronts and I am certain will develop into a leader in our program and his field in years to come. I urge you to consider supporting this dynamic young investigator and his proposal.

If you need more information, please contact me.

Best wishes,

Rick Kesseli

Rick Kesseli
Professor and Chair
Biology Department