The California State University
COUNCIL ON OCEAN AFFAIRS, SCIENCE & TECHNOLOGY (COAST)

Dr. Kenneth H. Coale Graduate Scholar Awards
AY 2022-2023 Application Form
Application Deadline: Wednesday, January 25, 2023, 5:00 p.m. PST

Please see information on Dr. Kenneth H. Coale Graduate Scholar Awards on the COAST **website** and read the **Announcement** for full details and instructions.

Submit this form (which includes the Advisor Sign-Off Form) as both a Word document and a PDF file named as follows: *LastName_FirstName_App.docx* and *LastName_FirstName_App.pdf*. Submit both files as attachments, along with your **Department Commitment Form** (if needed) in **ONE** email to graduate@share.calstate.edu. **Please note**: A signature is required from your advisor on the **Advisor Sign-Off Form** only in the PDF version of your application that you submit. Your Advisor must submit your LOR to gradletter@share.calstate.edu separately.

Student Applicant Information

First Name:	Bailey	Last Name:	McCann
CSU Campus:	Cal Poly Humboldt	Student ID#:	
Email:		Phone:	
Degree Program:		Degree Sought (e.g., MS, PhD):	MS
Matriculation Date (mm/yy):		Anticipated graduation date (mm/yy):	
GPA in Major Courses:		Thesis-based? (Y/N):	Y

Advisor Information

First Name:	Paul	Last Name:	Bourdeau
CSU Campus:	Cal Poly Humboldt	Department:	Biological Sciences
Email:		Phone:	

Research Project Title:	**Does climate warming amplify the effects of a range-expanding marine gastropod?**
Project Keywords (5-7 keywords related to your project):	Range-expanding species, invasion biology, intertidal ecology

Budget Summary (must add up to $4,000)

Award amount directly to awardee (through financial aid):	$1,984.00
Award amount to Department (DCF required for department funding):	$2016.00

The information on this page is for COAST use only and will not be shared with potential reviewers.

Have you previously received a COAST Graduate Student Research Award? (Y/N)	N
If yes, please provide year(s) of award(s):	

Committee Members (Required)

Name	Department	Campus

CSU Suggested Reviewers (Required): Suggested reviewers must be from the CSU. Do not suggest any reviewers from your campus or reviewers with a potential conflict of interest.

Name:		
CSU Campus:		
Department:		
Email:		

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Please refer to the **Award Announcement** for detailed instructions on the information required for each of the following sections. All the boxes below will expand as you type.

Project Description (65 points total): 1,500-word maximum; any text over this limit will be redacted

Background

Humans are causing unprecedented changes to the earth's climate [1, 2], including increases in air and sea surface temperatures (IPCC 2014), which have been shown to be major threats to marine biota [3]. Increases in temperature can have important effects on the physiology, demography, and abundance of marine species [4], and can play a dominant role in determining the distribution of marine organisms, as most are ectothermic [5]. Thus, marine species whose distributions are limited by cold temperature may be able to expand poleward as air and/or water temperature increases [6]; such species are considered range-expanding species.

The effects of climate warming on the distribution of range-expanding species are well documented [7], but the interactive effects of climate warming and range-expanding species on recipient communities remain understudied. Range-expanding species may be able to take advantage of emerging opportunities for colonization and population growth created by climate change [8]. Further, recipient communities may be especially vulnerable to climate driven range-expanding species because these communities face the dual challenge of both the warming climate and the range-expanding species, the latter of which may be more equipped to handle the warmer conditions [9, 10, 11]. Thus, range-expanding species may become a threat to local biodiversity due to their strong competitive or predatory effects on potentially weakened recipient communities [12, 13], making them a topic of considerable interest in ecology and conversation biology [14].

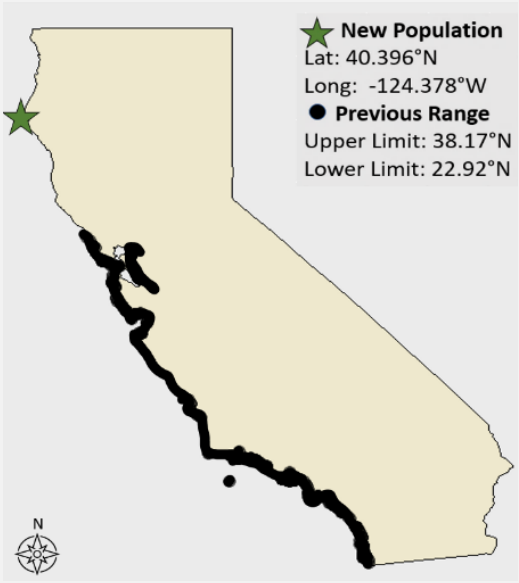

Fig. 1. A map showing the previous range and new population of *A. spirata*.

Acanthinucella spirata is a North American carnivorous marine gastropod [15, 16] that has expanded its distribution along the California coast since the Pleistocene via a poleward geographical range expansion, tracking climatic change [17]. The previously documented distribution for this species ranged from Punta Baja, Baja California, Mexico (22.92°N) to Tomales Bay, California, USA (38.17°N; 18). However, a population of *A. spirata* was recently documented at Cape Mendocino, California, USA (40.40°N), indicating a 'jump' range expansion and the first record of this species north of its currently recognized northern geographic range limit (Figure 1A; 19). At *A. spirata's* southern range limit, average water temperatures are approximately 10 °C warmer

than at Cape Mendocino, CA [Servicio Meterological Nacional]. Due to its evolution in warmer locations, *A. spirata* may be better adapted than native snails to the warming environment [20].

In its historical range, *A. spirata* is a generalist, feeding on barnacles, mussels, snails, and other invertebrate taxa [21, 22], however, it has been shown that *A. spirata* prefers barnacles (*Balanus glandula* and *Cthamalus dalli/fissus*) over other prey [23]. *Balanus glandula* (Darwin, 1854) is a prominent foundation species of rocky intertidal communities on the California coast. Found locally on Cape Mendocino, *Balanus glandula* may represent the preferred prey of recently expanded *A. spirata* populations [24, 25, 26]. Further, barnacles are the preferred resource among local muricid snails, including *Nucella lamellosa* (Gmelin, 1791) on Cape Mendocino. If *A. spirata* preferentially consume barnacles, their presence could cause a shift in native predatory snail assemblages via reductions in barnacles, altering local community structure [23, 27].

For my thesis, I am determining how *Acanthinucella spirata* will impact local assemblages under predicted warming conditions. Specifically, I will assess whether *A. spirata* is (1) likely to take advantage of feeding opportunities created by climate warming in its new location, and (2) better suited to the warming conditions than a native competitor (*N. lamellosa*) due to stronger predatory effects on their shared barnacle prey. I am using a combination of field and laboratory studies to examine the feeding activity of *A. spirata* and *N. lamellosa* on shared prey on Cape Mendocino under ambient conditions and predicted warming scenarios.

Preliminary Field Results

I hypothesized that *A. spirata* could be a novel competitive threat to local predatory snails due to its high local abundance, overlapping habitat, and shared prey preferences. To test this, I recorded snail abundance, distribution, and behavior though a series of field surveys on Cape Mendocino in the summer of 2022. I quantified the abundance and vertical distribution of *A. spirata* and their potential competitors (the whelks *Nucella ostrina* and *Nucella lamellosa*), and documented *A. spirata*'s propensity to feed on their shared prey (the barnacle *Balanus glandula*). I found that *A. spirata* is three to ten times more abundant than *N. lamellosa* and *N. ostrina,* respectively (Fig. 2A), and overlaps almost completely in vertical distribution with *N. lamellosa* (Fig. 2B). In addition, I observed that *A. spirata* exclusively feeds on the barnacle *B. glandula,* the preferred prey of *N. lamellosa* (Fig. 2C). Based on these results, I predict that *A. spirata* and *N. lamellosa* are competing for both habitat and prey.

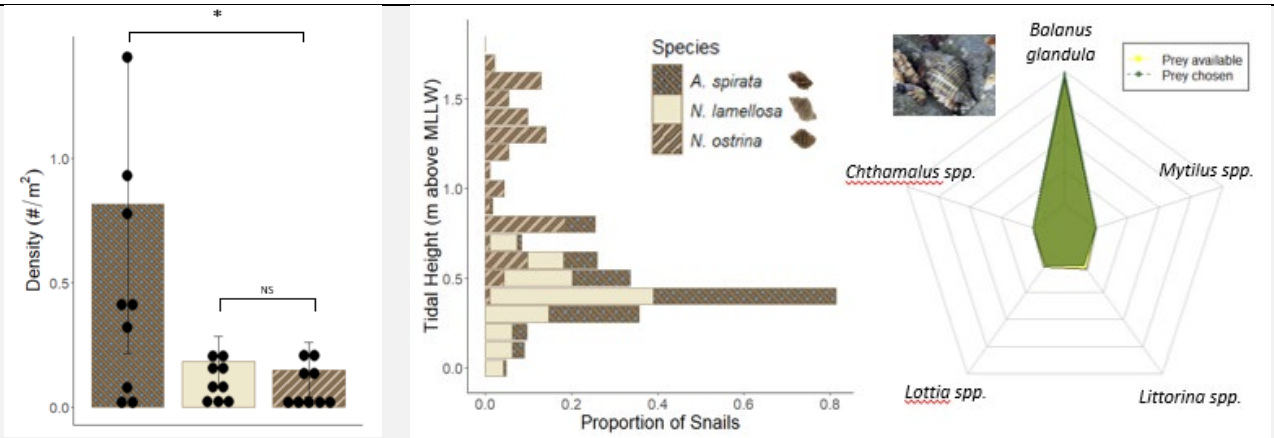

Fig 2. (A) Abundance (individuals · m^{-2}) and (B) vertical distribution of predatory snails; and (C) proportions of available prey and prey selection exhibited by *A. spirata*, at Cape Mendocino, CA.

Laboratory Methods

Feeding rate

To understand how air and water temperature will affect the feeding and competitive abilities of *A. spirata* and *N. lamellosa* on their shared prey (*B. glandula*), I will record feeding rates of snails under ambient conditions and conditions simulating air and sea surface warming. Air and water temperature were selected according to the data collected from the field and climate change predictions made by the IPCC [28]. I will have four temperature treatment combinations:

A. ambient conditions (water 12 °C, air 16 °C)
B. increased water temperature (water 14 °C)
C. increased air temperature (air 20 °C)
D. increased water temperature and increased air temperature (temps from B & C)

Each of the temperature treatment combinations will be crossed with three levels of competitor presence (two individuals of *A. spirata*, two individuals of *N. lamellosa*, one individual of each species). Each experimental treatment combination will be replicated a minimum of 3 times per trial for a total of 36 experimental aquaria. The experiment will be carried out as two trials to increase the replication of each experimental treatment combination to 6. To maintain water temperature, 4 header tanks will supply ambient or warmed water to 40 insulated replicate (18 x 28 x 20 cm) aquaria (Fig. 3). To maintain elevated air temperature, individual aquaria will be fitted with a ceramic heat emitter. Tidal exchanges mimicking those experienced by the snails in nature will be simulated each day. Each replicate aquarium will house either two individuals of the same species or one individual of each species, and one barnacle-encrusted rock scraped to a uniform number of *B. glandula* individuals. As a control for natural barnacle death, 4 aquaria without snails will be set to the four temperature treatments (A-D). The barnacle prey chosen for this experiment are based on field observations of the snails' preferred prey item in the field survey (*B. glandula*; Fig. 2C). Snails will be starved and conditioned to one of the four temperature treatment combinations listed above (A-D) in the aquaria for a week before recording feeding rate. To eliminate non-independence of replicate containers connected to a particular header tank, I will

clean header tanks and reassign them to different treatment combinations every 7 days, during which time we will also haphazardly re-arrange the spatial distribution of replicate aquaria, so that the replicates within each treatment combination do not always have the same single header tank.

In each trial, feeding will be monitored for 2 weeks, and dead barnacles will be counted daily. Barnacles will be considered eaten by *A. spirata* if their opercular plates split when tapped or eaten by *N. lamellosa* if the opercular plates or tests have drill holes [29], and their tests are empty. Feeding rate will be reported as number of barnacles eaten per snail per day. A separate generalized linear mixed model with competitor presence, water temperature, and air temperature as fixed factors, and header tanks as a random factor, will be used to analyze differences in barnacle consumption for each snail species.

Handling time

Random replicates from the feeding rate experiment will be selected for estimating snail handling time. During the two-week trial, snails will be recorded anywhere from 6-12 hours, with observations of behavior every 10 minutes. Time lapse footage (GoPro Hero 11) will be analyzed to determine the amount of time needed for a snail to ingest a barnacle. In any encounter, handling time will be accrued only when a snail stops moving after initial contact with a barnacle and ends when the snail leaves the fully consumed barnacle. The drilling and ingestion times will be combined into a total handling time.

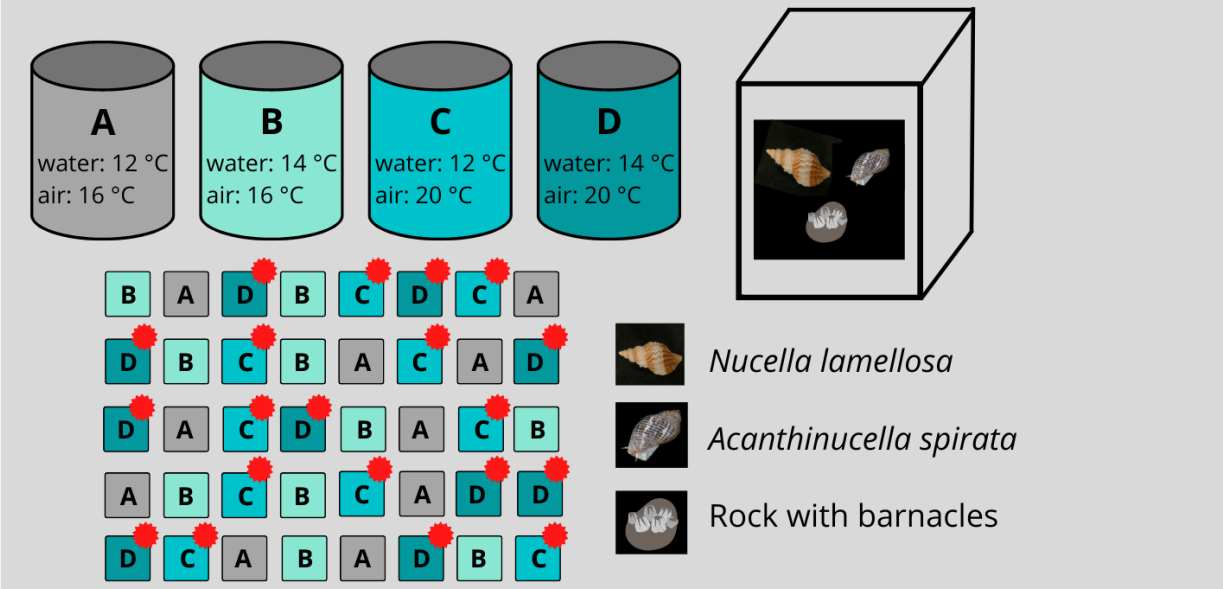

Fig. 3. Schematic of experimental design and treatment for the laboratory experiment. Four header tanks will supply ambient (12°C) or warmed seawater (14°C) to 40 aquaria. Ceramic heaters will be installed ~12 cm above an individual aquarium (red star) to maintain elevated air temperature (20 °C).

References (0 points): no limit

LITERATURE CITED

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Timeline (10 points total): 250-word maximum; any text over this limit will be redacted

Date	Project Aspect
Spring 2023	Finish coursework Begin thesis draft
Late May 2023	Collect laboratory specimens Train research assistants
June 2023	Conduct laboratory experiment
July 2023	Data Analysis Finish results & discussion section of thesis draft
August 2023	Thesis defense
Fall 2023	Prepare manuscript for publication

Need for Research (7 points total): 250-word maximum; any text over this limit will be redacted

Whereas range shifts have been documented for hundreds of species across taxa and ecosystems, species interactions and community impacts of the range expanding species are still poorly understood [7]. This may be because the impacts of range-expanding species may develop more slowly than the impacts of introduced species, and so have received less attention than the impacts of introduced species [30] Thus, our ability to predict future outcomes from range-expansion is still limited. This leaves an important knowledge gap related to range-expansion that I hope to fill with my thesis work. Understanding how *A spirata* responds to changing climatic conditions will contribute to the bigger picture of understanding whether climate change accentuates the effects of range-expanding species on local and regional biodiversity.

I believe my research will help resource and conservation managers consider the interactive effects of climate change and range-expanding species when formulating management plans to conserve or restore native species and populations. In some situations, a species of conservation concern may be able to adapt to climate change but may additionally face competition or predation from range-expanding species driven by climate change. Therefore, it is important to understand how climate change and range-expanding species will interact to affect local species, so future management plans will take into consideration the combined and interactive effects of these stressors on native communities.

Relevance to state of California (3 points total): 100-word maximum; any text over this limit will be redacted

The California rocky intertidal is one of the harshest environments in the world; organisms must survive desiccation, temperature stress, wave stress, and biotic factors such as predation and competition. California has taken many measures to protect the nearshore coastal environment, such as dedicating 16% of state waters to Marine Protected Areas. However, an under-studied threat to local biodiversity, is the range-expansion of *A. spirata* and many other coastal species, which are expanding northward in California [31]. My research will provide relevant data for future management plans for the California intertidal zone, by considering the effect of climate driven range-expanding species.

Budget and Justification (15 points total)

Example Budget (to use this format, erase the content below and add additional rows as necessary; alternatively, you are welcome to create your own table):

Item/Description	Unit Price	Quantity	Amount to Awardee (via Financial Aid)	Amount to Department
Travel Costs to Cape Mendocino	$0.65/mile	280	$182	
Travel Costs to TML	$0.65/mile	1,080	$702	
Living Expenses (Rent + Utilities)	$550/month	2	$1,100	
Research Assistant Wages	$16/hour	126		$2,016
Subtotals:			$1,984	$2,016
Grand Total				**$ 4,000.00**

Justification (250-word maximum; any text over this limit will be redacted):
I am requesting funds to cover transportation to and from the Cape Mendocino field site where organisms will be collected, and the Telonicher Marine Lab, where experiments will take place. Transportation to and from the field site is approximately 140 miles roundtrip and I need to travel there twice for the collections. I will be in lab 6 days a week for 6 weeks to complete experiments, equaling 1,080 driving miles. At state rate for fuel reimbursement, I will incur $884 in personal costs to complete this portion of my thesis.

A portion of funds will go toward supporting myself financially as a graduate student living below the poverty line. To live in Humboldt County, I am paying rent that costs as much as my monthly salary. With my full-time commitment to graduate school and part-time work as a writing consultant, I rely on grant money to support myself through the summer.

Remaining funds will go towards hiring undergraduate research assistants. While an undergraduate, I was given the opportunity to work as a research assistant thanks to the COAST undergraduate student research program. This program changed the trajectory of my life and I would love to pay this opportunity forward to students who may struggle to get research experience because of financial constraints.

I have received funding from the Conchologists of America, Western Society of Malacologists, and Humboldt Marine and Coastal Science Institute for the costs of materials for the lab experiment.

Application Deadline: Wednesday, January 25, 2023, 5:00 p.m. PST
Save as both a Word document and a PDF file named as follows:
***LastName_FirstName_App.docx* and *LastName_FirstName_App.pdf*.**
Submit both files as email attachments in ONE email (with other required forms) to graduate@share.calstate.edu.

Within 24 hours of application submission, you will receive a confirmation email from COAST. Please save this confirmation email for future reference. If you do not receive a confirmation email, please contact Kimberly Jassowski (kjassowski@csumb.edu) to ensure your application was received.

The California State University
COUNCIL ON OCEAN AFFAIRS, SCIENCE & TECHNOLOGY (COAST)

Dr. Kenneth H. Coale Graduate Scholar Awards
AY 2022-2023 Advisor Sign-Off Form

To encourage you to engage with your CSU Advisor as you develop your application, **we are now requiring this form for all applications submitted to the Dr. Kenneth H. Coale Graduate Scholar Awards Program**. By signing this form, your advisor indicates that they have reviewed your application, provided guidance and input, and approved it for submission. All information except signatures must be typed. Electronic signatures are acceptable. **Please note:** A signature is required from your advisor on this **Advisor Sign-Off Form** in the **PDF version** of your application that you submit (the word document does NOT need to be submitted with a signature)

Please note: this form is NOT a substitute for a letter of recommendation (LOR). Your Advisor must submit your LOR to gradletter@share.calstate.edu separately.

Applicant Name:

Bailey McCann

CSU Advisor Information:

Name:	Paul Bourdeau	Phone:	(707) 826-3600
Department:	Biological Sciences	Email:	peb112@humboldt.edu

I have reviewed my student's application and provided guidance and input. My signature below indicates my approval of the application.

CSU Advisor Signature: Paul Bourdeau Date: Jan. 25, 2023