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

Graduate Student Research Award Program
AY 2017-2018 Application Form
Application Deadline: Monday, October 23, 2017, 5:00 p.m. PDT

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 to graduate@share.calstate.edu.

Student Applicant Information

First Name:	Jamie	Department or Degree Program:	Marine Sciences
Last Name:	Yin	GPA in Major Courses (If first semester as a graduate student, please enter, “n/a, first semester”.):	
Student ID#:		Matriculation date (mm/yy):	08/17
CSU Campus:	San Francisco State University	Anticipated graduation date (mm/yy):	05/19
Email:		Degree Sought (e.g., MS, PhD):	MS
Phone		Thesis-based? (Y/N):	Y

Advisor Information

First Name:	Frances	Position/Title:	Adjunct Professor and Senior Research Scientist
Last Name:	Wilkerson	Email:	fwilkers@sfsu.edu
CSU Campus:	San Francisco	Phone:	415-338-3519
Department:	Biology/RTC		

Research Project Title: **Phytoplankton productivity and nutrient dynamics in the Sacramento Delta as a function of light availability**

Project Keywords (5-7 keywords related to your project): Phytoplankton, light limitation, nutrients, San Francisco Estuary food web, Sacramento Delta

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

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Award amount directly to awardee:	$3,000
Award amount to Department:	-

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Please refer to the Award Announcement for detailed instructions on the information required for each of the following sections.

Project Description (60 points total)-1,500 word maximum

Background

Primary production in the San Francisco Estuary (SFE) has been decreasing for the past 40 years (Jassby et al. 2002). Some hypotheses for this decline are that phytoplankton are light inhibited in turbid estuarine waters due to excess sediment, that phytoplankton use of nitrate (NO_3^-) for growth is constrained by anthropogenic ammonium (NH_4^+), and that invasive clams exert intense grazing pressure that reduces phytoplankton biomass. A holistic ecological view would consider that all these factors play a role (Cloern 1987, Parker et al. 2012, Alpine et al. 1992). The lack of blooms and low phytoplankton biomass are hypothesized to have caused or contributed to the food web collapse in the North SFE (Baxter et al. 2008). Of special interest is the Delta Smelt, a threatened fish species endemic to the Upper SFE whose low abundances have been attributed to reductions in zooplankton prey availability and entrainment in the water pumps of the South Delta (Moyle et al. 2016).

Both anthropogenic and natural nutrient inputs such as nitrogen and phosphorous rich agricultural run-off have been shown to cause phytoplankton blooms (e.g. Spatharis et al. 2007, Zhou et al. 2008). Phytoplankton blooms have been observed after agricultural flow pulses through the Delta and during years with high water flow such as in 2011 (Schemel et al. 2004, Wilkerson et al. 2015). The winter of 2016-2017 was characterized by high precipitation in California with the potential for a phytoplankton bloom in the fall, which is part of the reason for this study.

The availability of photosynthetically active radiation (PAR) is the primary driver that limits primary productivity in the SFE (Cole and Cloern 1984; Alpine and Cloern 1992, Kimmerer et al. 2012). However, there have been no studies that examine the interaction of available light and nutrient uptake by SFE phytoplankton in parallel with traditional photosynthesis (P) versus irradiance (I) measurements of carbon fixation. In fact, most productivity values reported for the SFE are derived from a light utilization model using chlorophyll, PAR and light attenuation (Harding et al. 2002, Cole and Cloern, 1987, Jassby et al. 2002, Parker et al. 2012) instead of direct rate measurements. Of interest is whether the phytoplankton from different parts of the SFE and Delta exhibit uptake and photosynthetic kinetics which reflect the light availability of the water from which they were sampled. Are the phytoplankton populations in more turbid regions of the Delta adapted to fix carbon and take up nutrients at low light? Are these phytoplankton inhibited by high light when compared to phytoplankton collected in less turbid waters where there is greater light penetration? Kimmerer et al. 2012 (Fig.3) showed hyperbolic relationships for P vs. I measured in 2006 where phytoplankton saturated by ~25% of surface irradiance with photoinhibition above 50%, which could support the hypothesis that phytoplankton from high turbidity waters saturate uptake at lower irradiances. Uptake of NO_3^- and NH_4^+ by phytoplankton is typically light dependent and shows a similar hyperbolic relationship (e.g. MacIsaac and Dugdale, 1972; Cochlan et al. 1991), although dark NH_4^+ uptake may sometimes result in the hyperbola having a positive intercept. The direct response of SFE phytoplankton uptake of nutrients to light has not been reported.

The Wilkerson Group, with whom I am conducting my research, is currently focused on the processes affecting phytoplankton production in the North SFE and Sacramento Delta. The Wilkerson Group is working with the California Department of Water Resources (DWR) to sample phytoplankton productivity in the Northern SFE and Delta from Cache Slough to Suisun Bay in fall

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2017 and 2018 (Fall Bloom Study (FBS)). My project will focus on determining whether phytoplankton in the Delta take up nutrients at a slower rate in low light conditions or if they show shade adapted uptake rates. The FBS allows The Wilkerson Group to investigate the role of nutrients and flow in bloom initiation as described and modeled in Dugdale et al. (2012 and 2013).

Research Questions and Hypothesis

Q_1: Do phytoplankton from Suisun Bay (Northern SFE) and the Cache Slough Complex (Delta) show different capacities for primary productivity and nutrient uptake related to the water turbidity in which they occur?

H_A: Phytoplankton from high turbidity locations will show shade-adapted uptake kinetics and those from lower turbidity will show light adapted kinetics reflected in their kinetic parameters (i.e.: K_{LT} which is the half-saturation constant for light).

Q_2: Do phytoplankton from these areas have different uptake of carbon, nitrate, and ammonium versus irradiance curves and kinetic parameters?

H_{2A}: Phytoplankton from high turbidity areas will saturate their uptake of nitrogen (N) and carbon (C) at low light levels; phytoplankton from low turbidity areas will saturate their uptake of N and C at higher light levels.

Methods and Analysis

I am fortunate to be able to combine my proposed research project with the ongoing Fall Bloom Study (FBS) in the SFE Delta being conducted by my advisor Dr. Wilkerson. This study involves weekly sampling along a transect from Cache Slough to the Carquinez Bridge using the R/V Questuary during Fall 2017 and 2018. This transect includes locations with different ambient water turbidity, as recorded with Secchi disk measurements and provides an ideal backdrop for my proposed uptake versus irradiance incubations and measurements.

Out of the nine stations the Wilkerson Group is sampling for nutrients and phytoplankton biomass during the FBS I will collect near-surface water samples from four stations. Going from landward to seaward these stations have different turbidity conditions and are as follows: RYI which is at Ryer Island (38.214, -121.668) and the northernmost station, USGS 657 (38.148, -121.688) which is at Rio Vista, USGS 649 (38.062, -121.800) which is near the confluence of the Sacramento and San Joaquin Rivers and has the most suspended sediment, and US5 (38.060, -121.980) which is in Suisun Bay near Port Chicago, and is the last station on the transect. RYI was selected, along with US5, to get the broadest geographic range. US657 and US649 are sites where fall blooms were observed in 2011 and 2012 following high spring flows (Wilkerson, Pers. Comm). At each station, Secchi depth, incoming PAR, beam c (estimate of turbidity from the R/V Questuary CTD package system), and concentration of total suspended solids (TSS) measured using EPA method 160.2 will be recorded for this study.

The water samples containing ambient phytoplankton will be used to measure uptake of ^{13}C labeled bicarbonate and ^{15}N labeled NO_3^- or NH_4^+ in incubations at six different light levels. Twelve 150 mL samples will be collected from each station and transported back to the Romberg Tiburon Center (RTC), inoculated with trace (at 10% of ambient concentration) additions of stable isotope tracers ($H^{13}CO_3$ and $^{15}NO_3^-$, or $^{15}NH_4^+$) and incubated at 100%, 50%, 25%, 10%, 5%, and 1% of surface light levels, obtained using different layers of window screening. Incoming PAR will be obtained from the adjacent SFBeams station http://sfbeams.sfsu.edu/ and from Onset HOBO Pendant Data Loggers. Samples will be incubated outside, in natural photoperiod, in running seawater at in situ temperatures for ~24 hours, filtered onto combusted Whatman Glass Microfiber Filters (GF/F) and

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frozen. A 24-hour photoperiod was selected due to time constraints that would not allow for a shorter, light-only incubation period. Isotopic enrichment on filters will be analyzed on a PDZ Europa 20/20 gas chromatograph mass spectrometer and uptake rates (ρ, µmol C or N L^{-1} d^{-1}), biomass specific uptake rates (V, d^{-1}), and assimilation number (µmol C µg chl d^{-1}) will be calculated according to Dugdale and Wilkerson (1986) and Legendre and Gosselin (1997). No correction for NH_4^+ regeneration and isotope dilution will be made to NH_4^+ uptake rates (Wilkerson et al. 2015). However, the potential impact of NH_4^+ regeneration on calculated NH_4^+ uptake rates is likely low because of relatively low NH_4^+ uptake and high NH_4^+ concentrations in the SFE (Parker et al. 2012). NO_3^-, NH_4^+, dissolved inorganic carbon (DIC) and chlorophyll concentrations will be measured following protocols in Wilkerson et al. (2015) and will be provided as part of the FBS work plan. Uptake versus irradiance data was collected at US649 by the Wilkerson Group in the fall of 2010, 2011, and 2012 and samples were incubated at the same light levels that I have proposed. I will use this previously collected dataset as a comparison. Uptake will be plotted as both ρ and V (see above) versus irradiance and hyperbolic curves will be fitted following Platt and Gallegos (1980) and Kudela and Cochlan (2000) equation 2 which factors in nitrogen uptake in the dark. From these hyperbolic Michaelis-Menten type curves and equations the following kinetic constants/parameters will be calculated P or V_{max} (the maximum light-saturated uptake rate, α, the initial slope, β-photoinhibition if it occurs, and for E_k (irradiance required for P_{max} to be reached).

These kinetic constants will be compared for the different stations and cruises and plotted versus the ambient irradiance and/or turbidity conditions, by plotting versus Secchi depth, attenuation coefficient k (calculated from Secchi and PAR), beam c estimate of turbidity and concentration of TSS.

References (0 points)-no limit

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Timeline (10 points total)-250 word maximum

Fall 2017: Collect data on weekly cruises running from 9/12/17-11/14/17

Winter 2017: Analyze samples on mass spectrophotometer and calculate uptake rates

Spring 2018: Work up data and plan for follow up experiments in the fall

Summer 2018: Work up dataset of previous data collected in fall 2010, 2011, and 2012

Fall 2018: Collect second set of data on weekly cruises

Winter 2018: Analyze samples on mass spectrophotometer and calculate uptake rates
Present findings at the Delta Science Conference

Spring 2019: Finish working up data, write and defend thesis, and prepare manuscript for publication

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Relation to COAST Goals (15 points total)-300 word maximum

This project will directly benefit the COAST goal of advancing our knowledge of coastal ecosystems by providing insight into the bottom up processes that affect the Northern San Francisco Estuary (SFE). The SFE is one of the most heavily used estuaries in the world and has been subjected to numerous anthropogenic influences including invasive species, freshwater diversions for agricultural land, and pollution. This project will help determine if light limitation due to high turbidity is a major factor for phytoplankton growth in the SF Bay, or if these phytoplankton are adapted to low light conditions which has implications in the SFE, but also in other estuarine ecosystems with high nutrients but low chlorophyll (HNLC). Little is known about why the SFE does not support a large amount of phytoplankton but this project will test the hypothesis that the reason for this low chlorophyll in the SFE is due to decreased light availability.

This project supports the COAST goal of developing innovative solutions by determining the reasons that the SFE has low levels of phytoplankton, we can work towards solutions that reverse the trend of low phytoplankton biomass in the SFE such as through agricultural flow pulses. All marine life relies on phytoplankton for food, either directly or indirectly. Marine life whose populations are directly affected by zooplankton and phytoplankton availability are forage fish such as the northern anchovy, Pacific sardine, the Delta smelt, and Longfin smelt. These results will be relevant in terms of prey availability for forage fish who are the link between phytoplankton and zooplankton to larger predators such as seabirds, sharks, marine mammals, and fish such as salmon and tuna. With the support of COAST I would be able to conduct research that would help us better understand prey availability in the SFE food web.

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Budget and Justification (15 points total)

Item/Description	Unit Price	Quantity	Amount to Awardee (via Financial Aid)	Amount to Department
Cryovials	$0.50 cents each	384	$192	-
Vial labels	$1.50 per sheet of 60 labels	8 sheets	$12	-
GF/F Filters	$78 for a box of 100	4 boxes	$312	-
Rite in the Rain Paper	$0.50 cents per sheet	20	$10	-
Incubation Bottles	$6.25 each	48	$300	-
Gallon ziplocs	$3.20 per box	1 box	$3.20	-
Colored label tape	$40 for pack of 3 colors	1 pack of 3	$40	-
Window screening 60 x 90 inches	$13.20	2 rolls	$26.40	-
Costech tin caps for mass spec	$33 per box	2	$66	
Costech quartz wool	$55 for 20g piece	1	$55	
Liners for mass spec	$30	10	$300	
Copper wires for reduction tube	$22	3	$66	
Gas and bridge toll for field days	$14	9	$126	-
Student Fees	$758	1	$758	-
Living expenses	-	-	$733	-
		Grand Total	**$3,000.00**	

Justification (250-word maximum):

The Wilkerson Group has generously provided me with ship time aboard the R/V Questuary in conjunction with the Fall Bloom Study so I can collect water samples, however I still need funds to pay for the materials needed for water sample collection and subsequent analyses on the mass spectrophotometer.

I am very lucky to have received the Grad State University Grant which covers my tuition for the 2017-2018 academic year, however it does not pay for student fees which total $758 per semester, money from the COAST grant would be allocated to cover this cost. The remaining $733 would be used to help defray the cost of transportation to and from the Romberg Tiburon Center and for groceries and part of my rent. I live in San Francisco where the cost of living is high, my grad student salary does not cover my monthly living expenses so in addition to a full class load and research I also have a part time job which I work on the weekends. Receiving the COAST grant would allow me to cut back on my outside job so as to more fully focus on my research and thus graduate faster.

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