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

Graduate Student Research Award Program
AY 2021-2022 Application Form
Application Deadline: Thursday, January 27, 2022, 5:00 p.m. PST

Please see information on Graduate Student Research Awards on the COAST **website** and read the **Announcement** for full details and instructions.

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 attachments, along with your **Advisor Sign-Off Form** and **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** in the PDF version of your application that you submit (the word document does NOT need to be submitted with a signature). Your Advisor must submit your LOR to gradletter@share.calstate.edu separately.

Student Applicant Information

First Name:	Taylor	Last Name:	Azizeh
CSU Campus:	Moss Landing Marine Laboratories / San José State University	Student ID#:	
Email:		Phone:	
Degree Program:	Marine Science	Degree Sought (e.g., MS, PhD):	Master's
Matriculation Date (mm/yy):		Anticipated graduation date (mm/yy):	
GPA in Major Courses:		Thesis-based? (Y/N):	Y

Advisor Information

First Name:	Birgitte	Last Name:	McDonald
CSU Campus:	San José State University	Department:	Moss Landing Marine Laboratories
Email:		Phone:	

Research Project Title: Using fine-scale data to understand the foraging ecology of late chick-rearing emperor penguins (Aptenodytes forsteri) at Cape Crozier, Antarctica

Project Keywords (5-7 keywords related to your project): Foraging ecology, penguins, accelerometer, optimal foraging theory, biologging, doubly labelled water

Budget Summary (must add up to $3,000)

Award amount directly to awardee: $3,000

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

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):	

CSU Suggested Reviewers (Required): Suggested reviewers must be from the CSU. Use the COAST member database to help identify potential reviewers. 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

The heterogeneous and dynamic nature of marine environments necessitates that prey are distributed unevenly and, thus, predators must constantly adjust their at-sea behavior to maximize their energy intake and minimize foraging costs[1,2]. Foraging efficiency (the ratio of energy gained to energy expended to acquire food)[1,3,4,5] has been shown to influence many important life processes in marine predators such as reproduction[6], growth[3,7], and survival[8]. In extreme ecosystems, animals may already be living at the limit of their physical capabilities and may not have much flexibility within their energy budget[9]. This could reduce behavioral plasticity that would allow for reallocation of energy to meet emerging needs. Energetic demands further increase during periods of pre- and post-natal investment, such as incubation, gestation, and young-rearing[10].

Marine seabirds are ideal species for studying the effects of intrinsic and extrinsic factors on foraging efficiency since they are central-place foragers[11], meaning they forage at sea and return to land to nest and rear young, allowing them to be accessed and studied by researchers. This also means that seabirds must adjust their at-sea behavior to maximize energetic gain before returning to the colony[2]. Despite the higher level of accessibility of marine seabirds, especially when compared to fully marine wildlife such as cetaceans, the challenge of confirming prey acquisition at sea remains. To properly approximate foraging efficiency, energy gained versus energy expended must be accurately estimated. Previous studies have estimated foraging efficiency for diving seabirds such as penguins through dive depth and duration[11,12], but, more recently, accelerometers have been used to estimate the energy expended by marine foragers on a finer scale[13] and resolution[14]. Accelerometers can be used to determine 3-axis (longitudinal, lateral, dorso-ventral) acceleration, allowing researchers to identify foraging events throughout the water column[13]. One common metric of foraging events are known as jerks or “wiggles”, wherein short and rapid vertical movements are used as a proxy for number of attempted prey capture events in a dive[15,16,17,18,19]. The efficacy of using accelerometer data to estimate foraging efficiency is even more accurate when validated with methods that estimate metabolic rate such as doubly labelled water (DLW)[8,20]. In addition, some studies have used animal-borne video cameras to understand how animals make foraging decisions and identify successful versus unsuccessful foraging events[21].

In extreme ecosystems, such as the Antarctic, obtaining these kinds of data is even more crucial as effects from climate change are intensified in polar environments. Antarctic sea ice habitat is particularly dynamic and changes rapidly on a fine scale[22]. For ice-obligate species, this can alter foraging routes and exacerbate foraging effort[23,24]. Sudden changes in ice near penguin colonies, for instance, has led to large mortality events of both chicks and adults[25,26]. As the climate warms, extent and thickness of sea ice is expected to decrease, negatively affecting ice-obligate species such as penguins (family *Spheniscidae*). Endemic to Antarctica, the emperor penguin (*Aptenodytes forsteri*) is a model species to understand foraging ecology of ice-dependent marine seabirds. Obtaining baseline data on these animals is critical, considering emperor penguin colonies north of 70°S will be considered unlivable as sea-ice habitat continues to degrade[27]. However, current models predict that colonies located further south will remain viable for longer[16,26,27].

Throughout the Southern Ocean, penguins are widely distributed and play an important role in the trophic web[28]. As a top marine predator, they can act as ecosystem sentinels for the health of the ocean. The Ross Sea is one of the most productive regions of the Southern Ocean[29,30] and is not following current decreasing sea ice trends; therefore, it may act as a future refuge for the ice-obligate emperor penguin[31]. Despite their importance in the Ross Sea ecosystem, little is known about the emperor penguin's foraging ecology in this region[32,33,34]. To address these knowledge gaps, I plan to use a combination of accelerometer, doubly labelled water, and video data to better understand the foraging ecology of emperor penguins in the Ross Sea at Cape Crozier, Antarctica.

Objectives & Hypotheses

O_1: Validate the use of accelerometry data to estimate energy expenditure

H_1: DLW-estimated metabolic rate will be positively correlated to vectorial dynamic body acceleration (VeDBA)

O_2: Determine if acceleration "jerks" can be used to identify foraging events and calculate the frequency of jerks at depth throughout the dive profile

H_2: Acceleration jerks will be a good proxy for foraging events

H_3: Frequency of jerks will be the highest in the bottom phase of the dive

O_3: Identify if energy expenditure can be combined with foraging events to determine foraging efficiency

H_4: Emperor penguins will forage optimally (according to Optimal Foraging Theory) by minimizing energy expenditure and maximizing energy gain

Experimental Design & Methodology

Study species, site and period: The study will take place at Cape Crozier, Antarctica (77°31'00" S, 169°24'00" E). Cape Crozier was the first discovered breeding colony in 1902[35] and is one of the only colonies to be studied systematically since the late 1990's[36]. The late chick rearing period is when the penguin's energetic requirements are the highest[37], therefore, data will be collected in the late chick rearing season, between October and November 2022.

Capture and instrumentation: 15-20 adult emperor penguins will be captured as they leave the colony to forage. To calm the bird and minimize stress, a fabric hood will be placed over the head. Birds will be weighed, and flipper length will be measured to calculate body condition (initial mass and recapture mass/flipper length)[38,39]. Feathers will be collected to identify sex *ex-situ* using PCR[40,41].

Birds will be instrumented with four devices: an Axy-Trek™ biologger, a very high frequency (VHF) tag (to permit recapture), and in some cases, a video camera. To reduce drag, the biologger and VHF tag will be attached to the upper mid-line of the back and are designed in a streamlined shape[42]. Cameras will be placed to have the best view of feeding events.

Tag programming: The tag will record depth and temperature at 1Hz, 3-axis acceleration at 100Hz, and location using geospatial positioning (1 fix per 5 minutes). Video cameras will be programmed to begin recording 2-3 days post-release[21].

Doubly labelled water: 10-12 penguins will be injected with 4ml of sterile 97 atom percent ^{18}O-labelled water and 2 ml 99 atom percent sterile deuterium in the pectoralis muscle. After a 3-hour equilibrium period, a blood sample will be collected from the bird's foot vein to estimate total body water. When the penguin returns to the colony, another blood sample will be collected.

Recapture: Post-release, VHF scans will be conducted throughout the day to determine when the penguin returns to the colony. Birds will be captured as soon as possible, prior to it reaching the colony, ensuring the most accurate recapture mass. After capture, the instruments will be removed, the mass will be recalculated, and the bird will be released.

Data Analyses

Data analyses will be conducted using R[43], MATLAB[44], and Solomon Coder (https://solomon.andraspeter.com/).

Accelerometry data: For dive data, we will use the Data Processing Toolbox (AnimalTagTools 2017) in MATLAB[44]. Dynamic body acceleration (DBA) will be measured using the summation of all three-dimensional axes' acceleration vectors[45]. These data will be combined to estimate activity and time budgets, which describe the percentage of time a penguin will spend doing each behavior[21]

Deep-diving Sphensicids don't often forage in depths shallower than 40m, therefore, foraging events will be identified by detecting jerks in dives where the maximal depth of a dive $\geq$40m[14]. Jerks/wiggles are defined as a rapid combination of increases and decreases in depth which create a vertical bump in the dive profile[14,18].

Doubly labelled water: DLW blood samples will be analyzed *ex-situ* following the methods of Hicks et al. (2021)[46] and CO_2 production (metabolic rate) will be calculated using the two-pool method[47]. We will then link DLW-derived metabolic rates to activity budgets, determined from accelerometry data[46].

Video data: Video data will be audited using Solomon Coder with latitude/longitude and time stamps calibrated from each video to the accelerometer and GPS data to ensure they are synced[21]. Feeding events will be visually confirmed in the photic zone and prey will be identified to species.

Statistical Analyses

All statistical analyses will be performed in R[43]. Dive data will be analyzed in R using the package *diveMove*[48], MATLAB[44] (*Antarctic Mapping Tools*) and custom scripts[49]. For each trip, dive duration, maximum distance from the colony (maximum straight-line distance), track length, heading from the colony, maximum depth, average depth, and number of dives will be quantified. Specific statistical tests will be identified in the process of data analysis through literature review and other online resources.

Significance

Understanding the energetics of marine predators will be invaluable in protecting natural resources and mitigating effects of climate change. The late chick-rearing period is the most energetically demanding, and therefore, may represent the limits of their behavioral plasticity. This study is vital to testing methods of understanding the foraging efficiency of diving seabirds, and can be applied to numerous other study species' and systems.

(1476 words)

References (0 points): no limit

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

Summer 2022
- Analyze data collected in 2019, this will allow me to develop code to use with new data
- Prepare for upcoming field season
- Thesis proposal approved

Fall 2022
- Field season

Spring 2023
- Finish MLML coursework
- Process data from Fall 2022 field season
- Process doubly labelled water samples and PCR work to sex feathers

Summer 2023
- Finish lab work
- Finish data processing
- Attend the Ecological Society of America (ESA) Conference

Fall 2023
- Data analysis
- Begin writing thesis chapters
- Attend the Western Society of Naturalists Conference

Spring 2024
- Finalize thesis writing
- Thesis defense

I plan on working with different scientific outreach groups within California throughout my grant period such as Skype-A-Scientist and Future Leaders in Marine Science (FLMS), which both put scientists in touch with schoolchildren interested in marine biology, and NexGeneGirls, a group based in the Bay Area which connects scientists with socioeconomically disadvantaged students from San Francisco's most marginalized neighborhoods.

(166 words)

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

In 1902, Cape Crozier was the first discovered colony of emperor penguins. Since the 1990s, this colony has been systematically studied, however, there is still very little known about the at-sea behaviour of this species. Understanding the foraging efficiency of a top marine predator is essential as it can indicate changes throughout the trophic web. Gaining novel information about the foraging ecology of emperor penguins in the Ross Sea will fill existing knowledge gaps. Additionally, as the Antarctic ecosystem shifts in response to climate change, it will be essential to understand the degree of behavioral plasticity exhibited by emperor penguins.

By understanding the degree of behavioral and physiological plasticity in an organism, it is possible to predict the resilience of marine predators to stressors. Additionally, as Cape Crozier becomes a more important location for displaced penguins, it is imperative to fill the knowledge gaps regarding the foraging ecology for animals in this area. Lastly, it will be crucial to gain baseline data on the understudied emperor penguin before it is too late.

(172 words)

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

COAST promotes the advancement of marine resources to inform stakeholders on the creation of responsible policy. The effects of climate change are exacerbated in polar environments and have cascading impacts on the global oceanic environment. The international collaboration of this project will allow us to inform a far-ranging group of stakeholders.

This project will contribute novel information about the overall oceanic environment, and these methods can be applied to studying the energetics of diving seabirds in California, which we know little about.

Additionally, I will continue my outreach efforts in California, informing a new generation of scientists.

(97 words)

Budget and Justification (15 points total)
Example Budget (feel free to erase the content and use this format, adding additional rows as necessary, or create your own):

Item/Description	Unit Price	Quantity	Amount to Awardee (via Financial Aid)	Amount to Department
Living expenses (rent for field season)	$850.00	3	$2,550	
Antarctic field gear (e.g. wool field clothing, cold weather jackets, gloves and hats)	-	-	$450	
		Grand Total	**$3,000.00**	

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

I have been employed as a work study student at the MLML Front Desk for 20 hours/week (the maximum number of hours allowed for student workers) since June to financially support myself. I am completely financially independent and have worked throughout my undergraduate career to provide for my education and living expenses. For tuition, I rely on financial aid and grant funding. In my spare time, I work as a dog, house, and babysitter for local families in my area, which is another source of income I will lose during the field season. Receiving the COAST grant would allow me to pay my rent while I am unable to work during the field season. Additionally, cold-weather gear is an expense I must cover. For the six-week field season, I will need to buy wool layers, gloves, and thick outer jackets; therefore, I have factored this cost into my budget. The COAST grant would alleviate financial pressure and allow me to collect the data necessary for my thesis.

Thank you in advance for your time and consideration of my application. Please do not hesitate to contact me with any questions.

(189 words)

Application Deadline: Thursday, January 27, 2022, 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.