CSU 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:	Tessa	Last Name:	Filipczyk
CSU Campus:	San Francisco	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:	Katharyn	Last Name:	Boyer
CSU Campus:	San Francisco	Department:	Estuary and Ocean Science Center
Email:		Phone:	

Research Project Title:	The effect of Zostera marina restoration on blue carbon storage in San Francisco Bay
Project Keywords (5-7 keywords related to your project):	blue carbon, carbon sequestration, eelgrass, restoration, San Francisco Bay

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

Award amount directly to awardee (through financial aid):	$2500

Award amount to Department (DCF required for department funding): $1500

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

Vegetated coastal ecosystems such as seagrasses, salt marshes, and mangroves are in decline globally due to a host of environmental and anthropogenic impacts[1,2,3]. Coastal development and pollution, as well as climate change, are major drivers of decline[1,2,3]. These ecosystems are important sinks in the global carbon cycle because of their ability to store disproportionately large amounts of organic carbon in their sediment and thus have been termed 'blue carbon' habitats[4,5]. Blue carbon ecosystems are of special concern for management and conservation efforts as global CO_2 emissions continue to rise, as it has been shown that this carbon storage can offset greenhouse gas emissions[5]. Therefore, the restoration of these valuable ecosystems is of great interest as it can lead to more carbon drawdown[6,7]. As we continue to explore nature-based solutions to combat climate change, it is important to quantify the amount of carbon sequestered in these natural systems, and how restoration actions can contribute.

Seagrasses, such as eelgrass (*Zostera marina)*, provide a suite of ecosystem functions that render these habitats highly productive. For example, eelgrass belowground biomass contributes to sediment stabilization, while aboveground biomass provides wave energy attenuation, which both assist in protecting the coastline from erosion and storm surges[8,9]. Eelgrass also serves as a nursery habitat for commercially valuable species, such as Dungeness crab (*Metacarcinus magister*), which has an annual value of roughly $100 million USD[10,11]. In addition, eelgrass serves as important foraging grounds for migratory birds, as well as spawning grounds for Pacific herring (*Clupea pallasi*) in San Francisco Bay (SFB)[12].

Given both the economic value of eelgrass in SFB, and the ecological value in the global carbon cycle, it is imperative that we seek to understand the efficacy and success of restoration projects in regard to carbon storage. Local studies have focused on invertebrate assemblages in restored eelgrass beds[13], and regional/statewide studies have examined carbon stocks and exchanges between eelgrass and salt marsh habitats[14]. To date, however, restoration projects have not examined the role of restoration in helping to establish blue carbon storage. In this study, I am assessing sediments from four sites throughout the north San Francisco Bay, across 3 different habitat types (natural eelgrass beds, restored eelgrass, and unvegetated areas) in order to comprehensively assess carbon stocks in the region and determine if restoration may lead to blue carbon storage. This will allow us to contribute to the growing body of knowledge regarding *Zostera marina's* role in sequestering carbon and elucidate how the San Francisco Bay may act as a net carbon sink.

Objectives:

1. Quantify the differences in organic carbon storage among habitat types: natural eelgrass beds, restored eelgrass beds, and unvegetated areas.
2. Quantify differences in organic carbon storage between sites.
3. Determine the sources of carbon across all sites and habitat types.

Answering these questions will determine if restoration efforts have been effective in increasing carbon storage and will be addressed by the following hypotheses:

1. When comparing natural and restored eelgrass beds, Total Organic Matter plotted against sediment core depth will show a higher percentage of TOM throughout the profile in natural beds. When comparing all three habitat types, unvegetated areas will show the least amount of organic carbon storage.
2. The differences in organic carbon storage between sites will be attributed to sediment type & grain size. I hypothesize that sites with a higher percentage of fine sediment (mud) will store more organic matter compared to sandier sites. This will be determined via grain size analysis.
3. Marsh vegetation signatures from isotopic analysis will appear in those cores sampled closer to marsh habitats.

Experimental design + methods

Study Sites:
To begin testing my hypotheses, I selected 4 main sites (Figure 1) to collect sediment cores from across San Francisco Bay that all contain 3 subsites (Figure 2); natural eelgrass beds, restored eelgrass beds, and unvegetated areas. For one of the sites, Marin Rod & Gun Club, Point Molate was used as a reference bed since that site does not have a natural eelgrass bed. Over the course of one month, I collected 5 sediment cores from each natural, restored, and unvegetated area within the 4 main sites. To choose the sampling points, I referenced the 2014 Baywide Inventory Report[15] that used an interferometric sidescan sonar system to survey eelgrass cover throughout San Francisco Bay. For natural eelgrass beds, I determined that 90-100% eelgrass density since 2014 was adequate for sampling. Using this report, I plotted the sampling points in ArcMap in the ArcGIS suite and translated these into GPS points to use in the field.

Core Collection:
Sediment cores were sampled by inserting 20cm long open-barrel PVC pipes at the predetermined GPS points. Five cores along a 50m transect were taken from each subsite. All cores were collected at a similar depth. Cores were extruded into 2 cm sections in the field to prevent mixing of layers in transit. Once the samples were extruded and transported back to the lab, they were weighed and placed in the freezer until further processing.

Lab Analyses:
For all compositional analysis, I will follow the methods according to Ward et al. 2021, detailed below.

Bulk Density
Each 2cm interval will be dried at 60C for a minimum of 24 hours, then weighed to determine dry bulk density (DBD). After drying, each 2cm interval will be divided into 10g subsamples for compositional analyses: inorganic carbon content, TOM, C:H:N and isotope analysis, and grain size analyses. To avoid bias in the subsampling process, the interval will be ground and homogenized.

Measuring inorganic/carbonate content

Inorganic carbon content will be determined by acidification of carbonates in one of the subsamples. The dried sample will be weighed prior to analysis, and then acidified using a 1.2 M HCl solution. The sample will be rinsed, dried at 60 C for at least 24 hours or to constant mass, then reweighed.

Total Organic Material (TOM) via Loss-on-Ignition

Of the 10g acidified subsample, only 1.3 grams will be used for TOM analysis. Once the desired weight is achieved, the sediment will be placed into crucibles and weighed prior to combustion. The samples will be burned in a muffle furnace at 550C for 3 hours, then cooled and weighed post-combustion. The difference in sediment weight from pre and post-combustion is the amount of total organic material that was lost on ignition (LOI).

C:H:N and Isotope Analysis

To determine the sources of carbon across all sites, I will generate a C:N ratio paired with isotopic analyses of δ13C and δ15N. I will be using the UC Davis Stable Isotope Facility, and as such will follow their protocol for preparing samples for the elemental analyzer/mass spectrometer.

Grain Size Analyses

Grain size analysis will be conducted using a 63 µm sieve. Deionized water will be poured over the sediment in its sample cup, then spread onto the sieve. I will then go through a series of DI water rinses to ensure that all small particles are pushed through the sieve, and only the large particles remain. The sediment will be returned to its sample cup, dried for at least 24 hours, and reweighed.

Data Analysis Plan:

All statistical analyses will be conducted using R software.

1. Organic carbon storage:
   Dry bulk density will be used to estimate carbon storage by multiplying bulk density and TOM. To compare organic carbon stored in all habitat types (natural eelgrass, restored eelgrass beds, unvegetated), I will use a generalized linear mixed model (GLMM). 'Depth', a proxy for time, and 'habitat' will be used as fixed effects, with 'core' as a random effect.

2. Grain size:
   I will analyze the relationship between grain size and TOM using a linear regression across all habitat types and sites. To account for site-based variability specifically, I will use another GLMM and use 'site' as a random factor.

3. C:N Ratios
   Variations in C:N ratios or δ13C % between sediment core depth, and cores collected at each subsite, will also be determined using a linear model.

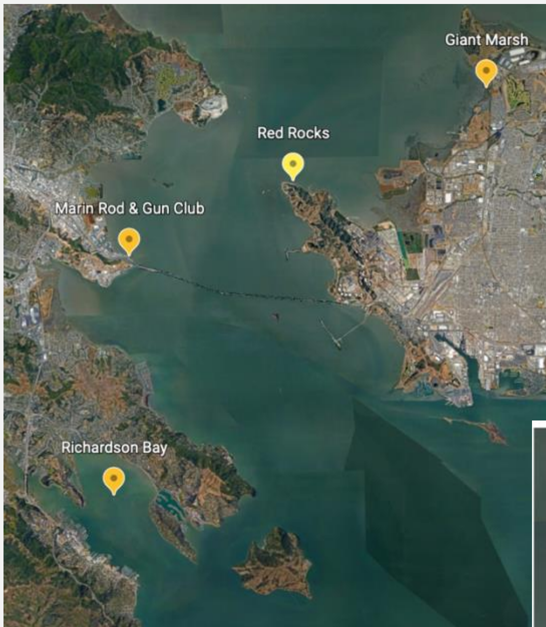

Figure 1: Map of 4 main sites throughout the north San Francisco Bay.

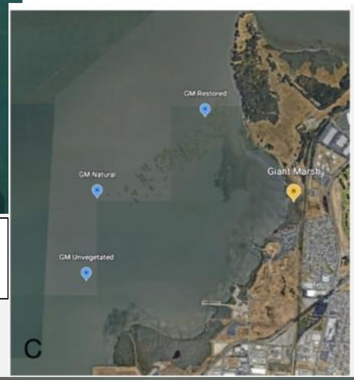

Figure 2: A)Map of Richardson Bay sampling sites. B) Map of Red Rocks sampling sites. C) Map of Giant Marsh sampling sites. D) Map of Marin Rod & Gun Club sampling sites, including the natural reference bed at Point Molate.

References (0 points): no limit

[1]Waycott, M., Duarte, C. M., Carruthers, T. J. B., Orth, R. J., Dennison, W. C., Olyarnik, S., Calladine, A., Fourqurean, J. W., Heck, K. L., Hughes, A. R., Kendrick, G. A., Kenworthy, W. J., Short, F. T., & Williams, S. L. (2009). Accelerating loss of seagrasses across the globe threatens coastal ecosystems. *Proceedings of the National Academy of Sciences*, *106*(30), 12377–12381.

[2] Orth, R. J., Carruthers, T. J. B., Dennison, W. C., Duarte, C. M., Fourqurean, J. W., Heck, K. L., Hughes, A. R., Kendrick, G. A., Kenworthy, W. J., Olyarnik, S., Short, F. T., Waycott, M., & Williams, S. L. (2006). A Global Crisis for Seagrass Ecosystems. *BioScience*, *56*(12), 987.

[3] Duffy, J. (2006). Biodiversity and the functioning of seagrass ecosystems. *Marine Ecology Progress Series*, *311*, 233–250.

[4] Mcleod, E., Chmura, G. L., Bouillon, S., Salm, R., Björk, M., Duarte, C. M., Lovelock, C. E., Schlesinger, W. H., & Silliman, B. R. (2011). A blueprint for blue carbon: Toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. *Frontiers in Ecology and the Environment*, *9*(10), 552–560.

[5] Oreska, M. P. J., McGlathery, K. J., Aoki, L. R., Berger, A. C., Berg, P., & Mullins, L. (2020). The greenhouse gas offset potential from seagrass restoration. *Scientific Reports*, *10*(1), 7325.

[6] Greiner, J. T., McGlathery, K. J., Gunnell, J., & McKee, B. A. (2013). Seagrass Restoration Enhances “Blue Carbon” Sequestration in Coastal Waters. *PLoS ONE*, *8*(8), e72469.

[7] Macreadie, P. I., Nielsen, D. A., Kelleway, J. J., Atwood, T. B., Seymour, J. R., Petrou, K., Connolly, R. M., Thomson, A. C., Trevathan-Tackett, S. M., & Ralph, P. J. (2017). Can we manage coastal ecosystems to sequester more blue carbon? *Frontiers in Ecology and the Environment*, *15*(4), 206–213.

[8] Short, F. T., Polidoro, B., Livingstone, S. R., Carpenter, K. E., Bandeira, S., Bujang, J. S., Calumpong, H. P., Carruthers, T. J. B., Coles, R. G., Dennison, W. C., Erftemeijer, P. L. A., Fortes, M. D., Freeman, A. S., Jagtap, T. G., Kamal, A. H. M., Kendrick, G. A., Judson Kenworthy, W., La Nafie, Y. A., Nasution, I. M., … Zieman, J. C. (2011). Extinction risk assessment of the world’s seagrass species. *Biological Conservation*, *144*(7), 1961–1971.

[9] Ondiviela, B., Losada, I. J., Lara, J. L., Maza, M., Galván, C., Bouma, T. J., & van Belzen, J. (2014). The role of seagrasses in coastal protection in a changing climate. *Coastal Engineering*, *87*, 158–168.

[10] Hughes, B. B., Eby, R., Van Dyke, E., Tinker, M. T., Marks, C. I., Johnson, K. S., & Wasson, K. (2013). Recovery of a top predator mediates negative eutrophic effects on seagrass. *Proceedings of the National Academy of Sciences*, *110*(38), 15313–15318.

[11] Grimes, T., Tinker, M., Hughes, B., Boyer, K., Needles, L., Beheshti, K., & Lewison, R. (2020). Characterizing the impact of recovering sea otters on commercially important crabs in California estuaries. *Marine Ecology Progress Series*, *655*, 123–137.

[12] Watters, D., Brown, H., Griffin, F., Larson, E., Cherr, G. (2004). Pacific Herring Spawning Grounds in San Francisco Bay: 1973–2000. *American Fisheries Society Symposium* 39. 39. 3-14.

[13] Pinnell, C. M., Ayala, G. S., Patten, M. V., & Boyer, K. E. (2021). Seagrass and Oyster Reef Restoration in Living Shorelines: Effects of Habitat Configuration on Invertebrate Community Assembly. *Diversity*, *13*(6).

[14] Ward, M. A., Hill, T. M., Souza, C., Filipczyk, T., Ricart, A. M., Merolla, S., Capece, L. R., O'Donnell, B. C., Elsmore, K., Oechel, W. C., & Beheshti, K. M. (2021). Blue carbon stocks and exchanges along the California coast. *Biogeosciences*, *18*(16), 4717–4732.

[15] Merkel, K. W., and Associates. 2014. San Francisco Bay Eelgrass Inventory. Submitted to National Marine Fisheries Service.

[16] Beheshti, K. M., Williams, S. L., Boyer, K. E., Endris, C., Clemons, A., Grimes, T., Wasson, K., & Hughes, B. B. (2022). Rapid enhancement of multiple ecosystem services following the restoration of a coastal foundation species. *Ecological Applications*, *32*(1).

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

- October – December 2022: I collected a total of 60 sediment cores spanning all 4 main sites.
- January – May 2023: Begin lab processing, which will include total organic matter and grain size analysis.
- May 15 2023: Receive COAST funds. Send samples to UCD Stable Isotope Facility for ^{13}C & ^{15}N analysis.
- June – August 2023: Over the summer, I will begin visualization and analysis of all my samples using R software.
- August - December 2023: Analyze stable isotope results, continue visualizing and analyzing data.
- January – March 2024: Begin drafting thesis manuscript.
- April – July 2024: Continue writing thesis manuscript, present at a scientific conference.
- August - December 2024: Finalize thesis writing and prepare to publish in an academic journal. Anticipated defense and graduation.

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

There is an increasing need for research in the carbon sequestration space due to the continued rise of atmospheric carbon dioxide. Because of this, there is also more effort made to finding new approaches to carbon dioxide reduction and removal. While there have been a multitude of studies that examine the relationship between eelgrass restoration and blue carbon storage[6,7,16], there has yet to be a study conducted looking at the same relationship in San Francisco Bay. As we continue to examine the efficacy of nature-based climate solutions in San Francisco Bay, it is important to determine if restoring eelgrass leads to more blue carbon storage.

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

San Francisco Bay is one of the most ecologically and economically important regions in California. It is the largest Pacific estuary in North America and provides habitat to many fish and endangered species[13]. As anthropogenic CO_2 emissions continue to rise, we must understand the relative role that this system plays in carbon storage. Blue carbon research has garnered attention in recent years, though no studies to date in San Francisco Bay have included the potential enhancement of carbon storage due to restoration. This research will inform future management decisions that aim to conserve eelgrass.

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**
Dual ^{13}C & ^{15}N difficult sample at UC Davis Stable Isotope facility	$11.50	120	-	$1380
Tin Capsules Pressed Standard Weight 8 x 5mm, 250 pack	$30	1	-	$30
96-Well MicroWell Plate w/ Lid, 10 pack	$86	1	-	$90
Living Expenses	$506/mo	3 months	$1,520	-
Car insurance	$58/mo	6 months	$348	-
Gas, 2 full tanks per month	$105.33/2 full tanks)	6 months	$632	-
		Subtotals:	*$2,500.00*	*$1,500.00*
		Grand Total	**$4,000.00**	

Justification (250-word maximum; any text over this limit will be redacted):

Being awarded the Dr. Kenneth H. Coale Graduate Scholar Awards would not only provide me with the funding to complete a significant portion of my thesis, it would also alleviate much of the financial burden of living in the Bay Area. This award would fund an essential part of my project, which is the stable isotope analysis at the UC Davis Isotope Facility. I am choosing to run isotopic analysis on all 60 sediment cores (2 samples per core = 120 samples) to generate a broad-scale understanding of carbon sources in each of the eelgrass habitats I am studying. In addition to this analysis, I have included the cost of living and transportation in my budget. The Estuary & Ocean Science Center at the Romberg Tiburon Campus, which is where the TOM and grain size analysis will occur, lies 29 miles from my home in Oakland. To complete these analyses, I will need to commute via car as there is no viable public transportation from Oakland to Tiburon. While these costs span both personal and laboratory expenses, they are all necessary to effectively conduct this research.

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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.

CSU 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:

Tessa Filipczyk

CSU Advisor Information:

Name:	Katharyn Boyer	Phone:	510-504-2424
Department:	Estuary & Ocean Science Center	Email:	katboyer@sfsu.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: Katharyn E Boyer   Date: January 25, 2023