MID-HOLOCENE CLIMATE RECONSTRUCTION IN THE SOLEDAD BASIN USING PLANKTIC FORAM ASSEMBLAGES

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I Abstract

The instrumental climate record for the subtropical Pacific is useful for reconstructing interannual climate variability, though it is limited by its short-term duration. Climate proxies from high-resolution sites can be used in extending this record to geologic time scales, but only if the proxies are properly calibrated. The Soledad Basin (SB) off the coast of Baja, California (25°12′ N, 112° 43′ W) is a viable locale for constructing such proxies due to its high sedimentation rate, providing a temporal resolution of ~10 yr/cm. Here, we present a pilot study of modern analog temperature estimates based on planktic foraminiferal faunal assemblages from SB gravity (MV99-GC-41) and piston (MV99-PC-14) cores. The goal of this study is to explore whether productivity in the SB during the mid-Holocene, a period of strong summer insulation, was higher or lower than modern values. These faunal temperature estimates are calibrated against a 1083 sample data set (Ortiz et al., 1997) and 1995-1998 Santa Barbara Basin (34°14′N, 120°02′W) sediment trap faunas from Black et al. (2001). Comparing NCEP instrument SSTA anomalies for the equatorial Pacific NINO3 region, Santa Barbara Basin (SBB), and SB across the 1995-1998 interval (including the prominent 1997-98 El Niño event) indicates similar thermal structure at all three locations (Fig. 1), but the SB data exhibits greater ENSO influence than the SBB. Modern analog temperature estimates, using our method on the SBB sediment traps faunas, indicate values that range from 9-21°C in agreement with instrumental measurements. When the modern analog method is applied to coretop samples from GC-41 and mid-Holocene samples from PC-14, we estimate mid-Holocene temperature of ~10-24°C, though averaging to be somewhat cooler than the modern coretop value of ~14°C. Black et al. (2001) suggests that increases in the percent abundance of G. bulloides and G. quinquloba indicate enhanced La Nina-like conditions, while increases in the percent abundance of G. ruber and G. rubescence indicate El Niño-like conditions. A comparison of these four foram species, between GC-41, PC-14, and the SBB sediment trap calibration data, suggests at least part of mid-Holocene in the SB was characterized by more La Niña-like conditions, a trend which is consistent with benthic foram abundances in the same samples.

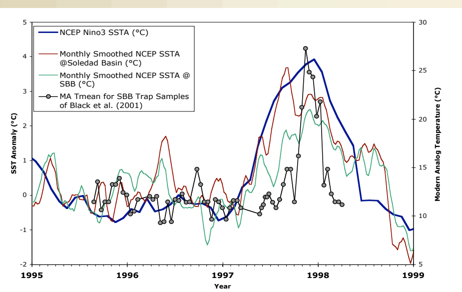

Figure 1. A comparison of NCEP NINO3 SSTA data, monthly smoothed NCEP SSTA data for the Soledad and Santa Barbara Basins, and modern analog temperature estimates for the SBB trap samples of Black et al. (2001). All four sets clearly demonstrate the influence of the 1997-1998 El Niño event.

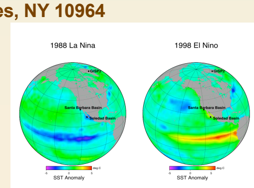

Figure 2. Sea Surface Temperature anomalies of the 1998 La Niña (left) and the 1998 El Niño (right). Noted are the location of the relevant sample locations.

II Results

The relative percent abundances of two cold water species of planktonic foraminifera (*G. bulloides and G. quinqueloba*) were compared to the percent of two warm water species of planktonic foraminifera (*G. ruber and G. rubescence*) across the modern coretop (MV99-GC-41) and mid-Holocene downcore (MV99-PC-14) samples. These species were selected by Black et al. (2001) to distinguish between El Niño and non El Niño conditions. When the average "break" between warm and cold species of the modern samples was compared to each mid-Holocene sample, two distinct groups were found, one with more warm water species than the modern values and one with more cold water species than modern values. The group with more cold water species was far more abundant, comprising roughly two-thirds of the mid-Holocene samples thus far analyzed. Please see Figure 3 for a sample by sample analysis.

The Modern Analog technique was applied to the coretop and downcore samples using two data sets for correlation, a 1083 sample data set (Ortiz et al. 97; Morey et al, 98?) and the Santa Barbara Basin (SBB) sediment trap data of Black et al. (2001). Average analog sea surfaces temperatures (SSTs) attainted through the 1083 samples data set (Table 1) were compared across the modern samples, the mid-Holocene samples with more warm water species. It was found that the warm water species group had the highest average SST at 15.86°C, the cold water species group had the lowest average SST at 11.21°C, and the modern samples had an average SST of 13.61°C.

SeaWiFS chlorophyll data was obtained for the location of each analog found using the 1083 sample data set and used as a proxy for productivity (SeaWiFS Project). This data was averaged across each sample (Table 1) as with the SST estimates and then averaged for the warm water foram species samples, the cold water foram species samples, and the coretop samples. The cold water foram species group had the highest chlorophyll levels (19.08 mg/m^3), the warm water foram species group had the lowest levels (15.81 mg/m^3), and the modern samples had an intermediate value of 18.77 mg/m^3.

The Santa Barbara Basin sediment trap data was correlated against the Soledad Basin (SB) samples. This comparison indicates if conditions were more like the 97-98 El Niño recorded in these samples or like the non El Niño conditions present before the 97-98 event. While the bulk of the samples were more El Niño-like (and better analogs than found in the 1083 sample data set), it should be noted that the SBB is further north than the SB (see Fig.2) thus analogs showing warm conditions are to be expected.

Core	Sample #	Age	MA SST Estimate (deg C)	MA Ave Squared Chord Distance	Ave. SeaWiFS Chla (mg/m3)	SBB Trap ENSO Estimate	SBB Ave Squared Chord Distance
MV99-GC-41	0 cm	0.34 ka	14.81	0.3133	19.02	Non	0.3412
MV99-GC-41	5 cm	0.41 ka	11.59	0.3459	19.24	El Nino	0.2581
MV99-GC-41	10 cm	0.48 ka	15.26	0.3311	17.20	El Nino	0.3208
MV99-GC-41	15 cm	0.55 ka	14.82	0.265	19.16	El Nino	0.2205
MV99-GC-41	20 cm	0.62 ka	11.57	0.2751	19.24	El Nino	0.2969
MV99-PC-14	350 cm	4.68 ka	19.48	0.5419	10.06	El Nino	0.4290
MV99-PC-14	375 cm	4.87 ka	13.83	0.3226	17.23	El Nino	0.2182
MV99-PC-14	380 cm	4.91 ka	16.54	0.364	16.96	El Nino	0.2590
MV99-PC-14	385 cm	4.94 ka	12.37	0.2881	17.42	El Nino	0.1957
MV99-PC-14	398 cm	5.04 ka	14.00	0.3265	17.23	El Nino	0.2395
MV99-PC-14	403 cm	5.08 ka	11.59	0.2562	19.24	El Nino	0.2202
MV99-PC-14	408 cm	5.12 ka	10.17	0.2794	19.74	Non	0.3055
MV99-PC-14	413 cm	5.15 ka	10.16	0.5353	20.14	Non	0.5528
MV99-PC-14	418 cm	5.20 ka	10.22	0.4422	19.74	Non	0.3759
MV99-PC-14	423 cm	5.24 ka	10.30	0.6661	20.31	Non	0.4838
MV99-PC-14	428 cm	5.29 ka	10.19	0.2065	19.74	Non	0.2952
MV99-PC-14	438 cm	5.37 ka	10.22	0.2593	19.74	Non	0.2468
MV99-PC-14	443 cm	5.42 ka	10.15	0.3545	19.74	Non	0.2315
MV99-PC-14	448 cm	5.46 ka	10.41	0.2943	19.96	Non	0.1207
MV99-PC-14	458 cm	5.55 ka	12.33	0.3288	17.42	El Nino	0.1859
MV99-PC-14	463 cm	5.59 ka	9.83	0.2073	19.21	El Nino	0.1897
MV99-PC-14	469 cm	5.65 ka	10.33	0.1774	19.74	El Nino	0.2053
MV99-PC-14	473 cm	5.68 ka	11.63	0.259	19.24	El Nino	0.1923
MV99-PC-14	478 cm	5.73 ka	14.51	0.3503	16.79	El Nino	0.3252
MV99-PC-14	498 cm	5.87 ka	14.21	0.3353	17.26	El Nino	0.2901
MV99-PC-14	503 cm	5.91 ka	13.46	0.2867	16.42	El Nino	0.1893
MV99-PC-14	508 cm	5.94 ka	24.91	0.4341	11.67	Non	0.4839
MV99-PC-14	513 cm	5.96 ka	10.44	0.2619	19.16	El Nino	0.2411
MV99-PC-14	518 cm	6.00 ka	12.09	0.2848	19.98	El Nino	0.1526
MV99-PC-14	523 cm	6.03 ka	12.62	0.2781	17.64	El Nino	0.1364
MV99-PC-14	528 cm	6.06 ka	13.52	0.3207	17.09	El Nino	0.2318
MV99-PC-14	532 cm	6.08 ka	10.16	0.2371	19.74	Non	0.2205
MV99-PC-14	690 cm	7.34 ka	11.52	0.314	19.52	Non	0.1826

Table 1. Results of the modern analog technique on the 1083 sample set and the Black et al. (2001) sediment traps.

(a) Core notes whether the sample originated from the gravity core (GC-41) or the piston core (PC-14). (b) Sample number is depth in core. (c) Age are dates interpolated from a series of ^{14}C ages (van Geen et al., 2003). (d) MA SST estimate is the average of sea surface temperatures given by the five least dissimilar modern analogs derived from the Modern Analog Technique used to correlate the 1083 sample data set to the Soledad Basin data. (e) MA Ave squared chord distance is the average of dissimilarity coefficients of the top five analogs for each sample taken from the 1083 samples data set. Values greater than 0.2 indicate increasingly poor analogs. (f) Ave. SeaWiFS Chla The locations of analogs obtained for the SST estimates were compared against the SeaWiFS chlorophyll data to be used a a productivity proxy. The values for the five analogs for each samples were averaged. (g) SBB Trap ENSO estimates are the result of using the Modern Analog Technique to correlate the Santa Barbara sediment trap data to the Soledad Basin data. This indicates where the top five least dissimilar analogs were taken from El Niño or Non El Niño conditions. (h) SBB Ave squared chord distance is the average dissimilarity coefficients of the top five analogs for each sample taken from the Santa Barbara Basin sediment trap data set. Values greater than 0.2 indicate increasingly poor analogs.

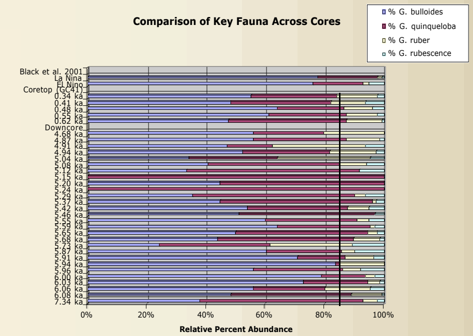

Figure 3. A comparison of the 4 key species of Black et al. (2001) across the Soledad Basin samples. The black line represents an averaged composition "break" between warm and cool water species.

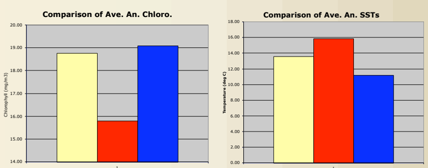

Figure 4. Comparing the average analog SeaWiFS chlorophyll data (left) and average analog SSTs (right) for modern coretop (yellow), warm water foram species group (red), and cold water species group (blue).

III Conclusions

- The high resolution data available from cores MV99-GC-41 and MV99-PC-14 indicate that mid-Holocene conditions in the Soledad Basin consisted of cooler sea surface temperatures and higher levels of productivity.
- These conditions are representative of a more La Niña-like climate within the basin during this time period.

IV References

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