CALFED Progress Report
California Sea Grant College Program

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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: 8/31/2011

ProjectTitle_4: Reconstructing Climate Variability, Aridity and Water Availability in the Sacramento-San Joaquin Watershed Based on Isotopic Evidence in Sediments ...

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Additional Research Mentors and Community Mentors

Additional Research Mentors_8

Additional Community Mentors_9

ProjectYear_2A 1st **ProjectNo_2C** R/SF-40

TypeQuestionnaire_2B Annual Report

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

ProjectObjectives_10

My overall research objective was to piece together, from evidence in the sedimentary record, a detailed, long-term history of past climate change and water availability in the western Sierra Nevada, the drainages of which are the 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 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.

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 on 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 δ^2H 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 three years (including work stoppages) since the proposal was submitted and funded I have largely completed each of the project components, and am in the midst of preparing manuscripts presenting my results that will be (or have already been) submitted for publication in peer-reviewed scientific journals. A summary of my major results and conclusions will be submitted separately, since this form does not allow space to include this information.

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

Several modifications of the project have occurred since submittal of my 1st year progress report in August 2010. First, as discussed in the summary of results and conclusions, I have changed my interpretation of the n-alkane δ2H proxy based on my comparison of the 20th century δ2H record with instrumental climate records. Second, I have developed a stand-alone 12,000-year record of n-alkane abundance changes, which relate to changes in vegetation assemblage and lake levels over time. The n-alkane abundance record is distinct from both the bulk sedimentary OM and n-alkane δ2H records, and provides an additional line of evidence for environmental change at Swamp Lake.

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 may 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 (a) length (~20,000 years) (b) detail (decades to centuries), and (c) use of proxies (esp. n-alkane δ2H). In conjunction with other regional records, the Swamp Lake records allow us to examine the relationships between hydrologic conditions in the Sierra Nevada and past regimes of ocean-atmospheric circulation in the North Pacific. (MORE INCLUDED in (19) BELOW)

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 and A. Paytan (2010). A leaf-wax δ2H record of Holocene climate variability in the Sierra Nevada: Links to the North Pacific & ENSO. Geological Society of America Annual Meeting, Denver, CO, Oct. 31 – Nov. 3, 2010. Oral Presentation.

Street, J.H., R.S. Anderson and A. Paytan (2011). Close coupling of continental climate and ocean circulation in California since the LGM – organic geochemical evidence from Swamp Lake, Yosemite NP. Quaternary Science Reviews, in review.

Street, J.H., R.S. Anderson and A. Paytan (in prep.). n-Alkane evidence for a shift to wetter conditions in the central Sierra Nevada at the mid-late Holocene transition. To be submitted to Quaternary Research.

Street, J.H., A.L. Sessions, R.S. Anderson and A. Paytan (in prep). Late Holocene record of shifts in the Pacific storm track based on the δ2H sedimentary leaf-waxes from Swamp Lake, Yosemite NP, Sierra Nevada.

Street, J.H., A.L. Sessions, R.S. Anderson and A. Paytan (in prep). A leaf-wax δ2H record of Holocene climate variability in the Sierra Nevada: Links to the North Pacific & ENSO.

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

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

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

Additions_19

(10) Objectives -- continued: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 changes in the El Nino-Southern Oscillation (ENSO) and other decadal-scale Pacific ocean-atmospheric processes on Sierra Nevada climate variability.

(13) Project Benefits - continued: For instance, if we interpret n-alkane δ2H as a proxy for precipitation δ2H values, and thus moisture source, storm track, and atmospheric circulation regimes, the 20th century experienced a relatively stable climate, with only moderate variability in North Pacific atmospheric circulation. Earlier periods, notably the 12th – 16th centuries, experienced much larger (and often very abrupt) shifts in the dominant circulation regime – shifts that may underlie some of the hydrologic extremes observed in other climate records of this period (which spans the transition between the "Medieval Warm Period" and "Little Ice Age"). Judging from long-term δ2H baselines (i.e., δ2H averaged over several centuries) the 20th century circulation regime also appears to have been an intermediate, with much more extreme end-member regimes apparent during past intervals (e.g., low δ2H, "El Nino-like" regimes, 750-450 yr BP, 2100-1600 yr BP; high δ2H, "La Nina-like" regimes, 1500-1100 yr BP, 6100-5300 yr BP).
Ideally, the Swamp Lake record will allow us to make connections between on-the-ground hydrologic conditions in the Sierra Nevada and various atmospheric and oceanic circulation regimes, ultimately improving long-term predictions of water supply under future climate conditions. However, the hydrologic implications (and ultimate causes) of the types of large-scale, long-term changes in atmospheric circulation that we infer from the Swamp Lake record are just beginning to be explored.

(15) Cooperating Organizations - continues

Northern Arizona University
• Dr. R. Scott Anderson, Professor of Quaternary and Environmental Sciences, Center for Sustainable Environments: Sediment core material and scientific advice.

Scripps Institute of Oceanography
• Dr. Lydia Roach: Scientific advice & discussion.

Stanford University
• Dr. C. Page Chamberlain, Professor, Department of Environmental Earth Systems Science: Doctoral committee member
• Dr. Kate Maher, Assistant Professor, Department of Geological and Environmental Sciences: Doctoral committee member
• Dr. Jessica Oster, Post-doctoral Fellow, Department of Geological and Environmental Sciences: Scientific advice and discussion.

United States Geological Survey (Menlo Park & Denver)
• Dr. Carol Kendall, Isotope Tracers Project: Water isotope sample analyses.
• Robert J. Rosenbauer, Geologist, Western Coastal and Marine Geology Program: Organic geochemical laboratory space and facilities, technical support in gas chromatography-mass spectrometry (GC-MS)
• Dr. Scott W. Starratt, Geologist, U.S. Geological Survey, Menlo Park: Scientific advice; community mentor.
• Dr. John Barron, Research Geologist, USGS Menlo Park: Scientific advice and discussion.
• Dr. Lesleigh Anderson, Research Geologist, USGS Boulder: Scientific advice and discussion.

University of Alaska, Anchorage
• Dr. Jeffrey M. Welker, Director, Environment and Natural Resources Institute and Professor, Biological Sciences Department: Hydrogen & oxygen isotope data for precipitation samples collected in Yosemite NP, 1989-2001.