CALFED Progress Report
California Sea Grant College Program

ConfirmationNumber: 20100901132304

Printed: 9/1/2010 1:43:39 PM

ProjectYear_2A: 1st

ProjectNo_2C: R/SF-40

TypeQuestionnaire_2B: Annual Report

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Project Information

ProjectNo_2C: R/SF-40

StartDate_3a: 1/1/2009

EndDate_3b:

ProjectTitle_4: Reconstructing Climate Variability, Aridity and Water Availability in the Sacramento-San Joaquin Watershed Based on Isotopic Evidence in Sediments from Swamp Lake, Yosemite NP

CALFed Fellow contact information

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Additional Research Mentors and Community Mentors

Additional Research Mentors_8:

Additional Community Mentors_9:

Project Objectives: Please type your responses, and answer the questions in a style appropriate for laymen.

ProjectObjectives_10

As described in more detail in the original proposal, my overall research objective is to develop a detailed, long-term record of past climate changes and water availability in the western Sierra Nevada, the drainages of which are a major source of water to the Sacramento-San Joaquin river system and ultimately the San Francisco Bay-Delta. In the context of this project, "long-term" refers to the last 20,000 years or so, since the last glaciation; my particular interest, however, is the most recent 10,000 years of the Holocene interglacial epoch, during which earth's climate system has been in a warm phase and is thus most comparable and pertinent to present and future conditions. A "detailed" climate record, in this context, refers to variations occurring on timescales of decades to centuries. The general lack of detailed, high-resolution paleoclimatic studies in the Sacramento-San Joaquin watershed extending beyond the last ~1000 years was a primary motivator for the current study. My approach has been to employ geochemical "proxies" – tracers of past climate and environmental conditions – contained in organic matter (OM, literally, the bulk and molecular remains of dead organisms) recovered from sediments collected at Swamp Lake in Yosemite National Park. The proposed project was further sub-divided into three major components: (1) A record of hydrologic variability at Swamp Lake based on hydrogen isotopes (δ2H) in individual plant leaf wax compounds (*n*-alkanes), spanning the entire 20,000-yr sedimentary sequence; (2) A concurrent 20,000-yr record of ecosystem responses to water balance and temperature changes based on bulk carbon (δ13C) and nitrogen (δ15N) isotopes, C and N elemental abundances (C/N), and *n*-alkane abundances in sedimentary OM; (3) A modern calibration study providing a basis for interpreting the down-core records. To these original project components, I have since added a fourth: (4) A record of decadal-scale variability during specific Holocene intervals, based on high resolution analyses of the above proxies, in order to examine the effects of long-term

Summary of progress in meeting each of these goals and objectives

ProgressSummary_11

At the time the proposal was submitted, my early results were promising but based data sets at various stages of completion. I had largely completed the century-scale, bulk OM record (component 2), but had only low-resolution records of *n*-alkane δ2H and abundance (component 1) containing large gaps at key intervals, and only scattered field data on modern conditions (component 3). The high-resolution study (component 4) had yet to be initiated. In the time since the proposal was submitted and funded I have made substantial progress on each of the project components. Work in the laboratory has moved into its latter stages, focusing on the high resolution records, while I have begun to write manuscripts reporting on the long, 20,000 year records. Aspects my research were presented at the 24th Pacific Climate Workshop in April 2009, and at the American Geophysical Union Fall Meeting in December 2009. A summary of the work completed over the first "year" (actually covering a longer period, with several work stoppages due to budget problems on the state government level) of the fellowship is presented below, along with a few key results and the work planned for 2010-2011.

Field & Modern Calibration Study

I collected water, plant, and POM samples at Swamp Lake on two occasions (May and July) in 2009, and on four occasions to date (March, May, June, August) in 2010. Water samples were analyzed for δ2H composition; plant and POM samples were analyzed for bulk δ13C, δ15N, C/N, as well as *n*-alkane abundances and δ2H. Combined with data collected during the summers of 2007 and 2008, I am using the resulting data set to draw conclusions about the factors controlling our climate proxies over time. Based on the observed differences between summers following normal to wet winters (2009, 2010) and dry winters (2007, 2008), lake water δ2H during the plant growing season appears to be sensitive to the magnitude and timing of winter-spring inputs of new water (low δ2H), from runoff and snowmelt, with dry season temperature and evaporation a secondary factor. A broad range of modern plants produce *n*-alkanes of the carbon chain lengths found in Swamp Lake sediments, while concentrations among lake microorganisms (sampled as POM) are extremely low. A comparison of the chain-length distributions between plants and sediments suggests that the main contributors to the sedimentary *n*-alkane pool are aquatic and riparian plants, which use lake water as a moisture source and thus should record the lake δ2H signature. Field sampling at Swamp Lake will continue through the summer of 2010.

PROJECT MODIFICATIONS: Please explain any substantial modifications in research plans, including new directions pursued. Describe major problems encountered, especially problems with experimental protocols and how they were resolved. Describe any ancillary research topics developed.

Modifications_12

For the most part, work completed on the project to date has conformed to the plan outlined in the original proposal. The major exceptions have been (a) the refinement of the expected level of detail (time resolution) of the "long" (20,000-yr) proxy records, and (b) the addition of the high-resolution study described above.

The degree of detail proposed for the 20,000-yr proxy records (components 1 and 2) was deliberately kept vague (20- to 50-yr resolution was suggested as possible for the "combined record"), as I remained uncertain how much of a time constraint would be imposed by the extensive chemical separation procedure and duplicate analyses required for compound-specific hydrogen isotope measurements. I was also unsure whether my chosen proxies would be sufficiently sensitive to record decadal-scale climate fluctuations. As things have turned out, the leaf-wax δ2H proxy is sensitive to sub-decadal climate variations, but is very labor intensive, while the analytically routine bulk OM proxies are less informative on short timescales. My compromise (outlined above) has been to complete the long-term, 20,000-yr records at century-scale resolution, while adding a high-resolution (decadal) study examining several multi-century windows in order to resolve my questions about the influence of interannual and decadal-scale oceanic climate drivers during past Holocene climate regimes.

BENEFITS AND APPLICATIONS: Suggest the relevance of these new findings to management. Describe any accomplishment, that is significant effects your project has had on resource management or user group behavior. CALFED is looking for "management cue" (see http://science.calwater.ca.gov/pdf/soemgmtcues.pdf).

BenefitsApplic_13

In an indirect way, this study is likely to contribute to the CALFED goal of ensuring an adequate water supply for both human and environmental uses in the future. A major question facing water managers in California is how human-caused climate warming will interact with natural variability in key hydrologic variables, especially the amount and timing of winter precipitation, snowmelt and runoff. The major contribution of this and other paleoclimatic studies is to reveal a broader range of past conditions than is captured in the last ~100 years of instrumental measurements. What separates this study from other paleoclimatic studies that have been conducted in the Bay-Delta watershed is its unusual combination of length (~20,000 years) and relative detail (decades to centuries). The Swamp Lake records, when completed, will allow for examination of hydrologic conditions in the Sierra Nevada during past climate regimes distinct from that of the 20th century, for example, during warm or dry centuries, and across major regime shifts in the circulation of the North Pacific ocean and atmosphere. With the caveat that the high resolution Swamp Lake record remain incomplete, and that the data and interpretations have not been finalized, I have included examples of the type of information this study will provide below.

δ2H values in leaf waxes from Swamp Lake sediments during the 20th century were similar to the long-term average, implying that during past centuries, the size of the snowpack and the timing of runoff has at times been either larger/later and smaller/earlier than at present. In comparison to the period between between 5300 and 6000 years ago, the modern snowpack has been large and persistent. In other words, for a period lasting about 800 years, the frequency

PUBLICATIONS: List any publications, presentations, or posters that have resulted from this funded research. Give as many details as possible, including status of paper (e.g., in review; in press), journal name, conference location and date of presentation. Please note (as outlined in the conditions of the award) that each fellow is required to submit an abstract for an oral or poster presentation at each State of the Estuary conference and CALFED Science Conference during the duration of the fellowship.

Publications_14

Street, J.H., A.L. Sessions, R.S. Anderson, J.M. Welker and A. Paytan (2009). Hydrologic variability in the western Sierra Nevada since the LGM from D/H ratios in leaf waxes. 24th Pacific Climate Workshop, Asilomar State Conference Grounds, Pacific Grove, CA. Oral presentation, April 20, 2009.

Street, J.H., A.L. Sessions, R.S. Anderson, J.M. Welker and A. Paytan (2009). Holocene hydrologic variability in the Sierra Nevada from D/H ratios in leaf waxes. Eos Trans AGU, 91(54). American Geophysical Union Fall Meeting, Abstract PP12C-04. Oral Presentation, December 14, 2009.

Street, J.H., A.L. Sessions, R.S. Anderson, J.M. Welker and A. Paytan (2009). Holocene hydrologic variability in the Sierra Nevada from D/H ratios in leaf waxes. 6th Biennial Bay-Delta Science Conference, Sacramento Convention Center, Sacramento, CA, September 27-29, 2010. Poster Presentation.

Street, J.H., R.S. Anderson. S. Starratt and A. Paytan (2010). Close coupling between continental climate and ocean circulation in California since the LGM – organic geochemical evidence from Swamp Lake, Yosemite NP. Manuscript in internal review; to be submitted to Palaeogeography, Palaeoclimatology, Palaeoecology.

COOPERATING ORGANIZATIONS: List those agencies and/or persons who provided financial, technical or other assistance to your project since inception. Describe the nature of their collaboration.

CoopOrganiz_15

California Institute of Technology

- Dr. Alex L. Sessions, Associate Professor of Geobiology, Division of Geological and Planetary Sciences: Facilities for compounds specific hydrogen isotope analysis, technical support, and scientific advice.

National Park Service

- Dr. Alison Colwell, Botanist, Yosemite NP: Logistical support for field work, scientific advice, and plant identifications.
- James Stringfellow, Lake Eleanor Area Ranger, Yosemite NP: Logistical support for field work

Northern Arizona University

- Dr. R. Scott Anderson, Professor of Quaternary and Environmental Sciences

AWARDS: List any special awards or honors that you, or mentor or members of the research team, have received during the duration of this project.

Awards_16

KEYWORDS: List keywords that will be useful in indexing your project.

Keywords_17

California, Climate, Geochemistry, Isotope tracers, Paleoclimatology, Paleolimnology, Sediment, Sierra Nevada, Water Supply

PATENTS: List any patents associated with your project.

Patents_18

ProjectYear_2A: 1st
ProjectNo_2C: R/SF-40
TypeQuestionnaire_2B: Annual Report

Additions: Additional information can be added here. Please begin the text with the number of the question you are adding to.

Additions_19