Cover Page for Proposal Submitted to the National Aeronautics and Space Administration

NASA Proposal Number

TBD on Submit

NASA PROCEDURE FOR HANDLING PROPOSALS

This proposal shall be used and disclosed for evaluation purposes only, and a copy of this Government notice shall be applied to any reproduction or abstract thereof. Any authorized restrictive notices that the submitter places on this proposal shall also be strictly complied with. Disclosure of this proposal for any reason outside the Government evaluation purposes shall be made only to the extent authorized by the Government.

SECTION I - Proposal Information

Principal Investigator	E-mail Address	Phone Number
Jarrett Byrnes	**jarrett.byrnes@umb.edu**	**401-529-4104**

Street Address (1)	Street Address (2)
100 William T Morrissey Blvd	

City	State / Province	Postal Code	Country Code
Boston	**MA**	**02125-3300**	**US**

Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**

Proposed Start Date	Proposed End Date	Total Budget	Year 1 Budget	Year 2 Budget	Year 3 Budget	Year 4 Budget
10 / 01 / 2016	**07 / 01 / 2020**	**910,628.00**	**117,008.00**	**313,028.00**	**265,095.00**	**215,497.00**

SECTION II - Application Information

NASA Program Announcement Number	NASA Program Announcement Title
NNH16ZDA001N-CSESP	**Citizen Science for Earth Systems Program**

For Consideration By NASA Organization *(the soliciting organization, or the organization to which an unsolicited proposal is submitted)*

NASA , Headquarters , Science Mission Directorate , Earth Science

Date Submitted	Submission Method	Grants.gov Application Identifier	Applicant Proposal Identifier
	Electronic Submission Only		

Type of Application	Predecessor Award Number	Other Federal Agencies to Which Proposal Has Been Submitted
New		

International Participation	Type of International Participation
No	

SECTION III - Submitting Organization Information

DUNS Number	CAGE Code	Employer Identification Number (EIN or TIN)	Organization Type
808008122	**9B961**		**2A**

Organization Name (Standard/Legal Name)	Company Division
University Of Massachusetts, Boston	**UNIVERSITY OF MASSACHUSETTS BOSTON**

Organization DBA Name	Division Number
DEPT GRANTS & ADM CONTRACTS	

Street Address (1)	Street Address (2)
100 MORRISSEY BLVD RM 80	

City	State / Province	Postal Code	Country Code
BOSTON	**MA**	**02125**	**USA**

SECTION IV - Proposal Point of Contact Information

Name	Email Address	Phone Number
Jarrett Byrnes	**jarrett.byrnes@umb.edu**	**401-529-4104**

SECTION V - Certification and Authorization

Certification of Compliance with Applicable Executive Orders and U.S. Code

By submitting the proposal identified in the Cover Sheet/Proposal Summary in response to this Research Announcement, the Authorizing Official of the proposing organization (or the individual proposer if there is no proposing organization) as identified below:

- certifies that the statements made in this proposal are true and complete to the best of his/her knowledge;
- agrees to accept the obligations to comply with NASA award terms and conditions if an award is made as a result of this proposal; and
- confirms compliance with all provisions, rules, and stipulations set forth in this solicitation.

Willful provision of false information in this proposal and/or its supporting documents, or in reports required under an ensuing award, is a criminal offense (U.S. Code, Title 18, Section 1001).

Authorized Organizational Representative (AOR) Name	AOR E-mail Address	Phone Number

AOR Signature *(Must have AOR's original signature. Do not sign "for" AOR.)*	Date

PI Name : **Jarrett Byrnes**	NASA Proposal Number
Organization Name : **University Of Massachusetts, Boston**	TBD on Submit

Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**

SECTION VI - Team Members

Team Member Role	Team Member Name	Contact Phone	E-mail Address
PI	**Jarrett Byrnes**	**401-529-4104**	**jarrett.byrnes@umb.edu**
Organization/Business Relationship: **University Of Massachusetts, Boston**		Cage Code: **9B961**	DUNS#: **808008122**
International Participation: **No**	U.S. Government Agency		Total Funds Requested: **0.00**

Team Member Role	Team Member Name	Contact Phone	E-mail Address
Co-I/Institutional PI	**Kyle Cavanaugh**	**703-489-4671**	**kcavanaugh@geog.ucla.edu**
Organization/Business Relationship: **REGENTS UNIVERSITY OF CALIFORNIA LOS ANGELES**		Cage Code: **67NC6**	DUNS#: **830637687**
International Participation: **No**	U.S. Government Agency		Total Funds Requested: **0.00**

Team Member Role	Team Member Name	Contact Phone	E-mail Address
Co-I/Institutional PI	**Alison Haupt**	**805-705-5231**	**ahaupt@csumb.edu**
Organization/Business Relationship: **California State University, Monterey Bay**		Cage Code: **1GMS5**	DUNS#: **082412920**
International Participation: **No**	U.S. Government Agency		Total Funds Requested: **0.00**

Team Member Role	Team Member Name	Contact Phone	E-mail Address
Co-I/Institutional PI	**Laura Trouille**	**312-322-0820**	**trouille@zooniverse.org**
Organization/Business Relationship: **Adler Planetarium**		Cage Code: **33EH9**	DUNS#: **083081802**
International Participation: **No**	U.S. Government Agency		Total Funds Requested: **0.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
Organization Name : **University Of Massachusetts, Boston**	TBD on Submit

Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**

SECTION VII - Project Summary

Climate change is rapidly impacting numerous ecosystems. Climate-related impacts on foundation species, dominant species that provide food and habitat, are particularly consequential. Giant kelp, Macrocystis pyrifera, is a globally distributed foundation species that supports some of the most productive coastal ecosystems in the world. However, giant kelp is sensitive to changes in environmental conditions; we do not know how its global distribution and abundance has changed in the modern era.

Characterizing change in kelps at even regional scales is impractical via field sampling. Luckily, increases in the availability of long-term global satellite imagery has made it possible to observe kelp forests at large spatial and temporal scales via Landsat. However, the process of creating maps of kelp canopy from satellite imagery has defied automation, requiring time-consuming manual analysis. Here we propose to expand the geographic scope of a citizen science platform using Landsat data (http://floatingforests.org) to examine change in giant kelp abundance over time and ask fundamental questions about climate impacts on global kelp productivity. This project will develop a generalized tool in collaboration with Zooniverse to build online citizen science projects using Landsat imagery.

Prototype Phase:
Thus far, we have collaborated with the online citizen science organization Zooniverse to build a platform, Floating Forests, to harness the power of citizen science to map the world's giant kelp forests over 30 years (http://floatingforests.org). We have amassed an initial dataset of over 2 million classifications to validate citizen science classifications of kelp. We are now ready to move from small regional datasets to map the planet alongside our citizen scientists and answer fundamental questions about the effects of global change on giant kelp at an unprecedented scale.

Given these efforts, we have established our next set of goals to move the project forward. 1) Finalize a data pipeline converting user-generated data into geospatial data ready for analysis. 2) Finalize calibration and validation of user classifications with pre-existing expert classifications. 3) Use the process of importing remaining Landsat data for the rest of the planet to create a generalized Landsat-Zooniverse data pipeline. 4) Finalize a data-sharing framework so that citizen scientists can access ith Floating Forests data. 5) Begin crafting an education and outreach strategy to broaden our reach.

Implementation Phase:
During implementation, we will address our scientific goals by using data to model the long-term changes in giant kelp. We will merge our kelp data with variables such as water temperature (from MODIS data), nutrients (derived from sea surface temperatures in certain regions), photosynthetically available radiation (from MODIS ocean color data), wave disturbance (from Wave Watch III) and human impact variables to model the impact of human and environmental drivers on giant kelp forests.

We will use lessons learned from our data import process to aid Zooniverse's efforts to expand the functionality of their Project Builder to support the broader research community in creating citizen science projects based on NASA satellite data. The Zooniverse team will host in-person and online training workshops for researchers in using the Project Builder to build their own Landsat-based crowd-sourced research projects, incorporate the results into their research, and sustain and nurture their online volunteer communities.

Finally, to draw in more citizen scientists, we will 1) build a series of Floating-Forests inquiry-based science curricula for primary, secondary, university, and museum classrooms and 2) further our efforts in online outreach, hosting online seminars on kelp research and open data hackathons where we will teach citizen scientists how to use our data.

PI Name : **Jarrett Byrnes**	NASA Proposal Number
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SECTION VIII - Other Project Information

Proprietary Information

Is proprietary/privileged information included in this application?

Yes

International Collaboration

Does this project involve activities outside the U.S. or partnership with International Collaborators?

No

Principal Investigator	Co-Investigator	Collaborator	Equipment	Facilities
No	**No**	**No**	**No**	**No**

Explanation :

NASA Civil Servant Project Personnel

Are NASA civil servant personnel participating as team members on this project (include funded and unfunded)?

No

Fiscal Year	Fiscal Year	Fiscal Year	Fiscal Year	Fiscal Year	Fiscal Year
Number of FTEs	Number of FTEs	Number of FTEs	Number of FTEs	Number of FTEs	Number of FTEs

PI Name : **Jarrett Byrnes**	NASA Proposal Number
Organization Name : **University Of Massachusetts, Boston**	TBD on Submit

Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**

SECTION VIII - Other Project Information

Environmental Impact

Does this project have an actual or potential impact on the environment?	Has an exemption been authorized or an environmental assessment (EA) or an environmental impact statement (EIS) been performed?
No	**No**

Environmental Impact Explanation:

Exemption/EA/EIS Explanation:

PI Name : **Jarrett Byrnes**	NASA Proposal Number
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SECTION VIII - Other Project Information

Historical Site/Object Impact

Does this project have the potential to affect historic, archeological, or traditional cultural sites (such as Native American burial or ceremonial grounds) or historic objects (such as an historic aircraft or spacecraft)?

No

Explanation:

SECTION IX - Program Specific Data

Question 1 : Short Title:

Answer: Observing Thirty Years of Floating Forests with Citizen Science

Question 2 : Type of institution:

Answer: Educational Organization

Question 3 : Will any funding be provided to a federal government organization including NASA Centers, JPL, other Federal agencies, government laboratories, or Federally Funded Research and Development Centers (FFRDCs)?

Answer: No

Question 4 : Is this Federal government organization a different organization from the proposing (PI) organization?

Answer: N/A

Question 5 : Does this proposal include the use of NASA-provided high end computing (HEC)?

Answer: No

Question 6 : Research Category:

Answer: 2) Data analysis/data restoration/data assimilation/Earth System modeling (including Guest Observer Activities)

Question 7 : Data Management Plan (Part 1)

Answer:

1. Overview
Our project will generate multiple forms of data in the process of citizen science classification of giant kelp forests. PI Byrnes will coordinate data management. Broadly, code for the Project Builder and derived images from Landsat scenes will be hosted at Zooniverse and mirrors on Amazon web services. Everything is open source and made freely available via GitHub (https://github.com/zooniverse). Data derived from the project will be publically available via Temperate Reefbase (http://temperatereefbase.imas.utas.edu.au/) on a monthly update cycle and mirrored at the NASA Ocean Biology Distributed Active Archive Center (https://earthdata.nasa.gov/about/daacs/daac-obdaac). Code will be freely available via GitHub repositories.

1.1 Project & Science Objectives
Our project seeks to use citizen science efforts to categorize giant kelp forests globally from Landsat imagery for use in scientific investigations. We will use these classifications to build global consensus maps of giant kelp forests over thirty years. Using these maps, we will assess the effect of climate drivers assessed via different NOAA and NASA data products on kelp populations.

2. Project Science Data Generation and Flow
Both the current Ouroboros and future Project Builder platforms begin by downloading Landsat scenes from the US Geological Survey Landsat server. Scenes are cut into smaller images (~131 km2 per image), color corrected, and checked against coastline shapefiles and for

excessive cloudiness. Images failing to meet clarity and coastal criteria are discarded. The remaining subjects are retained and shown to users for classifications. Image metadata is saved in a MongoDB database along with information about user classifications.
Monthly, the Floating Forest team downloads and reprocesses the MongoDB into 1) a simpler flat comma separated value database, 2) a NetCDF raster file with each cell containing the number of users classifying kelp in that cell, and 3) cleaned ESRI Shapefile format of kelp beds based on calibration thresholds of the number of users required to classify a cell as kelp. These three data sources will then be archived for use by project scientists and others.

2.2 Science Operations
The Zooniverse will handle all Landsat data downloading, reprocessing, and recording of image metadata. The Zooniverse will also host the Floating Forests project website and record all user classifications. Project PI Byrnes's lab will handle all data reprocessing and archiving. Co-Investigator Cavanaugh's lab will handle all the acquisition of other environmental data sets

2.3 Project Data and Code Storage and Distribution
All code for the project - both for Project Builder and analysis code - will be made available via GitHub. Zooniverse's code can currently be found at https://github.com/zooniverse and analysis code is located at https://github.com/jebyrnes/floatingForests. Analysis code can be merged to NASA's GitHub code repository upon the completion of each project analysis.
All images used by the Floating Forests website as well as the database of classifications will be hosted by Zooniverse via Amazon Web Services. Zooniverse provides an API that allows any interested party to read from the data or database directly.
Processed data products - including a cleaned CSV, NetCDF consensus classifications, and quality-controlled shapefile of kelp beds over time will be hosted by the Australia Ocean Data Network's Temperate Reefbase (TRB). After meta-data generation, we will submit the data and metadata to the NASA Ocean Biology Distributed Active Archive Center (OBDAAC) as a secondary mirror in order to ensure data longevity and to ensure that the data becomes part of NASA's public catalogue.

Question 8 : Data Management Plan (Part 2)

Answer:

3. Access and Stewardship
3.1 Transition to Science Data Center
Derived data products from Floating Forests classifications will be generated monthly. After establishment of the data pipeline during the prototype phase, data will be archived at TRB. If possible TRB and OBDAAC will be updated on the same cycle. Otherwise, OBDAAC will be updated annually for the lifetime of the project. Code will be archived on GitHub, and analysis code will be archived under NASA's account as requested.

3.2 Directories and Catalogs
Launched in June of 2016, TRB is a joint project of the AODN, the University of Tasmania, the Institute for Marine & Antarctic Studies, and the Kelp Ecosystem Ecology Network (PI Byrnes, Network coordinator) and is supported by the Australian National Data Service. TRB is a public data portal for access to tabular, raster, and other forms of data about temperate rocky reefs. It is supported by AODN funding and is planned to run as a long-term archival solution. TRB is currently exploring membership in Data One (http://dataone.org) so that data catalogs are accessible both via AODN as well as Data One's search engine.

3.3 Standards and Policies for Access
Upon archiving materials at TRB, we will generate metadata for all data products. TRB requires project scientists to generate metadata using the ISO19115 compliant Marine Community Profile 2.0 metadata schema via an intuitive user interface on intitial data creation. Metadata is maintained through data update cycles and can be edited as needed.
All Floating Forests data products and analysis code will be made available under a Creative Commons attribution required license. Data will be made freely available upon upload to TRB, and users will be requested to cite either the data product of subsequent first publications by the science team using the data set as a reference. All Zooniverse code is publically accessible under their own license which is available at https://www.zooniverse.org/privacy?lang=en.

3.4 Associated Archive Products
Associated code for Floating Forests and analysis products will all be available via GitHub. Analysis code can be forked and archived by NASA as requested.

Question 9 : Team Members Missing From Cover Page:

Answer:

Isaac Rosenthal, University of Massachusetts Boston, Boston, MA: Graduate Student on project with PI Byrnes
Unnamed Postdoctoral Researcher, University of California, Los Angeles, CA: Climate analysis researcher with Co-I Cavanaugh

Unnamed Undergraduates, California State University Monterey Bay, Monterey Bay, CA: Education interns with Co-I Haupt

Question 10 : Does this proposal contain information and/or data that are subject to U.S. export control laws and regulations including Export Administration Regulations (EAR) and International Traffic in Arms Regulations (ITAR)?

Answer: No

Question 11 : I have identified the export-controlled material in this proposal.

Answer: N/A

Question 12 : I acknowledge that the inclusion of such material in this proposal may complicate the government's ability to evaluate the proposal.

Answer: N/A

Question 13 : Does the proposed work include any involvement with collaborators in China or with Chinese organizations, or does the proposed work include activities in China?

Answer: No

Question 14 : Are you planning for undergraduate students to be involved in the conduct of the proposed investigation?

Answer: Yes

Question 15 : If yes, how many different undergraduate students?

Answer: 2

Question 16 : What is the total number of student-months of involvement for all undergraduate students over the life of the proposed investigation?

Answer:

Question 17 : Provide the names and current year (1,2,3,4) for any undergraduate students that have already been identified.

Answer:

Currently unnamed.

Question 18 : Are you planning for graduate students to be involved in the conduct of the proposed investigation?

Answer: Yes

Question 19 : If yes, how many different graduate students?

Answer: 1

Question 20 : What is the total number of student-months of involvement for all graduate students over the life of the proposed investigation?

Answer: 56

Question 21 : Provide the names and current year (1,2,3,4, etc.) for any graduate students that have already been identified.

Answer:

Isaac Rosenthal, 2nd year graduate student University of Massachusetts Boston with PI Byrnes.

Question 22 : Topical Area

Answers :

biodiversity and conservation biology

Question 23 : Proposal Type

Answer: Citizen science research

Question 24 : Identify NASA Earth-observing Satellite(s)

Answer:

Landsat

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Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**

SECTION X - Budget

Cumulative Budget

Budget Cost Category	Funds Requested ($)				
	Year 1 ($)	Year 2 ($)	Year 3 ($)	Year 4 ($)	Total Project ($)
A. Direct Labor - Key Personnel	**4,443.00**	**4,577.00**	**4,714.00**	**4,855.00**	**18,589.00**
B. Direct Labor - Other Personnel	**21,348.00**	**31,673.00**	**31,673.00**	**31,673.00**	**116,367.00**
Total Number Other Personnel	**1**	**1**	**1**	**1**	**4**
Total Direct Labor Costs (A+B)	**25,791.00**	**36,250.00**	**36,387.00**	**36,528.00**	**134,956.00**
C. Direct Costs - Equipment	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
D. Direct Costs - Travel	**2,491.00**	**3,491.00**	**3,491.00**	**3,491.00**	**12,964.00**
Domestic Travel	**2,491.00**	**3,491.00**	**3,491.00**	**3,491.00**	**12,964.00**
Foreign Travel	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
E. Direct Costs - Participant/Trainee Support Costs	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Tuition/Fees/Health Insurance	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Stipends	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Travel	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Subsistence	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Other	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Number of Participants/Trainees					**0**
F. Other Direct Costs	**48,445.00**	**235,857.00**	**204,281.00**	**154,467.00**	**643,050.00**
Materials and Supplies	**5,000.00**	**0.00**	**0.00**	**0.00**	**5,000.00**
Publication Costs	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Consultant Services	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
ADP/Computer Services	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Subawards/Consortium/Contractual Costs	**43,445.00**	**235,857.00**	**204,281.00**	**154,467.00**	**638,050.00**
Equipment or Facility Rental/User Fees	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Alterations and Renovations	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Other	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
G. Total Direct Costs (A+B+C+D+E+F)	**76,727.00**	**275,598.00**	**244,159.00**	**194,486.00**	**790,970.00**
H. Indirect Costs	**40,281.00**	**37,430.00**	**20,936.00**	**21,011.00**	**119,658.00**
I. Total Direct and Indirect Costs (G+H)	**117,008.00**	**313,028.00**	**265,095.00**	**215,497.00**	**910,628.00**
J. Fee	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
K. Total Cost (I+J)	**117,008.00**	**313,028.00**	**265,095.00**	**215,497.00**	**910,628.00**
Total Cumulative Budget					**910,628.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
Organization Name : **University Of Massachusetts, Boston**	TBD on Submit

Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
10 / 01 / 2016	**06 / 30 / 2017**	**Project**	**1**

A. Direct Labor - Key Personnel

Name	Project Role	**Base Salary ($)**	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	**Fringe Benefits ($)**	Funds Requested ($)
Byrnes, Jarrett	**PI**	**81,808.00**			**.5**	**4,363.00**	**80.00**	**4,443.00**
							Total Key Personnel Costs	**4,443.00**

B. Direct Labor - Other Personnel

Number of Personnel	Project Role	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
1	**Graduate Students**		**8**		**21,000.00**	**348.00**	**21,348.00**
1	Total Number Other Personnel					Total Other Personnel Costs	**21,348.00**
						Total Direct Labor Costs (Salary, Wages, Fringe Benefits) (A+B)	**25,791.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
Organization Name : **University Of Massachusetts, Boston**	TBD on Submit
Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**	

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
10 / 01 / 2016	**06 / 30 / 2017**	**Project**	**1**

C. Direct Costs - Equipment

Item No.	Equipment Item Description	Funds Requested ($)
	Total Equipment Costs	**0.00**

D. Direct Costs - Travel

	Funds Requested ($)
1. Domestic Travel (Including Canada, Mexico, and U.S. Possessions)	**2,491.00**
2. Foreign Travel	**0.00**
Total Travel Costs	**2,491.00**

E. Direct Costs - Participant/Trainee Support Costs

		Funds Requested ($)
1. Tuition/Fees/Health Insurance		**0.00**
2. Stipends		**0.00**
3. Travel		**0.00**
4. Subsistence		**0.00**
Number of Participants/Trainees:	Total Participant/Trainee Support Costs	**0.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
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SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
10 / 01 / 2016	**06 / 30 / 2017**	**Project**	**1**

F. Other Direct Costs

	Funds Requested ($)
1. Materials and Supplies	**5,000.00**
2. Publication Costs	**0.00**
3. Consultant Services	**0.00**
4. ADP/Computer Services	**0.00**
5. Subawards/Consortium/Contractual Costs	**43,445.00**
6. Equipment or Facility Rental/User Fees	**0.00**
7. Alterations and Renovations	**0.00**
8. Other:	**0.00**
9. Other:	**0.00**
10. Other:	**0.00**
Total Other Direct Costs	**48,445.00**

G. Total Direct Costs

	Funds Requested ($)
Total Direct Costs (A+B+C+D+E+F)	**76,727.00**

H. Indirect Costs

	Indirect Cost Rate (%)	**Indirect Cost Base ($)**	Funds Requested ($)
UMB Indirect Cost, subcontractors included only to first 25K	**52.50**	**0.00**	**40,281.00**
Cognizant Federal Agency: **DHHS, Darryl W Mayes, 212-264-2069**		Total Indirect Costs	**40,281.00**

I. Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Costs (G+H)	**117,008.00**

J. Fee

	Funds Requested ($)
Fee	**0.00**

K. Total Cost

	Funds Requested ($)
Total Cost with Fee (I+J)	**117,008.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
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SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2017	**06 / 30 / 2018**	**Project**	**2**

A. Direct Labor - Key Personnel

Name	Project Role	**Base Salary ($)**	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	**Fringe Benefits ($)**	Funds Requested ($)
Byrnes, Jarrett	**PI**	**0.00**			**.5**	**4,494.00**	**83.00**	**4,577.00**
							Total Key Personnel Costs	**4,577.00**

B. Direct Labor - Other Personnel

Number of Personnel	Project Role	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
1	**Graduate Students**		**8**	**4**	**31,500.00**	**173.00**	**31,673.00**
1	Total Number Other Personnel					Total Other Personnel Costs	**31,673.00**
						Total Direct Labor Costs (Salary, Wages, Fringe Benefits) (A+B)	**36,250.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
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SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2017	**06 / 30 / 2018**	**Project**	**2**

C. Direct Costs - Equipment

Item No.	Equipment Item Description	Funds Requested ($)
	Total Equipment Costs	**0.00**

D. Direct Costs - Travel

	Funds Requested ($)
1. Domestic Travel (Including Canada, Mexico, and U.S. Possessions)	**3,491.00**
2. Foreign Travel	**0.00**
Total Travel Costs	**3,491.00**

E. Direct Costs - Participant/Trainee Support Costs

		Funds Requested ($)
1. Tuition/Fees/Health Insurance		**0.00**
2. Stipends		**0.00**
3. Travel		**0.00**
4. Subsistence		**0.00**
Number of Participants/Trainees:	Total Participant/Trainee Support Costs	**0.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
Organization Name : **University Of Massachusetts, Boston**	TBD on Submit
Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**	

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2017	**06 / 30 / 2018**	**Project**	**2**

F. Other Direct Costs

	Funds Requested ($)
1. Materials and Supplies	**0.00**
2. Publication Costs	**0.00**
3. Consultant Services	**0.00**
4. ADP/Computer Services	**0.00**
5. Subawards/Consortium/Contractual Costs	**235,857.00**
6. Equipment or Facility Rental/User Fees	**0.00**
7. Alterations and Renovations	**0.00**
8. Other:	**0.00**
9. Other:	**0.00**
10. Other:	**0.00**
Total Other Direct Costs	**235,857.00**

G. Total Direct Costs

	Funds Requested ($)
Total Direct Costs (A+B+C+D+E+F)	**275,598.00**

H. Indirect Costs

	Indirect Cost Rate (%)	**Indirect Cost Base ($)**	Funds Requested ($)
UMB Indirect Cost, subcontractors included only to first 25K	**52.50**	**0.00**	**37,430.00**
Cognizant Federal Agency: **DHHS, Darryl W Mayes, 212-264-2069**		Total Indirect Costs	**37,430.00**

I. Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Costs (G+H)	**313,028.00**

J. Fee

	Funds Requested ($)
Fee	**0.00**

K. Total Cost

	Funds Requested ($)
Total Cost with Fee (I+J)	**313,028.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
Organization Name : **University Of Massachusetts, Boston**	TBD on Submit

Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2018	**06 / 30 / 2019**	**Project**	**3**

A. Direct Labor - Key Personnel

Name	Project Role	**Base Salary ($)**	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	**Fringe Benefits ($)**	Funds Requested ($)
Byrnes, Jarrett	**PI**	**0.00**			**.5**	**4,629.00**	**85.00**	**4,714.00**
							Total Key Personnel Costs	**4,714.00**

B. Direct Labor - Other Personnel

Number of Personnel	Project Role	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
1	**Graduate Students**		**8**	**4**	**31,500.00**	**173.00**	**31,673.00**
1	Total Number Other Personnel					Total Other Personnel Costs	**31,673.00**
						Total Direct Labor Costs (Salary, Wages, Fringe Benefits) (A+B)	**36,387.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
Organization Name : **University Of Massachusetts, Boston**	TBD on Submit

Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2018	**06 / 30 / 2019**	**Project**	**3**

C. Direct Costs - Equipment

Item No.	Equipment Item Description	Funds Requested ($)
	Total Equipment Costs	**0.00**

D. Direct Costs - Travel

	Funds Requested ($)
1. Domestic Travel (Including Canada, Mexico, and U.S. Possessions)	**3,491.00**
2. Foreign Travel	**0.00**
Total Travel Costs	**3,491.00**

E. Direct Costs - Participant/Trainee Support Costs

		Funds Requested ($)
1. Tuition/Fees/Health Insurance		**0.00**
2. Stipends		**0.00**
3. Travel		**0.00**
4. Subsistence		**0.00**
Number of Participants/Trainees:	Total Participant/Trainee Support Costs	**0.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
Organization Name : **University Of Massachusetts, Boston**	TBD on Submit

Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
07 / 01 / 2018	**06 / 30 / 2019**	**Project**	**3**

F. Other Direct Costs

	Funds Requested ($)
1. Materials and Supplies	**0.00**
2. Publication Costs	**0.00**
3. Consultant Services	**0.00**
4. ADP/Computer Services	**0.00**
5. Subawards/Consortium/Contractual Costs	**204,281.00**
6. Equipment or Facility Rental/User Fees	**0.00**
7. Alterations and Renovations	**0.00**
8. Other:	**0.00**
9. Other:	**0.00**
10. Other:	**0.00**
Total Other Direct Costs	**204,281.00**

G. Total Direct Costs

	Funds Requested ($)
Total Direct Costs (A+B+C+D+E+F)	**244,159.00**

H. Indirect Costs

	Indirect Cost Rate (%)	**Indirect Cost Base ($)**	Funds Requested ($)
UMB Indirect Cost, subcontractors included only to first 25K	**52.50**	**0.00**	**20,936.00**
Cognizant Federal Agency: **DHHS, Darryl W Mayes, 212-264-2069**		Total Indirect Costs	**20,936.00**

I. Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Costs (G+H)	**265,095.00**

J. Fee

	Funds Requested ($)
Fee	**0.00**

K. Total Cost

	Funds Requested ($)
Total Cost with Fee (I+J)	**265,095.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
Organization Name : **University Of Massachusetts, Boston**	TBD on Submit
Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**	

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 30 / 2019	**07 / 01 / 2020**	**Project**	**4**

A. Direct Labor - Key Personnel

Name	Project Role	**Base Salary ($)**	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	**Fringe Benefits ($)**	Funds Requested ($)
Byrnes, Jarrett	**PI**	**0.00**			**.5**	**4,768.00**	**87.00**	**4,855.00**
							Total Key Personnel Costs	**4,855.00**

B. Direct Labor - Other Personnel

Number of Personnel	Project Role	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
1	**Graduate Students**		**8**	**4**	**31,500.00**	**173.00**	**31,673.00**
1	Total Number Other Personnel					Total Other Personnel Costs	**31,673.00**
						Total Direct Labor Costs (Salary, Wages, Fringe Benefits) (A+B)	**36,528.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
Organization Name : **University Of Massachusetts, Boston**	TBD on Submit

Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 30 / 2019	**07 / 01 / 2020**	**Project**	**4**

C. Direct Costs - Equipment

Item No.	Equipment Item Description	Funds Requested ($)
	Total Equipment Costs	**0.00**

D. Direct Costs - Travel

	Funds Requested ($)
1. Domestic Travel (Including Canada, Mexico, and U.S. Possessions)	**3,491.00**
2. Foreign Travel	**0.00**
Total Travel Costs	**3,491.00**

E. Direct Costs - Participant/Trainee Support Costs

		Funds Requested ($)
1. Tuition/Fees/Health Insurance		**0.00**
2. Stipends		**0.00**
3. Travel		**0.00**
4. Subsistence		**0.00**
Number of Participants/Trainees:	Total Participant/Trainee Support Costs	**0.00**

PI Name : **Jarrett Byrnes**	NASA Proposal Number
Organization Name : **University Of Massachusetts, Boston**	TBD on Submit

Proposal Title : **Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 30 / 2019	**07 / 01 / 2020**	**Project**	**4**

F. Other Direct Costs

	Funds Requested ($)
1. Materials and Supplies	**0.00**
2. Publication Costs	**0.00**
3. Consultant Services	**0.00**
4. ADP/Computer Services	**0.00**
5. Subawards/Consortium/Contractual Costs	**154,467.00**
6. Equipment or Facility Rental/User Fees	**0.00**
7. Alterations and Renovations	**0.00**
8. Other:	**0.00**
9. Other:	**0.00**
10. Other:	**0.00**
Total Other Direct Costs	**154,467.00**

G. Total Direct Costs

	Funds Requested ($)
Total Direct Costs (A+B+C+D+E+F)	**194,486.00**

H. Indirect Costs

	Indirect Cost Rate (%)	**Indirect Cost Base ($)**	Funds Requested ($)
UMB Indirect Cost, subcontractors included only to first 25K	**52.50**	**0.00**	**21,011.00**
Cognizant Federal Agency: **DHHS, Darryl W Mayes, 212-264-2069**		Total Indirect Costs	**21,011.00**

I. Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Costs (G+H)	**215,497.00**

J. Fee

	Funds Requested ($)
Fee	**0.00**

K. Total Cost

	Funds Requested ($)
Total Cost with Fee (I+J)	**215,497.00**

Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery

TABLE OF CONTENTS

Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery

1. INTRODUCTION

To understand the global impact of climate change, we need long-term global data sets. Long-term remote sensing of earth systems has opened up new vistas in understanding planetary change (*1*). These data are limited, however, as automated classification is not possible for many applications – particularly when working with older sensors or features at the limit of a sensor's detection (*2*). Small teams of researchers can only classify so much on their own. Citizen science fills a key gap in the use of remote sensing data to understand long-term, large scale shifts to biological systems across the planet. **Here we propose to expand the geographic scope of our citizen science platform using Landsat data to examine change in the global abundance of the foundation species giant kelp, *Macrocystis pyrifera,* in order to assess climate change impacts. In the process, we will expand an existing Citizen Science project-building tool from the Zooniverse enabling any scientist to freely and easily create a project using NASA Landsat data.**

Climate change is already impacting numerous ecosystems (*3*). For example, rising temperatures have shifted the abundance and distributions of hundreds of plant species towards higher latitudes and elevations (*4*). Climate-related impacts to foundation species, species that provide food and habitat for entire ecological communities, are likely to be especially consequential due to the critical influence these species have on ecosystem structure and function (*5*). Giant kelp is a classic example of a foundation species and supports one of the most productive and valuable coastal ecosystems in the world. However, giant kelp is particularly sensitive to changes in environmental conditions, and climate change has already impacted the abundance and distribution of giant kelp forests globally.

Characterizing these impacts on regional to global scales is often impractical using classic field sampling techniques. Examining a recent compilation of all long-term kelp forest monitoring data[1] (*6*) reveals that only 0.03% of the entire range of giant kelp has ever been sampled, most of it for less than five years and focused on the United States of America and

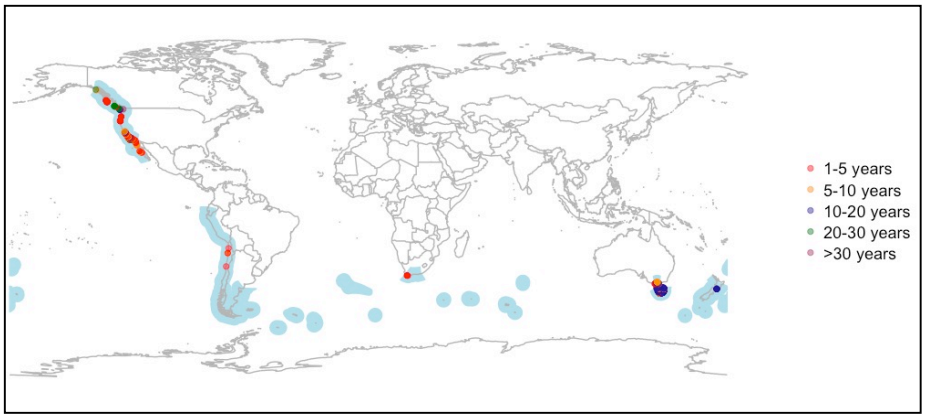

Figure 0 Distribution of the giant kelp, *Macrocystis pyrifera*, and location of all sampling efforts >3 years to date. Shaded blue regions are Ecoregions (*sensu* Spalding et al. 2008) that contain giant kelp. Points represent areas (typically <80m2) where kelp has been sampled for >3 years with color denoting times series length.

Tasmania (Fig. 1). Fortunately, recent increases in the availability of long-term satellite imagery with global coverage have made it possible to observe kelp forest ecosystems on larger space and time scales. Mapping giant kelp from remote sensing data, however, cannot yet be fully

[1] http://temperatereefbase.imas.utas.edu.au/portal/search?uuid=ecbe5cc3-3fbf-4569-b5e8-07c2201fcb9c

automated, so is highly time and work intensive. To remedy this problem, we have worked with the Zooniverse to create Floating Forests (http://floatingforests.org), a citizen science project. Citizen science has enabled us to map thirty years of giant kelp forests from Point Reyes to San Diego and around the entirety of Tasmania in less than two years. These two years have provided a roadmap for (1) the expansion of Floating Forests to the rest of the planet and (2) a general framework for the use of citizen science for the analysis of remote sensing data.

1.1 Giant Kelp and Climate Change

Forests of giant kelp (sensu *7*) are both a biologically ideal and socially important system to examine the consequences of climate change in nearshore ecosystems. Giant kelp is a foundation species (*8*) that regulates the diversity and productivity of many coastal habitats (*9-19*). As a result giant kelp provides a host of important ecosystem services: food for commercially fished species, larvae and prey; alter flow of currents and reduce shoreline erosion; tourism for local economies through SCUBA divers, kayakers, and recreational fishermen, food and chemicals for aquaculture, fertilizer and pharmaceuticals; and a potential source of blue carbon and may help mitigate ocean acidification locally. Given this diversity of critical ecosystem services, giant kelp forests' wide distribution across the planet (Fig. 1), and their strong response to shifts in ocean climate, we need to understand how they have changed due to human influences over the past several decades and how they might change in the future.

Giant kelp is the mostly widely distributed kelp (*15*) so it is an ideal species to examine the generality of global climate change on kelps. Because of giant kelp's large size (up to 30m), short life span of ~2.5 years (*20*), and poor ability to store nutrients, it responds quickly to fluctuations in large storm-waves (*21*) and warm nutrient depleted waters(*22*) . Scientists have long observed kelps' rapid short-term response to climate forcing and its follow-on effects on associated biological communities. Prolonged periods of warm, nutrient-depleted water such as those associated with El Niño Southern Oscillation (ENSO) events can lead to local (*23*) and widespread (*22*) kelp loss, and prevent subsequent recovery (*24*). Winter storms and swell are an important annual source of plant mortality and recruitment (*15*, *25*, *26*). Loss from both phenomena often trigger intensive grazing that can suppress the recovery of entire beds (reviewed in *8*, *27*) and fundamentally reshape whole food webs at large scales (*18*).

Figure 2. Aerial view of giant kelp canopy near Santa Barbara, CA, with buoy in foreground and boat in background for scale. Photo credit: Santa Barbara LTER

Climate change has been implicated in longer-term loss of giant kelp beds in Tasmania (*28*). Since the 1940s, giant kelp abundance has declined by 95% (*28*, *29*). This change has been coincident with warming waters in Tasmania pushing nitrogen concentrations below that required by giant kelp for growth (*28*) as well as the ocean warming-facilitated range expansion of the black sea urchin, which caused massive deforestation of kelp forests (*30*, *31*). As a result of these climate-driven shifts, the Australian government has listed giant kelp forests in this region as endangered.

Do these climate-driven phenomena scale to change in the global abundance and distribution of kelp forests? The highly dynamic nature of kelp in the preceding examples can easily be seen at regional scales (100s of km) where kelp biomass shows high variability at

seasonal, interannual, and decadal scales (*32*). And this variability means that large fluctuations in the range extent and abundance of kelps can be seen at relatively short timescales (years to decades) in response to climate forcing events. Observing these fluctuations at a monthly time-scale over large spatio-temporal scales has proven elusive, because of the vast range that kelps cover and the difficulty of surveying even a single patch. Most data comes from SCUBA diver surveys, but divers are time limited by time, depth, and environmental conditions. The total area of diver-surveys of giant kelp for more than two years comprises only 0.03% of the possible range of giant kelp.

1.2 Remote Sensing of Giant Kelp with Landsat

Remote sensing provides the solution to understanding change in giant kelp over time. Giant kelp is among the few benthic marine algae amenable to remote sensing. Adult giant kelp have a holdfast that anchors the plant to hard substrate and vine-like fronds buoyed by small gas bladders that reach the surface and form a dense canopy that can cover over 1250 hectares (Fig. 2. The distinctive surface canopy of giant kelp forms a narrow band that fringes the shoreline and makes kelp forests distinctive when viewed from above, particularly in the infrared spectral region, and suitable for aerial mapping and satellite remote sensing (*33*, *34*).

We developed a technique to measure kelp canopy area and biomass from Landsat satellite imagery (*32*). The Landsat program has acquired 30 m spatial resolution, multispectral imagery over the entire globe nearly continuously from 1984 to the present every 16-days, which allows for resolution of giant kelp forests that range in area from 100s to 10000s of m^2. Landsat's repeat time sequence makes it suited to monitor the high frequency cycles of giant kelp. With this dataset we can observe giant kelp populations on seasonal to annual to decadal temporal scales and regional to global spatial scales. It should enable us to develop the most comprehensive dataset of global giant kelp distributions to date, document changes in these distributions over the past 30 years, and monitor variability in the abundance of giant kelp forests across its entire global range. Efforts to date to automate classification of pixels from Landsat have so far proved unsuccessful. Analyzing giant kelp on a global scale over long time periods at simply would not be possible without the help of citizen science. To scale up, we turned to The Zooniverse to help us create a Citizen Science solution to crowdsource the classification and enable us to create a large-scale open data set.

1.3 Online Citizen Science and The Zooniverse

The Zooniverse is the world's largest and most successful platform for citizen science online. It now supports more than forty active projects, producing data that has been used in more than a hundred peer reviewed papers. Its volunteer workforce of 1.5 million volunteers is shared across these projects. Furthermore, while the original Zooniverse projects were built as stand-alone web applications, the commonalities between projects led to the development of a single platform model, with one suite of software supporting many projects (see Section 5 for details). At a time when citizen science is gaining in prominence across the world, the Zooniverse is becoming a core part of the research infrastructure landscape to support citizen science.

The Zooniverse arose from an attempt to classify the 893,212 images of galaxies from the Sloan Digital Skies Survey, which proved impossible for computers and experts were only able to classify 2% of images. Project scientists created Galaxy Zoo (*35*), allowing citizen scientists to walk through the simple steps of galaxy classification. Since building Galaxy Zoo, the Zooniverse has expanded to support online citizen science projects in disciplines ranging from astronomy to climate reconstruction to deep sea ecology. A basic principle guiding Zooniverse

projects is that certain tasks within the data processing chain are hard and costly to do based on computers, but comparatively trivial to carry out for a human worker. Zooniverse crowd-sources aspects of data processing by supporting the general public to participate in the cleaning, annotating, and processing of scientific data (*36*)

Zooniverse has invested considerable thought and effort to ensure that crowd-sourcing is used to ensure data quality and reliability. Lack of specialist knowledge or misclassification can lead to errors within data produced by citizen scientists (*37*). Zooniverse's approach to citizen science directly addresses these concerns and has led to an established track record of producing quality data for use by the wider scientific community. By creating consensus results based on numerous classifications, Zooniverse has been able to work with a disparate crowd of volunteers to produce reliable results (*35*, *38*, *39*), leading to publications across the disciplines. The Zooniverse infrastructure (*40*) provides a robust means of testing projects, tools for providing feedback to volunteers (*41*), and routines for generating consensus from classification, with more than a dozen projects having published over 100 peer-reviewed papers.

Zooniverse projects also facilitate direct interaction between citizens and scientists. Raddick et al. (*42*) found that the most important motivator for Zooniverse volunteers is the desire to contribute to science. Through the Zooniverse discussion forums, volunteers discuss objects of interest, generating hypotheses and examining them in the light of new evidence, alongside members of the research team. In addition, each Zooniverse project has a blog and other social media outlets through which research team members share results of the data analysis, publications, and more.

Zooniverse is unique among the open source, free, crowdsourcing options as a result of its 1) shared software, experience, expertise, and input from users across the disciplines, 2) reliable, flexible, and scalable back-end, which can be used for a variety of development tasks, 3) free, do-it-yourself (DIY) 'Project Builder' (also known as Panoptes) capabilities as described below, and 4) the scale of its existing audience of participating volunteers, drawing on 1.4 million volunteers worldwide. With this project, Zooniverse hopes to expand the scope of 'Project Builder' to enable scientists working with difficult to classify remote sensing data to easily create their own citizen science projects.

1.4. Floating Forests

In 2013, we worked with Zooniverse to create Floating Forests, an online citizen science platform to classify kelp forests from Landsat imagery. We split each Landsat scene into 400 images of equal size along a 20 x 20 grid (~131 km^2 per image). When available, we record the angle of the sun hitting the water, apply minor color correction for overly dark imagery, and filter out images that either contain no ocean or are completely obscured by clouds. Each resulting image is put into the Floating Forests queue. After a brief tutorial, users are asked to circle any kelp beds they see in a randomly selected image before going to the next image. Users also note whether the image is cloudy and can skip the image if no kelp is visible.

Floating Forests uses consensus-based classification to ensure that we accurately detect kelp (Fig. 2). *Every image in Floating Forests is seen at least four times.* If after four, no one has noted any kelp, the image is retired. If one of the four viewers sees kelp, the image is retained and *seen by a total of 15 users before being retired*. Once an image is retired, we take the classifications by all users, overlay them, and generate a consensus map of what 30 x 30m pixels users would classify as kelp (Fig. 3).

Floating Forests launched in August of 2014 with data from California and Tasmania. Since launch, we've worked with 6,676 citizen scientists who have made 2.67 million

classifications of Landsat images of kelp forests in California and Tasmania. Over 270 volunteers and research team members have made 7,230 comments within the project's discussion forum. Moreover, we are already using the project in the classroom at both the second grade (Wilson 2015) and university level with free curricula provided at Zooteach[2] (Zooniverse 2015). The platform has also been translated into Spanish, Polish, and Chinese. We also interact via blog entries by project scientists, and maintain a twitter account @FloatingForests as a clearinghouse for kelp forest science and news.

2. PROPOSAL GOAL & RATIONALE

Here we propose to take the preliminary work we've done with Floating Forests and extend it to answer questions about the impact of climate change on giant kelp abundance at the global scale, use our project as a model to enable future citizen science projects using Landsat data, and enhance education about kelp forest biology at the high school and university level.

This work relates directly to the goals of Earth Science at NASA, particularly the focus area of Carbon Cycle & Ecosystems. Kelp forests are among the most productive ecosystems in the world, but this productivity will almost certainly be affected by climate change. This research will also directly aid NASA's goal to support the activities of the U.S. Global Change Research Program and the research carried out on behalf of the National Ocean Council insofar as it will address questions regarding the impacts of climate change on coastal marine habitats that provide extensive ecosystem services to coastal communities. Furthermore, this project will contribute to NASA's efforts to support crowdsourcing and citizen science projects. We will expand the scope of an already-successful citizen science program and develop a general framework for utilizing citizen science in the analysis of Landsat satellite imagery.

3. OBJECTIVE 1 – Process and validate Floating Forests citizen science giant kelp data

One of the primary challenges of citizen science is the assurance of quality data for scientific analysis. We have built Floating Forests ensuring that multiple users see each image (four if no kelp is detected, fifteen if any one of the first four users see kelp). Users may still make errors, however. To use this data for analyses, we must build consensus maps of kelp forests where individual pixels

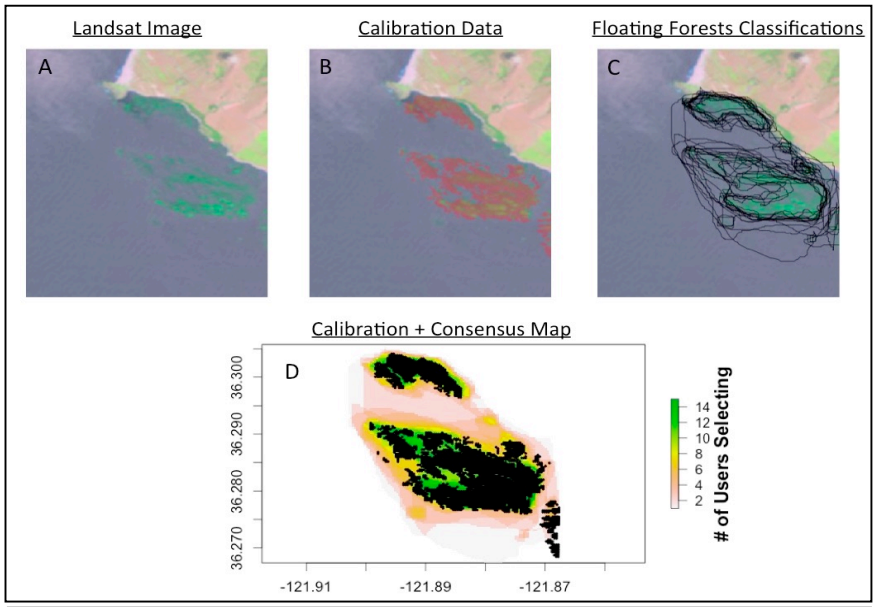

Figure 3. Comparison of calibration and Floating Forests data. A) Image taken from Landsat scene and used in Floating Forests. B) Image with calibration data from Cavanaugh et al 2011. C) All classifications from fifteen users from Floating Forests. D) Consensus map from Floating Forests (colors) overlaid with calibration data (black points).

[2] http://www.zooteach.org/

are classified as 'kelp' if more than some threshold of number of users select them. This threshold might be static across the entire data set, or it might vary by region, satellite, or due to environmental conditions at the time an image was taken. Some regions contain multiple canopy-forming species, which also may affect classifications. During the prototype phase, we will use validation data from California and Tasmania to create a consensus-map building pipeline that incorporates these concerns and dynamically sets the consensus threshold for any image based on calibration data (Fig. 3).

3.1 Sources of Calibration Data

To calibrate data from Floating Forests, we will rely on multiple types of data sources that are reported either in the literature or by government agencies (Table 1). The first data source includes previous efforts to use Landsat to classify kelp forests. These data, available for California (*32*) and soon for a subset of Tasmania from our collaborator Craig Johnson's group at the University of Tasmania and from Edyvane (*29*), are already formatted as geospatial data and are directly comparable to the data generated by Floating Forests, as shown in the example in Fig. 3D. The second data source is aerial surveys from planes or other aircraft. These data have been digitized into a variety of geospatial formats, but often at much finer resolution than Landsat data, such as the Alaska Department of Fish and Game's 1999 *Macrocystis* survey in southern Alaska (*43*). We will therefore need to downscale these datasets to the 30 x 30m resolution of Landsat, classifying a pixel as containing kelp if any pixels within it contain kelp. The third data source is historical maps, such as those around Tasmania collated by Edyvane (*29*) for 1984-1999. These maps are often at a coarser resolution than Floating Forests imagery, so we will project these data sets on the 30 x 30m scale before calibration analysis.

Table 1. Validation data sets. All imagery and maps sets have been processed into geospatial file formats for analysis already according to the references listed.

Area	Source	Description of Data Source
California	Cavanaugh et al. 2011, Bell et al. 2015	Expert classifications of Landsat imagery along the California coast
Tasmania	Edyvane 2003	Historical maps, aerial photography, and some Landsat imagery covering 1984-1999
Sub-Antarctic Islands	Attwood et al. 1991	Aerial photography of the Prince Edward Islands and Marion Island in 1988-1989
New Zealand	Fyfe et al. 1999	Aerial photography of New Zealand Beds from 1990-1998
Alaska	Van Tamalen and Woodby 2001	Aerial photography in 1999
South America	Torusio 2009	Argentine satellite data from 2002-2004, Landsat data from 1999-2004 from kelp beds in Tierra del Fuego
Washington State	Berry and Mumford 2005	Aerial photography of kelp beds in Washington from 1989-2004

3.2 Merge Floating Forests and Calibration Data

To determine the threshold number of users needed to classify a single pixel as kelp, we have developed a pipeline to take user classification data and convert it into a consensus raster map for each image showing the number of users classifying each pixel as kelp (Fig. 3). We will overlay Floating Forests classifications on calibration data and ask at what number of users classifying kelp (Fig. 3D) do we obtain a) the most similar estimate of kelp area as the calibration set (Fig. 3D, 4A) and b) a >75% probability of a pixel actually containing kelp (Fig. 4B).

3.3. Determine a General Threshold

To scale the single-image approach above to a whole calibration dataset to determine a threshold, we will and model the number of users needed to accurately estimate kelp cover in each image as compared to validation data and how this number is modified by image properties (e.g. sun angle). This will allow us to incorporate dynamic information about future images to obtain accurate classifications. First we will determine the number of users that produced the closest areal coverage of kelp to the corresponding calibration data set closest in time to when the Landsat image was taken for all images (Fig. 3A), we will then fit an appropriate (i.e., poisson or quasipoisson) generalized linear mixed model evaluating how the number of users needed to match the calibration area of kelp is influenced by clouds, sun angle, region, and satellite. From this model, we can calculate the optimal user threshold for any image to ensure that results will be as close to calibration data as possible. As a complementary approach, we will perform a similar analysis at the pixel scale using logistic models.

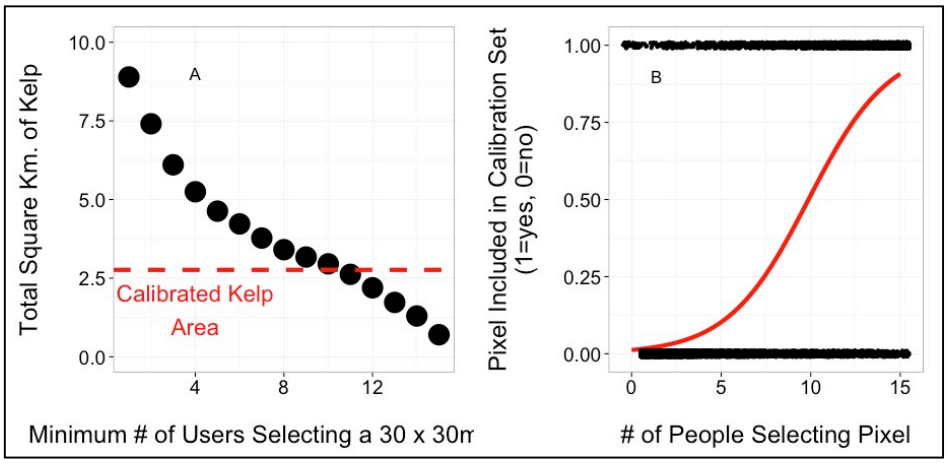

Figure 4. Performance of users selecting kelp. A) Total square km of kelp selected at different user thresholds. Dashed red line shows true kelp cover from calibration data. B) Logistic regression of the relationship between number of people selecting a pixel and whether or not it was classified as kelp in the calibration data set.

3.4 Incorporating Local Parameters that Alter Kelp Detectability

The above models may be too simple to set a correct threshold for kelp classification in some conditions. Kelp can be difficult to detect via satellite if the tide is high (canopies may be submerged), if conditions are wavy, or if canopies have experienced seasonal dieback. Water depth can also influence measurements: shallower depths may create denser canopies. We can estimate how environmental factors influence the detectability of kelp using calibration datasets generated by aerial photography taken when conditions were optimal for kelp detection (i.e. low tide on a cloudless calm day). For these data sets we can use the ETOPO1 Global Relief Model (*44*) to obtain the depth of water, hindcasts from NOAA WaveWatch III (*45*) to determine the local swell-height, and the global tide database from OSU TOPEX/Poseidon Global Inverse Solution (*46*) to determine the tide height for all Floating Forests image. With will refit the above calibration models incorporating terms for tide height, bed depth, swell height, season, and all possible interactions. We will compare this information-rich model to the previous calibration models using Akaike's Information Criterion as a model selection tool to determine whether incorporating environmental information produces a more accurate threshold.

3.5 Pipeline to Generate Calibrated Data for Future Analyses

The above analyses will tell us if there is one universal threshold value for the entire dataset, one threshold for each region, or if we need to incorporate the scene or image-level properties into

account when calculating a threshold. Ultimately, we will generate two raster maps from each Ecoregion using Spaulding et al.'s Marine Ecoregions of the World (*47*). The first will be a heatmap of raw user generated classifications. The second will be a clean map assembled from data for each image after applying the relevant threshold based on our calibration model results.

4. OBJECTIVE 2 – Evaluate Links Between Climate Change and Giant Kelp Populations

The sensitivity of giant kelp forests to changes in environmental conditions suggests that these systems may serve as a bellwether for the effects of climate change. As discussed above, we have already witnessed significant climate change related impacts on giant kelp distributions in Tasmania and the northeast Pacific, but these studies span only a small portion of the range of giant kelp. Furthermore, we do not know how the abundance and distribution of giant kelp has changed in other regions or if those changes might be related to shifts in climate. To address this knowledge gap, **we will use the dataset produced by Floating Forests to (1) examine spatiotemporal variability in giant kelp abundance across its entire global range, and (2) identify the primary drivers of this variability.**

4.1 Documenting trends in giant kelp abundance on global scales

After the processing/validation steps described in Objective 1 are completed, we will create a map of the global distribution of giant kelp by identifying all locations where it was observed at any point during the Landsat time series (1984-present). This global dataset will then be separated in 7 regions: northeast Pacific (Aleutian Islands to Baja California), southeast Pacific (Peru and Chile), Argentina, South Africa, Southern Australia (including Tasmania), New Zealand, and the sub-Antarctic Islands (Fig. 1). For all of the subsequent analyses we will bin the kelp data into 5 km alongshore segments – the approximate size of a Zooniverse image – by assigning each kelp canopy observation to the closest coastline segment and calculating the composite canopy area within that segment alont with temporal variability. Giant kelp populations are variable on intra-annual timescales due to seasonal cycles of environmental factors (*48*) and inter-annual timescales due to longer scale variability in environmental conditions as well as biotic processes (*22*, *32*). We are interested in variability that might affect the long-term persistence of giant kelp populations, so we will concentrate on characterizing variability on annual to decadal timescales. We will calculate maximum canopy area for each coastline segment for each year from 1984-2016 in order to remove the influence of seasonal variation for the assessment of long-term annual trends.

We will use generalized linear mixed models to estimate proportional rates of change per year for the entire time series (1984-2016) as well as each decade (1984-1993, 1994-2003, 2004-2015). This analysis will enable us to characterize long-term trends in giant kelp abundance on local (kms) to regional (100s to 1000s of kms) to global scales. We will also examine the degree to which these trends have been accelerating or decelerating in recent decades. We will use Bayesian analysis to explicitly estimate our degree of confidence in these trends. This analysis will represent the largest comprehensive analysis of kelps undertaken and will have more spatial and temporal coverage than any analysis to date.

4.2. Identifying environmental and climatic controls of giant kelp abundance

There has been a large amount of research into the environmental factors that control dynamics of giant kelp populations (*15*, *32*, *48*), but most of observational studies have been performed in the west coast of California. It is unclear how the roles of these drivers vary on regional to global scales and whether long-term trends in temperature and wave energy match trends in kelp abundance, as we hypothesize. We expect the relative importance of those drivers to vary a great

deal, as we have observed a large amount of variability *within* California (*48*). We must identify environmental drivers associated with changes in kelp abundance and the variability in their local importance in order to understand how climate change will impact giant kelp distributions.

We will compare our time series of kelp abundance to variables that describe processes anticipated to control giant kelp dynamics and evaluate how their importance changes within and across regions. We will focus on macroclimatic controls of kelp growth and survival -, waves, SST, nutrient availability, and photosynthetically available radiation - as well as the local-scale anthropogenic drivers of such nutrient pollution and coastal development. For each of these drivers, we have identified available data layers or modeling techniques to generate them (*44*, *45*, *49*-*57*) (Table 2). Not all of the environmental data sets will be available for the entire period over which we can construct our proposed Landsat time series of kelp dynamics (1984-present). Thus, some analyses will be necessarily regional, restricted in time, or variables will be incorporated into hierarchical models.

Table 2. Environmental predictor datasets and their sources.

Parameter	**Source**	**Spatial/temporal coverage**
Sea surface temperature	MODIS/AVHRR data products, Coastal Zone Color Scanner, SeaWiFS	Global; 1984-present
Surface nitrate	Modeled using *in situ* measurements of temperature, chlorophyll *a*, and nitrate from the World Ocean Database and MODIS and MODIS level 3 imagery of SST and chlorophyll *a* Silió-Calzada et al. 2008	Global; 1997-present
Chlorophyll *a*	MODIS/VIIRS data products, SeaWiFS data products	Global; 1997-present
Wave disturbance	WAVEWATCH III, SWAN Tolman 2009, Chawla et al. 2012, Tolman et al. 2014, Booij et al. 1999, Ris et al. 1999	Global; 1984-present
Surface and bottom PAR	Modeled using MODIS/VIIRS, MERIS, and SeaWiFS surface PAR and kd 490 data products Saulquin et al. 2013	Global; 1997-present
Substrate	California Seafloor Mapping Program Cochrane and Lafferty 2002	California
Bathymetry	NOAA ETOPO1 Global Relief Model Amante and Eakins 2009	Global
Coastal development	VIIRS city lights groundtruthed against known population densities Miller et al. 2008	Global; 2011-present
Coastal Nutrient Runoff	Marine Cumulative Impacts Map Halpern et al. 2008	Global; Static

We will use a variety of statistical techniques to assess the relationships between kelp dynamics and environmental variables. These will include regression based approaches comparing trends in kelp to trends in drivers, Empirical Orthogonal Function analyses (*48*, *58*), hierarchical Bayesian methods of raw data (*59*), and generalized additive models GAMS; (*48*, *60*). We will use the spatial (within-region) and temporal variability in the data to partition variation in kelp abundance into components due to variation in environmental conditions vs. relatively fixed spatial environmental variability. This will enable us to examine the interactive effects of drivers operating at different spatial scales (*61*). With GAMs we can identify thresholds where slight differences in a predictor variable may have a disproportionate effect on giant kelp abundance (*48*). We will use these relationships to identify tipping points where a

small environmental change may have a significant impact on kelp forests ecosystems and evaluate which regions might be sensitive to small future changes relative to current environmental conditions.

5. OBJECTIVE 3: Develop a general platform for creating Landsat-based Citizen Science projects

Floating Forests provides single example of how Landsat data can be incorporated into a citizen science program to answer transformative research questions. We propose to develop a platform that will allow any scientist to rapidly launch a Landsat-based online citizen science project. In July 2015 Zooniverse launched a new version of its platform that supports a free, DIY Project Builder. The Project Builder is transformative; prior to its development a typical project required professional web development and months to years of development time. Now anyone can build and deploy a project within hours, using browser-based tools. The Project Builder supports the most common types of interaction including classification, multiple-choice questions, comparison tasks, and marking and drawing tools. All Project Builder projects come with a landing page, classification interface, discussion forum, 'About' for content about the research and the research team, and blog. Before public launch, all Project Builder built projects go through a beta review process in which several hundred Zooniverse volunteers provide feedback about usability and clarity through a standardized form. Since the launch of the Project Builder in July 2015, over 2000 DIY projects have been created, 150 have been serious attempts generating classifications, and over 20 have had public launches with promotion through Zooniverse.org. Each week, ~1 new Project Builder built site requests to be reviewed by our beta testers. We will **optimize the Project Builder to support members of the Earth Science community working with NASA satellite data. Our efforts will focus on Landsat data, but this framework can be applied to any earth observation dataset. We will make available the needed annotation and marking tools, a user-friendly data pipeline for uploading NASA earth observation data into the Project Builder, and data visualizations for citizen scientists and researchers to contextualize the images and their results.**

5.1 Project Prototype & Data Pipeline

During the prototype phase, the research team will create a prototype version of the Floating Forests project using the Project Builder. The current Floating Forests project is hosted by the previous generation Zooniverse infrastructure, called 'Oroborous', which does not support the DIY aspects of the Project Builder. The prototype Project Builder version of Floating Forests will provide a pared down version of the Floating Forests site. The other key expansion of the Project Builder that we propose here is to implement a NASA-Zooniverse data pipeline. During the prototype phase, we will resolve known issues with the processing of the NASA Landsat data before it is ingested into the current 'Oroborous' supported Floating Forests site. For example, there is a known issue with incorrect georeferencing of individual images as they are subdivided for upload into the Zooniverse site. Color correction also still requires manual calibration for each new scene uploaded. We will fully automate this process for future use in Project Builder. We will test this process by adding a single new area – Tierra del Fuego - into the existing Floating Forests site.

5.2 Implementation - Project Builder for Landsat Data

In the implementation phase, the Zooniverse team will implement full integration of Project Builder with Landsat data. ***This will enable any scientist to launch and maintain a Landsat-based citizen science project with no help from Zooniverse staff. This effort ensures that***

future Landsat-based citizen science projects can be created long after this proposal is completed. To do this, we will implement new functionality within the Project Builder infrastructure to support the full functionality needed for the Floating Forests project (e.g., a freehand selection tool). Future teams will be able to use this and existing classification tools already in Project builder (e.g., identify if a feature is present or absent, and how many times), creating possibilities for a diverse suite of Landsat-based projects beyond Floating Forests.

During the implementation phase, the Zooniverse team will fully implement the NASA-Zooniverse data pipeline for public use through the Project Builder. This full implementation will include a user-friendly interface. Through the interface, the researcher will first identify the regions and time period of interest. We have prototyped a version[3] of this step using the Google Map API, in which a researcher marks out the area on a Google map of the Earth, the coordinates are stored in a KML file, and used to kickstart a query to the NASA API. The researcher will indicate how many sub-images to create, including the overlap to include between images to mitigate edge effects. We will provide recommendations on minimum/maximum values to use. The researcher will have the ability to toggle whether to include or remove images with only ocean or land. The interface will also include the ability to select which spectral bands to use and how to adjust brightness and contrast. As new Landsat data is constantly becoming available, we will automate the insertion of new data on an annual cycle. Finally, the data will be uploaded into the researcher's Project Builder project. The images will then appear within the classification interface for volunteers to annotate. An important aspect of the data pipeline is the ability to scale with use. With this in mind, the pipeline will be loaded in a Docker container and hosted on Amazon Web Services, mirroring the architecture for Zooniverse as a whole. The Floating Forests research team will work closely with Zooniverse as they develop and implement the data pipeline, and Floating Forests will serve as the first use case for the data pipeline.

5.3 Project Builder Infrastructure

The software requirements for citizen science online are stringent. Each project must present an easily understood interface to the data and cope with extremely uneven traffic flows. For example, the most recent project featured on the BBC's Stargazing Live program – Snapshot Supernova – received more than a million classifications in under half an hour. In such circumstances, being able to scale rapidly and prioritize recording classifications is essential. Any platform that aspires to support a large range of projects must be easily extendable and allow for adaptive improvement of features. These requirements have led to a modular approach to software system design that underlies the new Zooniverse Panoptes/Project Builder system.

At its core, Panoptes is an application written in the common Ruby on Rails framework, which supports a powerful Application Programing Interface. The core tasks of the Panoptes API are the creation and management of projects, passing subjects to the front end software for classification, and the receiving and recording of classifications. Further modules handle secondary tasks such as data aggregation, discussion, or the provision of statistics on project progress or user behavior. Data is saved in a format (JSON in a PostgreSQL database) that maximizes flexibility by avoiding the need to define a rigid structure for classifications, while still providing easy search.

5.4 Best Practices and Facilitating the Spread of a Landsat-based Project Builder

[3] See https://www.youtube.com/watch?v=7dqJa9ZdZrs&feature=youtu.be

Zooniverse created a 'Best Practices Guide' for research teams to use the Project Builder to build their site as well as successfully engage with their online volunteer communities. This 'Best Practices Guide', which was developed collaboratively with Zooniverse volunteers, research team members, and Zooniverse team members, thoughtfully addresses the recommendations from the Federal Crowdsourcing and Citizen Science toolkit. To spread these best practices and get more scientists to implement citizen-science based Landsat projects, PIs will host a Project Builder workshop at the annual American Geophysical Union meeting in San Francisco. There, they will introduce scientists to Project Builder, help them begin to create projects for their own data, and lead a discussion on the best practices in creating a broader citizen science project.

6. OBJECTIVE 4 - Improve Citizen Science access to and interaction with Floating Forests

As part of the Floating Forests project, we want to allow citizen scientists and interested stakeholders to be able to access our data and results in whatever context they find most meaningful. This could mean anything from providing raw data for parties interested in looking at the efficacy of citizen science to providing dynamic visualizations of change in local kelp beds to students and citizen groups. We want people to get to know the kelp forest in their back yard. These efforts will take multiple forms.

6.1. Floating Forests Data Dissemination

Project PIs have recently been involved in the creation of a data portal for all temperate rocky reef data, Temperate Reefbase[4] (TRB). This site allows for the dissemination of tabular and geospatial data sets from anyone. All data is catalogued using the ISO 19115 compliant Marine Community Profile 2.0 (*62*) as a metadata standard. TRB also provides tools for users to access multiple different datasets that co-occur in the same geospatial area, such as benthic habitat layers, local nutrient runoff data, and co-occuring kelp forest data. All data is publically accessible with a user-selected license. TRB has agreed to host both the raw Floating Forests classification data and geospatial quality controlled data as described in Objective 1. Raw classifications will be provided as tabular data with full MCP 2.0 compliant metadata. Raster data of kelp areas over time will be made available as downloadable NetCDF files. Data will be updated on a quarterly cycle by PI Byrnes. ***During the prototype phase, we will upload all extant data to TRB for public access.*** We will make a new forum on Floating Forests to announce data access and discuss issues of analysis, as well as posting relevant information on our blog. Integration with TRB will allow raw data and data products derived from Floating Forests to be readily available to anyone.

6.2. Data Visualization with Zooniverse

At Zooniverse, we will build comparable data visualization tools for citizen scientists and researchers to contextualize the images and their results for Floating Forests during year two. This will include an interactive map in which the user can toggle on and off the presence of kelp (based on aggregated results from citizen scientist classifications), and scrub through time; i.e., animate change over time. We will also include tools to overlay and toggle on and off other layers of information from the climate analysis in Objective 2.

In addition, the Zooniverse site will include a project statistics page in which researchers and citizen scientists can view the 'health' of their project, e.g., total number of classifications needed, percent complete, number of total volunteers to date, number of volunteers online now, number of classifications per day, week, month, number of comments on Talk per day, week,

[4] http://temperatereefbase.imas.utas.edu.au

month, etc. Each citizen scientist's personal profile page will indicate the number of classifications s/he has contributed, posts on Talk, etc.

6.3 Recruitment of New Citizen Scientists

While Floating Forests has built a large audience thus far, and it intends to reconnect with citizen scientists at each update of the data and interface, we will also pursue other avenues to recruit new citizen scientists. In addition to promotion via Google Hangouts and social media (see 6.3), we will build new partnerships. We will target existing ocean and climate change podcasts such as Thank You Ocean, Warm Regards, and others to promote our project. We will pitch a story to Public Radio International's Living on Earth, currently hosted at UMB. We will also engage PADI Reef Check, a large-scale field-based citizen science effort, and seek to tap some of their pool of citizen scientists who want to engage with the oceans when they aren't able to get into the water. We will seek to retain them via continued interaction as discussed in 6.4.

6.4. Retain citizen scientists via interaction with project scientists

We want Floating Forests to retain interested citizen scientists by being as interactive as possible. As part of the current and future project websites, we have a Talk section where citizen scientists can discuss and ask questions about the images they are classifying currently with 7,230 comments. The science team regularly drops in to answer questions and provide guidance. The sites also host a forum for longer-form discussion of objects and kelp forest science that 271 users currently use. This forum has been so successful that it led to the recruitment of one citizen scientist to join part of the science team. She ended up re-writing a crucial part of our data-filtering pipeline, implementing color correction and cloud filtering algorithms that we still use. This was not something she had been trained in, but rather something she learned as part of her passion for Floating Forests and citizen science. As part of the project, scientists will check in on each of these weekly to provide guidance and discussion.

To reach beyond the project website, we will use available social media outlets. We maintain a project blog to discuss both Floating Forests and kelp forest science. Starting in the prototype phase, project students will host monthly 'kelp chats' via Google Hangouts with kelp forest scientists around the globe to discuss kelps, climate change, ecosystem services, and what's hot in kelp forest science today. PI Byrnes has a track record of using these for saltmarsh science[5]. Information is also disseminated via our project Twitter feed, @FloatingForests, and re-disseminated by PI Byrnes to his 3.3K followers of @jebyrnes with the hashtag #kelp. The use of this hashtag allows for broader dissemination to Twitter users interested in kelp biology, ecology, tourism, and farming; it currently has an estimated reach of 1.27 million users[6].

7. OBJECTIVE 5 - Bringing kelp forest citizen science into the classroom

A key value in this proposal is a partnership between citizen science, research, and science education and outreach. Research has underscored the importance of field experiences and hands-on learning in courses for inspiring lasting interest in science. Through educational partnerships, we will create curricula that can be downloaded from the floating forests website for use in a variety of high school and college classrooms. These curricula will expose students who do not have easy access to the marine environment to the importance of kelp forests and marine ecology through hands-on and inquiry-based projects that will encourage teaching the

[5] http://marshlife.org

[6] As estimated by http://keyhole.co/ on July 13, 2016

science practices and the cross cutting concepts in line with Next Generation Science Standards (NGSS).

At CSUMB, funding will benefit a primarily undergraduate institution (PUI), an early career female PI (Haupt), and underrepresented undergraduates who are primarily first-generation college students. CSUMB hosts the Recruitment in Science Education (RISE) program, an after-school STEM enrichment program serving first-generation college bound students from low-income and underrepresented communities in science. PI Haupt will work with educators from the RISE program to create curricula that will be implemented at CSUMB and through the RISE program. During the prototype year PI Haupt will develop sample curricula products for the RISE summer session that will encourage students to implement the science practices of NGSS: from asking questions and defining problems to analyzing/interpreting data and communicating results (www.nsta.org/ngss). During year one, these curricula projects will be used in RISE after school programs and at CSUMB. PI Haupt will implement kelp forest curricula in content-based and project-based courses at CSUMB. At the completion of year one, curricula will be revisited and honed for high school and college classrooms beyond RISE and CSUMB. During year two, we will make these curricula available. Lessons will consist of background information for teachers, online worksheets for students, and instructions for inquiry-based projects for any classroom regardless of proximity to the ocean. At the completion of year two, we will survey participating teachers to assess the utility of curricula and improve them. In year three we will improve curricula and create new lesson plans that further implement NGSS standards and practices.

Additionally two undergraduates will be selected each year to conduct research internships that tie directly to the proposed project: one based in science communication and the other to examine potential effects of urban development on kelp. The Marine Science program at CSUMB specifically focuses on geospatial tools and undergrads at CSUMB are particularly well prepared to participate in this project. During the academic year, these two undergraduates will work in PI Haupt's lab. CSUMB's Undergraduate Research Opportunities Center (UROC), which hosts several minority participation programs, will provide students guidance and financial support (note: nine UROC-supported CSUMB undergraduates have received NSF GFRPs in the past three years).

All lesson plans will be uploaded to Zooteach, Zoonivere's teacher resource center, SciStarter's citizen science curriculum collection[7], and Curriki[8] for long-term access. PI Byrnes will also work with current collaborators at the Dearborn STEM Academy and Newton North High School. University curricula will be disseminated to the Kelp Ecosystem Ecology Network[9], an international coalition of kelp forest scientists working to understand kelp global change biology.

8. PLAN FOR PROJECT AFTER THE CONCLUSION OF THE AWARD

The science, public implementation of Project Builder, and educational curriculum will continue after the completion of the award. First, Floating Forests itself will continue in perpetuity and will be updated on an annual basis with new imagery unless tools are implemented to generate automated kelp classification from Landsat images. If that happens, we will work with those researchers to merge our data sets, and maintain a unified global giant kelp data set that is freely

[7] http://scistarter.com/page/Educators.html

[8] http://www.curriki.org/

[9] http://kelpecosystems.org

available. As the time series grows, so will its utility to kelp forest researchers around the world. Second, Zooniverse will continue to maintain the Landsat-enabled Project Builder. The broad research community will continue to benefit as they can create new remote-sensing citizen science projects as needed. Last, educational materials will continue to be hosted at Zooteach, SciStarter and Curriki. PIs will use and expand on these materials and the relationships they build in future proposals to NOAA SeaGrant, NSF Biological Oceanography, and NASA as a key building block for their broader impacts.

9. PERSONNEL AND PROJECT MANAGEMENT PLAN

Jarrett Byrnes will serve as lead PI and be responsible for overall project coordination, management, and reporting. He will coordinate and direct bimonthly meetings of all PIs to assess progress and conformance to timelines. He will also hold an annual "all-hands" in-person meeting or workshop to distribute responsibilities, share results, review progress, plan manuscripts, and establish deadlines. Working with a graduate student whose dissertation will focus on Floating Forests data, PI Byrnes will manage the data pipeline for Floating Forests, coordinate the project blog and social media efforts, and lead Objective 1, data validation, both during the prototype phase and for new areas of the globe. Co-PI-Cavanaugh will lead the tasks associated with Objective 2 (analysis of long-term change in global giant kelp abundance and impacts of climate) and contribute to the activities associated with Objective 1 and 3 (development and validation of Floating Forests). PI-Cavanaugh will supervise a postdoc student at UCLA whose will focus on the analysis of environmental and human impacts on global kelp forests. Co-PI Alison Haupt will lead all of the curriculum development and teacher outreach activities in Objective 5. She will supervise two undergraduate interns each year. She will also lead our efforts to develop educational modules targeted towards high school students and undergraduates. Co-PI Laura Trouille from Zooniverse will lead Objective 3, the development of a Landsat-based Project builder, and data visualization at the Zooniverse in Objective 4. She and Zooniverse will handle all of the activities associated with porting the Floating Forests website into the Project Builder and creating a Landsat data pipeline.

10. PROJECT TIMELINE

During the prototype phase, we will accomplish our validation goal, fully automate our Landsat data import pipeline using Tierra del Fuego as an example, build a prototype of the future Project Builder Landsat site, and create an initial high school kelp forest curriculum. If fully funded, we will complete implementation of the Project Builder version of Floating Forests, use this to classify the rest of the global giant kelp dataset, analyze the influence of climate change and human drivers on global kelp forests, release this Landsat-based project builder to the scientific community, and fully implement our data visualization and curriculum development goals.

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23. R. C. Zimmerman, D. L. Robertson, Effects of El Niño on local hydrography and growth of the giant kelp, Macrocystis pyrifera, at Santa Catalina Island, California. *Limnology and Oceanography* (1985).

24. M. S. Edwards, G. Hernández-Carmona, Delayed recovery of giant kelp near its southern range limit in the North Pacific following El Niño. *Mar. Biol.* **147**, 273–279 (2005).

25. P. K. Dayton, M. J. Tegner, Catastrophic Storms El-Niño and Patch Stability in a Southern California USA Kelp Community. *Science*. **224**, 283–285 (1984).

26. A. W. Ebeling, D. R. Laur, R. J. Rowley, Severe storm disturbances and reversal of community structure in a southern California kelp forest. *Mar. Biol.* **84**, 287–294 (1985).

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32. K. Cavanaugh, D. Siegel, D. Reed, P. Dennison, Environmental controls of giant-kelp biomass in the Santa Barbara Channel, California. *Marine Ecology Progress Series*. **429**, 1–17 (2011).

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38. L. C. Johnson, A. C. Seth, J. J. Dalcanton, M. L. Wallace, R. L. Simpson, C. J. Lintott, A. Kapadia, E. D. Skillman, N. Caldwell, M. Fouesneau, D. Weisz, B. F. Williams, L. C. Beerman, D. A. Goulermis, and A. Sarajedini, PHAT Stellar Cluster Survey. II. Andromeda Project Cluster Catalog. *The Astrophysical Journal*. **802**, 127 (2015).

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42. M. Jordan Raddick, M., G. Bracey, P. L. Gay, C. J. Lintott, C. Cardamone, P. Murray, K. Schawinski, A. S. Szalay, and J. Vandenberg, Galaxy Zoo: Motivations of Citizen Scientists. *Astronomy Education Review*. **12** (2013)

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45. H. L. Tolman and The WAVEWATCH III Development Group, *User manual and system documentation of WAVEWATCH III® version 4.18, Tech* Environmental Modeling Center Marine Modeling and Analysis Branch, U. S. Department of Commerce National Oceanic and Atmospheric Administration, National Weather Service. (2014).

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Biographical Sketch for Dr. Jarrett E. K. Byrnes

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(a) Appointments

Assistant Professor. University of Massachusetts Boston, Department of Biology 2012 – Present

(b) Professional Preparation

1997-2001 Brown University, Providence RI Bachelor of Science in Biology
2002-2008 UC Davis, Davis CA Population Biology, M.S. Ph.D.
2008-2010 Santa Barbara Long Term Ecological Research Project, Postdoctoral Fellow
2010-2012 National Center for Ecological Analysis and Synthesis, Postdoctoral Fellow

(c) Products

(i) List of Five Relevant Products

1. Krumhansl, K., Rasweiler, A., Novak, M., Okamoto, D. and **Byrnes, J.E.K.** 2016. Global kelp timeseries from National Center for Ecological Analysis and Synthesis/Kelp Ecosystem Ecology Network Kelp forests and climate change working group. Data Product. http://temperatereefbase.imas.utas.edu.au/portal/search?uuid=ecbe5cc3-3fbf-4569-b5e8-07c2201fcb9c

2. Witman, J.E., Lamb, R., **Byrnes, J.E.K.** 2015. Towards an integration of scale and complexity in marine ecology. *Ecological Monographs.* 85: 475-504.

3. Byrnes, J.E.K., Cavanaugh, K.C., Haupt, Bell, T.W., Harder, B., A.J., Rassweiller, A., Pérez-Matus, A., Assis, J., and The Zooniverse. 2014. Floating Forests. http://floatingforests.org. See also http://blog.floatingforests.org/ and http://talk.floatingforests.org/ for more.

4. Byrnes, J.E.K., J. Ranganathan, J., Walker, B.L.E., and Faulkes, Z. 2014. To Crowdfund research, scientists must build an audience for their work. PloS one 9:e110329. [doi]

5. 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]

(ii) List of Five Additional Products

1. Elahi, R., O'Connor, M.I., **Byrnes, J.E.K.,** Dunic, J., Eriksson, B.K., Hensel, M.J.S., Kearns, P.J. 2015. Recent Trends in Local-Scale Marine Biodiversity Reflect Community Structure and Human Impacts. Current Biology. 25: 1938–1943. [doi]

2. Byrnes, J. E. K., L. Gamfeldt, F. Isbell, J. S. Lefcheck, J. N. Griffin, A. Hector, B. J. Cardinale, D. U. Hooper, L. E. Dee, and J. E. Duffy. 2014. Investigating the relationship between biodiversity and ecosystem multifunctionality: Challenges and solutions. *Methods in Ecology and Evolution* 5: 111-124. [doi] [R package]

3. Lefcheck, J.S., **Byrnes, J.E.K.,** Isbell, F., Gamfeldt, L., Griffin, J.N., Eisenhauer, N., Hensel, M.J.S., Hector, A., Cardinale, B.J., Duffy, J.E., 2015. Biodiversity enhances ecosystem multifunctionality across trophic levels and habitats. Nature Communications 6, 6936. [doi]

4. Byrnes J.E., Johnson L.E., Connell S.D. et al. 2013. The sea urchin – the ultimate herbivore and biogeographic variability in its ability to deforest kelp ecosystems. PeerJ PrePrints, 1, e174v1. [doi]

5. Byrnes, J.E.K., Cardinale, B.J., and Reed, D.R. 2013. Sea urchin grazing increases with prey diversity on temperate rocky reefs. *Ecology*. 94:1636-1646. [doi]

(d) List of Five Synergistic Activities

1. Coordinator for the international Kelp Ecosystem Ecology Network. http://kelpecosystems.org

2. Contributing Developer to *lavaan*, *sem*, and *semTools*- Libraries for the analysis of Structural Equation Models in R http://lavaan.org, https://github.com/simsem/semTools/wiki

3. Marshlife.org http://marshlife.org - A blog part of a MIT SeaGrant on salt marsh food web structure where researchers tell stories of life in the field and current advances in salt marsh research.

4. Global Impacts of Climate Change on Kelp Forests. Leader, National Center for Ecological Analysis and Synthesis working group.

5. SciFund Challenge, co-founder and board president. SciFund Challenge is a nonprofit organization that empowers scientists to shrink the gap between science and society. We train scientists how to connect to the public, back scientists in their outreach, and crowdfund to support research.

(e) Collaborators and Co-Authors: Balvanera, Patricia, UNAM; Bolton, John, University of Cape Town; Cavanaugh, Kyle, Smithsonian Environmental Research Center; Connell, Sean, University of Adelaide; Duffy, J. Emmett, Virginia Institute of Marine Sciences; Edwards, Kyle, University of Michigan; Gamfeldt, Lars, University of Gothenburg, Sweden; Gonzalez, Andrew, McGill University; Holbrook, Sally, University of California Santa Barbara; Hooper, David, Western Washington University; Hughes, A. Randall, Northeastern University; Isbell, Forest, University of Minnesota; Johnson, Craig, University of Tasmania; Kimbro, David, Northeastern University; Konar, Brenda, University of Alaska Fairbanks; Krumhansl, Kira, Simon Frasier University; Ling, Scott, University of Tasmania; Michaeli, Fiorenza, Stanford University; Norderhaug, Kjell-Magnus, Norwegian Institute for Water Research; Novak, Mark, Oregon State University; O'Connor, Mary, University of British Columbia; Perez-Matus, Alejandro. Pontificia Universidad Católica de Chile; Reynolds, Pamela, Virginia Institute of Marine Sciences; Salomon, Anne, Simon Frasier University; Schmitt, Russ, University of California Santa Barbara; Shears, Nick, University of Auckland; Sousa Pinto, Isabel, University of Porto; Wernberg, Thomas, University of Western Australia. (28)

Graduate Advisors (1) and Postdoctoral Sponsors (2): John J. Stachowicz, UC Davis. Bradley J. Cardinale, University of Michigan; Daniel C. Reed; UC Santa Barbara.

Thesis Advisor and Post-Graduate Scholar Sponsor: Alison Haupt, California State Monterey Bay, Postdoctoral Mentee. (1)

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Appointments and Positions

2014-present **Assistant Professor,** Department of Geography, University of California Los Angeles, Los Angeles, CA
2012-2014 **Postdoctoral Researcher,** Smithsonian Environmental Research Center, Smithsonian Institution, Edgewater, MD
2006-2012 **Research and Teaching Assistant,** Departments of Marine Science & Geography, University of California, Santa Barbara, CA
2004-2006 **Remote Sensing/GIS Analyst,** Earth Satellite Corporation, Rockville, MD

Professional Preparation

2011 Ph.D. Marine Science, University of California, Santa Barbara
2003 B.S. Geosciences & History, Trinity University, San Antonio, TX

Selected Publications

Cavanaugh K.C., Siegel D.A., Kinlan B.P., Reed D.C. (2010) Scaling giant kelp field measurements to regional scales using satellite observations. *Marine Ecology Progress Series* 403:13-27.

Cavanaugh K.C., Siegel D.A., Reed D.C., Dennison P.E. (2011) Environmental controls on giant kelp biomass in the Santa Barbara Channel, CA. *Marine Ecology Progress Series* 429:1-17

Cavanaugh K.C, Siegel D.A., Raimondi P.T., Alberto F. (2014) Patch definition in metapopulation analysis: a graph theory approach to solve the mega-patch problem. *Ecology* 95(2):316-328

Cavanaugh K.C, Kendall B.E, Siegel D.A., Reed D.C., Alberto, F., Assis J. (2013) Synchrony in dynamics of southern California giant kelp forests is driven by both local recruitment and regional environmental controls. *Ecology* 94:499-509

Bell, T. W[†]., **Cavanaugh, K. C.**,[†] & Siegel, D. A. (2015). Remote monitoring of giant kelp biomass and physiological condition: An evaluation of the potential for the Hyperspectral Infrared Imager (HyspIRI) mission. *Remote Sensing of Environment*. [†]*Authors contributed equality to this work*

Bell, T. W., **Cavanaugh, K. C.**, Reed, D. C., & Siegel, D. A. (2015). Geographical variability in the controls of giant kelp biomass dynamics. *Journal of Biogeography*.

Cavanaugh K.C, Kellner J.R., Forde A.J., Gruner D.S., Parker J.D., Rodriguez W., Feller I.C. (2014) Poleward expansion of mangroves is a threshold response to decreased frequency of extreme cold events. *Proceedings of the National Academy of Sciences* 111(2):723-727

Cavanaugh K.C, Kellner J.R., Cook-Patton S., Feller I.C., Williams A.P., Parker J.D. (2015) Integrating physiological threshold experiments with climate modeling to project mangrove species' range expansion. *Global Change Biology* 21(5), 1928-2938

Leslie, H. M., Basurto, X., Nenadovic, M., Sievanen, L., **Cavanaugh, K. C.**, Cota-Nieto, J. J., ... & Aburto-Oropeza, O. (2015). Operationalizing the social-ecological systems framework to assess sustainability. *Proceedings of the National Academy of Sciences*, *112*(19), 5979-5984.

Biographical Sketch: Dr. Laura Trouille

Director of Citizen Science at the Adler Planetarium, Co-lead for Zooniverse
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A. PROFESSIONAL PREPARATION

College/University	Major	Degree &Year
Dartmouth College	Physics, Summa Cum Laude	B.A., 2003
UW – Madison	Astronomy	Ph.D., 2010

B. ACADEMIC/PROFESSIONAL APPOINTMENTS

Director of Citizen Science at the Adler Planetarium and co-lead for Zooniverse, 2015+
NU CIERA Postdoctoral Fellow and Astronomer at the Adler Planetarium (joint appointment), 2013-2015
CIERA Postdoctoral Fellow, Northwestern University, 2010-2013
Astronomy Adjunct Faculty, Chicago State University, Spring 2011
Research Assistant, UW-Madison, Ph.D. Thesis Advisor: Dr. A. Barger, 2004-2010
National Science Foundation Graduate Research Fellow, UW-Madison, 2006-2009
CIRTL DELTA Education Research Intern, UW-Madison, 2009-2010
NASA International Year of Astronomy Outreach Ambassador, 2009
Instructor for Undergraduate Intro to Astronomy, UW-Madison, 2007
Computer & ESL Secondary School Teacher, Czech Republic & India, 2003-2004
Research Assistant (Senior Thesis), SwRI, Advisor: Dr. E. Young, 2002-2003
Research Assistant, L'Observatoire de Paris, Advisor: Dr. J. P. Zahn, 2002

C. Relevant Experience

Co-lead for Zooniverse. In close collaboration with the Zooniverse team at the University of Oxford and the wider Citizen Science Alliance, Dr. Trouille leads the Adler Zooniverse team of 14 staff, including 6 web developers, a designer, a data scientist, and 6 educators. Zooniverse drives over 40 active people-powered research projects, with 1.5 million registered users around the world making over 100,000 classifications each day. Zooniverse projects have led to over 100 published papers, plus nearly 2,000 papers citing Zooniverse data. Content spans astronomy through zoology, July 2015-present

D. Relevant Research Products

1. Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. Defining Computational Thinking for Mathematics and Science Classrooms. Journal of Science Education and Technology, 1-21, 2015
2. Weintrop, D., Orton, K., Horn, M.S., Beheshti, E., Trouille, L., Jona, K., & Wilensky, U., Computational Thinking in the Science Classroom. National Science Teachers Association (NSTA). Nashville, TN. 2016
3. Trouille, L., Coble, K., Cochran, G., Camarillo, C., Bailey, J., Cominsky. L. Investigating Student Ideas About Cosmology III: Big Bang Theory, Expansion, Age, and History of the Universe, Astronomy Education Review, 12, 1, 2013
4. Weintrop, D., Beheshti, E., Horn, M.S., Orton, K., Trouille, L., Jona, K., & Wilensky, U. Interactive Assessment Tools for Computational Thinking in High School STEM Classrooms. INTETAIN 2014, Springer International Publishing, 22-25, 2014
5. Hainline, K., Hickox, R. DiPompeo, M, & Trouille, L. A Spectroscopic Survey of WISE-selected Obscured Quasars with the Southern African Large Telescope, ApJ, 795, 124, 2014
6. Trouille, L., Barger, A. J., & Tremonti, C. The OPTX Project V: Identifying AGNs, ApJ, 742, 46. 2011
7. Farr, B., Mathias, G., & Trouille, L., Gravitational Wave Science in the High School Classroom, American Journal of Physics, 80, 10, 898, 2012

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PROFESSIONAL PREPARATION:

Undergraduate: University of California, Santa Barbara, Santa Barbara, CA, Biology, B.A., 2003.
Graduate: Stanford University, Stanford, CA, Biological Sciences, Ph.D., 2011.
Postdoctoral: West Coast Governors Alliance on Ocean Health Sea Grant Fellow, 2011-2013; University of Massachusetts Boston, Boston, MA, community ecology of kelp forests, 2013-2015.

APPOINTMENTS:

Assistant Professor, California State University Monterey Bay, 2015-present.

SELECTED PUBLICATIONS:

Haupt, AJ, B Woodson, F Micheli, SR Palumbi. *In Review.* Marine Biology. Subtle genetic structure translates to limited ecological connectivity in a commercially fished species.

Samhouri, JF, AJ Haupt, PS Levin, JS Link, R Shufford. 2013. Lessons learned from developing integrated ecosystem assessments to inform marine ecosystem-based management in the USA. ICES Journal of Marine Science 71:1205-1215.

Haupt, AJ. 2013. Ocean acidification as a West Coast Governors Alliance on Ocean Health priority area. Technical Report for WCGA.

Haupt, AJ, F Micheli, and SR Palumbi. 2013. Dispersal at a snail's pace: historical processes affect contemporary genetic structure in an exploited marine snail. Journal of Heredity 104:327-340.

Iles, AC, TC Gouhier, BA Menge, JS Stewart, AJ Haupt, MC Lynch. 2011. Climate-driven trends and ecological implications of event-scale upwelling in the California Current System. Global Change Biology 18:783-796.

Woodson, B, JA Barth, OM Cheriton, MA McManus, JP Ryan, L Washburn, KN Carden, BS Cheng, J. Fernandez, LE Garske, TC Gouhier, **AJ Haupt**, KT Honey, MF Hubbard, A Illes, L. Kara, MC Lynch, B Mahoney, M. Pfaff, ML Pinsky, MJ Robert, JS Stewart, SJ Teck, A True. Observations of internal wave packets propagating along-shelf in northern Monterey Bay. 2011. Geophysical Research Letters. 38

Micheli, F, AO Shelton, SM Bushinsky, AL Chiu, AJ Haupt, KW Heiman, CV Kappel, MC Lynch, RG Martone, and J Watanabe. 2008. Persistence and recovery of depleted marine invertebrates in marine reserves of Central California. Biological Conservation. 141:1078-1090.

Logan, CA, SE Alter, **AJ Haupt,** K Tomalty and SR Palumbi. 2008. An impediment to consumer choice: overfished species are sold as Pacific red snapper. Biological Conservation. 141:1591-1599.

Current and Pending Support
Dr. Jarrett Byrnes

Current

Project/Proposal Title: Feedbacks between coastal New England kelp beds and wave disturbance.
PI: Dr. Jarrett Byrnes
Source: MIT SeaGrant #NA140AR4170077.
Amount: $124,181.
Total Award Period Covered: 02/01/15 - 01/31/17
Person-Months Per Year Committed to Project: 0.25

Project/Proposal Title: Food web structure as a driver of multiple ecosystem functions.
PI: Dr. Jarrett Byrnes
Source: MIT SeaGrant #5710003602 (Prime NA14OAR4170077)
Amount: $154,835
Total Award Period Covered: 02/01/14 - 01/31/17
Person-Months Per Year Committed to Project: 0.1

Project/Proposal Title: Evaluating the relationship between kelp forest ecosystems and water temperature in the Southern Gulf of Maine.
PI: Dr. Jarrett Byrnes
Source: WHOI Sea Grant Amount: $99,186
Person-Months Per Year Committed to Project: 0.25
Total Award Period Covered: 02/01/16 - 01/31/18

Project/Proposal Title: LTER-Plum Island Ecosystems: Dynamics of Coastal ecosystems in a region of rapid climate change, sea-level rise, and human impacts.
PI: Dr. Anne Giblin
Source: National Science Foundation
Subaward to UMB Amount: $359,888
Total Award Period Covered: 10/1/16 - 9/30/22
Person-Months Per Year Committed to Project: 0.1

Pending

Project/Proposal Title: Detecting thirty years of change in global kelp forests via remote sensing and citizen science.
PI: Dr. Jarrett Byrnes
Source: NASA
Amount $910,628, $272,578 to PI
Period Covered: 10/1/16-6/30/20
Person-Months Per Year Committed to Project: 0.5

CURRENT/PENDING SUPPORT

Dr. Kyle Cavanaugh

Current

Title: Using HyspIRI to Identify Benthic Composition and Bleaching in Shallow Coral Reef Ecosystems
PI: Dr. Kyle Cavanaugh
Agency: NASA
Agency Contact: Woody Turner, 202-358-1662, woody.turner@nasa.gov
Award Period: August 2015 – August 2017
Person-Months Per Year Committed to the Project: 1.0

Title: Integrating physiological threshold experiments, remote sensing, and climate modeling to characterize the sensitivity of coastal ecosystems to climate change
PI: Dr. Kyle Cavanaugh
Agency: NASA
Agency Contact: Ming-Ying Wei, 202-358-0771, mwei@nasa.gov
Award Period: April 2016 – March 2019
Person-Months Per Year Committed to the Project: 1.0

Pending

Title: Assessing the response of global kelp ecosystems to climate change
PI: Dr. Kyle Cavanaugh
Agency: NASA
Agency Contact: Paula Bontempi, 202-358-1508, paula.bontempi@nasa.gov
Award Period: July 2016 – June 2019
Person-Months Per Year Committed to the Project: 1.0

Title: Historical Trends in the Distributions of Seagrasses and Mangroves Along California-Baja California Coastal Lagoons
PI: Dr. Kyle Cavanaugh
Agency: University of California MEXUS
Agency Contact: Andrea Kaus, 951-827-3586, andrea.kaus@ucr.edu
Award Period: July 2016 – December 2017
Person-Months Per Year Committed to the Project: 0.5

Title: Macroclimatic Controls of Blue Carbon in Coastal Wetlands – Thresholds, Regime Shifts, and Climate Change
PI: Dr. Michael Osland
Agency: NASA/USGS
Agency Contact: Paula Bontempi, 202-358-1508, paula.bontempi@nasa.gov
Award Period: January 2017 – December 2019
Person-Months Per Year Committed to the Project: 1.0

Title: Will coastal wetlands in southern California keep pace with sea level rise? A remote sensing approach to inform vegetation biological feedback
PI: Dr. Kyle Cavanaugh
Agency: California Sea Grant
Agency Contact: Kim Eckman, 858-534-4440, sgproposal@ucsd.edu
Award Period: Febuary 2017 – January 2018
Person-Months Per Year Committed to the Project: 1.0

Current and Pending Support
DR. LAURA TROUILLE
Director of Citizen Science, Adler Planetarium

CURRENT SUPPORT

Title: SOCS: Collaborative Research: Focusing Attention to Improve the Performance of Citizen Science Systems: Beautiful Images and Perceptive Observers
Type: Federal Award
Program/Sponsoring Agency: IIS Social Computational Systems/NSF
Agency Point of Contact: Ephraim Glinert, 703-292-8930, eglinert@nsf.gov
Adler PI: Laura Trouille
Performance Start: 7/1/12 **Performance End:** 8/31/17
Award Amount: $395,902 **Adler PI Amount:** $0
Cal-Months: 0.0

Title: Zooniverse: Live Science Development
Type: Corporate Subaward
Program/Sponsoring Agency: Google Impact Awards**,** Google Foundation
Lead Organization/Point of Contact: University of Oxford/Chris Lintott, 1865 (2) 73638, cjl@astro.ox.ac.uk
Adler PI: Laura Trouille
Performance Start: 10/1/13 **Performance End:** 9/30/16
Adler Award Amount: $449,569 **Adler PI Amount:** $23,726
Cal-Months: 1.2/year

Title: Asteroid Zoo
Type: Corporate Agreement
Program/Sponsoring Agency: Planetary Resource, Inc.
Agency Point of Contact: Chris Lewicki, chris@planetaryresources.com
Adler PI: Laura Trouille
Performance Start: 12/6/13 **Performance End:** 12/5/16
Award Amount: $60,000 **Adler PI Amount:** $0
Cal-Months: 0.0

Title: REU Site: Preparing a Diverse Workforce through Interdisciplinary Astrophysics Research
Type: Federal Subaward
Program/Sponsoring Agency: Research Experiences for Undergraduates/NSF
Lead Organization/Point of Contact: Northwestern University/Vicky Kalogera, (847) 491-5669, vicky@northwesern.edu
Adler PI: Laura Trouille
Performance Start: 2/1/14 **Performance End:** 1/31/17
Adler Award Amount: $0 **Adler PI Amount:** $0
Cal-Months: 0.0

Title: Pathways: Using Citizen Science to Study the Social Behavior of a Charismatic Rare Bat Species at Mammoth Caves National Park
Type: Federal Subaward
Program/Sponsoring Agency: Advancing Informal STEM Learning (AISL)/NSF

Lead Organization/Point of Contact: Western Kentucky University Research Foundation/Shannon Trimboli, 270-758-2422, shannon.trimboli@wku.edu
Adler PI: Laura Trouille
Performance Start: 4/10/14 **Performance End:** 8/31/17
Adler Award Amount: $36,458 **Adler PI Budget:** $0
Cal-Months: 0.0

Title: Bringing Wildlife Management into Focus: Integrating Camera Traps, Remote Sensing and Citizen Science to Improve Population Modeling
Type: Supplemental Funding, Federal Subaward
Program/Sponsoring Agency: ROSES 2012 Earth Science Applications: Ecological Forecasting for Conservation and Natural Resources Management/NASA
Lead Organization/Point of Contact: University of Wisconsin/Phil Townsend, 608-622-7445, ptownsend@wisc.edu
Adler PI: Laura Trouille
Performance Start: 1/6/15 **Performance End:** 1/5/17 (1/5/18 exp)
Adler Award Amount: $76,571 ($139,821 exp) **Adler PI Budget:** $6,480
Cal-Months: 0.28 Year 2, 0.14 Year 3, 0.09 Year 4

Title: Disk Detective: Finding Circumstellar Disks with WISE and 100,000 New Colleagues
Type: Federal Award
Program/Sponsoring Agency: Astrophysics Data Analysis Program (ADAP)/NASA
Lead Organization/Point of Contact: Goddard Space Flight Center/Marc J. Kuchner, 301-286-5165, marc.kuchner@nasa.gov
Adler PI: Laura Trouille
Performance Start: 7/1/15 **Performance End:** 6/30/17
Adler Award Amount: $82,466 **Adler PI Budget:** $0
Cal-Months: 0.0

Title: Collaborative Research: ABI Development: Notes from Nature: Advancing a Next Generation Citizen Science Platform for Biocollection Transcription
Type: Federal Subaward
Program/Sponsoring Agency: Advancing Digitization of Biodiversity Collections/NSF
Lead Organization/Point of Contact: University of Florida/Florida Museum of Natural History /Robert Guralnick, 352-273-1980, rguralnick@flmnh.ufl.edu
Adler PI: Laura Trouille
Performance Start: 7/15/15 **Performance End:** 6/30/18
Adler Award Amount: $145,561 **Adler PI Budget:** $1,835
Cal-Months: 0.05/year

Title: Broadening Participation in a Computational Future: Casting a wide net
Type: Foundation Subaward
Program/Sponsoring Agency: Lyle Spencer Research Awards/The Spencer Foundation
Lead Organization/Point of Contact: Northwestern University/Michael Horn, 617-803-5501, michael-horn@northwestern.edu
Adler PI: Laura Trouille
Performance Start: 8/1/15 **Performance End:** 7/31/18
Adler Award Amount: $0 **Adler PI Budget:** $0
Cal-Months: 0.0

Title: ADBC Proposal: Digitization TCN: Collaborative Research: The Key to the Cabinets: Building and sustaining a research database for a global biodiversity hotspot
Type: Federal Subcontract
Program/Sponsoring Agency: Advancing Digitization of Biodiversity Collections/NSF
Lead Organization/Point of Contact: Appalachian State University/Zack Murrell, 828-262-2674, murrellze@appstate.edu
Adler PI: Laura Trouille
Performance Start: 8/15/15 **Performance End:** 7/31/16
Adler Award Amount: $20,000 **Adler PI Budget:** $0
Cal-Months: 0.0/year

Title: Collaborative Research: Engaging Introductory Astronomy Students in Authentic Research through Citizen Science
Type: Federal Award
Program/Sponsoring Agency: Improving Undergraduate STEM Education (IUSE: EHR)/NSF
Agency Point of Contact: Miles G. Boylan, 703-292-4617, mboylan@nsf.gov
Adler PI: Laura Trouille
Performance Start: 10/1/15 **Performance End:** 9/30/18
Adler Award Amount: $137,513 **Adler PI Budget:** $7,656
Cal-Months: 0.2/year

Title: Collaborative Research: Engaging Introductory Astronomy Students in Authentic Research through Citizen Science
Type: Federal Subaward
Program/Sponsoring Agency: Improving Undergraduate STEM Education (IUSE: EHR)/NSF
Lead Organization/Point of Contact: Northwestern University/ David M. Meyer, 847-491-4516, davemeyer@northwestern.edu
Adler PI: Laura Trouille
Performance Start: 10/1/15 **Performance End:** 9/30/16 (9/30/18 exp.)
Adler Award Amount: $139,730 **Adler PI Budget:** $0
Cal-Months: 0.0/year

Title: INSPIRE: GlitchZoo: Teaming Citizen Science with Machine Learning to Deepen LIGO's View of the Cosmos
Type: Federal Subaward
Program/Sponsoring Agency: INSPIRE/NSF
Lead Organization/Point of Contact: Northwestern University/Vicky Kalogera, (847) 491-5669, vicky@northwesern.edu
Adler PI: Laura Trouille
Performance Start: 10/1/15 **Performance End:** 9/30/16 (9/30/18 exp.)
Adler Award Amount: $195,819 **Adler PI Budget**: $8,600
Cal-Months: 0.2/year

Title: The ADS All Sky Survey
Type: Federal Subaward
Program/Sponsoring Agency: Astrophysics Data Analysis Program (ADAP)/NASA
Lead Organization/Point of Contact: Harvard College Observatory/Alyssa Goodman, 617-495-9278, agoodman@cfaharvard.edu
Adler PI: Laura Trouille
Performance Start: 10/1/15 **Performance End:** 1/17/17
Adler Award Amount: $42,015 **Adler PI Budget:** $ 0

Cal-Months: 0.0

Title: CHS: Small: Collaborative Research: Optimizing Human-Machine Systems for Citizen Science
Type: Federal Award
Program/Sponsoring Agency: Information and Intelligent Systems (IIS): Core Programs/NSF
Agency Point of Contact: William S. Bainbridge, Cyber-Human Systems, (703) 292-8930, wbainbri@nsf.gov
Adler PI: Laura Trouille
Performance Start: 7/1/16 **Performance End:** 6/30/18
Adler Award Amount: $139,914 **Adler PI Budget:** $0
Cal-Months: 0.0

PENDING SUPPORT

Title: Science Learning+: Leveraging Citizen Science for Informal Science Learning
Type: Federal Award
Program/Sponsoring Agency: Science Learning+ Partnership Grants/NSF
Lead Organization: Adler Planetarium
Adler PI: Laura Trouille
Performance Start: 3/1/17 **Performance End:** 2/28/22
Award Amount: $1,465,420 **Adler PI Budget:** $6,084
Cal-Months: 0.5

Title: Transforming Libraries and Archives Through Crowd Sourcing
Type: Federal Award
Program/Sponsoring Agency: National Leadership Grants for Libraries/IMLS
Agency Point of Contact: Trevor Owens, 202-653-4654, tjowens@imls.gov
Adler PI: Laura Trouille
Performance Start: 9/1/16 **Performance End:** 8/31/19
Adler Award Amount: $1,275,124 **Adler PI Budget:** $25,152
Cal-Months: 0.6/year

Dr. Alison Haupt
Current and Pending Support

Pending

Project / Proposal Title: Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery (this proposal)
Investigator: Alison Haupt
Source of Support : University of Massachusetts Boston, NASA
Total Award Amount: $69,599
Total Award Period: October 1, 2016 to June 30, 2020
Location of Project: Monterey Bay
Person-Months Per Year Committed to the Project: 1.0 month of summer

Project / Proposal Title: Research Based Interventions to Increase STEM Degree Attainment
Investigator: Alison Haupt
Source of Support: US Department of Education
Total Award Amount: $5,622,465
Total Award Period: October 1, 2016 to September 30, 2021
Location of Project: Monterey Bay
Person-Months Per Year Committed to the Project: .067 AY and .37 Summer

PI: Byrnes
UMB Budget Narrative and Justification

"Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery"

Overview
The following is a narrative description and justification for the grant to PI Byrnes. Justifications and narratives for the Co-Investigator subawardees/subcontractors to follow.

Senior Personnel
PI Byrnes requests half a month of summer salary in the prototype phase and years one through three of the implementation phase.

Other Personnel
PIs Byrnes requests salary to support a Graduate Student Researcher (GSR), Isaac Rosenthal, at 50% time during the fall and winter semester of the prototype phase and then for 12 months of support during year one through three of the implementation phase. Standard graduate student salary at UMB is $10,500 for four months.

Fringe Benefits
Our University fringe benefit rate is 31.01% and is negotiated between Commonwealth of Massachusetts and DHHS. Fringe is calculated at 1.84% for PI Byrnes, 1.65% for the graduate student, and is only relevant for summer salary.

Travel (Domestic)

Prototype Phase
We have budgeted $2491 for PI Byrnes and a graduate student to travel to an all-hands team meeting in Chicago. Flight costs are estimated at $1000 for both, lodging at $1000, and food costs at standard UMB per diem rates at $491.

Year 1-3
We have budgeted $2000 for PI Byrnes and graduate student to travel to an all-hands team meeting in Chicago or Los Angeles. Flight costs are estimated at $1000, lodging at $1000, and food costs at standard UMB per diem rates at $491.

We have budgeted $1000 for PI Byrnes to travel to a second team meeting in Monterey, California. Flight costs are estimated at $1000 and lodging is covered.

Other Direct Costs

Materials and Supplies
PI Byrnes requests $5,000 for a dedicated computer (including monitor, external storage, and other peripherals) for the graduate student. This computer will have higher than typical memory and hard drive capacity in order to enable the graduate student to

complete the majority of their data processing and geospatial analysis tasks without using the University of Massachusetts High Performance Computing Cluster.

Dissemination and Publication Costs
PI Byrnes plans to disseminate manuscripts on calibration via the open access journal PeerJ. He is a fully paid lifetime member, and can publish 2-3 manuscripts per year at no charge.

Mandatory Health Benefits and Fee Remissions
Health insurance and fee remissions are mandatory for the hiring of graduate student researcher at 25% or greater during the academic term. These fees are exempt from indirect cost.

Indirect Cost (F&A)
F&A Rate of 52.5% is negotiated between DHHS and the University of Massachusetts Boston.

Facilities, Equipment and Other Resources - UMass Boston

UMB Laboratory: On the UMB campus, students will be housed in the PI's fully equipped research laboratory in the new UMB Integrated Sciences Complex. The lab is fully supplied with multiple Apple computers, a fume hood for sample processing, and sample freezer, a full range of shop tools, dissecting scopes, and other equipment for lab work. It includes desks in a write-up space for graduate students and postdocs.

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 University has licenses for all necessary software beyond use of open source tools (i.e., MATLAB, ArcGIS) although open source tools (R, Python) are prefered. The PI will provide computer facilities in his lab for student work. We also have access to a Chimera, a 128 core server for High Performance Computing where necessary and access to the University of Massachusetts High Performance Computing Cluster in Lowell, MA.

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 for any shipping needs.

PI: Kyle Cavanaugh
UCLA BUDGET JUSTIFICATION

"Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery"

Senior Personnel
PI Cavanaugh requests 0.5-month summer salary for each of four years.

Other Personnel
PI Cavanaugh requests salary to support a postdoctoral research associate at %100 time for years 3 and 4 of the project. The postdoc will lead the analysis of the climatic drivers of giant kelp dynamics. This analysis will utilize the data produced by Floating Forests and so the work will be concentrated in the second half of the project's implementation stage.

Fringe Benefits
Fringe benefits are estimated using figures approved by the University of California Systemwide Administration. Academic summer employment is 12.7% and Postdoctoral researcher is 19%.

Equipment
We request $7,000 to purchase a high-end desktop computer. This will be used to process and analyze the global kelp canopy data derived from Floating Forests. This estimate is based on a quote for a system that includes an Intel Xeon 3.5 GHz 12 core CPU with 128 Gb of RAM and 2 Tb of storage space.

Travel (Domestic)
Year 1 (Prototype phase)

We have budgeted $2000 for PI Cavanaugh to travel to an all-hands team meeting in Chicago or Boston. Flight costs are estimated at $500, lodging at $900, and food costs at $600.

Year 2

We have budgeted $2000 for PI Cavanaugh to travel to an all-hands team meeting in Chicago or Boston. Flight costs are estimated at $500, lodging at $900, and food costs at $600.

We have budgeted $1000 for PI Cavanaugh to travel to a second team meeting in Monterey, California. Mileage costs are estimated at $300, lodging at $400, and food costs at $300.

Year 3

We have budgeted $3000 for PI Cavanaugh and postdoc to travel to a national conference to present results from the project. Flight costs are estimated at $400/person, lodging at $700/person, and food costs at $400/person.

Year 4

We have budgeted $3000 for PI Cavanaugh and postdoc to travel to a national conference to present results from the project. Flight costs are estimated at $400/person, lodging at $700/person, and food costs at $400/person.

Other Direct Costs

Dissemination and Publication Costs

Page charges for one publication in an open-access journal ($1,500) for each of the final two years of the project.

Technology Infrastructure Fee

The Technology Infrastructure Fee (TIF) is a consistently-applied direct charge that is assessed to each and every campus activity unit, regardless of funding source, including units identified as individual grant and contract awards. The TIF pays for campus communication services on the basis of a monthly accounting of actual usage data. These costs are charged as direct costs and are not recovered as indirect costs. The charge is $33.28/FTE.

Indirect Cost (F&A)

On April 27, 2011, the University of California and the United States Department of Health and Human Services (the responsible Federal audit agency) entered into a new facilities and administrative (F+A) cost rate agreement for the Los Angeles campus. This agreement establishes facilities and administrative cost rates for the period of July 1, 2010, through June 30, 2016. The on-campus Research rate currently in effect is 54%. Indirect Costs are calculated at 54% of Modified Total Direct Costs (total costs – minus student tuition fees, equipment, fabrication costs, subcontracts and participant supports costs.). See: http://www.research.ucla.edu/ocga/sr2/idcinfo.htm#FA1

FACILITIES, SOFTWARE, AND EQUIPMENT – UCLA

The UCLA Department of Geography is well equipped to perform the necessary data analysis tasks described in the proposal. PI Cavanaugh has access to a 100TB data storage server, which will be used to store and manage datasets produced by this project. The PIs also have access to high-end personal computers (PC and Mac) and a high performance scientific computing cluster that can be used to perform the simulation analyses described here. UCLA has access to a variety of satellite imagery analysis, GIS, and scientific computing software including ArcGIS 10, ENVI/IDL 5.0, MODTRAN, and Matlab.

Adler Planetarium
Budget Justification Narrative:

A. Direct Labor– Key Personnel: NONE
PI Laura Trouille will oversee the project, but requests no salary support.

B. Direct Labor – Other Personnel:
Front End Developer commits the following level of effort per year.
Year 1 – 2%, Year 2 – 80%, Year 3 – 50%, Year 4 – 4%
Back End Developer commits the following level of effort per year.
Year 1 – 8%, Year 2 – 50%, Year 3 – 0%, Year 4 – 0%
Designer commits the following level of effort per year.
Year 1 – 0%, Year 2 – 38%, Year 3 – 4%, Year 4 – 4%
All salaries include a 3% annual increase.

C. Direct Costs – Equipment: NONE

D. Direct Costs – Travel: NONE

E. Direct Costs – Participant/Trainee Support Costs: NONE

F. Other Direct Costs:
1. Materials and Supplies: *None*
2. Publication Costs: *None*
3. Consultant Services: *None*
4. ADP/Computer Services:
Funds are requested to cover webhosting charges for the citizen science project. Cost estimates are based on hosting of a typical citizen science project during the prototype phase at an average rate of $1,500 per year and the full implementation phase at an average rate of $3,000 per year.
5. Subawards/Consortium/Contractual Costs: *None*
6. Equipment or Facility Rental/User Fees: *None*
7. Alterations and Renovations: *None*
8. Other: *None*

H. Indirect Costs:
Adler has a federally negotiated indirect cost rate. See cover page budget and Total Budget for details.

I. Total Direct and Indirect Costs:
The total cost of the award is given in the cover page budget and is included in the separately uploaded Total Budget pdf file per solicitation instructions.

J. Fee: NONE

Facilities and Equipment:

Zooniverse within the Adler Planetarium

The Adler Citizen Science department, alongside the Zooniverse team at the University of Oxford, supports the web development and education efforts for the collection of online citizen science projects known as the Zooniverse (zooniverse.org). Working in collaboration with science teams across the world, with volunteers in almost every country, the team takes large data sets that cannot be adequately analyzed by computers and puts them online. Volunteers are asked to perform simple tasks, such as counting, identification or measurement and the resulting data is fed back to science teams who use it to further their research. As well as performing a simple analysis task on behalf of the science teams, volunteers can participate in discussions with other volunteers and scientist (e.g. talk.galaxyzoo.org) or even undertake their own research (tools.zooniverse.org).

The Adler is located at 1300 S. Lake Shore Drive in Chicago. It is both a planetarium and a space science museum covering ~90,000 square feet. Within the building are the museums' exhibition galleries, collections, and all staff, including Facilities, Planning, and Operations; Human Resources; Financial; Visitor Experience (which includes Exhibits and Education); Marketing, Advancement, Astronomy, History/Collections, and Citizen Science (which includes Zooniverse and teen programs). The facility also houses museum stores, cafes, classrooms, planetarium, auditoriums, and lobbies.

The Adler Zooniverse project personnel have access to the necessary computing equipment, office space, Internet access, programming and design software, webhosting and server space necessary for this project. The Adler provides the required cloud server space to store and manage the data and to perform the computational tasks.

Administrative assistance is available to Adler project personnel to aid in grant management, as well as travel planning.

Budget Justification Details:
(see following spreadsheet)
YEAR 1-4 (12/1/16 – 6/30/20)

1. Direct Labor

A.	Direct Labor – Key Personnel:	Not listed here
B.	Direct Labor – Other Personnel:	Not listed here
Total Direct Labor Costs (A+B):		Not listed here

Salaries and fringe benefits not included here per solicitation guidelines. See Total Budget for details.

2. Other Direct Costs

C.	Direct Costs – Equipment:	None
D.	Direct Costs – Travel:	None
E.	Direct Costs – Participant/Trainee Support Costs:	None

Budget Narrative, Facilities & Equipment, Budget Details

F. Other Direct Costs:

1. Materials and Supplies:	None
2. Publication Costs:	None
3. Consultant Services:	None
4. ADP/Computer Services:	$10,500
Year 1 – prototype project = $1,500	
Year 2 – implementation project = $3,000	
Year 3 – implementation project = $3,000	
Year 4 – implementation project = $3,000	
Total = $10,500	
5. Subawards/Consortium/Contractual Costs:	None
6. Equipment or Facility Rental/User Fees:	None
7. Alterations and Renovations:	None
8. Other:	None

G. Total Direct Costs (A+B+C+D+E+F): Not listed here

3. Facilities and Administrative (F&A) Costs:

H. Indirect Costs: Not listed here

I. Total Direct and Indirect Costs (G+H): Not listed here

Indirect Costs and Total Costs are not included here per solicitation guidelines. See Total Budget for details.

4. Other Applicable Costs

J. Fee: None

5. Subtotal-Estimated Costs (YEAR 1)

K. Total Cost (I+J): Not listed here

The total cost of Year 4 is given in the Total Budget pdf file per solicitation instructions.

6. Total Estimated Costs (YEARS 1-4) Not listed here

The total cost of the project is given in the Total Budget pdf file per solicitation instructions.

University Corporation at Monterey Bay
On behalf of California State University, Monterey Bay

Budget Justification

Personnel:

PI Haupt (1 summer months) will work with educational partners to create curricula for K-12 and college students. Dr Haupt will also analyze data collected through the Zooniverse *Floating Forests* project to investigate the effects of urban environments on kelp forests and incorporate *Floating Forests* research into undergraduate courses at California State University, Monterey Bay. Dr. Haupt will also mentor one part-time undergraduate research assistant, sponsored by the CSUMB Undergraduate Research Opportunities Center who will be responsible for assisting with data analysis.

Year 1 = $8,691; Year 2 = $8,952; Year 3 = $9,221; Year 4 = $9,497; Total = $36,362

B. Fringe Benefits:

The University Corporation charges actual benefit rates which vary by individual. The benefits for summer work includes FICA, Medicare, SUI and Workers' Compensation. Fringe benefits are estimated at current average benefit rate of 9.1%; the grant will be charged at the rate in effect at the time the salary is charged.

Year 1 = $791; Year 2 = $815; Year 3 = $839; Year 4 = $864; Total = $3,309

C. Travel:
Year 1(prototype phase)
We have budgeted $2000 for PI Haupt to travel to an all-hands team meeting in Chicago or Boston. Flight costs are estimated at $500, lodging at $900, and food costs $600.
Year 2
We have budgeted $2000 for PI Haupt to travel to an all-hands team meeting in Chicago or Boston. Flight costs are estimated at $500, lodging at $900, and food costs $600.
We have budgeted $1000 for PI Haupt to travel to a second team meeting in Los Angeles. Mileage costs $300, lodging $400, and food $300.
Year 3
We have budgeted $1500 for PI Haupt to travel to a national conference to present results from the project. Flight costs are estimated to be $400, lodging $700, and food $400.
Year 4
We have budgeted $1500 for PI Haupt to travel to a national conference to present results from the project. Flight costs are estimated to be $400, lodging $700, and food $400.

Year 1 = $2,000; Year 2 = $3,000; Year 3 = $1,500; Year 4 = $1,500; Total = $8,000

D. Total Direct Costs:

Year 1 = $11,482; Year 2= $12,767; Year 3 = $11,560; Year 4 = $11,862; Total = $47,671

E. Indirect Costs:

The federally negotiated indirect cost rate for the University Corporation at Monterey Bay is

46% Modified Total Direct Costs (MTDC). This is a predetermined rate through 6/30/16 and provisional though 6/30/2017. The cognizant agency for the campus is the U.S. Department of Health & Human Services.

Year 1 = $5,282; Year 2 = $5,873; Year 3 = $5,318; Year 4 = $5,456; Total = $21,929

F. Total Amount of this Request: $69,599

Facilities, Equipment and Other Resources - CSUMB

Dr. Alison Haupt

CSUMB Laboratory: PI Haupt is a new faculty member who received startup support to establish a research program. The shared lab space is equipped with lab bench space, fume hood, chemical storage space, and desk space for students. In progress or recently completed lab purchases include 2 Leica Stereomicroscopes with light sources with 1 Leica HD camera attachment; Leica S8 APO Series Microscope (B-Stand Package); Garmin GPS; Canon Digital Rebel T3i + Backscatter Sea & Sea RDX-600D underwater housing, and 10 Onset temperature loggers.

CSUMB Computer: Computing facilities are available to CSUMB students and technicians for use in data entry, word processing, and data analysis (R, MATLAB). The PIs also have licenses for all software necessary to analyze (MATLAB) and display data (Excel, Matlab) and write manuscripts (MS Office).

CSUMB Office Support: All PIs offices are equipped with a Macintosh desktop computer with Microsoft software, and have access to shared printers, copiers, and other supplies

CSUMB Shared Lab Space: The Chapman Science Center contains faculty office space, teaching and research labs, student and administrative workspace that will be utilized for mentoring and research activities. The eight laboratory classrooms hold at least 24 students, some up to 40. Carts with 24 wireless Apple Mac Powerbook laptops or 24 wireless Hewlett-Packard PC laptops are used to convert classrooms to computer labs. Two to three additional computer work stations are permanently situated in each laboratory classroom for student use. The teaching labs are fully equipped, including a geology laboratory, a physics laboratory, three biology laboratories, two chemistry laboratories, and one organic chemistry laboratory. The instructional laboratory equipment includes microscopes, centrifuges, power supplies, gel boxes, pcr machines, spectrophotometers, digital cameras, and much else. Venier LabPro Software and Technology is utilized in the general chemistry laboratories to provide students hands on experience with the most recent technologies.

CSUMB Undergraduate Support: Undergraduate Research Opportunities Center (UROC) – is a cross-campus center that trains, supports, and engages students in undergraduate research. UROC students work on relevant and innovative research projects at CSU Monterey Bay and at regional research institutions. Their work is guided by a research mentor and is supported by extensive training in research proposal writing, presentation skills, communication skills, professionalism, and graduate school preparedness. Students are also given the opportunity to communicate their work to the academic community through presentations and publications. UROC will collaborate on the recruitment, selection, and training of student research assistants.

PI Byrnes Budget Detail

Period of Performance: October 1, 2016 to June 30, 2020					
Budget Period:	**Year 1**	**Year 2**	**Year 3**	**Year 4**	
Start Date:	10/1/16	7/1/17	7/1/18	6/30/19	
End Date:	6/30/17	6/30/18	6/30/19	7/1/20	**Total**
A. Senior/Key Personnel	$4,363.00	$4,494.00	$4,629.00	$4,768.00	$18,254.00
PI Byrnes, 0.5 mo summer					
B. Other Personnel					
Graduate Student - Isaac Rosenthal	$21,000.00	$31,500.00	$31,500.00	$31,500.00	$115,500.00
Fringe Benefits					
Faculty (1.84%)	$80.00	$83.00	$85.00	$88.00	$336.00
Graduate Student(1.65%)	$348.00	$173.00	$173.00	$173.00	$867.00
Total Fringe Benefits	$428.00	$256.00	$258.00	$261.00	$1,203.00
Total Salaries & Fringe Benefits	**$25,791.00**	**$36,250.00**	**$36,387.00**	**$36,529.00**	**$134,957.00**
C. Equipment Description	$0.00	$0.00	$0.00	$0.00	$0.00
D. Travel	$2,491.00	$3,491.00	$3,491.00	$3,491.00	
Travel for PI & Grad Student to Chicago/LA Team Meeting	$1,000.00	$1,000.00	$1,000.00	$1,000.00	
Hotel for GS & PI in Chicago/LA	$1,000.00	$1,000.00	$1,000.00	$1,000.00	
Per Diem for GS & PI in Chicago/LA	$491.00	$491.00	$491.00	$491.00	
Travel for PI to Monterey Team Meeting		$1,000.00	$1,000.00	$1,000.00	
Total Travel	$2,491.00	$3,491.00	$3,491.00	$3,491.00	$12,964.00
E. Participant/Trainee Support Costs					
F. Other Direct Costs					
Materials and Supplies					
Computer and peripherals for graduate student	$5,000.00				$5,000.00
Subcontractors/Subawardees (see additional budget details)	$43,445.00	$235,857.00	$204,281.00	$154,467.00	$638,050.00
Total Other Direct Costs	$48,445.00	$235,857.00	$204,281.00	$154,467.00	$643,050.00
Total Direct Costs (A through F)	**$76,727.00**	**$275,598.00**	**$244,159.00**	**$194,486.00**	**$790,970.00**
MTDC (Base Rate for Indirect Cost calculation)	**$76,727.00**	**$71,296.00**	**$39,878.00**	**$40,019.00**	**$227,920.00**
Indirect Costs at 52.5%	$40,281.00	$37,430.00	$20,936.00	$21,011.00	$119,658.00
Total Direct and Indirect Costs	**$117,008.00**	**$313,028.00**	**$265,095.00**	**$215,497.00**	**$910,628.00**

Summary Proposal Budget

Principal Investigator: Kyle Cavanaugh

Project Title: Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery

Period of Performance: October 1, 2016 to June 30, 2020

			Year 1 10/1/16-6/30/17	Year 2 7/1/17-6/30/18	Year 3 7/1/18-6/30/19	Year 4 7/1/19-6/30/20	TOTAL
A. Senior/Key Person							
Cavanaugh	PI	0.5/9th	5,596	5,764	6,052	6,355	23,768
Total Senior Personnel:			**5,596**	**5,764**	**6,052**	**6,355**	**23,768**
B. Other Personnel:							
TBN - Postdoc					55,000	56,650	111,650
Total Other Personnel:			**-**	**-**	**55,000**	**56,650**	**111,650**
Fringe Benefits							
Faculty (12.7%)			711	732	769	807	3,019
Postdoc (19%)			-	-	10,450	10,764	21,214
Total Fringe Benefits:			**711**	**732**	**11,219**	**11,571**	**24,232**
Total Salaries & Fringe Benefits:			**6,307**	**6,496**	**72,271**	**74,576**	**159,650**
C. Equipment**			-	-			-
12 core desktop computer				7,000	-		7,000
Total Equipment:			**-**	**7,000**	**-**		**7,000**
D. Travel							
Domestic (incl. Canada, Mexico)			2,000	3,000	3,000	3,000	11,000
Total Travel:			**2,000**	**3,000**	**3,000**	**3,000**	**11,000**
F. Other Direct Costs							
Publication Costs					1,500	1,500	3,000
TIF (Technology Infrastructure Fee)			-	-	418	418	835
Total Other Direct Costs:			**-**	**-**	**1,918**	**1,918**	**3,835**
TOTAL DIRECT COSTS:			**8,307**	**16,496**	**77,189**	**79,493**	**181,486**
MTDC (Base Rate for Indirect Cost calculation)			**8,307**	**9,496**	**77,189**	**79,493**	**174,486**
Indirect Costs @ 54%			**4,486**	**5,128**	**41,682**	**42,926**	**94,222**
TOTAL PROJECT COSTS:			**12,793**	**21,624**	**118,871**	**122,420**	**275,708**

**Equipment - Items with a cost of $5000 or greater is exempt from overhead

NASA ROSES CSESP FF Proposal Budget										
PI Trouille										
Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery										
					YEAR 1	YEAR 2	YEAR 3	YEAR 4	CUMULATIVE	
					10/1/16 - 6/30/17	7/1/17 - 6/30/18	7/1/18 - 6/30/19	7/1/19 - 6/30/20		
A. Direct Labor - Key Personnel	**Unit**	**Calendar Months**	**Salary**						**Total**	**Description**
Laura Trouille Salary	0%	0.0	$ -		$0.00	$0.00	$0.00	$0.00	$0.00	3% annual increase
Laura Trouille Fringe	21%				$0.00	$0.00	$0.00	$0.00	$0.00	
Total Number Key Personnel	**0**		**Subtotal**		**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	
B. Direct Labor - Other Personnel	**Unit**	**Calendar Months**	**Salary**							
Front End Developer Salary	2% 80% 50% 4%	0.25/9.5/6/0.5 months	$ 60,000		$1,250.00	$48,925.00	$31,827.00	$2,731.82	$84,733.82	3% annual increase
Front End Developer Fringe	21%				$262.50	$10,274.25	$6,683.67	$573.68	$17,794.10	
Back End Developer Salary	8% 50% 0% 0%	1/6/0/0 months	$ 60,000		$5,000.00	$30,900.00	$0.00	$0.00	$35,900.00	3% annual increase
Back End Developer Fringe	21%				$1,050.00	$6,489.00	$0.00	$0.00	$7,539.00	
Designer Salary	0% 38% 4% 4%	0/4.5/0.5/0.5 months	$ 60,000		$0.00	$23,175.00	$2,652.25	$2,731.82	$28,559.07	3% annual increase
Designer Fringe	21%				$0.00	$4,866.75	$556.97	$573.68	$5,997.40	
Total Number Other Personnel	**3**		**Subtotal**		**$7,562.50**	**$124,630.00**	**$41,719.89**	**$6,611.00**	**$180,523.39**	
Total Direct Labor Costs (A + B)					**$7,562.50**	**$124,630.00**	**$41,719.89**	**$6,611.00**	**$180,523.39**	
C. Direct Costs - Equipment										
None					$0.00	$0.00	$0.00	$0.00	$0.00	
			Subtotal		**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	
D. Direct Costs - Travel										
Domestic					$0.00	$0.00	$0.00	$0.00	$0.00	
					$0.00	**$0.00**	**$0.00**	**$0.00**	**$0.00**	
Foreign					$0.00	$0.00	$0.00	$0.00	$0.00	
					$0.00	**$0.00**	**$0.00**	**$0.00**	**$0.00**	
			Subtotal		**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	
E. Direct Costs - Participant/Trainee Support Costs										
None					$0.00	$0.00	$0.00	$0.00	$0.00	
Number of Participants/Trainees	**0**		**Subtotal**		**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	
F. Other Direct Costs										
1. Materials and Supplies					$0.00	$0.00	$0.00	$0.00	$0.00	
2. Publication Costs					$0.00	$0.00	$0.00	$0.00	$0.00	
3. Consultant Services					$0.00	$0.00	$0.00	$0.00	$0.00	
4. ADP/Computer Services					$1,500.00	$3,000.00	$3,000.00	$3,000.00	$10,500.00	
5. Subawards/Consortium/Contractual Costs					$0.00	$0.00	$0.00	$0.00	$0.00	
6. Equipment or Facility Rental/User Fees					$0.00	$0.00	$0.00	$0.00	$0.00	
7. Alterations and Renovations					$0.00	$0.00	$0.00	$0.00	$0.00	
8. Other:					$0.00	$0.00	$0.00	$0.00	$0.00	
			Subtotal		**$1,500.00**	**$3,000.00**	**$3,000.00**	**$3,000.00**	**$10,500.00**	
G. Total Direct Costs (A+B+C+D+E+F)					**$9,062.50**	**$127,630.00**	**$44,719.89**	**$9,611.00**	**$191,023.39**	
H. Indirect Costs	**Base**		MTDC		$9,062.50	$127,630.00	$44,719.89	$9,611.00	$191,023.39	
	Rate		53.25%		**$4,825.78**	**$67,962.98**	**$23,813.34**	**$5,117.86**	**$101,719.96**	
I.Total Direct and Indirect Costs (G+H)					**$13,888.28**	**$195,592.98**	**$68,533.24**	**$14,728.85**	**$292,743.35**	
Cognizant Agency:	National Science Foundation									
Negotiator:	Meghan A. Benson, (703) 292-4884									
J. Fee					**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	
K. Total Cost (I+J)					**$13,888.28**	**$195,592.98**	**$68,533.24**	**$14,728.85**	**$292,743.35**	
Project Total					**$13,888.28**	**$195,592.98**	**$68,533.24**	**$14,728.85**	**$292,743.35**	

University Corporation at Monterey Bay

Budget Detail

Dr. Alison Haupt

	Year 1	Year 2	Year 3	Year 4	Total
PERSONNEL					
Alison Haupt: 1 month of summer	$8,691	$8,952	$9,221	$9,497	$36,362
BENEFITS	$791	$815	$839	$864	$3,309
TRAVEL	$2,000	$3,000	$1,500	$1,500	$8,000
TOTAL DIRECT COSTS	$11,482	$12,767	$11,560	$11,862	$47,671
INDIRECT COSTS @ 46% MTDC	$5,282	$5,873	$5,318	$5,456	$21,929
TOTAL COSTS	$16,764	$18,640	$16,877	$17,318	$69,599

NASA ROSES CSESP Floating Forests Statement of Personnel Effort

Using Citizen Science to Understand Thirty Years of Change in Global Kelp Cover by Expanding the Zooniverse to NASA Satellite Imagery

Personnel	**YEAR 1 10/1/16 - 6/30/17**	**YEAR 2 7/1/17 - 6/30/18**	**YEAR 3 7/1/18 - 6/30/19**	**YEAR 4 7/1/19 - 6/30/20**
PI Byrnes	0.5 months	0.5 months	0.5 months	0.5 months
Graduate Student Isaac Rosenthal	12 months at 50% time	12 months at 50% time	12 months at 50% time	12 months at 50% time
PI Trouille	0.5 months	0.5 months	0.5 months	0.5 months
Zooniverse Web Designer		4.5 months	0.5 months	0.5 months
Zooniverse Frontend Developer	1 week	9.5 months	6 months	0.5 months
Zooniverse Backend Developer	1 month	6 months		
PI Cavanaugh	0.5 months	0.5 months	0.5 months	0.5 months
Unnamed Postdoctoral Associate			12 months	12 months
PI Haupt	1 month	1 month	1 month	1 month
Two Undergraduate Interns		10 hrs/week each semester	10 hrs/week each semester	10 hrs/week each semester

Data Management Plan

1. Overview

Our project will generate multiple forms of data in the process of citizen science classification of giant kelp forests. PI Byrnes will coordinate data management. Broadly, code for the Project Builder and derived images from Landsat scenes will be hosted at Zooniverse and mirrors on Amazon web services. Everything is open source and made freely available via GitHub (https://github.com/zooniverse). Data derived from the project will be publically available via Temperate Reefbase (http://temperatereefbase.imas.utas.edu.au/) on a monthly update cycle and mirrored at the NASA Ocean Biology Distributed Active Archive Center (https://earthdata.nasa.gov/about/daacs/daac-obdaac). Code will be freely available via GitHub repositories.

1.1 Project & Science Objectives

Our project seeks to use citizen science efforts to categorize giant kelp forests globally from Landsat imagery for use in scientific investigations. We will use these classifications to build global consensus maps of giant kelp forests over thirty years. Using these maps, we will assess the effect of climate drivers assessed via different NOAA and NASA data products on kelp populations.

2. Project Science Data Generation and Flow

Both the current Ouroboros and future Project Builder platforms begin by downloading Landsat scenes from the US Geological Survey Landsat server. Scenes are cut into smaller images (~131 km^2 per image), color corrected, and checked against coastline shapefiles and for excessive cloudiness. Images failing to meet clarity and coastal criteria are discarded. The remaining subjects are retained and shown to users for classifications. Image metadata is saved in a MongoDB database along with information about user classifications.

Monthly, the Floating Forest team downloads and reprocesses the MongoDB into 1) a simpler flat comma separated value database, 2) a NetCDF raster file with each cell containing the number of users classifying kelp in that cell, and 3) cleaned ESRI Shapefile format of kelp beds based on calibration thresholds of the number of users required to classify a cell as kelp. These three data sources will then be archived for use by project scientists and others.

2.2 Science Operations

The Zooniverse will handle all Landsat data downloading, reprocessing, and recording of image metadata. The Zooniverse will also host the Floating Forests project website and record all user classifications. Project PI Byrnes's lab will handle all data reprocessing and archiving. Co-Investigator Cavanaugh's lab will handle all the acquisition of other environmental data sets

2.3 Project Data and Code Storage and Distribution

All code for the project - both for Project Builder and analysis code - will be made available via GitHub. Zooniverse's code can currently be found at

https://github.com/zooniverse and analysis code is located at https://github.com/jebyrnes/floatingForests. Analysis code can be merged to NASA's GitHub code repository upon the completion of each project analysis.

All images used by the Floating Forests website as well as the database of classifications will be hosted by Zooniverse via Amazon Web Services. Zooniverse provides an API that allows any interested party to read from the data or database directly.

Processed data products – including a cleaned CSV, NetCDF consensus classifications, and quality-controlled shapefile of kelp beds over time will be hosted by the Australia Ocean Data Network's Temperate Reefbase (TRB). After meta-data generation, we will submit the data and metadata to the NASA Ocean Biology Distributed Active Archive Center (OBDAAC) as a secondary mirror in order to ensure data longevity and to ensure that the data becomes part of NASA's public catalogue.

3. Access and Stewardship

3.1 Transition to Science Data Center

Derived data products from Floating Forests classifications will be generated monthly. After establishment of the data pipeline during the prototype phase, data will be archived at TRB. If possible TRB and OBDAAC will be updated on the same cycle. Otherwise, OBDAAC will be updated annually for the lifetime of the project. Code will be archived on GitHub, and analysis code will be archived under NASA's account as requested.

3.2 Directories and Catalogs

Launched in June of 2016, TRB is a joint project of the AODN, the University of Tasmania, the Institute for Marine & Antarctic Studies, and the Kelp Ecosystem Ecology Network (PI Byrnes, Network coordinator) and is supported by the Australian National Data Service. TRB is a public data portal for access to tabular, raster, and other forms of data about temperate rocky reefs. It is supported by AODN funding and is planned to run as a long-term archival solution. TRB is currently exploring membership in Data One (http://dataone.org) so that data catalogs are accessible both via AODN as well as Data One's search engine.

3.3 Standards and Policies for Access

Upon archiving materials at TRB, we will generate metadata for all data products. TRB requires project scientists to generate metadata using the ISO19115 compliant Marine Community Profile 2.0 metadata schema via an intuitive user interface on intitial data creation. Metadata is maintained through data update cycles and can be edited as needed.

All Floating Forests data products and analysis code will be made available under a Creative Commons attribution required license. Data will be made freely available upon upload to TRB, and users will be requested to cite either the data product of subsequent first publications by the science team using the data set as a reference. All Zooniverse code is publically accessible under their own license which is available at https://www.zooniverse.org/privacy?lang=en.

3.4 Associated Archive Products

Associated code for Floating Forests and analysis products will all be available via GitHub. Analysis code can be forked and archived by NASA as requested.

FLOATING FORESTS PROJECT TIMELINE & MILESTONES

	Prototype Phase		YEAR 1				YEAR 2				YEAR 3			
TASKS	**Q1**	**Q2**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Validate current California citizen science user classification of giant kelp canopy														
Build Floating Forests to TRB Data Pipeline														
Build Project Builder to TRB Data Pipeline														
Validate Tasmania classifications														
Write Landsat Citizen Science validation manuscript														
Make processing source code available via github														
Validate new data sources														
Model giant kelp canopy detectability														
Write manuscript on kelp detectability issues														
Manage Incoming Data from Project Builder														
Monthly Kelp Chats, Weekly Blog Posts														
Rebuild the Landsat to Zooniverse data pipeline with new demo area														
Create Prototype of Project Builder Floating Forests Site														
Build Project Builder for Landsat Data														
Migrate Floating Forests to New Project Builder Site														
Develop Best Practices Guide for Landsat Projects with Project Builder														
Develop Simple Data Visualization Tools for Floating Forests Porject Builder Site														
Project Builder for Landsat Workshop at AGU														
Develop analytic pipeline to model global giant kelp canopy change over time														
Analyze long-term changes in global kelp cover over time														
Write manuscript on long-term change in global kelp cover														
Acquire and merge new data layers of climatic and anthropogenic variables														
Model trends influence of climatic variability and anthropogenic factors on giant kelp abundance														
Write manuscript on climate change and giant kelp forests														
Create sample undergraduate floating forests kelp ecology curriculum														
Develop & deploy educational modules for K-12 students and undergraduates														
Write manuscript on Floating Forests in the Classroom														
PI coordination and discussion Meetings														
Write manuscripts and present results at national conference														