

## COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE / If not in response to a program announcement/solicitation enter NSF 11-1  <b>NSF 12-590</b> <b>11/09/12</b>					<b>FOR NSF USE ONLY</b>																																																																																																													
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)  <b>DEB - Population and Community Ecology</b>					<b>NSF PROPOSAL NUMBER</b>																																																																																																													
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 15%;">DATE RECEIVED</th> <th style="width: 15%;">NUMBER OF COPIES</th> <th style="width: 15%;">DIVISION ASSIGNED</th> <th style="width: 15%;">FUND CODE</th> <th style="width: 20%;">DUNS# (Data Universal Numbering System)</th> <th style="width: 20%;">FILE LOCATION</th> </tr> <tr> <td><b>11/09/2012</b></td> <td><b>1</b></td> <td><b>08010000 DEB</b></td> <td><b>1182</b></td> <td><b>005421136</b></td> <td>08/02/2013 11:59am S</td> </tr> <tr> <td colspan="2">EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)   <b>362177139</b></td> <td colspan="2">SHOW PREVIOUS AWARD NO. IF THIS IS  <input type="checkbox"/> A RENEWAL  <input type="checkbox"/> AN ACCOMPLISHMENT-BASED RENEWAL</td> <td colspan="2">IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? 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## CERTIFICATION PAGE

### Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, lobbying activities (see below), responsible conduct of research, nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 11-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

### Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

### Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

### Debarment and Suspension Certification

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

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency?

Yes

No

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

### Certification Regarding Lobbying

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

### Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

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

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

### Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

### Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

- (1) community in which that area is located participates in the national flood insurance program; and
- (2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

- (1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
- (2) for other NSF Grants when more than \$25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

### Certification Regarding Responsible Conduct of Research (RCR)

(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.

The undersigned shall require that the language of this certification be included in any award documents for all subawards at all tiers.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME Denise Dooley	Electronic Signature	Nov 9 2012 1:03PM
TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS ddooley@uchicago.edu	FAX NUMBER
* EAGER - EARly-concept Grants for Exploratory Research ** RAPID - Grants for Rapid Response Research		

**Directorate for Biological Sciences  
Division of Environmental Biology  
Population and Community Ecology**

**Proposal Classification Form  
PI: Pfister, Catherine / Proposal Number: 1311286**

**CATEGORY I: INVESTIGATOR STATUS (Select ONE)**

- |   |
|---|
| <input type="checkbox"/> Beginning Investigator - No previous Federal support as PI or Co-PI, excluding fellowships, dissertations, planning grants, etc. |
| <input type="checkbox"/> Prior Federal support only   |
| <input type="checkbox"/> Current Federal support only   |
| <input checked="" type="checkbox"/> Current & prior Federal support   |

**CATEGORY II: FIELDS OF SCIENCE OTHER THAN BIOLOGY INVOLVED IN THIS RESEARCH (Select 1 to 3)**

- |   |                                      |   |
|---|--------------------------------------|---|
| <input type="checkbox"/> Astronomy        | <input type="checkbox"/> Engineering | <input type="checkbox"/> Psychology                   |
| <input type="checkbox"/> Chemistry        | <input type="checkbox"/> Mathematics | <input type="checkbox"/> Social Sciences              |
| <input type="checkbox"/> Computer Science | <input type="checkbox"/> Physics     | <input checked="" type="checkbox"/> None of the Above |
| <input type="checkbox"/> Earth Science    |                                      |   |

**CATEGORY III: SUBSTANTIVE AREA (Select 1 to 4)**

- |  |  |  |
|--|--|--|
| <input type="checkbox"/> BIOGEOGRAPHY                          | <input type="checkbox"/> Decomposition   | <input type="checkbox"/> Molecular Evolution             |
| <input type="checkbox"/> Island Biogeography                   | <input type="checkbox"/> Biogeochemistry   | <input type="checkbox"/> Methodology/Theory              |
| <input type="checkbox"/> Historical/ Evolutionary Biogeography | <input type="checkbox"/> Limnology/Hydrology                                     | <input type="checkbox"/> Isozymes/ Electrophoresis       |
| <input type="checkbox"/> Phylogeography                        | <input type="checkbox"/> Climate/Microclimate                                    | <input type="checkbox"/> Nucleic Acid Analysis (general) |
| <input type="checkbox"/> Methods/Theory                        | <input type="checkbox"/> Whole-System Analysis                                   | <input type="checkbox"/> Restriction Enzymes             |
| <input type="checkbox"/> CHROMOSOME STUDIES                    | <input type="checkbox"/> Productivity/Biomass                                    | <input type="checkbox"/> Nucleotide Sequencing           |
| <input type="checkbox"/> Chromosome Evolution                  | <input type="checkbox"/> System Energetics                                       | <input type="checkbox"/> Nuclear DNA                     |
| <input type="checkbox"/> Chromosome Number                     | <input type="checkbox"/> Landscape Dynamics                                      | <input type="checkbox"/> Mitochondrial DNA               |
| <input type="checkbox"/> Mutation                              | <input type="checkbox"/> Chemical & Biochemical Control                          | <input type="checkbox"/> Chloroplast DNA                 |
| <input type="checkbox"/> Mitosis and Meiosis                   | <input type="checkbox"/> Global Change   | <input type="checkbox"/> RNA Analysis                    |
| <input type="checkbox"/> COMMUNITY ECOLOGY                     | <input type="checkbox"/> Climate Change  | <input type="checkbox"/> DNA Hybridization               |
| <input checked="" type="checkbox"/> Community Analysis         | <input type="checkbox"/> Regional Studies  | <input type="checkbox"/> Recombinant DNA                 |
| <input checked="" type="checkbox"/> Community Structure        | <input type="checkbox"/> Global Studies  | <input type="checkbox"/> Amino Acid Sequencing           |
| <input type="checkbox"/> Community Stability                   | <input type="checkbox"/> Forestry  | <input type="checkbox"/> Gene/Genome Mapping             |
| <input type="checkbox"/> Succession                            | <input type="checkbox"/> Resource Management (Wildlife, Fisheries, Range, Other) | <input type="checkbox"/> Natural Products                |
| <input type="checkbox"/> Experimental Microcosms/ Mesocosms    | <input type="checkbox"/> Agricultural Ecology                                    | <input type="checkbox"/> Serology/Immunology             |
| <input checked="" type="checkbox"/> Disturbance                | <input type="checkbox"/> EXTREMOPHILES   | <input type="checkbox"/> PALEONTOLOGY                    |
| <input type="checkbox"/> Patch Dynamics                        | <input type="checkbox"/> GENOMICS (Genome sequence, organization, function)      | <input type="checkbox"/> Floristic                       |
| <input type="checkbox"/> Food Webs/ Trophic Structure          | <input type="checkbox"/> Viral   | <input type="checkbox"/> Faunistic                       |
| <input type="checkbox"/> Keystone Species                      | <input type="checkbox"/> Microbial   | <input type="checkbox"/> Paleoecology                    |
| <input type="checkbox"/> COMPUTATIONAL BIOLOGY                 | <input type="checkbox"/> Fungal  | <input type="checkbox"/> Biostratigraphy                 |
| <input type="checkbox"/> CONSERVATION & RESTORATION BIOLOGY    | <input type="checkbox"/> Plant   | <input type="checkbox"/> Palynology                      |
| <input type="checkbox"/> DATABASES                             | <input type="checkbox"/> Animal  | <input type="checkbox"/> Micropaleontology               |
| <input type="checkbox"/> ECOSYSTEMS LEVEL                      | <input type="checkbox"/> MARINE MAMMALS  | <input type="checkbox"/> Paleoclimatology                |
| <input type="checkbox"/> Physical Structure                    | <input type="checkbox"/> MOLECULAR APPROACHES                                    | <input type="checkbox"/> Archeozoic                      |
|  |  | <input type="checkbox"/> Paleozoic                       |
|  |  | <input type="checkbox"/> Mesozoic                        |

<input type="checkbox"/> Cenozoic <input type="checkbox"/> POPULATION DYNAMICS & LIFE HISTORY <input type="checkbox"/> Demography/ Life History <input type="checkbox"/> Population Cycles <input type="checkbox"/> Distribution/Patchiness/ Marginal Populations <input type="checkbox"/> Population Regulation <input type="checkbox"/> Intraspecific Competition <input type="checkbox"/> Reproductive Strategies <input type="checkbox"/> Gender Allocation <input type="checkbox"/> Metapopulations <input type="checkbox"/> Extinction <input type="checkbox"/> POPULATION GENETICS & BREEDING SYSTEMS <input type="checkbox"/> Variation <input type="checkbox"/> Microevolution <input type="checkbox"/> Speciation <input type="checkbox"/> Hybridization <input type="checkbox"/> Inbreeding/Outbreeding <input type="checkbox"/> Gene Flow Measurement <input type="checkbox"/> Inheritance/Heritability	<input type="checkbox"/> Quantitative Genetics/ QTL Analysis <input type="checkbox"/> Ecological Genetics <input type="checkbox"/> Gender Ratios <input type="checkbox"/> Apomixis/ Parthenogenesis <input type="checkbox"/> Vegetative Reproduction <input type="checkbox"/> SPECIES INTERACTIONS <input type="checkbox"/> Predation <input type="checkbox"/> Herbivory <input type="checkbox"/> Omnivory <input type="checkbox"/> Interspecific Competition <input type="checkbox"/> Niche Relationships/ Resource Partitioning <input type="checkbox"/> Pollination/ Seed Dispersal <input type="checkbox"/> Parasitism <input type="checkbox"/> Mutualism/ Commensalism <input type="checkbox"/> Plant/Fungal/ Microbial Interactions <input type="checkbox"/> Mimicry <input type="checkbox"/> Animal Pathology <input type="checkbox"/> Plant Pathology	<input type="checkbox"/> Coevolution <input type="checkbox"/> Biological Control <input type="checkbox"/> STATISTICS & MODELING <input type="checkbox"/> Methods/ Instrumentation/ Software <input type="checkbox"/> Modeling (general) <input type="checkbox"/> Statistics (general) <input type="checkbox"/> Multivariate Methods <input type="checkbox"/> Spatial Statistics & Spatial Modeling <input type="checkbox"/> Sampling Design & Analysis <input type="checkbox"/> Experimental Design & Analysis <input type="checkbox"/> SYSTEMATICS <input type="checkbox"/> Taxonomy/Classification <input type="checkbox"/> Nomenclature <input type="checkbox"/> Monograph/Revision <input checked="" type="checkbox"/> Phylogenetics <input type="checkbox"/> Phenetics/Cladistics/ Numerical Taxonomy <input type="checkbox"/> Macroevolution <input type="checkbox"/> NONE OF THE ABOVE
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#### CATEGORY IV: INFRASTRUCTURE (Select 1 to 3)

<input type="checkbox"/> COLLECTIONS/STOCK CULTURES <input checked="" type="checkbox"/> Natural History Collections <input type="checkbox"/> DATABASES <b>FACILITIES</b> <input type="checkbox"/> Controlled Environment Facilities	<input type="checkbox"/> Field Stations <input type="checkbox"/> Field Facility Structure <input type="checkbox"/> Field Facility Equipment <input type="checkbox"/> LTER Site <input type="checkbox"/> INDUSTRY PARTICIPATION	<input type="checkbox"/> Technique Development <b>TRACKING SYSTEMS</b> <input type="checkbox"/> Geographic Information Systems <input type="checkbox"/> Remote Sensing <input type="checkbox"/> NONE OF THE ABOVE
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#### CATEGORY V: HABITAT (Select 1 to 2)

##### TERRESTRIAL HABITATS

<input type="checkbox"/> GENERAL TERRESTRIAL <input type="checkbox"/> TUNDRA <input type="checkbox"/> BOREAL FOREST <input type="checkbox"/> TEMPERATE <ul style="list-style-type: none"> <li><input type="checkbox"/> Deciduous Forest</li> <li><input type="checkbox"/> Coniferous Forest</li> <li><input type="checkbox"/> Rain Forest</li> <li><input type="checkbox"/> Mixed Forest</li> <li><input type="checkbox"/> Prairie/Grasslands</li> <li><input type="checkbox"/> Desert</li> </ul> <input type="checkbox"/> SUBTROPICAL <ul style="list-style-type: none"> <li><input type="checkbox"/> Rain Forest</li> <li><input type="checkbox"/> Seasonal Forest</li> </ul>	<input type="checkbox"/> Savanna <input type="checkbox"/> Thornwoods <input type="checkbox"/> Deciduous Forest <input type="checkbox"/> Coniferous Forest <input type="checkbox"/> Desert <b>TROPICAL</b> <ul style="list-style-type: none"> <li><input type="checkbox"/> Rain Forest</li> <li><input type="checkbox"/> Seasonal Forest</li> <li><input type="checkbox"/> Savanna</li> <li><input type="checkbox"/> Thornwoods</li> <li><input type="checkbox"/> Deciduous Forest</li> <li><input type="checkbox"/> Coniferous Forest</li> <li><input type="checkbox"/> Desert</li> </ul>	<b>CHAPARAL/ SCLEROPHYLL/ SHRUBLANDS</b> <input type="checkbox"/> ALPINE <input type="checkbox"/> MONTANE <input type="checkbox"/> CLOUD FOREST <input type="checkbox"/> RIPARIAN ZONES <input type="checkbox"/> ISLANDS (except Barrier Islands) <input type="checkbox"/> BEACHES/ DUNES/ SHORES/ BARRIER ISLANDS <input type="checkbox"/> CAVES/ ROCK OUTCROPS/ CLIFFS <input type="checkbox"/> CROPLANDS/ FALLOW FIELDS/ PASTURES <input type="checkbox"/> URBAN/SUBURBAN <input type="checkbox"/> SUBTERRANEAN/ SOIL/ SEDIMENTS <input type="checkbox"/> EXTREME TERRESTRIAL ENVIRONMENT <input type="checkbox"/> AERIAL
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<b>AQUATIC HABITATS</b>		
<input type="checkbox"/> GENERAL AQUATIC <input type="checkbox"/> FRESHWATER <input type="checkbox"/> Wetlands/Bogs/Swamps <input type="checkbox"/> Lakes/Ponds <input type="checkbox"/> Rivers/Streams <input type="checkbox"/> Reservoirs <input checked="" type="checkbox"/> MARINE	<input type="checkbox"/> Open Ocean/Continental Shelf <input type="checkbox"/> Bathyal <input type="checkbox"/> Abyssal <input type="checkbox"/> Estuarine <input checked="" type="checkbox"/> Intertidal/Tidal/Coastal <input type="checkbox"/> Coral Reef <input type="checkbox"/> HYPER SALINE	<input type="checkbox"/> EXTREME AQUATIC ENVIRONMENT <input type="checkbox"/> CAVES/ ROCK OUTCROPS/ CLIFFS <input type="checkbox"/> MANGROVES <input type="checkbox"/> SUBSURFACE WATERS/ SPRINGS <input type="checkbox"/> Ephemeral Pools & Streams <input type="checkbox"/> MICROPOOLS (Pitcher Plants, Tree Holes, Other)
<b>MAN-MADE ENVIRONMENTS</b>		
<input type="checkbox"/> LABORATORY	<input type="checkbox"/> THEORETICAL SYSTEMS	<input type="checkbox"/> OTHER ARTIFICIAL SYSTEMS
<b>NOT APPLICABLE</b>		
<input type="checkbox"/> NOT APPLICABLE		

<b>CATEGORY VI: GEOGRAPHIC AREA OF THE RESEARCH (Select 1 to 2)</b>		
<input type="checkbox"/> WORLDWIDE <input type="checkbox"/> NORTH AMERICA <input type="checkbox"/> United States <input type="checkbox"/> Northeast US (CT, MA, ME, NH, NJ, NY, PA, RI, VT) <input type="checkbox"/> Northcentral US (IA, IL, IN, MI, MN, ND, NE, OH, SD, WI) <input checked="" type="checkbox"/> Northwest US (ID, MT, OR, WA, WY) <input type="checkbox"/> Southeast US (DC, DE, FL, GA, MD, NC, SC, WV, VA) <input type="checkbox"/> Southcentral US (AL, AR, KS, KY, LA, MO, MS, OK, TN, TX) <input type="checkbox"/> Southwest US (AZ, CA, CO, NM, NV, UT) <input type="checkbox"/> Alaska <input type="checkbox"/> Hawaii <input type="checkbox"/> Puerto Rico <input type="checkbox"/> Canada <input type="checkbox"/> Mexico <input type="checkbox"/> CENTRAL AMERICA (Mainland) <input type="checkbox"/> Caribbean Islands <input type="checkbox"/> Bermuda/Bahamas <input type="checkbox"/> SOUTH AMERICA	<input type="checkbox"/> Eastern South America (Guyana, Fr. Guiana, Suriname, Brazil) <input type="checkbox"/> Northern South America (Colombia, Venezuela) <input type="checkbox"/> Southern South America (Chile, Argentina, Uruguay, Paraguay) <input type="checkbox"/> Western South America (Ecuador, Peru, Bolivia) <input type="checkbox"/> EUROPE <input type="checkbox"/> Eastern Europe <input type="checkbox"/> Russia <input type="checkbox"/> Scandinavia <input type="checkbox"/> Western Europe <input type="checkbox"/> ASIA <input type="checkbox"/> Central Asia <input type="checkbox"/> Far East <input type="checkbox"/> Middle East <input type="checkbox"/> Siberia <input type="checkbox"/> South Asia <input type="checkbox"/> Southeast Asia <input type="checkbox"/> AFRICA	<input type="checkbox"/> North Africa <input type="checkbox"/> African South of the Sahara <input type="checkbox"/> East Africa <input type="checkbox"/> Madagascar <input type="checkbox"/> South Africa <input type="checkbox"/> West Africa <input type="checkbox"/> AUSTRALASIA <input type="checkbox"/> Australia <input type="checkbox"/> New Zealand <input type="checkbox"/> Pacific Islands <input type="checkbox"/> ANTARCTICA <input type="checkbox"/> ARCTIC <input type="checkbox"/> ATLANTIC OCEAN <input checked="" type="checkbox"/> PACIFIC OCEAN <input type="checkbox"/> INDIAN OCEAN <input type="checkbox"/> OTHER REGIONS (Not defined) <input type="checkbox"/> NOT APPLICABLE

<b>CATEGORY VII: CLASSIFICATION OF ORGANISMS (Select 1 to 4)</b>		
<input type="checkbox"/> VIRUSES <input type="checkbox"/> Bacterial <input type="checkbox"/> Plant <input type="checkbox"/> Animal <input type="checkbox"/> PROKARYOTES <input type="checkbox"/> Archaeabacteria <input type="checkbox"/> Cyanobacteria <input type="checkbox"/> Eubacteria <input type="checkbox"/> PROTISTA (PROTOZOA) <input type="checkbox"/> Amoebeae <input type="checkbox"/> Apicomplexa <input type="checkbox"/> Ciliophora <input type="checkbox"/> Flagellates <input type="checkbox"/> Foraminifera <input type="checkbox"/> Microspora	<input type="checkbox"/> Radiolaria <input type="checkbox"/> FUNGI <input type="checkbox"/> Ascomycota <input type="checkbox"/> Basidiomycota <input type="checkbox"/> Chytridiomycota <input type="checkbox"/> Mitosporic Fungi <input type="checkbox"/> Oomycota <input type="checkbox"/> Zygomycota <input type="checkbox"/> LICHENS <input type="checkbox"/> SLIME MOLDS <input type="checkbox"/> ALGAE <input type="checkbox"/> Bacillariophyta (Diatoms) <input type="checkbox"/> Charophyta <input checked="" type="checkbox"/> Chlorophyta <input type="checkbox"/> Chrysophyta	<input type="checkbox"/> Dinoflagellata <input type="checkbox"/> Euglenoids <input checked="" type="checkbox"/> Phaeophyta <input checked="" type="checkbox"/> Rhodophyta <input type="checkbox"/> PLANTS <input type="checkbox"/> NON-VASCULAR PLANTS <input type="checkbox"/> BRYOPHYTA <input type="checkbox"/> Anthocerotae (Hornworts) <input type="checkbox"/> Hepaticae (Liverworts) <input type="checkbox"/> Musci (Mosses) <input type="checkbox"/> VASCULAR PLANTS <input type="checkbox"/> FERNS & FERN ALLIES <input type="checkbox"/> GYMNOSEPERMS <input type="checkbox"/> Coniferales (Conifers) <input type="checkbox"/> Cycadales (Cycads)

<input type="checkbox"/> Ginkgoales (Ginkgo)	<input type="checkbox"/> Polyplacophora (Chitons)	<input type="checkbox"/> Coleoptera (Beetles)
<input type="checkbox"/> Gnetales (Gnetophytes)	<input type="checkbox"/> Scaphopoda (Tooth Shells)	<input type="checkbox"/> Hymenoptera (Ants, Bees, Wasps, Sawflies)
<input type="checkbox"/> ANGIOSPERMS	<input type="checkbox"/> Gastropoda (Snails, Slugs, Limpets)	<input type="checkbox"/> Chilopoda (Centipedes)
<input type="checkbox"/> Monocots	<input type="checkbox"/> Pelecypoda (Bivalvia) (Clams, Mussels, Oysters, Scallops)	<input type="checkbox"/> Diplopoda (Millipedes)
<input type="checkbox"/> Arecaceae (Palmae)	<input type="checkbox"/> Cephalopoda (Squid, Octopus, Nautilus)	<input type="checkbox"/> Pauropoda
<input type="checkbox"/> Cyperaceae	<input type="checkbox"/> ANNELIDA (Segmented Worms)	<input type="checkbox"/> Symphyla (Symphyla)
<input type="checkbox"/> Liliaceae	<input type="checkbox"/> Polychaeta (Parapodial Worms)	<input type="checkbox"/> PENTASTOMIDA (Linguatulida) (Tongue Worms)
<input type="checkbox"/> Orchidaceae	<input type="checkbox"/> Oligochaeta (Earthworms)	<input type="checkbox"/> TARDIGRADA (Tardigrades, Water Bears)
<input type="checkbox"/> Poaceae (Graminae)	<input type="checkbox"/> Hirudinida (Leeches)	<input type="checkbox"/> ONYCHOPHORA (Peripatus)
<input type="checkbox"/> Dicots	<input type="checkbox"/> POGONOPHORA (Beard Worms)	<input type="checkbox"/> CHAETOGNATHA (Arrow Worms)
<input type="checkbox"/> Apiaceae (Umbelliferae)	<input type="checkbox"/> SIPUNCULOIDEA (Peanut Worms)	<input type="checkbox"/> ECHINODERMATA
<input type="checkbox"/> Asteraceae (Compositae)	<input type="checkbox"/> ECIIUROIDEA (Spoon Worms)	<input type="checkbox"/> Crinoidea (Sea Lilies, Feather Stars)
<input type="checkbox"/> Brassicaceae (Cruciferae)	<input type="checkbox"/> ARTHROPODA	<input type="checkbox"/> Asteroidea (Starfish, Sea Stars)
<input type="checkbox"/> Fabaceae (Leguminosae)	<input type="checkbox"/> Cheliceriformes	<input type="checkbox"/> Ophiuroidea (Brittle Stars, Serpent Stars)
<input type="checkbox"/> Lamiaceae (Labiatae)	<input type="checkbox"/> Merostomata (Horseshoe Crabs)	<input type="checkbox"/> Echinoidea (Sea Urchins, Sand Dollars)
<input type="checkbox"/> Rosaceae	<input type="checkbox"/> Pycnogonida (Sea Spiders)	<input type="checkbox"/> Holothuroidea (Sea Cucumbers)
<input type="checkbox"/> Solanaceae	<input type="checkbox"/> Scorpionida (Scorpions)	<input type="checkbox"/> HEMICHORDATA (Acorn Worms, Pterobranchs)
<input type="checkbox"/> <b>ANIMALS</b>	<input type="checkbox"/> Araneae (True Spiders)	<input type="checkbox"/> UROCHORDATA (Tunicata) (Tunicates, Sea Squirts, Salps, Ascidians)
<input type="checkbox"/> <b>INVERTEBRATES</b>	<input type="checkbox"/> Pseudoscorpionida (Pseudoscorpions)	<input type="checkbox"/> CEPHALOCHORDATA (Amphioxus/Lancelet)
<input type="checkbox"/> MESOZOA/PLACOZOA	<input type="checkbox"/> Acarina (Free-living Mites)	<input type="checkbox"/> VERTEBRATES
<input type="checkbox"/> PORIFERA (Sponges)	<input type="checkbox"/> Parasitiformes (Parasitic Ticks & Mites)	<input type="checkbox"/> AGNATHA (Hagfish, Lamprey)
<input type="checkbox"/> CNIDARIA	<input type="checkbox"/> Crustacea	<input type="checkbox"/> FISHES
<input type="checkbox"/> Hydrozoa (Hydra, etc.)	<input type="checkbox"/> Branchiopoda (Fairy Shrimp, Water Flea)	<input type="checkbox"/> Chondrichthyes (Cartilaginous Fishes) (Sharks, Rays, Ratfish)
<input type="checkbox"/> Scyphozoa (Jellyfish)	<input type="checkbox"/> Ostracoda (Sea Lice)	<input type="checkbox"/> Osteichthyes (Bony Fishes)
<input type="checkbox"/> Anthozoa (Corals, Sea Anemones)	<input type="checkbox"/> Copepoda	<input type="checkbox"/> AMPHIBIA
<input type="checkbox"/> CTENOPHORA (Comb Jellies)	<input type="checkbox"/> Cirripedia (Barnacles)	<input type="checkbox"/> Anura (Frogs, Toads)
<input type="checkbox"/> PLATYHELMINTHES (Flatworms)	<input type="checkbox"/> Amphipoda (Skeleton Shrimp, Whale Lice, Freshwater Shrimp)	<input type="checkbox"/> Urodela (Salamanders, Newts)
<input type="checkbox"/> Turbellaria (Planarians)	<input type="checkbox"/> Isopoda (Wood Lice, Pillbugs)	<input type="checkbox"/> Gymnophiona (Apoda) (Caecilians)
<input type="checkbox"/> Trematoda (Flukes)	<input type="checkbox"/> Decapoda (Lobster, Crayfish, Crabs, Shrimp)	<input type="checkbox"/> REPTILIA
<input type="checkbox"/> Cestoda (Tapeworms)	<input type="checkbox"/> Hexapoda (Insecta) (Insects)	<input type="checkbox"/> Chelonia (Turtles, Tortoises)
<input type="checkbox"/> Monogenea (Flukes)	<input type="checkbox"/> Aptygotata (Springtails, Silverfish, etc.)	<input type="checkbox"/> Serpentes (Snakes)
<input type="checkbox"/> GNATHOSTOMULIDA	<input type="checkbox"/> Odonata (Dragonflies, Damselflies)	<input type="checkbox"/> Sauria (Lizards)
<input type="checkbox"/> NEMERTINEA (Rynchocoela) (Ribbon Worms)	<input type="checkbox"/> Ephemeroptera (Mayflies)	<input type="checkbox"/> Crocodylia (Crocodilians)
<input type="checkbox"/> ENTOPROCTA (Bryozoa) (Plant-like Animals)	<input type="checkbox"/> Orthoptera (Grasshoppers, Crickets)	<input type="checkbox"/> AVES (Birds)
<input type="checkbox"/> ASCHELMINTHES	<input type="checkbox"/> Dictyoptera (Cockroaches, Mantids, Phasmids)	<input type="checkbox"/> Passeriformes (Passerines)
<input type="checkbox"/> Gastrotricha	<input type="checkbox"/> Isoptera (Termites)	<input type="checkbox"/> MAMMALIA
<input type="checkbox"/> Kinorhyncha	<input type="checkbox"/> Plecoptera (Stoneflies)	<input type="checkbox"/> Monotremata (Platypus, Echidna)
<input type="checkbox"/> Loricifera	<input type="checkbox"/> Phthiraptera (Mallophaga & Anoplura) (Lice)	<input type="checkbox"/> Marsupalia (Marsupials)
<input type="checkbox"/> Nematoda (Roundworms)	<input type="checkbox"/> Hemiptera (including Heteroptera) (True Bugs)	<input type="checkbox"/> Eutheria (Placentals)
<input type="checkbox"/> Nematomorpha (Horsehair Worms)	<input type="checkbox"/> Homoptera (Cicadas, Scale Insects, Leafhoppers)	<input type="checkbox"/> Insectivora (Hedgehogs, Moles, Shrews, Tenrec, etc.)
<input type="checkbox"/> Rotifera (Rotatoria)	<input type="checkbox"/> Thysanoptera (Thrips)	<input type="checkbox"/> Chiroptera (Bats)
<input type="checkbox"/> ACANTHOCEPHALA (Spiny-headed Worms)	<input type="checkbox"/> Neuroptera (Lacewings, Dobsonflies, Snakeflies)	<input type="checkbox"/> Primates
<input type="checkbox"/> PRIAPULOIDEA	<input type="checkbox"/> Trichoptera (Caddisflies)	<input type="checkbox"/> Humans
<input type="checkbox"/> BRYOZOA (Ectoprocta) (Plant-like Animals)	<input type="checkbox"/> Lepidoptera (Moths, Butterflies)	<input type="checkbox"/> Rodentia
<input type="checkbox"/> PHORONIDEA (Lophophorates)	<input type="checkbox"/> Diptera (Flies, Mosquitoes)	<input type="checkbox"/> Lagomorphs (Rabbits, Hares, Pikas)
<input type="checkbox"/> BRACHIOPODA (Lamp Shells)	<input type="checkbox"/> Siphonaptera (Fleas)	<input type="checkbox"/> Carnivora (Bears, Canids, Felids, Mustelids, Viverrids, Hyena, Procyonids)
<input type="checkbox"/> MOLLUSCA		<input type="checkbox"/> Perissodactyla (Odd-toed Ungulates) (Horses, Rhinos, Tapirs, etc.)
<input type="checkbox"/> Monoplacophora		
<input type="checkbox"/> Aplacophora (Solenogasters)		

<input type="checkbox"/> Artiodactyla (Even-toed Ungulates) (Cattle, Sheep, Deer, Pigs, etc.)	<input type="checkbox"/> TRANSGENIC ORGANISMS <input type="checkbox"/> FOSSIL OR EXTINCT ORGANISMS	<input type="checkbox"/> NO ORGANISMS
<input type="checkbox"/> Marine Mammals (Seals, Walrus, Whales, Otters, Dolphins, Porpoises)		

#### CATEGORY VIII: MODEL ORGANISM (Select ONE)

<input checked="" type="checkbox"/> NO MODEL ORGANISM	<input type="checkbox"/> Escherichia coli	<input type="checkbox"/> Fruitfly ( <i>Drosophila melanogaster</i> )
MODEL ORGANISM (Choose from the list)	<input type="checkbox"/> Mouse-Ear Cress ( <i>Arabidopsis thaliana</i> )	

## **DISSERTATION RESEARCH: The Roles of Evolutionary History and Ecological Interactions in the Maintenance of a High-Diversity Algal Assemblage**

### **Intellectual Merit:**

Evaluating the ecological, environmental and evolutionary processes that organize species into distinct communities and ecosystems is of growing importance, particularly in the context of increasing human disturbances to the environment. The evolutionary history and trait diversity of assemblages are variables that have been demonstrated to have predictive power in determining the response of communities to environmental perturbations such as climate change and species introductions, and provide a new means to determine how diversity contributes to ecosystem services. Proposed work will test the relative contributions of ecological processes and evolutionary history to community assembly and disturbance recovery. Further, it will determine whether marine macroalgal assemblages exhibit shared, conserved traits and constrained evolutionary history in response to environmental pressures (environmental filtering), or if the assemblages exhibit convergent traits and species drawn from a range of clades, a signature of competition for conserved niches. I am integrating the dynamic ecological processes of herbivory and physical disturbance into studies of phylogenetic and functional community structure that have traditionally focused solely on competition and environmental filtering. To identify functional traits and macroalgal clades vulnerable to disturbance, and traits and clades that contribute to community recovery, I will exploit existing strong environmental gradients and use manipulative experiments in the rocky intertidal macroalgal community - a highly tractable, phylogenetically diverse and well-studied community where temperature, wave disturbance and herbivore abundance changes dramatically over a scale of only meters.

### **Broader Impacts:**

Understanding the algal community structure along a strong environmental gradient and during recovery from disturbance is imperative to predict ecosystem change. My field-based studies will identify traits and clades vulnerable to disturbance, and community meta-analyses will evaluate the extent to which temperature structures communities along a large gradient from Alaska to Mexico. Furthermore, macroalgae contribute to economically important fisheries.

I will communicate my science broadly, from publishing in top journals and attending conferences, to working with the Makah Tribe to increase participation of underrepresented groups in ecology. As part of my DNA sequencing work, I will participate in "Talk to the Scientist Hour," a daily Q&A session with museum visitors and will involve several undergraduates in my research. The impacts of the proposed work are both ecological and cultural; the Pfister laboratory group has longstanding ties with the Makah Tribe and the Makah Tribe Research and Cultural Center through decades of research on the Makah Indian Reservation. The Makah and other coastal communities on the Olympic Peninsula, WA, depend socioeconomically on the fishing industry, which is linked to coastal ocean productivity. I will enhance our lab's outreach opportunities and strong relationship with the Makah Tribe by working with a Makah intern each year during the field season on ecological field studies and physiological lab studies. Results from my research will be used for teen and adult educational outreach to increase literacy about ecological change, with emphasis on effects of climate change on coastal ecological communities. I will also continue to participate in Creating Opportunities for After School Thinking (COAST), an organization that tutors children grades K-8 from disadvantaged homes in the Cape Flattery, WA school district in core academic areas and takes several field trips to field sites similar to mine throughout the year.

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Project Description (Including Results from Prior NSF Support) (not to exceed 15 pages) (Exceed only if allowed by a specific program announcement/solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)	8	_____
References Cited	4	_____
Biographical Sketches (Not to exceed 2 pages each)	4	_____
Budget (Plus up to 3 pages of budget justification)	8	_____
Current and Pending Support	2	_____
Facilities, Equipment and Other Resources	1	_____
Special Information/Supplementary Documents (Data Management Plan, Mentoring Plan and Other Supplementary Documents)	3	_____
Appendix (List below.) (Include only if allowed by a specific program announcement/ solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)	_____	_____
Appendix Items:		

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

## **DISSERTATION RESEARCH: The roles of evolutionary history and ecological interactions in the maintenance of a high-diversity macroalgal assemblage**

Communities comprise a non-random sample of regional species pools, whether in phenotypic or phylogenetic terms (Weiher & Keddy 1995; Kraft *et al.* 2007). With increasing acknowledgment that community diversity influences ecosystem function and stability (Harmon *et al.* 2009; Hector 2011; Cadotte *et al.* 2012), a major focus of community ecology has been to determine the relative contributions of environmental and organismal variables to species interactions and community assembly. As ecological communities are increasingly subjected to the effects of climate change and intensifying environmental disturbance, researchers have focused on the question of how to use these variables to predict community responses to environmental change (Agrawal *et al.* 2007; Wood *et al.* 2010). Two competing mechanisms - environmental filtering and competition – may determine community structure; both are evident in the phylogenetic signature of communities. Environmental filtering, where the physiological demands of a habitat limit colonization and establishment of species to a subset of adapted lineages, yields a phylogenetically clustered pattern (Weiher & Keddy 1995; Webb *et al.* 2002). In contrast, since related species are likely to need similar resources, competitive exclusion may prevent close relatives from co-occurring, resulting in a pattern where community members are phylogenetically overdispersed.

While phylogenetic community structure is a powerful tool to evaluate the generation and maintenance of diversity, ecological mechanisms of community assembly cannot be inferred from patterns of phylogenetic structure alone; one also needs to know whether phenotypes are clustered or overdispersed (Cavender-Bares *et al.* 2006; Losos 2008). Many studies have successfully integrated phylogenetic and phenotypic community metrics into evaluations of competition and environmental filtering (Cavender-Bares *et al.* 2004; Kembel & Hubbell 2006; Kraft & Ackerly 2011; Graham *et al.* 2012). However, few studies take into account additional dynamic ecological processes such as herbivory, disturbance or colonization, or fine-scale environmental patterns such as temperature gradients or habitat heterogeneity (Verdú & Pausas 2007; Helmus *et al.* 2010; Cadotte & Strauss 2011). Where it has been evaluated, disturbance has been demonstrated to be a driver of phylogenetic clustering, as in woody plant communities (Norden *et al.* 2012, Cavender-Bares & Reich 2012) and in zooplankton communities (Helmus *et al.* 2010). Disturbance contributes to species diversity (Connell 1978; Huston 1979), but is rarely evaluated as a driver of phylogenetic community structure.

I propose to expand studies of drivers of community structure to a species-rich system that experiences strong local disturbance gradients: the sessile marine macroalgal community of the temperate marine rocky intertidal zone. In this system, I am able to directly measure both physical environmental variables and functional traits of species, which will allow me to determine the relative importance of environmental filtering and competition on community structure. Further, I can manipulate herbivory intensity and physical disturbance regimes to determine how these additional processes influence community structuring. This will allow me to address a number of fundamental questions in ecology. Do marine macroalgal assemblages exhibit shared conserved traits and constrained evolutionary history in response to environmental pressures (environmental filtering) or do the assemblages exhibit convergent traits and species drawn from a range of clades, a signature of competition for set niches? How do species interactions, shared evolutionary history and trait diversity among species mediate co-occurrence patterns and responses to disturbance and herbivory?

My dissertation research addresses these questions in three distinct phases: 1) assessing

regional diversity in order compare regional and local diversity in a phylogenetic and functional context, 2) building a phylogeny of all species in the regional pool and 3) installing field manipulations to directly quantify the effects of environmental filtering, functional traits correlated with competition, herbivory, and disturbance on community structure. Here I will first describe progress in aims 1)-3) and the further work required to complete them. I then introduce hypotheses of the effects of high phylogenetic distance, high environmental stress and high biotic stress on community structure.

### **Intertidal Macroalgal Communities at Tatoosh Island, WA**

In the Northeast Pacific rocky intertidal system, the strengths of physical and biological stressors vary across a very small spatial scale, resulting in discrete zonation of macroalgae over tens of meters in vertical extent. Physical environmental stressors include: temperature; substrate texture, heterogeneity and slope; wave disturbance; and light and nutrient availability (Stephenson & Stephenson 1972). Natural disturbance events by wave action or logs clear sessile communities and expose new habitat regularly. Biological stressors include: interspecies competition for space (the major resource), and herbivory by grazers. At a small scale ( $<1\text{m}^2$ ) phylogenetically disparate taxa compete directly for resources, and interaction strengths for these organisms are quantifiable (Wootton 1997; Wootton & Emmerson 2005; Wood *et al.* 2010). Three natural treatments are apparent: 1) a distinct temperature, wave and light stress gradient; 2) major habitat-generating disturbances; and 3) grazer disturbance.

While ecological communities subjected to severe or constant disturbance are often low in diversity (Connell 1978; Chase 2007), the red, green and brown macroalgae (Rhodophyta, Chlorophyta, Phaeophyta) of the rocky intertidal community are remarkably diverse. In the Northeast Pacific, there are thousands of species, with a diversity of morphology, phylogenetic history, competitive abilities and resistance to herbivores (Lubchenco & Gaines 1981; Paine 1984). Macroalgae compete strongly for shared limiting resources in extreme environments; high phylogenetic distance, high environmental stress and high biotic stress (competition and herbivory) allow for testing of the correlations of each of these factors in community assembly.

The rocky intertidal shores of Washington State are systems in which ecology, species dynamics, and natural history are well documented, concomitant with physical features of nearshore seawater and habitat (Dayton 1975; Paine 1977; Wootton *et al.* 2008). At Tatoosh Island, WA, a high-resolution instrumental record documents water quality measurements (pH, temperature, dissolved oxygen, salinity, and chlorophyll a) at 30-minute increments during the spring and summer months of 2000-present (Wootton *et al.* 2008; Pfister *et al.* 2011). Thus, my experiments designed to evaluate drivers of community structure at Tatoosh Island are placed in the context of long-term environmental data.

#### **1) Quantifying the regional species pool near Tatoosh Island**

To evaluate potential drivers of community structure in macroalgal communities, I am quantifying the regional macroalgal species pool using literature-based range maps (after Caley & Schluter 1997) and large-scale survey data (after Russell *et al.* 2006) to assess the effects of each approach in generating null community hypotheses. I am compiling a literature-based range map of intertidal macroalgae occurring in Washington State from the online database AlgaeBase (Guiry & Guiry 2012) and data on habitat preference (Gabrielson *et al.* 2012). AlgaeBase lists worldwide distribution records for marine algae based on primary literature observations, with especially high coverage in the Northeast Pacific Ocean. I am focusing on macroalgae excluding epiphytic and epizoic algae (the majority of which are microscopic). Thus far, the red algal regional intertidal species pool includes species from 66 genera, the majority of

which belong to a diverse group of families within the Class Florideophyceae. I am also using curated intertidal survey data from PISCO (Partnership for Interdisciplinary Studies of Coastal Oceans) to compile a cumulative species list from field observations.

## **2) Building a phylogeny of the macroalgal community**

To understand how phylogenetic diversity changes under varying environmental and ecological conditions, I will sequence seven genes for species found in community plots and species in the local region beginning December 2012. Many species from the regional and local species pools have some sequences already published (see Budget Justification). Nuclear, mitochondrial and plastid genes commonly used in macroalgal molecular systematics and DNA barcoding will be sequenced using well-established protocols and published primer sequences (Saunders & McDevit 2012). Candidate markers to sequence include SSU (18S), LSU (28S), *rbcL*, *cox1*, and EF2, markers that currently have >50% coverage across red algal families (Verbruggen *et al.* 2010) as well as *psaA* and 16S (Silberfeld *et al.* 2010). Currently, there are family-level phylogenies of the red (Verbruggen *et al.* 2010) and brown algae (Silberfeld *et al.* 2010).

While phylogenetic analyses can be performed for this system using published phylogenetic trees at the family level, a more well-resolved tree at the species level will enable finer determination of phylogenetic community structure within algal families. A species-level phylogeny will enable evaluation of phylogenetic hypotheses of environmental filtering (Hypothesis 1) and phylogenetic community response to disturbance (Hypothesis 3). It will also allow me to investigate the degree to which evolutionary history and functional diversity correlate in this highly-disturbed and highly structured ecosystem with more power. Funding from a grant awarded to me by the University of Chicago Hinds Fund and departmental student research funds will support the cost of initial DNA extractions and preliminary reaction optimization from specimens collected in 2012. Funding from this Doctoral Dissertation Improvement Grant would support sequencing of a suite of seven genes from approximately 150 additional individuals, and the DNA barcoding of 150 individuals to catalog the full extent of diversity in the Tatoosh Island intertidal macroalgal community. Molecular laboratory work will be conducted at the Pritzker Laboratory at the Field Museum of Natural History (Chicago, IL).

I will use both abundance (as percent cover) and presence-absence metrics to analyze my community data, as species abundances may be the outcome of competitive interactions (Vellend *et al.* 2011). I will compare community metrics to null communities drawn from the regional species pool. For presence-absence analyses I will use the richness-independent metric Phylogenetic Species Variability (PSV) (Helmus *et al.* 2007), Mean Phylogenetic Distance (Webb 2000), and Mean Nearest Neighbor Distance (Webb 2000). For abundance-weighted analyses I will employ Phylogenetic Species Evenness (PSE) (Helmus *et al.* 2007) and abundance-weighted Mean Phylogenetic Distance (Warwick & Clarke 1995).

## **3-I) Establishing communities on Tatoosh Island to evaluate environmental, disturbance and grazer effects**

I am assessing community structure across three environmental regimes (low, mid, and high intertidal zone), two disturbance levels (intact vs. cleared), and two herbivory levels (ambient vs. reduced grazer abundance). Seventy-two 0.25x0.25m community plots were established in 2011 and 2012. Initial algal species abundance was recorded as percent cover; number and size of herbivores was also recorded. Twenty-seven plots were established in the low zone and the mid zone, and 18 were established in the high zone. Treatments include unmanipulated control plots; major disturbance plots where the existing community was removed down to bare rock; and reduced grazer density plots, where the existing community

was removed down to bare rock and copper sheeting was placed on the borders to exclude grazers (low, mid zones: n=9; high zone: n=6 for all treatments). Thus, I now have three distinct scenarios over which to ask how the phylogenetic history influence community assembly and structure: 1) an unmanipulated control that allows me to look only at the environmental gradient imposed by the intertidal, 2) a physical disturbance treatment, and 3) a physical disturbance treatment where grazers are reduced in abundance. Existing studies of phylogenetic responses to disturbance consist of comparisons of disturbed versus undisturbed sites (Knapp *et al.* 2008; Verdú & Pausas 2009). I am censusing the same community plots pre- and post-disturbance to establish phylogenetic and functional community baselines. Upon completion of fieldwork in 2015, I will have community data for plots at 21 time points across 42 months.

To confirm field identifications of ambiguous red and brown algae, I am collecting tissue samples to perform DNA barcoding analysis using the *cox1* and *rbcL* markers (Saunders 2005; Lane *et al.* 2007; McDevit & Saunders 2009). I will identify species using the Barcode of Life Data (BOLD) Systems DNA barcoding registry (Ratnasingham & Hebert 2007), the Algal Global Life Audit (ALGA), and Genbank. The Northeast Pacific macroalgal community is especially well represented in these databases.

### **3-II) Evaluating fine-scale environmental parameters of Tatoosh Island macroalgal communities to assess environmental filtering**

To evaluate the contribution of environmental filtering to phylogenetic structure and functional diversity of macroalgal communities, I am quantifying abiotic habitat parameters that differ along a vertical gradient. I am measuring wave flow (Thompson & Glenn 1994), habitat slope, tidal height, and desiccation (a composite index of temperature, light and wind stress). Temperature, light and wind exposure generally increase with height (Stephenson & Stephenson 1972); wave action decreases with tidal height (Thompson & Glenn 1994); and habitat slope and texture vary across the height gradient (Stephenson & Stephenson 1972, Johnson 1989). These gradients give rise to intertidal zones characterized by distinct flora and fauna.

I can readily expand my phylogenetic analyses to encompass latitudinal gradients from California to Alaska using PISCO survey data. These larger studies will be conducted using a family-level phylogeny constructed from the literature (Silberfeld *et al.* 2010, Verbruggen *et al.* 2010). I have identified four PISCO datasets for latitudinal comparisons: two broad-ranged datasets that will provide data on sites from Alaska to Baja California (quadrat and transect surveys), and two higher-resolution datasets that will provide a more in-depth comparison of Tatoosh plots to Central and Southern California sites (quadrat and point contact surveys).

### **3-III) Measuring functional trait diversity**

By categorizing a subset of macroalgae into seven functional groups, researchers have shown that traits can predict community structure in biogeographically diverse intertidal communities (Steneck & Dethier 1994). To understand how morphological and functional traits structure communities, I will measure species traits that have been linked to ecological functions.

Species identified in community plots from 2011 and 2012 will be collected and surveyed for functional diversity metrics in 2013. I will measure: thallus size, which has been correlated with herbivory defense (Littler & Littler 1980), growth rate (Pfister & Wang 2005) and species interaction strength (Wood *et al.* 2010); thallus toughness and branching architecture, which have been correlated with resistance to wave action (Norton 1991); desiccation rate, which indicates resistance to wind, temperature and light stress (Norton 1991); and surface area to volume ratio, which correlates with desiccation tolerance (Stewart & Carpenter 2003).

I will also measure a less-studied but important functional trait that may drive macroalgal

community structure: carbon acquisition efficiency. Macroalgae employ diverse mechanisms to acquire inorganic carbon from their environment. They can acquire carbon as either dissolved carbon dioxide ( $\text{CO}_2$ ) or more energetically-favorable bicarbonate ( $\text{HCO}_3^-$ ) (Hepburn *et al.* 2011). Carbon-concentrating mechanisms differ between macroalgae living in intertidal versus subtidal habitats (Murru & Sandgren 2004, Raven *et al.* 2012), indicating a possible response to the availability of different carbon forms across the intertidal gradient. There is also intraspecific variation in carbon acquisition efficiency based on tidal height (Murru & Sandgren 2004), suggesting that carbon acquisition mechanisms could therefore affect the fitness of individuals depending on their location along the intertidal gradient. I will test whether macroalgae acquire dissolved  $\text{CO}_2$  versus  $\text{HCO}_3^-$  in different proportions across the intertidal gradient using pH drift and alkalinity tests (Maberly 1990; Murru & Sandgren 2004). I have designed and prototyped a chamber for testing the ability of macroalgal individuals to take up dissolved  $\text{CO}_2$  versus  $\text{HCO}_3^-$ .

I will use my carbon acquisition studies, functional analyses and field experiments to generate: 1) matrices representing species composition of intertidal communities over three years, 2) matrices of environmental habitat parameters such as plot tidal height, desiccation and wave action, and 3) morphological and functional traits of species. Combining these data with a community phylogeny resolved to the species level will allow me to evaluate the relative contributions of environmental parameters, herbivory and disturbance to community phylogenetic structure and functional diversity.

***Hypothesis 1: Phylogenetic signatures of macroalgal communities indicate environmental filtering in response to a strong environmental gradient***

If environmental filtering structures macroalgal communities, community phylogenetic structure will be clustered (e.g.  $\text{PSE}_{\text{plots}} < \text{PSE}_{\text{null}}$ ). Alternatively, if biotic interactions contribute more towards community assembly, community phylogenetic structure will be phylogenetically overdispersed ( $\text{PSE}_{\text{plots}} > \text{PSE}_{\text{null}}$ ). I predict that communities will be more phylogenetically clustered at higher tidal heights, where environmental stressors such as temperature, desiccation and UV exposure are more intense (environmental filtering) (Webb *et al.* 2002). At lower tidal heights, I predict that assemblages will be phylogenetically overdispersed and include species with a greater range of functional traits, as a result of a less stressful environment and increased biotic competition for resources. The intertidal zone is strongly qualitatively delineated by environmental gradients (Stephenson & Stephenson 1972), including thermal (Helmuth & Hofmann 2001), hydrodynamic (Stewart & Carpenter 2003) and microhabitat and textural differences (Brawley & Johnson 1991). These parameters interact to form a strong gradient over a scale of only meters, potentially leading to distinct suites of adaptive traits and different patterns of phylogenetic structure in the low, mid and high zones. Phylogenetic clustering has previously been observed at the Class level in subtidal macroalgal assemblages in southern Australia from a regional pool of 400 algal species (Smale *et al.* 2010).

***Hypothesis 2: Ecological traits contribute to membership in macroalgal communities across intertidal zones***

I predict that species in the high zone will exhibit traits that improve desiccation tolerance, while traits contributing to herbivory defenses and wave resistance may be more prevalent in species inhabiting the low zone. In more environmentally stressed zones - the mid to high tidal heights (Stephenson & Stephenson 1972) - I expect traits that contribute to environmental tolerance to be more prominent, while in the low zone I expect traits that contribute to enhanced competitive abilities to be more prominent. Because macroalgae occupying the high

intertidal zone are exposed for more hours each day during low tides and therefore experience a longer period without access to seawater, I predict that species and individuals occupying habitats at higher tidal heights will demonstrate increased overall dissolved inorganic carbon acquisition efficiency and increased bicarbonate acquisition efficiency.

**Hypothesis 3: Grazers and physical disturbance are determinants of phylogenetic and functional diversity**

Following manual plot clearing (a major disturbance event opening new habitat), I expect recolonizing communities to be temporarily more phylogenetically clustered, then eventually recover and return to patterns observed in plots prior to disturbance. Evaluations of a subset of five macroalgal species found that while initial colonizers show high productivity, late successional species show resistance wave-shearing forces and have tougher thalli (Littler & Littler 1980). I am expanding these predictions to encompass a full macroalgal assemblage. Early in succession, I expect functional traits that increase productivity to prevail, while species recruiting at later stages should be tougher, more resistant to desiccation and wave action, and have higher competitive ability.

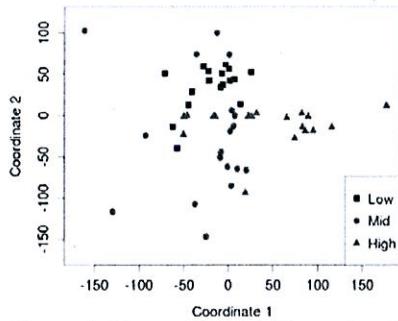
Grazers have been demonstrated to alter the successional process (Lubchenco 1983). Macroalgae may be under increased pressure from herbivory in the mid and low zones, as grazers are more abundant in these zones (Bustamante *et al.* 1995; Bracken *et al.* 2011). Manipulations of grazers (chitons) in the low intertidal zone have resulted in significant changes in macroalgal community composition (Duggins & Dethier 1985). Because invertebrate grazers are more abundant at lower tidal heights, I predict that macroalgal species with functional traits contributing to herbivore resistance will be prevalent in the low zone. In grazer exclusion treatments, species with functional traits contributing to herbivory resistance will be less prominent in the community. If key functional traits contributing to herbivore resistance are evolutionary conserved, then trophic interactions in the form of invertebrate herbivory of macroalgae will lead to phylogenetically clustered communities in communities subjected to stronger herbivory. If those traits are convergent, then communities will be phylogenetically overdispersed (Webb *et al.* 2002; Losos 2008).

**Preliminary results of macroalgal species diversity and community composition**

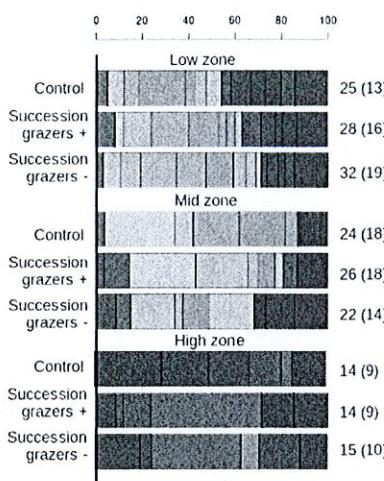
Censuses of macroalgae in 54 0.25x0.25m plots established in 2011 in the low, mid and high zones ( $n = 18/\text{zone}$ ) have revealed 57 unique macroalgal species from 26 different families with distinct patterns among zones (Table 1). While eight species are found in all three zones, 27 are unique to one zone, and the remaining 22 are found across two zones. The mid zone communities have the highest family diversity (24, compared to 13 in the high zone and 20 in the low zone). Beta diversity among community plots (Whittaker's species turnover, (total number of species in a zone divided by average richness per plot)-1) in the low zone is 3.519, in the mid zone is 5.638, and in the high zone is 7.850, implying lower similarity in species composition

among community plots within mid and high zones. Multivariate analyses (Nonmetric Multidimensional Scaling (NMS) and Multiple Response Permutation Procedures (MRPP)) of low, mid and high communities are distinct from one another in algal community composition (MRPP low:mid  $A=0.097$ ,  $p<0.001$ ; MRPP low:high  $A=0.1822$ ,  $p<0.001$ ; MRPP mid:high  $A=0.107$ ,  $p<0.001$ , Figure 1).

Table 1: Total species and family richness per zone and mean richness per site within zone.		
Zone	No. species / families per zone	Mean No. species / families per plot
Low	37 / 20	13.1 / 7.7
Mid	33 / 24	18.9 / 7.2
High	17 / 13	6.7 / 4.5



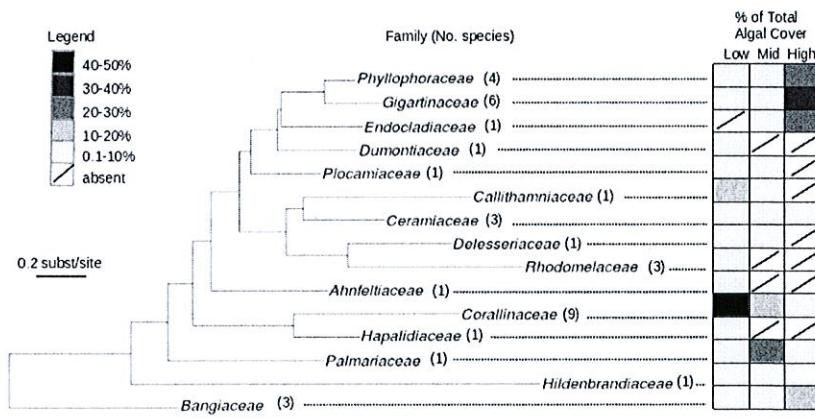
**Figure 1:** Nonmetric multidimensional scaling (NMS) ordination of plots ( $n=18$ /tidal height) in algal species space ( $p=0.001$ ) using Bray-Curtis distances. Tidal height coded by shape and color. August 2012 (month 13).



**Figure 2:** Species composition (as % total algal cover) by zone and by treatment in August 2012. Control: undisturbed. Succession grazers+: community removed, succession allowed with ambient grazers. Succession grazers--: community removed, succession allowed with reduced grazers. Final 15% of species is a composite of species with smallest percent cover. Total number of species depicted at far right of bars, number of species in 15% indicated in ( ). Each color represents a different species.

The diversity and distinctness among these three zones provide the raw material for me to query phylogenetic signals of communities under varying disturbance regimes. Contrasts in community composition among treatments within zones reveal significant differences already within the mid and high zones, indicating there is sufficient variance in community composition to explore the contributions of herbivory and abiotic disturbance to community assembly (**Figure 2**). Grazer effects on species composition are already notable in the high and mid zones (high:MRPP,  $A=0.1183$ ,  $p=0.007$ ; mid:MRPP,  $A=0.0472$ ,  $p=0.014$ ), and succession effects are noted in the high zone (MRPP,  $A=0.09338$ ,  $p=0.006$ ).

In addition to having high species diversity, macroalgal communities are diverse phylogenetically in species and family composition across the low, mid and high zones in the Rhodophyta (**Figure 3**). In the transition from low to mid communities, mid zone communities lose five families from the low and gain nine unique families in the red, green and brown algal divisions combined. In the transition from the mid zone to the high zone, high zone communities gain no new families and lose 11 families. These findings provide motivation to build a species-level phylogeny of the macroalgal community to test the relative contributions of environmental filtering, competition, herbivory and disturbance in structuring these highly diverse assemblages.



**Figure 3:** Phylogenetic tree of red algal families represented in surveyed algal communities. Total number of species observed per family is listed (summation of all zones). Heat map indicates total percent cover of normalized algal percent cover. Tree adapted from Verbruggen et al. 2010. Algal diversity differs among tidal heights; family diversity is lowest in the high zone, where many families are absent.

### **Intellectual Merit**

My proposed combination of techniques to understand community structure is novel. I am integrating the dynamic ecological processes of herbivory and physical disturbance into studies of phylogenetic and functional community structure that have traditionally focused on competition and environmental filtering. By combining approaches from ecology, physiology and phylogenetics, I will be able to evaluate drivers of community assembly and maintenance from environmental, ecological and evolutionary perspectives in tandem. The evolutionary history and trait diversity of assemblages are variables that have been demonstrated to have predictive power in determining the response of communities to environmental perturbations such as climate change and species introductions (Willis *et al.* 2010). These variables provide a new means to determine how diversity contributes to ecosystem services (Cardinale 2011) and for identifying clades vulnerable to anthropogenic disturbance and climate change (Pau *et al.* 2011). Therefore, phylogenetic community studies that directly incorporate dynamic ecological processes (such as herbivory, disturbance, and colonization) and fine-scale environmental patterns (such as temperature and light) will increase the descriptive and predictive power of phylogenetic and functional diversity metrics, and allow for an in-depth comparison of the two metrics. My field-based studies in a highly tractable, well-studied system will incorporate ecological and environmental patterns into a phylogenetic and functional community analysis to identify species traits and macroalgal clades vulnerable to disturbance, and traits and clades that contribute to community recovery.

### **Broader Impacts**

My studies of community structure continue to provide opportunities to work closely with researchers at other institutions and young scientists, both in the lab and the field. In Chicago, DNA sequencing work at Pritzker Lab at the Field Museum of Natural History will provide opportunities to discuss my research with the public regularly during the daily "Talk to the Scientist Hour" where lab scientists host a Q&A session with museum visitors. The lab is additionally an active exhibit and is adjacent to a DNA Discovery Center; visitors will be able to see first-hand that research is undertaken by a diverse group of men and women scientists. Through a partnership with City Year I have taught biology lessons and basic science demonstrations at after-school science clubs at the Dulles School of Excellence and Sherman School of Excellence on the South Side of Chicago and will continue to visit these schools.

The impacts of the proposed work are cultural as well as ecological. Through decades of research conducted on the Makah Indian Reservation, the Pfister laboratory group has cultivated a strong relationship with the Makah Tribe and the Makah Research and Cultural Center. The Makah and other coastal communities on the Olympic Peninsula, WA, depend socioeconomically on the fishing industry, which is linked to coastal ocean productivity. Results from my research will be used for teen and adult educational outreach to increase literacy about ecological change, with emphasis on effects of climate change on coastal ecological communities. I will enhance our lab's outreach opportunities and longstanding ties with the Makah Tribe by working with a Makah intern each year during the field season on ecological field studies and physiological lab studies, thus enhancing participation of underrepresented groups in ecology. I will also continue to participate in Creating Opportunities for After School Thinking (COAST), an organization that tutors children grades K-8 from disadvantaged homes in the Cape Flattery, WA school district in core academic areas and takes several field trips to field sites similar to mine throughout the year.

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## BIOGRAPHICAL SKETCH

Courtney C. Stepien

Committee on Evolutionary Biology, University of Chicago

### (a) Professional Preparation

Wellesley College	Biological Sciences	B.A. 2008
University of Chicago	Evolutionary Biology	M.S. 2012
University of Chicago	Evolutionary Biology	Ph.D. 2015 (expected)

### (b) Appointments

- September 2010 – present, Ph.D. Candidate, Committee on Evolutionary Biology, University of Chicago  
March 2011 – Visiting Scientist, Charles Darwin Research Station, Puerto Ayora, Galápagos Islands  
September 2009 – August 2010, Research Assistant and Lab Manager, Dr. Andrea Sequeira Lab, Dept. of Biological Sciences, Wellesley College  
March 2010 – Visiting Scientist, Charles Darwin Research Station, Puerto Ayora, Galápagos Islands  
September 2008 – August 2009, Howard Hughes Medical Institute Post-Graduate Intern, Dr. Andrea Sequeira Lab, Dept. of Biological Sciences, Wellesley College  
January 2006 – June 2008, Research Assistant, Dr. Emily Buchholtz Lab, Dept. of Biological Sciences, Wellesley College

### (c) Products

#### Other publications:

2012. Sequeira A. S., **Stepien C. C.**, Sijapati M., Roque Albelo L. Past and present of genetic exchange: Comparative genetic structure, variability and demographic history in introduced and endemic populations of Galápagos weevils. *Journal of Heredity*. 103(2): 206-220.  
doi: 10.1093/jhered/esr124

2010. **Stepien C. C.**, Kaczmarek M. E., Mok H. F., Stuckert A., Chen P., Downer S., Sequeira A.S. Isolation and characterization of microsatellite loci for the introduced weevil *Galapaganus howdenae* in the Galápagos archipelago. *Molecular Ecology Resources Notes* 10(3): 576-579. Permanent Genetic Note available online on *Molecular Ecology Resources* Primer Database.  
doi: 10.1111/j.1755-0998.2010.02851.x

2009. Buchholtz, E. A. and **Stepien, C. C.** Anatomical transformation in mammals: developmental origin of aberrant cervical anatomy in tree sloths. *Evolution & Development*. 11(1): 69-79. doi: 10.1111/j.1525-142X.2008.00303.x

### (d) Synergistic Activities

Editor, Bio for the Win. Science blog by biology graduate students for non-scientist citizens.

October 2012 – present

Educational outreach, STEM discussions with high school students underrepresented in STEM October 2012

Poster Presentation at public reception, Chicago Council on Science and Technology Public Event “Our Oceans’ Health: An Ecosystem on the Brink” March 2012  
Mentor to First-Year Graduate Student, Committee on Evolutionary Biology, University of Chicago 2011-2012  
Organizer and Moderator, Committee on Evolutionary Biology / Dept. of Ecology and Evolution Annual Retreat 2011

**(e) Collaborators and Other Affiliations**

Collaborators and Co-Editors

Emily A. Buchholtz (Wellesley College), Peggy Chen (U. Texas, Southwestern Medical Center), Susan Downer (Wellesley College), Maryska E. Kaczmarek (U. Texas, Austin), Sophie McCoy (U. Chicago), Hoi-Fei Mok (U. Melbourne), Catherine Pfister (U. Chicago), Trevor Price (U. Chicago), Richard Ree (U. Chicago), Lazaro Roque-Albelo (Curtin University), Andrea Sequeira (Wellesley College), Manisha Sijapati (Wellesley College), Austin Stuckert (Medical College of Wisconsin), Spencer Wood (Stanford University), Timothy Wootton (U. Chicago)

Graduate Advisors and Postdoctoral Sponsors

Catherine A. Pfister (PhD), University of Chicago

**SUMMARY  
PROPOSAL BUDGET**

YEAR 1

		FOR NSF USE ONLY				
ORGANIZATION		PROPOSAL NO.		DURATION (months)		
<b>University of Chicago</b>				Proposed	Granted	
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR		AWARD NO.				
<b>Catherine Pfister</b>						
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)		NSF Funded Person-months			Funds Requested By proposer	Funds granted by NSF (if different)
		CAL	ACAD	SUMR		
1.	0.00	0.00	0.00			
2.						
3.						
4.						
5.						
6. ( 0 ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. ( 1 ) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. ( 0 ) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0		
2. ( 0 ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. ( 0 ) GRADUATE STUDENTS				0		
4. ( 0 ) UNDERGRADUATE STUDENTS				0		
5. ( 0 ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. ( 0 ) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)					0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING \$5,000.)						
TOTAL EQUIPMENT					0	
E. TRAVEL		1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)		500		
		2. FOREIGN		0		
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS	\$ 0					
2. TRAVEL	0					
3. SUBSISTENCE	0					
4. OTHER	0					
TOTAL NUMBER OF PARTICIPANTS ( 0 )		TOTAL PARTICIPANT COSTS		0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				6,879		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				1,000		
TOTAL OTHER DIRECT COSTS				7,879		
H. TOTAL DIRECT COSTS (A THROUGH G)				8,379		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) <b>Materials and Supplies (Rate: 58.0000, Base: 7879) (Cont. on Comments Page)</b>						
TOTAL INDIRECT COSTS (F&A)				4,860		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				13,239		
K. RESIDUAL FUNDS				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				13,239		
M. COST SHARING PROPOSED LEVEL \$ 0		AGREED LEVEL IF DIFFERENT \$				
PI/PD NAME <b>Catherine Pfister</b>		FOR NSF USE ONLY				
		INDIRECT COST RATE VERIFICATION				
ORG. REP. NAME* <b>Denise Dooley</b>		Date Checked	Date Of Rate Sheet	Initials - ORG		

1 \*ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

## **SUMMARY PROPOSAL BUDGET COMMENTS - Year 1**

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**\*\* I- Indirect Costs**

Travel Domestic (Rate: 58.0000, Base 500)

**SUMMARY PROPOSAL BUDGET**      YEAR 2

ORGANIZATION <b>University of Chicago</b>		FOR NSF USE ONLY				
		PROPOSAL NO.		DURATION (months)		
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR <b>Catherine Pfister</b>		AWARD NO.				
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)		NSF Funded Person-months			Funds Requested By proposer Funds granted by NSF (if different)	
		CAL	ACAD	SUMR		
		1.	0.00	0.00		0.00
		2.				
		3.				
		4.				
		5.				
6. ( <b>0</b> ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	<b>0</b>		
7. ( <b>1</b> ) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	<b>0</b>		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. ( <b>0</b> ) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	<b>0</b>		
2. ( <b>0</b> ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	<b>0</b>		
3. ( <b>0</b> ) GRADUATE STUDENTS				<b>0</b>		
4. ( <b>0</b> ) UNDERGRADUATE STUDENTS				<b>0</b>		
5. ( <b>0</b> ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				<b>0</b>		
6. ( <b>0</b> ) OTHER				<b>0</b>		
TOTAL SALARIES AND WAGES (A + B)					<b>0</b>	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					<b>0</b>	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					<b>0</b>	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING \$5,000.)						
TOTAL EQUIPMENT					<b>0</b>	
E. TRAVEL		1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)			<b>2,968</b>	
		2. FOREIGN			<b>0</b>	
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS \$		<b>0</b>				
2. TRAVEL		<b>0</b>				
3. SUBSISTENCE		<b>0</b>				
4. OTHER		<b>0</b>				
TOTAL NUMBER OF PARTICIPANTS ( <b>0</b> )			TOTAL PARTICIPANT COSTS		<b>0</b>	
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES					<b>1,653</b>	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					<b>0</b>	
3. CONSULTANT SERVICES					<b>0</b>	
4. COMPUTER SERVICES					<b>0</b>	
5. SUBAWARDS					<b>0</b>	
6. OTHER					<b>0</b>	
TOTAL OTHER DIRECT COSTS					<b>1,653</b>	
H. TOTAL DIRECT COSTS (A THROUGH G)					<b>4,621</b>	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) <b>Materials and Supplies: Carbon Acquisition Analysis (Rate: 58.0000, Base: 1653) (Cont. on Comments Page)</b>						
TOTAL INDIRECT COSTS (F&A)					<b>2,680</b>	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					<b>7,301</b>	
K. RESIDUAL FUNDS					<b>0</b>	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)					<b>7,301</b>	
M. COST SHARING PROPOSED LEVEL \$		<b>0</b>	AGREED LEVEL IF DIFFERENT \$			
PI/PD NAME <b>Catherine Pfister</b>		FOR NSF USE ONLY				
ORG. REP. NAME* <b>Denise Dooley</b>		Date Checked	Date Of Rate Sheet	Initials - ORG		

2 \*ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

## **SUMMARY PROPOSAL BUDGET COMMENTS - Year 2**

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**\*\* I- Indirect Costs**  
**Travel Domestic (Rate: 58.0000, Base 2968)**

<b>SUMMARY PROPOSAL BUDGET</b>		Cumulative				
		<b>FOR NSF USE ONLY</b>				
ORGANIZATION <b>University of Chicago</b>	PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR <b>Catherine Pfister</b>	PROPOSAL NO.		DURATION (months)		
				Proposed	Granted	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)		NSF Funded Person-months			Funds Requested By proposer	Funds granted by NSF (if different)
1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE) 7. ( <b>0</b> ) TOTAL SENIOR PERSONNEL (1 - 6)		CAL	ACAD	SUMR		
0.00    0.00    0.00					<b>0</b>	<b>0</b>
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. ( <b>0</b> ) POST DOCTORAL SCHOLARS 2. ( <b>0</b> ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.) 3. ( <b>0</b> ) GRADUATE STUDENTS 4. ( <b>0</b> ) UNDERGRADUATE STUDENTS 5. ( <b>0</b> ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY) 6. ( <b>0</b> ) OTHER		0.00	0.00	0.00	<b>0</b>	<b>0</b>
TOTAL SALARIES AND WAGES (A + B)					<b>0</b>	<b>0</b>
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					<b>0</b>	<b>0</b>
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					<b>0</b>	<b>0</b>
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING \$5,000.)						
TOTAL EQUIPMENT					<b>0</b>	<b>0</b>
E. TRAVEL    1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					<b>3,468</b>	
2. FOREIGN					<b>0</b>	
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS    \$ <b>0</b> 2. TRAVEL <b>0</b> 3. SUBSISTENCE <b>0</b> 4. OTHER <b>0</b>						
TOTAL NUMBER OF PARTICIPANTS ( <b>0</b> )					<b>0</b>	
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES					<b>8,532</b>	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					<b>0</b>	
3. CONSULTANT SERVICES					<b>0</b>	
4. COMPUTER SERVICES					<b>0</b>	
5. SUBAWARDS					<b>0</b>	
6. OTHER					<b>1,000</b>	
TOTAL OTHER DIRECT COSTS					<b>9,532</b>	
H. TOTAL DIRECT COSTS (A THROUGH G)					<b>13,000</b>	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)						
TOTAL INDIRECT COSTS (F&A)					<b>7,540</b>	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					<b>20,540</b>	
K. RESIDUAL FUNDS					<b>0</b>	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)					<b>20,540</b>	
M. COST SHARING PROPOSED LEVEL \$ <b>0</b>		AGREED LEVEL IF DIFFERENT \$				
PI/PD NAME <b>Catherine Pfister</b>		<b>FOR NSF USE ONLY</b>				
		INDIRECT COST RATE VERIFICATION				
ORG. REP. NAME* <b>Denise Dooley</b>		Date Checked	Date Of Rate Sheet	Initials - ORG		

C \*ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

## BUDGET

Funding is requested over two years: \$13,239 in Year 1 and \$7,301 in Year 2

- A) Senior Personnel: \$0
- B) Other Personnel: \$0
- C) Fringe Benefits: \$0
- D) Permanent Equipment: \$0
- E) Travel: \$3468**

**Year 1:** \$500 for round-trip airfare, **Year 2:** \$2968 for round-trip airfare and round-trip drive

Project	Budget Item	Item Cost per Unit	Item Total
<b>Travel Domestic</b>	Chicago – Seattle airfare	\$500/round trip x 2	\$1000
	Chicago – Seattle drive	\$0.555 x 4487 miles round trip	\$2490
		<b>Total:</b>	<b>\$3,490</b>
		<b>Requested from NSF:</b>	<b>\$3,468</b>

### Travel

**Chicago-Seattle airfare:** Transportation from Chicago to Washington for a Spring helicopter trip to Tatoosh Island, WA in April 2014 and April 2015.

**Chicago-Seattle drive:** To provide vehicle access for 2014 Summer field season (Jun-Sept). The field site and surrounding region is remote, such that a vehicle is required for travel to mainland field sites for additional specimen collections. One round-trip for the Summer 2013 season is paid for by a Departmental Travel allowance and student expense account, and funding is requested for one round-trip for a second field season in Summer 2014. Costs of a 3.5-month car rental based out of Washington (and airfare from Chicago-Seattle to travel to field site and pick up the rental) exceed the round-trip costs of driving from Chicago by several thousand dollars.

**Travel to Tatoosh:** Travel between Neah Bay, WA and the primary field site on Tatoosh Island, WA by boat and helicopter and all related expenses will continue to be paid for by funds to my advisor, CA Pfister. Seven trips in 2013 and seven to eight trips in 2014 are provided for.

F) Participant Support Costs: \$0

G) Other Direct Costs

#### 1. Materials and Supplies: \$8532

**Year 1:** \$6879 for phylogenetic analysis, **Year 2:** \$1653 for carbon analysis

**Phylogenetic Analysis:\$6,879**

Project	Budget Item	Item Cost per Unit	Item Total
<b>Phylogenetic Analysis</b>	AcroPrep 96-well filter plate	\$90.46 x 5 units	\$452
	Extraction reagents	\$650	\$650
	Primers	\$8 x 56	\$448
	Agarose gel	\$254 x 2 for 100g	\$508
	Taq Gold polymerase	\$197 x 12 for 200 rxns	\$2364
	Other PCR reagents	\$550	\$550

<b>Project</b>	<b>Budget Item</b>	<b>Item Cost per Unit</b>	<b>Item Total</b>
<b>Phylogenetic Analysis Continued</b>	QIAquick PCR Purification Kit	\$498 x 4 for 250 units	\$1992
	Pritzker Lab Startup Fee	\$100	\$100
	Misc. tubes, tips, loading dye, running buffer	\$750	\$750
		<b>Total:</b>	<b>\$7,814</b>
		<b>Requested from NSF:</b>	<b>\$6,879</b>

### **Phylogenetic Analysis:**

Laboratory work will be conducted at the Pritzker Laboratory for Molecular Systematics and Evolution at the Field Museum of Natural History in 2013. Costs include estimates of repetition due to: exhaustion of available DNA template and resulting secondary extractions, difficulty in isolation of single-copy gene regions and necessary repetition for reaction optimization.

**Lab materials:** The protocol developed for extracting DNA from marine macroalgae has been modified and improved from existing protocols and is thus not commercially available as a kit. Several primer pairs will be tested to optimize amplification. While the Pritzker Laboratory makes available sequencing equipment and facilities for molecular systematics (see Facilities, Equipment and Other Resources), researchers are entirely responsible financially for consumable materials and machine runs.

**Gene Sequencing:** Un-sampled genes of the 55 species found in plots (below), and 15 additional local species outside experimental plots, are targeted for each of 7 genes. The goal is to obtain a complete suite of species for each gene. Sampling is determined from existing sequences in GenBank database. Additionally, requested funding includes resources for DNA barcoding of possibly cryptic species in some lineages of the Rhodophyta. Twenty-three candidate species for barcoding have been identified thus far for confirmation of field and morphological species identification, for which 5-10 individuals will be collected per candidate species.

Number of gene sequences already obtained and sequences and base pairs still needed for each of seven genes. Underlining indicates established DNA barcoding genes in macroalgae.

	SSU rDNA	<u>LSU</u> rDNA	EF2 nuclear	<u>rbcL</u> plastid	PsaA plastid	<u>Cox1</u> mtDNA	16S mtDNA
<b>Gene sequences published</b>	16	12	4	38	11	25	5
<b>Unsampled species</b>	37	41	49	15	42	28	48
<b>N ind (2 per species)</b>	74	82	98	30	84	56	96
<b>bp</b>	1,450	2,134	780	1,428	2,079	663	1,451
<b>Total length (bp) per gene</b>	107,300	174,988	76,440	42,840	174,636	37,128	139,296
<b>Total length (bp):</b>	752,628						

**Carbon Acquisition Analysis: \$1,653**

Project	Budget Item	Item Cost per Unit	Item Total
<b>Carbon Acquisition Analysis</b>	HOBO Data Loggers UA002-64	\$55 x 2 units	\$110
	HOBOware Software License	\$92	\$92
	Submersible water pump	\$30	\$30
	UV sterilizer	\$40	\$40
	HACH portable pH meter HQ40d	\$943	\$943
	TMC Aquabeam 1000 GroBeam full-spectrum set of 10 LEDs	\$263 x 1	\$263
	Misc. aquarium supplies	\$175	\$175
	<b>Total:</b>		<b>\$1,653</b>
	<b>Requested from NSF:</b>		<b>\$1,653</b>

**Carbon Acquisition Analyses:**

Carbon acquisition analysis will be conducted in June-September 2014 out of rented housing used by PI for additional field research, which provides a field laboratory readily set up away from the university. This allows for specimens to be studied within 6-12 hours of collection.

**HOBO Data Loggers and Software:** Data loggers in the experimental setup will monitor light intensity and temperature at all times to ensure constant environmental conditions are maintained. A yearly renewable software license is required to read data output.

**HACH portable pH meter:** A portable pH meter is requested to use with a pH probe to monitor pH saturation curves in macroalgae specimens, a key measurement for determining carbon acquisition patterns. A pH probe is available at the field site laboratory.

**Water pump and UV sterilizer:** Sterilized seawater will be used to ensure repeatability, eliminate photosynthetic output and water chemistry changes by microbes, and ensure homogeneous water chemistry conditions.

**Full-spectrum LEDs:** One GroBeams light system is requested to provide constant light at the appropriate color temperature and intensity to macroalgal specimens.

**Miscellaneous aquarium supplies:** Including tubing, additional chambers and tanks, and costs of water chemistry analyses and kits.

**2. Other: \$1000 in Year 1**

We are requesting \$1000 for the sequencing of samples at the Pritzker Laboratory in Year 1 at the price of \$20 per run for 50 runs, a total of 2400 samples.

**H) Total Direct Costs: \$13,000****I) Indirect Costs: \$7540**

The University of Chicago has an indirect cost rate of 58% of all modified total direct costs. The University of Chicago's latest Federal Facilities and Administrative Agreement was approved on 4/23/2012.

**J) Total Direct and Indirect Costs: \$20,540****K) Residual Funds: \$0****L) Amount of This Request: \$20,540**

## **FACILITIES, EQUIPMENT, and OTHER RESOURCES**

**On-Site Laboratory in Sekiu, WA:** Fieldwork and on-site lab work will be conducted on the Olympic Peninsula in Washington State and based out of rented housing used by PI. This provides an on-site field laboratory facility readily available for functional and morphological analyses. Equipment available for use in this lab includes: 2 portable field balances; 1 pH probe; 2 digital cameras; 1 flow meter; 1 flow-through aquarium chiller; tank setup; seawater filtering equipment

### **Equipment at the University of Chicago laboratory:**

1 Nikon dissecting microscope with 7x zoom  
1 Olympus compound microscope with Nomarski, Phase Contrast, Polarized Light  
Ample refrigerator & freezer storage space

### **Pritzker Lab, Field Museum of Natural History, Chicago, IL:**

The Pritzker Laboratory for Molecular Systematics and Evolution is a multi-user facility supported by the Field Museum. All equipment necessary for DNA amplification, electrophoresis, sequencing are available. Major equipment includes:

ABI 3730 Genetic Analyzer for DNA sequencing  
Seven thermal cyclers and four gradient EP thermal cyclers for polymerase chain reaction  
Concentrators for drying and concentrating samples  
Ample -80°C storage space  
Nanodrop for measuring nucleic acid concentrations

**Clinical:** N/A

**Animal:** N/A

**Computer:** Computer expertise is available at the University of Chicago, and the PI has access to adequate computing power both on and off campus. Computer consultants are available through the PI's department. Multiple G3 and G4 PowerPCs and Pentium PCs are available for common use at the Pritzker Lab, and Field Museum research staff, post docs, students and visitors have access to an on-site computing cluster managed by a postdoctoral associate for phylogenetic analyses.

**Office:** The PI has dedicated office space at the University of Chicago provided by the Department of Ecology and Evolution, and dedicated rental office space near the primary field site.

**Other:** Despite being a remote field site, Tatoosh Island has the necessary equipment to complete the proposed work, including dissecting and compound microscopes for field identifications and solar power for recharging laptop computers and charging and programming electronic equipment while in the field.

## DATA MANAGEMENT PLAN

The proposed project generates very different datasets: 1) carbon acquisition patterns, 2) community presence-absence and abundance (as percent cover) of macroalgae, and counts of invertebrates, 3) environmental data (desiccation, wave action, light, and tidal height), 4) morphological data (e.g. body size, thallus toughness, desiccation rate and branching architecture), and 5) DNA sequence data for seven genes.

Data type 1 is recorded with a pH meter, and the files are transferred to a personal computer and backed up in the field. Data types 2-4 are recorded in paper notebooks in the field or in the field-based laboratory to ensure a paper record is maintained indefinitely. Periodically data notebooks are photographed to ensure a digital record of the raw data. Data are then entered into spreadsheets. Data type 5, DNA sequence data, will be provided as electronic data files upon completion of DNA sequencing. The digitized data are stored indefinitely on the Co-PI's personal computer and external hard drive and are backed up daily to a remote online server. Data will remain on the lab's computers post graduation, freely available to lab members. The data are also available to members of the scientific community by contacting me. My dissertation research is undertaken with the permission of the Makah Tribal Nation, who maintain rights to the field sites. As such, the Tribe will be provided with copies of the data.

I will analyze the data and present the results at national scientific conferences, and publish findings in peer-reviewed journals. I will also continue to maintain a scientific blog to share data (from the raw form through analysis) with the public. Community census data will be collected based on previous protocols used at the field site (Paine 1984). Carbon acquisition analyses will be performed using established protocols (Murru & Sandgren 2004). Environmental data such as desiccation will be collected based on Stachowicz et al.'s methods (Stachowicz et al. 2008), wave action will be recorded via dissolution of plaster cards (Thompson & Glenn 1994) and morphological data will be collected based on previous classification schemes (Steneck & Dethier 1994). There are also precedents for collection of biomechanical data such as thallus toughness and desiccation rate of macroalgae (Norton 1991).

Molecular systematic work is based on well-established protocols. I will use Saunders' protocol for tissue sampling and preservation, for DNA extraction of all macroalgal tissue samples, and for DNA barcoding using *cox1* and LSU across all three lineages of macroalgae (Saunders and McDevit 2012). This methodology is a standard protocol for the Red Algal Tree of Life Project and is widely used in the field. I will use Silberfeld's methods for *cox1*, LSU, *psaA*, *rbcL* and 16S for brown macroalgae (Silberfeld et al. 2010). Primers and reaction conditions for EF2 and SSU are also drawn from previous work (Le Gall and Saunders 2007).

Data types 1-4 will be uploaded to Dryad (<http://datadryad.org>), and to Ecological Archives for publications in ESA journals. DNA sequences (data type 5) will be curated and uploaded to GenBank (<http://www.ncbi.nlm.nih.gov/genbank/>) and the Algal Life Global Audit in the Barcode of Life Data Systems DNA barcoding registry (<http://www.boldsystems.org/>). Aligned sequence data and resulting phylogenetic trees will be made available on PhyloTA (<http://phylota.net/>) and TreeBASE (<http://treebase.org>). Upon uploading, the data will be freely available for analysis with the requirement that the original study is cited.

Data are derived from free-living non-human organisms, and as such are not subject to issues of confidentiality or other privacy concerns.

THE UNIVERSITY OF CHICAGO  
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Tuesday, October 23, 2012

To Whom It May Concern:

Courtney Stepien has advanced to candidacy for a Ph.D. degree.

Sincerely,



Michael I. Coates  
Professor and Chair

## CONTEXT FOR IMPROVEMENT

The goal of my research is to integrate the dynamic ecological processes of herbivory and physical disturbance into studies of phylogenetic and functional community structure that have traditionally focused on competition and environmental filtering. I am investigating how phylogenetic and functional diversity contribute to species coexistence in the rocky intertidal macroalgal community, and how these factors shape community responses to ecological disturbances and environmental processes. To understand how phylogenetic and functional diversity shape communities among and within discrete environmental zones in the field, I am: 1) evaluating fine-scale habitat and environmental parameters along a strong environmental gradient, 2) controlling herbivore abundance with grazer exclusions and 3) clearing new habitat to observe community succession and habitat recolonization under differential disturbance regimes. I am combining these field experiments with functional lab analyses and phylogenetic tools to identify functional traits and macroalgal clades vulnerable to disturbance, and traits and clades that contribute to community recovery and maintenance.

I am currently involved in several projects that explore factors contributing to the maintenance of community diversity. In 2011, I completed a three-month long mark-recapture study of sculpin communities with Cathy Pfister, in which I evaluated pairwise species interactions between three species of these tidepool fishes. With Spencer Wood, I am exploring the phylogenetic signatures of species interactions in a large dataset of pairwise species interactions from the intertidal community. We are investigating how strength and direction of pairwise interactions change with phylogenetic distance between a species pair.

The bulk of funding requested in this proposal is required to complete phylogenetic analyses to complement a three-year macroalgal community dataset I am generating from field experiments. Contrasts in experimental community composition reveal significant differences already within the mid and high zones; there is sufficient variance in community composition to warrant investigation of phylogenetic community structure across the intertidal gradient. While phylogenetic analyses can be performed using published phylogenetic trees at the family level, a well-resolved tree at the species level will enable finer determination of phylogenetic community structure within algal families. A species-level phylogeny will enable a finer-scale evaluation of phylogenetic hypotheses of environmental filtering (Hypothesis 1) and community response to disturbance (Hypothesis 3). It will also allow me to investigate the degree to which evolutionary history and functional diversity correlate in this highly-disturbed ecosystem with more power.

My advisor, Dr. Catherine Pfister, has expertise in population ecology and has been working at our field sites for 24 years. Her current research and funding is focused on ecosystem and nutrient effects of species interactions. While we have worked together on a species interaction project, my dissertation work focuses on the role of evolutionary history in assemblages, as informed by macroalgal successional communities, a line of research distinct from her own. I obtained funding for my 2011 field season for an intertidal sculpin project and pilot macroalgal studies from the University of Chicago Hinds Fund (\$1895). Hinds funding in 2012 (\$1000) has been necessarily earmarked for preliminary DNA extraction and initial sequencing work for specimens collected at field sites in 2012. My advisor's funding will continue to provide logistical support for travel (via boat and helicopter) to remote field sites on Tatoosh Island. Funding from a Doctoral Dissertation Improvement Grant will ensure that I am able to continue to work at coastal Washington sites in 2013 and 2014, complete the proposed phylogenetic analyses of intertidal macroalgal communities, and analyze algal carbon-acquisition patterns to evaluate the drivers of community structure in this high-stress high-diversity system.

## Proposal Status | MAIN ▶

**Organization:** University of Chicago

### Panel Summary #1

**Proposal Number:** 1311286

**Panel Summary:**

Panel Summary

If this a resubmission, how have previous criticisms been addressed?

NA

#### Criterion I: Intellectual Merit

**Intellectual Strengths:** The research presents a novel, innovative and impressive approach to look at community assembly of a diverse macro-algal community under various disturbances. The panel was impressed by the incorporation of phylogenetic data, functional trait data, and a multifactorial manipulative experimental design. The panel felt that the proposed research would be a significant extension to the dissertation research which was comprehensive on its own. The panel also looked favorably upon the experimental aspect of the research.

**Intellectual Weaknesses:** The panel felt that more clarity on the specific hypotheses to be addressed was warranted. The panel also suggested that a rationale for the number of genes to be used, a better description of the functional traits to be assessed, and some additional preliminary data were needed.

#### Criterion II: Broader Impacts

**Strengths:** The research could advance our understanding of what contributes to community assembly in a diverse system that is frequently exposed to disturbances. The approach was comprehensive and impressive. Broader impacts were reflected in education at both the undergraduate, K-8, and community levels, maintaining research partnerships with native peoples, and research findings will be shared.

**Weaknesses:** Broader impacts of the specific scientific novelties were not mentioned.

**Context for Improvement:** The proposed work will augment the dissertation by allowing the Co-PI to provide a more robust phylogeny to address questions related to the importance of evolutionary history in community assembly. The research is similar to the advisor but appears to be separate.

**Data Management Plan:** Data management plan was solid and well described. Environmental and molecular data will be submitted to appropriate venues and research published. The PI and Co-PI have impressive publication records so this seems likely that results will be disseminated.

### SYNTHESIS AND RECOMMENDATION

The PIs propose to understand what structures a diverse macro-algal community in a rocky intertidal area after various types of disturbances. The panel thought the questions were innovative and the scope of approaches novel. The research has a potential to make significant contributions to community ecology and approaches used in the field. The panel had some concerns over methods but felt that these could and would be resolved and thus they were of minor importance.

The panel recommendation is: Highly Competitive

This summary was read by the assigned panelists and they concurred that the summary accurately reflects the

panel discussion.

**Panel Recommendation:** Highly Competitive

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## Proposal Status | MAIN ▶

**Organization:** University of Chicago

### Review #1

**Proposal Number:** 1311286

**NSF Program:** Population and Community Ecology Program

**Principal Investigator:** Pfister, Catherine A

**Proposal Title:** DISSERTATION RESEARCH: The Roles of Evolutionary History and Ecological Interactions in the Maintenance of a High-Diversity Algal Assemblage

**Rating:** Excellent

#### REVIEW:

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

The proposed research will generate a community phylogeny of Pacific macroalgae for use in a community assembly study conducted on Tahoosh island. Using a set of manipulative experiments that have altered disturbance and grazer regimes, the proposed research will be able to dissect how a variety of factors contribute to community assembly in macroalgae communities.

Strengths: Phylogenetic community ecology approaches have gained wide popularity in the last decade. Despite this, most studies infer process from pattern in natural communities, and comparatively few have taken an experimental approach through manipulation to test predictions made from this theory. The approach here is novel and creative and the proposed molecular phylogeny and functional trait data will increase the power of the analyses. The experimental set up is well laid out and sample size is large and the hypotheses and predictions are clear. Previous research and presentation of those results suggest that this project will be able to successfully test predictions. The PI has a long history of successful research in the area and the team is well qualified to carry out the resources. Adequate resources are available. Overall, an excellent proposal.

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

Strengths: The research is of direct importance to society due to the importance of macroalgae communities to fisheries. Research will be communicated through peer reviewed publications, presentations, and outreach at the Field museum and through our outreach activities in high schools near the field site. Research will involve local Makah intern as research assistants.

Please evaluate the strengths and weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if applicable

The proposed research will greatly strengthen existing results by providing a higher resolution molecular phylogeny. The work is distinct from the research of the PI.

#### Summary Statement

Through a series of well designed manipulations and the creation of a high resolution molecular phylogeny, this research will shed light on the important biotic and abiotic drivers of community assembly in Pacific macroalgae communities. The research is novel in its incorporation of phylogenetics, functional traits, and experimental manipulations to test predictions about how these diverse algal communities are assembled. One of the best proposals I've reviewed.



## Proposal Status | MAIN ▶

**Organization:** University of Chicago

### Review #2

**Proposal Number:** 1311286  
**NSF Program:** Population and Community Ecology Program  
**Principal Investigator:** Pfister, Catherine A  
**Proposal Title:** DISSERTATION RESEARCH: The Roles of Evolutionary History and Ecological Interactions in the Maintenance of a High-Diversity Algal Assemblage  
**Rating:** Good

#### REVIEW:

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

The research is novel in that it tests specific phylogenetic hypothesis with observation and experimental data and looks at multiple factors that can structure communities. The research also has the potential to significantly contribute to our understanding of what influences community assembly in intertidal regions. The background and significance of the research is clearly detailed and impressive.

The research plan while novel and interesting was hard to follow. It was not clear what the three hypotheses being tested were – perhaps these could be highlighted? It was also not clear how quantification of the regional species pool would be incorporated into analyses. A rationale for sequencing 7 genes from species in community plots needs some attention. For example, why would two genes not be sufficient here (cox 1 and rbcL)? Some preliminary data on the number of genes needed to resolve the communities to a species level is needed and preliminary data showing that the Co-PI can accomplish the task. Sample sizes for the sequencing efforts are also unclear.

The experimental establishment of communities is a novel and worthwhile idea with potential to be very informative. The measurements of functional traits are also a good addition, although more description of methods is warranted.

While the ideas presented are certainly novel and the work is important, the proposal was hard to follow. Hypotheses and the rationale for collecting some data were unclear. The proposal lacked a sense of flow and did not present itself as a coordinated proposal. A better integration of the preliminary data in addressing the hypotheses is also warranted. Some clarity of statistical methods and integration of the parts to make a coherent whole is needed.

The presentation of ideas and the Co-PI's past work suggest that they are qualified for the research. However, much of the dissertation research is in its infancy and much work is still incomplete such as all the functional analyses and DNA sequencing (2000 sequences). This is a tremendous amount of work and it is not clear whether this can be accomplished in the time frame. Related to this whether the DDIG is an extension of the dissertation research that would significantly improve its quality is not apparent until more of the core research has been completed and synthesized.

Budget rationale was provided. It is not clear whether the carbon acquisition analysis is necessary. There is a lot of genetic work and as mentioned above a convincing and clear rationale for sequencing 7 genes/sample for a total of 2400 samples is needed.

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

Broader impacts are good. The broader impacts are reflected in educational programs (expertise to graduate students, mentoring field intern, and discussion with community members and K-8 groups interested in work through exposure via the Field Museum of Natural History or other programs), building infrastructure between labs (molecular work done in the lab of another PI via the Field Museum of Natural History and continued work with a native tribal group) and the dissemination of research through publications and other presentations (Co-PI has

shown that work is published in quality journals).

Please evaluate the strengths and weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if applicable

#### Summary Statement

The dissertation research and DDIG proposal seek to understand what structures or contributes to community assembly in a highly diverse macro-algal community that experiences various spatial disturbances. The research is novel in that it tests specific phylogenetic hypothesis with observation and experimental data and looks at multiple factors that can structure communities. The research also has the potential to significantly contribute to our understanding of what influences community assembly in intertidal regions. The weaknesses of the proposal are the research plan is hard to follow, hypotheses and rationale for some of the approaches are not clear, and the preliminary data is insufficient. While the detailed phylogenetic methods could improve the quality of the dissertation research, more work on the core of the dissertation is warranted. It is somewhat questionable whether the dissertation research could be completed without the DDIG funding.

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**Proposal Status** | MAIN ▶

**Organization:** University of Chicago

**Review #3**

**Proposal Number:** 1311286  
**NSF Program:** Population and Community Ecology Program  
**Principal Investigator:** Pfister, Catherine A  
**Proposal Title:** DISSERTATION RESEARCH: The Roles of Evolutionary History and Ecological Interactions in the Maintenance of a High-Diversity Algal Assemblage  
**Rating:** Excellent

**REVIEW:**

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

The project investigates how phylogenetic and functional diversity contribute to species coexistence, and how these factors shape community responses to ecological disturbances and environmental processes. The research combines field experiments with functional lab analyses and phylogenetic tools to identify functional traits and macroalgal clades vulnerable to disturbance, and traits and clades that contribute to community recovery and maintenance. The DDIG will support the completion of phylogenetic analyses. Overall, the research work addresses an important topic of community assembly with the consideration of ecological processes and evolutionary history. The overall research framework is well conceived and feasible. Results from this project should be relevant not only to community ecology, but also to conservation biology.

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

The project has the potential of improving our understanding in community ecology in general. It also has an interesting plan of encouraging underrepresented groups in ecology.

Please evaluate the strengths and weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if applicable

Summary Statement

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