CALFED BAY-DELTA PROGRAM

CALFED SCIENCE FELLOWS PROGRAM

In cooperation with the

California Sea Grant College Program

Sea Grant California

FELLOWSHIP APPLICATION COVER PAGE

APPLICANT TYPE ☒ Postdoctoral Researcher ☐ Ph.D. Graduate Student

PROJECT NUMBER _____

PROJECT TITLE Environmental Controls on the Distribution of Harmful Algae and their toxins in San Francisco Bay, California

FINANCIAL SUMMARY

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Will animal subjects be used? ☐ Yes ☒ No

APPROVAL DATE: _____ PROTOCOL #: _____ PENDING: _____

Does this application involve any recombinant DNA technology or research? ☐ Yes ☒ No

2009 California Sea Grant CALFED PROPOSAL
2. Proposed Research

A. Introduction/Question/Objectives

1. *Introduction and Identification of the Problem*

The major goal of work proposed here is to determine the distribution of harmful algae and their toxins in San Francisco Bay and characterize the environmental parameters that control toxin production by harmful algae with a specific emphasis on the invasive species *Microcystis aeruginosa*. This work is directly related to a few of CALFED's targeted topic areas. Specifically, work addresses issues related to research on **Trends and Patterns of Habitats** and **Populations and System Response to a Changing Environment**. Harmful algae are some of the less studied Bay and Delta species and their distribution, abundance and dynamics, as well as the conditions promoting their proliferation and toxin production are not well characterized. Research is needed to explore how these species currently respond to environmental conditions in order to establish a baseline for future comparison and for predicting changes associated with future climate and anthropogenic impacts. This is particularly important considering predicted future environmental change in temperature, stratification and nutrient and trace metal loading that can dramatically alter the abundance and toxic production of harmful algae. These changes are already starting to occur locally and globally [1, 2, 3] and more data is needed to determine if these are persistent trends. In addition a better understanding of the population and dynamics of harmful algae in the Bay and Delta system is needed for enhancing existing resource management and for developing new tools and decision support systems that improve management effectiveness that will ensure low risk associated with harmful algal blooms (HAB). The work also addresses the topic of **Aquatic Invasive Species**. *Microcystis aeruginosa* is an invasive bloom forming harmful algae that would be studied here and results will help predict the conditions under which this invasive species is successful and also under what conditions it produces toxins. The ultimate goal is to establish under which future scenarios including different water-management regimes, climate change, land use change, catastrophic events, and other potential changes harmful algal species including *M. aeruginosa* might bloom. Finally the work is also related to the topic of **Water Supply, Water Quality**; noxious toxins produced by harmful algae reduce the water quality and may impact the supply of clean water for drinking as well as the Bay and Delta water quality which directly impacts the livelihood of other species including several endangered species. The current global Water Crisis infers that it is crucial to gain a better understanding on the factors affecting water quality and Delta ecosystems that can limit the current and future management options and to develop sustainable solutions to minimize impacts to drinking water and to ecosystems. The Southwestern United States, and most particularly the San Joaquin-Sacramento Delta, ranks among the most vulnerable regions to the current global Water Crisis [4]. Indeed, models predict that water supply shortage will increase due to global warming and to overpopulation, while the contamination of water supplies is rising due to anthropogenic pollution and to the emergence of harmful and noxious toxin-producing algae blooms.

Harmful algal blooms are on the rise –

Over the past thirty years, harmful algal blooms (HABs) have increased in extent, frequency and types of organisms involved throughout the world, although the reasons for this remain unclear [5,6]. As the occurrence of HABs increases, their impacts also increase resulting in a plethora of acute, chronic and fatal illnesses in animals and humans [7, 8, 9, 10, 11, 12]. The economic impact of harmful algal blooms (HABs) on fisheries, recreation, human health, and the ecology of both marine and fresh water bodies in the United States is significant [13, 14]. Average annual economic losses in the United States

from HABs were approximated at $82 million [15]. Over the course of the last decade numerous scientific programs designed to increase the understanding of the fundamental processes underlying the causes and impacts of HABs have been initiated. Despite considerable progress made toward understanding and predicting HAB events and their impacts, the complexity of the problem has also become more apparent [16]. Indeed, a clear understanding of factors promoting algal growth and toxicity has remained elusive and hampers our ability to predict and prevent such events. It is therefore crucial to identify the drivers allowing the successful establishment and spread of harmful algae and their toxins under current conditions in order to predict the responses of these organisms in the context of a changing environment.

Factors which promote HABS and toxicity are not known –

HABs are diverse in terms of causative organisms, bloom dynamics and level of impact. Abundance and toxin production of the cyanobacterium *M. aeruginosa* suggest that they are influenced by a multitude of parameters including light, temperature, salinity, nitrogen, phosphate, and trace metals (Table 1). Nevertheless, most of the information concerning the environmental factors for toxin-producing cyanobacteria bloom development and persistence is compiled from freshwater lakes and reservoirs studies, less is known about the relative importance of environmental factors in estuaries, particularly nutrient-rich estuaries like San Francisco Estuary [17]. Laboratory experiments with various toxin-producing diatoms of the genus *Pseudo-nitzschia* spp. suggest that silicic acid limitation is the primary trigger of domoic acid (DA) production [18, 19, 20, 21, 22]. Field observations have corroborated this assumption [23, 24, 25]. However, other macronutrient limitations, including phosphate (P), and/or micronutrient supply [25, 26, 27] have also been shown to trigger DA production while nitrogen and light limitation have been shown to inhibit the production of DA [19, 29, 30, 31, 32, 33]. Similar complexity in controls over the growth and toxin production in various species of the dinoflagellate *Alexandrium* is also evident. In California, *Alexandrium catenella* has been associated with cold water conditions while *Alexandrium monilatum* the species abundant in Florida seems to grow best at high temperatures [34, 35]. Laboratory experiments show the enhanced toxin production in some *Alexandrium* strains under P limitation [36, 37, 38, 39, 40] and, in other toxic *Alexandrium* species N and P colimitation stimulate toxin production [41, 42] Blooms of another toxin producing dinoflagellate *Karenia brevis* have been linked to iron and nitrogen availability [43] yet this is not always consistent with field observations.

Although laboratory experiments indicate that toxicity is species-specific and is induced by a broad range of predictable environmental factors, little is known about what stimulates growth and triggers toxin production *in situ* [44]. Indeed when laboratory and field observations were compared it was determined that HABs do not always occur when conditions seem appropriate [35]. Such discrepancies might result from reciprocal interactions among members of the plankton community [45]. Also, bacteria associated with toxin-producing algae can be factors in determining the production levels of the toxin and its elimination under particular circumstances [30, 45, 46, 47, 48, 49, 50, 51, 52, 53]. Additional factors that make a bloom likely in the natural environment are currently unknown and specifically, conditions inducing toxin production in San Francisco (SF) Bay have not been studied. This crucial yet missing understanding, which is key for predicting and controlling HABs, is best gained from direct field observations and manipulations of algae in their natural environment.

Research on harmful algae has intensified throughout the US and the world, however, the focus of this research has been for the most part restricted to areas where negative impacts (on economies and ecosystems) from HABs have been reported. It is certainly important to monitor and study areas where HABs frequently re-occur, however, we concur that there is much to be learned from settings where toxic species have been documented but deleterious effects on human and ecosystem health are not yet prevalent. A comparison between areas where HABs are common and areas where they have

not been occurring frequently, within a broad general region such as the west coast of the United States, may provide vital information to our understanding of trigger mechanisms of HABs in the natural environment. Moreover, such a comparison and the characterization of the specific conditions that preclude HABs from occurring at some sites could be used to protect these locations from future episodes of HABs by designing best management plans that reduce the risk of inducing such blooms (*e.g.* one can compare this aspect to preventative medicine).

HABs in California Coastal Systems and San Francisco Estuary –

HABs and their impact have been documented in California waters since 1793 [53]. There are six groups of harmful algae that have a strong presence on the West Coast of the United States. Blooms of the cyanobacterium (blue-green alga) *Microcystis aeruginosa* have been recorded in California estuaries since 1999 [55, 56, 17] and the presence of other potentially harmful cyanobacteria has been documented. *Microcystis aeruginosa* can produce a variety of toxins collectively called microcystins which are associated with both acute and chronic liver damage [57]. Exposure to microcystins has been linked to cancer in humans and wildlife [58] and reduced feeding success in zooplankton [59]. These hepatotoxins have been detected in the Delta and entered the foodweb [56, 17]. Also, the toxin-producing cyanobacterium *Cylindrospermopsis raciborskii* has been observed recently in the northern SF Estuary (Mueller-Solger, personal communication). This cyanobacterium was originally thought to be a tropical or subtropical alga but has been recorded as rapidly expanding in some temperate geographical areas and is regarded as an invasive species [59]. It is thought that its increased occurrence, rather than being just a recent invasion, is a combination of several factors such as improved water quality monitoring, availability of suitable habitat through climate warming and eutrophication. Some species of *Pseudo-nitzschia*, produce domoic acid, responsible for amnesic shellfish poisoning. *Alexandrium catenella* produces a suite of toxins responsible for paralytic shellfish poisoning symptoms. Diarrhetic shellfish poisoning is due to a milder suite of toxins which are produced by some species of *Dinophysis. Heterosigma* is responsible for massive finfish mortalities, and it has recently been observed in SF Bay and Los Angeles waters. Finally, *Lingulodinium polyedrum* and *Gonyaulax spinifera* have been identified in California as yessotoxin producers, which may cause problems for marine mammals and humans. Most of the wide spread massive blooms in California are associated with *Alexandrium* that produces paralytic shellfish poisoning or *Pseudo-nitzschia* that produces domoic acid poisoning [34, 60]. Recorded events of HABs are prevalent in the coastline around SF Bay (Marine coast south of Pt. Reyes and north Muir Beach, Monterey Bay, and Santa Cruz County), however, only few events of HABs have been reported within SF Bay. Since there is free exchange of water through the Golden Gate it is likely that harmful marine species are regularly introduced into the Bay from adjacent coastal waters. Moreover, with inflow of river water into the North Bay and the Delta, freshwater toxin producing cyanobacteria blooms such as *M. aeruginosa* can also develop [56, 17, 61]. HAB events have been documented in the last few years in SF Bay, possibly suggesting change in the conditions that dampened the occurrences of HABs in the Bay and in accord with the increase in occurrences in this region.

A survey of the abundance and distribution of toxic phytoplankton, based on a historical phytoplankton database of monthly phytoplankton sampling between 1992 and 1995, was conducted by Rodgers and colleagues [62]. They found over twenty algal taxa regarded as harmful, noxious, or toxin-producing in the Bay waters. The occurrence of these taxa ranged from common to rare and some reached moderately high concentrations [62]. Some species showed marked variation in abundance and frequency of occurrence among the different regions within the Bay. The abundance of certain algae was not always correlated with their distribution in the coastal waters outside the Bay. Specifically, *Alexandrium* cells were present at very high concentrations in the spring in South and Central SF Bay reaching densities of 10^5 cells/L but correlation with toxin levels in the coast was weak, suggesting within Bay growth. A bloom of *Pseudo-nitzschia* species with densities of 4.6×10^6 cells/L was recorded

in the Berkeley marina in July-August 1993 and freshwater cyanobacteria (*Oscillatoria* and *Anabaena* spp.) were documented in the North Bay. One of the questions posed by Rodgers et al. [61] is **why is there absence of acute HABs in the Bay and what has kept this system immune from HAB epidemic**. No time-series sampling program has been implemented to monitor the occurrence of toxin producing algae and toxin levels in the Bay and no answer to that question is available. Work proposed here will shed light on this paradigm. Establishing a coherent and consistent data set for the distribution and abundance of harmful algal and their toxins in SF Estuary in relation to the conditions within the Bay and Delta will constitute a baseline for determining future change and aid in identifying the parameters that are conducive to HABs and allow forecasting and managing HABs in the Bay and beyond.

HABs impact San Francisco Bay-Delta system, a new trend? –

The first bloom occurrence of the harmful algae colonial forming cyanobacterium *Microcystis aeruginosa* was documented in 1999 in the upper SF Bay Estuary [54]. Total cyanobacteria biomass has increased between 1975 and 1993 throughout the north SF estuary (NSFE) coincident with a decline in diatom biomass [4]. The single-celled form is currently a common cyanobacterium in NSFE but was not identified as a dominant genus in the phytoplankton community between 1975 and 1982 [62]. The colonial form of *M. aeruginosa* is also the first known introduced phytoplankton species with adverse impact to the estuary [55]. Since 1999 the distribution, biomass and toxicity of *M. aeruginosa* have been documented and indicate that the colonial form of *M. aeruginosa* is present throughout 180 km of waterways from freshwater to brackish water environments. The toxicity was highly variable spatially and temporally (*e.g*. between blooms) but is usually highest at low water temperature, low water transparency and low salinity [55, 16]. In 2000, one surface water sample collected in the NSFE contained microcystins concentration above the World Health Organization advisory level of 1μg L^{-1} [54, 63]. Microcystins from blooms entered the food web and were present in both zooplankton and clam tissue. In 2007, the *M. aeruginosa* bloom was the worst on record in the Delta (P. Lehman, in prep.; 64). The center of distribution has shifted toward the West (near Antioch) as compared to previous years and might have affected invertebrates and fishes in the confluence and Suisun Bay regions of the upper estuary (P. Lehman, in prep.; 64). The toxicity and widespread distribution of *M. aeruginosa* in NSFE demonstrated the potential of this organism to negatively impact many beneficial uses in NSFE and suggested that an active and long-term monitoring forecasting and alert programs are needed. The potential adverse impact of this HAB on the estuary is large. Water from the northern region is used directly for drinking water and irrigation and the region is an important recreational area for sport fishing and water contact sports. The estuary is habitat for many anadromous commercial and recreational fish including striped bass and Chinook salmon and is a feeding ground for marine mammals. The estuary also contains many threatened or endangered aquatic organisms including the Delta smelt and Chinook salmon and many of these endangered fish species are declining [65, 66]. Some of these declines may be linked to the quantity and quality of the phytoplankton carbon available at the base of the food web. Indeed, *M. aeruginosa* blooms can reduce the growth of other phytoplankton impacting food quality and availability [55, 16].

Several HAB events have been documented in other parts of SF Bay as well. In September 2004, SF Bay had the largest red tide that U.S. Geological Survey scientists have observed since they began monitoring phytoplankton, nutrients, chlorophyll, and other water-quality indicators [66]. Some red tides are associated with phytoplankton that produce toxins, but fortunately for SF Bay the algal bloom dissipated within a week before any harmful effects occurred. The bloom was dominated by dinoflagellates in concentrations unprecedented in nearly three decades of observation. SF Bay is highly enriched in nutrients but has low summer-autumn algal biomass because wind stress and tidally induced bottom stress produce a well mixed and light-limited pelagic habitat. The bloom coincided with calm winds and record high air temperatures that stratified the water column and suppressed mixing long

enough for motile dinoflagellates to grow and accumulate in surface waters. This event followed a summer of weak coastal upwelling and high dinoflagellate biomass in coastal waters that apparently seeded the SF Bay bloom. This suggests that some blooms occur in response to changes in physical dynamics driven by large-scale atmospheric processes and operate over both the event scale of biomass growth and the antecedent seasonal scale that shapes the bloom community.

In 2005 phytoplankton species composition was determined by microscopic analyses of samples collected on Aug 18, Sept 13, Oct 19, and Nov 28 at a salt pond (Pond A18) in South SF Bay (SSFB) as part of a wetland restoration project (Cloern, personal communication). Six species of toxin-producing or harmful phytoplankton were abundant in samples taken in the pond. The cell counts of these harmful algae indicate much higher levels in the ponds than in open Bay water. These shallow ponds and other shallow bay lands (channels, marshes, etc.) may be regarded as high-productivity bioreactors that harbor harmful algae that could be introduced to the open Bay.

As seen in the above summary, **while there is indication that harmful algae are present throughout the bay and that their abundance is increasing in recent years there is little systematic information about the occurrence, distribution and dynamics (*e.g*. controls on growth and toxicity and ecosystem impacts) of harmful algae and their toxins in SF Bay**. No coherent baseline estimates for these species' abundance and distribution exist for the Bay. Determining the distribution of and controls on harmful algae and their toxins in SF Bay in relation to physical, chemical and biological controls would shed light on the parameters that are conducive to HAB events and aid in forecasting and managing HABs in the Bay and beyond particularly in view of potential future climate and environmental change.

2. Overall Project Goal or Objective

The major goals of this project are to elucidate the role of physical (temperature, light, turbulence, salinity, hydrodynamics), chemical (inorganic and organic nutrients, dissolved organic carbon, trace metals) and biological (bacterioplankton abundance, phytoplankton species abundance and density, zooplankton community structure and grazing) drivers on the distribution, growth, and toxicity of harmful algae in SF Bay and to enhance our understanding of the relationships between these parameters and the occurrence and consequences of HABs. This information will aid in predicting and mitigating HAB events in the future.

Research proposed here is guided by the following motivation:

A combination of environmental factors (biotic and/or abiotic) has precluded toxic blooms from occurring frequently in SF Bay despite their prevalence in the adjacent coastal ocean. Future anthropogenic or natural climatic changes in the Bay (particularly warming and water stratification) may alter this unique situation resulting in more frequent blooms and negative impacts on human and ecosystem health (Figure 1).

The working hypotheses for the proposed research are:

Hypothesis 1: Increased temperatures, stratification and longer water residence time due to seasonal heat waves and droughts will favor dinoflagellates and cyanobacterial growth (in South Bay and the Delta respectively) over diatoms and will result in increased frequency in blooms of these species.

Hypothesis 2: Alleviation of light limitation due to stratification and decreased turbidity will increase the influence (control) of nutrient and trace metal availabilities and relative concentrations on toxin production, resulting in enhanced toxicity of the harmful algae in the Bay and Delta.

Hypothesis 3: Changing environmental conditions in the Bay over the last decade have and will continue to increase HAB frequency and toxicity. Spatial and temporal mapping of harmful algae and their toxins in the Bay will help elucidate the triggers for this change, provide a baseline for measuring future trends and enable forecasting and prediction.

We believe that determining the combination of parameters that enhance seeding, growth and toxicity of harmful algae in this system can be used to predict and prevent HABs from occurring and will serve as an important tool for managers and regulators. We will establish a baseline of conditions in the Bay, determine the above relationships and use existing and newly obtained data to design a set of *in situ* manipulative incubation experiments that will aid in determining the parameters that control growth and toxicity in the natural population of harmful algae, with a special focus on the invasive cyanobacterium *M. aeruginosa*. We will monitor the spatial and temporal variations of these factors to identify the sources and triggers of HABs within the SF Estuary. Data obtained could be used to develop a model that would enable forecasting and preventing HAB events. Such information is needed to reduce the likelihood for future negative impact of HABs on estuarine processes and for designing best management and preservation plans.

B. Approach/Plan of work

We propose a work plan that will combine monitoring and mapping of biological, chemical and physical components throughout the Bay and Delta along with controlled manipulations to examine specific parameters that are likely to control growth and toxicity in the natural population of harmful algae in SF Bay. Work proposed here is primarily a field-oriented research program. The work includes (a) monthly sampling throughout the Bay and Delta to map the spatial and temporal distribution of algae and toxins in relation to a suite of important environmental parameters (b) seasonal *in situ* enrichment incubation experiments to determine which targeted parameters (or combinations of parameters) induce growth and toxicity of harmful algae including a focused study on *Microcystis aeruginosa* in the Delta. The data will be used to shed light on the physical, chemical and biological factors conducive to bloom events and in the future could be used to construct a predictive model for HABs in SF Bay in the context of a changing environment.

Study Area – The SF Estuary ecosystem comprises a continuum of conditions with freshwater input in the Delta to hypersaline ponds in South Bay with an area influenced by communication with coastal seawater in Central Bay. This setting provides a range of conditions that will result in a range of HAB species and environmental controls on toxin production. In general the Bay can be described as two estuarine systems, each with different hydrodynamic and hydrologic regimes [68]. Northern SF Bay is a partially mixed estuarine environment with a high annual freshwater input. It includes San Pablo Bay, Suisun Bay, and Sacramento River/San Joaquin River Delta. The Sacramento – San Joaquin River Delta is a hydrodynamically complex system comprised of an intensely managed network of natural and human-made levees and lakes, diked agricultural fields, and relicts of tidal marshlands. The watershed comprises approximately 40% of the area of California [69]. Southern SF Bay is a tidally oscillating tributary lagoon with density-driven exchanges with Central Bay which communicates directly and extensively with coastal waters [70]. While salinities in North SF Bay may vary from 0 to 30 depending primarily on discharge of water through the San Joaquin/Sacramento Delta (and distance from the ocean), salinities in the South SF Bay generally remain between 26 and 33 with higher salinities in shallows and ponds [71].

Task 1 - Spatial and temporal distribution of harmful algae and toxins in SF Bay and Delta

In order to describe the spatial and temporal distribution (occurrence and abundance) of harmful algae and their toxins in SF Bay we will work closely with the US Geological Survey SF Bay monitoring program (see letter of support). This program includes regular measurements of water quality along a 145-Km transect spanning the length of the entire estuarine system. A series of fixed stations from Rio Vista (lower Sacramento River) to South Bay mouth of Coyote Creek are visited (Fig. 2A). Measurements along the entire Bay are done at least once each month. In addition, more intensive sampling in the South Bay is conducted during spring and fall, the seasons of rapid water quality changes

associated with the phytoplankton blooms. Sampling is done aboard the research vessel *Polaris.* Data are collected using a submersible instrument package (CTD) that concurrently measures multiple water quality parameters (depth, conductivity, temperature, suspended solids, chlorophyll, light penetration, and dissolved oxygen). Vertical profiles are obtained at each sample station resulting in a two-dimensional (longitudinal and vertical) description of water quality for each sampling date. In concert with the submersible instrument package sampling, during each cruise discrete water samples (from 14 stations throughout the Bay) are collected and processed for determination of dissolved oxygen, suspended particulate matter, chlorophyll a, and dissolved inorganic nutrients. Discrete samples are collected at the surface and 1 meter off the bottom. All of the ancillary data from this USGS water quality monitoring program will be available to this project at no extra cost. For details see the web page: http://sfbay.wr.usgs.gov/access/wqdata/index.html. Tidal currents speed, wind speed and other hydrodynamic and meteorological data will also be available from USGS and DWR. Details on collection, analytical methods and data quality control are available on the above web page.

In the Delta, we will monitor the spatial and temporal distribution of harmful algae and their toxins with a special focus on *Microcystis aeruginosa* Fig. 2B). Sampling will be conducted monthly by partnering with Dr. Anke Mueller-Solger (Department of Water Resources) and the Environmental Monitoring Program of the Interagency Ecological Program (http://www.baydelta.water.ca.gov/emp/). This program includes regular monitoring of water quality variables (conductivity, pH, dissolved oxygen, turbidity, dissolved chloride, chlorophyll fluorescence, water temperature, air temperature, wind speed and direction, solar radiation) as well as biological characteristics, such as phytoplankton and zooplankton community composition and biomass in the Sacramento-San Joaquin Delta, Suisun Bay, and San Pablo Bay. For more details, see: http://www.baydelta.water.ca.gov/emp/metadata_index.html.
All these ancillary data will be available to this project at no cost. Sampling will be done on board the DWR/USBR research vessels during the monthly routine monitoring cruises at the discrete stations (Fig. 2B). We will compare our results (see below) with Dr. Mueller-Solger's Fluoroprobe data. Additionally, we are partnering with Dr. Peggy Lehman (DWR) to contribute to an ongoing seasonal sampling program during *Microcystis aeruginosa* blooming season (June-September). Sampling will be done every two weeks at seven stations covering the Delta and in the Eastern region of the Suisun Bay. Variables measured during this study include nutrients concentration, DOC, POC, turbidity, temperature, salinity and toxin levels (microcystins, anatoxin A). Using molecular methods, the program will also monitor the toxin-producing chemotypes of *Microcystis* the expression of the gene involved with toxin production. Results from this study will shed light on the link between the SF Estuary *Microcystis* community structure and function and will have direct implications with respect to management of this invasive species. We will contribute to this seasonal program by monitoring the trace metal concentrations as well as complementary analyses such as saxitoxin monitoring and incubation experiments (see below).

Concurrent with the above monitoring programs in the Bay and Delta as part of this CALFED project we will collect samples for algal identification and enumerations and toxin (domoic acid, saxitoxins, microcystins) levels at all discrete sampling location in the Bay and Delta described above. We will also add analysis of dissolved organic carbon, total organic nitrogen, total organic phosphorus and trace metal concentrations (using trace metal clean sampling protocols) because these are not routinely monitored but may influence the growth and toxin production of harmful algae. Detailed sampling, processing, and analysis methods used for the above work are described in detail in appendix I (available upon request to Ms. Shauna Oh at the Sea Grant office: shaunaoh@ucsd.edu).

Task 2- In-situ incubation experiments

We will conduct enrichment bioassay incubation experiments seasonally to examine the individual and combined effects of nutrients, trace metals, temperature and light on growth of and toxin production by harmful algae. This is aimed at elucidating the underlying mechanisms that control the

distribution and toxicity of harmful algae and evaluate under what conditions algae growth is induced and toxic levels are expected to increase. Such "bottle experiments" allow getting a better resolution of the impact of chemical and physical variables on toxin production and harmful algae growth by excluding other parameters (*e.g.* grazing, mixing). Bioassays will be conducted at 3 sites in the Bay and 2 sites in the Delta (as determined by the assessment of field distribution of harmful algae). We will investigate the phytoplankton responses to the individual and combined effects of fertilization with inorganic macronutrients (N, P), organic nutrients (DON, DOP, DOC) and trace metals (Fe, Mn, Zn, Li, Cu) under environmental light and temperature conditions. The effect of increased temperature will also be assessed. Specific perturbations that we will initially test are based on existing data from previous work [17, 18, 20, 28, 29, 72, 73, 74] that describes potential influencing parameters on growth and toxicity of various harmful species. Following the initial experiment and based on accumulated data over the first 6 months of this project we will determine which parameters in the Bay are most strikingly different than observed in the adjacent coastal California and manipulate these specific parameters in following incubations. For example if we find that the relative ratios of certain nutrients (Si:N, N:P, Urea:P, etc.) is consistently different in SF Bay compared to the coastal ocean we will change these ratios and document the effects. Table 1 and Figure 1 illustrate some examples of possible manipulations and bioassays with Microcystis and other harmful algae species, which are based on previous work and will be tested here. For example it was suggested that the nitrogen and phosphorus sources as well as iron, light intensity and temperature may impact toxin production by *Microcystis* [75], thus these parameters will be tested in Delta waters.

To conduct these incubations surface water from the 5 sites in the Bay and Delta will be collected. Four liters per sample of surface water will be pre-filtered over 100 µm nylon mesh to remove zooplankton grazers and collected into large (6 L) acid cleaned and sample rinsed, low-density, translucent polyethylene cubitainers (in triplicates). Water will be kept at *in situ* condition at all times except for the very short duration of filtration and nutrient/trace metal additions. Nutrient/metal additions will take place as soon as possible (pre-mixed aliquots will be prepared and added) and cubitainers returned to the water. An array of treatments will be tested; the specific details of these manipulations will be continuously evaluated and adjusted to reflect results from data accumulated in our monthly sampling. Following nutrient/metal additions, the cubitainers will be incubated for up to four days within the SF Estuary. The cubitainers will be secured to a peer or a buoy to ensure daily access. To simulate light impact the cubitainers will be deployed at different depths (or covered with mesh to lower light level) and for evaluation of the effect of increased temperature some incubations will be conducted on shore in the lab in controlled temperature chambers or at warmer shallow areas within the Bay. A full characterization (e.g. all the ancillary parameters such as temperature, salinity, oxygen, nutrients, etc.) of the ambient water used for the incubation experiments will be done. During the 4 days of incubation each cubitainer will be sampled daily for toxin levels, nutrients, trace metals, chlorophyll *a*, Fv/Fm, flow cytometery and cell identification and counts to monitor changes in these parameters. All reagent preparation and cleaning of culture ware and sampling bottles will be rendered trace metal clean via standard protocols established in the trace metal laboratory at UCSC. These incubation experiments will allow us to determine how various monitored parameters interact under ecologically relevant conditions to control the growth and toxicity of harmful algae.

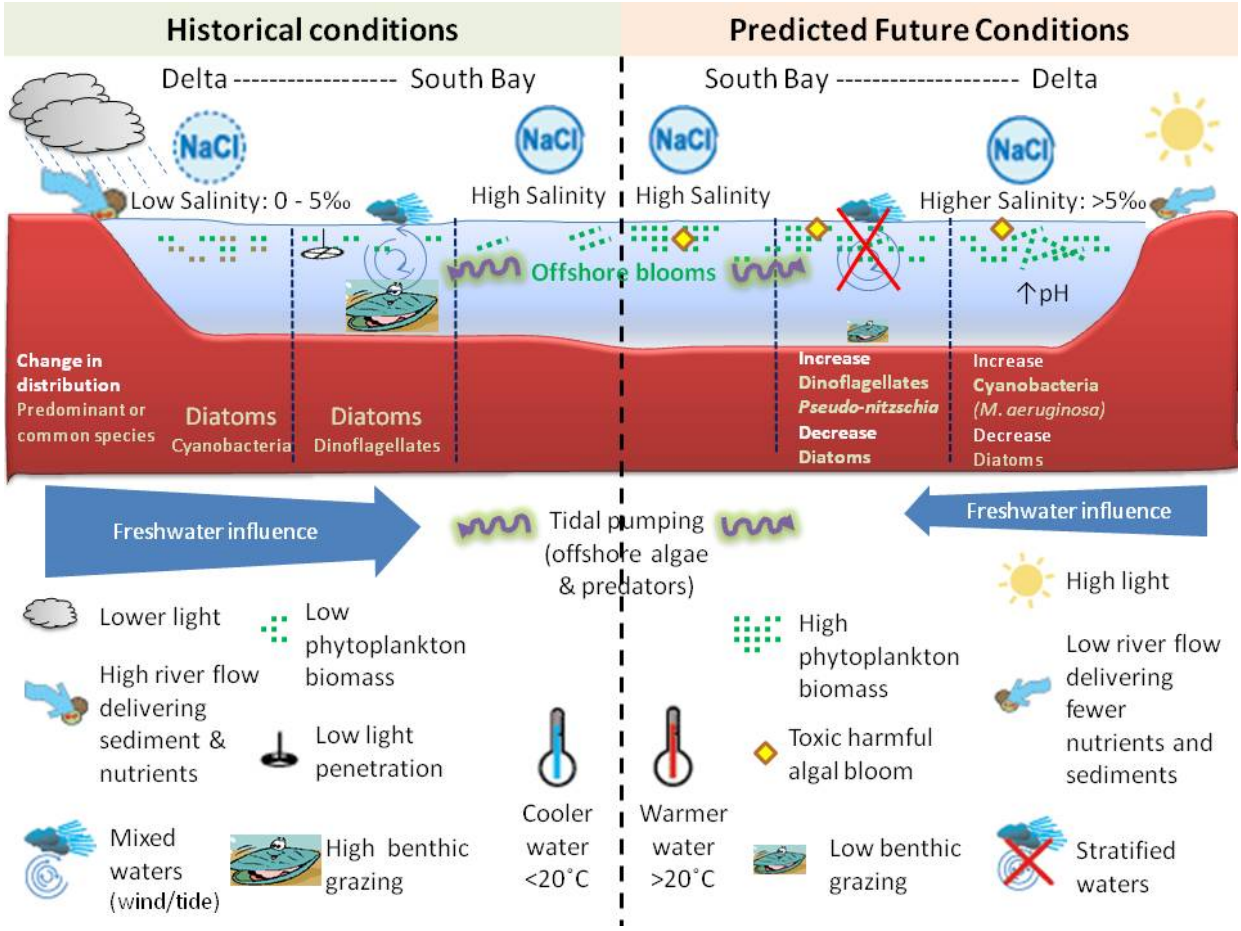
C. Output/Anticipated Products and/or Benefits

Recent reports such as that published by the U.S. Commission on Ocean Policy have highlighted the severity of the problem of HAB events and have stressed the importance to develop new management approaches (http://www.oceancommission.gov). Effective HAB management and regulatory interventions are stymied by lack of an integrated understanding of the physical, chemical and biological parameters that induce, sustain and regulate blooms and toxin production. Results from

this project include: (a) description of current status of harmful algae and related toxins in SF Bay-Delta system and development of a baseline dataset, and (b) better understanding of the mechanisms underlying the occurrence and toxicity levels of harmful algae in SF Bay and Delta. Data obtained through this project will be compiled to produce some simple distribution matrix (model) that assesses the impact of various parameters on the algal abundance, growth and toxin production in SF Estuary. These data could be used in the future to develop a prediction model that will have the ability to forecast various algae densities and toxin concentrations in SF Bay under various climate and development scenarios. Predictive model suitable for forecasting bloom occurrences are important tools for controlling and reducing the impact of HABs. The accuracy and predictive capability of such a model however dependents on the understanding and formulating the biotic and abiotic processes which are included in the models. Thus insight into the relation between algal abundance, toxin levels and various environmental parameters obtained through our proposed study is critical for the development of accurate and precise models. Data and understanding from this project will be relevant for environmentalists, regulators, local governments, and industries as well as environmental managers and policy makers interested in protecting the San Francisco Estuary and its watershed.

Specific outputs of the proposed project include research results (publications, presentation). We will disseminate the results broadly. Public outreach effort targeting resource managers and decision makers as well as stakeholders and the general public via open house lectures, workshops, newsletters, K-12 education initiatives and websites will be planed and executed. We will create monthly report cards describing the health of the Bay on our website and we will report elevated levels of toxins or toxic algae each month in a HAB alert section. Our website will be linked to the CALFED and USGS webpages. We will also partner with educators to develop research based education materials. All of the above outputs directly address the California Sea Grant CALFED priorities described in this solicitation: provide information needed to prevent, control and mitigate blooms of invasive species; examine the relationships between the primary production and the habitat quality by connecting nutrient and trace metal loading, HABs, and food web dynamics in a changing environment; investigate how the SF Bay ecosystem will respond to future conditions (e.g. raising water temperature, changes in salinity and turbidity); provide information that will enhance current HAB monitoring and forecasting efforts; help facilitate bloom prevention through an advanced understanding of the controlling factors.

This proposal brings together a multidisciplinary team (PI and collaborators) with expertise on hydrodynamic modeling, nutrient and trace metal dynamics, phytoplankton biology, HABs, and the SF Bay-Delta system to shed light on the occurrence, distribution and governing environmental parameters of harmful algae and their toxicity. While Dr. Paytan will be my principal research mentor, we will collaborate with Dr. Lisa Lucas' and Dr. Cloern's group (USGS), Dr. Mueller-Solger and Dr. Lehman (DWR) as well as Dr. Silver and Dr. Kudela (UCSC). Dr Mioni, the applicant, and Dr Paytan, as the PI and research mentor, will be responsible for the overall oversight of the project and the field work. Dr Lucas and Dr Cloern will provide knowledge on SF Bay and help provide access to boat facilities and monitoring data. Dr Lucas, an experienced modeler has agreed to assist with the interpretation and modeling of hydrodynamic and physical variables. Both Dr Mueller-Solger and Dr Lehman are involved in phytoplankton community and HAB monitoring in the SF Delta. They will provide knowledge and access to research vessels and monitoring data in the Delta. Both Kudela and Silver are involved in HAB research in California and will help identify target parameters for incubation experiments. Advantages of the collaborative research project include: (a) Enhancement of current monitoring programs and resulting management recommendation through complementary analyses as well as sharing of monitoring experience; (b) Economy of scale: this project will take full advantage of preexisting monitoring infrastructures and will focus on enhancing rather than duplicating the current programs and measurements.



	Microcystis aeruginosa	*Pseudo-nitzschia spp.*	*Alexandrium catenella*	*Akashiwo sanguinea*
Temperature (˚C)	>20 [16,76,77]	10 – 25[84]	10 – 25[90,91]	10 – 30 [92]
Light ($\mu E\ m^{-2}\ s^{-2}$)	>26 [75]	45 –200 [85]	120 [90]	14.4 – 114 [92]
Salinity (‰)	0 .1 – 10 [16] (survive up to 18‰)	15 – 40 [84, 86]	30 – 35 [90]	10 – 40 [92]
NO_3 (mM)	> 1.27 [75]	>0.055 [87,88]	0.22 – 8.83 [90]	Mixotrophic [93] (algal predator)
NH_4 (μM)	0 – >1,000 [78,79,80]	55 – 200 [87,88]	25 – 200 [90]	
Urea (μM)	0 – >1,000 [80]	200 [88]	–	
PO_4 (μM)	> 100 [75]	>3 [21]	40 – 60 [90]	
$Si(OH)_4$ (μM)	0 – 0.68x10^6 [81]	>100 [21,85]	100 – 540 [90]	
N:P	10 – <30 [76,82]	15 [88]		
Si:N	20 – 50 [16]	1:8 [85]		
Fe_T (μM)	>10 [75]	0.15 [89]	70 – 110	
Cu (M)	< 10^{-12} [83]	<10^{-9} – $10^{-10.5}$ [83,89]	$10^{-8.3}$–$10^{-7.4}$ [83]	< 10^{-11} [83]

Figure 1 – Conceptual diagram detailing the main factors that determine HABs and characteristics impacting growth and distribution of harmful algae species sighted in the SF Bay

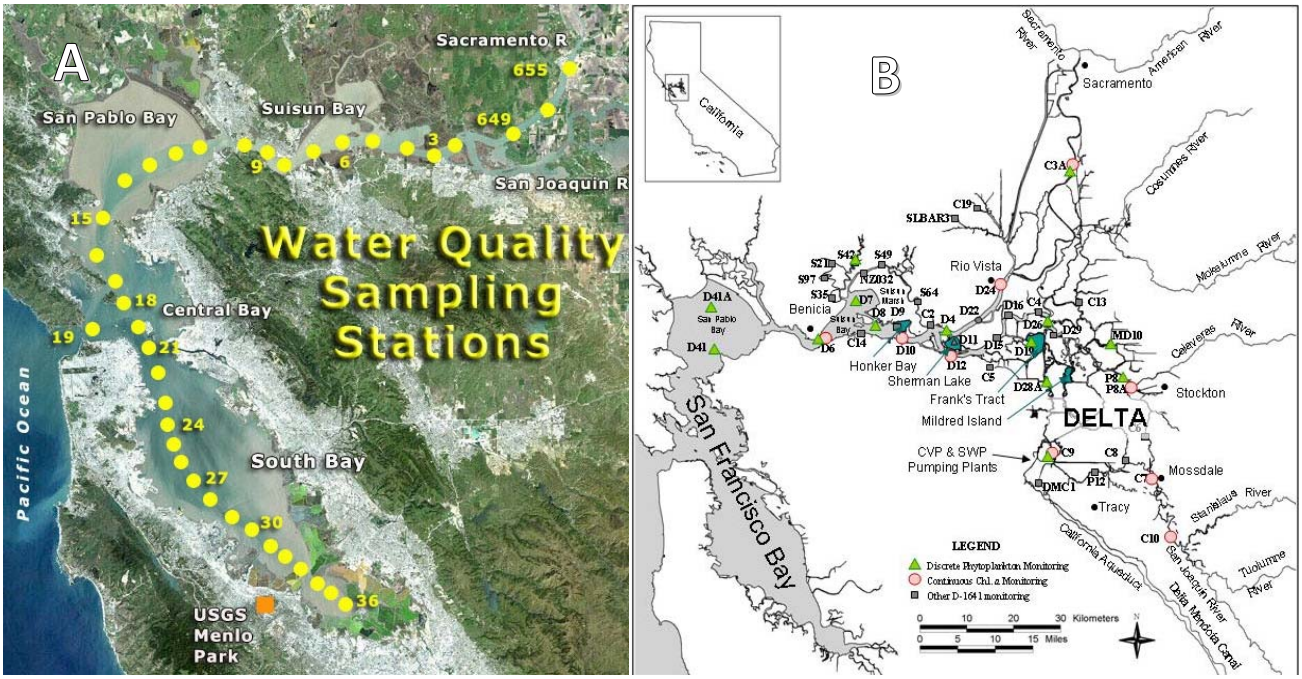


Figure 2 – Map of sampling stations and discrete sample sites in the San Francisco Bay (A) and in the upper San Francisco Estuary (B)

Table 1 - Environmental drivers associated with *Microcystis aeruginosa* growth and bloom development and with microcystin production. *In Situ* values represent observed values reported in the literature for the San Francisco Estuary and Delta Systems. In vitro values represent values reported in the literature for laboratory experiments. Model values represent statistically-significant predicted values for the formation of a toxic bloom of *Microcystis aeruginosa* [74].

Drivers	Growth/Bloom development	Microcystin production
Physical drivers		
Light intensity ($\mu E\ m^{-2}\ s^{-1}$)		
In situ	2000 [55]	–
In vitro	80 (μmax) [94]	80 (MCmax/cell) [94]
Model	**>26** [75]	
Temperature(˚C)		
In situ	> 20 [16]	20 – 25 [16]
In vitro	28 – 32 (μmax) [77]	20 – 24 [94,95]
Model	**>18.8** [75]	
Streamflow (m^3s^{-2})		
In situ (SJR)	28-32 [16]	–
Chemical drivers		
Salt tolerance *(‰)*		
In situ	0.1 – 18 [55]	<5 [16,55]
In vitro	<7[96,97], <10[98,99], <14[100]	<10 [99]
[NH_4^+] (μM)		
In situ	0.56 – 1.67 [16]	
In vitro	0 – 1000 [80]	0 [79,102]
[NO_3^-] (μM)		
In situ	3 – 5.8 [16]	–
In vitro	variable	350 – 5,800 [101]
Model	**>1270** [75]	
Inorganic Phosphate(μM)		
In situ	0.63 – 1[16]	–
In vitro	14.4 [100] – 176 [82]	14.4 –143.5 [101]
Model	**>100** [75]	
Si:N		
In situ	20 – 50 [16]	–
In vitro	–	–
N:P		
In situ	10 – 15 [16]	≤5 [76]
In vitro	18 – 51 [82]	16 – 46 [82]
Iron (μM)		
In situ		
In vitro	10 – 100 [101]	10 [79, 101]
Model	**>10** [75]	

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2009 California Sea Grant CALFED PROPOSAL
Appendix 1: Methods

Phytoplankton – All phytoplankton samples will be collected with a standard 20 µm mesh net. In the field rapid algal identification will be conducted with a Swift Instruments field microscope capable of 40x, 100x, and 400x magnifications. In addition, a 50 ml water sample will be preserved and stained with Lugol's solution for additional phytoplankton cell identification and enumeration using an inverted microscope (Utermohl 1958). The phytoplankton abundance will also be determined using flow cytometry as needed. All species composition data will be recorded as relative abundance; ancillary data on sampling effort (total length of plankton tow and depth of sampling) will also be recorded.

Toxins – Toxin levels including domoic acid, microcystins, and saxitoxin will be determined using tested commercially available enzyme linked immunosorbent assay (ELISA) kits. These kits provide quantitative analyses even at low concentrations and are highly sensitive to a given molecule. For domoic acid we will use the *BioSense DA ELISA kits* – which are marketed by BioSense for domoic acid detection and are based on a competitive binding assay and can be used with shellfish and plankton samples. The quantitative ELISA test kit is used for routine monitoring in water samples. A free software is provided for the automatic QA of the calibration and sample calculation. The kit has been thoroughly validated in an international intra- and inter- laboratory comparison study. For information about the validation results please contact Hans Kleivdal (hans.kleivdal@biosense.no) and for more information about the product see: http://www.biosense.com/comweb.asp?articleno=192&segment=3
Saxitoxin (paralytic shellfish poisons, PSP) ELISA test kit are also available commercially from BioSense and will be used for quantitative saxitoxin determination. The ELISA kit detects saxitoxins in water samples at the parts per trillion (ppt) levels. The antibody binds Saxitoxin and other related PSP toxins with varying degrees and does not cross-react with other non-related toxins or compounds. The assay range is between 0.02 ppb and 0.4 ppb in water. Total time for measurement is 60 minutes. The kit, a 96-well microtiter plate format with ready to use, color coded reagents, enables simultaneous measurement of multiple samples. As for the ASP kit accuracy and reliability were tested, results validated and QC and QA standards are available and are analyzed with samples. For more information see: http://www.biosense.com/comweb.asp?articleno=328&segment=3&session=
To detect microcystins, commercially available MCs-ELISA test kits (Abraxis LLC,) will be used. The detection limit for this assay based on MC-LR is 0.10 ppb (ng/L). Coefficients of variation (CVs) for standards are <10% and for samples <15%. The assay exhibits very good cross-reactivity with all cyanobacterial cyclic peptide toxin congeners tested to date. The evaluation of the ELISA can be performed using commercial ELISA evaluation programs: 4-parameters (preferred) or alternatively Logit/Log or point to point. For a manual evaluation the mean absorbance value for each of the standards can be calculated and a calibration curve produced. For more details see http://www.abraxiskits.com/product_algal.htm

Trace Metals – Samples will be collected using acid-cleaned all-plastic GO-Flo bottles or using a peristaltic pump with acid-cleaned plastic tubing (C-flex). Water will be filtered through in-line acid-cleaned 0.2-µm capsule filters with Supor membrane (Pall acropak) and collected in acid-cleaned low-density polyethylene bottles. Samples will be acidified under clean conditions with 4 mL 6N ultrapure HCl per L and stored for analysis. Trace metals (Li, B, Ag, Cd, Cs, Pb, V, Cr, Mn, Fe, Co, Ni, Cu, Zn) will be analyzed by ICP-MS. One mL sample will be diluted by 2% trace metal clean nitric acid (to 10 mL) and analyzed ICP-MS (Finnigan Element High-Resolution). The instrument is capable of detecting ppt levels of multiple elements simultaneously using less than 1mL sample. If needed we will pre-concentrate the

metals before analyses using column extractions. Samples will be analyzed in triplicates. Calibration will be obtained using multi element certified standards spanning the range of expected concentrations and run at least 3 times with each batch of samples. Matrix matched internal standards will be used for quality control every 5 samples and a certified seawater standard (NASS-5) used for assurance. Operation blank will be determined and the accuracy of the method will be assessed by analyzing standard reference seawater (NASS-5). All of the process will be done using trace metal clean protocols established in the trace metal laboratory at UCSC.

Nutrients – Total nitrogen and phosphorus will be analyzed on filtered samples using colorimetric methods described by Hansen and Koroleff (1999), and modified for a Flow Injection Autoanalyzer (FIA, Lachat Instruments Model QuickChem 8000) after a persulfate microwave digestion (Parkinson and Allen 1975). The precision of these methods in this analysis is 0.05 µmol L^{-1} for NO_2 and NO_3, and 0.02 µmol L^{-1} for SRP and reproducibility is better than 98%. Calibration standards will be matrix matched and cover the range of expected concentration. Standards will be run 3 times and QC standards will be run throughout the analyses as well (every 7 samples). Inorganic nutrients are measured through the USGS SF Bay monitoring using standard methods.

Dissolved Organic Carbon – Samples for DOC analysis will be filtered through a sterile filter and collected into acid washed 20 ml borosilicate glass scintillation vials with teflon lined screw caps. Samples will be kept frozen until analysis. Before analysis samples will be acidified with HCl to pH 2 and purged to remove inorganic (and purgeable organic) carbon. Samples will be analyzed using a Total Organic Carbon Analyzer (Shimadzu TOC-5000A).

Data Analysis – All data will be assessed for normality and will be log transformed as appropriate. Chi-square, ANOVA, Duncan's multiple range test, correlation, cluster analysis and discriminant analysis will be preformed as appropriate using Statistica (Statsoft). Differences in the means for variables among regions in the Bay or within each region over time will be determined using the Kruskal–Wallis nonparametric technique. Multiple comparisons will be evaluated using least significant differences and correlation will be evaluated using Spearman rank correlation coefficients. The regression, correlation and principal components analysis will be used to assess the relative effects of various environmental factors and harmful algal abundance (each species will be considered separately). The above described data set and related analysis will help determine interaction and relations under natural field conditions and discern the patterns of environmental and biological factors stimulating the algal abundance and toxin levels. Key factors leading to enhances numbers and toxin concentrations will be documented. Data collected in San Francisco bay will be compared to the large existing data set from ongoing programs in coastal areas within the geographic area (e.g. Marine County, Santa Cruz County and Monterey Bay). This comparison will help determine the unique properties that protect the Bay from frequent and re-occurring HABs as those seen in the nearby coast.

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FISCAL YEAR Start Date: 9/1/08 (mm/dd/yy) End Date: 9/1/09

PROJECT NUMBER	Adina Paytan NAME OF MENTOR
UCSC INSTITUTION	Cecile Mioni NAME OF FELLOW

	CALFED FUNDS
A. EXPENDABLE SUPPLIES AND EQUIPMENT	
1. Domoic Acid ELISA test kits (14x$533)	7,462
2. Paralytic Shellfish Poinson ELISA test kits (14x$754)	10,556
3. Microcystins ELISA test kits (14x$400)	5,600
4.	
5.	
TOTAL SUPPLIES	23,618
B. PERMANENT EQUIPMENT	
1.	
2.	
3.	
4.	
5.	
TOTAL EQUIPMENT	
C. TRAVEL	
1. DOMESTIC-U.S. AND ITS POSSESSIONS	700
2. INTERNATIONAL (INCLUDING CANADA AND MEXICO)	2,000
TOTAL TRAVEL	2,700
D. PUBLICATION AND DOCUMENTATION COSTS TOTAL PUB COSTS	200
E. OTHER COSTS	
1. Fellowship Stipend (review call for proposals)	45,000
2. Health Insurance	3,330
3.	
4.	
5.	
6.	
TOTAL OTHER COSTS	48,330
F. TOTAL DIRECT COSTS *(A THROUGH E)* TOTAL DIRECT COSTS	74,848
G. INDIRECT COSTS	
ON CAMPUS 25.0% OF 29,848	7,462
OFF CAMPUS 25.0% OF	
TOTAL INDIRECT COSTS	7,462
H. TOTAL COSTS TOTAL COSTS	82,310

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DATE:

YEAR 2 Start Date: 9/1/09 (mm/dd/yy) End Date: 9/1/10

PROJECT NUMBER	Adina Paytan NAME OF MENTOR
UCSC INSTITUTION	Cecile Mioni NAME OF FELLOW

		CALFED FUNDS
A. EXPENDABLE SUPPLIES AND EQUIPMENT		
1. Domoic Acid ELISA test kits (14x$533)		7,462
2. Paralytic Shellfish Poinson ELISA test kits (14x$754)		10,556
3. Microcystins ELISA test kits (14x$400)		5,600
4.		
5.		
	TOTAL SUPPLIES	23,618
B. PERMANENT EQUIPMENT		
1.		
2.		
3.		
4.		
5.		
	TOTAL EQUIPMENT	
C. TRAVEL		
1. DOMESTIC-U.S. AND ITS POSSESSIONS		700
2. INTERNATIONAL (INCLUDING CANADA AND MEXICO)		2,000
	TOTAL TRAVEL	2,700
D. PUBLICATION AND DOCUMENTATION COSTS	TOTAL PUB COSTS	200
E. OTHER COSTS		
1. Fellowship Stipend (review call for proposals)		45,000
2. Health Insurance		3,330
3.		
4.		
5.		
6.		
	TOTAL OTHER COSTS	48,330
F. TOTAL DIRECT COSTS *(A THROUGH E)*	TOTAL DIRECT COSTS	74,848
G. INDIRECT COSTS		
ON CAMPUS 25.0% OF 29,848		7,462
OFF CAMPUS 25.0% OF		
	TOTAL INDIRECT COSTS	7,462
H. TOTAL COSTS	TOTAL COSTS	82,310

DATE:

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CUMULATIVE BUDGET

PROJECT NUMBER	Adina Paytan NAME OF MENTOR
UCSC INSTITUTION	Cecile Mioni NAME OF FELLOW

	CALFED FUNDS
A. EXPENDABLE SUPPLIES AND EQUIPMENT	47,236
B. PERMANENT EQUIPMENT	
C. TRAVEL	
1. DOMESTIC-U.S. AND ITS POSSESSIONS	1,400
2. INTERNATIONAL (INCLUDING CANADA AND MEXICO)	4,000
D. PUBLICATION AND DOCUMENTATION COSTS	400
E. OTHER COSTS	96,660
F. TOTAL DIRECT COSTS *(A THROUGH E)*	149,696
G. INDIRECT COSTS	14,924
H. TOTAL COSTS	164,620

Budget Justification

	Adina Paytan
PROJECT NUMBER	NAME OF MENTOR
	Cecile Mioni
INSTITUTION	NAME OF FELLOW

The budget for this proposal is primarily support for two years for a post doctoral Fellow (Cecile Mioni). Cecile will be responsible for all aspects of the work with the guidance of her mentors Dr. Patytan and Dr. Lucas. We are also requesting funds to cover health benefits for Cecile. The above components were calculated based on the CALFED and UCSC guidelines.

In addition to the Post Doctoral stipend support we budgeted for expenses on materials and supplies which are needed for conducting the research. Specifically, kits for analyses of toxin levels which are not cheap are included. This calculation was based on the cost of the kits and the number of samples to be analyzed each year. Other expenses include travel to meetings to present the work (CALFED meeting and ASLO meeting in France) and some support to cover publication costs.

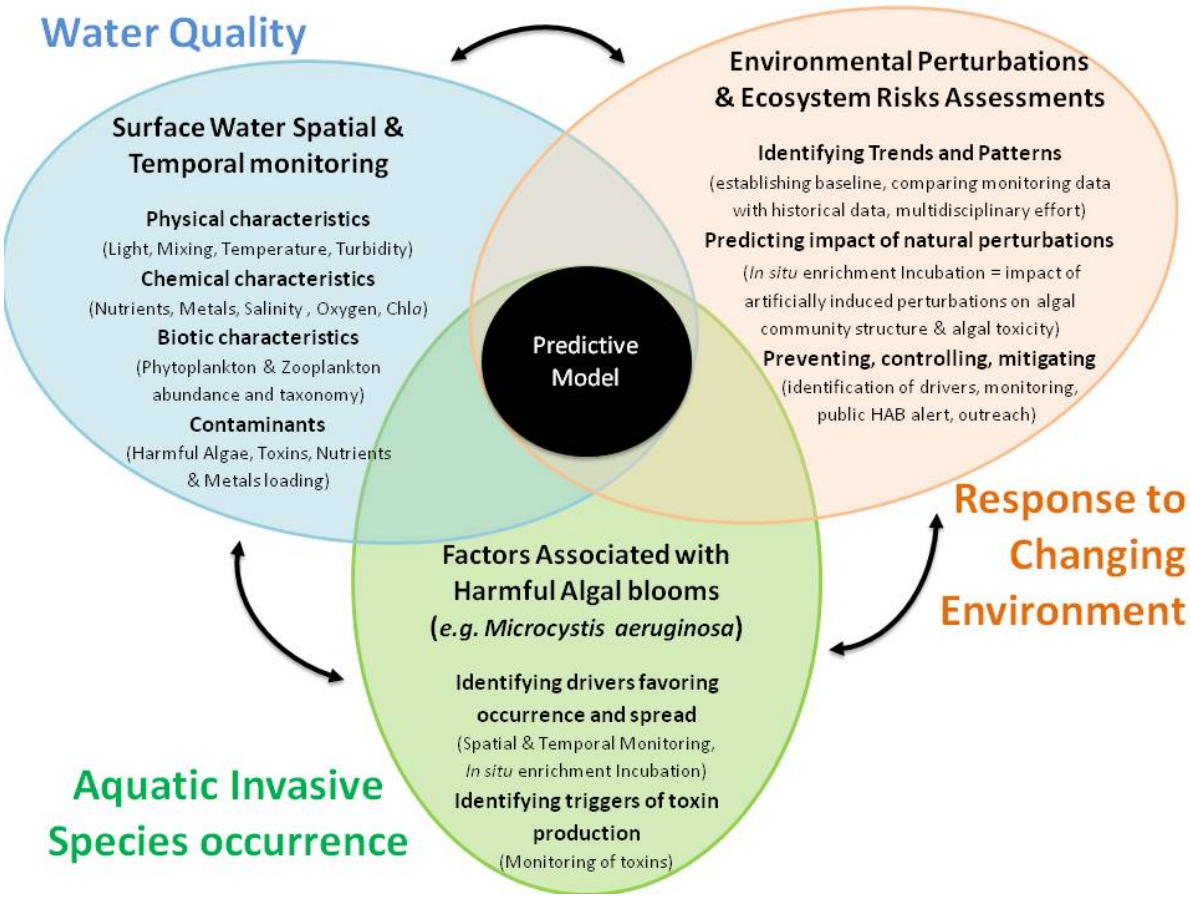
* $700 - Funds are requested to support for domestic travel per year.

  - $255/year : We anticipate to attend the state of the Estuary CALFED/Science conference to present results each year (estimated approx. 300 miles round trip from Santa Cruz x $0.35 per mile = $105 and one night of room and board @ $150/night = $255 per year).

  - $445/year: We also anticipate twelve monthly field trips from Santa Cruz to the USGS Boat and to the Delta for sampling, estimated at 106 miles per trip (approx. 106 miles x $0.35 per mile x 12 trips = $445).

* $2,000 - Funds are requested per year to support international travel to attend international scientific meetings to present results (estimated $1,100 airfare and five nights of room and board @ $150/night for each year)

2008 California Sea Grant CALFED PROPOSAL
3. Research Links to CALFED Program



The main goal of the proposed research is to determine the distribution of harmful algae and their toxins in San Francisco Bay-Delta and characterize the environmental drivers controlling toxin production by harmful algae. This work is directly linked to CALFED's targeted topic areas. Specifically, it addresses issues related to research on **Trends and Patterns of Habitats, Populations and System Response to a Changing Environment**. Harmful algae are some of the less studied Bay and Delta species and their distribution, abundance as well as the conditions promoting their proliferation are not well characterized. Research is needed to explore how they currently respond to environmental conditions. This is particularly important considering predicted future environmental changes in temperature, stratification and nutrient and trace metal loading that can dramatically alter the abundance and toxin production of harmful algae. A better understanding of the population and dynamics of harmful algae in the Bay-Delta system is needed for enhancing existing resource management or develop new tools and decision support systems that improve management effectiveness. The work also addresses the topic of **Aquatic Invasive Species**. *Microcystis aeruginosa* is an invasive cyanobacterium that would be studied here and results will help predict the conditions under which this invasive species is successful and when it produces toxins. We will establish under which future scenarios this species might bloom. Finally the work is also related to the topic of **Water Supply, Water Quality**, noxious toxins produced by harmful algae reduce the water quality and may impact the supply of drinking water as well as the Bay water quality which directly impacts other species livelihood, including endangers species.

2008 California Sea Grant CALFED PROPOSAL
2. Personal Statement

I believe that my research and teaching experience as well as my personal background will be a valuable addition to the CALFED program and could contribute to its intellectual and social enrichment. In my past educational experience I have unfortunately had to overcome economical and physical hardships which made me extremely motivated to focus on my career and devote my love to science and education to this project. Should my application be accepted, it would allow me to expand my experience and horizons and get involved in an interdisciplinary network which would be very valuable for my future career and allow me to set up a valuable multidisciplinary research and outreach program.

My experience in microbial ecology and cellular physiology will contribute to the diverse team that will be working on HABs in SF Bay if this project is funded and my expertise will be a valuable addition to the proposed research project. So far, my research has focused on the impact of environmental stimuli (e.g. nutrients bioavailability, intercellular communication molecules such as defensins and autoinducers) on microbial cell physiology, on microbial secondary metabolites production and on microbial processes through molecular and biochemical studies.

Throughout graduate school, my research mainly focused on the impact of iron limitation on both autotrophic and heterotrophic aquatic microorganisms. Indeed, iron is a key element controlling plankton community structure and function not only in large areas of the World's Ocean, but also in some freshwater systems. My Masters research was performed with marine chemists at the European Institute of Marine Studies (Plouzané, France) and focused on the impact of Fe limitation on the elemental ratio of oceanic and coastal diatoms. I have further broadened this research by studying the response of the carbon metabolism of the diatom *T. weissflogii* to iron deficiency in Professor Morel's laboratory (Geochemistry department, Princeton). Results from this research work suggested that Fe deficiency in diatoms induce changes in phophoenolpyruvate carboxylase activity and organic acid (malate) efflux. Throughout my doctoral research, I've applied biosensor technology to assess the bioavailability of iron to aquatic microbial organisms. My research involved designing and characterizing a new biomolecular tool (a bioluminescent bacterial bioreporter) to monitor iron bioavailability to heterotrophic bacteria and to elucidate how different iron-binding organic ligands influence iron bioavailability. The use of bioreporters (intact, living bacterial cells that have been genetically engineered to reproducibly produce a quantifiable signal in response to an environmental stimulus) is becoming popular in many areas of research. I have fully characterized the bioreporter in the laboratory and successfully tested it during field studies performed in three distinct oceanic systems. One of the main conclusions of this research work is that iron chemistry and physical speciation, as well as interactions among species, greatly influences the response of plankton communities in aquatic ecosystems. By using this device, I also demonstrated that iron released from phage-mediated lysate is far more bioavailable than inorganic Fe (Fe(III)) or cognate siderophores and that this increase in Fe bioavailability may reflect a diversification of Fe sources.

During my time as a postdoctoral researcher, I have developed a passionate interest in applying my experience in microbial ecology to health-related and other environmentally relevant applications. I have developed new culturing strategies to isolate marine bacteria for novel, natural products-based drug discovery, focusing on neglected infectious diseases (specifically malaria, leishmaniasis and cholera). In line with the OSMAC strategy ("One Strain MAny Compounds"), I have maximized each isolate's potential to generate novel, biologically active compounds by diversifying the growth conditions. More specifically, my work resulted in promoting secondary metabolite production by challenging each isolate with microbial growth inhibitors (e.g. triclosan), plant defensins (e.g. jasmonic acid), siderophores (e.g. Desferrioxamine B), or by inducing them with interspecific quorum sensing signaling molecules (e.g. 4-hydroxy-5-methyl-3(2H) furanone). Last, isolates are grown in controlled

mixed cell cultures to stimulate and to investigate eventual synergetic and antagonistic (*e.g*. antimicrobial) interactions that might trigger the production of new bioactive compounds that would not be produced in pure culture. The proposed research project will allow me not only to deepen my research experience in microbial ecology and microbial physiology but also to acquire new areas of research expertise (i.e. ecotoxicology, applied environmental research) before tackling a tenure-track job. Indeed, my ultimate goal is to pursue an academic career as a professor at a college or university. Broadening my experiance and working with an interdisciplinary group on environmentally relevant issues will prepare me better for this future career plan.

In addition to my research experience I also have some experience working with students at several levels, including teaching, mentoring, field instruction, and informal laboratory instruction. I generally try to guide students and to share my knowledge but I do not provide all the answers right away because I believe that questioning and anticipating problems are part of the learning process. Although this method can (and does) at times lead to frustration, it is beneficial and has helped undergraduate students to gain confidence and to understand the process of experimentation.

Because I would not have reached graduate school without advice from outstanding professors, it is important for me to inform students about internships and research opportunities that could be beneficial for their education. Indeed, I was born in France to a multicultural family and I moved to the United States to pursue my education. I am the first in my family to have achieved a graduate degree. I was able to reach this level by applying to various fellowships and teaching assistantships and working to support myself while studying. Although my mother, Dolorès Mioni, would have had the intellectual capacity to get an academic education, she never had the opportunity to go to college. She was the eldest child in the family and made the sacrifice to work to assist my grandparents and to give her siblings the educational opportunities she did not have. My father, Charles Mioni, pulled himself through college by obtaining fellowships. My maternal grand-father, Santiago Martinez, was "commissario de la republica" during the Spanish civil war. He survived the Spanish exile and was interned in the French concentration camp of Argelès-sur-Mer. My paternal grandparents were Italian immigrants. Both of my parents grew up in a context in which hostility and xenophobia toward new immigrants were not uncommon. Needless to say, respect of others' cultures and beliefs was the corner stone of my education and it is important for me to foster a work environment based on respect and tolerance.

Because of my background, I firmly believe that education should not be a privilege but that students should be encouraged to take responsibility of their own education. I completed my Ph.D. in three years and generated six publications, with four as a first author (and a fifth is on its way). Concomitantly, I was diagnosed with cervical cancer at the end of my first year and had a lumpectomy few months later. Although these health problems were definitely hard to cope with emotionally and financially, I believe that these hardships have helped me to become a more compassionate person and perhaps a better collaborator. Also, it has motivated me to get involved with research and activities that are relevant to the society. For example, I moved from a very fundamental field of research to a more applicable and health related field. Upon graduation, I had to place my career on hold while applying for US residency. I came back to work with an unequalled motivation to set the priority on my career. I decided to gain more teaching experience and I accepted a temporary faculty position at the Lane Community College in Eugene, OR. I have learned a lot from this experience as a teacher and the transfer of knowledge was anything but unidirectional. My best achievement was to motivate a working single-mother (Ms. Zelta Montgomery) to pursue higher education in Microbiology. In return, Zelta and other students were a great source of motivation to pursue a career in academia and to get involved in outreach program for disadvantaged population of students. In line with these research and teaching interests and activities, I am excited to join Dr Adina Paytan's lab because I will benefit from her outstanding experience in public outreach activities but I will also gain experience in various areas of environmental geosciences and applied biogeochemistry.

Cécile Élise Mioni, Ph.D.

CONTACT INFORMATION

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EDUCATION

2001 – 2004 **Ph.D. Microbiology.** University of Tennessee, Knoxville, TN.
Dissertation: "Using a bioluminescent bacterial bioreporter to assess iron bioavailability in the Oceans".
Advisor : Dr. Steven W. Wilhelm

2000 **M.S. Biological Oceanography & Marine Environment**, *cum laude*. Université Pierre et Marie Curie, Paris (France).
Thesis: "Responses of the diatom *Thalassiosira oceanica* to Iron limitation" (in French).
Advisors: Pr. Paul Tréguer and Dr. Stéphane Blain

1999 **Maîtrise Biology of Populations & Ecosystems**, *magna cum laude, Valedictorian (rank 1/83).* European Institute of Marine Studies – Université de Bretagne Occidentale, Plouzané (France).
Thesis: "Trends of abundance indices for demersal fish species of the Guinea's waters and the relationship with their catches" (in French).
Advisor: Dr. Eric Morize

1998 **B.S. General Biology & Earth Sciences**, *magna cum laude, Salutatorian (rank 2/140).* Université de Bordeaux I, Talence (France).

PROFESSIONAL EXPERIENCE

Aug. 2007 – present *Postdoctoral scholar*, Chemistry & Biochemistry Department, University of California, Santa Cruz. Isolation of new marine culturable microbial strains for drug discovery, novel culturing strategies, DNA fingerprinting. Advisor: Dr Roger G. Linington.

Jan. – Aug. 2007 *Adjunct faculty*, Science division, Lane Community College, Eugene, OR.

Aug. – Oct. 2006 *Research assistant*, Department of Oceanography, The University of Hawaii, Manoa.
Seawater sampling for cyanobacterial DNA and RNA analyses. Advisor: Dr Zackary I. Johnson.

Jan. – May 2006 Processing of my Green Card application - not authorized to work during this time.

2001 – 2005 *Research and teaching assistant*, Department of Microbiology and Center for Environmental Biotechnology, The University of Tennessee, Knoxville, TN.
Molecular biology (PCR, cloning, *lux*- and *gfp*-based bioreporters), microbiology (aseptic techniques, optimization of culture media), class 100 clean room experience, trace metal clean techniques. Advisor : Dr Steven W. Wilhelm.

2001 (Spring) *Research Assistant*, Observatoire Midi-Pyrénées (LEGOS lab), Toulouse (France).
Inter-calibration of Autonomous Nutrient Analyser *In Situ* and Technicon analyzer. Advisor : Dr. Véronique Garçon.

2001 (March) *Trainee*, Groupement pour le Développement de la Télédétection Aérospatiale, Toulouse (France). Geographic Information Systems (Arcview software).

2000 (Summer) *Visiting Scientist*, Geosciences department, Princeton University, Princeton NJ.
Culture of the diatom *T. weissflogii*, class 100 clean room experience, trace metal clean & aseptic techniques. Advisors: Pr. François M. Morel and Dr. Allen J. Milligan.

2000 *Research assistant*, European Institute of Marine Studies, Plouzané (France).
Culture and chemical analyses of oceanic diatoms, class 100 clean room experience, trace metal clean and aseptic techniques. Advisors: Pr. Paul Tréguer and Dr. Stéphane Blain

1998 –1999 *Research assistant*, Institut de Recherche pour le Développement, Plouzané (France).
Fish stock assessment & analyses of stock evolution. Advisor: Dr. Eric Morize

1998 (Summer) *Trainee*, Laboratory of Biological Oceanography, Arcachon (France).

HONORS, AWARDS AND FELLOWSHIPS

2008	Poster selected for an oral presentation. Gordon Research Conference, Marine Natural Products, Ventura, CA. Feb. 24th – 28th, 2008.
2005	DIALOG VII symposium participant. DISL, Mobile, AL. Dec. 3rd – 10th, 2005.
2005	University of Tennessee Travel Award and Graduate Student Senate Travel Awards.
2004	University of Tennessee Travel Award and Graduate Student Senate Travel Awards.
2003	Daniel Jouvance international research Award "Recherches sur le plancton marin 2003".
2003	Ryan Kelley Memorial scholarship – International Women's Fishing Association.
2001 – 2003	Center for Environmental Biotechnology – Center of Excellence Graduate Fellowships.
2000	M.S., *cum laude*. Université Pierre et Marie Curie, Paris (France).
1999 – 2000	"Ministère de la Recherche et de l'Education" Fellowship.
1999	Maîtrise, *magna cum laude*, Valedictorian (rank 1/83). European Institute of Marine Studies.
1998	B.S., *magna cum laude*, Salutatorian (rank 2/140). University of Bordeaux I, France.

TEACHING ASSIGNMENTS

2007	*Instructor*. Lane Community College (Eugene, OR). General Biology 101J: "Unseen Life on Earth" telecourse.
2001 – 2004	*Teaching Assistant*. The University of Tennessee (Knoxville). Introduction to Microbiology (Micro 210) laboratory courses.
2002 (Spring)	*Guest Lecturer*. The University of Tennessee (Knoxville). Oceanography 446: Carbon cycle.

MENTORING EXPERIENCE

2007 – present	Navid Adnani and Christopher Rundell (undergraduate research assistants, UCSC): Microbiology techniques & natural products chemistry.
2005	Margaret Henke (summer project, UTK): Bioreporter & trace metal clean techniques.
2003	Sarah M. Handy (research assistant, UTK): Bioreporter & trace metal clean techniques.
2003	Matt Smith (undergraduate research assistant, UTK): Molecular biology techniques.
2002	Bruce Applegate Jr. (summer project, Purdue): Bioreporter & trace metal clean techniques.

SERVICES

2007 – present	*Volunteer Mentor* – ASM Science Educator Network & ASM Minority Mentoring Program
2006	*Volunteer* – ASLO/TOS/AGU Ocean Sciences Meeting
2004	*Student Volunteer* – ASLO/TOS Ocean Research Conference (Audiovisual).
2003 – present	*Reviewer for Professional Journals* : Limnology and Oceanography, Deep Sea Research II, Aquatic Microbial Ecology, Environmental Science & Technology.

PROFESSIONAL AFFILIATIONS

2005 – present	American Geophysical Union.
2005 – present	American Society for Microbiology.
2005 – present	ANDèS (Association Nationale des Docteurs ès Sciences).
2004 – present	The Oceanography Society.
2001 – present	American Society of Limnology and Oceanography.

FIELD RESEARCH PARTICIPATION (since Fall 2001)

08/15/06 – 10/13/06	R/V *Kilo Moana*, Fe in Equatorial Pacific Undercurrent (Honolulu, HI – Rabaul, PNG).
03/08/06 – 03/12/06	R/V *Kilo Moana*, HOT-179 cruise, ALOHA station (*volunteer participant*).
06/22/03 – 08/05/03	R/V *Kilo Moana*, NE Pacific Ocean and Bering Sea (Seattle, WA – Dutch Harbor, AK).
09/23/02 – 10/19/02	R/V *Nathaniel B. Palmer*, Eastern Pacific (Punta Arenas, Chile – San Diego, CA).

PUBLICATIONS

- ***Published (available on my website)***

Mioni, C.E., Palkuski, J.D., Poorvin, L., Baldwin, A., Twiss, M.R., Jeffrey, W.H., and S.W. Wilhelm (2007), Variability in the in situ bioavailability of Fe to bacterioplankton communities in the eastern subtropical Pacific Ocean, *Aquatic Microbial Ecology*, 46: 239 – 251.

Mioni, C.E., Poorvin, L., and S.W. Wilhelm (2005), Virus- and siderophore- mediated transfer of available Fe between heterotrophic bacteria : characterization using an Fe-specific bioreporter. *Aquatic Microbial Ecology*, 41: 233-245.

Mioni, C.E., Handy, S.M.*, Elwood, M.J., Twiss, M.R., McKay, R.M.L., Boyd, P.W., and S.W. Wilhelm (2005), Tracking changes in bioavailable Fe within high-nitrate low-chlorophyll oceanic waters: A first estimate using a heterotrophic bacterial bioreporter, *Global Biogeochemical Cycles*, *Invited article*, 19 (4), GB4S25, doi:10.1029/2005GB002476.

McKay, R.M.L., Wilhelm, S.W., Hall, J., Hutchins, D.A., Al-Rshaidat, M.M.D., **Mioni, C.E.**, Pickmere, S., Porta, D., and P.W. Boyd (2005), Impact of phytoplankton on the biogeochemical cycling of iron in subantarctic waters southeast of New Zealand during FeCycle, *Global Biogeochemical Cycles*, *Invited article*, 19 (4), GB4S24, doi:10.1029/2005GB002482.

Boyd, P. W., Law, C. S., Hutchins, D. A., Abraham, E. R., Croot, P. L., Ellwood, M., Frew, R. D., Hadfield, M., Hall, J., Handy, S.*, Hare, C., Higgins, J., Hill, P., Hunter, K. A., LeBlanc, K., Maldonado, M. T., McKay, R. M., **Mioni, C.**, Oliver, M., Pickmere, S., Pinkerton, M., Safi, K., Sander, S., Sanudo-Wilhelmy, S. A., Smith, M., Strzepek, R., Tovar-Sanchez, A.; Wilhelm, S. W. (2005), FeCycle: Attempting an iron biogeochemical budget from a mesoscale SF_6 tracer experiment in unperturbed low iron waters, *Global Biogeochemical Cycles*, 19 (4), GB4S20, doi:10.1029/2005GB002494.

Mioni, C.E., Howard, A. M.*, DeBruyn, J.M., Bright, N.G., Applegate, B.M., and S.W. Wilhelm (2003), Characterization and preliminary field trials of a bioluminescent bacterial reporter of iron bioavailability. *Marine Chemistry*, *Invited article*, 83: 31-46.

- ***Submitted – In Preparation***

Shyam, R. , **Mioni, C.E .,** Ritchie, A. E., Lai, J., and Z.I. Johnson (2007). Iron/Light colomitation in the deep chlorophyll maximum in the Western Pacific Ocean (in prep.).

Mioni, C.E., Fones, G.R., Saito, M., and S.W. Wilhelm (2005), Assessment of iron bioavailability in the subarctic Pacific Ocean during the summer of 2003 (in prep.).

Milligan, A.J., **Mioni, C.E**., and F.M.M. Morel, The response of carbon metabolism to iron deficiency in the marine diatom *Thalassiosira weissflogii* (in prep.).

MEETING PRESENTATIONS & SEMINARS

Adnani, N.X.*, **Mioni, C.E.**, Rundell, C.D., and R.G. Linington. High-Throughput Screening and Chemical Profiling of Marine Bacterial Isolates for Drug Discovery. 2008 J.F. Bunnett seminar, University of California, Santa Cruz, and ACS undergraduate symposium May 2008 (poster).

Rundell, C.D.*, **Mioni, C.E.**, Adnani, N.X., and R.G. Linington. Exploring the Great Oceans and Drug Discovery: Extraction Methods of Microbial Marine Natural Products for Novel Therapeutic Agents Against Neglected Infectious Diseases. 2008 J.F. Bunnett seminar, University of California, Santa Cruz, and ACS undergraduate symposium May 2008 (poster).

Mioni, C.E., and R.G. Linington. Bacterial warfare and peace talk: cellular interaction and secondary metabolite biosynthesis. Gordon Research Conference – Marine Natural Products, Ventura, CA, Feb. 2008 (poster, *invited*)

Shyam, R., **Mioni, C.E .,** Ritchie, A. E., Lai, J., Johnson, Z. I. Iron/Light colomitation in the deep chlorophyll maximum in the Western Pacific Ocean. ASLO Ocean Sciences meeting Orlando, FL, March 2008 (poster).

Mioni, C.E. From Siderophores to Antibiotics: Importance of secondary metabolites as mediators of microbial community structure and function. Santa Cruz Archae and Bacteria Society, University of California Santa Cruz, CA, Oct. 2007.

Mioni, C.E. Amazing microbes: Survival, resistance, and communication in the sea. Biological Oceanography Seminar, University of Washington, Seattle, WA, June 2007 (*invited*).

Mioni, C.E. Eukaryotic Microbes: The Protists. Oregon State University, Corvallis, OR, May 2007 (*invited*).

Mioni, C.E. *Let There be Light* on Iron Bioavailability in The Subarctic Pacific Ocean. DIALOG VII, Dauphin Island Sea Laboratory, AL, Dec. 2005 (*invited*).

Mioni, C.E., Poorvin, L., and S.W. Wilhelm. Bioluminescent bacterial reporters: a tool of biological & chemical relevance to estimate Fe bioavailability in aquatic systems. ASLO Ocean Research conference, Salt Lake City, UT, Feb. 2005.

Poorvin, L., **Mioni, C.E.**, Sander, S., and S.W. Wilhelm. Characterization and bioavailability of iron released by viral lysis of marine plankton. ASLO Ocean Research conference, Salt Lake City, UT, Feb. 2005.

Mioni, C.E., Handy, S.M.*, Twiss, M.R., Frew, R.D., Jeffrey, W.H., Boyd, P.W., and S.W. Wilhelm. Deployment of a heterotrophic bioluminescent bioreporter to estimate the bioavailability of iron in seawater. ASLO/TOS Ocean research conference, Honolulu, HI, Feb. 2004 (*invited*).

Wilhelm, S. W., **Mioni, C. E.**, Twiss, M. R., McKay R. M., and C. G. Trick. Resolving iron availability in Lake Erie. International Association of Great Lakes Researchers, Chicago, IL, June 2003 (*invited*).

Applegate, B.M. Jr.*, Bright, N.G., **Mioni, C.E.**, Husseiny, S.M., Wilhelm, S.W, and B.M. Applegate Sr. Development of a bioluminescence based assay to evaluate the efficacy of lactoferrin as a bacteriostatic agent. Annual Meeting of the Institute of Food Technologists, Chicago, IL, July 2003.

Mioni, C.E., Howard, A. M.*, DeBruyn, J.M., Bright, N.G., Applegate, B.M., and S.W.W. Wilhelm. Characterization and preliminary field trials of a bioluminescent bacterial reporter of iron bioavailability. AGU/ASLO Ocean Sciences Meeting, Honolulu, HI, Feb. 2002.

Garçon, V., Thouron, D., Philippon, X., Vuillemin, R., **C. Mioni**. ANAIS: Autonomous Nutrients Analyzer *In Situ*. ASLO/TOS Ocean Sciences Meeting, Honolulu, HI, Feb. 2002 (poster).

Garçon, V., Thouron, D., Philippon, X., Vuillemin, R., **C. Mioni**. ANAIS: Autonomous Nutrients Analyzer *In Situ*. Gordon Research Conference, Tilton, NH, Aug. 2001 (poster).

Milligan, A.J., **Mioni, C.E.**, and F.M.M. Morel. The response of carbon metabolism to iron deficiency in the marine diatom *Thalassiosira weissflogii*. ASLO meeting, Albuquerque, NM, Feb. 2001.

** mentored research assistants and undergraduate collaborators*

MISCELLANEOUS

- ***Languages:***

French (native), English (bilingual), Spanish (basic)

- ***Special skills & Training:***

E-Teaching experience: I have used and I worked with teams to deliver training at distance to diverse populations of students by using learning management systems such as Moodle and Blackboard. My responsabilities included semester-based courses, tutorials, online conferences, online forum, and online evaluation.

Geographic Information Systems : Arcview software. Groupement pour le Développement de la Télédétection Aérospatiale, Toulouse (France), March 2001.

2009 California Sea Grant CALFED PROPOSAL
7. Plan for Collaborating with Community Mentors

The proposed research project directly address the California Sea Grant CALFED priorities described in this solicitation: provide information needed to prevent, control and mitigate blooms of invasive species such as the previously rare cyanobacterium *Microcystis aeruginosa*; examine the relationships between the primary production and the habitat quality by connecting nutrient and trace metal loading, HABs, and food web dynamics in a changing environment; investigate how the SF Bay ecosystem will respond to future conditions (e.g. raising water temperature, changes in salinity and turbidity); provide information that will enhance current HAB monitoring and forecasting efforts; help facilitate bloom prevention through an advanced understanding of the controlling factors.

The proposed research project brings together a multidisciplinary team (PI and collaborators) with expertise on hydrodynamic modeling, nutrient and trace metal dynamics, phytoplankton biology, HABs, and the San Francisco Estuary system to shed light on the occurrence, distribution and governing environmental parameters of harmful algae and their toxicity. This project is a collaborative effort between researchers from UC Santa Cruz, US Geological Survey and CDWR. All collaborators have successfully been involved in interdisciplinary and inter-institutional research in the past and will bring a wealth of scientific and monitoring expertise to this project. Dr Paytan as the PI will be responsible for the overall oversight of the project and the field work. Dr Lucas has agreed to serve as community mentor for the proposed research project (see letter of support). Dr Lucas is currently research engineer in Dr Cloern's group at U.S. Geological Survey. Dr Lucas is an experienced modeler, has an extensive knowledge of the Bay-Delta ecosystems and has been involved with conducting long-term monitoring in the San Francisco Estuary system. She has agreed to assist with the interpretation and modeling of hydrodynamic and physical variables, and linking these physical variables to toxic algae growth and spread. Dr Lucas is also a regular participant in interagency and inter-institutional science and management activities, including acting as a session chair at the 2003 CALFED Science conference and is currently involved in CALFED-funded research projects (e.g. CASCADE). Finally, Dr Lucas and Dr Cloern will provide knowledge on SF Bay and help provide access to boat facilities and monitoring data. We will collaborate also with Dr Mueller-Solger (DWR, see letter of support) and Dr Lehman (DWR). Both Dr Mueller-Solger and Dr Lehman are involved in phytoplankton community and HAB monitoring in the SF Delta. Dr Lehman is an expert in *Microcystis aeruginosa* in the SF Bay-Delta system. She will provide seasonal water samples from the Delta. Dr Mueller-Solger is currently involved in CALFED-funded inter-institutional research. She is presently testing a submersible spectrofluorometer that allows monitoring of phytoplankton biomass associated with different taxonomic groups in the SF Estuary. She will provide knowledge and access to research vessels and monitoring data in the Delta. Both Dr Kudela and Dr Silver are involved in HAB research in California and will help identify target parameters for incubation experiments and their vast experience with HAB research. Finally, the applicant, Dr Mioni, is bringing her experience in microbial ecology, biogeochemistry and trace metal biochemistry. The applicant has considerable laboratory and field work experience and has conducted field research around the world. In line with an adaptive monitoring strategy, the applicant and the mentors have agreed to coordinate quarterly meetings to discuss and refine monitoring and incubation experiment objectives, interpret data and eventually adapt the monitoring strategy.

Advantages of the collaborative research project include: (1) Enhancement of current monitoring programs and resulting management recommendation through complementary analyses as well as sharing of monitoring experience; (2) Economy of scale: this project will take full advantage of preexisting monitoring infrastructures and will focus on enhancing rather than duplicating the current programs and measurements.

Table 1 – Project time line by task and products due dates

Activity	2008							2009												2010							
	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
Monthly sampling (Bay + Delta)				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Seasonal sampling (NSFE)	•	•	•	•									•	•	•	•									•	•	
***In situ* Incubation experiments**					•	•				•	•				•	•						•	•				
Sample analyses				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Data base, data entry, data management	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Data analysis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Organization meetings			•				•				•				•				•				•				•
Project oversight and synthesis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Project management	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Website, online database								•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Quarterly reports			•				•				•				•				•				•				•
Final report																											•
Presentations								•									•				•						•
Publications																				•	•	•	•	•	•	•	•
Broad dissemination											•	•	•					•	•	•			•	•	•	•	•

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CALFED Project Summary Form - California Sea Grant

Title: Environmental Controls on the Distribution of Harmful Algae and their toxins in San Francisco Bay-Delta System, California

Type of Fellowship: Postdoctoral

Initiation Date: 09/01/2008

Completion Date: 08/31/2010

	Last	First	Initial		
CALFED Fellow:	Mioni	Cecile	E	**Effort:**	
Affiliation:	University of California, Santa Cruz			**Affil. Code:**	0605
Research Mentor 1:	Paytan	Adina		**Effort:**	
Affiliation:	University of California, Santa Cruz			**Affil. Code:**	0605
Research Mentor 2:				**Effort:**	
Affiliation:				**Affil. Code:**	
Community Mentor 1:				**Effort:**	
Affiliation:				**Affil. Code:**	
Community Mentor 2:				**Effort:**	
Affiliation:				**Affil. Code:**	

Total CALFED Funds: 164,620

Related Projects: Trends and patterns of habitats, populations & system resp.

Parent Projects: Aquatic Invasive (Exotic) Species

Key Words: San Francisco Bay-Delta, , Harmful Algal Blooms, Microcystis aeruginosa, biotoxins, microcystins, Pseudo Nitzschia, Red Tides.

Objectives:

The major goal of work proposed here is to determine the distribution of harmful algae and their toxins in San Francisco Bay and characterize the environmental parameters that control toxin production by harmful algae in the Bay. This work is directly related to CALFED's targeted topic areas. Specifically, work addresses issues related to research on Trends and Patterns of Habitats, Populations and System Response to a Changing Environment. Harmful algae are some of the less studied Bay and Delta species and their distribution, abundance and dynamics as well as the conditions promoting their proliferation are not well characterized. Research is needed to explore how these species currently respond to environmental conditions. This is particularly important considering predicted future environmental change in temperature, stratification and nutrient and trace metal loading that can dramatically alter the abundance and toxic production of harmful algae. The work also addresses the topic of Aquatic Invasive Species such as Microcystis aeruginosa.

Research proposed here is guided by the following hypotheses:
- Predicted environmental changes will favor dinoflagellates and cyanobacterial growth (in South Bay and Delta respectively) over diatoms and will result in increased frequency in blooms of these species.
- Alleviation of light limitation due to stratification will increase the influence of nutrient availabilities and relative concentrations, resulting in enhanced toxicity of the harmful algae.
- Spatial and temporal mapping of harmful algae and their toxins will help elucidate the triggers, provide a baseline for measuring future trends and enable forecasting.

Methodology:

We propose a work plan that will combine monitoring and mapping of biological, chemical and physical components throughout the Bay and Delta along with controlled manipulations to examine specific

parameters that are likely to control growth and toxicity in the natural population of harmful algae in SF Bay. Work proposed here is primarily a field-oriented research program. The work includes (1) monthly sampling throughout the Bay and Delta to map the spatial and temporal distribution of algae and toxins in relation to a suite of important environmental parameters (2) seasonal in situ enrichment incubation experiments to determine which targeted parameters (or combinations of parameters) induce growth and toxicity of harmful algae including a focused study on Microcystis aeruginosa in the Delta.

(1) In order to describe the spatial and temporal distribution (occurrence and abundance) of harmful algae and their toxins in SF Bay we will work closely with the USGS SF Bay monitoring program as well as CDWR Delta monitoring programs (seasonal: Dr. Lehman; monthly: Dr. Mueller-Solger). Concurrent with these monitoring programs in the Bay and Delta we will collect samples for algal identification and enumerations and toxin (domoic acid, saxitoxins, microcystins) levels at all discrete sampling location in the Bay and Delta. We will also add analysis of dissolved organic carbon, total organic nitrogen, total organic phosphorus and trace metal concentrations (using trace metal clean sampling protocols) because these are not routinely monitored but may influence the growth and toxin production of harmful algae.

(2) We will conduct enrichment bioassay incubation experiments seasonally to examine the individual and combined effects of nutrients, trace metals, temperature and light on growth of and toxin production by harmful algae. This is aimed at elucidating the underlying mechanisms that control the distribution and toxicity of harmful algae and evaluate under what conditions algae growth is induced and toxic levels are expected to increase. Such “bottle experiments” allow to get a better resolution of the impact of chemical and physical variables on toxin production and harmful algae growth by excluding other parameters (e.g. grazing, mixing).

Rationale:

We believe that determining the combination of parameters that enhance seeding, growth and toxicity of harmful algae in this system can be used to predict and prevent HABs from occurring and will serve as an important tool for managers and regulators. We will establish a baseline of conditions in the Bay, determine the above relationships and use existing and newly obtained data to design a set of in situ manipulative incubation experiments that will aid in determining the parameters that control growth and toxicity in the natural population of harmful algae, with a special focus on the invasive cyanobacterium M. aeruginosa. We will monitor the spatial and temporal variations of these factors to identify the sources and triggers of HABs within the SF Estuary. Data obtained will be used to develop a model that would enable forecasting and preventing HAB events. Such information is needed to reduce the likelihood for future negative impact of HABs on estuarine processes and for designing best management and preservation plans.

Anticipated accomplishments:

Results from this project include: (1) description of current status of harmful algae and related toxins in SF Bay-Delta system and development of a baseline dataset, and (2) better understanding of the mechanisms underlying the occurrence and toxicity levels of harmful algae in SF Bay and Delta. Data obtained through this project will be compiled to produce some simple distribution matrix (model) that assesses the impact of various parameters on the algal abundance, growth and toxin production in SF Estuary. These data will be used to develop a prediction model that will have the ability to forecast various algae densities and toxin concentrations in SF Bay under various climate and development scenarios. This proposal brings together a multidisciplinary team with expertise on hydrodynamic modeling, nutrient and trace metal dynamics, HABs and the Bay-Delta ecosystem.
Advantages of the collaborative research project include: (1) Enhancement of current monitoring programs and resulting management recommendation through complementary analyses as well as sharing of monitoring experience; (2) Economy of scale: this project will take full advantage of preexisting monitoring infrastructures and will focus on enhancing rather than duplicating the current programs and measurements.

UNIVERSITY OF CALIFORNIA, SANTA CRUZ

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SANTA CRUZ, CALIFORNIA 95064

To: CALFED – Post Doctoral Fellowships

RE: letter of commitment for CALFED Post Doctoral Fellowship – Cecile Mioni

Dear Selection Committee,

This letter is to convey my interest in hosting and mentoring Dr. Cecile Mioni as a CALFED Postdoctoral Fellow as part of my research group at UCSC. Cecile's proposed research entitled "Environmental Controls on the Distribution of Harmful Algae and their toxins in San Francisco Bay, California" fits into the general interest areas of my research on biogeochemistry and the interactions between the environment and living organisms. The project also ties well with other research projects in my laboratory on the biogeochemical cycling of nutrients and trace metals in aquatic systems and the impact of groundwater input on ecosystems. Determining the distribution of harmful algae and their toxins in San Francisco Bay and characterize the environmental parameters that control toxin production by harmful algae in the Bay involves interdisciplinary research (chemistry, biology, oceanography, environmental science and toxicology) and is directly related to several of the CALFED targeted topic areas. Using chemical, physical and biological experimentation in the laboratory and at the field, Cecile proposes to examine the impact of environmental stimuli controlling cellular mechanisms of algal biotoxicity. Harmful algae are some of the less studied species in the SF Bay and their distribution, abundance and dynamics as well as the conditions promoting their proliferation and toxin production are not well characterized. Research is needed to explore how these species currently respond to environmental conditions. This is particularly important considering predicted future environmental change in temperature, stratification and nutrient and trace metal loading resulting from development and climate changes that can dramatically alter the abundance and toxic production of harmful algae. The work will address issues related to harmful algal bloom toxin function and effects on food webs and environmental resources. A better understanding of the population structure and dynamics of harmful algae (including *Microcystis aeruginosa*, an invasive bloom forming harmful cyanobacterium) in the Bay system is needed for enhancing existing resource management or develop new tools and decision support systems that improve management effectiveness that will ensure low risk associated with harmful algal blooms (HAB). The work will allow development of a model that will establish under which future scenarios including different water-management regimes, climate change, land use change, catastrophic events, etc. HAB species might bloom and produce their toxins.

I have read the proposal and am excited to work with Cecile on this project if funded. I will gladly support any expenses related to this project that are not covered by the grant and will ensure that all of the analytical facilities needed available for this project will be available. Cecile has the experience and intellectual capability to carry out this research, and I am certain that she will prove herself worthy of the fellowship. Cecile's presence in my laboratory would benefit my group by introducing exciting new techniques and ideas. At the same time this experience will offer her access to first class analytical

capabilities, a global look on environmental problems, and a chance to interact with a wide range of scientist and students from a variety of disciplines (the many scientists I collaborate with including several CALFED researchers). I will be able to provide Cecile with guidance and support to enable her to peruse her research, yet she would have the freedom to excel with her ideas and perform independent research, which is very important at this stage of her career. A large group of scientists at the University of California Santa Cruz and the USGS in Menlo Park and Santa Cruz are actively involved in the different aspects of Harmful Algal Blooms, thus Cecile will have ample opportunity to interact with colleagues at these institutes. Cecile will also be able to benefit from the ongoing outreach activities that I am involved in and devoted to.

My group's research interests lie in the fields of biogeochemistry (CV and link to web page enclosed). We use both chemical and isotopic tracers in diverse environmental samples (water, sediments, aerosol, and vegetation) to study present and past biogeochemical processes and their interaction with environmental parameters. This research spans a wide range of temporal (seasons to millions of years) and spatial (molecular to global) scales. An over-arching goal of our research is to link changes observed in the earth and ocean systems to global changes in climate and tectonics. In addition, we are interested in natural and anthropogenically induced perturbations that affect biogeochemical processes such as HABs toxin production, nutrient cycling, methane emission from wetlands, trace metal distribution, aerosol impact on the biota and water pollution. Once more, the role HABs assumes in environmental change is of undeniable importance, thus Cecile's proposed study will fit well in the general research activities of my laboratory.

Sincerely

Adina Paytan
Sponsoring Scientist

Dr. Adina Paytan
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BIOGRAPHICAL AND BIBLIOGRAPHIC INFORMATION

ADINA PAYTAN

EDUCATION

1996	Ph.D. Oceanography, Scripps Institution of Oceanography
1989	M.S. Earth Sciences Oceanography, Hebrew University, Jerusalem
1987	M.S. Science Education, Weizmann Institute of Science, Rehovot
1985	B.S. Geology and Biology, Hebrew University, Jerusalem

PROFESSIONAL EXPERIENCE

2007-present	Associate Research Scientist, Institute of Marine Sciences, UCSC
2007-present	Adjunct Scientist, Monterey Bay Aquarium Research Institute
1999-2007	Assistant Professor, Department of Geological and Environmental Sciences, Stanford University
1996-1999	Post Graduate Researcher, Scripps Inst. of Oceanography, UCSD
1991-1996	Science Research Assistant, Scripps Inst. of Oceanography, UCSD
1993-1994	Teaching Assistant, University of California - San Diego
1987-1989	Teaching Assistant, Hebrew University, Jerusalem
1980-1988	Tour Guide, Geographical Society and Jewish Agency
1986-1987	Education Coordinator of Instruction, Ministry of Education Israel
1984-1986	Research Assistant, Hebrew University
1983-1984	Science Teacher, Ophek Elementary School, Israel

HONORS AND AWARDS

2008	Consortium for Ocean Leadership Distinguished Lecturer
2007	Ellen Weaver Award
2006	Aldo Leopold Leadership Fellow
2006	Ocean Science Meeting - Plenary Session Speaker
2005	NSF CAREER Award
2005	GSA Ingerson Lecture
2004	AGU Oceanography Early Career Award
2003	Two research projects recognized in ODP Greatest Hits
2002	NASA New Investigator Program in Earth Science Award
2001	Terman Fellowship, Stanford University
2000	Terman Fellowship, Stanford University
1994	Dissertation Symposium in Chemical Oceanography
1993	Chemical Oceanography Gordon conference, Best Student Presentation
1990	Gerson Meerbaum Foundation for Oceanography Award
1989	M.S. Graduation Honors, Rectors list, Hebrew University, Jerusalem
1987	Golda Meir Fellowship Recipient
1985	B.Sc. Graduation Honors, Hebrew University Jerusalem
1983-85	Dean List, Hebrew University, Jerusalem

MEMBERSIPS IN PROFESSSIONAL AND SCHOLARLY ORGANIZATIONS

Geological Society of America
American Geophysical Union
Geochemical Society
American Society of Limnology and Oceanography
American Association of Advancements in Science
American Chemical Society
American Women in Science
Association for Women Geoscientists
Sigma Xi, The Scientific Research Society
Association of Women Geoscientists

SELECTED PROFESSIONAL ACTIVITIES

2006-present	Associate Editor – Limnology and Oceanography Methods
2003-present	Associate Editor - Marine Chemistry
2007-present	California COSEE – Advisory Board Chair
2004-2007	Associate Editor - Geology
2003-2007	Mentoring Co-Chair American Women in Science Association
2007	Invited session leader in the Marine Chemistry Gordon Conference
2007	Moderator - Getting Results: The Next Generation of Women Scientists
2007	Panelist – Strategies for Ecology Education, Development and Sustainability
2006	NATO – Science for Peace Program – Invited speaker
2006	Ocean Science Meeting – Plenary Speaker
2000-2005	Coordinator Summer High School Internship Program at Stanford
2005	NSF COSEE Review Panel
2005	Invited Speaker - Women who Turn the Tides: Setting New Benchmarks in Marine Sciences - Seymour Center Lectures
2005	Invited NSF- Sponsored Workshop on Outreach and Education
2005	Ingerson Keynote Lecture GSA – *The marine phosphorous cycle*
2004	EPA Washington DC - *Coastal groundwater and beach pollution* (invited)
2004	AGU Session Convener and Student Presentation Judge
2004	GEOTRACERS - Marine Geochemical Tracers Workshop
2004	CHRONOS - Geochemical Cycles - NSF Workshop, Invited Participant
2004	Linking Information Systems - JOI NSF Workshop, Invited Participant
2004	Excite - Science Camp for Middle School Girls - Workshop Coordinator
2001-2004	Elected Geochemical Society Program Committee Representative
2003	Santa Clara High School GAINS, The Success of Women in Science
2003	Invited to serve on the NSF review panel for Earth System History
2003	Workshop Coordinator - Sally Ride Science Festival
2002	Program Committee, Spring AGU, Washington DC.
2001	Invited to Represent the GSA in the Program Committee for Spring AGU
2001	Invited Session Chair ASLO Meeting
2000	Chair Discussion Group on the future of geochemistry in post 2003 drilling
2000	DOE Review Panel for Carbon Sequestration Proposals

ADVISEES RECEIVING DEGREES

2007 Tzvetie Erohina, Ph.D., *Aspects of the late quaternary paleoenvironmental and paleoceanographic history of Santa Monica basin, southern California borderland.*
2007 Ellen Gray, M.S., *Ocean productivity and seawater sulfur isotopic reconstruction over the PETM using marine barite.*
2007 Jessica Luo, M.S., *Carbon and nitrogen isotopes and trace metal concentrations of zooplankton tows from the Gulf of Aqaba, Red Sea.*
2007 Kate Elsbury, M.S., *Identifying phosphate and nitrate sources to Lake Erie using a multiple isotope approach.*
2006 Scott Wankel, Ph.D., *Nitrogen sources and cycling in coastal ecosystems: Insights from a stable isotope approach.*
2005 Karen McLaughlin, Ph.D., *The Oxygen Isotopic Composition of Phosphate in Marine and Estuarine Systems: A Tracer for Phosphate Sources and Cycling.*
2005 Lynn Asbeck, M.S., *^{226}Ra Activity in Bivalve Shells as a Tracer for Groundwater Input to Elkhorn Slough, California.*
2005 Michael Calhoun, M.S., *Carbonate and Marine Barite Accumulation Rates from Sediment Cores.*
2005 Nick Handler, M.S., *Time Series Investigation of Chemical and Human Health Indicators in California Coastal Watersheds*.
2005 Megan Young, Ph.D., *Methane Cycling and Groundwater Sources in Mangrove-Dominated Coastal Lagoons Yucatan Peninsula, Mexico..*
2005 Kristen Averyt, Ph.D., *Strontium and Calcium in Marine Barite: Implications for Marine Barite Formation and Seawater Chemistry.*
2004 Ashley Ivy, M.S., *Ocean Productivity at the C/T Boundary*.
2004 Gaurav Misra, M.S., *Hydrogeology of Elkhorn Slough.*
2003 Gregory Shellenbarger, M.S., *Radium isotopes and the Reynolds Transport Theorem.*
2003 David Nicholson, M.S., *P-status of Marine Phytoplankton Communities in Monterey Bay and San Francisco Bay.*
2002 Meagan Eagle, M.S., *Tracing Organic Matter Sources in Mangrove Estuaries Utilizing $\delta^{13}C$, $\delta^{15}N$ and C/N Ratios.*
2001 Sarah A. Mearon, M.S., *Cretaceous Strontium Isotope Stratigraphy Using Marine Barite.*

FORMER POST DOCTORAL FELLOWS

2007 Ying Chen, Ph.D., *Mineral dust components in aerosols and their effect on productivity.*
2006 John Breier, Ph.D., *Groundwater Discharge at Elkhorn Slough.*
2006 Robert Feranec, Ph.D., *Determining landscape use of Holocene mammals using strontium isotopes*.
2004 Kathrine Hoppe, Ph.D., *$\delta^{13}C$ and $\delta^{18}O$ of bison bones and teeth.*
2003 Kristina Faul, Ph.D., *Constructing a high resolution S isotope and P accumulation curves at the Late Paleocene thermal Maximum (LPTM).*

CURRENT ADVISEES

Current Graduate Student Advisees: Elizabeth Griffith, Katherine Rose Marie Mackey, Karen Knee, Andrea Erhardt, Joseph Street, Nadine Quintana Krupinski.
Undergraduate Research Supervision: Katy Yan, Christopher John Danford, Tim Lambert, Spencer Craven, Devon Anne Orme, Katherine Joann Lawrence, Alanna Belluzzi

PUBLICATIONS

Peer-Reviewed

1. Paytan, A., M. Kastner, E.E. Martin, J.D. Macdougall and T. Herbert. 1993. Marine barite as a monitor of seawater strontium isotope composition. *Nature* 366: 445-449.
2. Martin, E.E., J.D. Macdougall, T.D. Herbert, A. Paytan and M. Kastner. 1995. Strontium and neodymium isotopic analyses of marine barite separates, *Geochim. Cosmochim. Acta*, 59, 1353-1361.
3. Paytan, A. and M. Kastner. 1996. Benthic Ba fluxes in the central equatorial Pacific, implications for the oceanic Ba cycle. *Earth Planet. Sci. Lett.* 142: 439-450.
4. Paytan, A., M. Kastner, and F. Chavez. 1996. Glacial to interglacial fluctuations in productivity in the equatorial Pacific as indicated by marine barite. *Science* 274: 1355-1357.
5. Paytan, A., W.S. Moore, and M. Kastner. 1996. Sedimentation rate as determined by ^{226}Ra activity in marine barite. *Geochim. Cosmochim. Acta* 60: 4313-4319.
6. Paytan, A., M. Kastner, D. Campbell, and M.H. Thiemens. 1998. Sulfur isotope composition of Cenozoic seawater sulfate. *Science* 282: 1459-1462.
7. Martinez-Ruiz, F., M. Kastner, A. Paytan, M. Ortega-Huertas. and S.M. Bernasconi. 2000. Geochemical evidence for enhanced productivity during S1 sapropel deposition in the eastern Mediterranean. *Paleoceanography* 15: 200-209.
8. Paytan, A. and K. Arrigo. 2000. The sulfur-isotopic composition of Cenozoic seawater sulfate: Implications for pyrite burial and atmospheric oxygen. *International Geology Review* 42: 491-498.
9. Paytan, A. 2000. Sulfate clues for the early history of atmospheric oxygen. *Science* 288: 626-627.
10. Paytan, A. 2000. Iron Uncertainty. *Nature* 406: 468-469.
11. Paytan, A, Y. Kolodny, A. Neori, and B. Luz. 2002. Rapid biologically mediated oxygen isotope exchange between water and phosphate. *Global Biogeochemical Cycles* 16: 1-7.
12. Paytan, A., S. Mearon, K. Cob and M. Kastner. 2002. Origin of marine barite deposits: Sr and S isotope characterization. *Geology* 30: 747-750.
13. Paytan, A., M. Kastner, D. Campbell and M.H. Thiemens. 2002. Seawater sulfate and climate. In *ODP Greatest Hits, Volume 2* (White, K. and E.Urquhart, Eds.). Available at http://www.joiscience.org/greatesthits2/pdfs/paytansulfate.pdf.
14. Paytan A. 2002. Tales of black shales. In *ODP Greatest Hits, Volume 2* (White, K. and E.Urquhart, Eds.). http://www.joiscience.org/greatesthits2/pdfs/Paytanshales.pdf.
15. Porder, S., A. Paytan, and E. A. Hadly. 2003. Mapping the origin of faunal assemblages using strontium isotopes. *Paleobiology* 29: 197-204.
16. Mearon, S., A. Paytan, and T.J. Bralower. 2003. Cretaceous strontium isotope stratigraphy using marine barite. *Geology* 31: 1518.
17. Averyt, K. B., A. Paytan, and G. Li. 2003. A precise, high-throughput method for determining Sr/Ca, Sr/Ba, and Ca/Ba ratios of marine barite: Implications for

reconstructing seawater Sr and Ca concentrations. *Geochemistry, Geophysics, Geosystems,* 4: 1039.

18. Averyt, K. B. and A. Paytan. 2003. Empirical partition coefficients for Sr and Ca in marine barite: Implications for reconstructing seawater Sr and Ca concentrations. *Geochemistry, Geophysics, Geosystems* 4: 1043.

19. Paytan, A., B.J. Cade-Menun, K. McLaughlin and K.L. Faul. 2003. Selective phosphorus regeneration of sinking marine particles: evidence from 31P-NMR. *Virtual Journal of Geobiology* 2(6). Available at http://earth.elsevier.com/geobiology/.

20. Eagle, M., A. Paytan, K. R. Arrigo, G. van Dijken, and R. W. Murray. 2003. A comparison between excess barium and barite as indicators of carbon export. *Paleoceanography* 18(0), doi: 10.1029/2002PA000793.

21. González-Muñoz, M.T., B. Fernández-Luque, F. Martínez-Ruiz, K.B. Chekroun, J.M. Arias, M. Rodríguez-Gallego, M. Martínez-Cañamero, C. de Linares, and A. Paytan. 2003. Precipitation of barite by *Myxococcus xanthus*: Possible implications for the biogeochemical cycle of barium. *Applied and Environmental Microbiology* 69(9): 5722-5725.

22. Martínez-Ruiz, F., A. Paytan, M. Kastner, J. M. González-Donoso, D. Linares, S. M. Bernasconi, and F. J. Jimenez-Espejo. 2003. A comparative study of the geochemical and mineralogical characteristics of the sapropel in the western and eastern Mediterranean. *Palaeogeography, Palaeoclimatology, Palaeoecology* 190: 23-37.

23. Paytan, A., B., Cade-Menun, K. McLaughlin and K.L Faul. 2003. Selective phosphorus regeneration of sinking marine particles: Evidence from 31P-NMR. *Marine Chemistry* 82: 55-70.

24. Kurtz, A.C., L.R. Kump, M.A. Arthur, J.C. Zachos, and A. Paytan. 2004. Early Cenozoic decoupling of the global carbon and sulfur cycles. *Paleoceanography* 18(4) 1090, 10.1029/2003PA000908.

25. Porder, S., A. Paytan, and P.M. Vitousek. 2004. Erosion and landscape development affect plant nutrient status in the Hawaiian Islands. Oe*cologia* 142: 440-449.

26. Paytan, A., M. Lyle, A. Mix, and Z. Chase. 2004. Climatically driven changes in oceanic processes throughout the equatorial Pacific. *Paleoceanography* 19: 4017-4023.

27. Boehm, A.B., G.G. Shellenbarger and A. Paytan. 2004. Groundwater discharge: Potential association with fecal indicator bacteria in the surf zone. *Environmental Science and Technology* 38: 3558-3566, DOI 10.1021/es035385a.

28. Gonneea, M.E., A. Paytan, and J.A. Herrera-Silveira. 2004. Tracing organic matter sources and carbon burial in mangrove sediments over he past 160 years. *Estuarine, Coastal and Shelf Science* 61: 211-227.

29. Street, J. and A. Paytan. 2004. Iron, phytoplankton growth, and the carbon cycle. In *Metal Ions in Biological Systems* (Sigel, A, H. Sigel and R.K.O Sigel, Eds.). Volume 43 Biogeochemical Cycles of Elements, 153-185.

30. Averyt, K.B. and A. Paytan. 2004. A comparison of multiple proxies for export production in the equatorial Pacific. *Paleoceanography*19: PA4003.

31. McLaughlin K, S. Silva, C. Kendall, H. Stuart-Williams, and A. Paytan. 2004. A precise method for the analysis of $\delta^{18}O$ of dissolve inorganic phosphate in seawater. *Limnology and Oceanography Methods* 2: 202-212

32. Paytan, A., A. Boehm, and G. Shellenbarger. 2004. Bacterial contamination and submarine groundwater discharge - A possible link. *Environmental Chemistry* I: 1-2.

33. Paytan, A., F. Martínez-Ruiz, M. Eagle, A. Ivy, and S.D. Wankel. 2004. Using sulfur isotopes to elucidate the origin of barite associated with high organic matter accumulation events in marine sediments. In *Sulfur biogeochemistry - Past and Present* (Amend, J.P., K.J. Edwards, and T.W. Lyons, Eds.). GSA Special Paper 379, 151-160.

34. Paytan, A., M. Kastner, D. Campbell, and M.H. Thiemens. 2004. Seawater sulfur isotope fluctuations in the Cretaceous. *Science* 304: 1663-1665.

35. Cade-Menun B. J., C.R. Benitez-Nelson, P. Pellechia, and A. Paytan. 2005. Refining phosphorus-31 nuclear magnetic resonance spectroscopy for marine particulate samples: storage conditions and extraction recovery. *Marine Chemistry* 97: 293-306.

36. Lyle, M., N. Mitchell, N. Pisias, A. Mix, I. Martinez, and A. Paytan. 2005. Do geochemical estimates of sediment focusing pass the sediment test in the equatorial Pacific? *Paleoceanography* 20: PA1005.

37. Averyt, K.B., M. Calhoun, L. Schmalz, and A. Paytan. 2005. Data report: Carbonate and barite trends across the Eocene/Oligocene boundary at Shatsky Rise, ODP Leg 198. In *Proc. ODP, Sci. Results* (Bralower, T.J., P.I. Silva, and M.J. Malone, Eds.), 198.

38. Faul, K.L., and Paytan, A., 2005. Phosphorus and barite concentrations and geochemistry in Site 1221 Paleocene/Eocene boundary sediments. In *Proc. ODP, Sci. Results,* (Wilson, P.A., Lyle, M., and Firth, J.V. Eds.), 199.

39. Faul, K.L., A. Paytan, and M. L. Delaney. 2005. Phosphorus distribution in sinking organic particulate matter. *Marine Chemistry* 97: 307-333.

40. Young, M., M.E. Gonneea, J. Herrera-Silveira, and A. Paytan. 2005. Export of dissolved and particulate carbon and nitrogen from a mangrove-dominated lagoon, Yucatan Peninsula, Mexico. *International Journal of Ecology and Environmental Sciences* 31(3): 189-202.

41. Paytan, A., G.G. Shellenbarger, J.H. Street, M.E. Gonneea, K. Davis, M.B. Young, and W.S. Moore. 2006. Submarine groundwater discharge: An important source of inorganic nitrogen to coral reef ecosystems. *Limnology and Oceanography* 51: 343-348.

42. Nicholson, D., S. Dyhrman, F. Chavez, and A. Paytan. 2006. Alkaline phosphatase activity in the phytoplankton communities of Monterey Bay and San Francisco Bay. *Limnology and Oceanography* 51: 874-883.

43. McLaughlin, K., A. Paytan, C. Kendall, and S.R. Silva. 2006. Oxygen isotopes of phosphatic compounds: Application for marine particulate matter, sediments, and soils. *Marine Chemistry* 98: 148-155.

44. Boehm, A., A. Paytan, G.G. Shellenbarger, and K.A. Davis. 2006. Composition and flux of groundwater from a California beach aquifer: Implications for nutrient supply to the surf zone. *Continental Shelf Research* 26: 269-282.

45. Gonneea, M.E. and A. Paytan. 2006. Phase associations of barium in marine sediments. *Marine Chemistry* 100: 124-135.

46. Shellenbarger, G.G., S.G. Monismith, A. Genin, and A. Paytan. 2006. The importance of submarine groundwater discharge to the nearshore nutrient supply in the Gulf of Aqaba (Israel). *Limnology and Oceanography* Volume 51: 343-348.

47. Hoppe, K.A., A. Paytan, and P. Chamberlain. 2006. Reconstructing grassland vegetation and paleotemperatures using carbon isotope ratios of bison tooth enamel. *Geology* Volume 34: 649-652.

48. Wankel, S.D., C. Kendall, C.A. Francis, and A. Paytan. 2006. Nitrogen sources and cycling in the San Francisco Bay Estuary: A nitrate dual isotopic composition approach. *Limnology and Oceanography*, Volume 51: 1654-1664.

49. Wei, Z., M.J. Moldowan, and A. Paytan. 2006. Diamondoids and molecular biomarkers generated from modern sediments in the absence and presence of minerals during hydrous pyrolysis. *Organic Geochemistry* Volume 37: 891-911.

50. McLaughlin, K., C. Kendall, S.R. Silva, and A. Paytan. 2006. Phosphate oxygen isotope ratios as a tracer for sources and cycling of phosphate in North San Francisco Bay, California. *JGR Biogeochemistry*, Volume 111, G03003, doi:10.1029/2005JG000079.

51. Böhm, F., N. Gussone, A. Eisenhauer, W-C. Dullo, S. Reynaud, A. Paytan. 2006. Calcium Isotope Fractionation in Modern Scleractinian Corals. *Geochem. Cosmochim. Acta*, 70/17, 4452-4462, DOI: 10.1016/j.gca.2006.06.1546

52. McLaughlin, K., F.P. Chavez, J.T. Pennington, and A. Paytan. 2006. A time series investigation of the oxygen isotopic composition of dissolved inorganic phosphate in Monterey Bay, California. *Limnology and Oceanography*, Volume 51, 2370-2379, doi: 10.1016/j.ecss.2006.06.030.

53. Chen,Y., J. Street, and A. Paytan. 2006. Comparison between pure-water- and seawater-soluble nutrient concentrations of aerosols from the Gulf of Aqaba. *Marine Chemistry* 101, 141-152.

54. Chase, Z., A. Paytan, K.S. Johnson, J. Street, Y. Chen. 2006. Input and cycling of iron in the Gulf of Aqaba, Red Sea. *Global Biogeochemical Cycles* 20, GB3017, doi:10.1029/2005GB002646.

55. Handler, N.B., A. Paytan, C.P. Higgins, R.G. Luthy, and A.B. Boehm. 2006. Human development is linked to multiple water body impairments along the California coast. *Estuaries and Coasts* 29, 860-870.

56. McLaughlin, K., B.J. Cade-Menun, and A. Paytan. 2006. The oxygen isotopic composition of phosphate in Elkhorn Slough, California: A tracer for phosphate sources. *Estuarine, Coastal and Shelf Science* 70, 499-506. doi: 10.1016/j.ecss.2006.06.030.

57. Mackey, K.R.M., R.G. Labiosa, M. Calhoun, J.H. Street, A. Post, and A. Paytan. 2007. Phosphorus availability controls phytoplankton community dynamics and taxon specific nutrient status in the Gulf of Aqaba, Red Sea. *Limnology and Oceanography* Volume 52, 873-885.

58. Averyt, K.B., and A. Paytan. 2007. Reply to Comment on “Empirical partition coefficients for Sr and Ca in marine barite: Implications for reconstructing seawater Sr

and Ca concentrations". *Geochemistry, Geophysics, Geosystems*, 8, Q01009, doi:10.1029/2006GC001494.

59. Paytan, A. and K. McLaughlin. 2007. The Oceanic Phosphorus Cycle. *Chemical Reviews*, 107, 563-576.

60. Lyle, M.N., N. Pisias, A. Paytan, I. Martinez, and A. Mix. 2007. Reply to the comment by R. Francois et al. on "Do geochemical estimates of sediment focusing pass the sediment test in the Equatorial Pacific?": Further explorations of ^{230}Th normalization. P*aleoceanography*, 22, PA1217, doi:10.1029/2006PA001373.

61. Jiménez-Espejo, F.J., F. Martínez-Ruiz, A. Paytan, T. Sakamoto, M. Ortega-Huertas, G. Finlayson, K. Iijima, D. Gallego-Torres and D. Fa. 2007. Climate forcing and Neanderthal extinction in Southern Iberia: insights from a multiproxy marine record. *Journal of Quaternary Science Reviews.* 10.1016/j.quascirev.2006.12.013.

62. Chen, Y., S. Mills, J. Street, D. Golan, A. Post, M. Jacobson and A. Paytan. 2007. Atmospheric nutrient concentrations and dry deposition fluxes in the Gulf of Aqaba. *JGR Atmospheres*, 112, Do4309, doi:10.1029/2006JD007858.

63. Vengosh, A., S. Hening, J. Ganor, B. Mayer, C.E.Weyhenmeyer, T.D. Bullen, and A. Paytan. 2007. New isotopic evidence for the origin and age of groundwater from the Nubian Sandstone Aquifer in the Negev, Israel. *Applied Geochemistry*, doi:10.1016/j.apgeochem.2007.01.005.

64. Gallego-Torres, D., F. Martínez-Ruiz, A. Paytan, F.J. Jiménez-Espejo, and M. Ortega-Huertas. 2007. Pliocene-Holocene evolution of depositional conditions in the Eastern Mediterranean: role of anoxia *vs.* productivity at time of sapropel deposition. *Palaeogeography, Palaeoclimatology, Palaeoecology* doi:10.1016/j.paleo.2006.10.008.

65. Paytan, A., and E. M. Griffith. 2007. Marine barite: recorder of variations in ocean export productivity. *Deep Sea Research II* doi:10.1016/j.dsr2.2007.01.007.

66. Wankel, S., A. Paytan, C. Kendall, F. Chavez, and T. Pennington. 2007. Nitrification in the euphotic zone as evidenced by nitrate dual isotopic composition--Observations from Monterey Bay, California. *Global Biogeochemical Cycles* 21, GB2009, doi:10.1029/2006GB002723.

67. Leichter, J.J., A. Paytan, S. Wankel, K. Hanson, S. Miller, and M.A. Altabet. 2007. Nitrogen and oxygen isotopic signatures of subsurface nitrate: evidence of deep water nutrient sources to the Florida Keys reef tract. *Limnology and Oceanography*, 52, 1258-1267.

68. Paytan, A. and K. McLaughlin. 2007. Phosphorous in our waters. *Oceanography*, 20, 200-206.

69. Derse, E., K. Knee, S. Wankel, C. Kendall, C.J. Berg Jr. and A. Paytan. 2007. Identifying the sources of nitrogen to Hanalei Bay, Kauai utilizing the nitrogen isotope signature of macroalgae. *Environmental Science and Technology*. 41(15), 5217-5223.

70. Feranec, R., E. Hadly and A. Paytan. 2007. Determining landscape use of Holocene mammals using strontium isotopes. *Oecologia*, 153, 943-950.

71. Saltzman, J., and A. Paytan. 2007. Engaging First Grade Students in a Geoscience Campus Fieldtrip. *Journal of Geological Education*, 55, 326-332.

72. Paytan, A., K. Averyt, K. Faul, E. Gray, and E. Thomas. 2007. Barite accumulation, ocean productivity and Sr/Ba in barite across the Paleocene Eocene Thermal Maximum. *Geology*, 35, 1139-1142.

73. Feranec, S.R., E.A. Hadly, J.L., Blois, A.D., Barnosky,and A., Paytan. 2007. Preliminary Radiocarbon dates from the Pleistocene fossil deposits of Samwel Cave, Shasta County, California. *Radiocarbon*, 49, 117-121.

74. Street, J. H., E. Grossman, C. E. Storlazzi, K. L. Knee and A. Paytan. 2008. Submarine groundwater discharge and nutrient subsidies to the coastal zone of leeward Hawai'i. *Marine Chem.* doi:10.1016/j.marchem.2007.08.009.

75. Geibert, W., M. Charette, G. Kim, W. S. Moore, J. Street, M. Young, A. Paytan. 2008. The release of dissolved actinium to the ocean: a global comparison of different end-members. *Marine Chem*. doi:10.1016/j.marchem.2007.07.005.

76. Young, M., M.E. Gonneea, D. Fong, W.S. Moore, J. Herrera-Silveira, and A. Paytan. 2008. Characterizing sources of groundwater to a tropical coastal lagoon in a karstic area using radium isotopes and water chemistry. Marine Chemistry special volume. *Marine Chem.* doi: 10.1016/j.marchem.2007.07.010.

77. Griffith, E. M., A. Paytan, A. C. Ravelo, A. Eisenhauer, R. Kozdan, and T. D. Bullen. 2008. Influences on the fractionation of calcium isotopes in planktonic foraminifera. *Earth and Planetary Science Letters.* 268, 124-136. doi:10.1016/j.epsl.2008.01.006

78. Chen, Y., A. Paytan, Z. Chase, C. Martens, A. J. Beck and S.A. Sañudo-Wilhelmy. 2008. Sources and fluxes of atmospheric trace elements over the Gulf of Aqaba, Red Sea. *JGR Atmospheres.* 113, D05306, doi:10.1029/2007JD009110, 2008.

79. Griffith, E. M. and A. Paytan. 2008. Barite in the ocean - occurrence, geochemistry, and paleoceanographic applications. In *Authigenic minerals: sedimentology, geochemistry, origins, distribution and applications*, International Association of Sedimentology Special Publication. (In Press).

80. Mackey, K.R.M., and A. Paytan. 2008. "Phosphorus cycle", in *The Encyclopedia of Microbiology*, 3rd Edition, edited by Moselio Schaechter, Elsevier (in Press).

81. Mackey, K.R.M., A. Paytan, A.R. Grossman, and S. Bailey. 2008. Oxygen reduction in oceanic photosynthesis: a novel strategy for coping in a high light, low nutrient environment. *Limnology and Oceanography* (In Press).

82. Lazar, B., Y. Weinstein, A. Paytan, E. Magal, D. Bruce and Y. Kolodny. 2008. Ra and Th adsorption coefficients in lakes – estimates from the low $^{224}Ra/^{228}Ra$ ratio in Lake Kinneret (Sea of Galilee). *Geochem. Cosmochim. Acta*, (In Press).

83. Herrera-Silviera, J., N. Aranda, L. Troccoli, M. Young, and A. Paytan. 2007. Spring water quality in coastal lagoons of the Yucatan Peninsula. *Estuarine and Costal Shelf Science* (In Press).

Peer-Reviewed Invited Publications

1. De La Rocha, C.L. and A. Paytan. 2005. Directions in the study of ocean chemistry over the Phanerozoic and its links to geological processes. *Marine Geology* 217: 193-197.

Non-Reviewed

1. Paytan, A. 2004. Biogeochemistry of Marine Systems, (Ed. Kenneth D. Black and Graham B. Shimmield) Blackwell Publishing, book review, *Oceanography*, 17, 213-214.
2. Paytan A. 2006. Ocean Paleoproductivity. In *Encyclopedia of Paleoclimatology and Ancient Environments* (V. Gornitz, Ed). Encyclopedia of Earth Science Series. Kluwer Academic Publishers.
3. Paytan, A. and M-L Zoback (2007) Crossing boundaries, hitting barriers. *Nature* 445, 950.
4. Paytan, A (2007) A palaeoceanographer worries not about corals, but about coral reefs. *Nature – Journal Club*. 446, 587, doi:10.1038/446586a

Pending Peer-Reviewed

1. Gallego-Torres, D., F. Martinez-Ruiz, P.A. Meyers, A. Paytan, F.J. Jimenez-Espejo, M. Ortega-Huertas. 2008. Pliocene-Holocene paleoproductivity patterns associated with sapropel deposition in the Eastern Mediterranean and their paleoceanographic significance *Paleoceanography*, (submitted).
2. Breier, J. A., N., Nidzieko, S. Monismith, W. Moore, and A. Paytan. 2008. Groundwater and surface water exchange in Elkhorn Slough, California: a coupled geochemical and hydrodynamic approach. *Limnology and Oceanography*. (submitted).
3. Griffith, E. M., E. A. Schauble, T. D. Bullen and A. Paytan. 2008. Characterization of calcium isotopes in natural and synthetic barite. *Geochimica Cosmochimica Acta* (submitted).
4. Grossman, E., P. Chavez, J. Logan, J. Street, and A. Paytan. 2008. Groundwater and its Influence on Reef Evolution, *Moloka'i Atlas* - Chapter 13. (submitted).
5. Cade-Menun, B.J., A. Paytan, J.F. Stebbins and J. Baldock. 2008. Temporal and depth variability of particulate organic carbon compounds in marine samples from two regions in California: a solid-state CP/MAS ^{13}C-NMR study. *Marine Chemistry*. (submitted).
6. Mackey, K.R.M., A. Paytan, T. Rivlin, and A. F Post. 2008. Phytoplankton responses to natural and simulated transitions in nutrient and light regimes in the oligotrophic Red Sea. *Aquat. Microb. Ecol*. (submitted).
7. Wankel, S.D., C. Kendall, and A. Paytan. 2008. Using nitrate dual isotopic composition (δ^{15}N and δ^{18}O) as a tool for constraining sources and cycling of nitrate in an estuarine system: Elkhorn Slough, CA. *JGR Biogeochemistry* (submitted).
8. Knee, K., B., Layton, J.H. Street, A. Boehm, and A. Paytan. 2008. Sources of nutrients and fecal indicator bacteria to nearshore waters on the north shore of Kaua`i. *Estuaries and Coasts*. (submitted).
9. Paytan, A., K.R.M. Mackey, Y. Chen, I.D. Lima, S.C. Doney, N. Mahowaldand A. F. Post. 2008. Atmospheric Dust Deposition Variable Impacts on Marine Phytoplankton. *Nature Geosciences* (submitted).
10. Foster, R.A., A. Paytan, and J.P. Zehr. 2008. N_2 fixation and *nifH* gene diversity in the Gulf of Aqaba (Red Sea) during fall 2005. *Marine Ecology Progress Series*. (submitted).

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17. Young, M., L.G. Miller, J. Herrera-Silveira, A. Paytan. 2008. Methane flux from mangrove dominated tropical coastal lagoons, Yucatán, Mexico. *Biogeochemistry*, (submitted).

18. Natalie M. Mahowald, Sebastian Engelstaedter1, Chao Luo1 , Andrea Sealy, Paulo Artaxo, Sophie Bonnet, Ying Chen, Patrick Chuang, David D. Cohen, Barak Herut, Anne M. Johansen, Nilgun Kubilay, Remi Losno, Willy Maenhaut, Adina Paytan, Joseph M. Prospero, Lindsay M. Shank, Ronald L. Siefert. 2008. Atmospheric iron deposition: Global distribution, variability and human perturbations. *Annual Review for Marine Science*, (submitted).

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THE UNIVERSITY OF TENNESSEE

OFFICE OF THE UNIVERSITY REGISTRAR
209 STUDENT SERVICES BLDG.
KNOXVILLE, TENNESSEE 37996-0200

KEY TO TRANSCRIPT

1. **GRADING SYSTEM** - The University of Tennessee, Knoxville, uses a four point grading system to measure academic achievement. The following grades are used in computing the grade point average (GPA) for undergraduates, graduates, and veterinary medicine. See grading system for Law in #6 below.

Grade	Interpretation or Performance Level	Quality Points per Credit Hour
A	Superior	4
B+	Very Good	3.5
B	Good	3
C+	Fair	2.5
C	Satisfactory	2
D	Unsatisfactory	1
E	Conditioned (discontinued Fall, 1975)	0
F	Failure	0
I	Incomplete (computed as Failure for undergraduates prior to Fall Semester, 1988) (computed as Failure for graduates prior to Fall Quarter, 1976) "I" grades after the above dates are not used in GPA calculations.	0
WF	Withdrew failing	0
X	Examination missed (discontinued Fall, 1975)	0

The following grades or notations are also used by the University; however, they do not earn quality points and are not used in GPA calculations.

Grade	Explanation
Aud	Audit (courses not recorded on Academic Record - effective Fall, 1982)
Blank	No report
IW	Incomplete due to writing deficiency
N	No progress
NC	No credit
NG	No grade
NP	No progress or inadequate progress
NR	No report
P	Progress or Pass (progress toward completion of a thesis or dissertation)
S	Satisfactory (equates to A, B, or C for undergraduates; equates to A or B for graduates)
SI	Incomplete grade for course elected as S or NC grade
W	Withdrew from course without penalty
WP	Withdrew passing

The following grade symbols are also used:

* Repeated course - All hours (attempted and earned) and quality points for the course with the "*" are subtracted from the cumulative totals.

\# Repeated course - All earned hours for the course with the "#" are subtracted from the cumulative totals.

2. **CREDIT LEVEL AND COURSE NUMBERING SYSTEM**-"U" = Undergraduate; courses numbered in 100(0)'s and 200(0)'s are lower division; and 300(0)'s and 400(0)'s are upper division; 300(0) and 400(0) numbered courses are used for graduate credit if preceded by a "G" in Credit Level. "G"= Graduate level; courses numbered 500(0) = graduate level, however, any 500(0) numbered course with a "U" credit level is used as undergraduate credit. "L" = Law courses. "V" = Veterinary Medicine.

3. **COURSE TYPE** - Blank = Regular Credit; ADM = Admissions Deficiency Met; AP = Advanced Placement; CLP = College Level Exam; COP = Co-op Credit; COR = Correspondence; HON = Honors Credit; MIL = Military Credit; PRF = Proficiency Exam; NON = Non-credit; DP = Departmental Placement.

4. **TRANSFER POLICY** (effective Fall Quarter, 1985) - Transfer hours are counted for degree programs but are not computed in UTK's GPA for courses transferred after Summer Quarter, 1985.

5. **GOOD STANDING** - Unless otherwise noted, student is in good academic standing (eligible to enroll).

6. **GRADES, COLLEGE OF LAW** (effective Fall, 1969 a numerical grading system) 3.6 - 4.0 = A; 2.6 - 3.5 = B; 1.6 - 2.5 = C; .6 - 1.5 = D; 0 - .5 = F. Effective Fall, 1980; 3.6 - 4.0 = A; 2.6 - 3.5 = B; 1.6 - 2.5 = C; 1.0 - 1.5 = D; .0 - .9 = F. Effective Fall, 1996; Excellent/A+ = 4.3, A = 4.0, A- = 3.7; Good/B+ = 3.3, B = 3.0, B- = 2.7; Satisfactory/C+ = 2.3; C = 2.0; C- = 1.7; Poor/D+ = 1.3, D = 1.0; D- = .7; Failure/F = 0.0.

7. **CALENDAR SYSTEMS** - Unless otherwise noted, all course work completed prior to Fall Semester, 1988 is under the quarter system and all work completed after Summer Quarter, 1988 is under the semester system. College of Law course work completed after Spring Quarter, 1981 is under the semester system.

8. **ACCREDITATION** - The University of Tennessee is accredited by the Southern Association of Colleges and Schools.

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U.S. Patent 4,227,720

THE UNIVERSITY OF TENNESSEE, KNOXVILLE

ACADEMIC TRANSCRIPT

MIONI, CECILE E
Student Name

410-91-3324
Student ID

Date Printed: 05/13/2008

From: UNIVERSITY BORDEAUX 1
LICENSE
Degree Awarded 1998

From: UNIV DE BRETAGNE OCCIDENT
MATRISE
Degree Awarded 1999

From: UNIVERSITE PARIS 6
ADVANCED MASTERS DEGREE
Degree Awarded 2000

Course		Course Name	Course Type	Credit Hours	Credit Level	Grade
		FALL SEMESTER 2001	**GRADUATE**			
BCMB	517	PHYSICAL BIOCHEMISTRY		3.00	G	A
MICROBIOL	595	GENERAL SEMINAR		1.00	G	S
MICROBIOL	600	DOCTORAL/RES/DISSERT		3.00	G	P
MICROBIOL	605	JOUR CLUB MICRO GENET		1.00	G	S
MICROBIOL	610	TOP MICROBIAL PHYSIOL		3.00	G	A
		SPRING SEMESTER 2002	**GRADUATE**			
BCMB	512	ADV MOLECULAR BIOLOGY		3.00	G	A
ENGLISH	121	ACAD ENGL NON-NAT SPK		4.00	U	A
MICROBIOL	600	DOCTORAL/RES/DISSERT		4.00	G	P
MICROBIOL	601	JOURN CLUB MICROB PHY		1.00	G	S
		SUMMER SEMESTER 2002	**GRADUATE**			
MICROBIOL	600	DOCTORAL/RES/DISSERT		9.00	G	P
		FALL SEMESTER 2002	**GRADUATE**			
MICROBIOL	595	GENERAL SEMINAR		1.00	G	S
MICROBIOL	600	DOCTORAL/RES/DISSERT		10.00	G	P
MICROBIOL	605	JOUR CLUB MICRO GENET		1.00	G	S
		SPRING SEMESTER 2003	**GRADUATE**			
MICROBIOL	595	GENERAL SEMINAR		1.00	G	S
MICROBIOL	600	DOCTORAL/RES/DISSERT		7.00	G	P
MICROBIOL	601	JOURN CLUB MICROB PHY		1.00	G	S
MICROBIOL	670	ADV TOP ENVIR MICROB		3.00	G	A
		SUMMER SEMESTER 2003	**GRADUATE**			
MICROBIOL	600	DOCTORAL/RES/DISSERT		9.00	G	P

----------CONTINUED ON NEXT COLUMN----------

Course		Course Name	Course Type	Credit Hours	Credit Level	Grade
		FALL SEMESTER 2003	**GRADUATE**			
MICROBIOL	593	INDEPENDENT STUDY		1.00	G	A
MICROBIOL	595	GENERAL SEMINAR		1.00	G	S
MICROBIOL	600	DOCTORAL/RES/DISSERT		4.00	G	P
MICROBIOL	605	JOUR CLUB MICRO GENET		1.00	G	S
STATISTICS	531	SURVEY STAT METHODS I		3.00	G	A
		DOCTORAL COMPREHENSIVE EXAM PASSED: FALL 2003				
		SPRING SEMESTER 2004	**GRADUATE**			
MICROBIOL	595	GENERAL SEMINAR		1.00	G	S
MICROBIOL	600	DOCTORAL/RES/DISSERT		6.00	G	P
MICROBIOL	601	JOURN CLUB MICROB PHY		1.00	G	S
MICROBIOL	670	ADV TOP ENVIR MICROB		3.00	G	A
		ADM PHD CANDIDACY SPRING 2004				
		SUMMER SEMESTER 2004	**GRADUATE**			
MICROBIOL	600	DOCTORAL/RES/DISSERT		9.00	G	P
		FALL SEMESTER 2004	**GRADUATE**			
MICROBIOL	600	DOCTORAL/RES/DISSERT		9.00	G	P

Degree: DOCTOR OF PHILOSOPHY
Date: 12/10/2004
Major: MICROBIOLOGY
Dissertation: Using a bioluminescent bacterial bioreporter to assess iron bioavailability in the Oceans.

Cumulative:

U	Att:	4.00	Earned:	4.00	S/P:	0.00	Qpts:	16.00	GPA: 4.00
G	Att:	19.00	Earned:	19.00	S/P:	81.00	Qpts:	76.00	GPA: 4.00

END OF TRANSCRIPT

ISSUED TO STUDENT

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M.W. Anderson
Registrar

May 26, 2008

TO: CALFED Science Fellows Program

FR: Wade H. Jeffrey, PhD
Professor, Center for Environmental Diagnostics and Bioremediation

RE: Recommendation for Dr. Cecile Mioni

It is a great pleasure for me to recommend Dr. Cecile Mioni for California Sea Grant CALFED Science Fellows Program. I believe her extensive experience with both field and laboratory studies make her an outstanding candidate for your program.

I first met Cecile when she joined us on an oceanographic research cruise where we transitted the Southeastern Pacific Ocean in 2002. While this was her first research cruise, she very quickly had her trace metal area set up and was invaluable in our sampling protocols. She was meticulous, tireless and dedicated to her tasks. In addition, she assisted with collaborative experiments designed at sea (Mioni et al., 2007 *Aquatic Microbial Ecologyy* 46: 239-251) and demonstrated a willingness and easy ability to work with other people during long and tiring days at sea. It was enjoyable to have her join our group.

Dr. Mioni's PhD work has been recognized for its innovative approaches and techniques to studying the role of iron biogeochemistry in regulating production in the oceans. Field testing the bioreporter she used was no easy task, yet she has successfully demonstrated its application in a variety of locations. As a result, she has successfully integrated and become well trained in microbiology, molecular biology, microbial ecology, biogeochemistry and oceanography. These diverse skills demonstrate that she is able to adapt and learn new research areas and that her interdisciplinary training will make her an asset to any research program. Her CALFED research proposal examining Harmful Algal blooms in San Francisco Bay will take advantage of all of these skills. The proposed project is a balanced combination of both field observations as well as experimental manipulations. Dr. Mioni has established an excellent interdisciplinary collaborative team of experts to approach this important topic with broad ranging significance, not only to San Francisco Bay and California, but also to the broader field of Harmful Algal blooms in general.

Dr. Mioni has proven to be patient, conscientious, and motivational in her teaching and student mentoring. I personally know that when she explains her dissertation work, she does a great job of clearly explaining a complex hypothesis and process. These skills can only help with public outreach and broader impacts of the proposed project with benefits for California Sea Grant.

I can recommend Dr. Cecile Mioni without reservation for CALFED Science Fellows Program, and I urge you to give her application full consideration. She is dedicated, motivated, and broadly trained such that she will be an outstanding Sea Grant Fellow. If I may provide any additional information, please do not hesitate to contact me.

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Dear Committee Members,

This letter is to express my support for Cécile Mioni's application for the CALFED Post Doctoral Fellowship Program. I have known Cécile since advising her while she was a visiting researcher at Princeton University in the summer of 2000. I have, in the past, written letters of support for Cécile's graduate school application and various graduate fellowship applications. She is an exceptional scientist and I usually state that I place her in the top 1% of students that I have had research experience with. My view has only been strengthened over the years. My experience includes advising undergraduate and graduate students at the State University of New York at Stony Brook, the University of British Columbia and Princeton University. What I believe places Ms. Mioni above other competent candidates is her passion and undaunting dedication to the hard work of research. This passion has driven her to become knowledgeable in the fields of molecular biology and biological and chemical oceanography and her dedication has produced seven publications, five of which she is first author, while finishing a Ph.D. in three and a half years. During this time she also generated her own support through graduate fellowships and teaching assistantships. I believe that she will make an excellent research professional and will likely be an intellectual leader in the field.

Cécile's creative, multidisciplinary approach to science is evident in the research proposals that she has written in the past two years for fellowship applications. She has sent me each of these proposals to review and I have found them to be scientifically detailed, mature and carefully reasoned. This demonstrated to me that Cécile is not only highly intelligent and competent but also dedicated to understanding research questions in depth. No doubt the reviewers of her CALFED proposal will find out this for themselves.

Yours Sincerely

Allen J Milligan, Ph.D.
Assistant Professor, Senior Research

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Wednesday, May 07, 2008

Re: A recommendation for Dr. Cécile Mioni's application for the 2008 CALFED Science Fellows Program

Please accept this letter as my sincere and enthusiastic recommendation for Dr Cécile Mioni's application. As I am sure you are aware she completed her doctoral work in my research group (she defended in October 2004) and combined with her previous experience in several different research groups, I believe Cécile is well prepared to take on this challenge.

Cécile joined my group in 2001, having completed 3 degrees at top research institutes. Prior to joining my research group at the *University of Tennessee*, Cécile had previously completed projects in several noted labs, including those of Véronique Garçon, Francois Morel (where she worked with then postdoctoral fellow Allen Milligan) and Paul Tréguer (where she worked with Stephane Blain). Being impressed with her background and knowing she wanted to gain experience as a molecular biologist, I asked Cécile to take on our most difficult project – the construction and testing of bioluminescent bacterial bioreporters which provide a measure of Fe availability. Cécile completed her PhD project in just 3 ½ years. During this period she gathered enough data to have 4 lead-author papers published. Moreover, her work with other students and our collaborators should lead to her being listed on several other manuscripts (in fact she was listed on 2 manuscripts from the recent *FeCycle* program due to her contributions concerning the in-depth analysis of nutrient dynamics in the region as well as her review of the pertinent literature in the area). She has also presented this work at several scientific meetings, including an invited oral presentation at the *American Society for Limnology and Oceanography* meeting in February 2004. Finally, she has grown tremendously as a person, having added aspects of patience and understanding to her scientific drive that in sum will make her an outstanding colleague for whoever is fortunate enough to work with her.

Cécile's work was ground breaking as it is amongst the first papers to present a method for the quantification of *bioavailable* nutrients in marine systems. Many chemical techniques exist to measure nutrients, but none gauge the biological availability to the natural community. The bioreporter system which Cécile has developed solves this by having the microorganisms tell us which chemical forms of nutrient (in this case the micronutrient Fe) are bioavailable. The reporter system is, in essence, a fusion of the promoter region of an iron-responsive gene (in this case a component of the enterobactin biosynthetic pathway) with a *lux* reporter cassette.

While simple on the surface, great energy went into the construction and validation of this system, and several complications had to be overcome in moving this heterologous promoter into marine bacteria. Cécile was however able to accomplish this, and as her papers document, field tested the construct in a number of different aquatic systems. I expect that Cécile's publications will lead to significant alterations in the way we think about the regulation of microbial production (and the influence it has on the food web) in marine surface waters.

The interesting thing about Cécile's project is that the techniques she learned are highly applicable to a variety of fields. As part of her studies she was required to re-engineer a halotolerant *Pseudomonas putida* to produce light during periods of Fe stress. As such, while much of the work was applicable to oceanographic studies, the molecular and genetic tools she learned will be of great value in most any biological discipline. Moreover, the understanding required to deploy these systems covers that gamut of oceanic realms.

During her time at the *University of Tennessee*, Cécile received top grades in all her classes and was three times awarded a *Research Center for Excellence in Environmental Biotechnology Fellowship.* She also actively pursued other funding, and was awarded the *Daniel Jouvance Award* for "*Recherches sur le plancton marin 2003*", and the *Ryan Kelley Memorial* scholarship.

With regard to Cécile's character, she is a diligent, hardworking student whom was always the first to the lab in the morning (often around 7 am) and usually the last to leave here (around 7 pm). She remains highly motivated, pushing herself to thoroughly complete projects in a timely manner. Indeed, the "hold-up" in the publication of the rest of her thesis was not due to Cécile, but due to collaborators that we required data from (specifically Fe concentration measures – which we are in actuality still waiting for data from 2003!). In my laboratory she worked completely independently on the bioreporter construction, while at the same time working in a successful collaboration with another student (Leo Poorvin) to document the utility of this tool in working in complex chemical systems. I think this demonstrates her potential to not only carry out but to also lead scientific endeavours.

In all I believe Cécile will make an excellent candidate for this award.

With best regards,

Steven W. Wilhelm

Associate Professor and Associate Head, Department of Microbiology

wilhelm@utk.edu

Submitted online - electronically on Wednesday, May 07, 2008

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
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http://sfbay.wr.usgs.gov/access/wqdata

June 5, 2008

To Whom It May Concern:

It is my sincere pleasure to offer my support as a Community Mentor to Dr. Cecile Mioni, a post-doctoral applicant for a 2008 CALFED Science Fellowship. I am a Research Engineer with the National Research Program of the U.S. Geological Survey in Menlo Park and a member of Dr. James Cloern's "Plankton Dynamics in Tidal Estuaries" group. I have met with Dr. Mioni and have reviewed her proposal. I am most impressed with the strength of her academic and research background and their relevance to her proposed project, as well as her resourcefulness, collegiality, and enthusiasm for science.

Dr. Mioni's proposed study of harmful algal species in the San Francisco Bay-Delta is important and timely. Recently in the Bay, colleagues have observed unprecedented blooms of potentially toxic algal species associated with dynamics in the coastal ocean and with the South Bay Salt Ponds. In recent years in the Delta, the potentially toxic cyanobacterium *Microcystis aeruginosa* has become increasingly prevalent. Dr. Mioni's proposed approach is geographically broad, temporally fine enough to resolve seasonal variability, and process-rich. This systematic study seeks to identify some of the triggers of harmful algal growth and toxicity in this diverse ecosystem and will define an important baseline against which to compare responses of toxic species to future ecosystem change driven by forces such climate, management, and restoration. The information produced from this effort will be most useful for environmental management and for the development of numerical models of HAB bloom formation.

Dr. Mioni recognizes that physical processes can interact with and profoundly influence biological processes and populations in aquatic systems. She has thus invited me to collaborate with her by providing research support in the form of a knowledge base and background in estuarine hydrodynamics, transport, and physical-biological coupling relevant to phytoplankton dynamics. Since 1992, I have performed modeling- and field-based research focusing on phytoplankton dynamics and their underlying physical and biological processes in the San Francisco Bay-Delta. I look forward to assisting Dr. Mioni by bringing an estuarine physics perspective to the interpretation of her data. I will

assist her with running a U.S.G.S. tide prediction model for the Bay, obtaining relevant meteorological data, acquiring hydrodynamic data for the Delta, and processing and synthesizing the resultant information to develop basic physical parameters for consideration alongside the biological and chemical parameters she will be measuring. In addition, Dr. Cloern's research group welcomes Dr. Mioni to conduct her Bay sampling on our regular U.S.G.S. research cruises aboard the Research Vessel *Polaris*. This will provide her 1) an at least monthly sampling platform travelling from the southernmost part of South San Francisco Bay to Rio Vista on the Sacramento River; 2) spatial and temporal correspondence between her measurements and those routinely taken (e.g. salinity, temperature, dissolved oxygen, turbidity, chlorophyll *a*) aboard the U.S.G.S. cruises; and 3) the opportunity to work alongside other scientists knowledgeable of the Bay, to exchange ideas and discuss measurements and observations in real-time, and forge new professional relationships. I look forward to meeting quarterly with Dr. Mioni, her research advisor Professor Paytan, and other of Dr. Mioni's collaborators (e.g. Dr. Mueller-Solger, Dr. Lehman) as her research progresses.

Unraveling the triggers of algal toxicity and HAB development along the Bay-Delta continuum represents a large and complex problem in need of many committed scientists and varied perspectives and approaches. It is evident that Dr. Mioni recognizes that collective progress is enhanced by mutual support, as she has established new collaborations with colleagues in academia and government agencies to ensure that her proposed research will complement related ongoing efforts and be strengthened by the knowledge and activities of her colleagues. I fully expect exciting results and important scientific surprises from this project. And I very much look forward to the opportunity to collaborate with Dr. Mioni.

Sincerely,

Lisa V. Lucas, Ph.D.
U.S. Geological Survey

Anke Mueller-Solger, Ph.D.
Staff Environmental Scientist
California Department of Water Resources, Division of Environmental Services
901 P Street, PO Box 942836, Sacramento, CA 95814-6424
Office: (916) 651-0179; Fax: (916) 651-0209; amueller@water.ca.gov

05-04-2008

Support letter for 2008 CALFED Science Fellows Proposal by **Dr. Cecile Mioni**

To Whom it May Concern:

I am writing to offer my enthusiastic support for a proposal to the CALFED Science Fellows Program by Dr. Cecile Mioni.

I am a Staff Environmental Scientist with the California Department of Water Resources and was previously a research scientist at UC Davis. In these capacities, I have been and continue to be intensely involved with a number of research projects funded by the CALFED program as well as with monitoring and research programs conducted in the upper San Francisco Estuary (SFE) by the Bay-Delta Interagency Ecological Program (IEP). I am thoroughly familiar with all IEP monitoring programs, including the Environmental Monitoring Program with which Dr. Mioni intends to coordinate some of her sampling activities. I have also led various planning aspects of CALFED Science Conferences, including serving as Conference Co-Chair for the 2006 and 2008 conferences, and I have participated in many CALFED and IEP workshops. I am also the current chair of the IEP Pelagic Organism Declines (POD) Management Team.

Results of studies coordinated by the POD team point to changes in trophic structure and species composition and increasing toxicity as possible mechanisms leading to the recent precipitous declines of several important fish species in the SFE. Of particular concern is the rise in harmful algal blooms, especially the steady increase in spatial extent and intensity of blooms of *Microcystis aeruginosa* in the Delta and into Suisun Bay, but also of several other potentially problematic algal species, including dinoflagellates in San Francisco Bay. These blooms are a concern because of their low nutritional value to primary consumers and/or the toxic compounds they can produce. While ongoing CALFED and POD work is already investigating the dynamics and ecological effects of *Microcystis* blooms in the Delta, the proposed work would add an important comparative dimension by also including HABs in the more saline Bays of the SFE. This is particularly interesting because the Bays have so far been less plagued by HABs than the Delta or the adjacent coastal ocean, but this could change quickly with predicted environmental changes due to climate change and water management. The *Microcystis* blooms in the Delta have regularly occurred for almost a decade, but are also a recent phenomenon relative to HABs in the adjacent coastal ocean. The comparative Bay and Delta study proposed by Dr. Mioni is likely to provide some very important clues about the conditions leading to the rise in HABs in both the Bay and Delta. It may also point to ways that these undesirable blooms might be avoided or at least kept to a minimum through more scientifically sound environmental management strategies. Furthermore, the results from this study will likely help assess the effects of future intentional and unintentional environmental changes that are currently the subject of intense debate by several high-profile Delta planning and management efforts aimed at reversing the dramatic decline in the ecological health of the San Francisco Estuary. Finally, this study is designed to encompass the full estuarine salinity gradient, and promises to yield insights into the factors promoting the worldwide rise in HABs in both oceanic and freshwater systems.

Dr. Mioni proposes to utilize appropriate and well established monitoring and experimental field methods to characterize the spatial and temporal HAB extent and factors stimulating HABs in the Delta and The Bays of the SFE. She proposes to coordinate her field work with existing monitoring and research projects, thus ensuring efficient use of resources and rapid exchange of observations and ideas with other scientists and agency personnel. I believe that her proposed work will be an excellent complement to ongoing research and monitoring work. Based on her previous research experience, Dr. Mioni is clearly highly qualified to carry out the proposed project, but also likely to gain a large amount of new research experience and understanding about estuarine ecosystems. I believe that Dr. Mioni's proposed research project is eminently suitable for an academic postdoctoral project under the guidance of experienced research and community mentors. I would be happy to serve as a State agency community mentor for this project and assure close connectedness to SFE issues, State agencies and resources, CALFED, and the IEP.

Sincerely, Anke Mueller-Solger, CA DWR, Sacramento