

Proxy Records of the Indonesian Low and the
El Niño-Southern Oscillation (ENSO)
from Stable Isotope Measurements of Indonesian Reef Corals

by

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MASTER

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Abstract

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Doctor of Philosophy in Integrative Biology

University of California at Berkeley

Professor Jere H. Lipps, Chair

The Earth's largest atmospheric convective center is the Indonesian Low. It generates the Australasian monsoon, drives the zonal tropospheric Walker Circulation, and is implicated in the genesis of the El Niño-Southern Oscillation (ENSO). The long-term variability of the Indonesian Low is poorly characterized, yet such information is crucial for evaluating whether changes in the strength and frequency of ENSO events are a possible manifestation of global warming. Stable oxygen isotope ratios ($\delta^{18}\text{O}$) in shallow-water reef coral skeletons track tropical convective activity over hundreds of years because the input of isotopically-depleted rainwater dilutes seawater $\delta^{18}\text{O}$. Corals also impose a temperature-dependent fractionation on $\delta^{18}\text{O}$, but where annual rainfall is high and sea surface temperature (SST) variability is low the freshwater flux effect dominates.

The Indonesian Seaway has high annual precipitation, large precipitation seasonality, minor SST variability and short surface water residence times. These factors maximize the sensitivity of seawater $\delta^{18}\text{O}$ to freshwater flux and thus provide an opportunity to use coral $\delta^{18}\text{O}$ to

study the past variability of the Indonesian Low. Monthly-resolution stable isotope records were developed from *Porites* cores from key sites by automated gas-source mass spectrometry. The $\delta^{18}\text{O}$ records were examined for their reproducibility, noise levels, periodicities, secular trends, and fidelity to the Australasian instrument record.

The $\delta^{18}\text{O}$ records are most reproducible and reliable on interannual timescales. Cross-spectral analysis reveals significant coherency to the Darwin SLP pressure record at ENSO periodicities. Singular-spectrum analysis reveals that the time-evolution of ENSO-bandwidth modes in the coral $\delta^{18}\text{O}$ records are nearly identical to those in the Darwin SLP record. The most accurate coral $\delta^{18}\text{O}$ records are from sites on the Pacific-Indian Ocean throughflow route with either large seasonal salinity variability or strong air-sea interactions. Secular trends in the $\delta^{18}\text{O}$ records are inconsistent and are considered artifacts of coral growth dynamics.

These results provide a foundation for extending the Indonesian coral $\delta^{18}\text{O}$ records into the pre-historical period, and suggest that hindcasting of the ENSO-related variability of the Indonesian Low can be achieved with acceptable levels of confidence.

Jose H. Lipp

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To Sa'id, for steering through the reefs despite the gales.

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CHAPTER 1

INTRODUCTION

INTERANNUAL VARIABILITY IN INDO-PACIFIC CLIMATE

The Southern Oscillation

By the turn of the century, global reporting of weather data had been underway for several decades and meteorologists had detected a curious feature of the Pacific: the slow "see-saw" of sea level pressure (SLP) on opposite sides of the basin (Hildebrandsson, 1897; Lockyer and Lockyer, 1902). This feature was further described and studied by Sir Gilbert Walker (1923), who named it the Southern Oscillation. The Southern Oscillation records the intensity of the Walker Circulation Cell, the zonal tropospheric circulation that connects the east and west sides of the equatorial Pacific.

The ascending branch of the Walker Circulation is the Indonesian Low. These rising air masses move eastward in the upper troposphere, then cool and sink at the S. Pacific High, forming the descending branch of the circulation. The trade winds and equatorial easterlies comprise the lower troposphere return flow. Walker's Southern Oscillation is shown in Figure 1, presented as a map of world-wide correlations of mean annual SLP with respect to SLP at Jakarta (Bjerknes, 1969; Berlage 1957). The pressure correlations reveal the position of the vertical branches of the Walker circulation, with the S. Pacific showing the highest correlation with Jakarta ($r = -0.80$). The high degree of spatial coherency in the SLP field allows records from single sites to be robust indices of the Southern Oscillation. The most widely-used of these is the difference in SLP between Tahiti, S. Pacific and Darwin, Australia: the Tahiti-Darwin Southern

Walker's Southern Oscillation

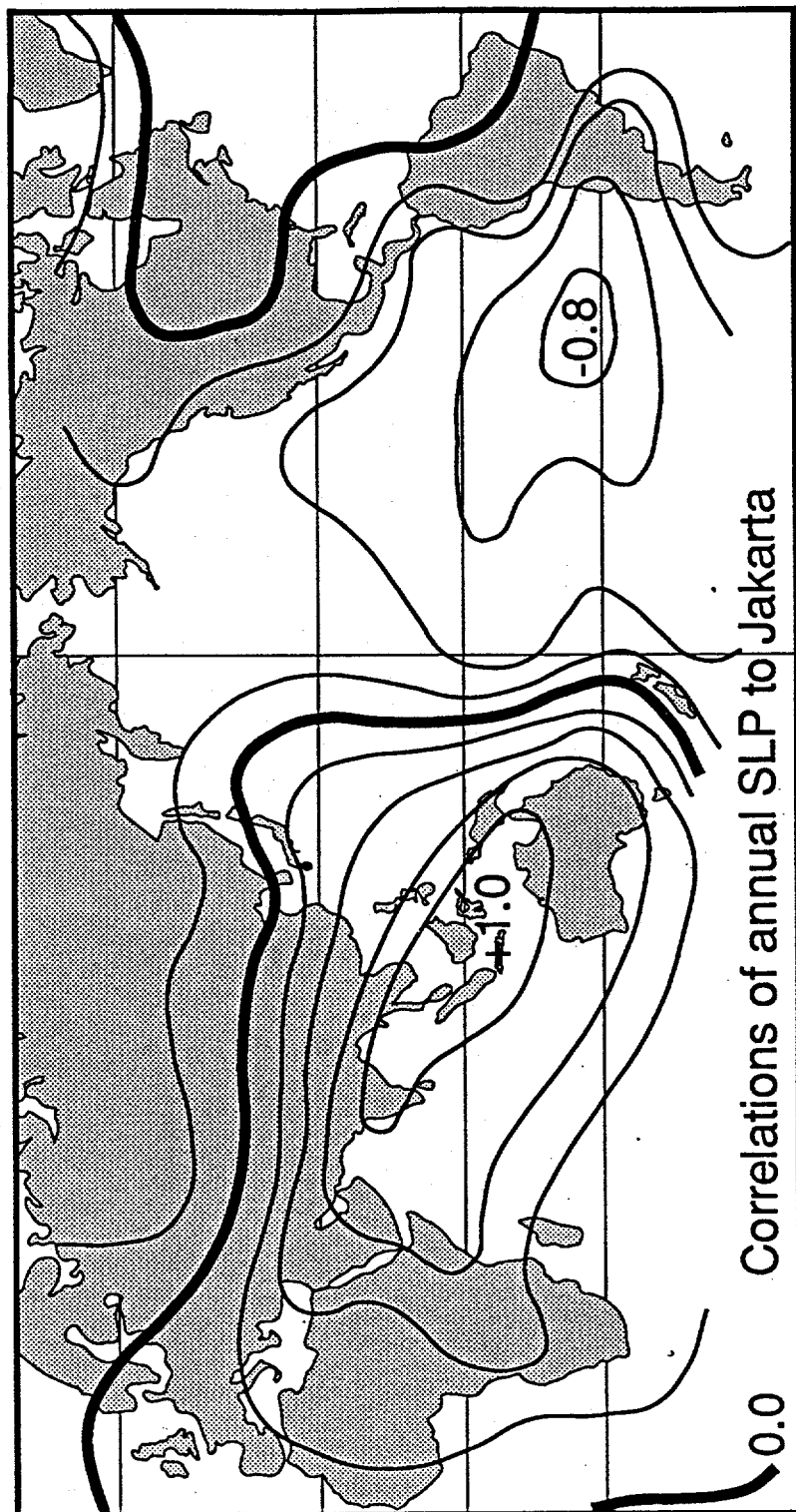


Figure 1. Walker's Southern Oscillation (after Bjerknes, 1969). Simultaneous pressure correlations to Jakarta, with the correlation isopleths in units of $r = 0.2$. The ascending branch of the Walker Circulation lies over Indonesia, the descending branch over the E. Pacific.

Oscillation Index (SOI).

The recognition that the Southern Oscillation was part of a global-scale ocean-atmosphere interaction came partly with the work of Berlage (1957, 1966) and Troup (1965), and then in a classic synthesis by Bjerknes (1966) who demonstrated the link between interannual fluctuations in precipitation and the zonal windfield near the equator due to the Walker Circulation and the episodic El Niño warming of the sea surface off the coast of South America. More recent studies reveal that the two features are so closely tied that they represent a single phenomenon: the El Niño/Southern Oscillation (ENSO) (Rasmusson and Carpenter, 1982).

The El Niño-Southern Oscillation (ENSO)

The ENSO oscillates between two extreme phases, a "cool" build-up phase and a "warm" event phase, with a period of 3-7 years. During a cool phase, (also referred to as a "La Niña" or "SOI positive phase") a large pressure differential exists across the Pacific, the Walker Circulation is vigorous, and winds in the W. Pacific blow strongly near the equator (Figure 2). Wind forcing on the sea surface maintains a mean westward flow, and warm surface waters accumulate in the W. Pacific warm pool, defined as the region where the annual mean SST is $> 29^{\circ}\text{C}$. The thermocline is deep and a sea level is anomalously high compared to the E. Pacific. These conditions create a positive feedback, in which the continuing accumulation of warm water serves to induce more convection over an increasingly larger area of the Pacific, which stimulates stronger equatorial winds and reinforces westward current flow. These conditions typically persist for 18 months prior to strong ENSO warm events (Cane, 1983).

By the fall of the year preceding the ENSO warm event, a warm SST anomaly covers much of the S. Pacific between 15°S-30°S and extends northward to the dateline. The eastward spread of this SST anomaly has the effect of pulling the main center of deep convection away from S.E. Asia and into the equatorial Pacific. The Indonesian Low is often observed to migrate eastward to a position near the date line (Figure 2). When the Indonesian Low shifts away from S.E. Asia, it becomes less organized and loses strength. High pressure conditions develop over Indonesia and the W. Pacific. The tradewinds subside and equatorial westerlies are generated. This change in wind forcing has a catastrophic effect because it allows warm water to surge eastward as the equatorial sea slope relaxes. The warm water mass moves eastward as an internal Kelvin wave, impinging on the coast of S. America in about two months time.

The arrival of the Kelvin wave is signaled by rising sea level and a deepening of the thermocline in the equatorial E. Pacific. The SST anomaly is first evident by December-January, and hits a maximum by May-June. The SST anomaly spreads northwest in the summer and then to the west to merge with the SST anomaly in the Central Pacific. By fall, the SST anomaly at the coast is only slight warmer than normal. A short period of warming occurs during December-February, followed by a sharp drop in which SST becomes cooler than normal by March. Cold water spreads west from the coast, reaching the dateline by fall. The Central Pacific SST anomaly has disappeared by this time and winds have re-established westward flow and reset the equatorial sea slope. This type of ENSO event is referred to as a "canonical" event because the SST anomaly peaks successively, first in spring and then in winter during the year of the event. Many of the recorded ENSOs follow this pattern, but there are notable

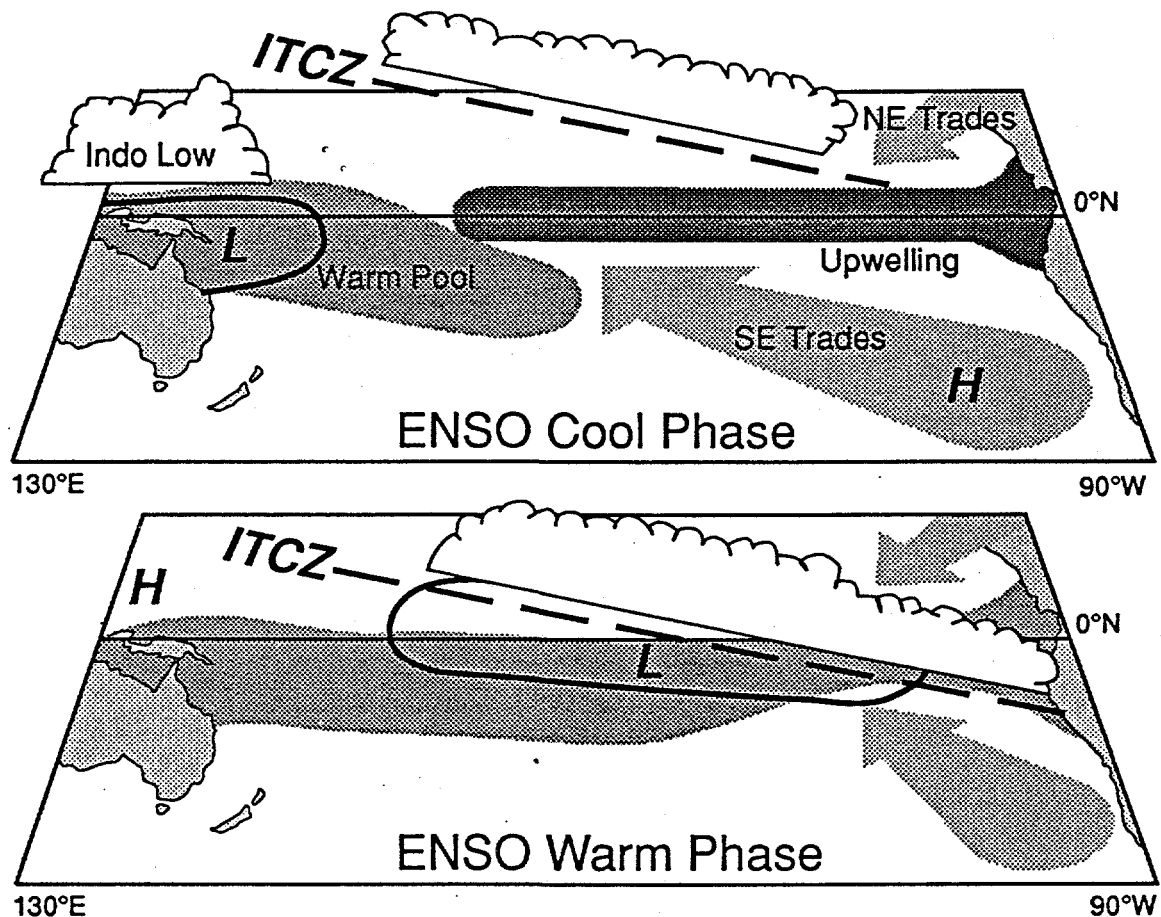


Figure 2.

ENSO Cool-Phase Conditions (upper panel). Deep convection produced by the Indonesian Low over S.E. Asia stimulates strong S.E. and N.E. Trades which serve to confine the warm pool surface waters to the W. Pacific. Upwelling occurs on the equator and along the coast of Central and S. America.

ENSO Warm-Phase Conditions (lower panel). Weak convection by the Indonesian Low allows the tradewinds to relax, and the warm pool waters surge into the Central and Eastern Pacific. Convection is stimulated in the Central Pacific, and westerly wind bursts emanate from W. Pacific. The ITCZ shifts south to the equator shutting down upwelling in the E. Pacific.

exceptions. The very strong 1982-83 ENSO warm event began in August, six months out-of-phase with the typical canonical pattern, with no strong precursor conditions evident at the time. The SST anomaly first appeared at the coast of S. America in late summer when SSTs are typically cool. SSTs increased rapidly at a steady rate of $2^{\circ}\text{C mo}^{-1}$ through 1982 and 1983. The SST anomaly peaked at 6°C above the climatological mean by June of 1983, and then dropped rapidly throughout the remainder of 1983 (Cane, 1983).

The surface water displacements observed during the 1992-93 ENSO warm phase, and the subsequent 1994 recovery, are a good example of the wind-forced cross-basin oscillations of the equatorial sea slope typical of the "canonical" ENSO described above. A time-longitude plot of the depth of the 20° isotherm at the equator ($\pm 15^{\circ}$) during the period 1990-94 is shown in Figure 3 (Leetma, 1994). In January 1990 the thermocline is about 40 m deep in the E. Pacific (90°W), and about 180 m deep in the W. Pacific near the dateline (180°E). By late 1991, the sea slope is starting to relax in response to weakening equatorial easterlies, indicating the onset of ENSO warm phase conditions. By February 1992, the thermocline has deepened to more than 80 m in the E. Pacific, and is about 120 m deep in the vicinity of the dateline. The thermocline shoals slightly in the E. Pacific through summer and fall, but by January 1993 the thermocline is depressed again, this time to 60m, indicating persistence of mature warm phase conditions through the second event year. Through the latter part of 1993, the switch to normal conditions occurs and the sea slope reestablishes. The thermocline deepens in the W. Pacific to 180m and shoals in the E. Pacific to less than 20 m by early 1994, indicating the reappearance of equatorial easterlies and slightly stronger than normal upwelling.

Time-Longitude Plot of 20°C Isotherm Depth: 1990-94

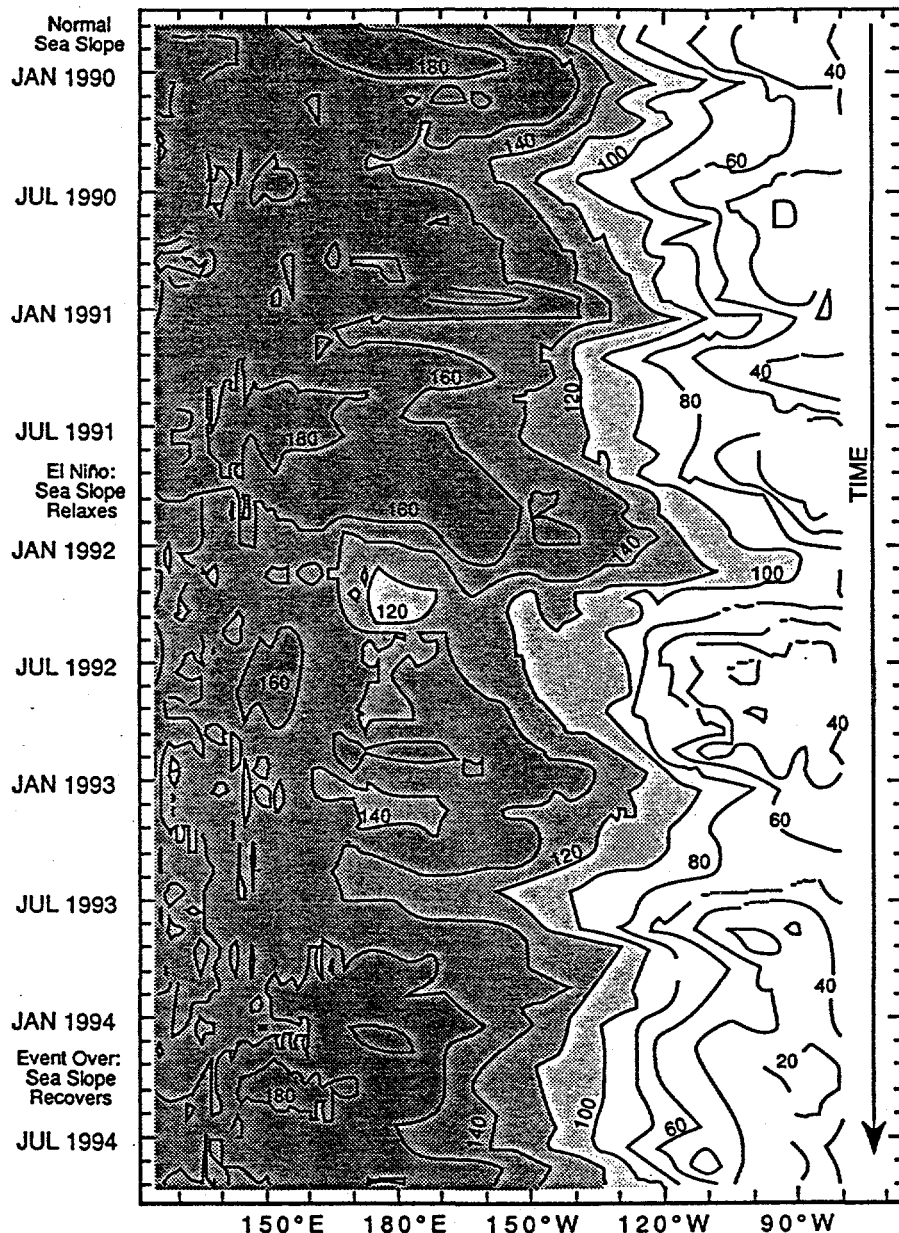


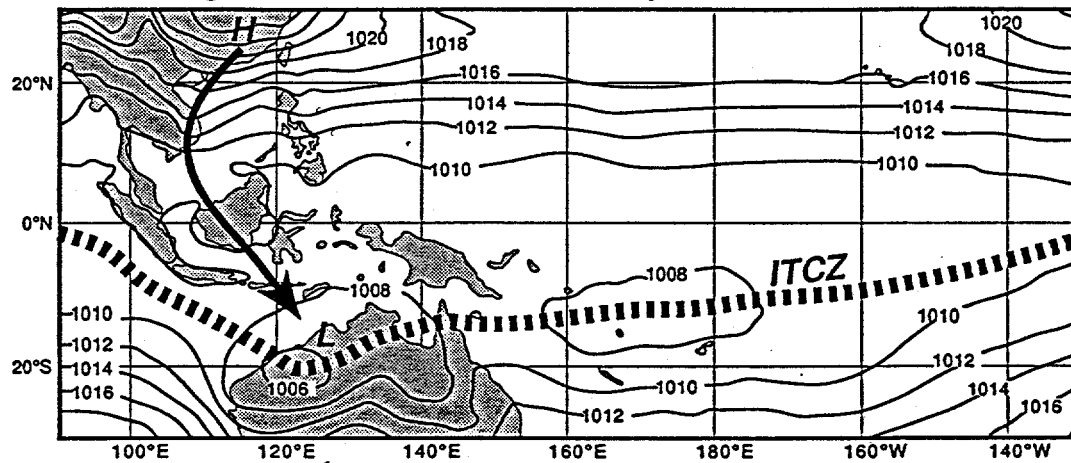
Figure 3. Time Longitude Plot of the 20° Isotherm Depth. Time is down in this plot. The 20° isotherm marks the base of the oceanic thermocline, and measures the volume of thermocline water in the upper water column. The upwelling centers in the E. Pacific (90°W) have a shallow thermocline depth, while the W. Pacific warm pool (150°E) has a deeper thermocline due to the wind-forced accumulation of surface waters. Superimposed on the normal seasonal oscillation is the eastward surge of thermocline water during late 1991 and early 1992 that marks the peak of the 1991-1993 ENSO warm phase. The eastward transfer of water mass is clearly seen in January-February 1992, where the depth of 20° isotherm more than doubled in the E. Pacific, while shoaling to 2/3 normal in the W. Pacific (after Leetma, 1994).

The Indonesian Low

The Earth's largest atmospheric convective center is the section of the ITCZ which lies over Southeast Asia, referred to as the Indonesian Low. Deep convection created by the Indonesian Low moves a tremendous amount of water vapor into the upper troposphere, accounting for 30% of the global atmospheric moisture budget. The latent heat of condensation released by the precipitation of 1 mm of daily rainfall is equivalent to about 30 W m^{-2} (Graham, 1994). Large areas of Indonesia typically have rainfall in excess of 3000 mm per year, resulting in an average daily heat flux to the atmosphere of more than 250 W m^{-2} . The Indonesian Low is an integral feature of the global tropospheric circulation, and its variability determines the strength of the Walker Circulation, the state of the Southern Oscillation, and the phase of the ENSO. On regional scales it is a significant climate forcing with a broad footprint covering the greater Australasian region.

The Indonesian Low is highly mobile and variable. The average position of the Inter-Tropical Convergence Zone during January (upper panel) and July (lower panel) based on the climatological mean sea level pressure field observed during 1985-90 is shown in Figure 4 (Vincent and Schrage, 1994). The Indonesian Low Pressure Cell is indicated by (L), and the monsoon flow by arrows. In January, the Indonesian Low occupies a position south of the equator and a broad low-pressure trough lies over Indonesia, tropical Australia, and the western and central Pacific. In July, the Indonesian Low shifts northward, and the trough occupies a position over Indochina-China, the northern Philippines, and stretches across the northern equatorial Pacific. It is this large seasonal shift in the position of the ITCZ and the Indonesian Low that produces the seasonally-reversing monsoon winds characteristic of Indonesia and Australasia.

Climatological Mean SLP Field: January



Climatological Mean SLP Field: July

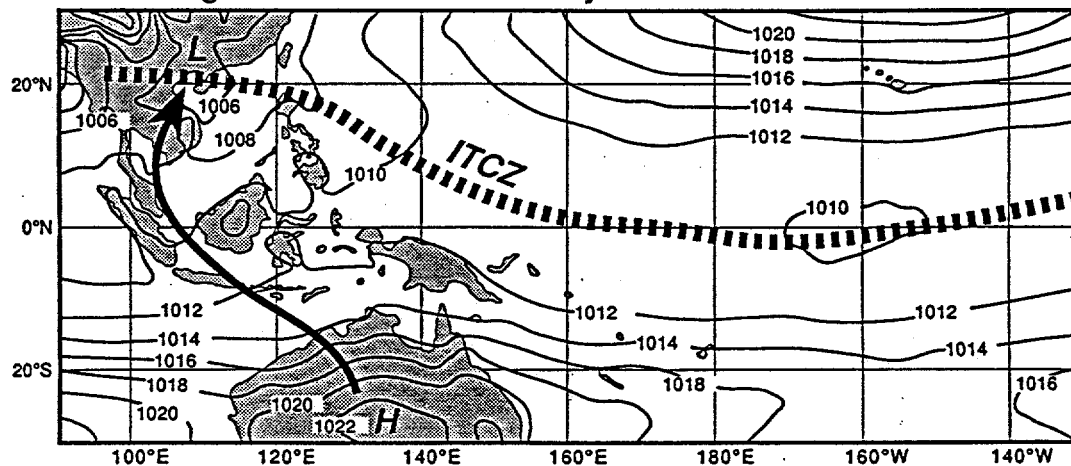


Figure 4. Monsoon Seasonality, January (upper panel) and July (lower panel). SLP isobars (in mb) show the seasonal shift of the Indonesian Low Pressure Cell. Position of the Intertropical Convergence Zone is shown as a dashed line, and the arrows depict the mean monsoon flow (after Vincent and Schrage, 1994).

The Indonesian Low dominates weather over a vast area of the equatorial W. Pacific. During ENSO events, changes in the position and strength of the Indonesian Low result in rainfall and SLP anomalies that are spatially coherent over a remarkably large area. The global distribution of precipitable water vapor during a normal and an ENSO warm-phase year are shown in Figures 5 & 6. The lowest water vapor values are found at high latitudes, and the highest in the tropical belt. The data are derived from the TOPEX/POSEIDON satellite sea surface height altimetry experiment. TOPEX/POSEIDON carries a radar altimeter that measures the time for a radar pulse to bounce off the sea surface. Since water vapor in the atmosphere delays the return of the radar pulse, a microwave radiometer is onboard to measure atmospheric water vapor integrated through the depth of the atmosphere. In January (Figure 5, upper panel), the ITCZ is in its southern position. Deep convection is occurring over the Congo, the southern Indian Ocean, Australia and Indonesia, the South Pacific and Brazil. The most intense convection (red) is seen over Indonesia; this corresponds to the position of the Indonesian Low. In August (Figure 5, lower panel), the ITCZ is in its northern position. Deep convection is occurring over northern Africa, India, Asia, Indochina, the Philippines, the northern equatorial Pacific, Central America, Mexico and the American Southwest. In this season, the intense convection of the Indonesian Low is centered over Indochina and the Bay of Bengal.

There are significant differences in spatial pattern of convection during an ENSO event. In January, during mature ENSO warm-phase conditions (Figure 6, upper panel), convection is weak over Indonesia, Australia and Oceania, and the Indonesian Low has shifted eastward, producing deep convection near the dateline. The South Pacific Convergence Zone has extended eastward,

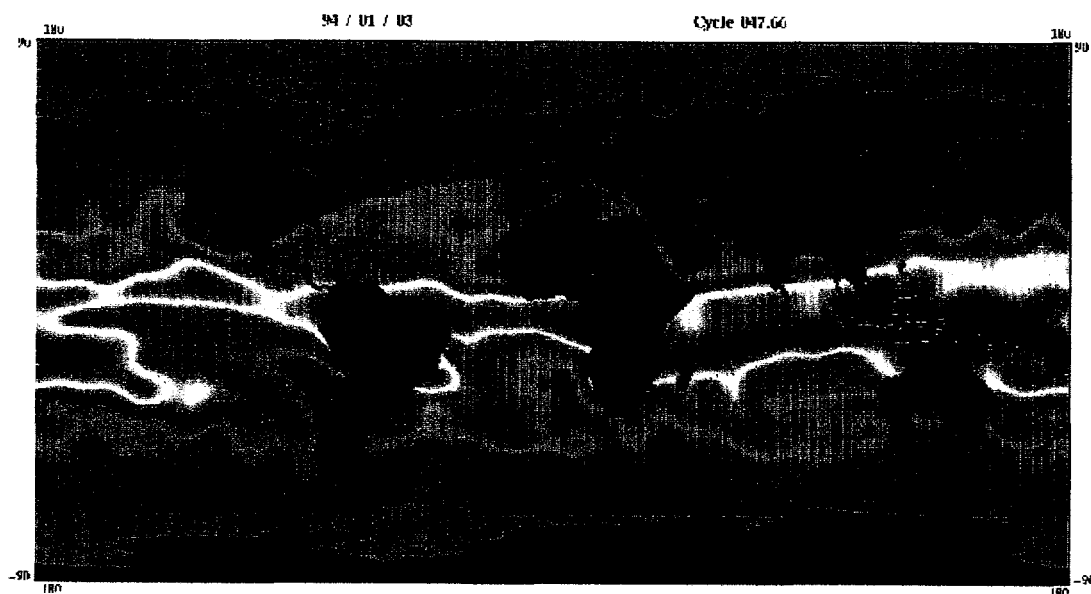
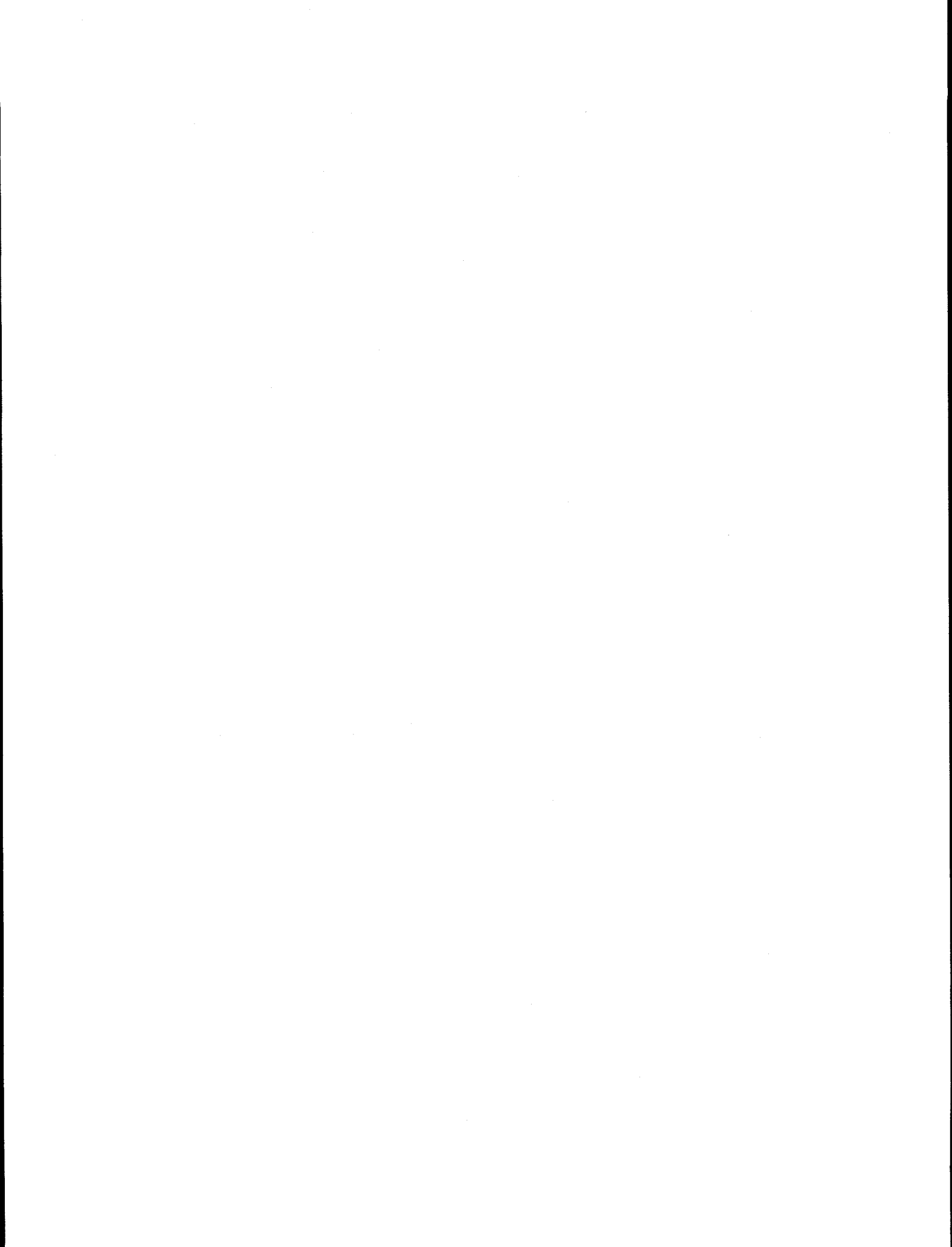


Figure 5. Global distribution of precipitable water vapor in a normal year, January (upper panel) and August (lower panel). The color ramp is precipitable water vapor in gm cm^{-2} , with purple less than 1.0, blue = 2.0, green = 3.0, yellow = 4.0, and red in excess of 5.0 gm cm^{-2} .



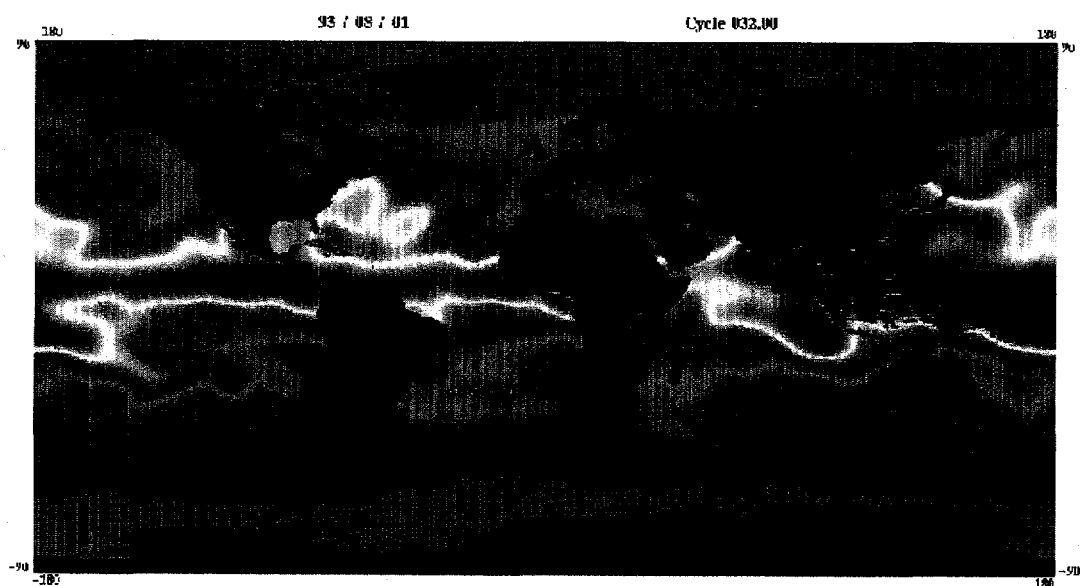
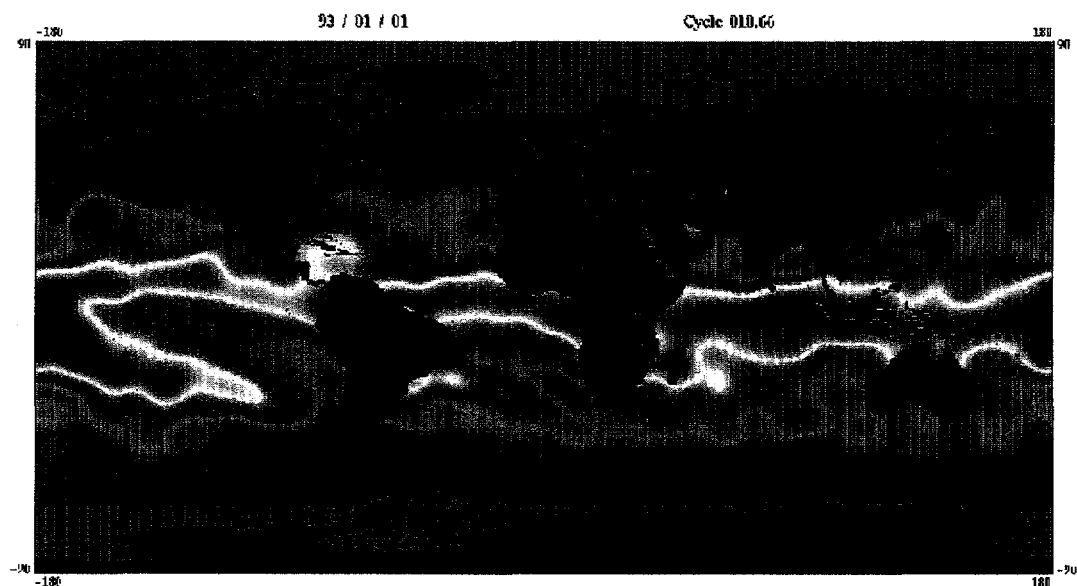
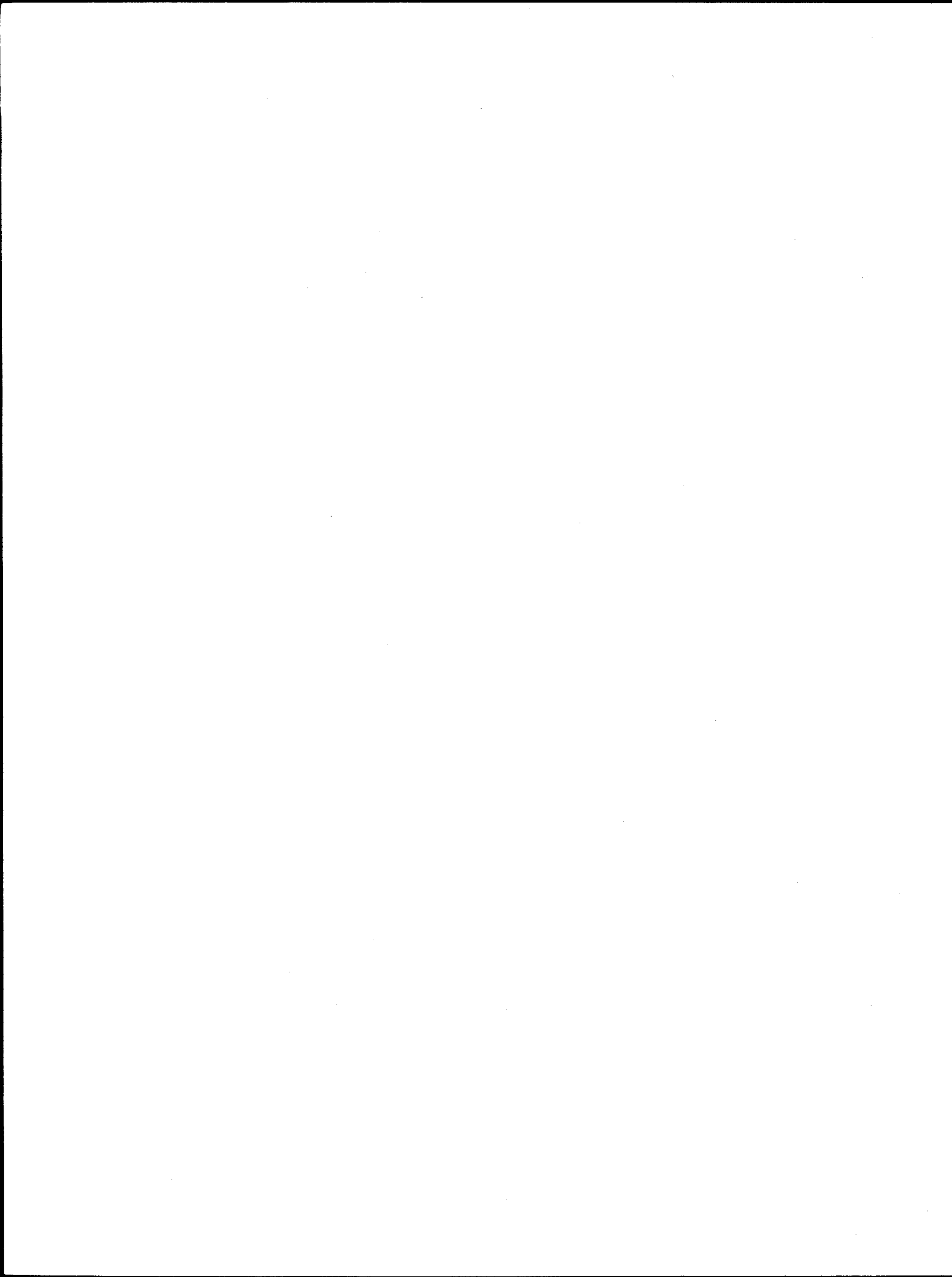


Figure 6. Global distribution of precipitable water vapor in an ENSO warm-phase year, January (upper panel) and August (lower panel). The color ramp is precipitable water vapor in gm cm^{-2} , with purple less than 1.0, blue = 2.0, green = 3.0, yellow = 4.0, and red in excess of 5.0 gm cm^{-2} .



bringing rain to the normally dry S.E. Pacific. Convection in the Indian Ocean is weak in the north, and enhanced near Madagascar. Convection is also enhanced over the Caribbean. In August, during the recovery period (Figure 6, lower panel), convection is still weaker than normal over India, S.E. Asia, Australia, and New Guinea. The Indonesian Low is shifted westward to a position over Oceania, and convection at the SPCZ is stronger than normal for this season. Convection is close to normal over Africa, the E. Pacific and the Americas.

Associated with the shifts of centers of deep convection during ENSO warm phases are significant global rainfall anomalies, that are the most pronounced in the domain of the Indonesian Low. A map of worldwide precipitation response during ENSO warm phase years is shown in Figure 7 (Ropelewski and Halpert, 1987). The eastward shift of the Indonesian Low Pressure Cell during ENSO warm phases produces wet anomalies over the central equatorial Pacific and dry anomalies over Southeast Asia, the northern equatorial Pacific, and much of Australia. From these maps (Figures 5-7) it can be seen that the spatial domains of ENSO-related convective variability are the largest in the Pacific, and that movements and changes in intensity of the Indonesian Low comprise the major atmospheric expression of the ENSO.

ENSO and Tropical Climate Variability

The ENSO is a natural part of the earth's climate system, and it is believed to have been in operation since the present land-sea distribution was established (Quinn, 1971). ENSO is a quasi-periodic oscillation with a periodicity of 3-7 years. Very large magnitude ENSO events are known from Holocene flood deposits in Peru (Wells, 1987; Wells, 1990). There are historical accounts of ENSO events

Areas with a Consistent ENSO Precipitation Response

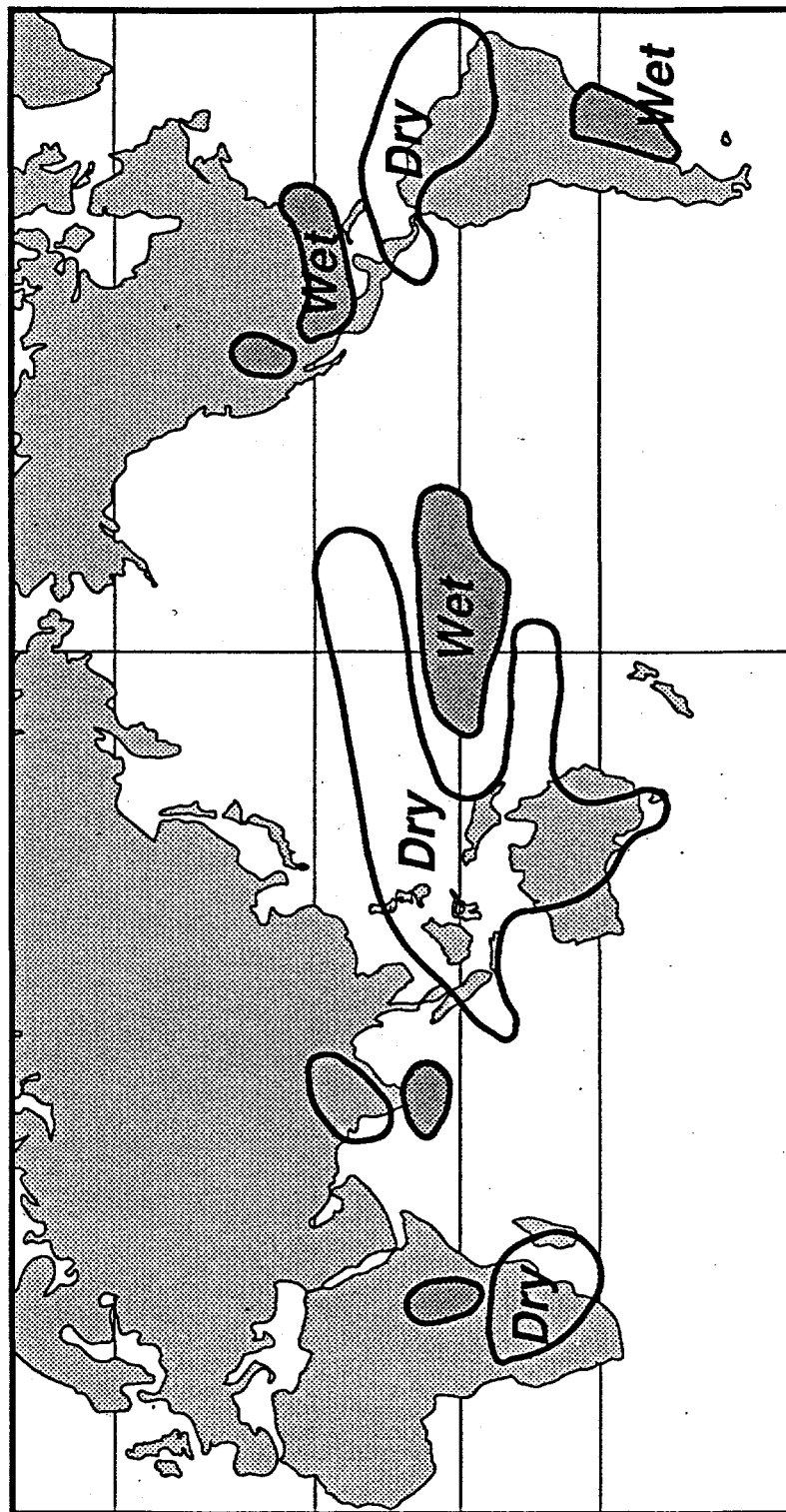


Figure 7. Areas of statistically consistent ENSO precipitation response based on the global precipitation record (after Ropelewski and Halpert, 1987).

dating to at least 1525 (Quinn et. al, 1987). The Tahiti-Darwin SOI indicates that the ENSO has varied from periods of relatively strong activity during 1880 to 1920 to periods of relative quiescence during the late 1920's to 1950. Since ENSO ultimately serves to export excess heat from the tropics to higher latitudes, a major issue is how the intensity or frequency of ENSO events will change because of global warming (Intergovernmental Panel on Climate Change, 1990). Significant warming of global air temperatures is observed to occur 3-6 months after an ENSO warm-phase event. The combined global land air and sea surface temperature record shows an increase of mean temperatures of 0.45 °C since 1861, and it appears that the ENSO signal is a major component of this increase. It has been proposed that recent strong ENSO activity is signaling the arrival of a permanently warmed global climate (Graham et al., 1994, Lau and Nash, 1994). Since 1989, the SOI mean has been negative and ENSO warm phase-like conditions have dominated the Pacific. Though similar SOI baseline shifts were recorded in 1911-13 and 1939-41, this is the longest continuous shift in the SOI baseline to date.

The spatial and temporal variability of the ENSO is poorly known, especially at the main centers-of-action in Australasia, the W. Pacific warm pool, and the equatorial E. Pacific. The lack of good climate data in the tropics bears directly on some key issues in ENSO research. First, the spatial expression of ENSO events is not well described. Most of the physical understanding of ENSO is based on data collected since 1960. Only a handful of ENSO events can be considered well documented, since many of the remote, but key regions of the equatorial Pacific were not instrumented until very recently (McPhaden, 1993). The instrument record for the equatorial Pacific is exceedingly sparse. Pacific island weather stations are widely scattered, and only a few have been in

operation since before WW II. ENSO forecasting also suffers from lack of long term climate data. Present ENSO models run in forecast mode have reasonably good skill with lead times of one year to sixteen months, however none of the models can forecast through successive ENSO phase changes. Since these models often depend on careful statistical identification of precursor conditions that signal an imminent ENSO phase-change, the strength of the models rests on the quality of their climatologies. More long records of tropical climate variability are certainly needed to fully evaluate the role of ENSO as an expression of climate change. There is almost no information on the long-term variability of ENSO in the pre-industrial era, and thus it is difficult to evaluate the significance of the recent SOI baseline shifts. Though some climate models can simulate low-latitude ENSO-like oscillations, the results are not completely realistic especially with regard to the distribution of SST anomalies. These models are inadequate for studying long-term variations in ENSO (Folland et al., 1990).

CORAL PROXY RECORDS OF TROPICAL CLIMATE VARIABILITY

Geochemical records developed from reef coral skeletons have the potential for addressing many of the shortcomings of the tropical climate record. Coral records offer the combination of wide spatial coverage, temporal depth, and high resolution. Massive reef building corals are ubiquitously distributed in the shallow water habitats of the tropics. Given the number of Pacific islands with reefs, there is clearly opportunity to obtain a geographically comprehensive climate record for the equatorial Pacific. With growth rates on the order of 1 cm yr⁻¹, certain genera, notably *Porites*, can grow colonies many meters high that will contain an uninterrupted sequence of deposited skeleton often dating back 250-500 years, and as much as 800 yr. Coral records of this length can provide better

descriptions of climatological mean conditions, better estimates of fundamental ENSO periodicities, and assessments of pre-industrial ENSO variability for the diagnosis of climate change.

Coral Tracers

Corals offer excellent temporal control, far better than other depositional systems (e.g. ice cores and lake varves) and on par with tree-ring chronologies. Absolutely dated coral chronologies can be constructed using annual skeletal density bands or measured $^{13}\text{C}/^{12}\text{C}$ ratios. Coral skeleton, being composed of aragonite (CaCO_3), can be analyzed for a variety of climate tracers, including stable isotopes, radiocarbon, Cd, Mg, Ba, Sr/Ca, U/Ca, and fluorescent organics. A brief list of these tracers and their interpretation is given in Table I.

Table I. Coral Tracer Systems

Coral Tracer	Interpretation	Recent Work by:
$\delta^{18}\text{O}$	SST and Freshwater Flux	Cole et al., 1992
$\delta^{13}\text{C}$	Seasonal Light, Nutrient Levels	Bosscher, 1992
$\Delta^{14}\text{C}$	Vertical Mixing, Currents	Druffel and Griffin, 1993
Cd/Ca	Upwelling, Nutrient Dynamics	Shen et al., 1987
Ba/Ca	Upwelling, Nutrient Dynamics	Lea et al., 1989
Sr/Ca	SST	Beck et al., 1992
U/Ca	SST	Edwards, 1994
Mn/Ca	Nutrients, Wave Energy	Shen et al., 1992
Fluorescent Organics	River discharge	Isdale, 1984

Tropical Climate Variability from Stable Oxygen Isotopes

The most widely used of these is the stable oxygen isotope, ^{18}O . In 1953, Epstein et al. demonstrated the phenomena of temperature-dependent fractionation of stable oxygen isotope ratios ($^{18}\text{O}/^{16}\text{O}$) in biologically-precipitated carbonates, and in so doing, provided a fundamental tool for the

determination of past ocean conditions. The $\delta^{18}\text{O}^1$ of calcium carbonate precipitated in equilibrium with seawater is observed to have a slope of -0.22 ‰ (per mil) per 1.0°C rise in sea water temperature. The marine protist fossil record has been used extensively in this regard, and much of what we know about the Cenozoic ocean derives from $\delta^{18}\text{O}$ measurements of benthic and planktonic foraminifera tests from deep sea sediment cores. Although it was quickly recognized that reef-building corals could offer excellent temporal resolution on short time-scales (months-centuries) early efforts at reconstructing tropical ocean conditions were slowed because coral $\delta^{18}\text{O}$ values were found to be offset from predicted seawater equilibrium values. Weber and Woodhead (1972) showed that the isotopic offset was constant within a genus, and Land et al. (1975) demonstrated that the offset was constant in the rapidly growing sections of the coral's skeleton. Fairbanks and Dodge (1979), using sub-seasonal samples taken along the coral's axis of growth, provided the first clear demonstration that coral $\delta^{18}\text{O}$ recorded changes in sea surface temperature. They showed that the Epstein equation was indeed valid for corals; this relationship has since been reconfirmed by others for a variety of coral genera in different tropical settings. The relationship between the annual range of SST and the range of coral $\delta^{18}\text{O}$ for several islands along the equatorial Pacific is shown in Figure 8 (after Druffel, 1985).

During distillation of freshwater from the ocean surface, whether by evaporation or freezing, mass-dependent fractionation of oxygen isotopes occurs.

$$^1\delta^{18}\text{O}_{\text{PDB}} = \left[\frac{(^{18}\text{O}/^{16}\text{O})_{\text{sample}}}{(^{18}\text{O}/^{16}\text{O})_{\text{standard}}} - 1 \right] \times 1000$$

where the laboratory standard is calibrated to the PeeDee Fm. belemnite standard (PDB). $\delta^{13}\text{C}$ is the measured stable carbon isotope ratio based on the sample and standard $^{13}\text{C}/^{12}\text{C}$ ratios.

Water vapor (or ice) derived from the ocean surface will be depleted in ^{18}O and will have a lower $\delta^{18}\text{O}$ compared to seawater. While the effect of salinity changes on sea water $\delta^{18}\text{O}$ is negligible, dilution of seawater by the addition of isotopically depleted freshwater can result in large changes in seawater $\delta^{18}\text{O}$, and naturally, salinity. For example, the input of isotopically-depleted meltwater into the North Atlantic systematically lowers the salinity and $\delta^{18}\text{O}$ of surface waters, as shown in Figure 9 (after Faure, 1986; data from Epstein and Mayeda, 1953; Craig and Gordon, 1965). In tropical regions marked by large seasonal and interannual fluctuations in rainfall, coral $\delta^{18}\text{O}$ will reflect the dilution of sea surface $\delta^{18}\text{O}$ and thus provide a record of hydrological variability. Cole and Fairbanks (1990) measured $\delta^{18}\text{O}$ in a coral from Tarawa Atoll in the equatorial Pacific, and were able to reconstruct interannual rainfall variability at this site over several decades. Much of this variability was shown to be related to the El Niño-Southern Oscillation.

Coral Stable Isotope Records of the Indonesian Low

The advent of automated gas-source mass spectrometry has made stable isotope measurements fast and inexpensive, and this method has found wide application in recent coral tracer studies. Coral $\delta^{18}\text{O}$ records have been developed for several sites in the Pacific: the Philippines (Pätzold, 1986), Tarawa Is. (Cole, 1990; Cole et al. 1992; Cole et al. 1993), the Galapagos and Panama (Druffel et al., 1990; Dunbar et al., 1991; Dunbar et al., 1994; Linsley et al., 1994), and the Great Barrier Reef (Druffel and Griffin, 1993). Many of these studies employ high-resolution sub-sampling to generate $\delta^{18}\text{O}$ records with monthly or near-monthly resolution. When I initiated this project in 1990, the research groups actively developing coral proxy records of ENSO variability had focused their attention on the Central and Eastern Pacific. In essence, these groups were

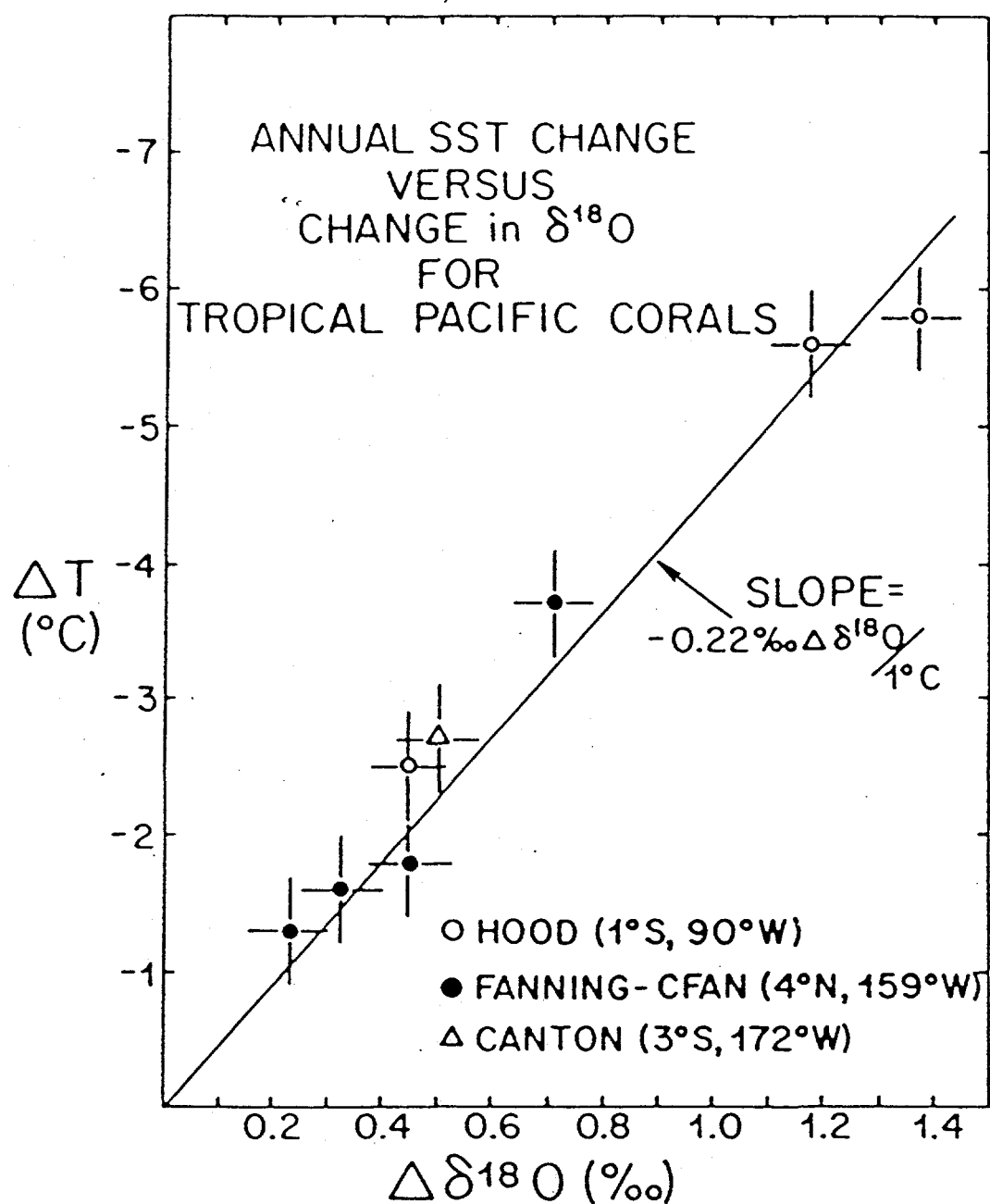


Figure 8. Annual variation in coral $\delta^{18}\text{O}$ plotted against annual range in SST for Pacific island sites (after Druffel, 1985).

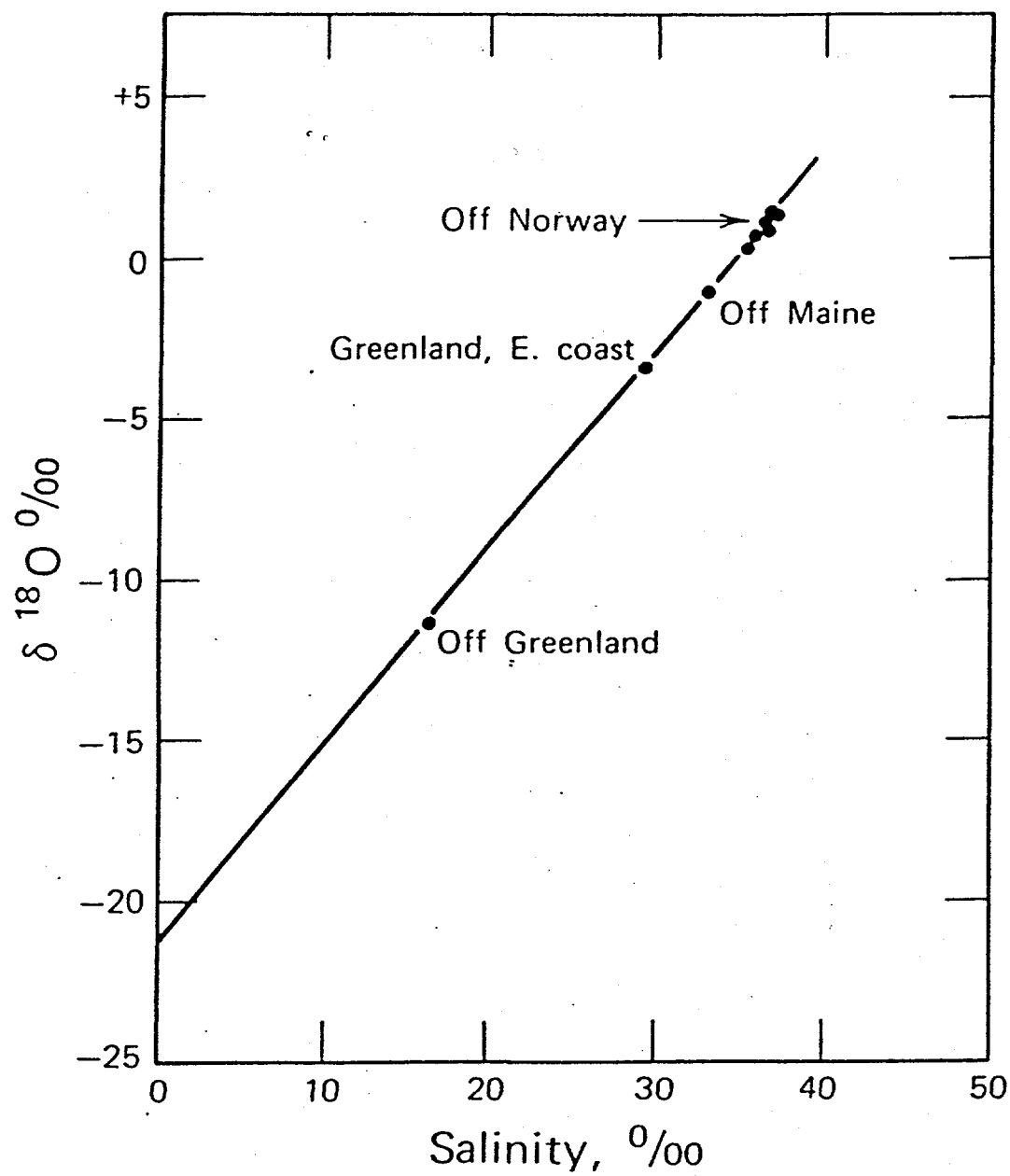


Figure 9. Relationship between surface water $\delta^{18}\text{O}$ and salinity in the North Atlantic (after Faure, 1986; data from Epstein and Mayeda, 1953; Craig and Gordon, 1965).

attempting to capture the "downstream" record of manifested ENSO events. However, numerous observational studies of ENSO propagation pointed to changes in atmospheric convection over S.E. Asia typically occurring 6-9 months prior to the onset of ENSO warm phases. Several mechanisms had been proposed in which slight SST anomalies ($\pm 0.5^{\circ}\text{C}$), phase-locked to the seasonal monsoon cycle, create a non-linear response in Indonesian Low convection, which in turn either strengthens or weakens the equatorial Pacific windfield, thereby setting the ENSO phase. The question of long-term variability of the Indonesian Low had been left untouched, and it was clear that if good proxy records could be developed from Indonesian corals, these records would represent a significant addition to our knowledge of the Southern Oscillation.

On the basis of the preliminary results from *Porites* cores collected in Bali in the summer of 1989, two drilling expeditions were launched in summer and fall of 1990. Several sites in the southern Makassar Strait were cored, as were sites in the Sulawesi Sea, the Lombok Strait, the Banda Sea and the Gulf of Siam. This coral collection is one of the largest of its kind and the most comprehensive ever assembled from S.E. Asia, totaling over 80 m. Contained in the collection are 17 cores dating back more than 225 yr, with the longest core dating back 288 yr. The climate data contained in this archive is largely untapped, but will continue to emerge as further stable isotope analyses are completed. This dissertation presents the principle results accrued in the first round of analyses, in which more than 4500 stable isotope determinations were made using cores from four of these sites. Monthly-resolution stable isotope time series have been developed which span the period 1860-1988 either continuously or in multi-decadal segments. The remainder of the dissertation explores issues related to

the development of climatologically useful data from these measurements, as described below.

For any meaningful paleoclimatic contribution to be derived from this collection, the first issue which needs to be addressed is the quality of the coral $\delta^{18}\text{O}$ records as proxies of the Indonesian Low. Chapter Two examines the sensitivity of the Indonesian coral $\delta^{18}\text{O}$ records to the Indonesian Low. The accuracy of the chronostratigraphy, reproducibility of the records, and the proportion of the coral $\delta^{18}\text{O}$ signal which can be related to the Indonesian Low are investigated in this chapter.

To be able to accurately hindcast ENSOs in pre-instrument era, it is essential to establish the reliability of the coral $\delta^{18}\text{O}$ records as retrodictors of the Darwin SLP component of Southern Oscillation on ENSO timescales. Chapter Three uses spectral estimation techniques to extract and examine the ENSO-related variability in the Indonesian coral $\delta^{18}\text{O}$ records. The frequency domain characteristics of the coral $\delta^{18}\text{O}$ records are described, and their spectral coherency to the Darwin SLP record is determined. Fundamental ENSO bandwidth modes (periodicities in the range of 2.75-7.0 yr) are extracted from the coral $\delta^{18}\text{O}$ records and compared to the ENSO modes in the Darwin SLP record.

Large ENSO events should be recorded by corals everywhere in the region given the length scales of the SLP field, yet the enclosed Indonesia seas have significant differences in the surface water hydrography. Chapter Four examines the regional variability of the Indonesian coral $\delta^{18}\text{O}$ records. Records from the Makassar Strait, Sulawesi Sea and the Banda Sea are compared to local precipitation records and to the Darwin SLP record. The different sites are

evaluated for their fidelity to the regional ENSO signal, and the factors influencing the quality of the interannual $\delta^{18}\text{O}$ response at each site are discussed. The secular trends present in the stable isotope are also investigated. The issue is raised as to whether these trends represent real shifts in the climate state or artifacts of coral growth dynamics.

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CHAPTER 2

CORAL STABLE ISOTOPE RECORDS FROM THE MAKASSAR STRAIT: 1860-1990

ABSTRACT

High-resolution stable isotope measurements were made on several *Porites* cores from two offshore reef sites in the southern Makassar Strait to study the long-term variability of the Indonesian Low Pressure Cell during the last century. The $\delta^{18}\text{O}$ depth series were converted to time series by projecting an age-model based on the record of annual $\delta^{13}\text{C}$ minima which was codetermined for each core, and then resampling the $\delta^{18}\text{O}$ data at monthly intervals. The error of the $\delta^{13}\text{C}$ age model is estimated to be ± 4 months. The $\delta^{18}\text{O}$ time series are cross-compared on both seasonal and interannual timescales to estimate inter-site reproducibility. Inter-site reproducibility is best on interannual time scales with average rms differences of 0.05-0.07‰. The two longest $\delta^{18}\text{O}$ time series show opposite trends of 0.5‰ during the last century which are unlikely to be climate related. The time series are also compared to the Darwin SLP record, which is used here as a surrogate for the regional convective activity of the Indonesian Low Pressure Cell. Correlations to the Darwin SLP record are also best on interannual timescales with $r = 0.5-0.7$.

INTRODUCTION

The deep convection of the Indonesian Low Pressure Cell drives much of the low-latitude tropospheric circulation in the Pacific and Indian Oceans. The variability of the Indonesian Low produces the meridional monsoon

circulation and the strongly seasonal precipitation patterns characteristic of Australasia (Hastenrath, 1985). On interannual timescales, the strength and position of the Indonesian Low determines the intensity of the zonal Walker Circulation and phase of the Southern Oscillation. During El Niño-Southern Oscillation (ENSO) cool-phases the Indonesian Low generates vigorous convection over S.E. Asia, stimulating strong easterly trade winds and raising sea level in the W. Pacific. During ENSO warm-phases the Indonesian Low breaks free of S.E. Asia and migrates to the dateline, inducing equatorial westerlies and the eastward surge of warm surface waters from the W. Pacific that mark the onset of an El Niño. Understanding the long-term variability of the Indonesian Low provides an important constraint on global warming scenarios, since shifts in ENSO event strength and frequency have been proposed as a potential response to the increase in tropical sea surface temperatures observed in this century (Houghton, 1990).

Stable isotope records developed from long-lived corals are well-suited for investigations of tropical climate phenomena on centennial time-scales. They offer the unique potential for absolutely dated monthly resolution records sensitive to seasonal and interannual shifts in freshwater flux and SST. While significant progress has been made in the emerging field of coral-based studies of the tropical climate system (Dunbar and Cole, 1992), many basic issues concerning the quality of coral proxy data have been left unexamined in the rush to climatic interpretation. This chapter describes the development of coral stable isotope records from a site in S.E. Asia that has arguably the largest, most responsive freshwater flux signal under the influence of the Indonesian Low. The coral $\delta^{18}\text{O}$ records are evaluated with regard to determinants of isotopic signal strength, local variability,

reproducibility of the time series on different timescales, and error estimates in reconstructions of climatic variability. These are issues which have been largely neglected in previous studies. The intent here is describe some of the apparent limitations of coral-based proxy data, and in so doing, provide a strong foundation for the forthcoming analysis of the climatic information contained in the Indonesian coral records.

SITE SELECTION

Selection Criteria

Atmospheric Factors

The primary signal of convective variability of the Indonesian Low detectable by stable isotope measurements is the flux of isotopically-depleted rainwater to the sea surface which serves to lower sea surface $\delta^{18}\text{O}$ values during the NW monsoon (boreal winter) rainy season. To best capture the precipitation signal of the Indonesian Low, the contribution of freshwater flux variability to the coral isotopic response should be greater than the SST contribution, since the coral $\delta^{18}\text{O}$ response will be a combination of both. The first criterion for site selection is therefore local rainfall sufficient to produce a large $\delta^{18}\text{O}$ dilution effect. If both the rainwater $\delta^{18}\text{O}$ value (δ_R) and the seawater $\delta^{18}\text{O}$ value (δ_w) are known, then the amount of rainfall (Z_R) required to dilute a closed-bottom column of seawater (Z) to a certain isotopic concentration (δ_{w+R}) can be simply computed as:

$$Z_R = Z \left(\frac{\delta_w - \delta_{w+R}}{\delta_{w+R} - \delta_R} \right)$$

Meteoric water $\delta^{18}\text{O}$ values in S.E. Asia average about -5.1‰ during the rainy season (IAEA 1979, 1986)¹. Seawater $\delta^{18}\text{O}$ during the dry season salinity maximum is about $+0.1\text{‰}$ ². Most of S.E. Asia has an annual SST range of $1.5\text{--}3.0\text{ }^{\circ}\text{C}$, equivalent to a coral $\delta^{18}\text{O}$ fractionation response of 0.33 to 0.66‰ (Espstein et al., 1953). For the coral $\delta^{18}\text{O}$ response to be clearly dominated by freshwater flux effects (e.g. factor of two or greater) requires a dilution in the range of -0.7 to -1.3‰ , or about -1.0‰ . Therefore, δ_{w+R} is -0.9‰ . Making the assumption that most of the dilution is occurring in the upper 10m of the thermocline³, solving for Z_R yields 2.38 m. Sites with annual totals less than this amount can be expected to have a relatively weak freshwater flux signal.

The ENSO is strongly phase-locked to the annual cycle in S.E. Asia, i.e. it is expressed as an amplification of the normal Australasian monsoon seasonality (Philander, 1990). ENSO warm-phases have drier rainy and dry seasons, while ENSO cool-phases have wetter rainy and dry seasons. Even during the very large 1982-83 ENSO, the normal monsoon seasonality was still evident though rainy season precipitation was down by 30% or more. Therefore, a second important criterion is that the site should have strongly seasonal rainfall so that detection of interannual variability in seasonal precipitation is maximized. Furthermore, interannual variability in precipitation should correlate to a regional index of convective activity of the Indonesian Low, such as the SLP record at Darwin Australia, widely used to

¹ For Jakarta during 1972-75, 1980-83.

² Based on measurements of water samples collected at 3m depth during 1992-93 at Kapoposang Is. (S. Sulawesi, see Figure 13).

³ The validity of this assumption with regard to vertical mixing rate and mixing depth estimates for the Indonesian seas will be examined in a later section.

monitor the ascending limb of the Walker Circulation (e.g. the Tahiti-Darwin SLP Southern Oscillation Index).

Oceanographic Factors

There are also some important oceanographic considerations in site selection. The SST variability should be a product of the monsoon flow such that it is in-phase with precipitation to minimize competing effects, and responds to changes in strength of the convective activity (e.g. wind-forced evaporative cooling). The site should have strong circulation and low residence times to provide the best potential for maximal coral isotopic response to seasonal variability in freshwater flux. Finally, the reef sites must be in good condition, sufficiently offshore to be out of the influence of local river discharge, and have a good population of long-lived *Porites* colonies.

The Makassar Strait

Within S.E. Asia, inspection of precipitation maps (Ho Tong, 1982) and surface current maps (Wytrki, 1961) reveals that the combination of highest total rainfall, highest precipitation seasonality, and strongest surface currents is found in the southern Makassar Strait, near Ujung Pandang, Sulawesi. This section will discuss the salinity variability, current patterns, residence times and sea surface temperature regimes at this site.

Freshwater Flux

Mean annual rainfall at Ujung Pandang exceeds 3000 mm, with an average of more than 2100 mm of rainfall in December-March during the NW Monsoon, and only 200 mm in June-September during the SE Monsoon. Numerous rivers draining Borneo and Sulawesi empty into the Makassar

Strait, producing a widespread lowering of salinity each rainy season. Maps of average salinity in Indonesian Seas during February and August are shown in Figures 1 and 2, and the annual variation shown in Figure 3 (Wytrki, 1961). During the NW monsoon, a low salinity field (< 33.0 psu) is observed from the Straits of Malacca and the Gulf of Siam to the southern Makassar Strait and the Flores Sea (Figure 1). During the SE Monsoon, the low salinity field is expanded in the vicinity of Vietnam and the South China Sea, but is restricted to the western part of the Java Sea (Figure 2). The Makassar Strait and the Flores Sea are filled with high salinity water in this season. As can be seen in Figure 3, the southern Makassar Strait and the adjoining Flores Sea have a large seasonal salinity variability.

Interannual variability in river discharge into the Makassar Strait is strongly related to the Indonesian Low. Time series of the Tahiti-Darwin SLP, Southern Oscillation Index, Darwin SLP, and staff gage height for coastal rivers in Sulawesi are shown Figure 4. During the 1982-83 ENSO warm phase the SOI was anomalously low because the Indonesian Low was shifted away from S.E. Asia, and a high-pressure system dominated the region as seen by the anomalously high SLP at Darwin. This development led to a remarkably severe drought in Indonesia which is clearly seen as 50% reduction in the normal interannual variability of the river staff gage height records. Zero-lag correlations of the Jeneberang and Maros River staff gage heights to the Darwin SLP record are -0.77 and -0.81, respectively. This close relationship is indicative of the strong control the Indonesian Low exerts over interannual climate variability in E. Indonesia.

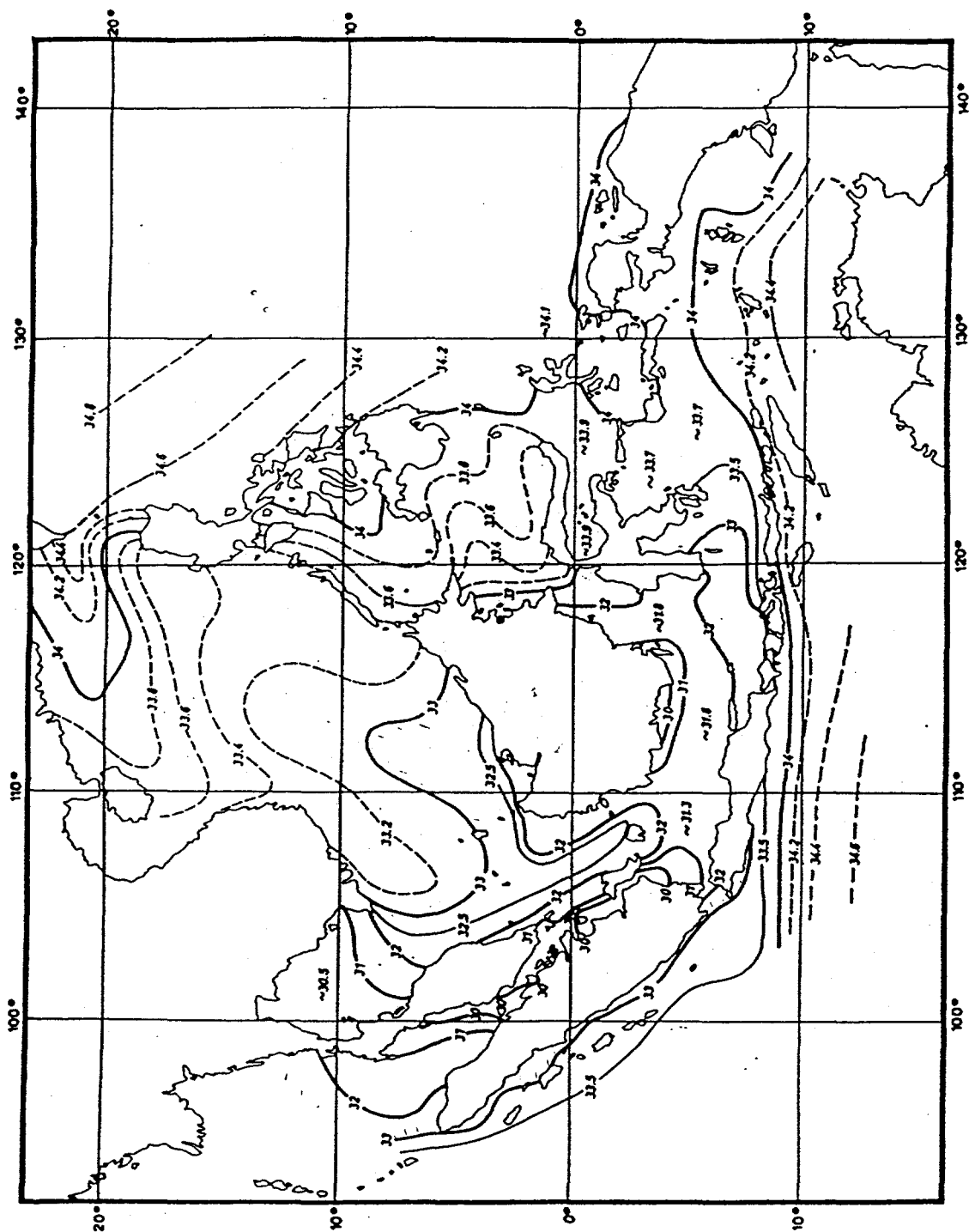


Figure 1. NW Monsoon Surface Water Salinity. Average salinity during February from observations during 1950-55. Low salinity (< 33.0 psu) is observed in the southern Makassar Strait and the Flores Sea (after Wytrki, 1961).

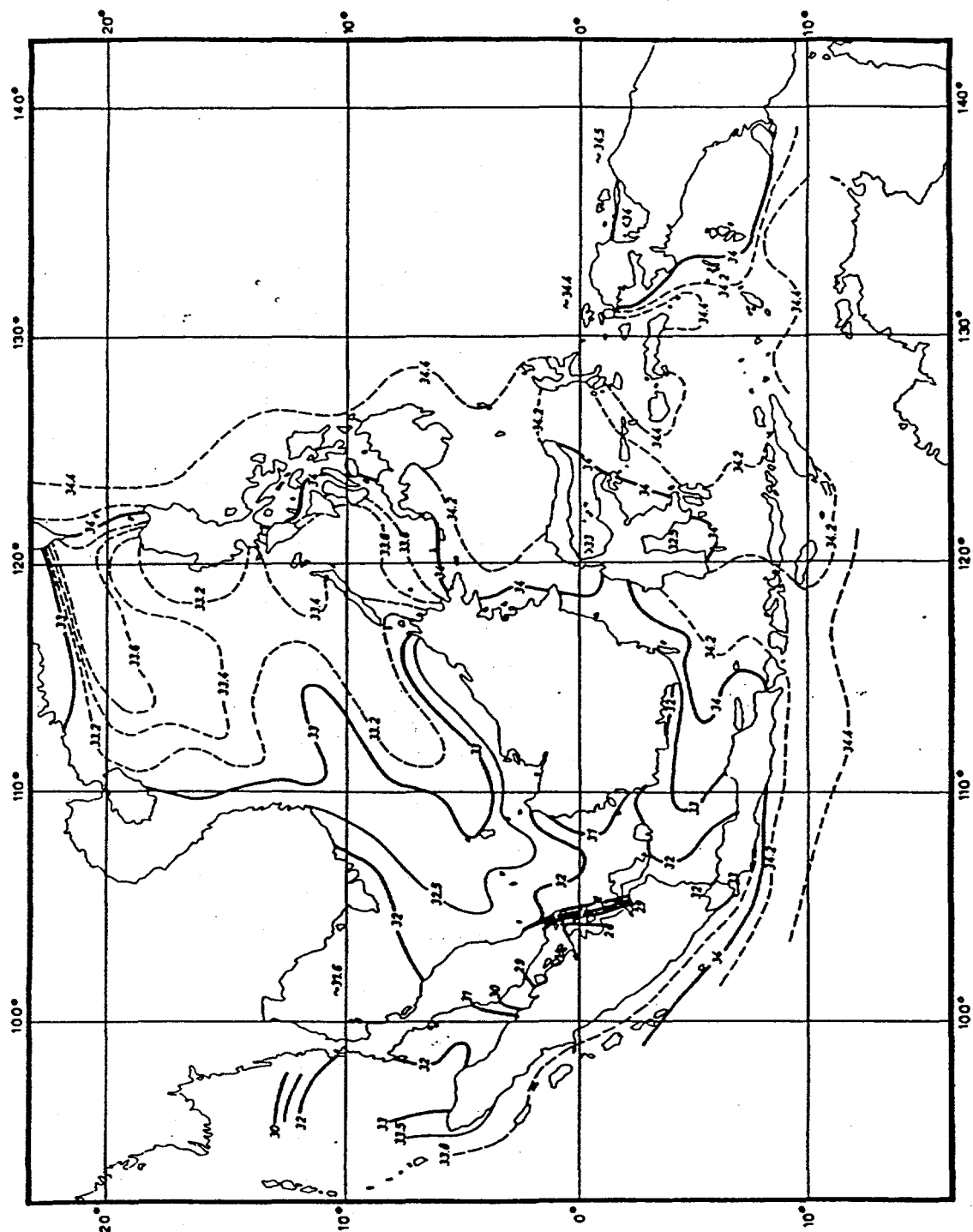


Figure 2. SE Monsoon Surface Water Salinity. Average salinity during August from observations during 1950-55. The Makassar Strait and the Flores Sea are filled with high salinity water derived from the Pacific (after Wytrki, 1961).

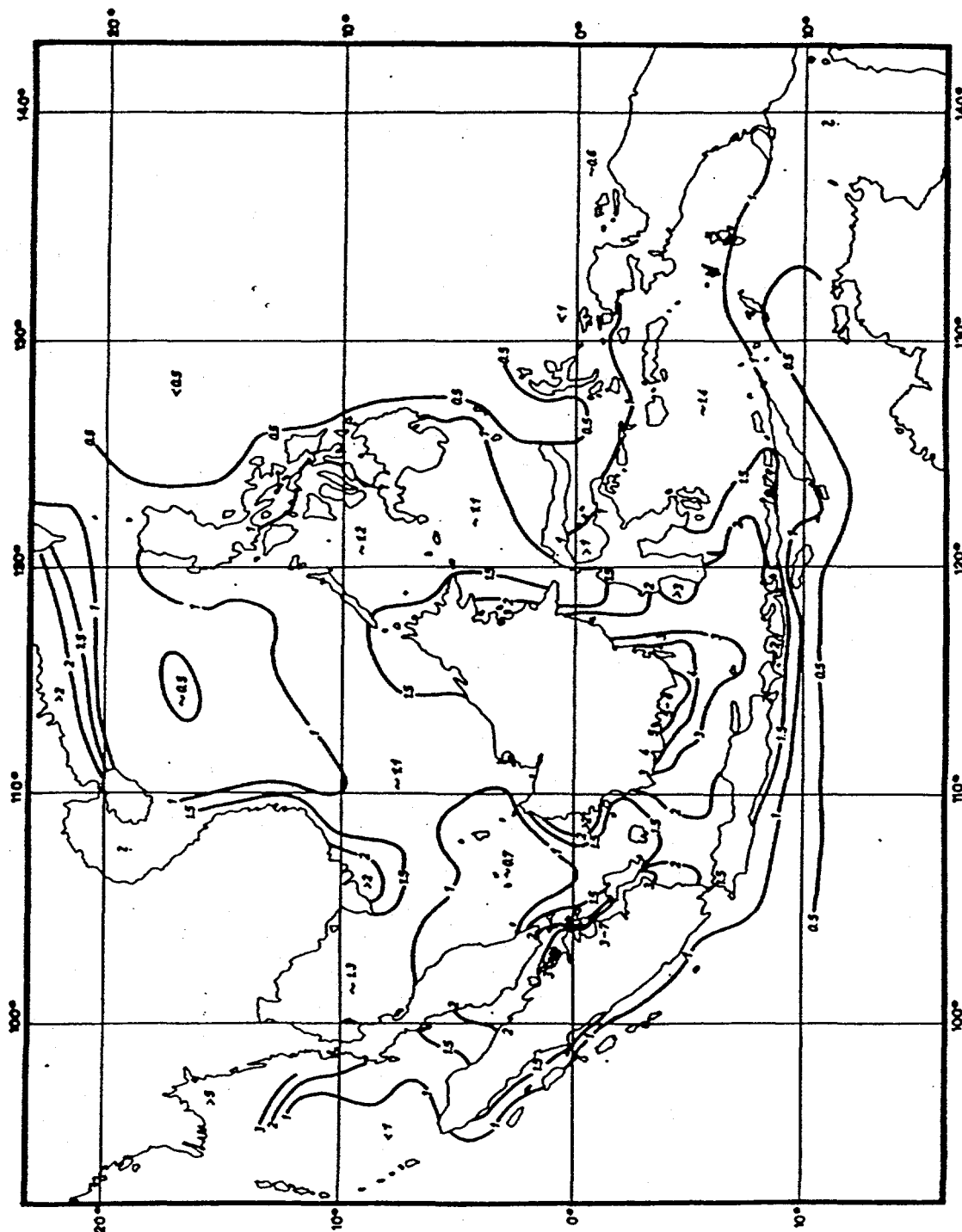


Figure 3. Annual Variation in Surface Salinity. High freshwater flux during the NW Monsoon and flushing by Pacific surface waters during the SE Monsoon combined with gives the southern Makassar Strait and the adjoining Flores Sea a large seasonal salinity variability (after Wytrki, 1961).

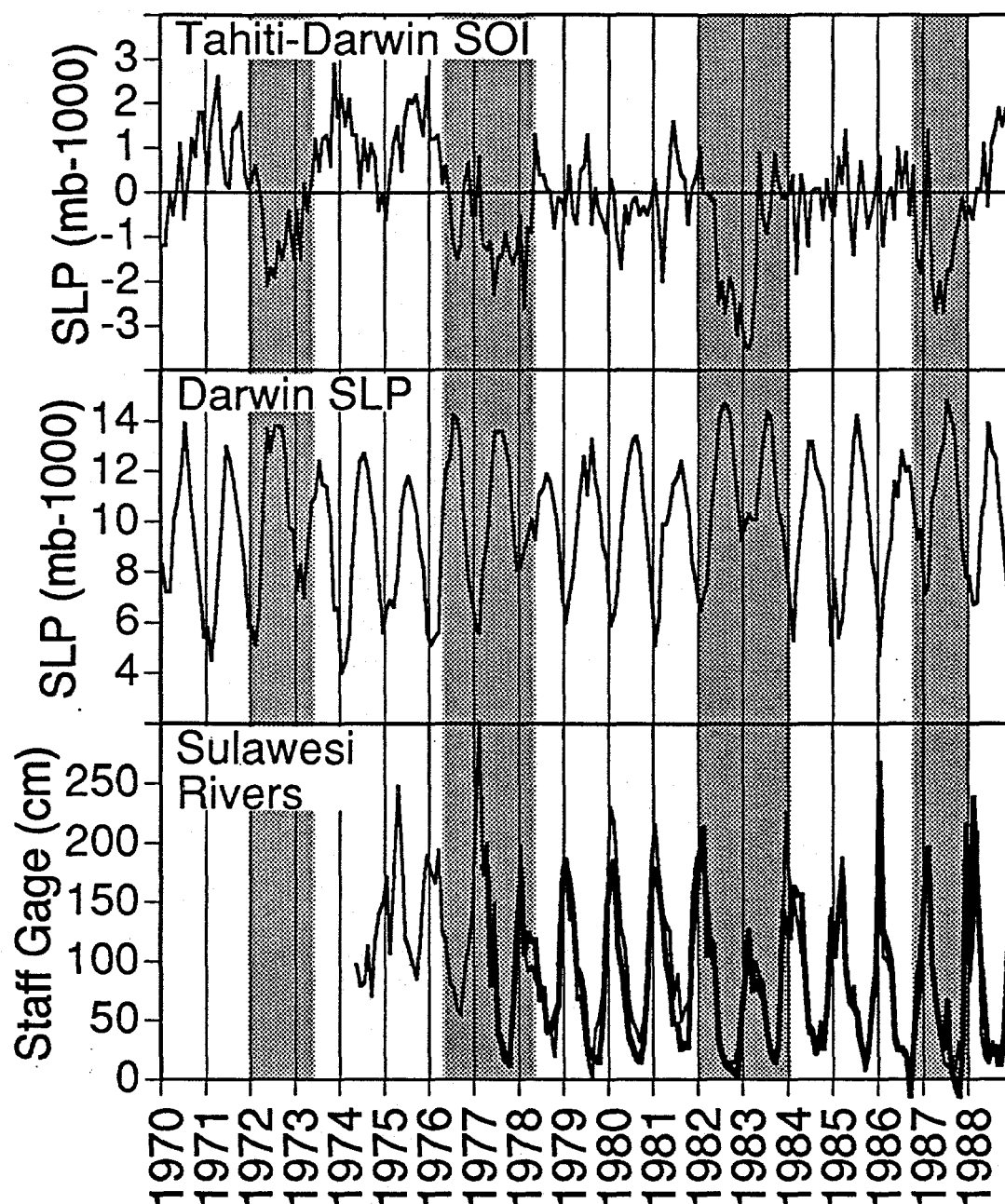


Figure 4. ENSO activity and streamflow in the Makassar Strait. Negative Tahiti-Darwin SLP Southern Oscillation Index (SOI) values (upper panel) are indicative of ENSO warm phase periods (shaded bars). SLP at Darwin (middle panel) is anomalously high during ENSO warm phases when the Indonesian Low is shifted east to the dateline; note the exceptionally high values during the 1982-83 period. Time series of coastal river streamflow in S. Sulawesi show a strong relationship to SLP. Staff gage heights for the Jeneberang River (light line) and Maros River (heavy line) have correlations of to Darwin SLP of $r = -0.77$ and -0.81 , respectively.

Surface Water Hydrography

The Makassar Strait is important component of the Pacific Ocean western boundary current system, as shown in Figure 5 (after Lukas et al., 1991; Levitus, 1982; Ffield and Gordon, 1992). Because sea level is higher on average in the W. Pacific than in the Indian Ocean, there is a throughflow of Pacific surface waters into the Indian Ocean via the Indonesian Seas (Wyrski, 1987). Strong southward flow occurs year-round in the Makassar Strait. Drifter buoys launched during WEPOCS III measured current speeds during the SE Monsoon peak flow period in the range 50-80 cm sec⁻¹, and residence times were estimated to be 2 months (Lukas et al, 1991).

As indicated by the current map, the two principle routes for throughflowing surface waters are via the Makassar Strait on the "Western Seas route" (Sulawesi Sea/Makassar Strait/Flores Sea) and via the Halmahera Strait on the "Eastern Seas route" (Halmahera Strait/Maluku Sea/Seram Sea/Banda Sea; Ffield and Gordon, 1992). Surface waters on the Makassar Strait route are derived from a North Pacific source, while surface waters on the Halmahera Strait route are supplied by an admixture of North Pacific and South Pacific water. Although there is the potential for a complicated source water mixing at the Makassar Strait, this appears not to be the case, as observational data indicates a year-round North Pacific source. This is especially evident during the dry season, when dissolved oxygen and salinity values representative of the North Pacific can be seen in the Makassar Strait, as shown in Figures 6 and 7 (Ffield and Gordon, 1992)

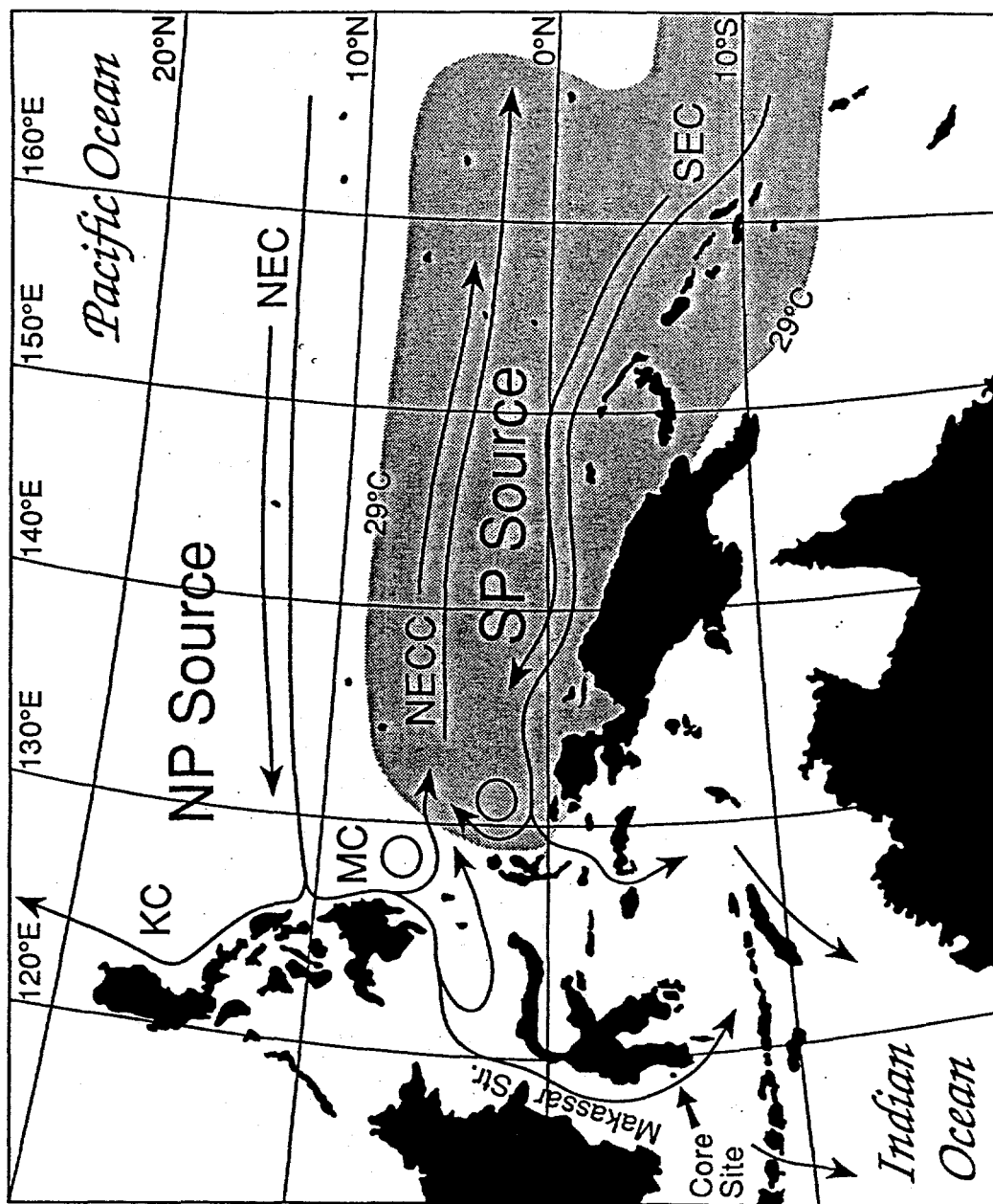


Figure 5. Map of Pacific western boundary currents and mean annual position of the 29°C SST isotherm (after Lukas et al, 1991; Ffield and Gordon, 1992; Levitus, 1982). The North Equatorial Current (NEC) and the South Equatorial Current (SEC) converge at the western boundary of the Pacific Ocean. The NEC bifurcates at the Philippines, with the northward branch supplying the Kuroshio Current (KC) and the southward branch supplying the Mindanao Current (MC). Most of the MC water is recirculated to feed the North Equatorial Countercurrent (NECC), but some is lost to throughflow via the Makassar Strait. Surface waters on the Makassar Strait route are derived from a North Pacific source (NP).

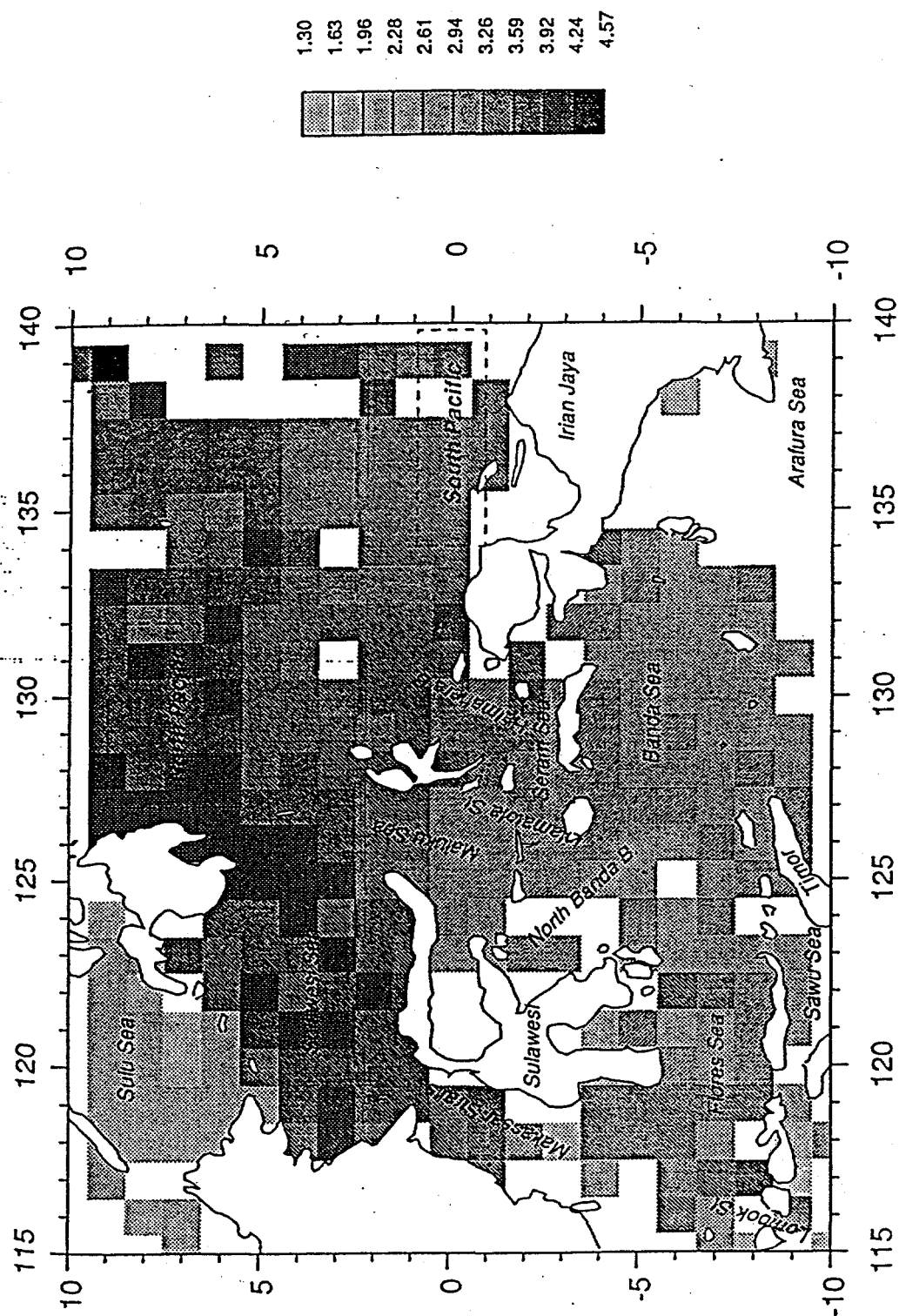


Figure 6. SE Monsoon DO₂. Map of dissolved oxygen values (ml l⁻¹) of the upper salinity maximum (after Ffield and Gordon, 1992). High oxygen values characteristic of the the NP source waters (darker shading) can be traced into the Makassar Strait and the Flores Sea.

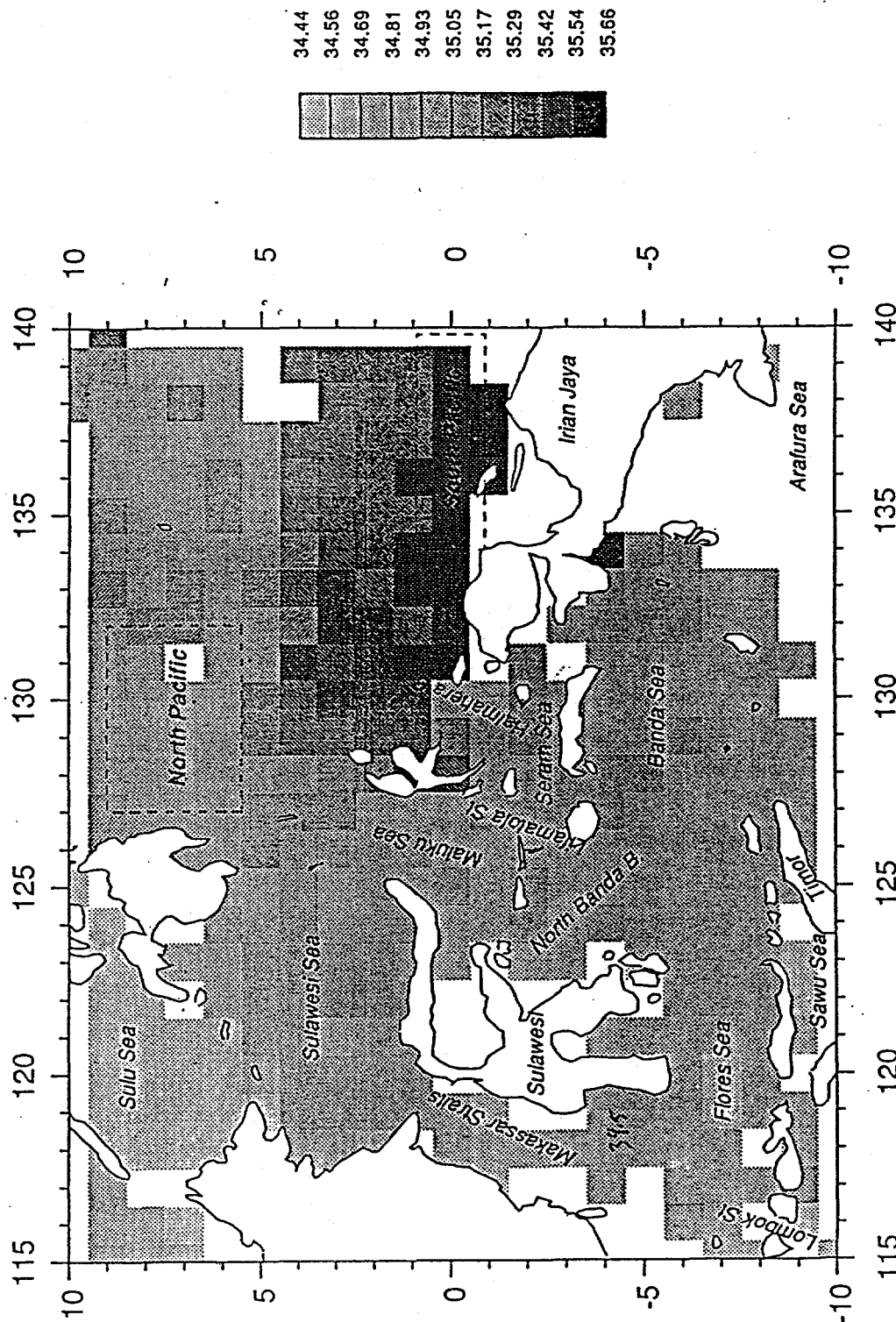


Figure 7. SE Monsoon Salinity. Map of salinity values (‰) for the upper salinity maximum (Ffield and Gordon, 1992). The NP salinity maximum (34.7, medium shading) is lower than the SP salinity maximum (35.4, dark shading) and can be traced into the Makassar Strait and the Flores Sea.

Residence Times

Ffield and Gordon (1992) estimated surface water residence times for the different Indonesian seas using an advection-diffusion model which successfully simulated the observed salinity and oxygen profiles. These results are given Table I. The dilution rate of thermocline water by mixing is given by the vertical diffusivity, K_Z . A large value of K_Z is required to transform the source water salinity and oxygen profiles to the profiles observed in the Indonesian Seas; in this model $K_Z = 1 \times 10^{-4} \text{ m}^2\text{s}^{-1}$. The total amount of mixing is described by the constant $K_Z\tau$, where τ is the residence time. The mixing depth is the square root of $K_Z\tau$, and describes the depth to which a surface flux will penetrate. These results indicate that only minor modification of North Pacific source water is required to produce the observed Makassar strait profiles (i.e. water in the Makassar Strait is derived directly from the open North Equatorial Pacific), and that of the Indonesian Seas, those on the "Western Seas" route have the shortest residence times.

Wyrski (1961) suggested that Sulu Sea water intruded the Makassar Strait during the rainy season, but recent measurements by Gordon (pers. comm., 1994) revealed the presence of high salinity Mindanao Current water at the entrance of the Makassar Strait in January of 1994. Thus, despite the potential for a complicated hydrography, Makassar Strait surface waters appear to have a year-round North Pacific source, with seasonal salinity variability that can be attributed river discharge and marine precipitation.

Table I. Residence Times for the Indonesian Seas (Field and Gordon, 1992).

Indonesia Sea	Source Water	$K_Z\tau$ (m ²)	Mixing Depth (m)	Residence Time
Western Seas:				
Sulawesi Sea	100% NP	600	24	2 months
Makassar Strait	100% NP	1200	35	5 months
Flores Sea	100% NP	1400	37	5 months
Eastern Seas:				
Halmahera Str.	50% NP-50% SP	1700	41	6 months
Maluku Sea	50% NP-50% SP	3100	56	1 year
Seram Sea	50% NP-50% SP	3400	58	1.1 years
Banda Sea	75% NP-25% SP	13800	117	4.4 years

Sea Surface Temperature

Seasonal SST variability in the Makassar Strait is about 1.5 °C, as shown by the SST maps for February and August (Figures 8 and 9; 1°x1° GOSTA data; Bottomley, 1990). The grayscale ramps in these maps have been selected to emphasize the 28° isotherm. The SST seasonality in the Java, Flores, and Banda Seas is a product of solar heating of the surface waters during the NW monsoon (Figure 8) and evaporative cooling during the SE Monsoon (Figure 9). Throughflowing surface waters carry a seasonal SST signal into the Makassar Strait. In February, the 28° isotherm can be seen wrapping around the island of Mindanao as cool water enters the Sulawesi Sea from the east carried by the Mindanao current, and from the north across the Sulu Sill. This water continues southward down the Makassar Strait, and can be seen spreading eastward into the Flores Sea, consistent with surface currents in this month (Wytrki, 1961). In August, the 28° isotherm lies just off of the Spermonde Bank and warmer water fills the Sulawesi Sea and the northern part of the Makassar Strait. The SST maps show that SST regime at the Spermonde Bank in February is set by the interaction of warm water from the Java Sea mediated by cool water from the Sulawesi Sea, and in August by

February Mean Sea Surface Temperature

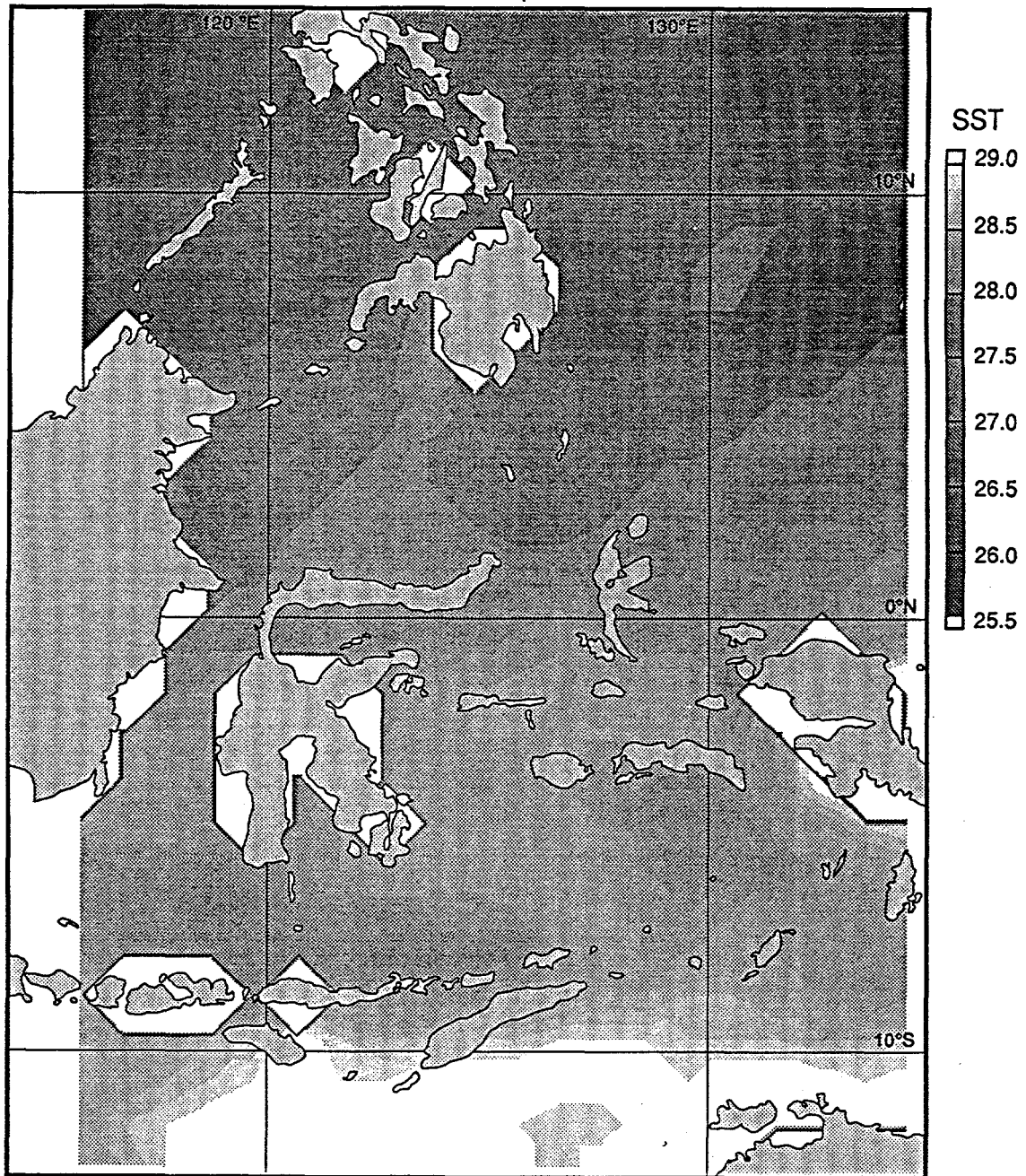


Figure 8. February SST (GOSTA 1°x1° Mean Monthly SST; Bottomley, 1990).

August Mean Sea Surface Temperature

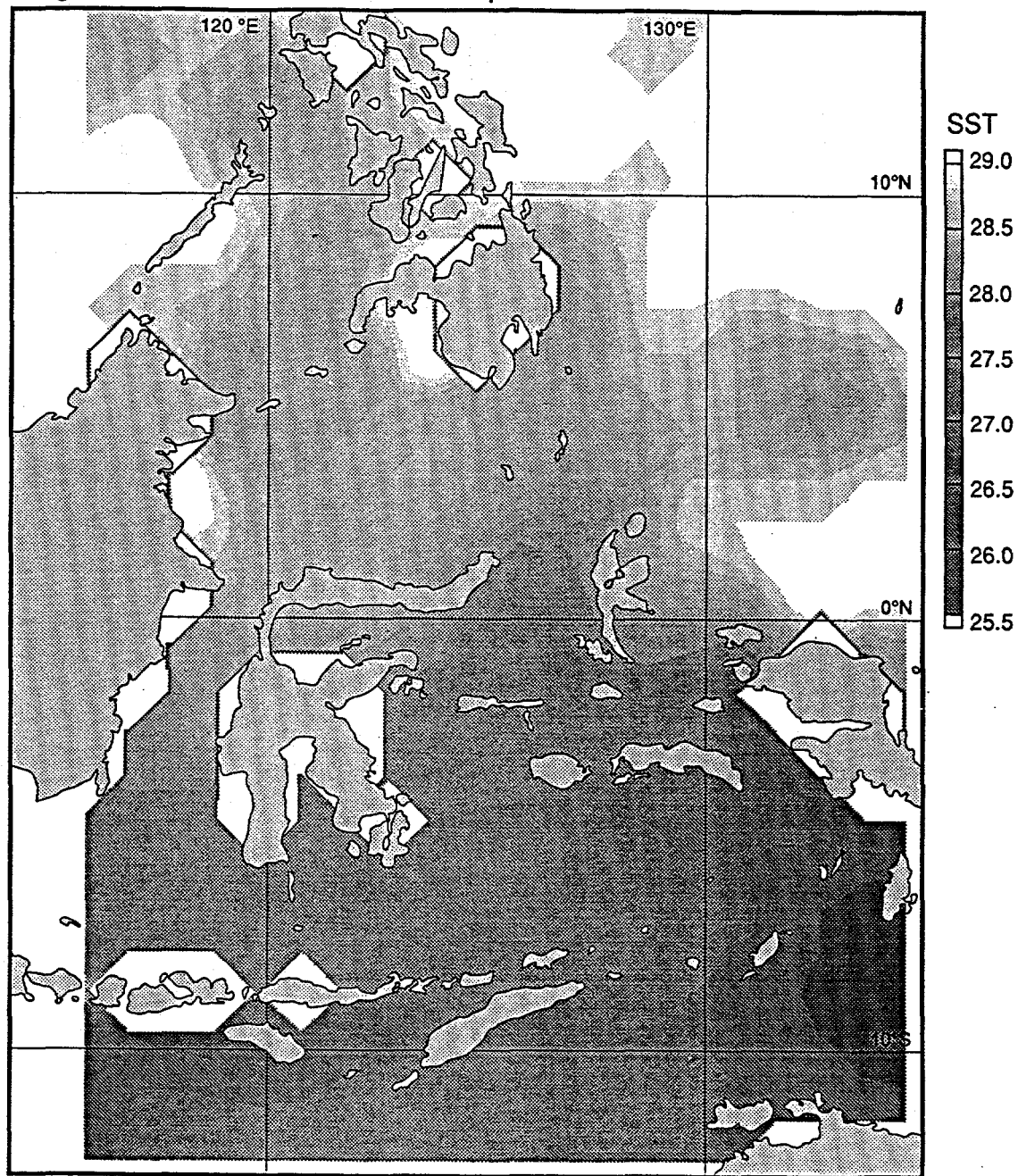


Figure 9. August SST (GOSTA 1°x1° Mean Monthly SST; Bottomley, 1990).

cool water from Flores Sea mediated by warm water from the Sulawesi Sea. The phase relationship of salinity to SST variability is shown in Figure 10. Freshwater flux and SST variability are in-phase and thus do not compete with respect to $\delta^{18}\text{O}$.

Expected Coral $\delta^{18}\text{O}$ Variability in the Makassar Strait

The large freshwater flux variability and minor SST variability indicated by atlas data suggests the coral $\delta^{18}\text{O}$ response in the Makassar Strait should be freshwater flux dominated. In this section, the results of a year-long site monitoring program will be used to establish that this is the case.

The coral's $\delta^{18}\text{O}$ response to SST variability can be easily estimated from the Epstein et al. (1953) equation if the SST regime is known. However, the coral's response to freshwater flux requires that the relationship between salinity and seawater $\delta^{18}\text{O}$ be empirically determined at the site. This is because the dilution of seawater $\delta^{18}\text{O}$ by rainwater integrates several variables, including the seawater $\delta^{18}\text{O}$, the rainwater $\delta^{18}\text{O}$, the vertical diffusivity, mixing depth and the rainwater volume. 2-hourly measurements of SST were made at 4m at Kapoposang Island in the southern Makassar Strait during 1992-93 (see Figure 13), and weekly water samples were collected at 3m for salinity and $\delta^{18}\text{O}$ determinations⁴. These data are presented in Figure 11.

The relationship between salinity and seawater $\delta^{18}\text{O}$ at 3m depth is shown in Figure 12. Isotopic dilution during the rainy season shifted surface

⁴ Seawater $\delta^{18}\text{O}$ values were determined by mass spectrometry using the CO_2 equilibration method (Epstein and Mayeda, 1953) at the LBL Center for Isotope Geochemistry.

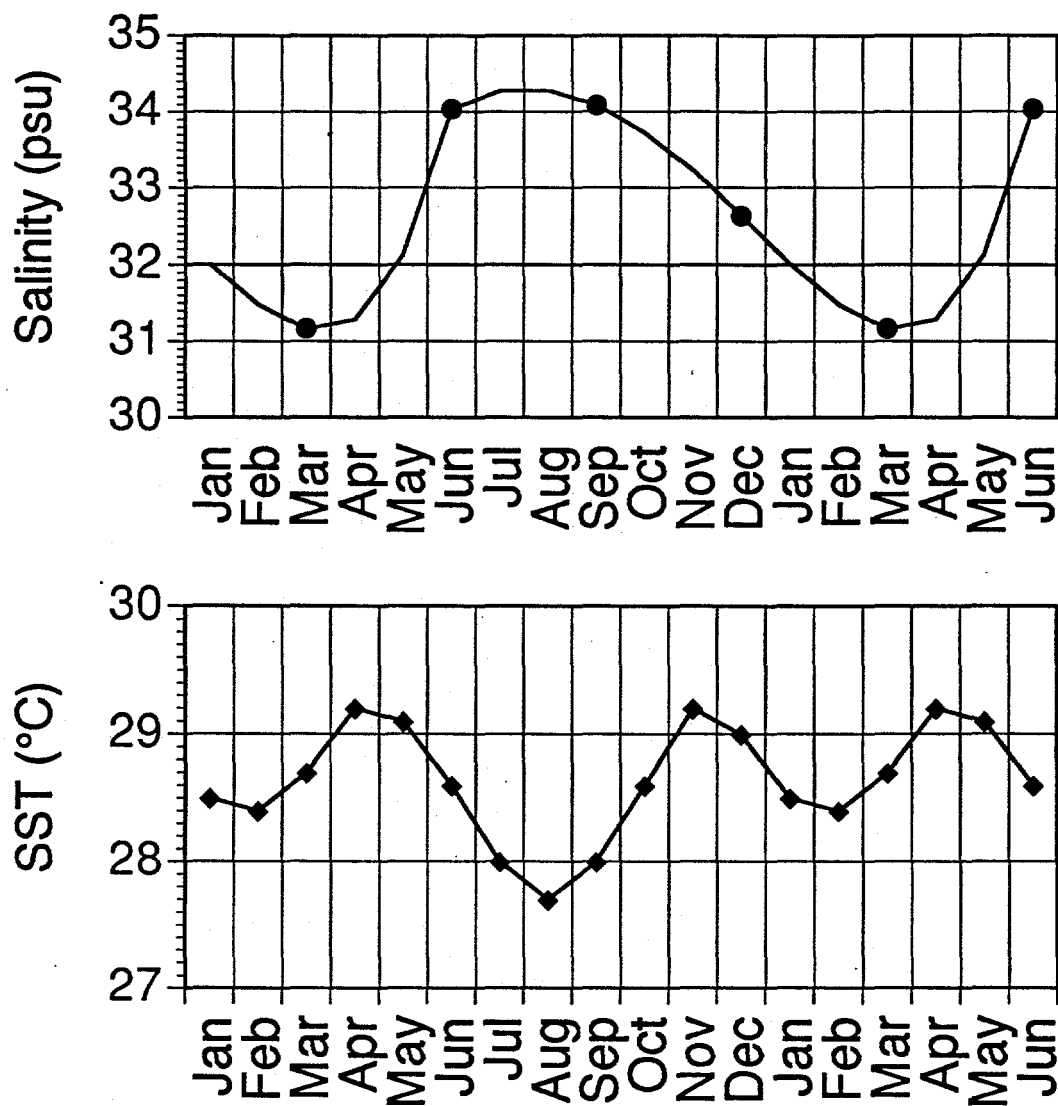


Figure 10. Sea surface salinity (Levitus, 1982) and SST temperature (Bottomley, 1990) in the southern Makassar Strait (vicinity of 119°E, 5°S). 18 months of data shown for clarity. Salinity and SST variability are out-of-phase, i.e. the August salinity maximum corresponds to the SST minimum. Similarly, the April SST maximum corresponds to the salinity minimum.

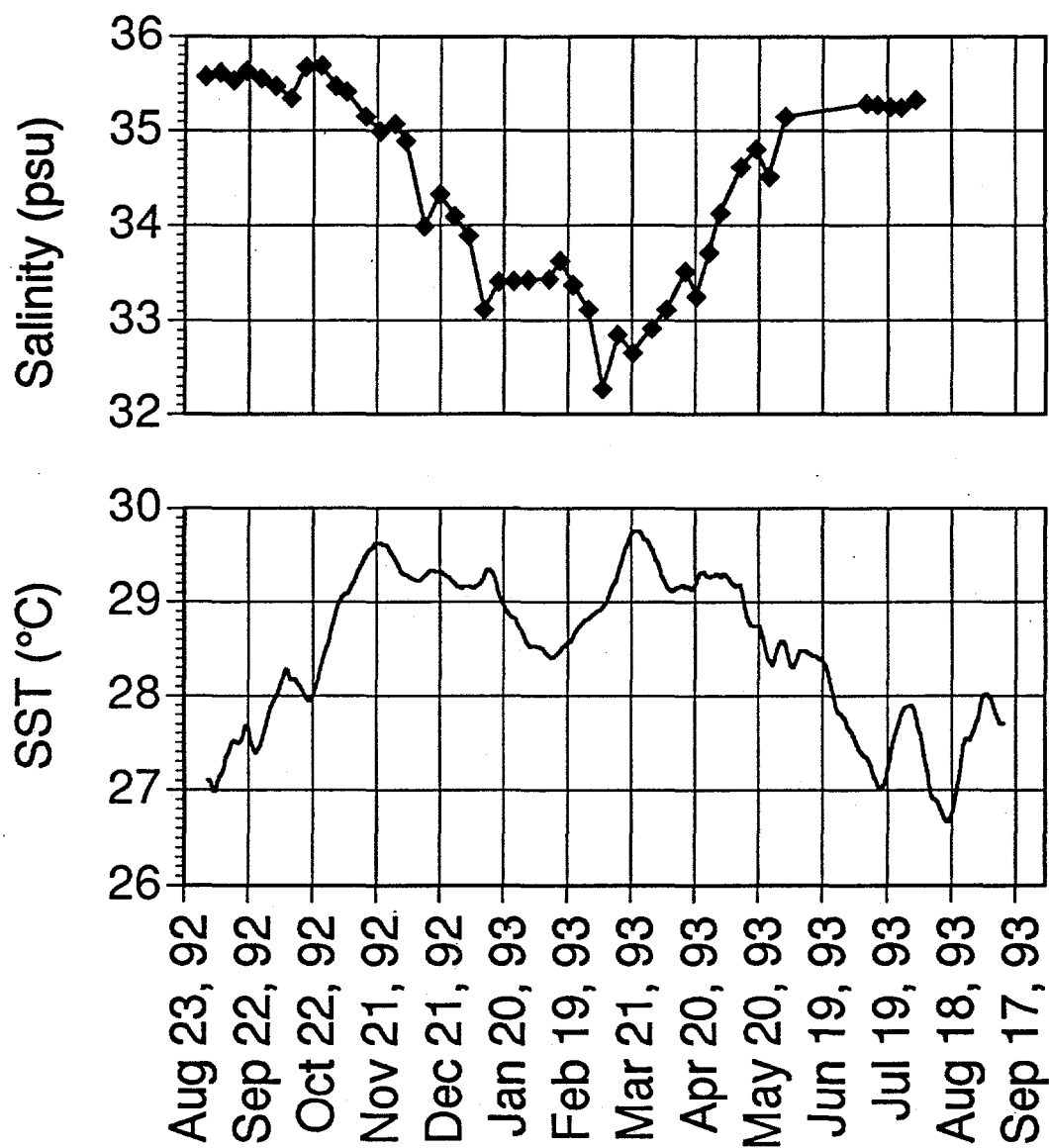


Figure 11. Salinity and SST at Kapoposang Island (Makassar Strait). Field observations during 1992-93 of salinity (weekly at 3m depth) and SST (2 hourly at 4m; smoothed with a 15 day moving average).

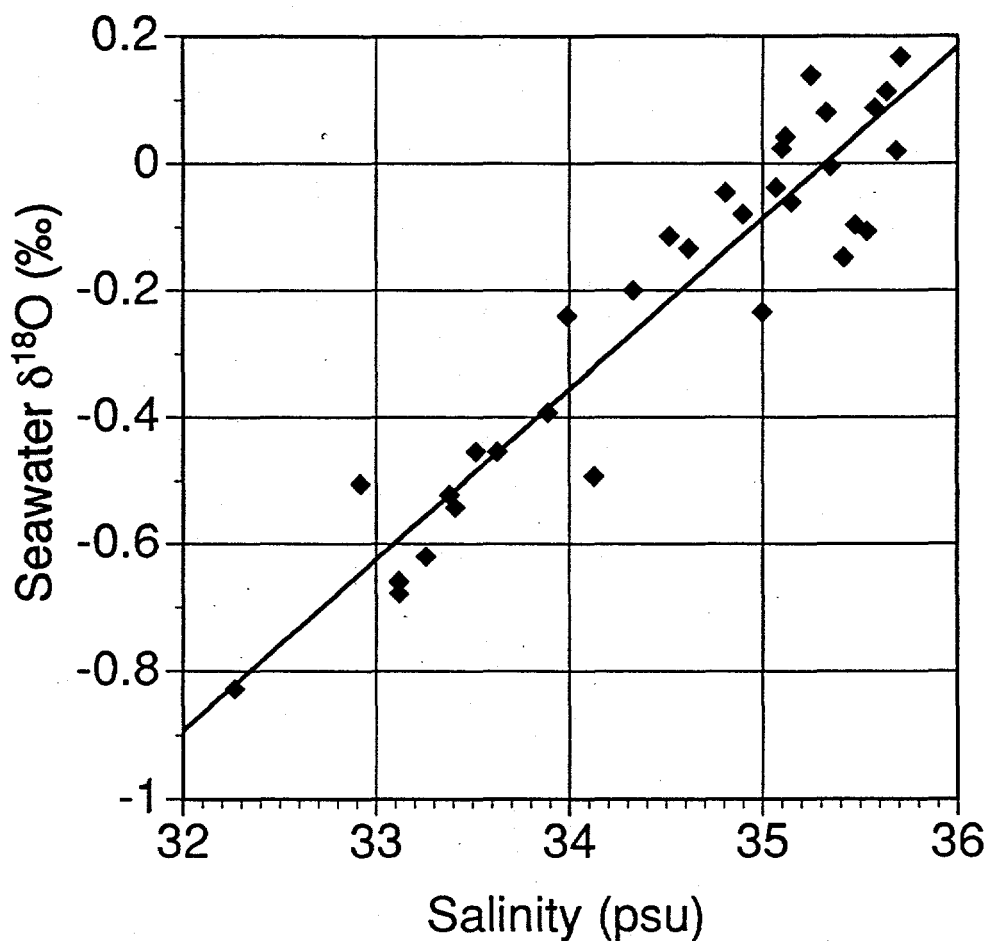


Figure 12. Relationship between surface water salinity and $\delta^{18}\text{O}$ (3m depth) during 1992-93 at Kapoposang Island. The input of isotopically-depleted rainwater during the NW monsoon lowered seawater $\delta^{18}\text{O}$ values by about 1.0‰. This decrease corresponds to a salinity decrease of about 3.5 psu. The $\delta^{18}\text{O}$ /salinity mixing line is $f(x) = 0.269x - 9.504$, $r^2 = 0.894$.

water $\delta^{18}\text{O}$ (δw) by about -1.0‰ . This decrease corresponds to a salinity decrease of about 3.5 psu. A linear fit to the data yields the $\delta^{18}\text{O}$ /salinity mixing line: $\delta\text{w} = 0.269\text{‰ psu}^{-1}$, $r^2 = 0.89$. The coral temperature-dependent fractionation response can be estimated by applying the Epstein et al. (1953) slope ($-0.22\text{‰ }^{\circ}\text{C}^{-1}$) to the seasonal range of the SST data; this yields a shift of about 0.55‰ ($2.5^{\circ}\text{C} \times 0.22^{\circ}\text{C}^{-1}$). Thus, coral $\delta^{18}\text{O}$ response will be dominated by the freshwater flux effect, as it is about twice as the SST effect. Freshwater input was low during the 1992-93 year because of ongoing ENSO-warm phase conditions, so during non-ENSO or ENSO cool phases, anomalously large freshwater flux would be expected to produce even greater isotopic variability. Wyrski (1961) noted salinities as low as 30.5 psu covering the Makassar Strait during 1950-55; applying previous equations, this is equal to a seawater $\delta^{18}\text{O}$ value of -1.3‰ , which suggests an increase in seawater $\delta^{18}\text{O}$ variability to 1.5‰ . On this basis, one might expect an interannual variability of 0.5‰ . Slight interannual SST anomalies are known to occur in Indonesian waters, typically -0.5°C during ENSO warm-phases (Allan and Pariwono, 1990); this suggests that the interannual variability might be as large as 0.7‰ .

The relatively high seasonal and interannual variability in the estimate of the convolved $\delta^{18}\text{O}$ signal suggests that corals in the Makassar Strait will have a strong, resolvable $\delta^{18}\text{O}$ response to freshwater flux and will be good proxies for the Indonesian Low.

METHODS

Spermonde Bank Core Site, S. Sulawesi

On the east side of the Makassar Strait, a large, shallow-water carbonate bank adjoins the southern peninsula of mainland Sulawesi. Known as the

Spermonde Bank, it includes 75 islands and over 400 coral patch reefs (Figure 13). At the shelf edge, some 40-75 km offshore, coral reefs are bathed by open waters of the Makassar Strait and are in generally pristine condition. Nearshore reefs are subject to a variety of ecological impacts, some natural (osmotic shock and high sedimentation from coastal rivers) and some anthropogenic (eutrophication, overfishing, coral mining, and dredging). In July, 1990, large *Porites* colonies were cored at Kapoposang and Langkai Is. These two offshore sites are separated by 37 km, and both reflect the conditions of the open waters of the Makassar Strait. Neither are under the direct influence of local river discharge from mainland Sulawesi. There are some differences in bathymetry and presentation to weather between the two sites: Kapoposang is on promontory surrounded by a vertical drop off, and Langkai is situated where the shelf slopes off to depth. Both sites have strong water flow, and there is no reason to believe that surface waters impinging on the two islands would have significantly different properties, especially on monthly or interannual timescales.

Coring Operations

Reefs were surveyed extensively prior to drilling and the largest colonies found were cored. Where possible, duplicate cores were collected. Generally, the most complete recovery was obtained by drilling down from the apex of the colony, but occasionally hiatuses were encountered in the interior of the colony. The KAP1A colony is on the north-facing reef at Kapoposang Is., while the LAN1A colony is on the east-facing reef at Langkai Is. Both colonies were growing at the relatively shallow depth of 2.5 m. The upper surface of the KAP1A colony was only partially covered by live tissue, whereas the LAN1A colony was completely covered by live tissue. A list of

Core Sites in the Spermonde Bank (Makassar Strait)

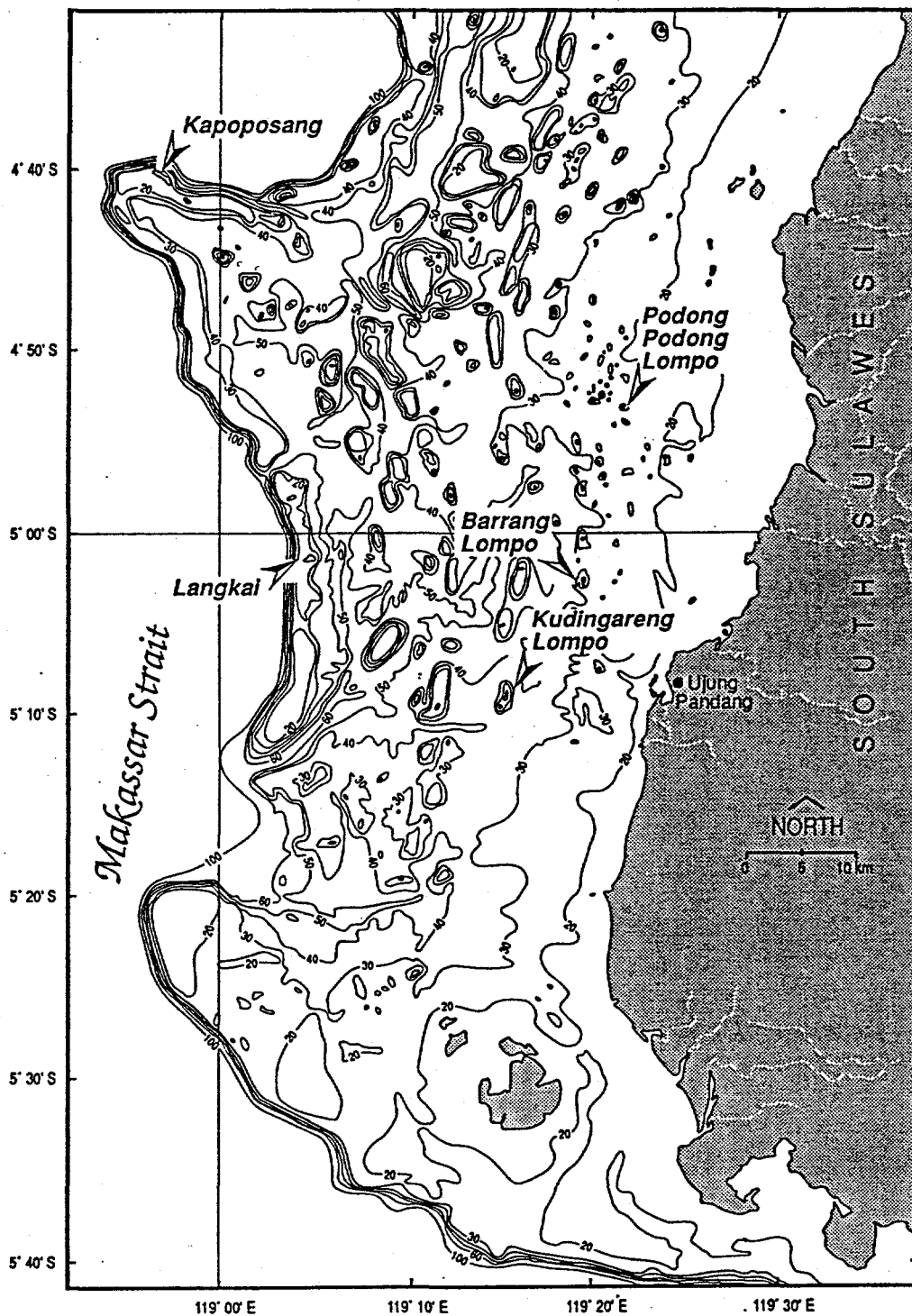


Figure 13. Map of the Spermonde Bank (S. Sulawesi). The offshore Kapoposang and Langkai core sites are indicated, as well as the mid-shelf core sites, Barrang Lompo, Podong Podong Lompo, and Kudingareng Lompo.

cores collected from these sites is given in Table II. Later stable isotope analyses revealed a suspect section in the uppermost part of the KAP1A core, and a short core (KAP3A) covering this time span was collected in 1992 from a smaller *Porites* colony growing at 4m depth near the KAP1A colony.

Table II. Spermonde Bank Cores (Makassar Strait, Indonesia)

Coral Core Site	Core No.	Core Length (meters)	Hiatus (depth)	Core Top	Date Collected	Age (years)
Kapoposang	1A	2.62		dead	16-Jul-90	245
Kapoposang	3A	0.30		live	18-Dec-92	23
Langkai	1A	2.3		live	3-Jul-90	141
Langkai	1B	1.9		live	3-Jul-90	
Langkai	2A	1.57	0.78 m	dead	4-Jul-90	
Langkai	2B	1.01		live	4-Jul-90	
Langkai	3A	2.05		dead	4-Jul-90	105

The underwater hydraulic coral drilling system is shown in Figure 14. Divers used a surface-supplied breathing system (hookah), which is preferable for underwater operations in remote locations with no SCUBA support. The hydraulic drill uses a 3" diamond core barrel, 25" in length, to which extension rods can be fitted for deeper drilling. The drill is light enough to be handled by a single diver, who controls the speed and rotation direction of the core barrel with the 4-way valve, and the rate of water flushing with the water pressure relief valve. Including the set-up and break-down of all the drilling and diving equipment, the average coring rate turned out to be about one meter per hour under normal circumstances.

Preliminary Analyses

Cores were reassembled and inspected to determine the orientation that would provide the best presentation of the annual density bands. A specially-constructed water cooled rock saw fitted with two diamond blades

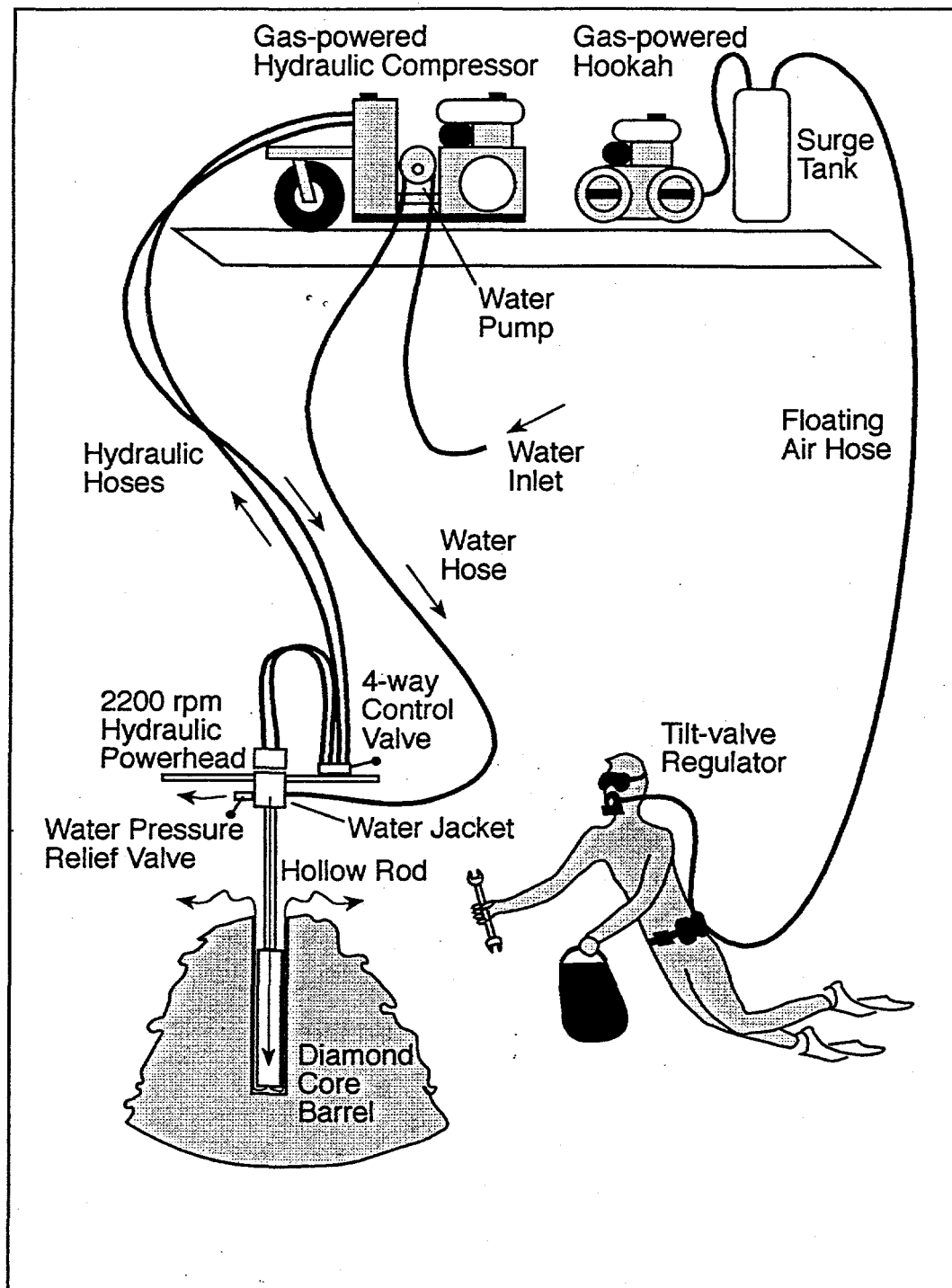


Figure 14. Underwater Drilling.

1 cm apart was used to produce a single, continuous, parallel-sided slab (9 mm thick) taken lengthwise out of the center of the core. The slab was allowed to air-dry at room temperature and then X-rayed (Kodak AR film, 60 kV, 20 mA, 30 s exposure); the X-radiographs were used to make the initial age determinations by density band-counting.

The X-radiographs were also used to map out optimal transects for isotopic sub-sampling. Transects were selected to be parallel to the coral growth axis and which minimized the number of splices needed to sample the entire length of the slab. The transect path was marked by permanently affixing a flexible rule to the slab to guarantee an accurate stratigraphy. Where it was deemed necessary to create a splice, care was taken to ensure that the new transect overlapped the previous by several annual bands.

The slab was not treated in any way prior to isotopic analysis; the only fresh water to come in contact with the slab was that used in the cutting process. Powder samples were collected along the transects at 1 mm increments using a high-speed drill press fitted with a 1.2 mm diameter bit. Drilling depth was held constant at 3 mm. Filtered air (Dust-Off+ brand) was used to clean the slab prior to drilling the next sample. Because the bit was slightly larger than the sample increment, the holes overlapped and hence all the skeletal material on the transect was sampled.

Mass Spectrometry

Analyses of the KAP1A core were performed on a Finnegan MAT 151 gas-source mass spectrometer with an automated carbonate device at Lamont-Doherty Geological Observatory, in the laboratory of Dr. Rick Fairbanks. The

carousel holds up to 47 samples per run; the sample run was typically bracketed with three NBS-20 standards at the beginning, and two in the middle and at the end. Samples were individually reacted in a common bath of water-free orthophosphoric acid at 90°C for 11 minutes in a constantly stirred vessel. Precision of the measurement of NBS-20 standards is 0.08‰ for $\delta^{18}\text{O}$ and 0.05‰ for $\delta^{13}\text{C}$. Analyses of the LAN1A and KAP3A cores were performed using a VG Prism gas-source mass spectrometer fitted with an automated carbonate device, in the laboratory of Dr. Don dePaolo (Center for Isotope Geochemistry UCB/LBL). The reaction time was shortened to 8 min to achieve greater sample throughput, and the water trap was baked-out between each run. Slightly better precision was achieved on the measurement of laboratory standards (in this case, CM-1 (Carrera marble) and PDA (coral aragonite)) than with the LDEO runs: $\pm 0.05\text{‰}$ on $\delta^{18}\text{O}$ and ± 0.01 on $\delta^{13}\text{C}$. Recalling that the Epstein slope is $0.22\text{‰ } ^\circ\text{C}^{-1}$ and the Makassar Strait salinity/ $\delta^{18}\text{O}$ mixing line is $0.27\text{‰ } \text{psu}^{-1}$, this level of precision (0.05-0.08‰) means that coral $\delta^{18}\text{O}$ can potentially detect SST shifts of 0.3-0.4°C or salinity shifts of 0.2-0.3 psu. Typical run-to-run precision is indicated in Table III, which summarizes precisions for two laboratory standards over the course of a week.

Table III. Stable Isotope Precision (between runs)

Run Date:	PDA $\delta^{13}\text{C}$	PDA $\delta^{18}\text{O}$	N	CM-1 $\delta^{13}\text{C}$	CM-1 $\delta^{18}\text{O}$	N
4/15/94	-1.400	-5.031	11	1.929	-1.719	4
4/16/94	-1.419	-5.121	6	1.904	-1.740	4
4/17/94	-1.428	-5.087	6	1.926	-1.651	3
4/18/94	-1.441	-5.100	6	1.917	-1.741	3
4/19/94	-1.439	-5.175	6	1.918	-1.767	3
Average:	-1.43	-5.10		1.92	-1.72	
± 1 sigma:	0.01	0.05		0.01	0.04	

Data Reduction

Two corrections were applied to the data. The laboratory carbonate standard was used as an absolute reference to control the accuracy of the isotopic determinations over the course of an automated run and from day to day. The first correction adjusted to absolute values based on the average of the first three laboratory standards. The second correction accounted for an artifact typically introduced into the data during automated analyses, and involves subtracting the reference gas fractionation slope from the data, estimated by linear fit to all of the standards for the run. A basic principle of gas source mass spectrometry is that the isotopic ratios of the sample CO_2 gas are determined by comparison to the isotopic ratios of a reference CO_2 gas with a well-established isotopic composition. A design feature of the mass spectrometer is that during measurement cycles it continually bleeds sample or reference gas via a crimped capillary into the high vacuum of the flight tube which encloses the hot ionizing filament (the source) and the charged collector cups (the detector). The sample gas and reference gas are held in separate bellows which balance the gas pressures such that the amount of sample gas and reference gas that is alternatingly bled into the source is exactly equal. While the gas in sample bellows is naturally refreshed with each new sample, the reference bellows is not, and instead slowly depletes over the course of the 14-hour automated analysis. As it depletes, it is subject to mass-dependent fractionation which causes a shift in the samples towards isotopically lighter values. This effect is shown in Figure 15, in which PDA standards (values: $\delta^{13}\text{C} = -1.30\text{‰}$, $\delta^{18}\text{O} = -5.34\text{‰}$) for six runs in May 1994 are plotted against carousel position. A linear regression has been applied to the standards for each run; the slope of this line is the reference gas fractionation correction that would be applied to the sample data for the run.

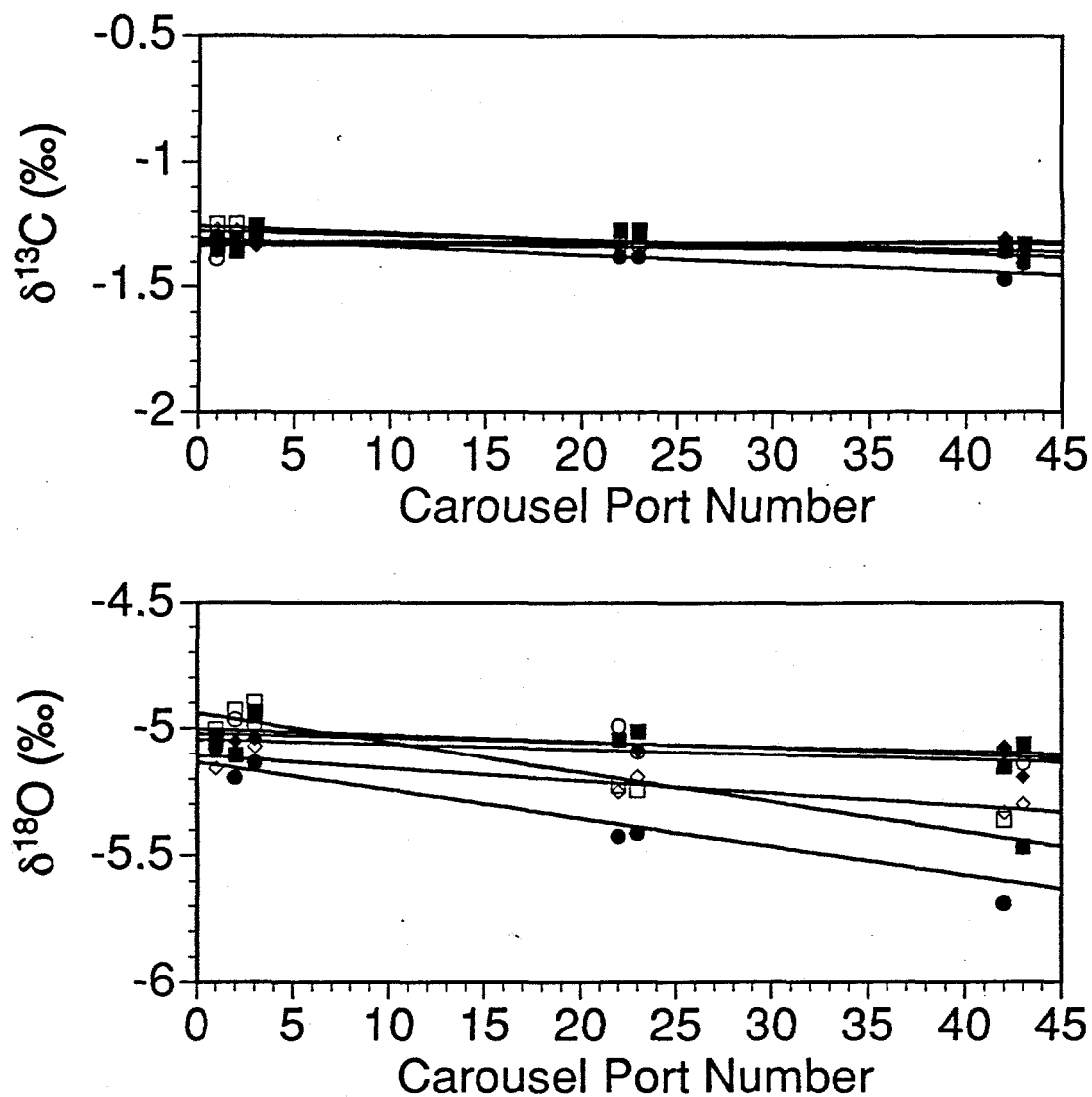


Figure 15. Reference Gas Corrections. PDA standards ($\delta^{13}\text{C} = -1.30\text{‰}$, $\delta^{18}\text{O} = -5.34\text{‰}$) for six runs in May 1994 plotted against carousel position (run dates: 5/15, 5/16, 5/26/93, 5/27, 5/28, 5/29). The shift is less strong for $\delta^{13}\text{C}$ (upper panel) than for $\delta^{18}\text{O}$ (lower panel). $\delta^{18}\text{O}$ can drift significantly, by as much as a 0.5‰ as in these examples.

Generation of Time Series

The construction of an age-model, that is the translation of a depth-dependent data series to a time-dependent series, is a critical interpretive step. The two most common methods of dating coral $\delta^{18}\text{O}$ depth series are by projection of the position of either annual density bands or annual $\delta^{13}\text{C}$ minima onto the $\delta^{18}\text{O}$ depth series. Annual band age models are not well-suited to high-resolution isotopic studies where the recovery of seasonal proxy climate data is the ultimate goal. There are significant errors associated with transferring stratigraphic data off of the X-radiograph due to image distortion, not to mention the difficulty in consistently picking the appropriate density inflection, especially in corals from areas of low seasonality that do not display strong skeletal density patterns. Also, it is typical to encounter sections of indistinct banding in long cores where growth bands have an oblique presentation and thus lose clarity in X-radiographs. $\delta^{13}\text{C}$ age models offer superior temporal control since the $\delta^{13}\text{C}$ inflections can be clearly and precisely identified on monthly or sub-monthly timescales. Since $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ are codetermined from the same sample, there are no errors associated in projecting the age model onto the $\delta^{18}\text{O}$ depth series. $\delta^{13}\text{C}$ is also useful in identifying seasonal transitions in sections of core with indistinct or oblique banding. Thus, coral $\delta^{13}\text{C}$ is a more useful and precise stratigraphic tool in detecting the basic annual cycle and the change of seasons.

Light has a positive modulating effect on coral $\delta^{13}\text{C}$. Coral skeletal $\delta^{13}\text{C}$ is observed to decrease with increasing depth, following the light attenuation curve (Fairbanks and Dodge, 1978; Chalker, 1981; Bosscher, 1992). Seasonal variations $\delta^{13}\text{C}$ are also driven by changing light levels, and coral $\delta^{13}\text{C}$

maxima are observed to occur during the season with the most incident sunlight (Fairbanks and Dodge, 1978; Pätzold, 1984; Walsh, 1975). Age models based on $\delta^{13}\text{C}$ assume that $\delta^{13}\text{C}$ is primarily tracking variability in local insolation, and therefore the $\delta^{13}\text{C}$ inflection points can be interpreted as markers of seasonal changes in average cloud cover or solar azimuth. The $\delta^{13}\text{C}$ age model used here is based on the assumption that the $\delta^{13}\text{C}$ minima occurs at the height of the E. Indonesian rainy season (January) as shown in Figure 16 (Ho Tong, 1982). A two-step procedure used in developing a $\delta^{13}\text{C}$ age model for each of the $\delta^{18}\text{O}$ depth series, as shown in Figure 17. In the first step, $\delta^{13}\text{C}$ minima are identified and projected onto the $\delta^{18}\text{O}$ depth series. In the second step, data for each year is individually interpolated using the cubic spline function and then reassembled to form the final time series⁵.

RESULTS

Stable Isotope Time Series

The analyses for the three cores, KAP1A, LAN1A (in two sections), and KAP3A are summarized in Table IV. The basic sampling strategy was to develop a continuous time series from the KAP1A core spanning the period of the Australasian instrument record, and then to sample the LAN1A core in two sections: the last forty years and thirty years centered around the turn-of-the century to assess reproducibility of the $\delta^{18}\text{O}$ time series. The KAP1A record (1860-1987) is presented in Figure 18, and the KAP3A record is presented in Figure 19. The LAN1A record (1951-1989) is presented in Figure 20, and the turn-of-the century LAN1A record (1875-1911) is presented in Figure 21.

⁵ The data smoothing associated with this procedure is negligible: for example, interpolation of the Langkai $\delta^{18}\text{O}$ series (1951-1989) reduced the variance by 0.8% (N=665, variance = 0.160; reduced to N=468, variance = 0.158).

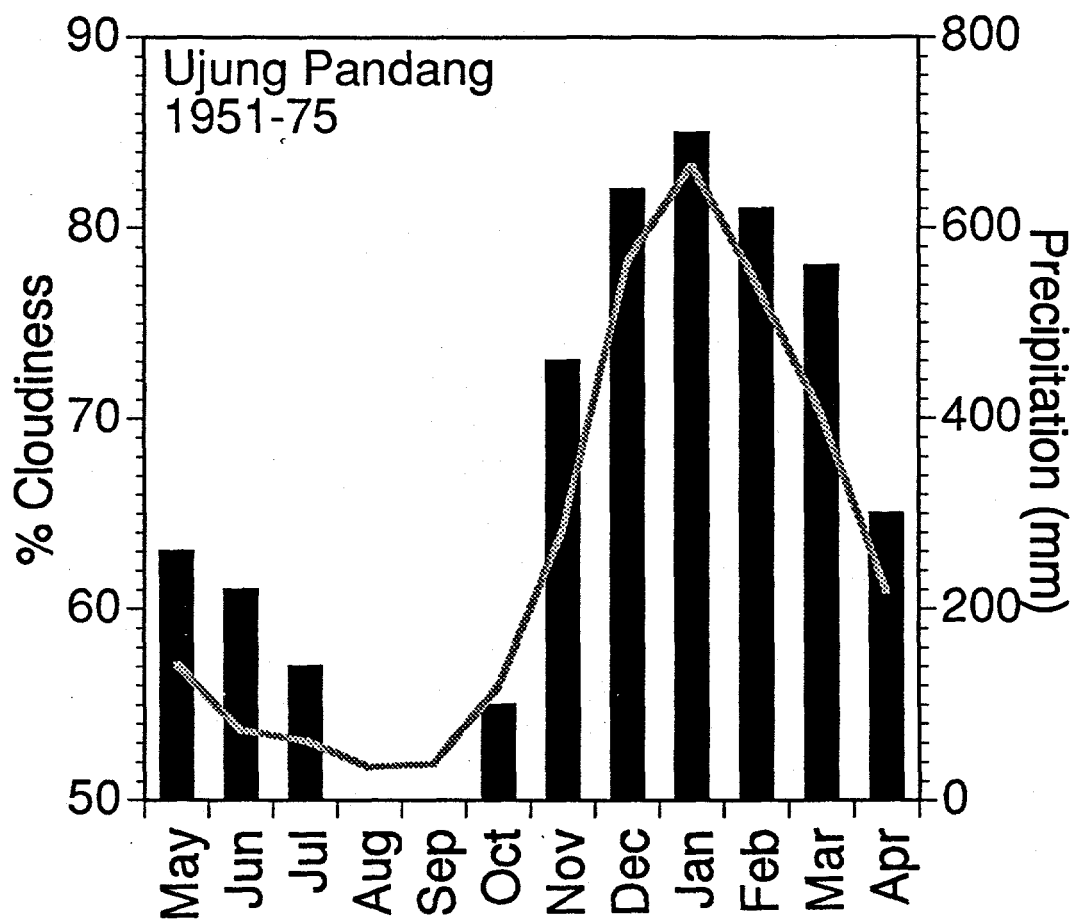


Figure 16. Cloud Cover and Precipitation at Ujung Pandang, S. Sulawesi. Both cloud cover and rainfall peak in January, and fall to minimum values in August and September.

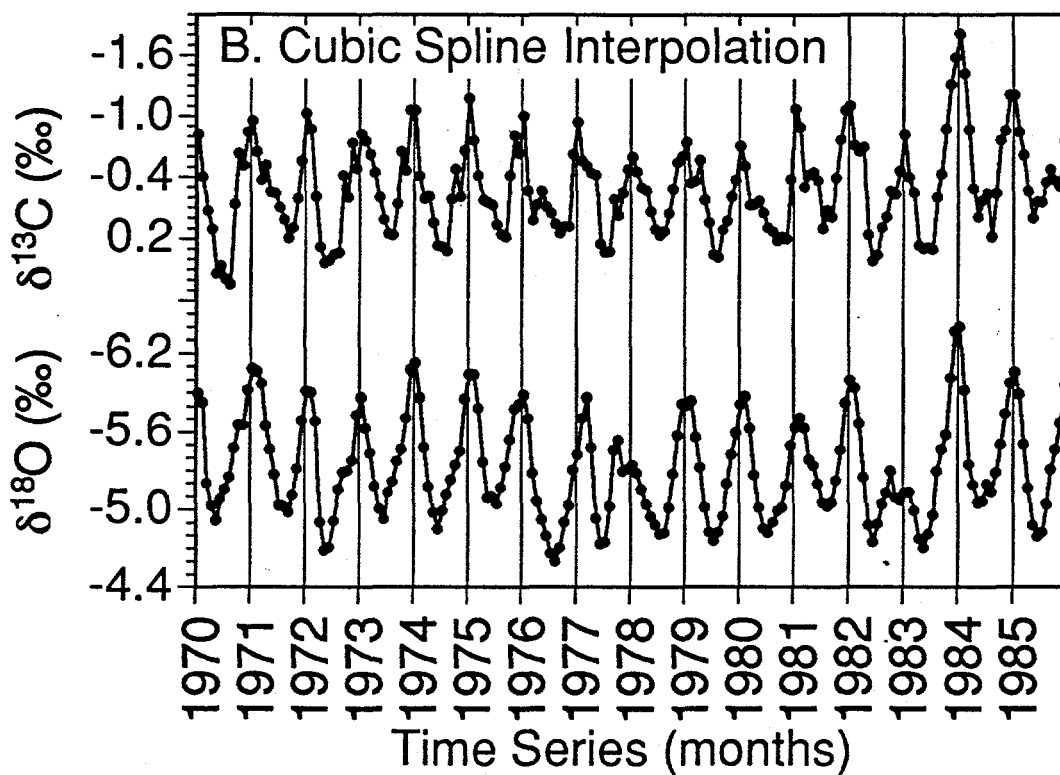
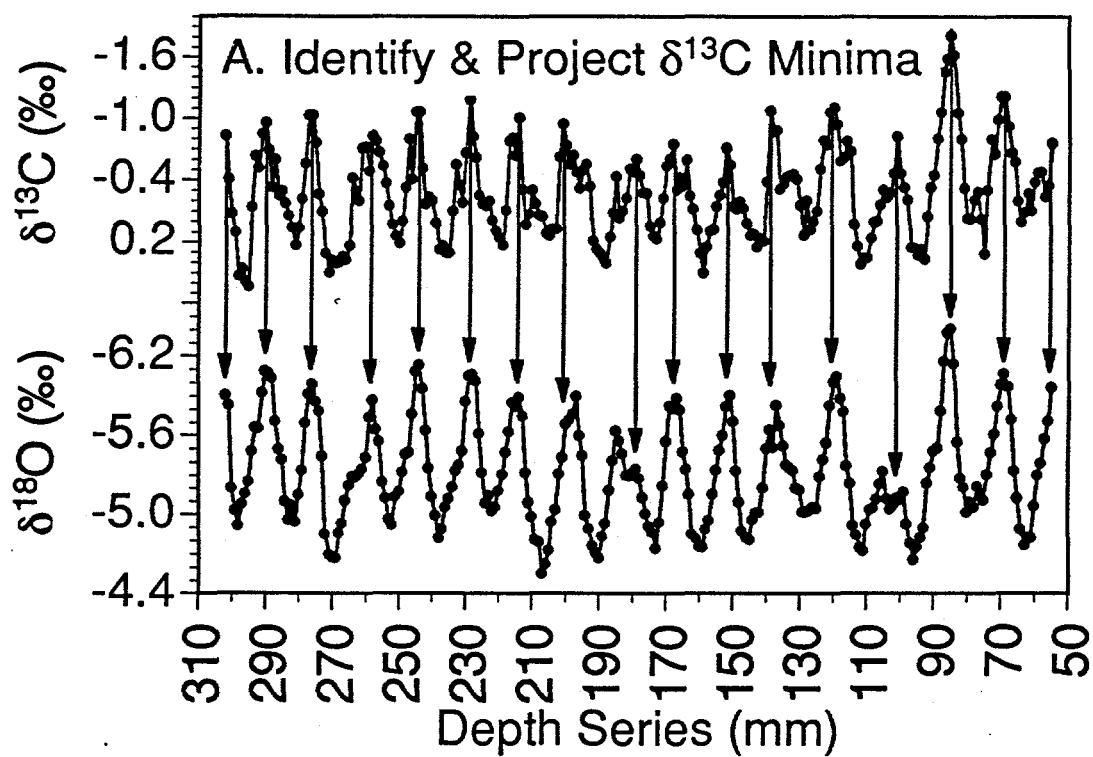


Figure 17. Generation of Time Series from $\delta^{13}\text{C}$ Age Models.

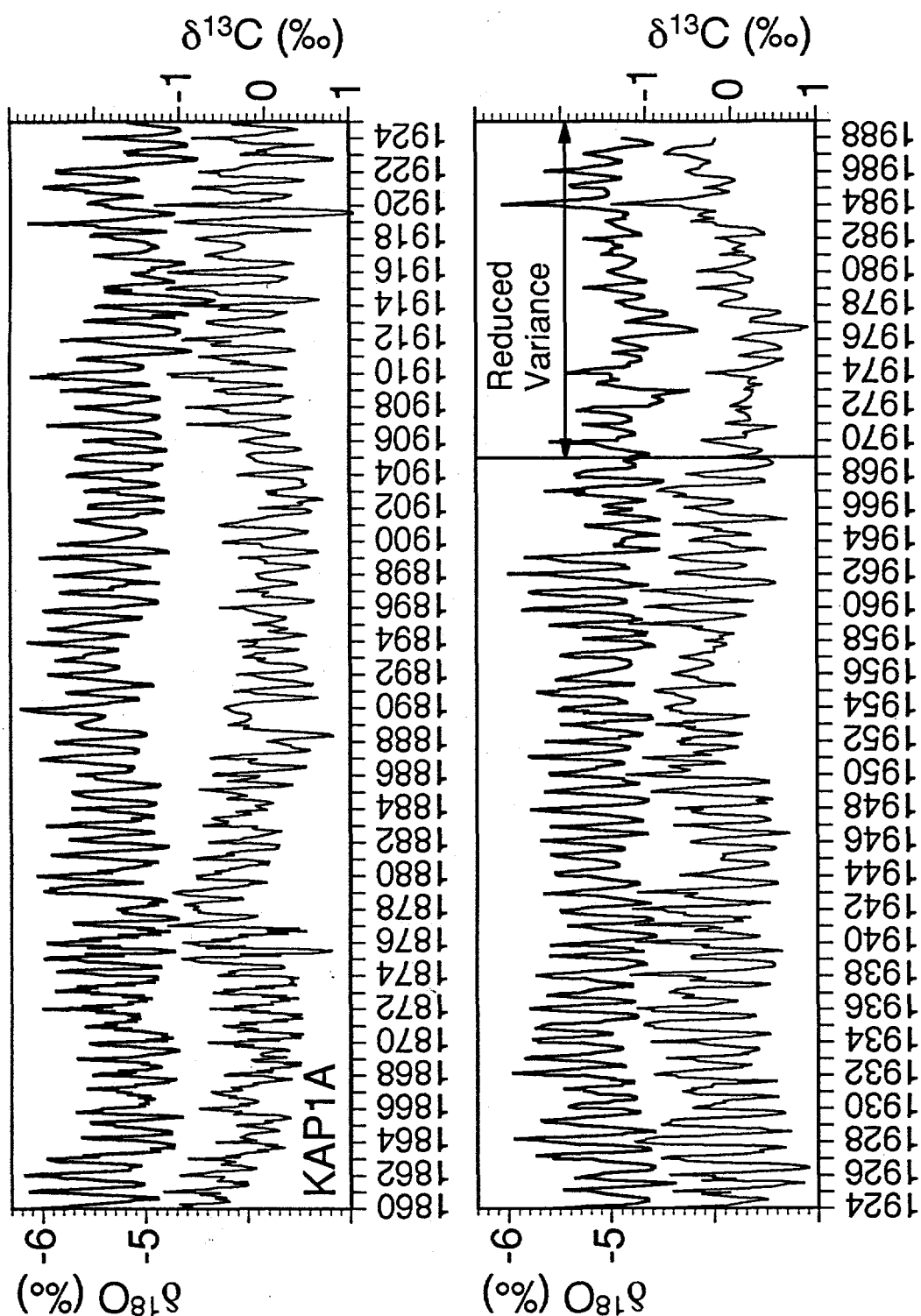


Figure 18. KAP1A stable isotope record (1860-1987), with the y-axes reversed so the data correspond to increased SST/fresh water flux (δ¹⁸O) and increased light attenuation (δ¹³C); this plotting convention is followed throughout.

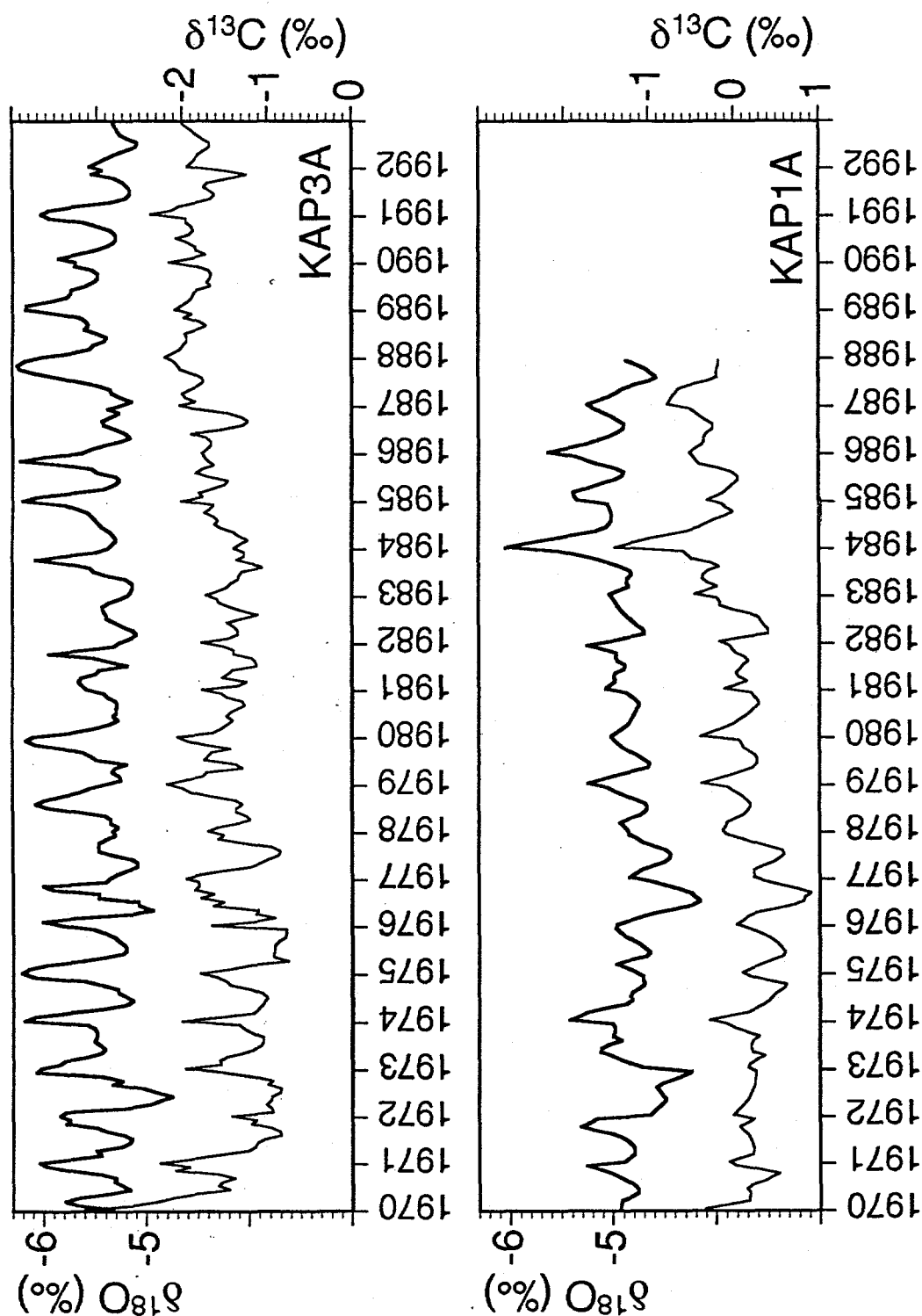


Figure 19. KAP3A stable isotope time series (1970-1992), shown with the suspect section of the KAP 1A time series (1970-1987).

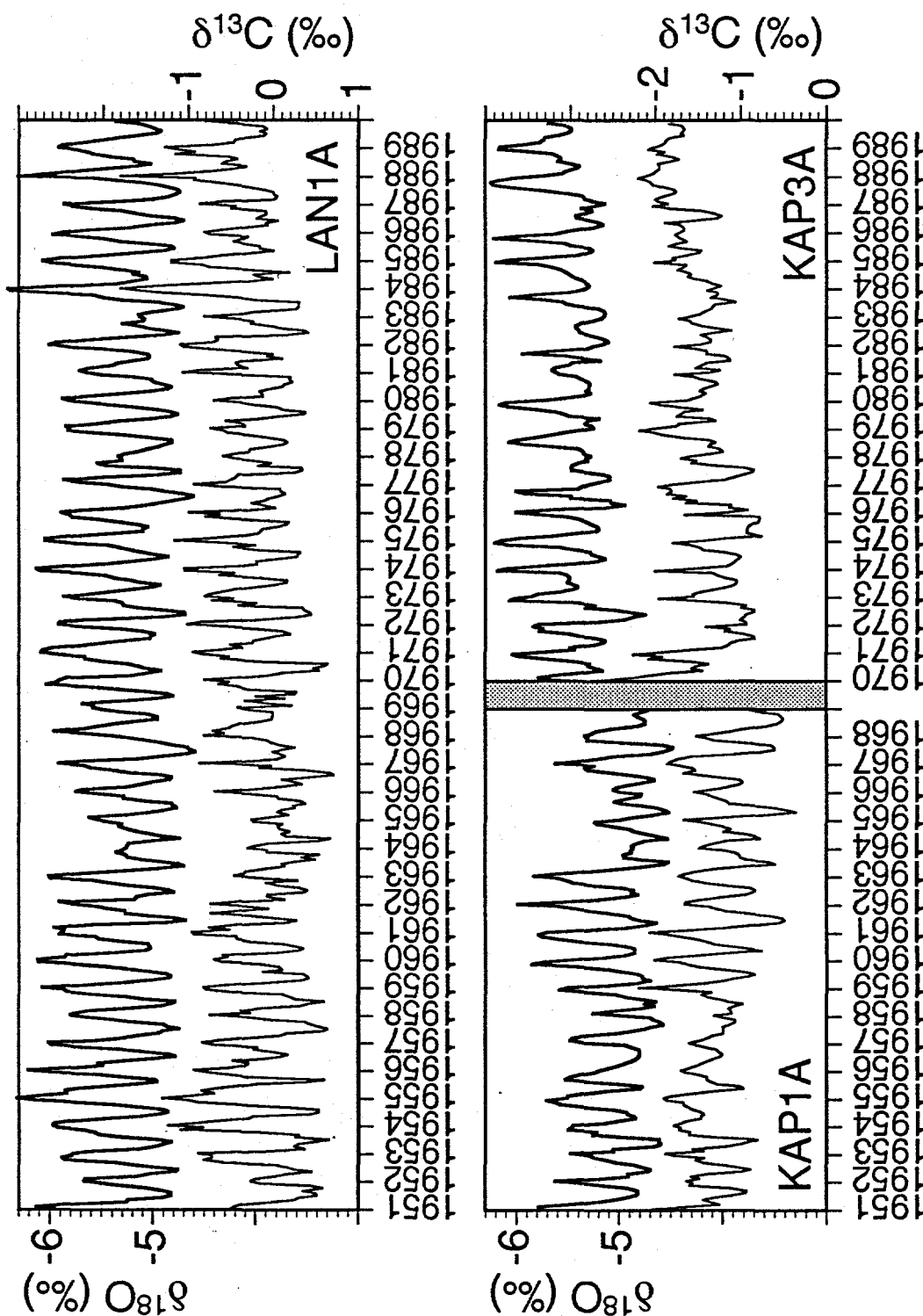


Figure 20. LAN1A stable isotope time series (1951-1989), shown with the KAP1A (1951-1968) and KAP3A time series (1970-1989).

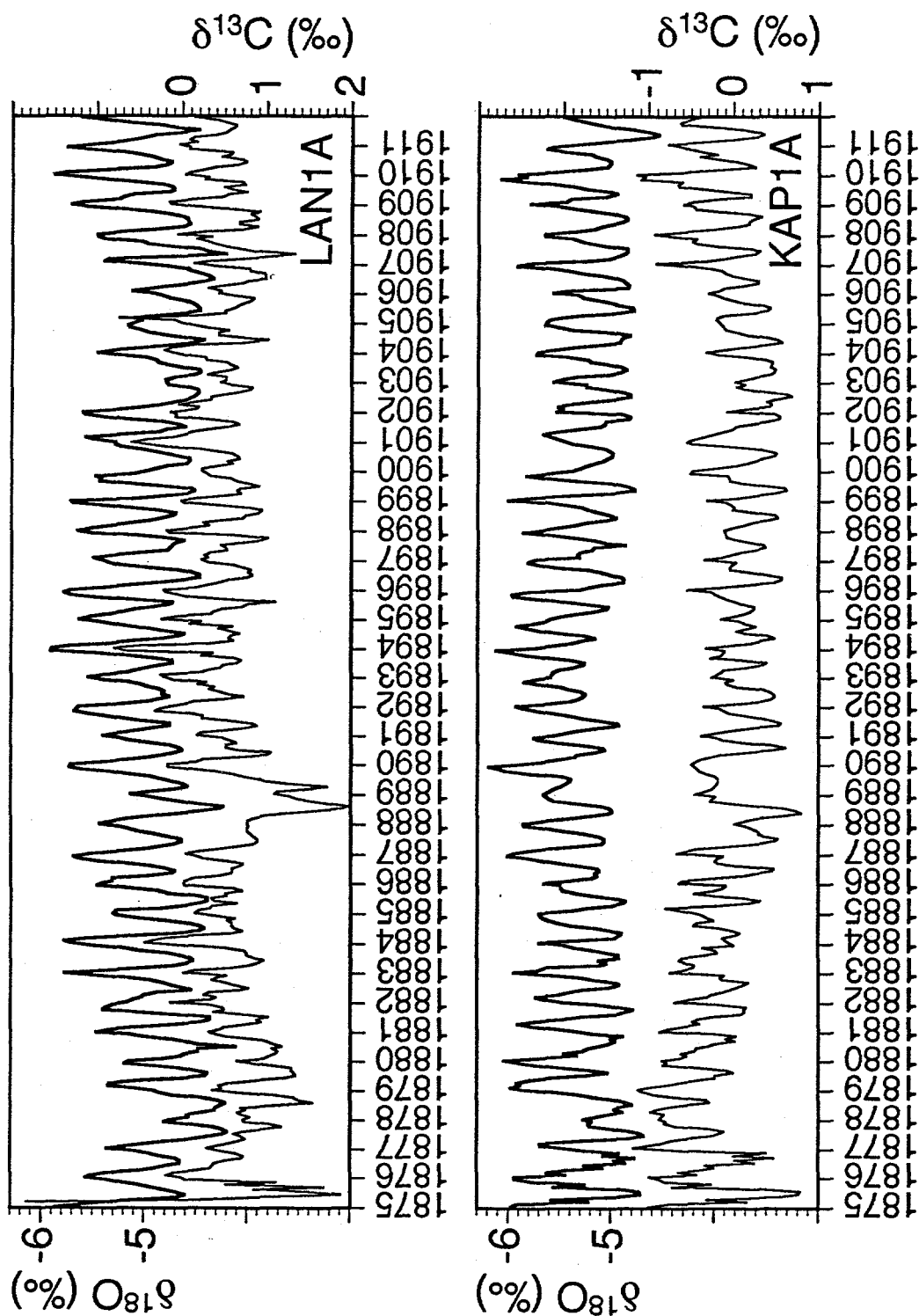


Figure 21. LAN1A stable isotope time series (1875-1911), shown with the KAP1A time series (1875-1911).

Time Series Resolution

An estimate of the time series resolution is given by the sampling rate value, which is the average ratio of measured samples to interpolated monthly values. At the 1 mm sample increment with a monthly resolution interpolation, The KAP1A core is under-sampled by 20% because it has a average growth rate of less than 10 mm yr⁻¹. The LAN1A core during 1951-1989 is over-sampled by 40%, as it has a average growth rate of 17 mm yr⁻¹. The other cores are sampled at about monthly resolution.

Table IV. Stable Isotope Analyses

Coral $\delta^{18}\text{O}$ Record	Analyses	Time Span	Yr.	Growth Rate (mm yr ⁻¹)	Sampling Rate ($\Delta x \Delta t^{-1}$)
KAP 1A	1242	1860-1987	128	9.7	0.81
KAP 3A	299	1970-1992	23	13.0	1.08
LAN 1A	666	1951-1989	39	17.1	1.42
LAN 1A	449	1875-1911	37	12.1	1.01

Seasonality

The means, mean seasonality, and maximum and minimum seasonality for each stable isotope time series are given in Table V. Seasonality was determined by maxima and minima differencing, which gives the maximum isotope shift occurring in each year. The KAP1A section from 1969-1987 has anomalously low variance compared to the rest of the time series (Figure 18). The mean $\delta^{18}\text{O}$ seasonality is 0.91‰ during 1860-1968, and only 0.56‰ during 1969-1987; this represents a 40% decrease in seasonality. This section of the core has a very low growth rate and is texturally different than the lower sections. The KAP1A colony was growing at about 2.5 m depth, and may have been occasionally exposed at low tide. The $\delta^{18}\text{O}$ seasonality in KAP3A time series is 0.79‰ (Figure 19), comparable to the lower section of the KAP1A core, and 40% greater than the suspect

section. The mean seasonality in the LAN1A core is greater during 1951-1989 (Figure 20) than during 1875-1911 (Figure 21), and greater than the contemporaneous KAP1A and KAP3A time series. The LAN1A 1875-1911 time series has comparable mean seasonality to the KAP1A 1860-1968 time series.

Table V. Stable Isotope Time Series Statistics (‰)

Time Series	$\delta^{18}\text{O}$	Mean	Max	Min	$\delta^{13}\text{C}$	Mean	Max	Min
	Mean	Seas	Seas	Seas	Mean	Seas	Seas	Seas
KAP1A 1860-1968	-5.187	0.910	1.364	0.397	-0.166	1.088	2.098	0.276
KAP1A 1969-1987	-4.898	0.562	1.031	0.275	0.035	0.592	1.382	0.265
KAP3A 1970-1992	-5.497	0.787	1.321	0.323	-1.549	0.793	1.783	0.323
LAN1A 1951-1989	-5.326	1.164	1.665	0.721	-0.224	1.262	1.991	0.655
LAN1A 1875-1911	-4.972	1.032	1.355	0.640	0.506	1.033	1.888	0.625

Reproducibility

The mean monthly seasonality (monthly averages) for the KAP1A, KAP3A and LAN1A time series was computed to determine the reproducibility of the seasonal phasing, as shown in Figure 22. The $\delta^{18}\text{O}$ minima consistently falls in January for all of the time series, while the $\delta^{18}\text{O}$ maxima falls in June-July for KAP1A and LAN1A, but in May-June for KAP3A. This timing is consistent with the precipitation climatology, and lends strength to the age model.

To assess their inter-site reproducibility, the time series were cross-correlated over contemporaneous sections. The correlations between KAP1A and LAN1A are fairly high during 1951-1968 ($r = 0.70$), and during 1875-1911 ($r = 0.64$), as shown in Table VI. The correlation between LAN1A and KAP3A is low, only $r = 0.46$. To assess the interannual reproducibility, the time series

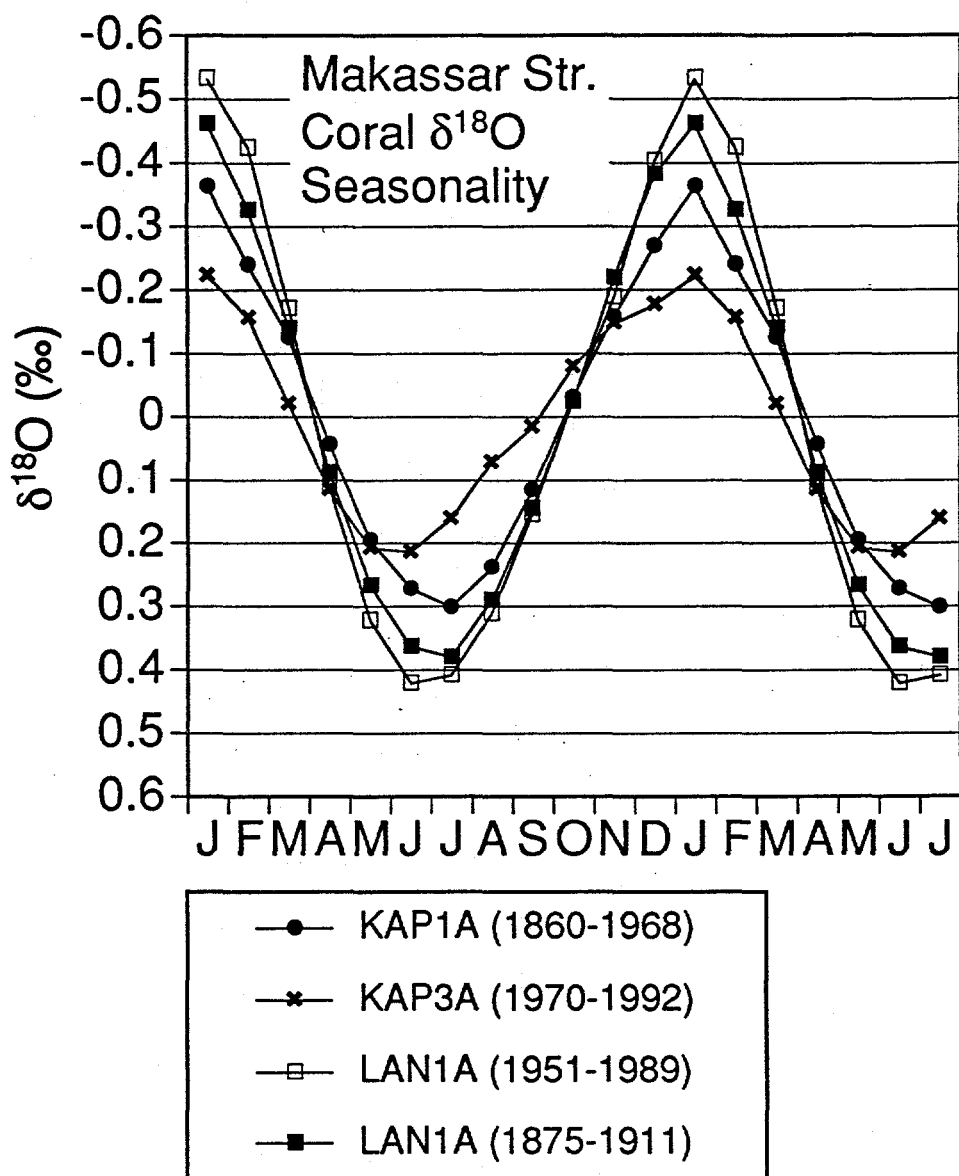


Figure 22. Monthly Mean $\delta^{18}\text{O}$ for KAP1A, KAP3A, and LAN1A time series.

were smoothed using a peak-centered 13 month running mean (applied twice) to suppress seasonal variability and cross-correlated again (Figure 23). Agreement between LAN1A and KAP1A is higher on interannual time scales during 1951-1968 ($r = 0.76$), but diminished during 1875-1911 ($r = 0.56$). Agreement between LAN1A and KAP3A is higher on interannual time scales, $r = 0.51$.

Table VI. Zero-lag Correlations (r)

<i>Monthly</i>	KAP1A 1860-1968	KAP3A 1970-1989
LAN1A 1951-1989	0.70	0.46
LAN1A 1875-1911	0.64	N/A
<i>Interannual</i>		
LAN1A 1951-1989	0.76	0.51
LAN1A 1875-1911	0.56	N/A

While LAN1A and KAP3A have comparable mean $\delta^{18}\text{O}$ values, KAP1A and LAN1A display opposite trends, with KAP1A $\delta^{18}\text{O}$ increasing by $+0.4\text{‰}$ and LAN1A $\delta^{18}\text{O}$ decreasing by -0.5‰ . The significance of these trends will be further discussed in Chapter 4, but here it can be stated that these trends are unlikely to be climate-related given the proximity of the two sites to each other and the magnitude of the trends (equivalent to about 2°C).

DISCUSSION

Seasonal $\delta^{18}\text{O}$ Response

The ensemble average seasonality for the KAP1A (1860-1969) and LAN1A (1875-1911, 1951-1989) time series is 1.00‰ . This result compares favorably to the seasonality estimates from the atlas and field data presented earlier. The GOSTA mean annual SST variation is for the $1^\circ \times 1^\circ$ grid box adjacent to the Spermonde Bank is 1.5° , which implies a freshwater flux excess of 0.67‰ ($1.0\text{‰} - 1.5^\circ\text{C} \times 0.22\text{‰ } ^\circ\text{C}^{-1}$). Applying the Kapoposang 3m

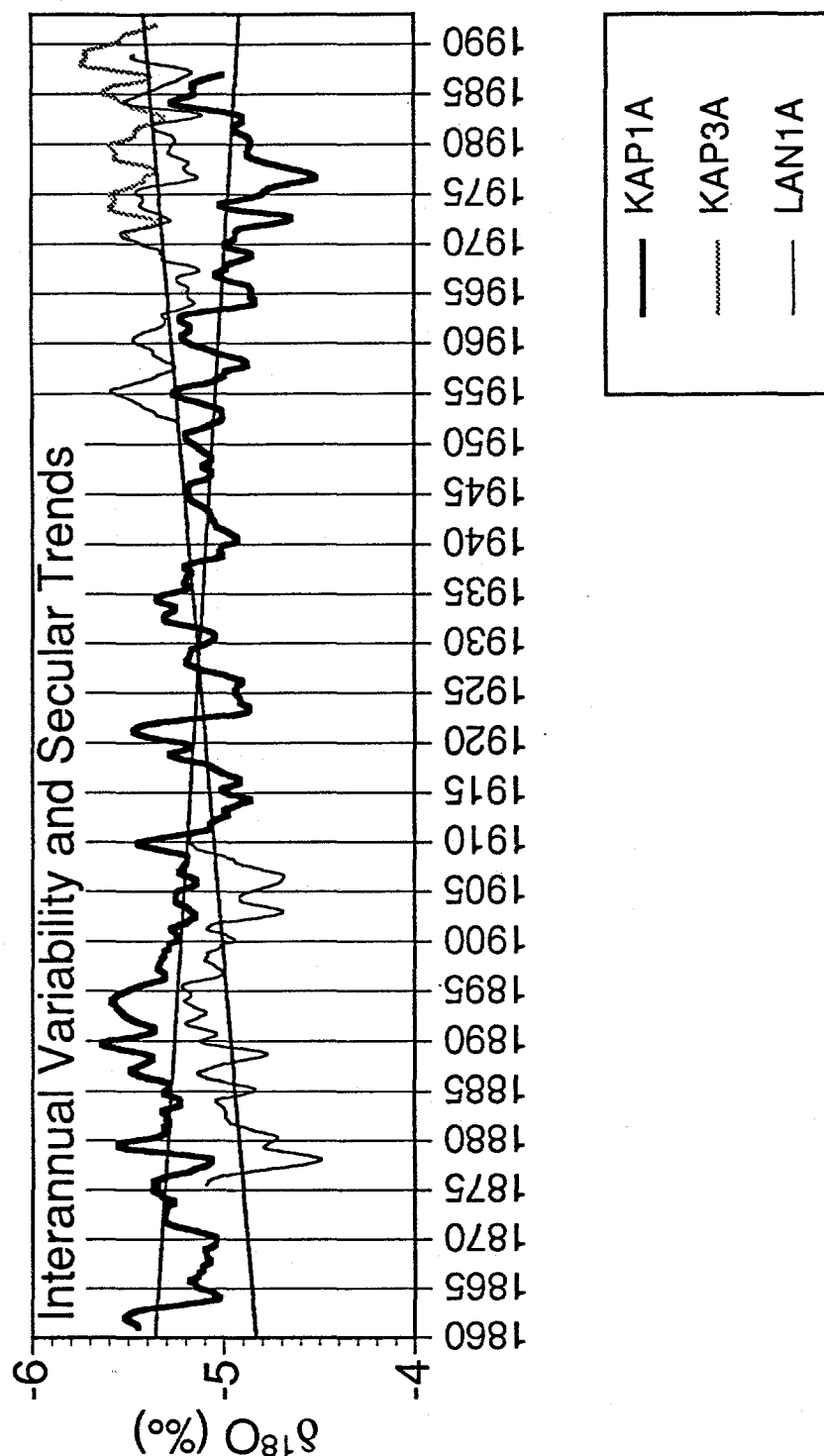


Figure 23. Interannual Variability in KAP1A, KAP3A and LAN1A $\delta^{18}\text{O}$. Time series were smoothed twice with a 13-month running mean to suppress seasonal variability. Linear fit curves shown for KAP1A ($+2.86\text{e-}4 \text{ ‰ mo}^{-1}$) and LAN1A ($-3.66\text{e-}4 \text{ ‰ mo}^{-1}$).

seawater $\delta^{18}\text{O}$ /salinity mixing line ($0.66\text{‰} / 0.269 \text{‰ psu}^{-1}$), this is equivalent to a salinity variability of 2.45 psu, in close agreement with observations (Wytrki, 1961; Levitus, 1982; see Figure 10).

Earlier it was estimated that 2380 mm of rainfall with an average $\delta^{18}\text{O}$ value of -5.1‰ would produce an isotopic depletion of -1.0‰ in a 10m column of water. Precipitation maps indicate that the southern Makassar Strait receives 2400mm annually. Assuming the SST climatology is correct, the lower-than-expected freshwater flux seasonality in the coral data (0.67‰) implies, not surprisingly, that mixing is occurring over a greater depth range, closer to 15 m using the simple closed-bottom dilution estimate. The Ffield and Gordon (1992) advective-diffusion model estimate for the Makassar Strait mixing depth $(K_Z\tau)^{-0.5}$ is 35 m (see Table I). Thus for the purposes of site selection, the simple dilution estimate may be made with a column depth taken as $0.40(K_Z\tau)^{-0.5}$.

This relationship reveals another important constraint on site selection, since sites with high $K_Z\tau$ values will require significantly greater precipitation to achieve the same degree of isotopic dilution as was found in the Makassar Strait. In the Banda Sea the mixing depth estimate is 117 m⁶ (Ffield and Gordon, 1992); this can be modeled as a 47 m column, and about 11 m of rainfall is required to produce a -1.0‰ $\delta^{18}\text{O}$ dilution. Therefore, despite the fact that annual precipitation in the Banda Sea is 1700 mm (or 71% of the Makassar Strait precipitation) freshwater flux will produce a dilution effect of only -0.15‰ , or less than 25% of the response seen in the Makassar Strait. Furthermore, if the mixing depth varies as a function of seasonal or

⁶ Assuming an admixture of 25% North Pacific and 75% South Pacific water.

interannual changes in current velocity or throughflow (as it probably does in the case of the Indonesian Seas) this would have the effect of producing a $\delta^{18}\text{O}$ anomaly independent of freshwater flux or SST. This has not been explored in coral-based studies, and deserves further attention. If both SST and freshwater flux variability can be constrained, then it should be possible to reconstruct variability in mass transport, and by extension, horizontal or inter-basin heat flux. This type of study would be limited to sites with time series observations of both SST and precipitation, and in practice, may only be possible for recent decades.

Local Variability

The basic interannual response in the $\delta^{18}\text{O}$ records is a suppression of the $\delta^{18}\text{O}$ minima during periods of low freshwater flux, sometimes coupled with enhanced or prolonged $\delta^{18}\text{O}$ maxima. The degree to which both sites respond in synchrony is a function of the strength of the regional climate signal is compared to the local variability (which in this case might include variations in local climate, reef micro-environments, health of the coral, etc.). The local variability in the $\delta^{18}\text{O}$ time series can be simply determined by computing the root mean square (rms) difference of the two time series⁷, a procedure widely used in signal analysis to quantify noise levels in time series data. Where cross-correlation analysis (Table VI) gives a reduced single-value estimate of agreement, the rms difference gives a picture of the time-dependent reproducibility (or fidelity) over the length of the record.

⁷ The standard deviation from the expected mean at time t , in the special circumstance when the mean equals zero and the standard deviation is a constant (Wirsching, 1992).

The rms differences were computed for each of the contemporaneous sections of the detrended and deseasonalized $\delta^{18}\text{O}$ time series. The monthly residuals for KAP3A and LAN1A are shown in Figure 24 with the computed rms differences. The monthly residual time series were smoothed by twice applying a 13 month peak-centered running mean, and the rms differences recomputed, as shown in the lower panel of Figure 24. Large rms differences occur in 1971, 1978-79, 1982, 1984, 1987. Smallest differences occur in 1973-74, 1977, 1980, 1983, 1985-86, 1989. Through several of these years, the time series have a very similar response, as can be seen in both panels for 1972, 1980, 1982-83, and 1986. The rms differences for the KAP1A and LAN1A time series during 1951-1968 are shown in Figure 25. The largest rms differences occur in 1955, 1958, 1962-63, and 1967. The smallest rms differences occur in 1953, 1958-59, 1963-64. The rms differences for KAP1A and LAN1A during 1875-1911 are shown in Figure 26. Largest rms differences are in 1879-80, 1888-89, and 1903-1907. Smallest rms differences are in 1877, 1882-83, 1886, 1891, 1895-1901, 1908, and 1910. The average of the rms differences for each of the contemporaneous sections is given in Table VII. On monthly timescales, the records appear noisy, with the average rms difference no better than 0.11‰. However, on interannual timescales the rms differences are better than 0.06‰, which is comparable to the laboratory precision of ± 0.05 -0.08‰ for the measurement of $\delta^{18}\text{O}$.

Table VII. Inter-Site rms Differences

$\delta^{18}\text{O}$ Time series	Avg. rms Difference (Monthly Res.)	Avg. rms Difference (Interannual)
KAP3A, LAN1A 1970-1989	0.119 ‰	0.040 ‰
KAP1A, LAN1A 1951-1968	0.106 ‰	0.035 ‰
KAP1A, LAN1A 1875-1911	0.118 ‰	0.059 ‰

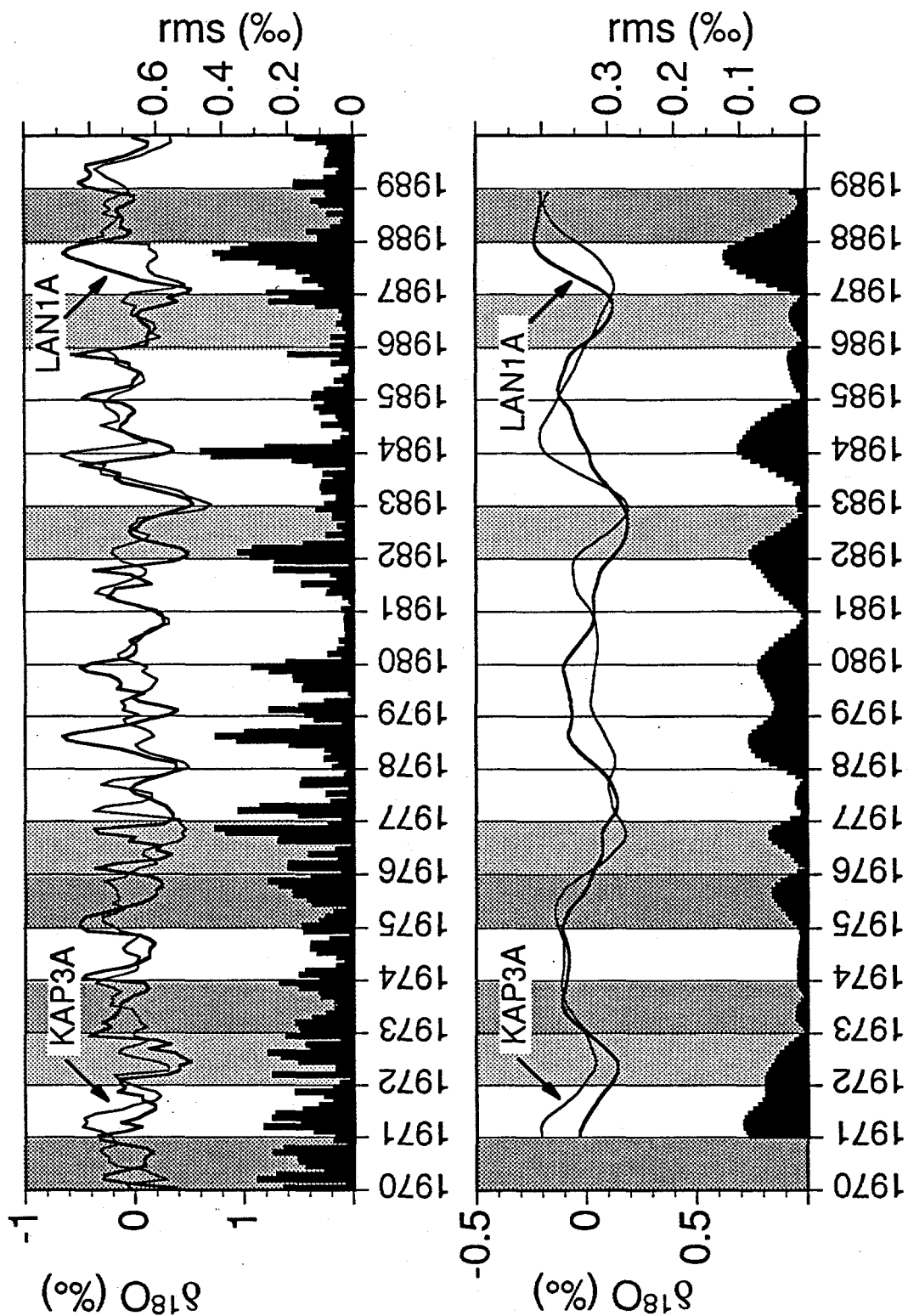


Figure 24. KAP3A and LAN1A rms Differences (1970-1987). Monthly values shown in upper panel, smoothed interannual values shown in lower panel. Bars are the Kiladis and Diaz (1989) El Niño (light) and La Niña (dark) phases.

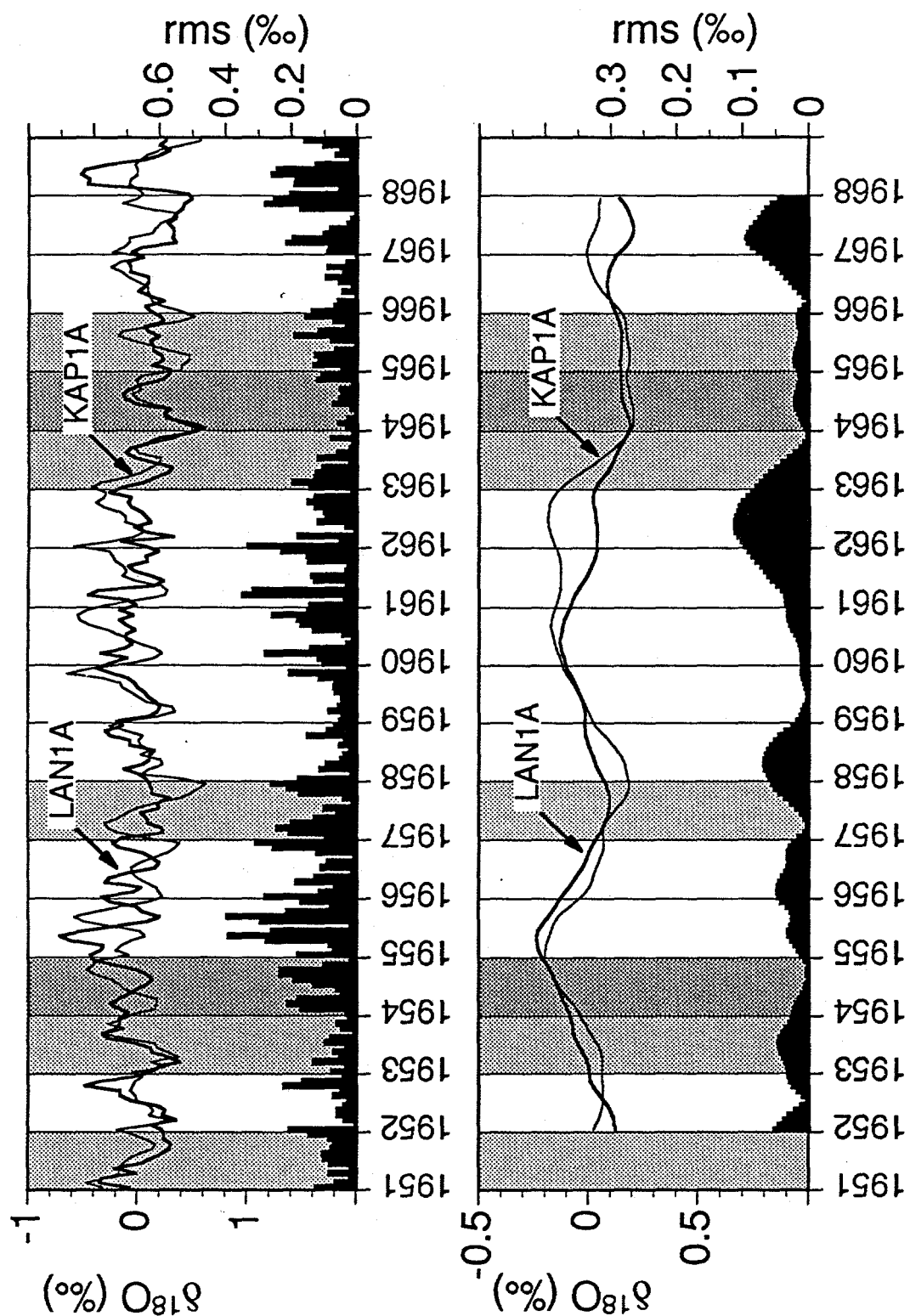


Figure 25. KAP1A and LAN1A rms Differences (1951-1969). Monthly values shown in upper panel, smoothed interannual values shown in lower panel. Bars are the Kiladis and Diaz (1989) El Niño (light) and La Niña (dark) phases.

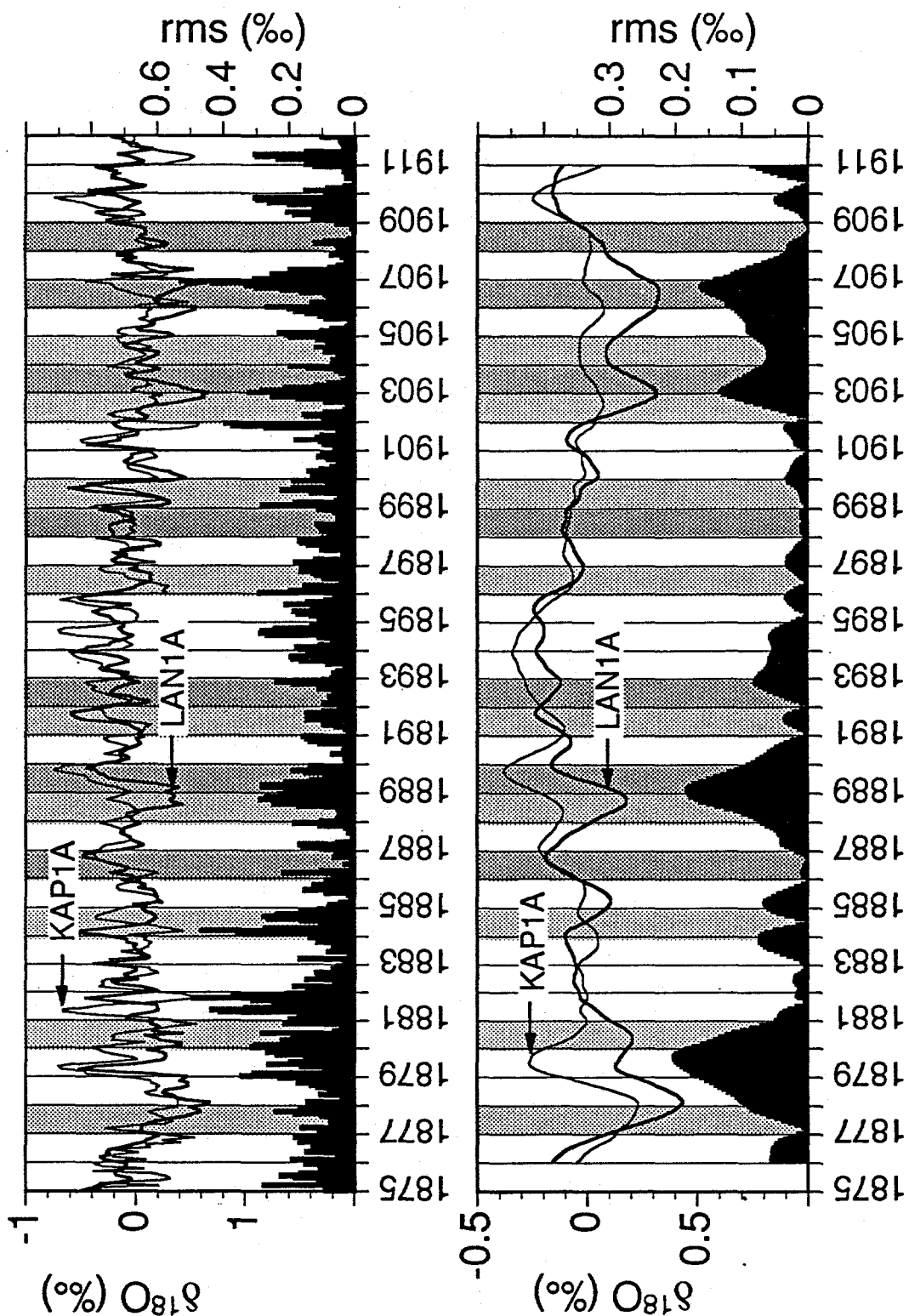


Figure 26. KAP1A and LAN1A rms Differences (1875-1911). Monthly values shown in upper panel, smoothed interannual values shown in lower panel. Bars are the Kiladis and Diaz (1989) El Niño (light) and La Niña (dark) phases.

The time series appear most coherent during the ENSO phases (El Niño and La Niña) in 1953-57, 1959, 1963-66, 1972-73, 1975-77, 1982-83, 1986 and 1988 (Figures 24 and 25). The least coherent years are not ENSO years: 1962, 1971, 1978-79, 1984, and 1987. For the turn-of-the-century period there are an equal number of cases (8) of both high and low coherency during ENSO phases (Figure 26). High coherency is observed for ENSO phases in 1877, 1882, 1891-92, 1896-1901, and 1908. Low coherency is seen for ENSO phases in 1880, 1884, 1888-89, and 1902-06. This suggests that each site is capturing the ENSO signal, and the two sites are responding in synchrony during periods of ENSO activity. Moreover, it is clear that single records may not provide sufficient information for distinguishing local variability from the regional climate signal. This is a compelling argument for the use of multiple $\delta^{18}\text{O}$ records in coral-based reconstructions.

Fidelity to Darwin SLP

In this section, the isotope records will be examined for their fidelity to interannual variability in the Darwin sea level pressure record, used here as a surrogate for deep convection generated by the Indonesian Low. The Darwin SLP record is the superior choice validating the performance of the Makassar Strait $\delta^{18}\text{O}$ records as climate proxies. The Darwin SLP pressure record is continuous since 1882, making it the longest complete SLP record in the region. For this analysis the record is extended to 1872 based on the reconstruction by Allan et al. (1990). Darwin is within the W. Pacific domain, and lies at the southeast end of the main axis of monsoonal ITCZ movement. Darwin has comparable seasonality to the Makassar Strait sites, and is highly sensitive to eastward displacements of the Indonesian Low during ENSO

warm phases. Because Darwin is relatively far from Sulawesi (1600 km), any coincident response in the Darwin SLP and Makassar Strait $\delta^{18}\text{O}$ records can be interpreted as representing a true regional-scale forcing.

As with the $\delta^{18}\text{O}$ time series, the Darwin SLP record was linearly detrended and deseasonalized by subtracting the monthly mean climatology, which is shown in Figure 27. The $\delta^{18}\text{O}$ KAP1A, KAP3A, and LAN1A time series were linearly detrended and deseasonalized in the same manner, using the climatologies described above. To facilitate the comparison between SLP and $\delta^{18}\text{O}$, all of the time series were normalized to ± 0.5 , based on the maximum and minimum values in each time series. Cross correlations and rms differences were computed for both the monthly residuals and the smoothed residuals (smoothed by twice applying a 13 point peak-centered running mean, as above).

The rms differences between the Darwin SLP and KAP1A and KAP3A are shown in Figures 28 and 29. KAP1A and Darwin SLP agree well up to 1915, although KAP1A appears insensitive to low pressure episodes in 1883-84 and 1898. There is a major discrepancy between the records in 1916-18, and again in 1922-25; in both cases the rms differences are greater than 10%. In the more recent section (Figure 29) the time series compare fairly well, and Darwin appears to lag KAP1A and KAP3A by several months. There are no periods of major discrepancy in this section, and the level of noise in records is moderate, ranging from 4-7%. The rms differences for Darwin SLP and LAN1A are shown in Figures 30 and 31. LAN1A agrees fairly well with Darwin SLP, and displays a lower level of noise than KAP1A over the same period. The largest discrepancies are in 1878-79 and 1907, where the LAN1A

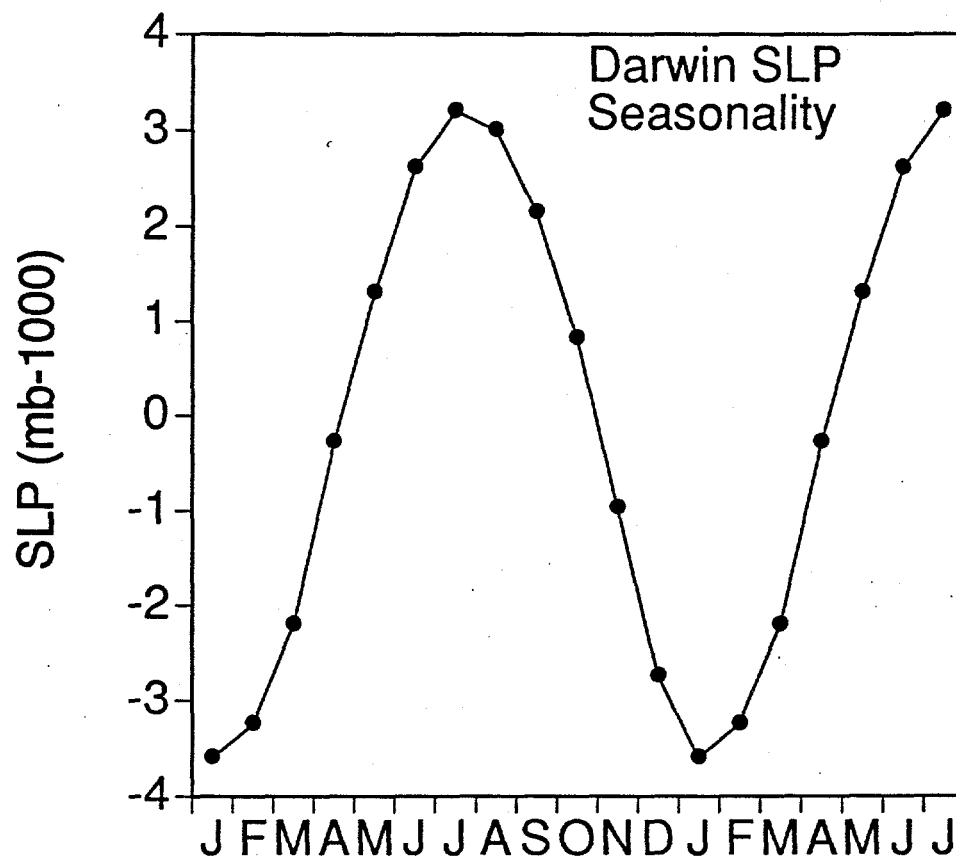


Figure 27. Variation in Mean Monthly SLP at Darwin Airport, Australia.

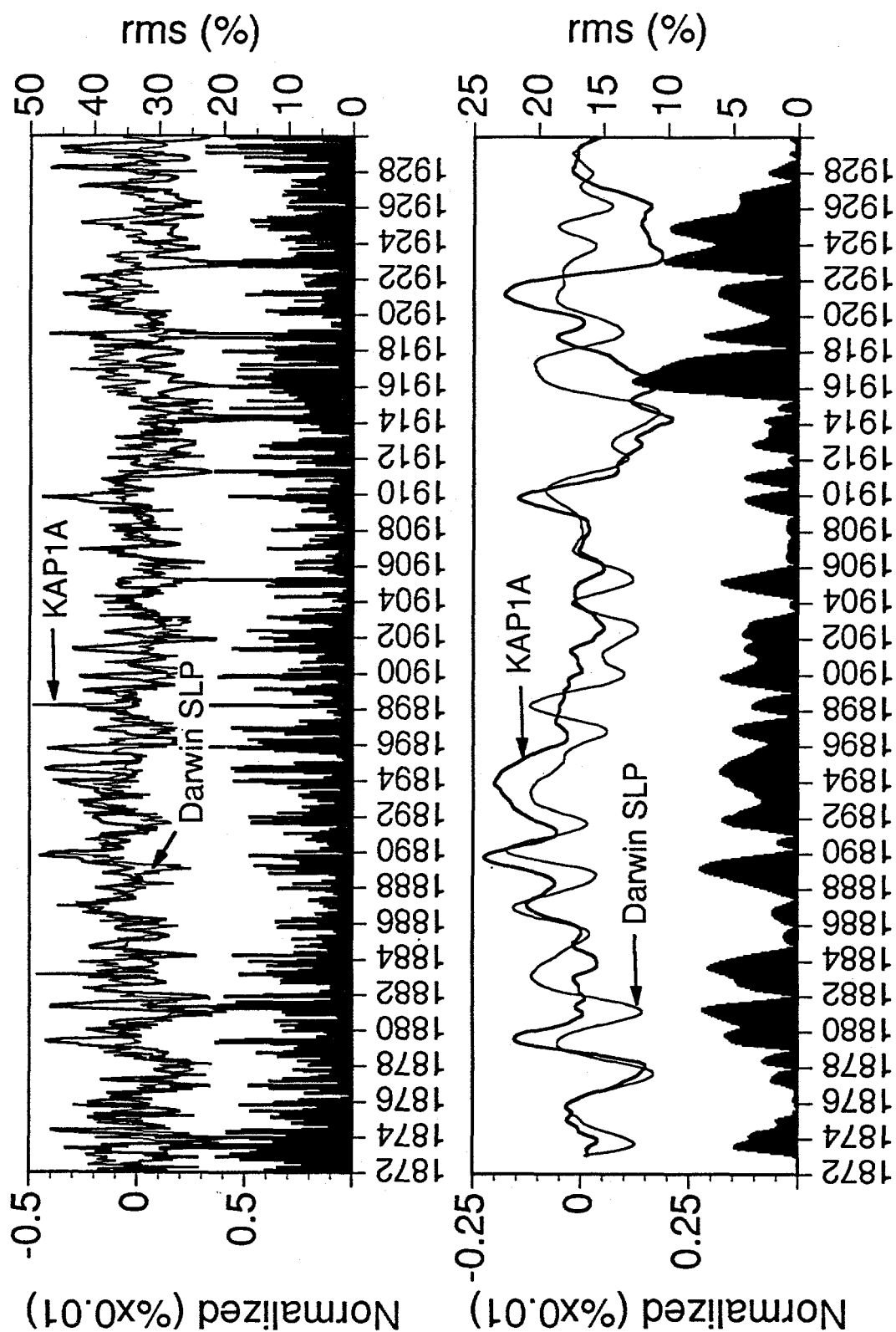


Figure 28. Darwin SLP and KAP1A $\delta^{18}\text{O}$ rms Differences (1872-1929), monthly (upper panel) and interannual (lower panel) values. Y-axes reversed.

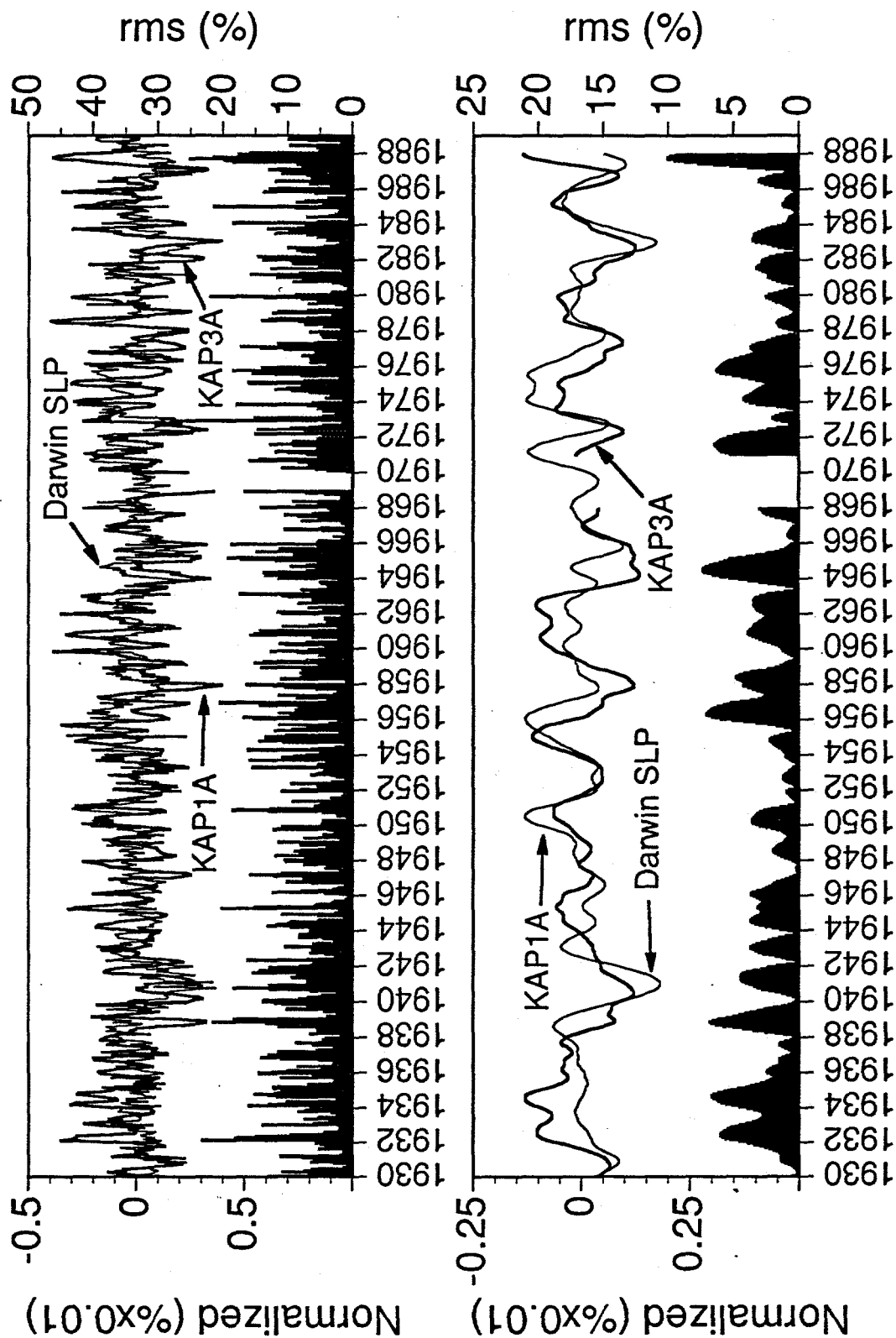


Figure 29. Darwin SLP and KAP1A and KAP3A rms Differences (1930-1987), monthly (upper panel) and interannual (lower panel) values.

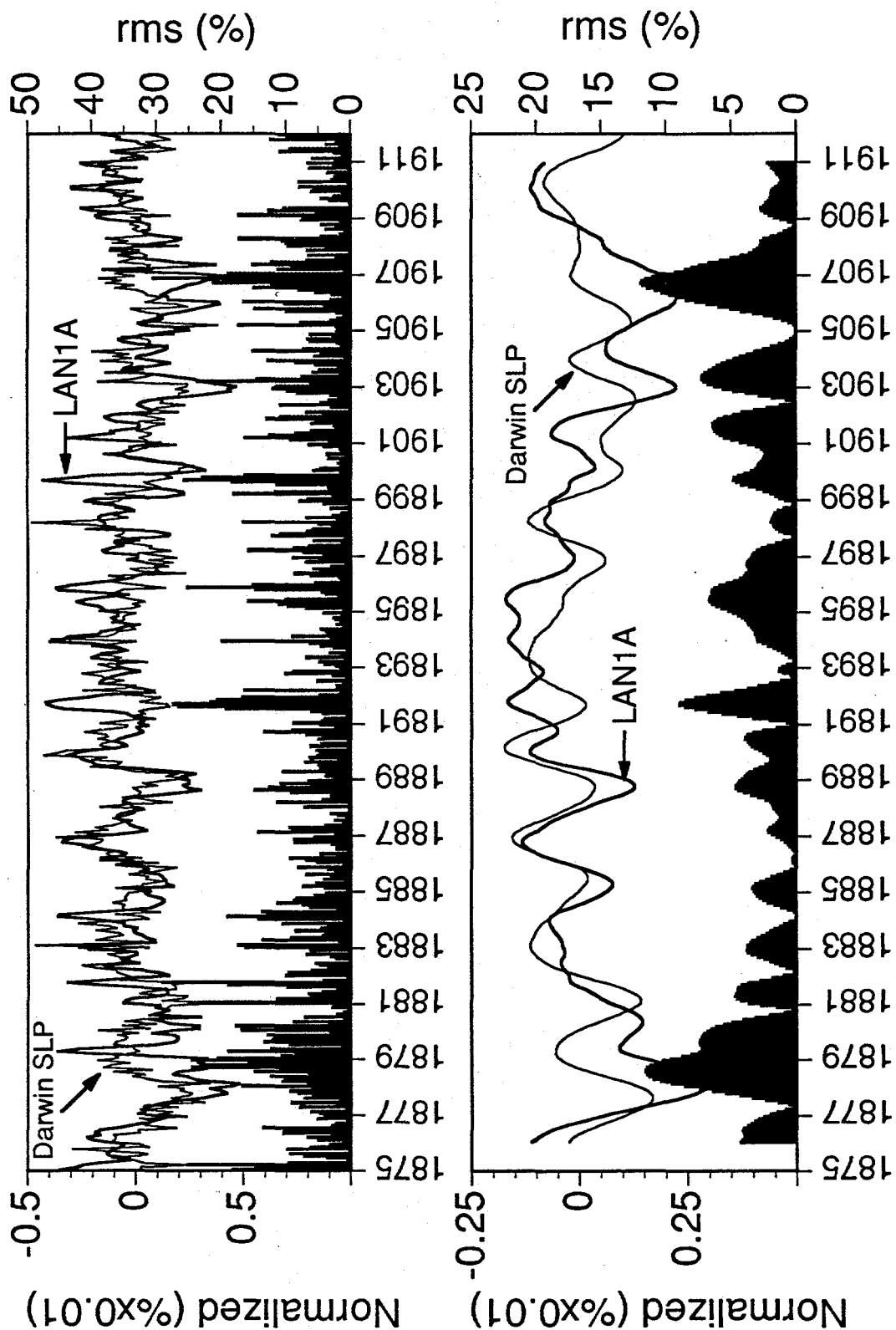


Figure 30. Darwin SLP and LAN1A rms Differences (1875-1911), monthly (upper panel) and interannual (lower panel) values. Y-axes reversed.

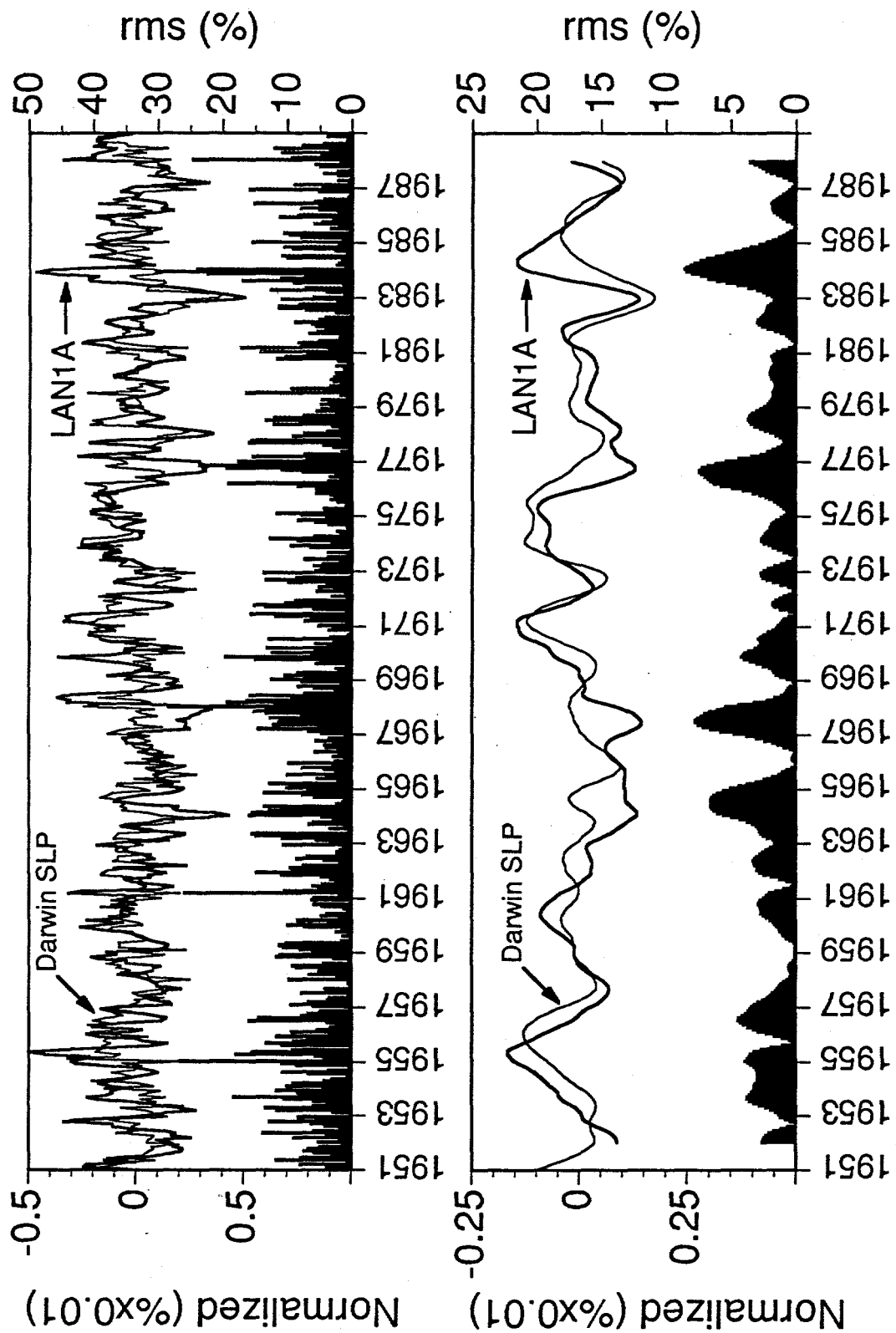


Figure 31. Darwin SLP and LAN1A rms Differences (1951-1987), monthly (upper panel) and interannual (lower panel) values. Y-axes reversed.

time series shows disproportionately large positive anomalies compared to Darwin SLP. The LAN monthly residual time series also shows some strong negative anomalies (1879, 1892, 1899) which are not seen in Darwin SLP. The recent section of the LAN1A time series (Figure 31) agrees fairly well with Darwin SLP. There are discrepancies related to persisting positive $\delta^{18}\text{O}$ anomalies in 1964, 1967 and 1977. There is a strong negative $\delta^{18}\text{O}$ anomaly in 1984 which does not appear in Darwin SLP. The cross-correlations and average rms differences for the monthly and interannual comparisons of the deseasonalized $\delta^{18}\text{O}$ and Darwin SLP time series are summarized in Table VIII. Cross-correlations for the monthly residuals are low, no better than $r = 0.3$. The average rms differences are about 7%. Smoothing the monthly residuals improves the correlations, and interannual zero-lag correlations are in the range of $r = 0.4$ - 0.6 . Smoothing also reduces the rms differences by about factor of two.

Table VIII. Comparison between $\delta^{18}\text{O}$ and Darwin SLP time series

$\delta^{18}\text{O}$ Time Series	Zero-lag Correlation (r)	Avg. rms Difference
<i>Monthly</i>		
KAP1A, 3A 1872-1988	0.21	7.2%
LAN1A 1875-1911	0.32	7.1%
LAN 1A 1951-1988	0.31	6.6%
<i>Interannual</i>		
KAP1A, 3A 1875-1988	0.50	3.1%
LAN1A 1875-1911	0.63	3.6%
LAN 1A 1951-1988	0.45	2.6%

Phase Relationships

The zero-lag cross-correlations of the $\delta^{18}\text{O}$ time series to Darwin SLP are low compared to the known fidelity of the regional climate suggested by the high correlations ($r = 0.8$) between river flow and SLP that were described

earlier. In some of the rms difference figures, $\delta^{18}\text{O}$ can be seen to occasionally lead Darwin SLP by several months (e.g. Figure 31). To further examine these lead/lag relationships, cross-correlation functions of the smoothed normalized residual series were computed to ± 60 lags (± 5 years) using the ARAND spectral analysis package (Howell, Brown University). The cross-correlation function of KAP1A with respect to Darwin SLP during 1872-1929 is shown in Figure 32. The highest correlation between KAP1A and Darwin SLP is at lag $m = 0$, $r = 0.53$. A moderate correlation ($r = 0.34$) is present at about ± 39 months. The cross-correlation function for LAN1A to Darwin SLP during 1876-1910 shown in Figure 33, and the highest correlation is found at $m = +4$, $r = 0.66$. Also present is the same periodicity at $m = \pm 39$ months. The similarity in $\delta^{18}\text{O}$ correlations at this lag suggests that is a real feature of the interannual variability in the regional climate. This periodicity (3.25 yr) lies within the typical 2.75-7.0 yr range of ENSO periodicities (Barnett, 1991).

The cross-correlation function for the KAP1A and KAP3A time series⁸ with respect to Darwin SLP during 1930-87 is shown Figure 34. The highest correlation is found at $m = -5$ months, $r = 0.58$. Another positive correlation is found at about $m = \pm 55$ months. The cross-correlation function for LAN1A to Darwin SLP during 1952-1987 is shown in Figure 35. The highest correlation is found at $m = -4$ months, $r = 0.66$. The positive correlation found earlier at $m = \pm 55$ months is also present. This periodicity, at about 4.5 yr, also represents an ENSO frequency.

⁸ Normalized KAP3A appended to normalized KAP1A, with missing data in 1969. The cross-correlation function can be computed with missing values.

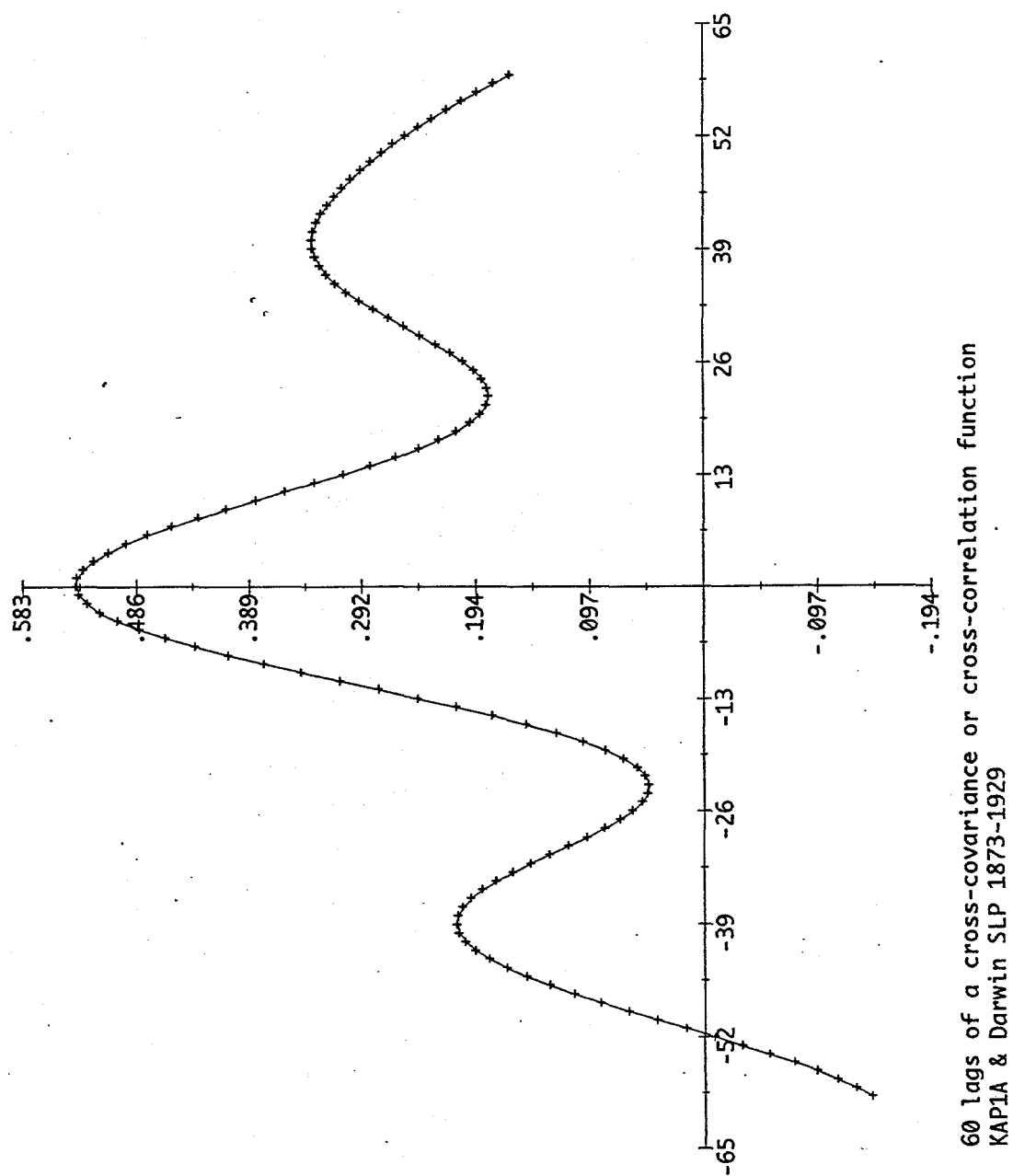


Figure 32. Cross-correlation for Darwin SLP and KAP1A (1872-1929). The y-axis is values of r and the x-axis is the lag (m) in months; negative values of m are KAP1A leading Darwin SLP, positive values of m are KAP1A lagging Darwin SLP.

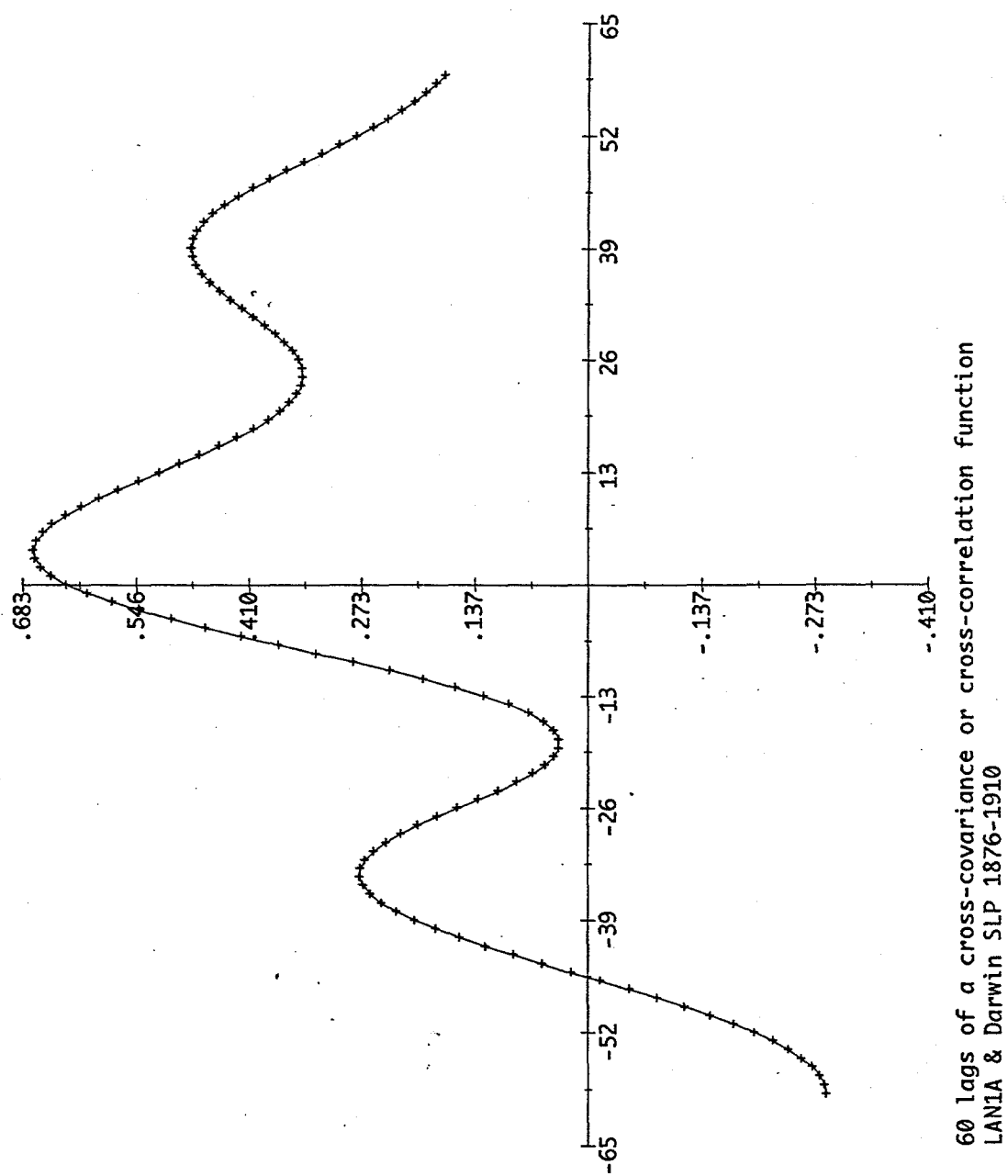
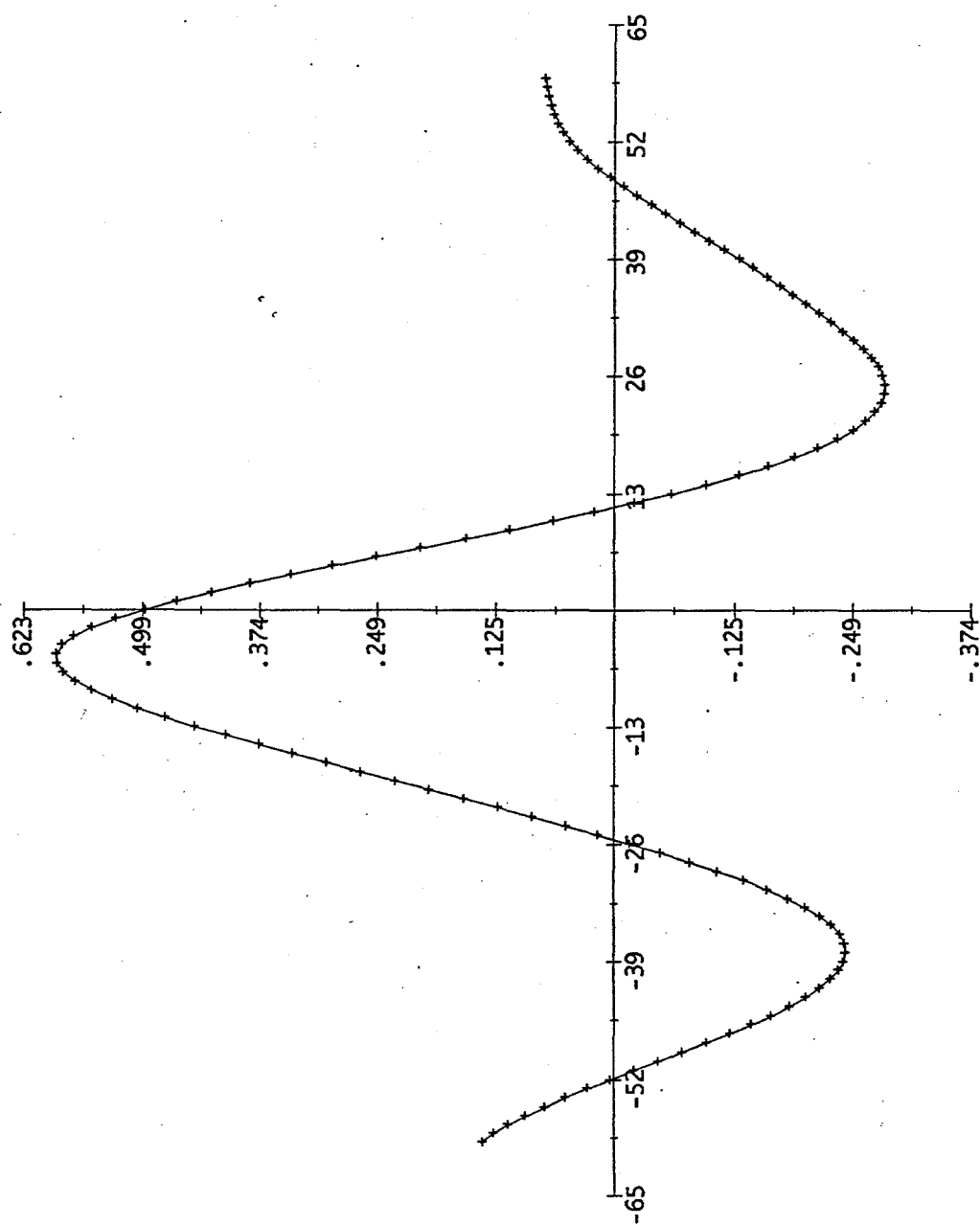


Figure 33. Cross-correlation for Darwin SLP and LAN1A (1875-1911).



60 lags of a cross-covariance or cross-correlation function.
KAP1A, 3A & Darwin SLP 1930-1987

Figure 34. Cross-correlation for Darwin SLP and KAP1A and 3A (1930-1987).

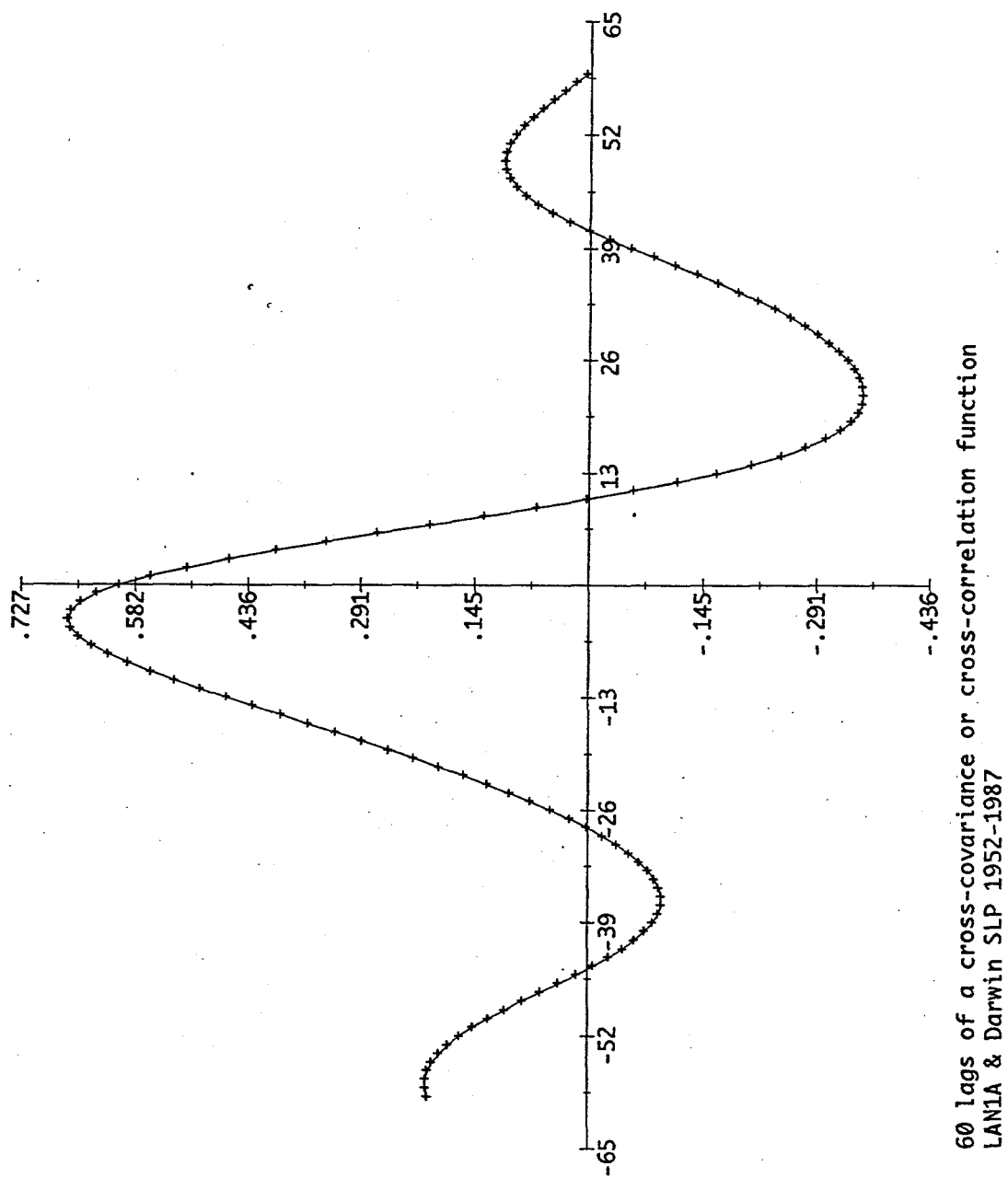


Figure 35. Cross-correlation for Darwin SLP and LAN1A (1951-1987).

The cross-correlation functions show that three of the interannual residual time series KAP1A (1930-1987) and LAN1A (1951-1987, 1875-1910) lead Darwin SLP by 4-5 months, suggesting a systematic error in the $\delta^{13}\text{C}$ age model. There should be no room for a lead lag relationship if the $\delta^{13}\text{C}$ minima age model is specified as January, since the S. Sulawesi cloud cover and precipitation maxima both occur in January, as does the SLP minimum at Darwin. Since the $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ minima are exactly in phase, the issue becomes whether the isotopic minima occur exactly in January, or occur later in the year. If there is a systematic error in month assignments in the $\delta^{18}\text{O}$ time series, cross-correlations between the deseasonalized residuals of $\delta^{18}\text{O}$ and SLP (as above) would reveal a phase-shift because the interannual variability is phase-locked to the seasonal cycle. The effects of vertical mixing, horizontal transport, watersheds, and the coral's own calcification response may introduce lags in the isotopic response. The actual timing of the coral $\delta^{18}\text{O}$ minima can be estimated from the field SST and salinity data, for at least the 1992-93 monitoring year. The time series were converted to per mil units; the Epstein et al. slope was applied to the daily SST time series and the Kapoposang 3m seawater $\delta^{18}\text{O}$ /salinity mixing line was applied to the weekly 3m salinity time series. The sum of these two time series is a time series of the convolved SST and freshwater flux effects as might be recorded by coral $\delta^{18}\text{O}$ at the site. The three time series; SST (in ‰), salinity (in ‰) and their sum (convolved response) is shown in Figure 36. The $\delta^{18}\text{O}$ minima of the convolved response occurs in April, i.e. it lags the precipitation maximum by four months. This would explain why the KAP1A and LAN1A time series appear to lead Darwin SLP by this amount.

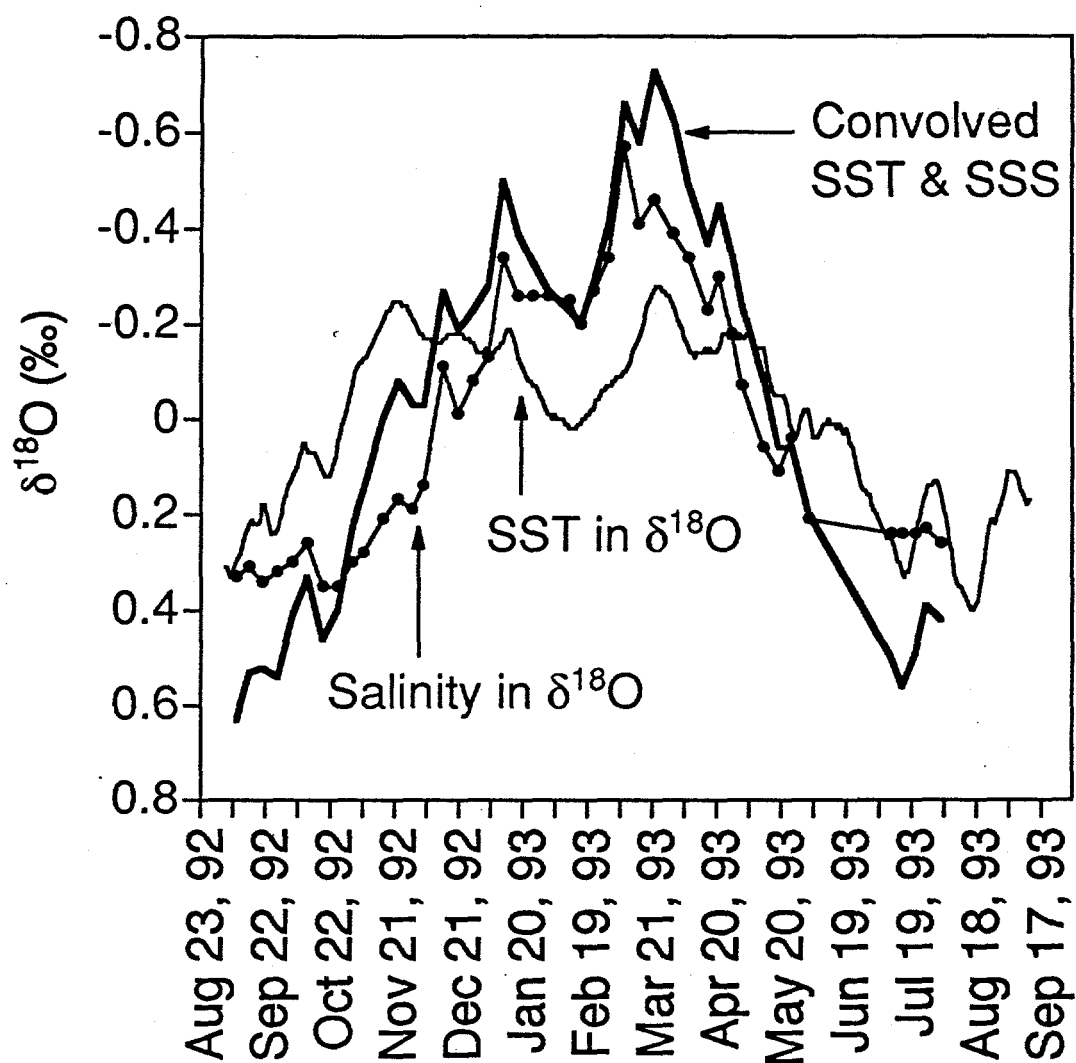


Figure 36. $\delta^{18}\text{O}$ Response from SST and Freshwater Flux Combined. 4 m SST times series from Kapoposang converted to $\delta^{18}\text{O}$ by applying the Epstein et al. (1953) slope (thin line); weekly 3 m salinity time series converted to $\delta^{18}\text{O}$ using the Kapoposang δw /salinity mixing line (dotted line). The time series are summed to produce a time series of the estimated convolved coral $\delta^{18}\text{O}$ seasonality (heavy line). The convolved minima occurs in April.

If such shifts are accounted for, can it be argued that the $\delta^{13}\text{C}$ age models have absolute monthly precision? Probably not, for several reasons. The $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ minima are phase locked, which is why the mean seasonality naturally shows the $\delta^{18}\text{O}$ minima to occur in January when the $\delta^{13}\text{C}$ minima is assigned to this month. The field data implies that a four month lag for $\delta^{18}\text{O}$ is a real feature of the site, and correcting for this dictates a shift in $\delta^{13}\text{C}$. This implies that $\delta^{13}\text{C}$ is lagging the cloud cover maximum by several months. Furthermore, the cross-correlation function shows no lead for KAP1A during 1872-1929, which suggests there is some variability in $\delta^{13}\text{C}$ phasing, since the other time series show 4 month leads. Thus, one is forced to conclude that while the $\delta^{13}\text{C}$ minima accurately track the annual cycle, the phase-locking is not so tight as to provide absolute monthly reconstructions. Instead, the $\delta^{13}\text{C}$ age models should be assumed to have errors of several months.

CONCLUSIONS

Coral stable isotope records from two offshore sites in the Southern Makassar Strait have been analyzed for their reproducibility, isotopic response, degree of local variability, and sensitivity to regional climate forcing on monthly and interannual time scales. The results support the following conclusions:

1. The $\delta^{18}\text{O}$ time series have a strong, regular seasonality that corresponds very closely to the monthly climatologies for the region, and the $\delta^{18}\text{O}$ response is clearly dominated by freshwater flux.

2. In addition to meteoric $\delta^{18}\text{O}$ concentration and precipitation volume, the thermocline vertical diffusivity and surface water residence times exert strong control on δw and deserve consideration in site selection.
3. The time series show moderate reproducibility, with the inter-site cross-correlations ranging from $r = 0.5-0.8$ on monthly and interannual timescales. Analysis of the rms differences between the deseasonalized residuals for the two sites show the noise levels to be fairly high on monthly time scales, but on interannual timescales the noise levels falls to $0.05-0.07\%$.
4. The time series also have significant secular trends which are not reproducible, and are not climate-related. This suggests that long-term trends are subject to coral growth dynamics and should be treated with caution.
5. The interannual timescale may be the most reliable in coral-based climate reconstructions. The rms differences also suggest that coherency between the sites is generally higher during ENSO activity, which argues for the use of multiple records to constrain local effects.
6. The lag-adjusted cross-correlations to the Darwin SLP record are good on interannual time scales, in the range of $r = 0.5-0.7$, but still less than the fidelity of the local hydrologic response to Darwin SLP.
7. There appears to be some variability in the interannual lead/lag relationships, from which it can be concluded that the $\delta^{13}\text{C}$ age models have slight errors of ± 4 months.

8. All of the $\delta^{18}\text{O}$ time series contain 3-4 year ENSO periodicities indicative of a strong underlying response to interannual variability of the Indonesian Low. These low frequency signals will be analyzed by spectral estimation techniques in Chapter 3.

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CHAPTER 3

CORAL $\delta^{18}\text{O}$ VARIABILITY ON ENSO TIMESCALES: THE SIGNATURE OF THE INDONESIAN LOW

ABSTRACT

Monthly stable oxygen isotope ($\delta^{18}\text{O}$) time series from two sites in the southern Makassar Strait covering the period 1871-1992 are tested for their spectral coherency to the Darwin SLP pressure record, used here as a surrogate for convective variability of the Indonesian Low Pressure cell. Cross-spectra are computed in the first analysis, revealing statistically significant interannual coherency within the ENSO low-frequency (LF) bandwidth (period 2.75-7.0 yr; Barnett, 1991). In the second analysis, the data-adaptive technique of singular-spectr2ntify the fundamental frequency modes in the coral $\delta^{18}\text{O}$ and Darwin SLP time series. The time-evolution of each of the fundamental modes are examined using the SSA reconstructed components. In the third analysis, the additive properties of the SSA reconstructed components are exploited to generate a single ENSO LF mode for each of the coral $\delta^{18}\text{O}$ time series, which are then cross-correlated to the corresponding ENSO LF mode derived from the Darwin SLP time series. High correlations to the Darwin SLP record are found on this time scale, $r = 0.7-0.8$, and although the amplitudes are not exactly reproduced, there are no large oscillations in the Darwin SLP record which are not captured by the coral $\delta^{18}\text{O}$ records. These results provide a foundation for extending the Indonesian coral $\delta^{18}\text{O}$ records into the pre-historical period, and suggest that hindcasting of the ENSO-related variability of the Indonesian Low can be achieved with acceptable levels of confidence.

INTRODUCTION

The El Niño-Southern Oscillation (ENSO) has far-reaching, nearly global effects. Its periodicities can be detected in climate records throughout most of the tropics and even into the mid-latitudes. The ENSO has been termed a quasi-periodic oscillator (Barnett, 1991) because it has the features of a standing wave but the interval of its cycles varies. The ENSO appears to operate over three distinct timescales. The first, and least variable timescale is the annual cycle of seasons. ENSO phase changes are locked to the seasons, such that ENSO-related anomalies are expressed as an amplification of the normal seasonality. For example, in the equatorial Eastern Pacific, ENSO warm-phase SST anomalies typically peak during the boreal spring; this is the season of warmest SSTs (Philander, 1990). The second, and more variable timescale is the 18-24 month life-span typical of "canonical" ENSO events (Rasmusson and Carpenter, 1982). This two-year periodicity is referred to as the quasi-biennial (QB) timescale (Barnett, 1991). The third, and most variable timescale is the ENSO warm-phase recurrence interval. ENSO warm-phases occur on average every 2-8 years (Quinn et. al., 1987; Kiladis and Diaz, 1989). This lower frequency timescale is the dominant mode of interannual variability in the tropics, and has been referred to as the ENSO LF timescale (Barnett, 1991). A common feature of tropical SST, SLP, and zonal wind data is a concentration of energy in both the QB and ENSO LF bands (Figure 1, after Barnett, 1991).

The seasonal timescale is of lesser importance in ENSO dynamics because it completely dominates the expression of ENSO and shows little variation from year-to-year. In an analysis of global SLP data, Barnett (1991) found that the ENSO LF band describes about twice as much variance as the

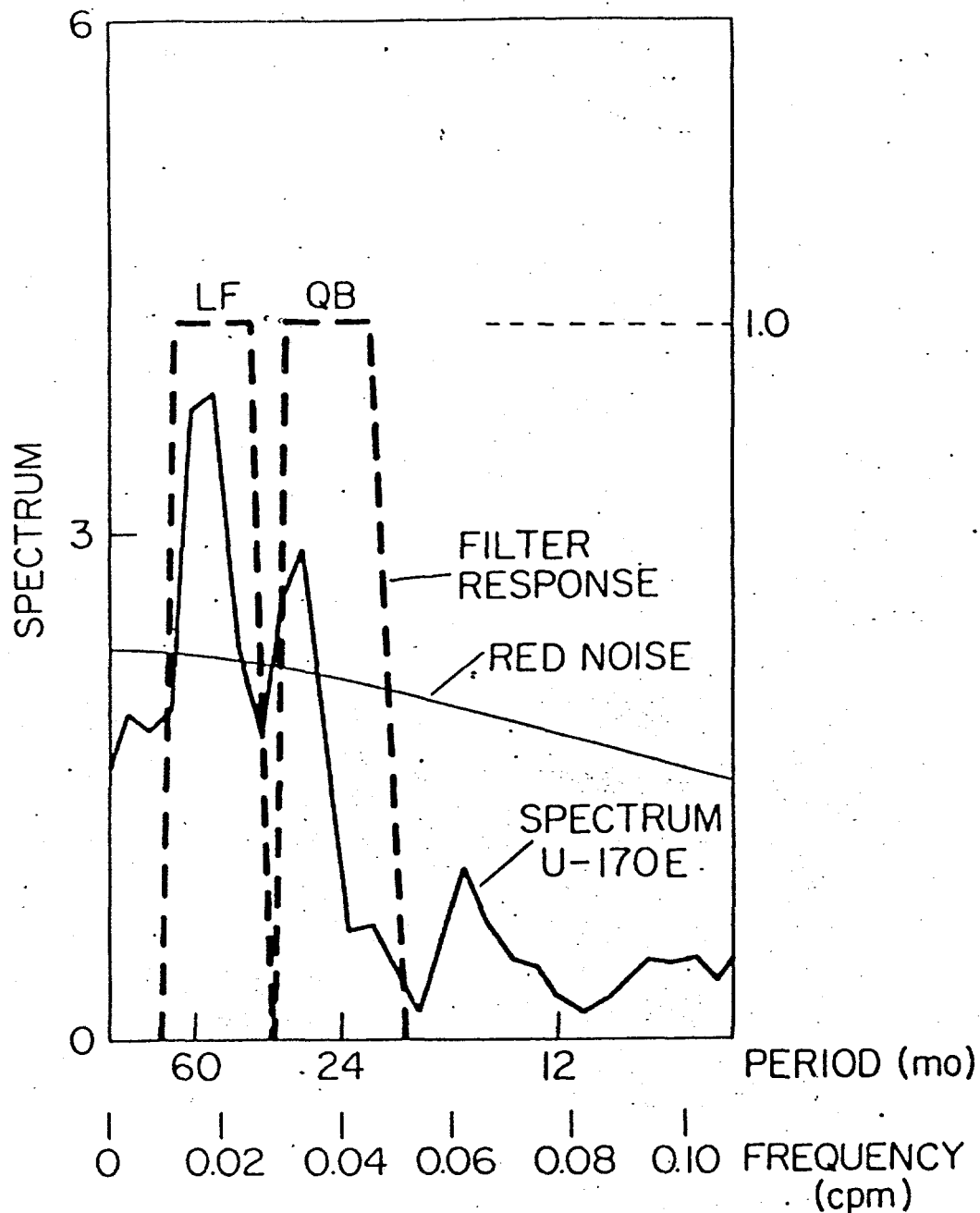


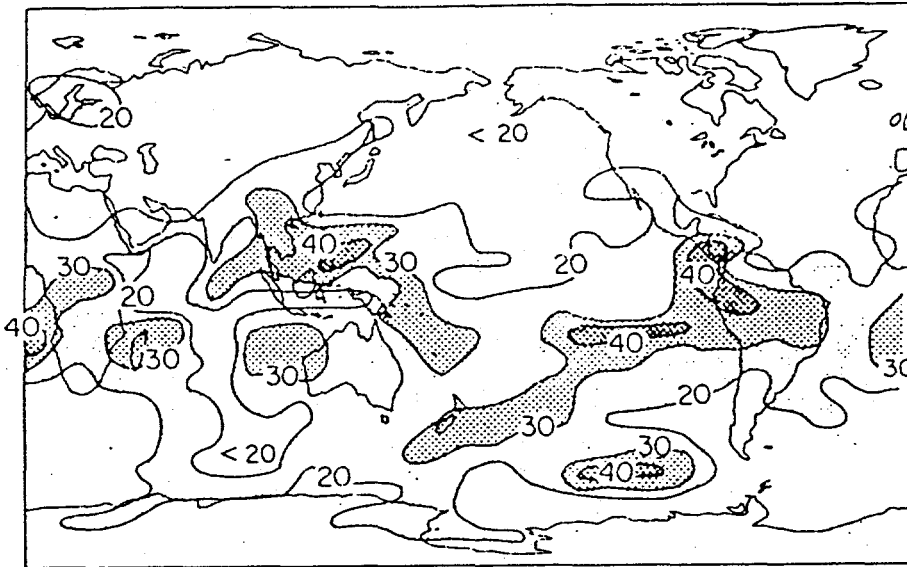
Figure 1. Power Spectrum of Equatorial Zonal Wind (after Barnett, 1991). The y-axis is spectral density (power) and the x-axis is the frequency domain (in months and cycles per month). Low frequency energy in tropical climate data is often concentrated in two bandwidths, the LF band (low frequency periods in the range 2.75-7.0 years) and the QB band (quasi-biennial periods in the range 1.5-2.5 yrs). The red noise line is the statistical limit below which low-frequency power cannot be differentiated.

QB band (Figure 2). QB band variance is weak in S.E. Asia, and phase relationships in the QB band suggest a propagating wave near the equator in the rest of the Pacific. The QB time scale appears to be related to the eastward propagation of ENSO energy from S.E. Asia¹. The ENSO LF band is strongest in S.E. Asia and the E. Pacific, accounting for over 30% of the variance in the SLP data, and it has a spatial pattern similar of Walker's plots of the Southern Oscillation. Phase relationships in the ENSO LF band suggest a standing wave, and the ENSO LF band appears to be more important energetically to the ENSO process as it is associated with phase changes. Barnett (1991) concludes that the ENSO LF band has the strongest expression in the Indo-Pacific climate system.

In the previous chapter, it was found that cross-correlations between the Makassar Strait coral $\delta^{18}\text{O}$ time series and the Darwin SLP record were lower than might be expected, due to the moderately high noise levels in the coral $\delta^{18}\text{O}$ time series. Smoothing the $\delta^{18}\text{O}$ time series improved the cross-correlations and revealed underlying interannual periodicities in the ENSO LF band. The observations by Barnett (1991) imply that an important test of the fidelity of the coral $\delta^{18}\text{O}$ proxy records to regional climate will be how much interannual $\delta^{18}\text{O}$ variance is concentrated in the QB and ENSO LF bands. Sites in S.E. Asia should have significant signal energy in the ENSO LF band. Furthermore, since the change in signal strength within the ENSO LF band over time represents the fundamental historical signature of the ENSO (especially in S.E. Asia), another key test will be how well the time-evolution of the coral $\delta^{18}\text{O}$ ENSO LF band signal agrees with that of the

¹ Barnett (1990) also concludes that the ENSO QB band is not strongly related to the stratospheric quasi-biennial oscillation (QBO) described by van Loon and Shea (1985).

PERCENTAGE SLP VARIANCE PASSED BY LF FILTER



PERCENTAGE SLP VARIANCE PASSED BY QB FILTER

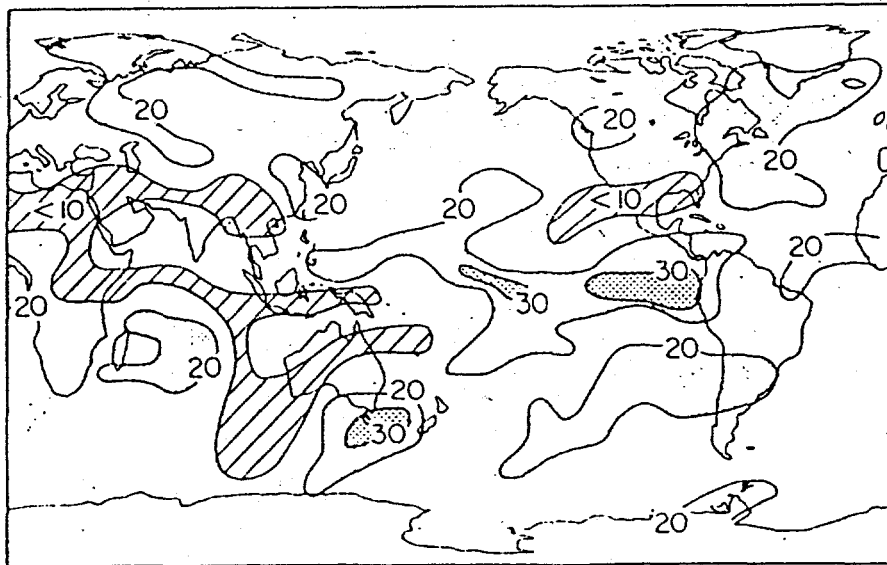


Figure 2. Maps of LF and QB Band Variance in Global SLP Data (after Barnett, 1991). Stippled areas are $> 30\%$ variance passed, hatched areas are $< 10\%$ variance passed. Most of the low-frequency energy is concentrated in the LF band, which has the spatial features of a standing wave with nodes in S.E. Asia and the E. Pacific. The LF band is sensitive to the energetics of ENSO processes and appears to be the fundamental mode in the Indo-Pacific.

regional instrument record.

Spectral analysis methods provide a means for estimating low frequency signals despite the presence of high frequency noise, and are well suited for the fidelity tests described above. This chapter will examine three aspects of the interannual variance of the Makassar Strait coral $\delta^{18}\text{O}$ time series. In the first section, the spectral density functions of the coral $\delta^{18}\text{O}$ time series are estimated and compared to the Darwin SLP spectrum, and the significantly coherent frequencies are determined. The distribution of variance in the ENSO and QB bands is described, and the $\delta^{18}\text{O}$ and SLP coherency at the two time scales determined. In the second section, the fundamental frequency modes are isolated, ranked and their change in strength with respect to time described. In the third section, the dominant frequency components of the $\delta^{18}\text{O}$ time series in the ENSO LF band are pooled to reconstruct a single mode that comprises the essential ENSO-related variance captured by the coral $\delta^{18}\text{O}$ records. The coral $\delta^{18}\text{O}$ ENSO LF modes are cross-correlated to similarly-reconstructed Darwin SLP ENSO LF modes to assess their fidelity to regional climate variability on this fundamental ENSO timescales.

DATA SETS

Three coral $\delta^{18}\text{O}$ time series are used. Two are from the same core collected from Langkai Is.: LAN1A (1875-1911) and LAN1A (1951-1988). The third is from Kapoposang Is, KAP1A (1872-1968), and is truncated slightly to conform to the length of the extended Darwin SLP time series. The Darwin SLP time series is continuous since 1882, and is extended to 1872 based on the reconstruction by Allan et al. (1991).

METHODS

Estimation of Power Spectra and Cross-Spectra

Power spectra and cross-spectra are estimated using the ARAND time series analysis package developed at Brown University². Power spectra are estimated using the Blackman-Tukey method of taking the Fourier transform of the smoothed autocovariance function (Jenkins and Watts, 1968)³. The autocovariance function computes the variance of the time series relative to a copy of the time series over a specified range of lags (m). The autocovariance function is expressed as:

$$C(u) = \frac{1}{N} \sum_{t=1}^{N-u} x(t)x(t+u) \quad \text{where } u = 0, 1, 2, 3 \dots m$$

At $u = 0$, $C(u)$ is the variance of the time series with no lag, at $u=1$ $C(u)$ is the covariance of each point relative to the previous data point, etc. The autocorrelation function is:

$$R(u) = \frac{C(u)}{C(0)} \quad \text{where } u = 0, 1, 2, 3 \dots m$$

The statistics of spectral estimates are improved by smoothing the autocovariance function by multiplying it by a set of m filter weights. This is equivalent to smoothing in the frequency domain with a filter whose bandwidth is:

$$b = \frac{1.33}{m\Delta t}$$

² Dr. Phillip Howell, Dept. of Geology, Brown University.

³ This discussion follows Imbrie et. al. (1987), Crowley and North (1991), and Anderson (1992).

where m is the number of lags and Δt is the time interval between data points. Since the bandwidth is inversely proportional to the lag, the amount of detail seen in the spectrum and its accuracy depends mainly on the lag. The practical limit for spectral resolution is $m = N/3$. The spectrum is calculated by taking the discrete Fourier transform of the autocovariance function:

$$z_k = \sum_{t=1}^N x_t e^{2\pi i(t-1)\omega_k} \quad \text{where } \omega_k = \frac{(k-1)}{m}, \text{ and } k = 1, 2, 3, \dots, m.$$

ω_k are the frequencies running from the lowest at $1/m$ to the highest at 1. The frequency is in units of $1/\Delta t$. This reduces the autocovariance function to a set of sinusoids, represented in the frequency domain as a spectrum that describes the amount of variance per frequency band (σ^2/f). The area under the spectral curve is equal to the variance in the time series. When comparing time series composed of different variables (e.g. $\delta^{18}\text{O}$ and mb), spectral estimates are scaled by a constant so that the area under the spectral curve equals one; this is referred to as the spectral density function $R(f)$. Sometimes better spectral estimates are realized using normalized data, in which case $R(f)$ is computed using the autocorrelation function instead of the autocovariance function. The ARAND package computes the spectral density function for 101 ω_k given a user-specified starting frequency and bandwidth.

Frequency domain relationships between two time series x_i , ($1 \leq i \leq N$), y_i , ($1 \leq i \leq N$) can be examined by computing the cross-spectrum. The results of cross-spectral analysis are three functions, the first being the cross-correlation/covariance function, which is a function of the lag m . The

covariance function (valid if the means for the two time series equals zero) is given by:

$$R(m) = \frac{1}{N} \sum_{t=1}^{N-m} x(t)y(t+m) \quad \text{where } N = \text{the number of data points}$$

The cross-correlation function is the correlation between the two time series as they are shifted past each other by 0,1,2,3... m sample intervals:

$$r(m) = \frac{R(m)}{\left(\sum x(t)^2 \sum y(t)^2 \right)^{\frac{1}{N}}}$$

A Fourier transform of the cross-correlation/cross-covariance function allows for the determination of the coherency, which is the frequency dependent correlation between the two time series, as well as the phase relationship between the two time series as a function of frequency. The $\text{coh}^2(f')$ function gives the percentage variance contributed by frequency (f') in the y time series that is also associated with the frequency (f') in the x time series. $\text{Coh}^2(f')$ is scaled from 0-1.0, and a given value of $\text{coh}^2(f')$ can be thought of as percent variance in y produced by a forcing at frequency f' by x . The ARAND package performs a statistical test of the hypothesis that x and y are coherent, with the critical value of the test statistic user-defined at the 0.80 or 0.95 level.

Singular Spectrum Analysis

Classical spectral analysis has several deficiencies when applied to the study of chaotic and intermittent phenomena such as ENSO. In spectral analysis the base functions are a set of prescribed sines and cosines, which

assumes that the time series is continuously periodic. This assumption is not necessarily valid for ENSO, and other methods are called for. Singular-spectrum analysis (SSA), described in Vautard and Ghil (1989) and Vautard et. al. (1992), is essentially a linear analysis technique where the basic functions are determined from the time series itself, using several lagged copies of the time series in an EOF analysis. SSA is particularly useful in analyzing frequency components in short and noisy time series common in paleoclimatology. SSA can also easily localize in time intermittent oscillations, which are described using no more information than is in the time series itself. Another deficiency of spectral analysis is that the spectral density function represents the variance per frequency band (σ^2/f) averaged over all the cycles in the time series. No information is supplied about the time-domain characteristics of the frequency response, thus changes in the distribution of variance across frequencies with respect to time are difficult to assess. In SSA the principle components of the eigenvectors are reconstructed as functions of time (called reconstructed components), and their time-evolution can be examined. The reconstructed components, by virtue of their additive properties, can be combined to reconstruct any subset of components of the original time series.

SSA is analogous to multivariate principle components analysis (PCA)⁴. Classical PCA is used with multi-channel time series composed of M variables sampled over time ($x_i, 1 \leq i \leq N$) and gives the principle axes for a sequence of eigenvectors with M dimensions by expanding it with respect to an orthonormal basis ($E^k, 1 \leq k \leq M$). In single-channel SSA the time series is cloned into M copies to form a multivariate time series $x_i = (x_{i+1}, x_{i+2}, x_{i+3},$

⁴ This discussion follows Vautard et. al., 1992.

..., x_{i+M}), where M is the lag, or window length. The expansion of the sequence is given by:

$$x_{i+j} = \sum_{k=1}^M a_i^k E_j^k, \quad 1 \leq j \leq M$$

where the coefficients a_i^k are the principle components (PCs) and the vectors E^k are the empirical orthogonal functions (EOFs) or eigenvectors of the matrix that contains in column j and row i the covariance of x at lag $i-j$. The form of the autocovariance matrix is:

$$T_x = \begin{pmatrix} C(0) & C(1) & . & . & . & C(M-1) \\ C(1) & C(0) & C(1) & . & . & . \\ . & C(1) & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & C(1) & . \\ C(M-1) & . & . & . & C(1) & C(0) \end{pmatrix}$$

The matrix has the properties of being non-negative and symmetric, with constant diagonals corresponding to equal lags. The matrix T_x is estimated by Burg's algorithm:

$$C(j) = \frac{1}{N-j} \sum_{i=1}^{N-j} x_i x_{i+j}$$

In the solution the eigenvectors are sorted by decreasing eigenvalue. Because of the form of the matrix, the eigenvectors are strictly positive and symmetric or anti-symmetric with respect to $1/2M$. Eigenvectors are typically realized as symmetric/antisymmetric pairs. Each pair of high-variance

eigenvalues can be observed to represent a fundamental oscillation, with the symmetric/antisymmetric eigenvectors in quadrature with each other.

Choice of the window length, M , is a key problem of SSA. SSA does not resolve periods longer than the window length. For a finite M , all the eigenvalues fall between the maximum and minimum of the spectral density, with the largest eigenvalue corresponding to the maximum of the spectrum. As M approaches infinity, the eigenvectors tend to pairs of sines and cosines, and the associated eigenvalues tend to the corresponding spectral density values. For the purposes of resolving chaotic behavior, the largest possible values of M are desirable, up to the limit of $M=N/3$. Statistical errors begin to dominate the autocovariance function at window length larger than $M=N/3$.

When using SSA to study intermittent behavior, the choice of M is critical. When the ratio of M to the lifetime of the intermittent oscillation (the typical time interval of sustained high amplitude) is large, spells of the oscillation, weak or strong, will be smoothed out. The spectral estimate of the intermittent oscillation is strongly affected by choice of M . If M is too small, the coarse spectral resolution will cause neighboring peaks to coalesce; if M is too large, the high spectral resolution will split the peak into neighboring frequencies. Best SSA estimates of intermittent oscillations are found when the window length is longer than the period of the oscillation and shorter than the lifetime of its spells.

An implementation of single-channel SSA developed at Columbia University⁵, called SSA-2400, is used here. SSA-2400 provides a maximum of 20 eigenvectors in the solution for the covariance matrix, and accepts time series up to 2400 data points. Output from the SSA package includes estimates of variance for each eigenvector, a spectral estimate of its peak frequency, and the PCs as a function of time in the original data units (the reconstructed components). SSA-2400 also features a user-definable band-pass filter which can be applied to the time series prior to SSA.

The current implementation of SSA-2400 is limited to single-channel analyses, and does not perform tests of spectral coherency between different time series. For this reason, it was deemed important to perform cross-spectral analyses on the $\delta^{18}\text{O}$ and Darwin SLP time series using the ARAND package prior to using the SSA-2400 package. In the analyses that follow, the longest lag or window length afforded by the time series is used in the cross-spectral estimates and SSA so as to achieve maximum spectral resolution. Use of a long lag is justified for the SSA of ENSO-related phenomena because ENSO oscillations have a character which is more chaotic than intermittent. For example, in the Kiladis and Diaz (1989) El Niño/La Niña chronology (1882-1988), intervals without ENSO phase changes are less than nine years long, while spells of continuous phase changes (every 2-4 yr) range from 10 to 23 yr long.

⁵ Dr. Edward Cook, Tree-Ring Laboratory, Lamont-Doherty-Earth Observatory of Columbia University.

RESULTS

Cross-spectra: Coherent Frequency Modes

Prior to computing the cross-spectra the time series were normalized to ± 1.0 . The power spectra and cross-spectrum for Darwin SLP and LAN1A $\delta^{18}\text{O}$ (1951-1988) is shown in Figure 3. The LAN1A time series is 38 years in length, and therefore the lowest resolvable periodicity is 12.67 years. A lag of 12 years was selected for this analysis ($m = 144$ months), and the test statistic for non-zero coherency was set at the 0.80 level. The plot of the cross-spectrum reveals significant coherency in the QB bandwidth (periods 18-26 months) and the ENSO LF bandwidth (periods 40-120 months). The strongest coherency observed in LAN1A/Darwin SLP cross-spectrum is in the ENSO LF band.

The cross-spectrum for the Darwin SLP and the LAN1A $\delta^{18}\text{O}$ during the period 1875-1911 is shown in Figure 4. 37 years of data are represented, and the Nyquist frequency is 12.33 years. Comparing this cross-spectrum with Figure 3, it is evident that the significant coherency has shifted to lower frequencies. There is still strong coherency in the ENSO LF band, (here periods 32-50 months), but not in the QB band. Strong coherency is apparent in the decadal-scale band.

The cross-spectrum for Darwin SLP and the KAP1A $\delta^{18}\text{O}$ time series (1882-1964) is shown in Figure 5⁶. 83 years of data are represented, and the Nyquist frequency is 27.6 years. Better spectral resolution is achieved here because the length of the time series allows for a longer lag, and reduces the

⁶ Although the KAP1A $\delta^{18}\text{O}$ series covers 1872-1968, the time series had to be truncated slightly to $N = 996$ months because the ARAND software is limited to $N < 1000$ points.

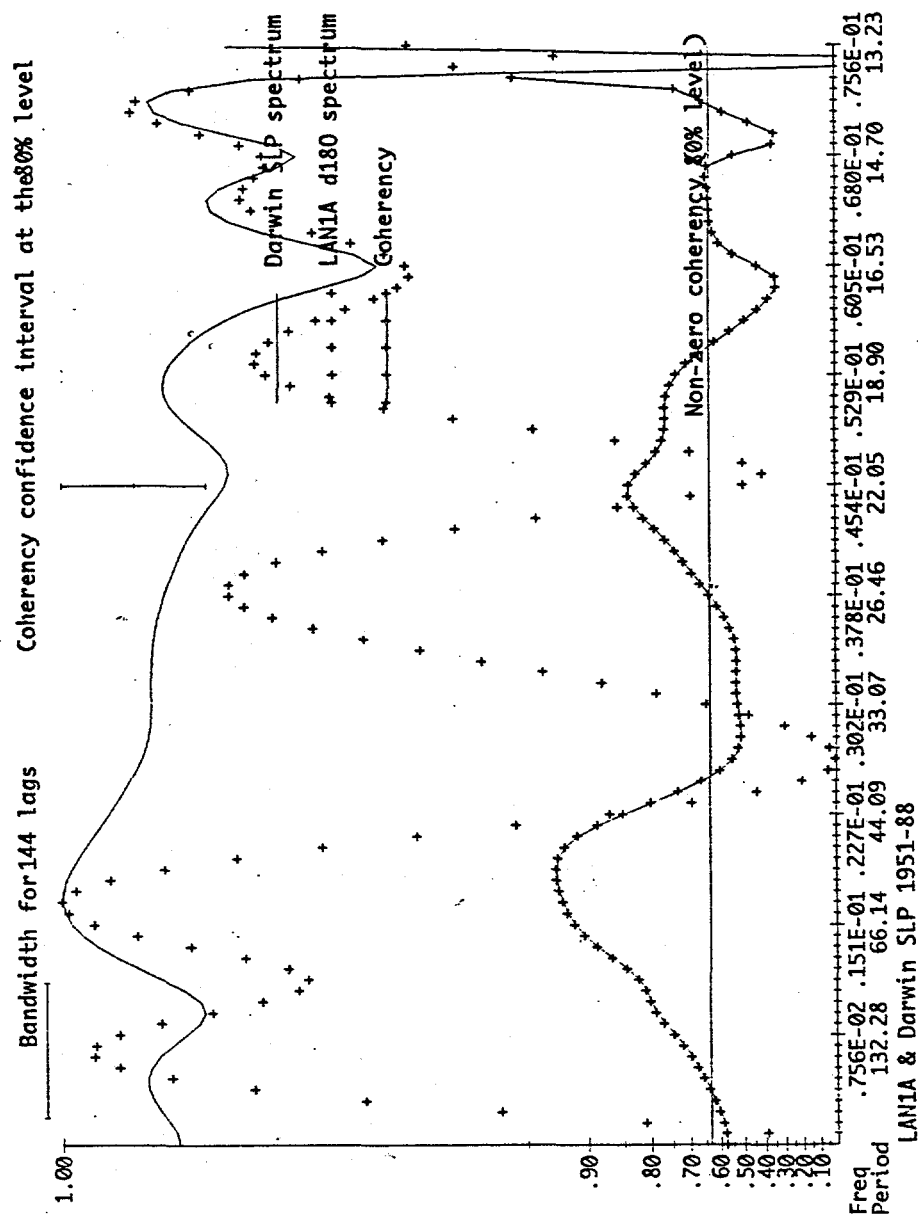


Figure 3. Power Spectra and Cross-Spectrum for Darwin SLP and LAN1A $\delta^{18}\text{O}$ (1951-88). The Darwin SLP power spectrum is indicated by the solid line, the LAN1A $\delta^{18}\text{O}$ power spectrum by the crosses, and the spectral coherence of the two time series by the crossed line. The x-axis is in frequency units ($1/\Delta t$), with the period in months indicated. The x-axis is scaled logarithmically, allowing the bandwidth to be valid for all frequencies. The y-axis is in units of coherence squared (coh^2) which can be read as percent similarity between the two time series at frequency (x). The y-axis is scaled on the hyperbolic arc tangent function ($y = \tan^{-1}(x)$), which allows the coherence confidence interval, indicated by the vertical bar, to be valid for all frequencies. The test statistic for non-zero coherence is set at the 0.80 level.

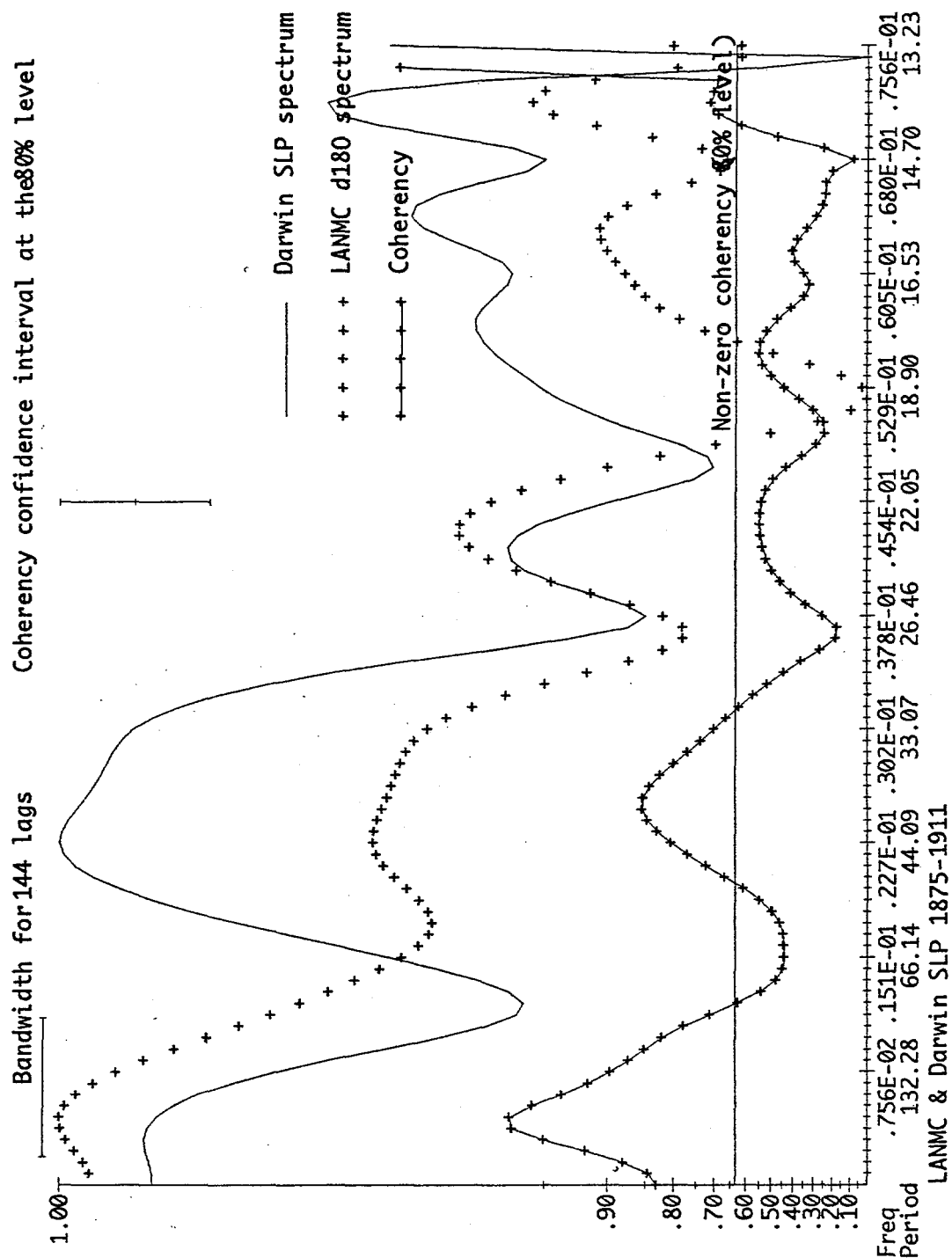


Figure 4. Power Spectra and Cross-Spectrum for Darwin SLP and LAN1A $\delta^{18}\text{O}$ (1875-1911). The Darwin SLP power spectrum is indicated by the solid line, the LAN1A $\delta^{18}\text{O}$ power spectrum by the crosses, and the spectral coherency of the two time series by the crossed line.

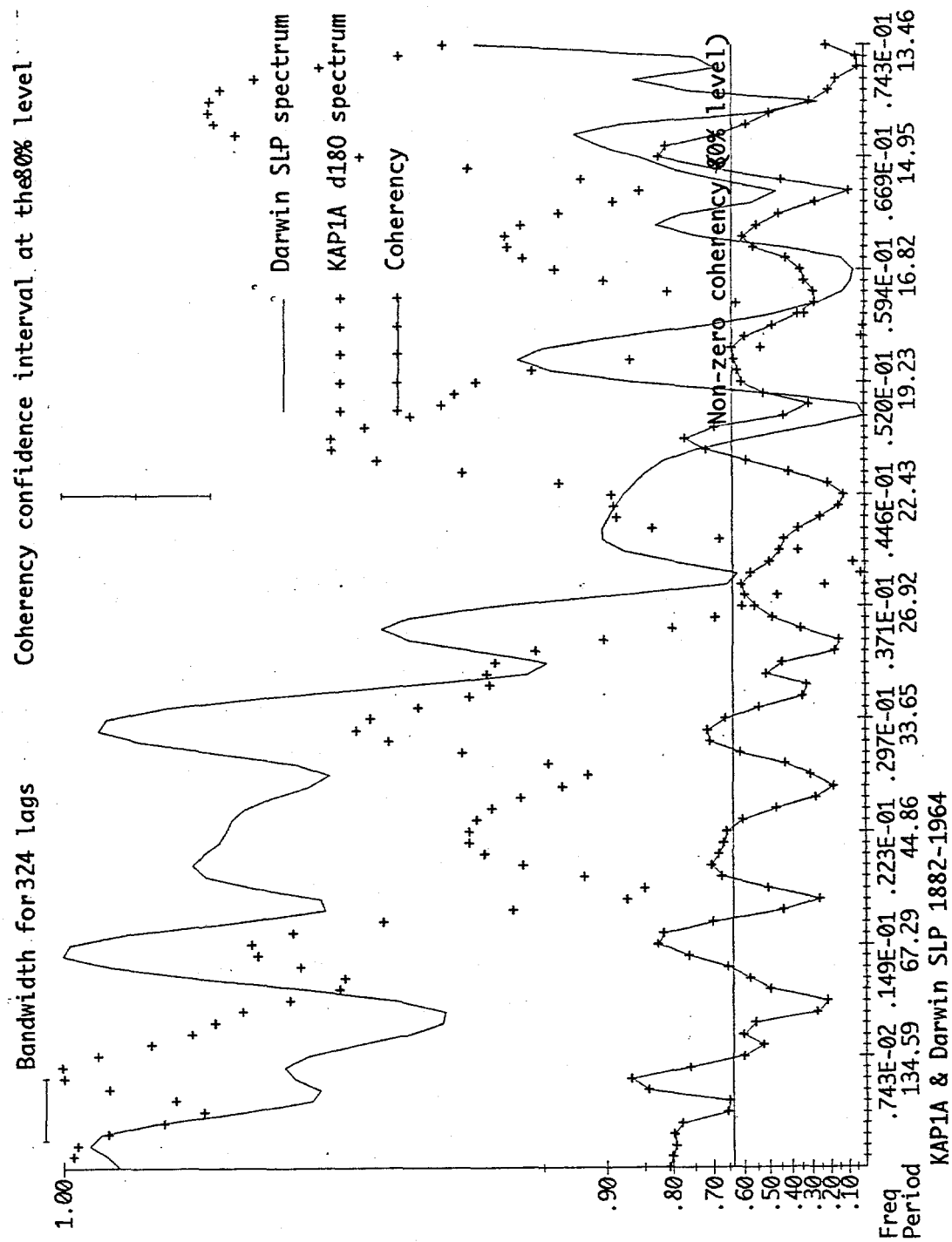


Figure 5. Power Spectra and Cross-Spectrum for Darwin SLP and KAP1A $\delta^{18}\text{O}$ (1882-1964). The Darwin SLP power spectrum is indicated by the solid line, the KAP1A $\delta^{18}\text{O}$ power spectrum by the crosses, and the spectral coherency of the two time series by the crossed line.

bandwidth by more than a factor of two compared to the cross-spectra in Figures 3 and 4. In the ENSO LF band (32-84 months) the Darwin SLP and KAP1A $\delta^{18}\text{O}$ power spectra are strong and similar, but in QB band the Darwin SLP is weak compared to KAP1A $\delta^{18}\text{O}$. The time series have strong coherency at discrete frequencies in the ENSO LF band (periods 5.5 yr, 4.2 yr, 3.0 yr) and in the decadal-scale at 12-14 yr. The only high-frequency band coherency appears at period 20 months. Although the ENSO LF band coherency in the KAP1A $\delta^{18}\text{O}$ time series is weaker (80%) than with LAN1A $\delta^{18}\text{O}$ time series (85% for 1875-1911, 93% for 1951-88), this cross-spectrum still reveals a significant ENSO response.

Singular Spectra: Time Evolution of Fundamental Modes

In the previous section it was determined that statistically significant coherency exists between the Darwin SLP time series and the Makassar Strait coral $\delta^{18}\text{O}$ time series. This result provides the basis for further analyses using Singular Spectrum Analysis (SSA), as discussed earlier. In this section SSA is used to estimate the dominant frequency modes in the Makassar Strait coral $\delta^{18}\text{O}$ time series and describe their time evolution. These results will be compared to SSA of the Darwin SLP time series. To facilitate this comparison, only the sections of the Darwin SLP record contemporaneous to the coral $\delta^{18}\text{O}$ time series will be analyzed. Because SSA estimates variance by lagging the time series against itself, this approach avoids the problem of having an SSA estimate of Darwin SLP that incorporates variance external to time period represented by the coral $\delta^{18}\text{O}$ time series.

All of the time series were detrended using a high-pass binomial spline filter with the 50% frequency response set at 20 years. The annual component

was removed from all of the time series using a low-pass binomial spline filter with the 50% frequency response set at 18 months. The value for this filter was arrived at by repeated experimentation, where it was found that values less than 18 months allowed unacceptable leakage of the annual mode into the filtered time series, and values greater than 18 months produced low frequency artifacts in the filtered time series that could potentially confound the analysis.

In evaluating the significance of the SSA-determined EOF modes, an EOF is considered fundamental only if it was realized in "clean quadrature." This means the EOF mode has to have a consecutively occurring symmetric/antisymmetric EOF component pair of the same frequency. Frequencies which are not cleanly realized by SSA typically have unmatched symmetric/antisymmetric EOFs, and while occasionally one of the unmatched components may have the same frequency as a realized fundamental mode with a matched pair of EOFs, this outcome can only be considered coincidental. Although examples can be found in the literature where variance from an unmatched EOF component is pooled with variance from a fundamental mode occurring in clean quadrature, this practice is highly questionable. In this analysis only modes occurring in clean quadrature were considered significant. Additionally, the variance represented by fundamental mode components had to sum to at least a few percent of the interannual variance of the pre-whitened (filtered) time series to so as to represent some real level of operational significance. There is not much point in describing EOF modes with variance less than the typical laboratory precision on the measurement of $\delta^{18}\text{O}$. In this regard, the sum of the variance represented by SSA modes in the ENSO LF bandwidth is

considered to be more significant than the distribution of variance among the individual modes.

The SSA results for the LAN1A $\delta^{18}\text{O}$ time series (1951-88) are shown in Figure 6. 13.8% of the original variance is retained for spectral analysis. SSA was performed, with lag $m = 144$ months. Three fundamental modes appeared in clean quadrature. The first two modes, the 4.8 yr and the 3.7 yr, are in the ENSO LF band and account for 33.4% of the interannual variance. The high-frequency 2.6 yr mode accounts for only 5.6% of the interannual variance. Comparing the time-evolution of these modes, the 4.8 yr mode is quite regular, showing a slight suppression of amplitude in the mid-1960's. The 3.7 yr mode shows a monotonically increasing variance contribution during 1951-1988. The 2.6 yr mode appears noisy and poorly resolved.

SSA of the Darwin SLP time series (1951-1988) is shown in Figure 7. The time series was prepared identically to the LAN1A time series (1951-1988) above. 9.3% of the original variance in the detrended time series was retained. SSA was then performed, with $m = 144$ months. Five fundamental modes appeared in clean quadrature. The dominant interannual modes in the Darwin SLP record are all in the ENSO LF band, and these account for 45% of the interannual variance (and about 4% of the total variance). The 4.9 yr mode has strong contribution during the 1950's and in the 1970-80's, but essentially no contribution in the 1960's. The 3.6 yr mode is weak up until 1965 and then consistently strong through the latter part of the record. The 2.9 yr mode has the largest contribution in the 1970's.

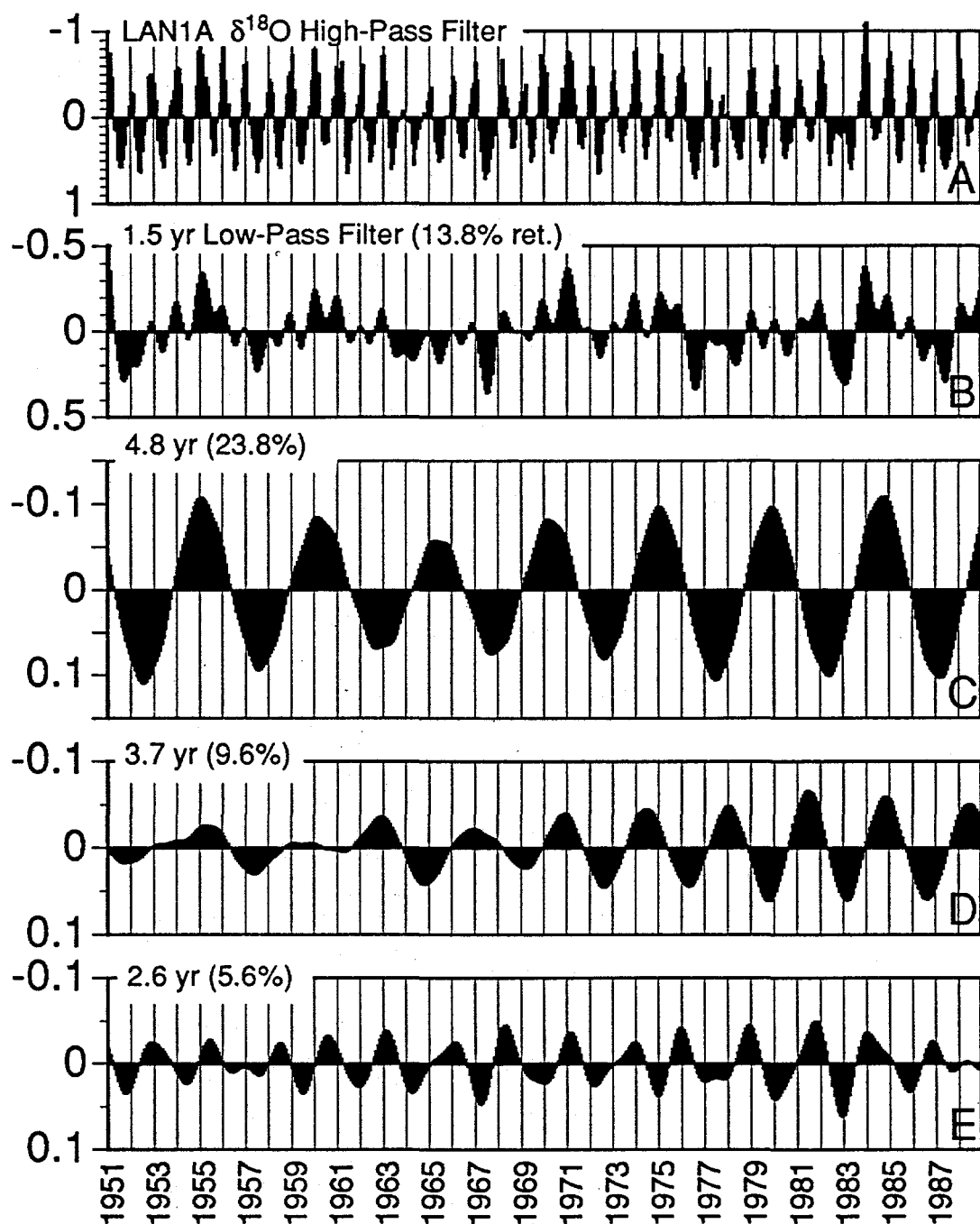


Figure 6. LAN1A $\delta^{18}\text{O}$ (1951-88) SSA. The time series was detrended (A) and the annual component was removed (B). The dominant SSA modes were computed, and their reconstructed components ranked by variance contribution (C-E). The period and percent variance contribution to the low-pass filtered time series are given for each reconstructed component. Y-axes are $\delta^{18}\text{O}$ anomaly in ‰, reversed as per convention.

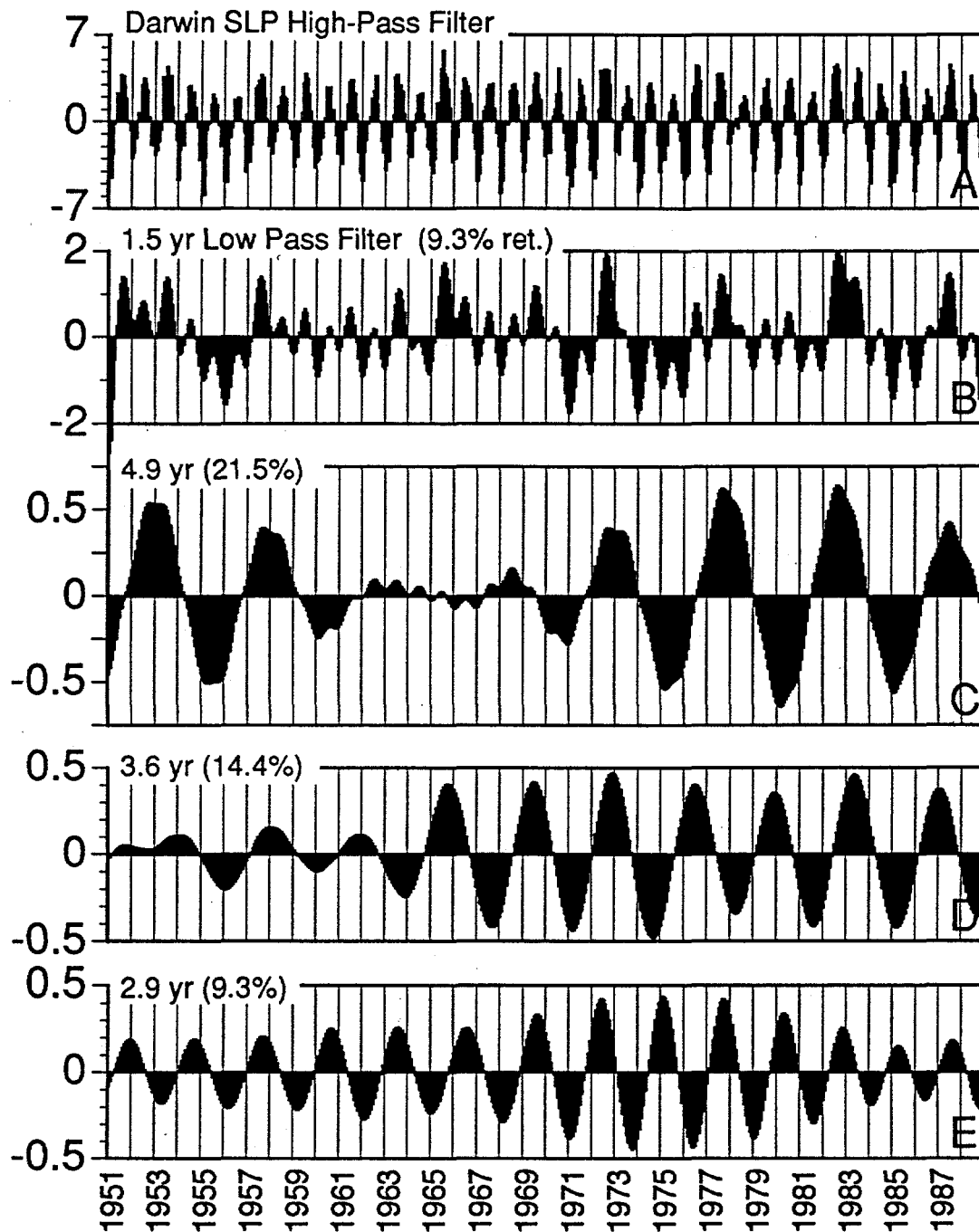


Figure 7. Darwin SLP (1951-88) SSA. Detrended time series (A), Low-pass filtered time series and % retained variance (B). SSA dominant mode reconstructed components and % variance (C-E). Y-axes are SLP anomaly in mb-1000.

SSA of the LAN1A $\delta^{18}\text{O}$ time series (1875-1911) is shown in Figure 8. 20.4% of the original variance in the detrended time series is retained. SSA was then performed, with $m = 144$ months. The first fundamental mode is a decadal-scale, 9.0 yr mode that accounts for 22.5% of the interannual variance. The next two modes are in the ENSO LF band, and account for 31% of the interannual variance. The 3.7 yr mode shows a decrease in amplitude during the period of record. The 2.8 year mode supplies almost as much variance as the previous mode.

SSA of the Darwin SLP time series (1875-1911) is shown in Figure 9. 11% of the original variance in the detrended time series is retained. SSA was then performed, with $m = 144$ months. The fundamental modes are low-frequency, with the first two ENSO LF band modes accounting for 43% of the interannual variance. The 3.8 yr mode is very strong in the early part of the record, but becomes completely attenuated at the turn of the century. The next mode, 5.1 yr, shows a steady gain in amplitude over the period of record. The last fundamental mode, the decadal scale 12.9 yr, represents only 4% of the interannual variance.

SSA of the KAP1A $\delta^{18}\text{O}$ time series (1872-1968) is shown in Figure 10. 18.6% of the variance of detrended time series was retained. SSA was performed with lag $m = 384$ months. The lower panels are the summed RCs, ranked by variance contribution. The first interannual mode is decadal-scale, 13.6 yr, and contributes 16% of the interannual variance. The remaining modes are all within the ENSO LF band, and comprise 28% of the interannual variance, or 5% of the total variance. The highest ranked ENSO LF mode, 5.7 yr contributes 11.7% of the variance, and the lesser modes (3.7 yr,

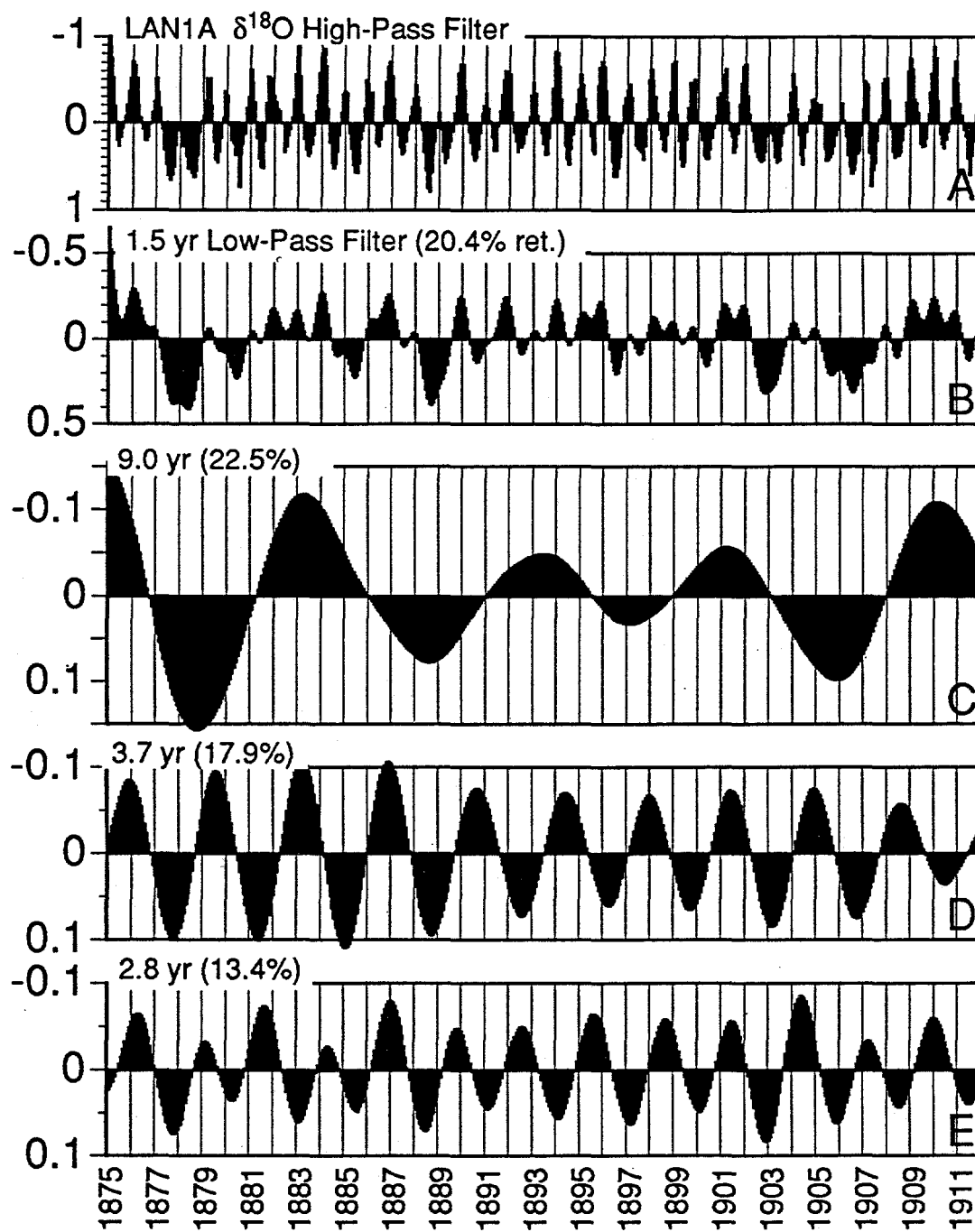


Figure 8. LAN1A $\delta^{18}\text{O}$ (1875-1911) SSA. Detrended time series (A). Low-pass filtered time series and % retained variance (B). SSA dominant mode reconstructed components and % variance (C-E). Y-axes reversed.

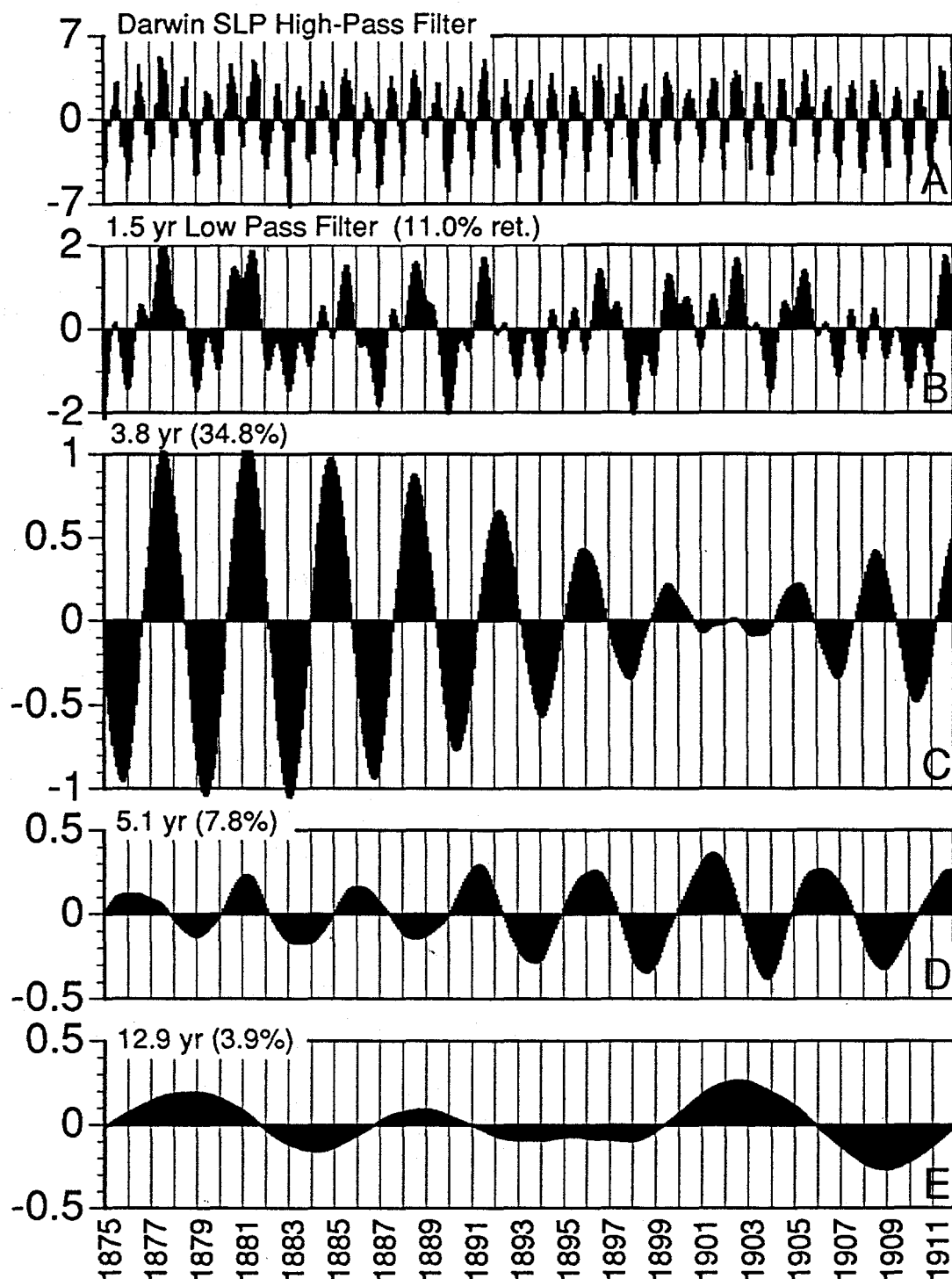


Figure 9. Darwin SLP (1875-1911) SSA. Detrended time series (A). Low-pass filtered time series and % retained variance (B). SSA dominant mode reconstructed components and % variance (C-E). Y-axes are SLP anomaly in mb-1000.

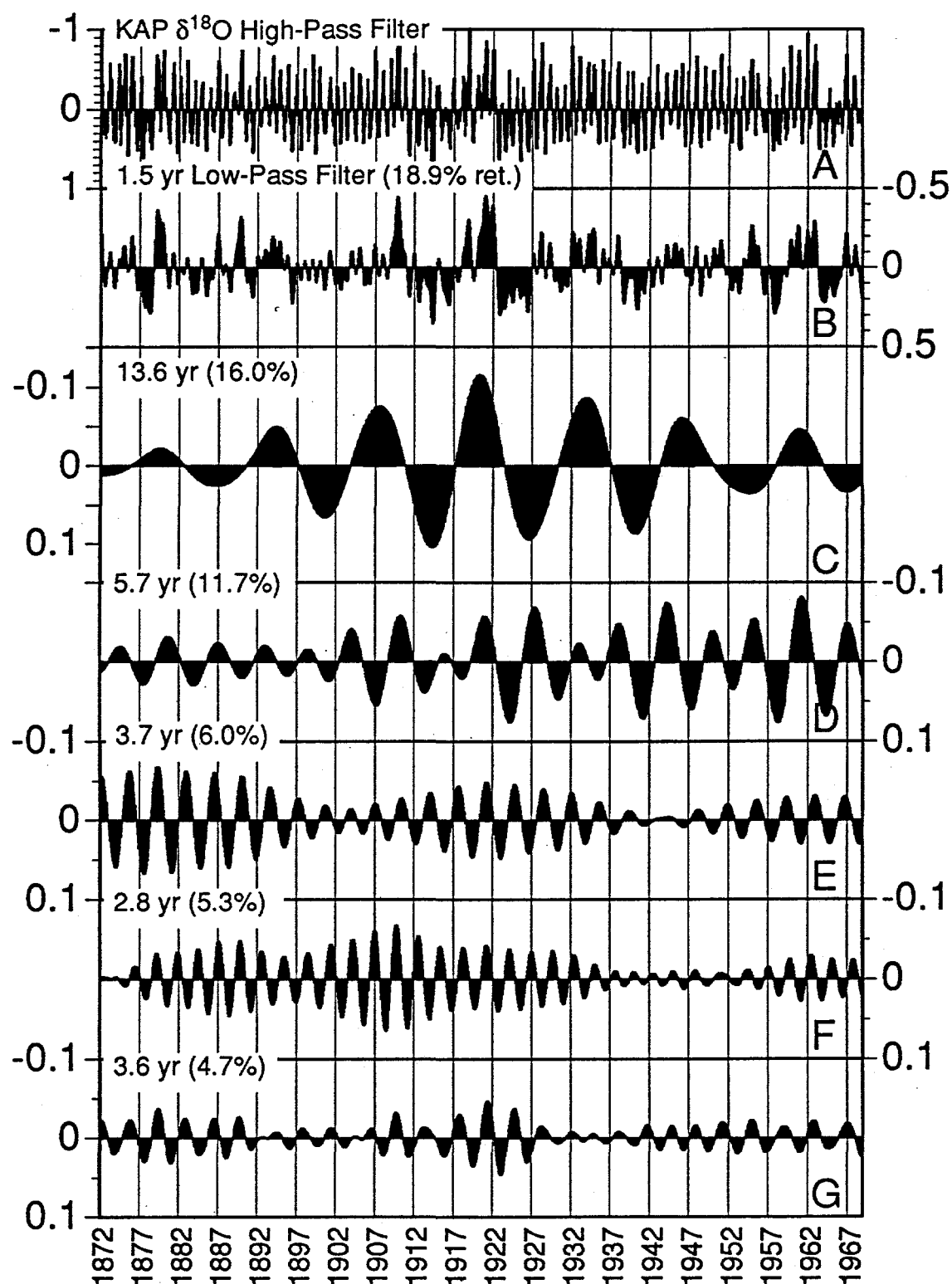


Figure 10. KAP1A $\delta^{18}\text{O}$ (1872-1968) SSA. Detrended time series (A). Low-pass filtered time series and % retained variance (B). SSA dominant mode reconstructed components and % variance (C-G). Y-axes reversed.

2.8 yr, 3.6 yr) contribute about 5% each. The amplitude of the 13.6 yr mode waxes and wanes over the period of record, with the maximum amplitude centered around the 1920's. The 5.7 yr mode shows a monotonic increase in amplitude. The 3.7 yr and the 3.6 yr modes have a very similar time evolution, with the 3.7 yr mode lagging the 3.6 yr mode by about five years. The 2.8 yr mode shows maximum amplitudes in the early part of the century, attenuation in 1940's and moderate strength in the 1960's.

SSA of the Darwin SLP time series (1872-1968) is shown in Figure 11. The annual component was not removed prior to SSA because of persistent problems with fundamental modes being resolved as higher-order harmonics when the 1.5 yr low-pass filter was used in combination with high values of m . SSA was performed with lag $m = 384$ months. The annual mode comprises 82.9% of the total variance. The interannual modes are all within the ENSO LF band and comprise 4.7% of the total variance (i.e. the same contribution to the total variance as with the earlier 1.5 yr filtered SSA analyses). The dominant interannual mode, 3.8 yr, contributes one third of the interannual variance. The 5.6 yr and the 2.9 yr modes contribute about 1% each, and the 3.5 yr and 4.4 yr modes contribute about 0.7%. The 3.8 yr mode is strong in the late 1800's, but weakens considerably over the period of record. The 5.6 yr and the 4.4 yr modes have a similar pattern of increasing amplitude through the turn of the century, followed by relative stability over the remainder of the record. The 2.9 yr and 3.5 yr modes show a similar pattern of attenuation during 1920-35.

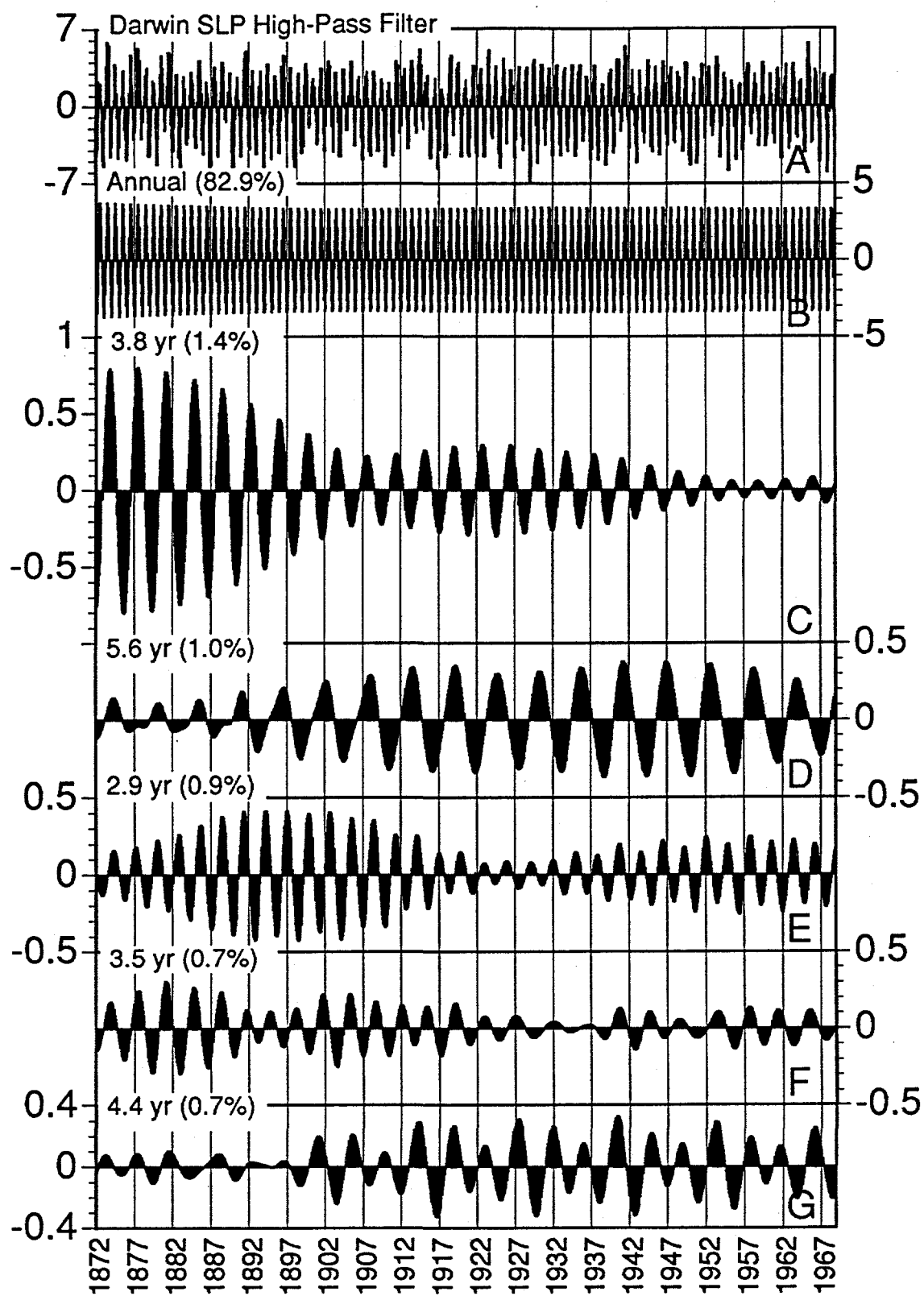


Figure 11. Darwin SLP (1872-1968) SSA. Detrended time series (A). Annual mode and % variance (B). SSA RCs and % variance (C-G). Y-axes are mb-1000.

Table I. SSA Results

Time Series	Eigen Vectors	Eigen Values	% Total Variance	Peaks (yr)
1951-88				
LAN1A	1, 2	0.384, 0.360	3.28	4.81, 4.87
	9, 10	0.151, 0.148	1.32	3.73, 3.68
	12, 13	0.090, 0.085	0.77	2.59, 2.61
Darwin SLP	3, 4	9.716, 9.418	1.99	4.90, 4.84
	4, 5	6.673, 6.158	1.34	3.50, 3.59
	7, 8	4.145, 4.105	0.86	2.90, 2.92
1875-1911				
LAN1A	1, 2	0.462, 0.422	4.59	8.82, 9.26
	3, 4	0.363, 0.341	3.65	3.66, 3.66
	5, 6	0.268, 0.259	2.73	2.85, 2.83
Darwin SLP	1, 2	19.87, 18.58	3.82	3.81, 3.79
	7, 8	4.558, 4.154	0.86	5.14, 5.14
	9, 10	2.312, 2.042	0.43	13.16, 12.71
1872-1968				
KAP1A	1, 2	0.624, 0.621	3.02	13.89, 13.39
	3, 4	0.459, 0.452	2.21	5.73, 5.73
	11, 12	0.230, 0.230	1.13	3.55, 3.81
	13, 14	0.209, 0.203	1.00	2.79, 2.79
	15, 16	0.190, 0.181	0.89	3.38, 3.77
Darwin SLP	1, 2	1110, 1109	82.9	1.00, 1.00
	3, 4	19.91, 19.73	1.48	3.79, 3.79
	5, 6	12.91, 12.67	0.96	5.56, 5.56
	7, 8	11.79, 11.67	0.88	2.87, 2.87
	9, 10	10.00, 9.732	0.74	3.47, 3.47
	11, 12	8.850, 8.583	0.64	4.39, 4.39

The results of the SSA analyses are summarized in Table I. Common modes for LAN1A and Darwin SLP during 1951-88 are at 4.8-4.9 and 3.6-3.7 yr, which are in phase, and show a similar time-evolution. Common modes during 1875-1911 are the 3.7-3.8 yr modes; these are in phase up until 1900. Common modes for KAP1A and Darwin SLP are the 5.6-5.7 yr modes (in

phase after 1882), the 3.5-3.7 yr modes (in phase except for the period 1930-1950), and the 2.8-2.9 yr modes (also in phase except for the period 1925-40). The 3.5-3.6 yr modes are weak and only in phase during 1872-1895, 1907-25, and from 1952 onwards. Consistent with the cross spectral results, the SSA results show a high degree of coherency between the $\delta^{18}\text{O}$ time and the Darwin SLP time series in the 2.75-7.0 yr ENSO LF band. Recalling that, the isotope time series have age model errors of ± 4 months, or ± 0.25 yr, it is clear that many of the same fundamental modes appear in both the $\delta^{18}\text{O}$ and Darwin SLP time series. Many of the common modes are in phase and show a similar time evolution. There is some variability in the ranking of the modes, with the exception of the 1951-88 LAN1A and Darwin SLP analysis where the same modes were realized in the same order of explained variance.

An interesting feature of the KAP1A and LAN1A SSA are the dominant decadal scale modes. These modes do not appear to be that important in the Darwin SLP record. For example the 13 yr mode found in the 1975-1911 period explains an order of magnitude less variance than the similar decadal scale mode (9.0 yr) in the LAN1A record. The 14 yr mode in the KAP1A time series comprises 3% of the total variance, yet no similar modes are found in the Darwin SLP record despite the 32 yr lag.

These spectral results are consistent with the work of Cole et al. (1993) at Tarawa Atoll. Tarawa is near the dateline (1°N , 172°E) and tends to experience anomalously high precipitation associated with the arrival of the Indonesian Low during ENSO warm phase events. In a spectral analysis of a monthly resolution, 96 yr coral $\delta^{18}\text{O}$ time series from Tarawa Atoll, Cole et al. (1993) found spectral peaks at 2.3, 3.0, 3.6, and 5.8 years, and showed that 75-

85% of the variance was significantly coherent with a local rainfall index used as a surrogate for ENSO-related changes in convection.

Cross-correlation of ENSO LF Modes

RCs within the ENSO LF bandwidth (2.75-7.0 yr) were summed for each of the coral $\delta^{18}\text{O}$ time series, and for the contemporaneous Darwin SLP time series. Cross-correlation functions were computed to 60 lags to determine the reproducibility of the coral $\delta^{18}\text{O}$ ENSO LF modes. Cross-correlation for LAN1A and KAP1A during 1875-1911 yields $r = 0.74$, with LAN1A leading by 2 months. Cross-correlation for LAN1A and KAP1A during 1951-1968 yields $r = 0.65$, with LAN1A lagging by 6 months. The ENSO LF bandwidth accounts for 5-10% of the total variance in the time series, with the coral $\delta^{18}\text{O}$ ENSO LF modes explaining slightly more variance than the Darwin SLP ENSO LF modes, as shown in Table II.

Table II. Percent Total Variance Explained by SSA ENSO LF Modes

Time Period	$\delta^{18}\text{O}$ ENSO LF Variance	SLP ENSO LF Variance
1951-1988	4.60	4.19
1875-1911	10.97	4.86
1872-1968	5.23	4.7

The comparison between the ENSO LF mode RCs for Darwin SLP and LAN1A for the period 1951-88 is shown in Figure 12. There is excellent agreement between the two ENSO LF time series, with the largest disagreement confined to the period 1960-68. The cross correlation for the lag-adjusted LAN1A ENSO LF mode and the Darwin ENSO LF mode is $r = 0.79$. It is unlikely that the disagreement is an artifact of the SSA analysis, since both ENSO LF band estimates were made with exactly the same parameters ($n = 456$ months, 18 month low pass filter, $m = 144$ months). It should also be

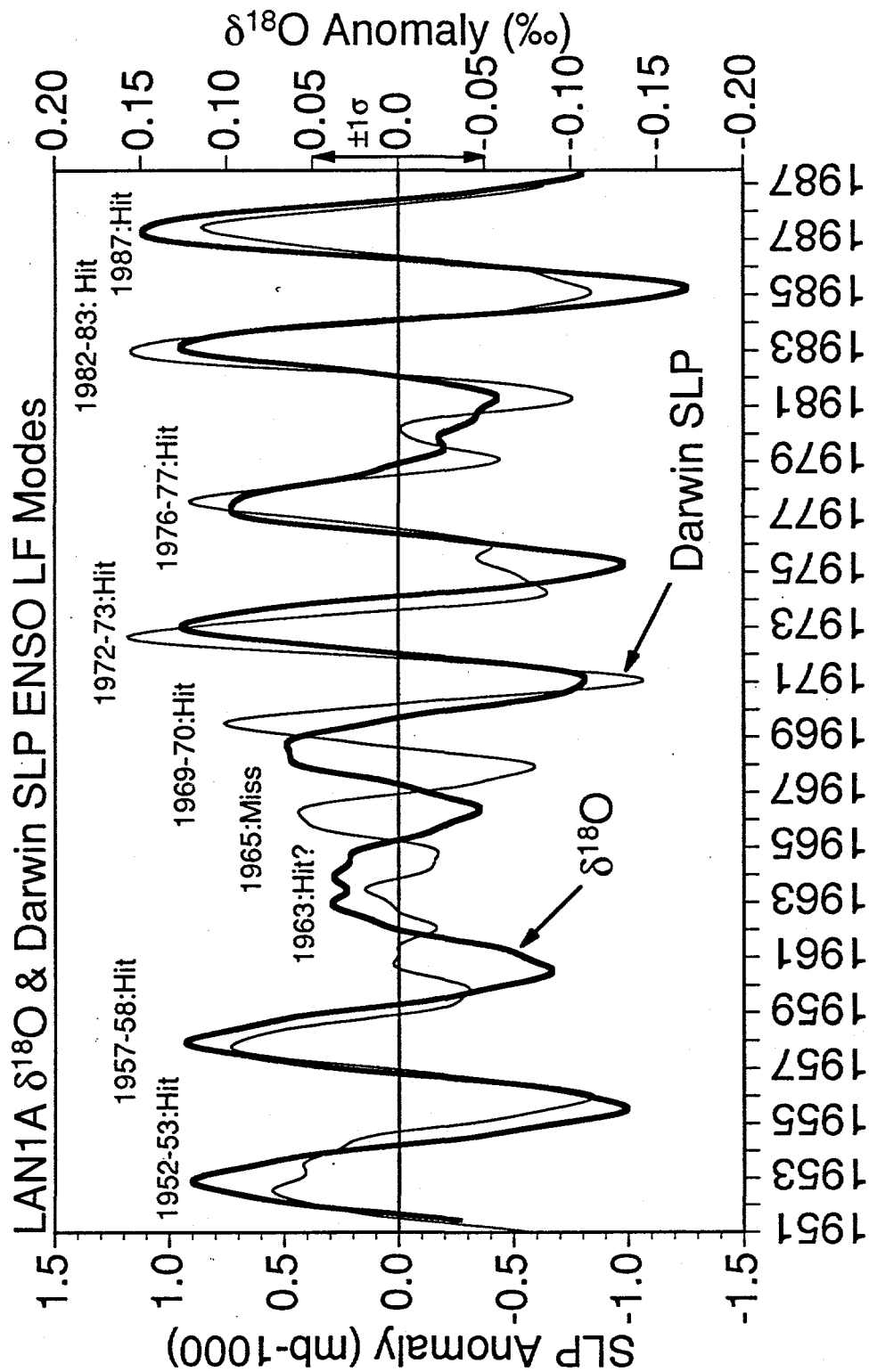


Figure 12. ENSO LF Modes for LAN1A $\delta^{18}\text{O}$ and Darwin SLP, 1951-88. $\delta^{18}\text{O}$ y-axis not reversed, $r = 0.74$. Quinn et al. (1987) El Niño events indicated.

noted that the disagreement exists within the ± 1 sigma measurement error of $\delta^{18}\text{O}$ and as such may simply represent the practical limit of amplitude resolution. The LAN1A ENSO LF captures all of the ENSO warm-phase events during the period of record with the exception of the 1966 event.

The comparison between the ENSO LF mode RCs for Darwin SLP and LAN1A for the period 1875-1911 is shown in Figure 13. Again, there is good agreement between the two ENSO LF time series, with the largest disagreement in confined to 1891-1894. The cross-correlation for the lag-adjusted LAN1A ENSO LF and the Darwin SLP ENSO LF time series is $r = 0.76$. The SSA estimate of the ENSO LF band in the Darwin SLP time series captures all of the strong events of record. The LAN1A ENSO LF captures all the ENSO warm-events during the period of record, with the exception of the 1891 ENSO. The Darwin SLP ENSO LF shows one positive anomaly occurring in 1908 which is not listed as an ENSO event, and not captured by the LAN1A ENSO LF mode.

The comparison between the SSA ENSO LF mode RCs for Darwin SLP and KAP1A $\delta^{18}\text{O}$ for the period 1872-1968 is shown in Figure 14. The amplitude of the KAP1A $\delta^{18}\text{O}$ ENSO LF appears weaker than that of the LAN1A $\delta^{18}\text{O}$ time series. However, the ENSO LF band estimates for the Darwin SLP and KAP1A $\delta^{18}\text{O}$ records benefit from the enhanced spectral resolution afforded by the 97 yr time series, and the overall agreement is good. The cross-correlation between the KAP1A ENSO LF and the Darwin SLP ENSO LF modes is $r = 0.71$. With the exception of 1966, there are no positive SLP anomalies which are not captured by the KAP1A $\delta^{18}\text{O}$ ENSO LF mode. The KAP1A $\delta^{18}\text{O}$ ENSO LF mode also captures all the non-ENSO

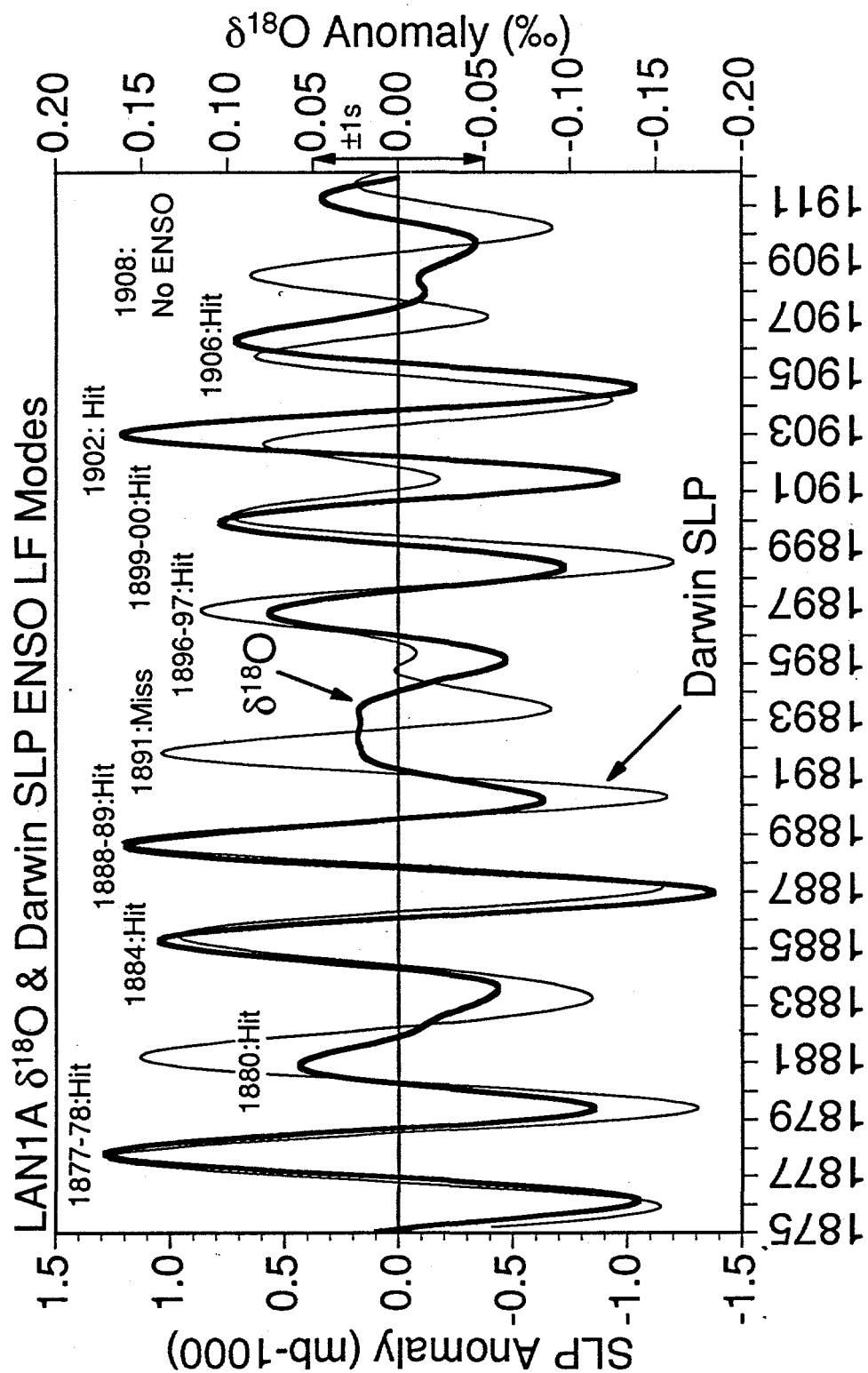


Figure 13. ENSO LF Modes for LAN1A $\delta^{18}\text{O}$ and Darwin SLP, 1875-1911. $\delta^{18}\text{O}$ y-axis not reversed, $r = 0.76$. Quinn et al. (1987) El Niño events indicated.

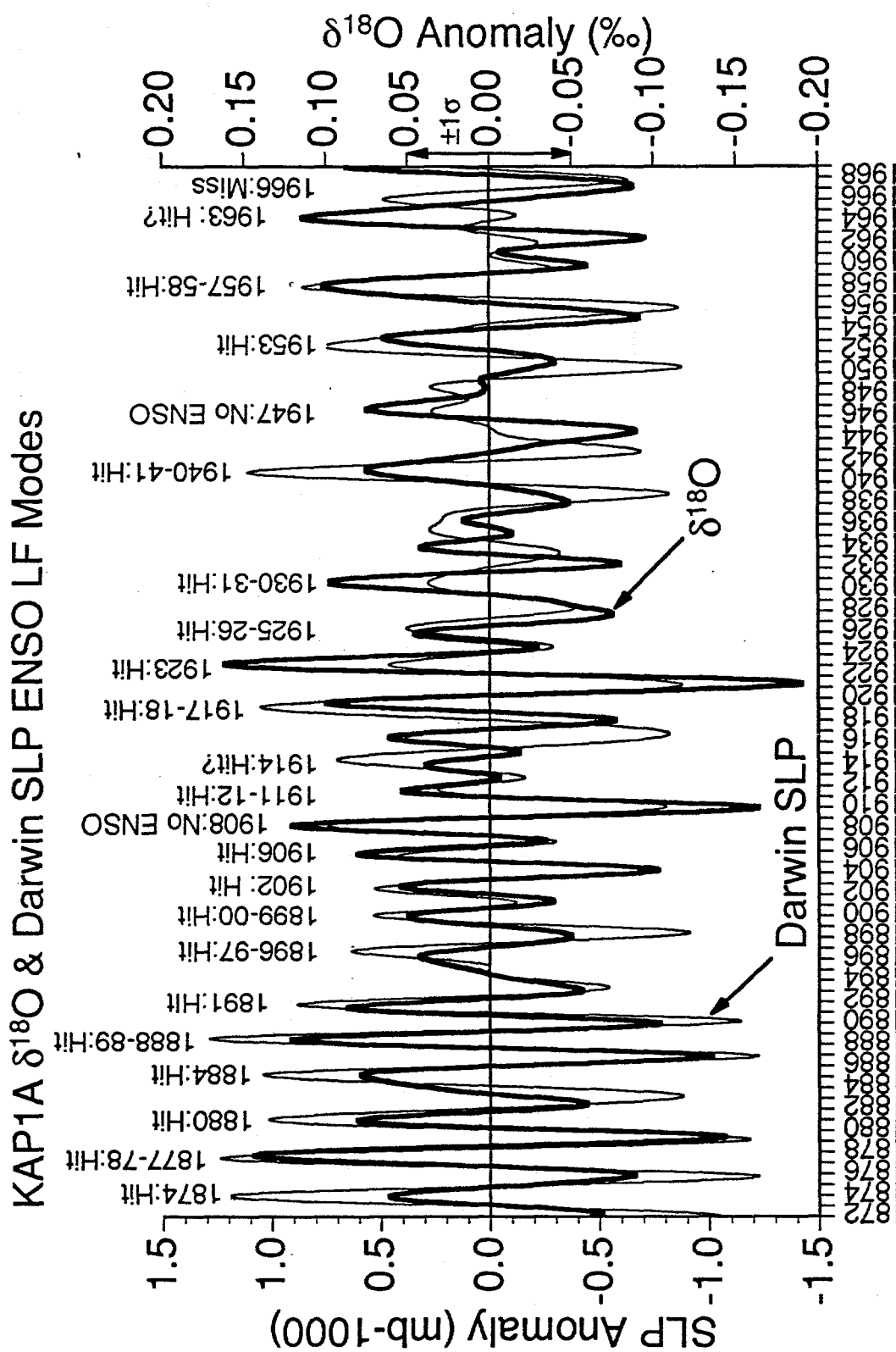


Figure 14. KAP1A $\delta^{18}\text{O}$ and Darwin SLP ENSO LF Modes, 1872-1968. $r = 0.71$.

positive SLP anomalies, some of which have been previously noted (1947-48; Deser and Wallace, 1987). Although these matches (including the 1908) do not record ENSOs, they do attest to the fidelity of the $\delta^{18}\text{O}$ proxy.

DISCUSSION

In Chapter 2 it was established that the coral $\delta^{18}\text{O}$ response in the southern Makassar Strait is dominated by freshwater flux effects. Closure on the seasonal $\delta^{18}\text{O}$ response was demonstrated; the observed 1.0‰ coral $\delta^{18}\text{O}$ seasonality was sufficiently large to explain the seasonality in sea surface salinity (2.5 psu) plus the seasonality in SST (1.5°C). It was also estimated that the proportionality of freshwater flux effects to SST effects in the seasonal coral $\delta^{18}\text{O}$ response was about 2:1. The pooled SSA ENSO LF modes suggest that interannual $\delta^{18}\text{O}$ shifts associated with ENSO phase-changes are only about 20% of seasonal $\delta^{18}\text{O}$ response. For example, the average interannual phase-change shifts in the KAP1A ENSO LF mode during 1872-1968 is 0.19‰ (determined by maxima-minima differencing of operationally significant peaks larger than $\pm 0.05\text{‰}$). If it is assumed that the salinity and SST proportionality seen in the seasonal coral $\delta^{18}\text{O}$ response also holds for the interannual $\delta^{18}\text{O}$ response, then this value is equivalent to average salinity shifts of 0.5 psu and SST shifts of 0.3°C.

The coral $\delta^{18}\text{O}$ ENSO LF modes have almost exactly the same zero-crossings as Darwin SLP ENSO LF modes, suggesting that the essential periodicities that describe the interannual variability of Indonesian Low are well-captured by the coral $\delta^{18}\text{O}$ response. However, mismatches between the coral $\delta^{18}\text{O}$ response and ENSO magnitude are common. The KAP1A $\delta^{18}\text{O}$ ENSO LF mode anomalies are ranked by magnitude and compared to the

ENSO event chronologies of Quinn et al. (1987) and Kiladis and Diaz (1989) in Table III.

Table III. KAP1A ENSO LF Mode $\delta^{18}\text{O}$ Anomalies (Ranked by Magnitude)

$\delta^{18}\text{O}$ (‰)	Year	El Niños (Quinn et al., 1987)	$\delta^{18}\text{O}$ (‰)	Year	La Niñas (Kiladis and Diaz, 1989)
0.16	1923	El Niño (medium)	-0.19	1921	La Niña
0.14	1878	El Niño (very strong)	-0.16	1910	
0.12	1888	El Niño (medium)	-0.14	1879	
0.12	1908	El Niño (medium)	-0.14	1887	La Niña
0.11	1964	El Niño (medium)	-0.10	1890	La Niña
0.10	1958	El Niño (strong)	-0.10	1904	La Niña
0.10	1931	El Niño (weak)	-0.09	1963	La Niña
0.10	1920	El Niño (weak)	-0.09	1955	La Niña
0.09	1969	El Niño	-0.09	1945	
0.09	1891	El Niño (very strong)	-0.09	1876	
0.08	1881	El Niño (medium)	-0.09	1967	
0.08	1906	El Niño (weak)	-0.08	1932	La Niña
0.08	1885	El Niño (strong)	-0.08	1918	
0.08	1941	El Niño (medium)	-0.07	1928	La Niña
0.07	1947		-0.07	1872	
0.07	1953	El Niño (medium)	-0.06	1883	
0.06	1874	El Niño (medium)	-0.06	1893	
0.06	1916	El Niño (strong)	-0.05	1898	La Niña
0.05	1903	El Niño (medium)	-0.05	1938	La Niña
0.05	1912	El Niño (strong)	-0.04	1951	
0.05	1900	El Niño (strong)	-0.04	1901	
0.05	1926	El Niño (very strong)	-0.03	1907	La Niña
0.04	1896	El Niño (medium)	-0.03	1925	La Niña
0.04	1934		-0.02	1915	La Niña
0.04	1914	El Niño (medium)	-0.01	1935	
0.02	1937		-0.01	1913	

Nearly all of the positive $\delta^{18}\text{O}$ anomalies correspond to El Niños, and more than half of the negative $\delta^{18}\text{O}$ anomalies correspond to La Niñas (known to 1886). Several of the largest El Niños are represented in the KAP1A $\delta^{18}\text{O}$ ENSO LF as relatively moderate $\delta^{18}\text{O}$ anomalies (e.g. 1885, 1891, 1926), while some of the larger $\delta^{18}\text{O}$ anomalies are considered weak or medium strength El Niños (e.g. 1888, 1908, 1964, 1931, 1920). For example, the

largest interannual shift seen in the KAP1A ENSO LF is the phase-change during the 1921-23 ENSO, where $\delta^{18}\text{O}$ increased by 0.35‰. This is equivalent to a 0.9 psu increase in salinity plus a 0.5°C drop in SST. This ENSO, ranked as a medium magnitude event, has a larger response than the 1877-78 ENSO, which is considered to have been as intense as the very strong 1982-83 ENSO (Kiladis and Diaz, 1986). The 1877-78 ENSO transition is seen as a shift of 0.28‰, equivalent to a 0.7 psu increase in salinity and a 0.4°C drop in SST.

There are two possible explanations for these discrepancies. The first explanation is that the $\delta^{18}\text{O}$ response represents variability in freshwater flux that is not consistently coupled to the Darwin SLP record. The other explanation is that $\delta^{18}\text{O}$ is responding to interannual shifts in SST or mixing depth. The precipitation record at Ujung Pandang can be used as an estimate of the interannual freshwater flux variability in the southern Makassar Strait. Annual rainfall totals were computed and compared to the KAP1A $\delta^{18}\text{O}$ ENSO LF mode maxima and minima, as shown in Figure 15. Most of the ENSO LF $\delta^{18}\text{O}$ anomalies correspond fairly well to the local precipitation anomalies (especially through the periods 1879-1886, 1896-1904, 1930-41, and 1950-60). Negative $\delta^{18}\text{O}$ anomalies not related to the interannual rainfall pattern are seen in 1887, 1894, 1910, 1921, 1929, and 1963, and positive $\delta^{18}\text{O}$ anomalies are seen in 1888, 1908, 1923, and 1964. If the mismatches in magnitude of $\delta^{18}\text{O}$ anomalies were due to some localized or regionally-specific freshwater flux response, then one would expect the $\delta^{18}\text{O}$ anomalies to closely follow the Ujung Pandang rainfall response. Since this is not the case, the first explanation can be eliminated and it can be concluded that the ENSO LF modes reflect shifts in SST and/or mixing depth. The fact that the mismatches are generally in phase with the interannual shifts in freshwater

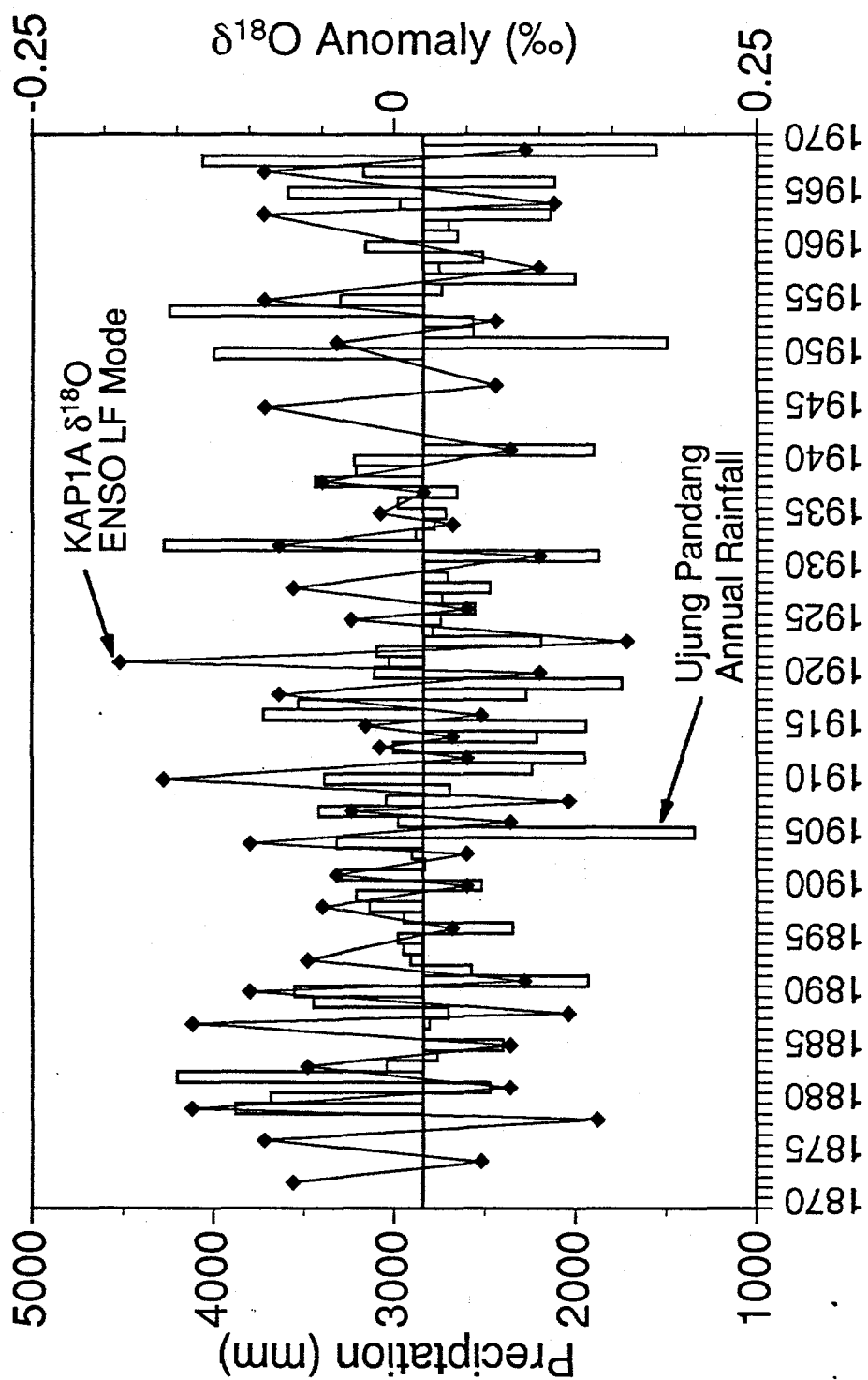


Figure 15. KAP1A $\delta^{18}\text{O}$ ENSO LF mode maxima and minima vs. annual rainfall totals at Ujung Pandang (S. Sulawesi), 1879-1969. No precipitation data is available for 1942-49.

flux suggests that they are ENSO features, yet their variability in amplitude also suggests the presence of an independent process not linearly-related to the energetics of basin-wide ENSOs. Without long-term time series data on SST or throughflow variability in Indonesia it is difficult to place these discrepancies in context, although they can be easily documented by differencing the $\delta^{18}\text{O}$ and SLP ENSO LF modes, as shown in Figure 16. It can be seen that the positive $\delta^{18}\text{O}$ -SLP ENSO LF residuals generally correspond to the El Niño years, and if interpreted as temperature anomalies, account for negative SST anomalies in the range of 0.25-0.75°C. These values are in agreement with observations of ENSO SST anomalies in the Indonesian seas (Nicholls, 1984, Allan and Pariwono, 1990).

One of the features of the ENSO is that while El Niños can be easily recognized by the presence of homogeneous warm conditions in E. Pacific, the La Niñas are more difficult to recognize because the weather anomalies associated with build-up conditions are more heterogenous (Philander, 1990). For this reason, La Niñas are less well known compared to El Niños. Kiladis and Diaz (1989) record 27 El Niños and only 21 La Niñas since 1877. Unlike the Central or Eastern Pacific, La Niñas are strongly manifested in Indonesia, with strong convective activity, heavy rainfall, and generally warmer SSTs. These conditions occur more frequently than is predicted by the La Niña event chronology of Kiladis and Diaz (1989), as can be seen in Table III. In the KAP1A ENSO LF mode the years 1876, 1879, 1883, 1893, 1910, 1945, and 1967 have large $\delta^{18}\text{O}$ minima in the range of -0.06 to -0.16‰, but are not listed as La Niñas. These years are clearly anomalous and strongly present in the fundamental ENSO LF band. These "non-reported" La Niñas deserve further investigation, especially considering that the coral ENSO LF modes

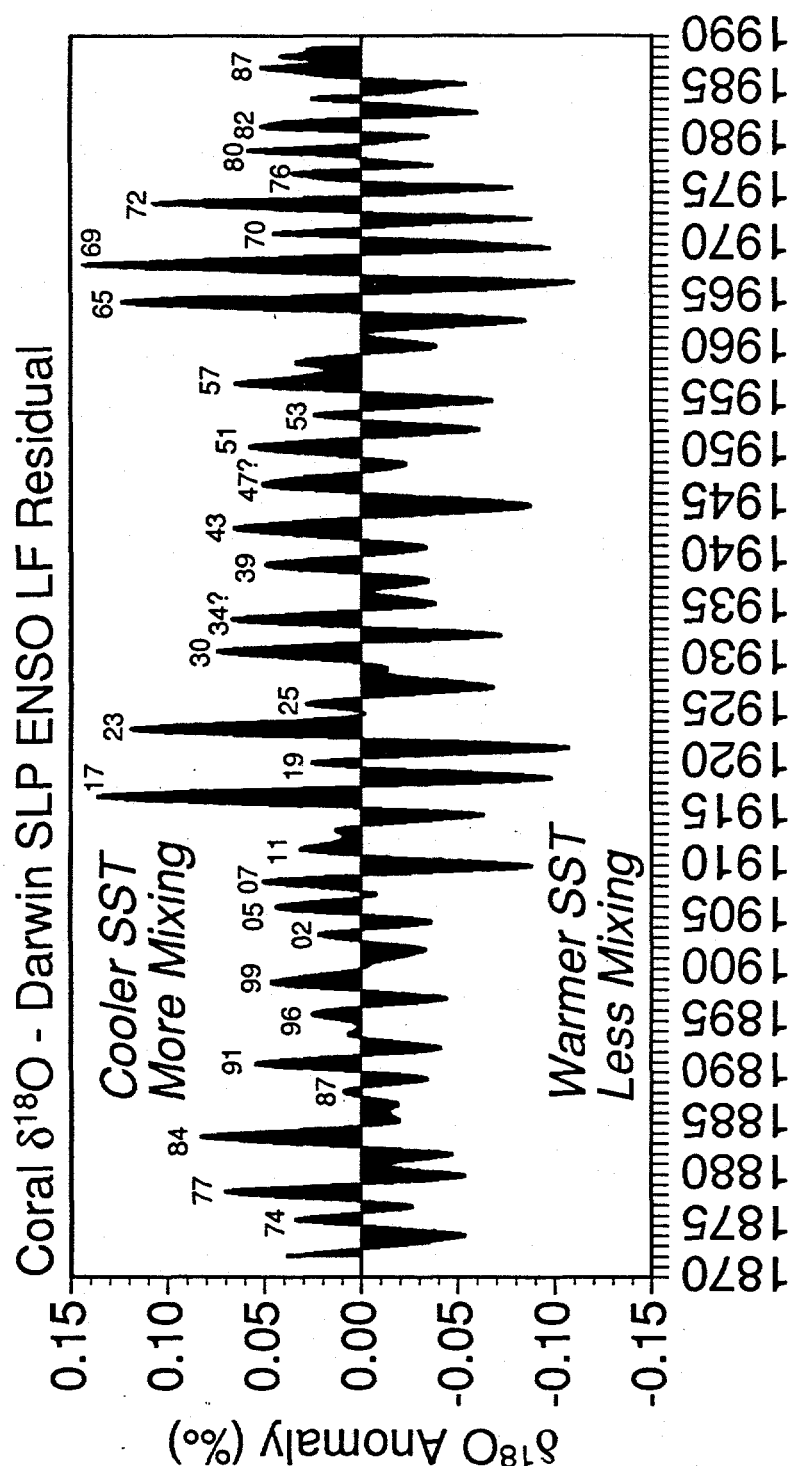


Figure 16. $\delta^{18}\text{O}$ ENSO LF modes minus Darwin SLP ENSO LF modes 1872-1988, in per mil units. Darwin SLP ENSO LF modes were scaled to per mil units by linear regression of mean monthly isotope values on mean monthly SLP values from the raw $\delta^{18}\text{O}$ and SLP time series. The Quinn et al. (1987) El Niño years are indicated. Y-axis not reversed.

are accurately capturing the El Niño phase of the ENSO.

Although Indonesia is one of the most volcanically active regions in the world and some of the greatest eruptions in history occurred relatively near to the Makassar Strait (e.g. Krakatoa, Tambora), there is no compelling evidence in the coral $\delta^{18}\text{O}$ records that suggests strong climate control by stratospheric volcanic aerosols. Neither the LAN1A or the KAP1A ENSO LF modes show strong sensitivity to the well-documented global coolings associated with the major eruptions of Krakatau (Java, 1883), Tarawera (1886), Una-Una (Sulawesi, 1898) or the Pelée group (1902-03) (see Figures 13 and 14). A global tropospheric cooling lasting for at least three years was produced by the 1963 eruption of Gunung Agung in Bali (Halpert et al., 1993). Both the LAN1A and KAP1A ENSO LF modes post positive $\delta^{18}\text{O}$ anomalies during 1963-64 indicative of persisting anomalous cool/salty conditions in the Makassar Strait. This anomaly may simply reflect the 1963 El Niño and the 1964 La Niña (Kiladis and Diaz, 1989), yet curiously the Darwin SLP response does not indicate a strong ENSO phase change and even appears to be decoupled from the isotopic response (Figures 12 and 14). Thus it appears from the Darwin record that there was an unusual climate response associated with the Agung eruption, but it remains unclear whether the positive $\delta^{18}\text{O}$ anomaly was the product of an ENSO phase change or an advected cool-water anomaly.

CONCLUSIONS

The frequency-domain associations between Makassar Strait coral $\delta^{18}\text{O}$ and Darwin SLP have been examined using spectral techniques. The results support the following conclusions:

1. Cross-spectral analysis shows significant coherency between the Makassar Strait coral $\delta^{18}\text{O}$ and Darwin SLP time series.
2. 80-90% of the variance in the ENSO LF bandwidth is significantly coherent at 0.80 level. Consistent with the analysis by Barnett (1991), the ENSO LF band is found to be more important than the shorter QB band.
3. SSA of the Makassar Strait coral $\delta^{18}\text{O}$ and Darwin SLP time series shows common fundamental frequency mode EOFs with similar periodicities. The $\delta^{18}\text{O}$ time series have dominant decadal-scale modes which appear not to be important in the Darwin SLP record.
4. Summing the reconstructed EOF components that represent fundamental oscillations in the ENSO LF bandwidth explains 5-10% of the total variance in the coral $\delta^{18}\text{O}$ time series and 5% of the variance in the Darwin SLP time series.
5. The coral $\delta^{18}\text{O}$ ENSO LF modes are considered to have operational significance because they have amplitudes which exceed the ± 2 sigma laboratory precision on the measurement $\delta^{18}\text{O}$ by as much as a factor of two.
6. Cross-correlations between the $\delta^{18}\text{O}$ and SLP ENSO LF modes are high, $r = 0.7-0.8$, which suggests that these ENSO LF modes describe the essential ENSO-related variance in the time series, and give strength to the interpretation that Makassar Strait coral $\delta^{18}\text{O}$ responds to interannual climate forcing by the Indonesian Low Pressure Cell.

7. Largest errors are occasional mismatches in the magnitude of the $\delta^{18}\text{O}$ response due to either SST or mixing depth anomalies. There are also slight errors in timing that are consistent with known error margin of the $\delta^{13}\text{C}$ age models (as discussed in the previous chapter).

8. These results show that by isolating interannual variance within the ENSO LF band, it is possible to produce a correct proxy for Darwin SLP, despite the previously described noise levels in the coral $\delta^{18}\text{O}$ data. The extracted ENSO LF modes have statistically significant spectral coherency to the Darwin SLP record and large, operationally significant signal amplitudes. The coral ENSO LF modes track the Darwin SLP record and attest to the overall reliability of coral $\delta^{18}\text{O}$ records on ENSO timescales.

This study supports the further development of longer $\delta^{18}\text{O}$ records from Indonesian corals. The spectral estimation techniques used here provide reliable proxy observations on ENSO timescales, and with existing cores it should be possible to produce records of the Indonesian Low over the last 250-300 years. These data will allow new investigations of the long-term variability of the ENSO. For example, coral $\delta^{18}\text{O}$ index of the Southern Oscillation could be generated using a multi-century Indonesian coral record and a coral record from a Central or Eastern Pacific site near the descending limb of the Walker Circulation. Beside providing basic observations of the long-term variability of the ENSO, such an index would be invaluable for assessing potential relationships between global warming and ENSO event frequency. It has also been suggested that the exposure of the Sunda Shelf during glaciations caused the Indonesian Low to be permanently locked over

S.E. Asia (Quinn, 1971), which if true, would have significantly altered the ENSO. $\delta^{18}\text{O}$ records are currently being developed from fossil corals collected in Pleistocene reef deposits to examine this proposition. Observations of the interannual variability of the Indonesian Low during recent centuries will be an extremely useful benchmark for interpreting these data.

Certainly the most accurate proxy estimates of tropical climate variability will be those based on multiple records from spatially distributed sites. The next chapter begins to address this goal by examining the ENSO response in coral $\delta^{18}\text{O}$ records from four different sites in E. Indonesia.

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CHAPTER 4

EAST INDONESIAN CORAL ISOTOPE RECORDS: REGIONAL VARIABILITY

ABSTRACT

Monthly-resolution coral stable isotope records have been developed from a network of sites in the Indonesian Seaway that includes the Lombok Strait, the Makassar Strait, the Sulawesi Sea, and the Banda Sea. The records sample the last century and are suitable for analysis of the style and range of seasonal $\delta^{18}\text{O}$ response, the fidelity of the $\delta^{18}\text{O}$ records to local and regional climate, and long-term shift in mean $\delta^{18}\text{O}$ values. A range of response styles is observed among the interannual residual of the $\delta^{18}\text{O}$ records, and the different sites are classified by the degree to which the $\delta^{18}\text{O}$ signal is dominated by local or regional climate variability. The Lombok Strait site has a $\delta^{18}\text{O}$ signal related to Indian Ocean surface water variability and the signal appears to be locally dominated. The Makassar Strait site has a $\delta^{18}\text{O}$ signal that is dominated by regional-scale freshwater flux, but is also sensitive to advected SST from the W. Pacific. The $\delta^{18}\text{O}$ signal at the Sulawesi Sea site agrees very well with local and regional climate records, and appears to be responding to strong air-sea interactions near the equator. The Banda Sea site has a complicated setting and the $\delta^{18}\text{O}$ signal is sufficiently confounded that no clear relationships to either local or regional climate are found. Secular trends in the $\delta^{18}\text{O}$ records over the last century are found to be inconsistent, and are strongly suggestive of slowly shifting isotopic fractionation thresholds in the corals rather than real climate change.

INTRODUCTION

In coral-based studies of the tropical climate system, attention to the site-specific nature of the isotopic signal is critically important. Since the coral's isotopic variability can only be a function of the variability of the surface waters that bathe the coral, the reconstructed signal is always a local, sites-specific response. The real issue is how "well-tuned" the site is to the regional climate variability. A common tendency in the coral isotope literature has been to assume that the isotope time series has regional (or global) significance, without evaluating whether in fact the data support such a conclusion. Besides being poor science, this has the result of undermining the credibility of coral-based climate reconstructions.

When considering regional variability, it is important to recognize that $\delta^{18}\text{O}$ time series from some sites can be climatologically worthless, and in fairness, must be described as such. Other sites can provide excellent, regional-scale data, and are worth continued analytical investment. Eastern Indonesia is an excellent place to examine some of the factors that contribute to the overall quality of the coral $\delta^{18}\text{O}$ response. E. Indonesia has a surface water hydrography that varies from simple to complex, and the region is overlain by a relatively homogenous atmospheric forcing supplied by the Indonesian Low Pressure Cell. The Indonesian Low is responsible for strong ENSO-related interannual climate variability in E. Indonesia, but as will be seen, corals from different sites capture this signal to varying degrees.

The coral $\delta^{18}\text{O}$ response convolves both SST and freshwater flux variability. The measured coral $\delta^{18}\text{O}$ signal is thus a product of the relative magnitude and phase relationship of SST and freshwater flux. Strong

movement of surface waters imparts a dynamic aspect to the isotopic signal. From the perspective of climate variability, the coral $\delta^{18}\text{O}$ signal is a function of the relative strength of the local SST and freshwater flux variability as compared to the regional SST and freshwater flux variability. The degree to which regional forcing dominates local climate is clearly a major control on the proxy value of coral $\delta^{18}\text{O}$ records. Regional domination of the $\delta^{18}\text{O}$ signal can come about in two ways: situations where air-sea interactions in the vicinity of the site dictate a highly correlatable response between local and regional variability, or situations where moving surface waters advect water properties that swamp the local meteorological effects.

In previous chapters it was established that coral proxy data appears most reliable on interannual timescales, and that it was possible to recover the regional climate signal using either filtering or spectral estimation techniques. This chapter will survey coral $\delta^{18}\text{O}$ records from four sites in Indonesian seaway, discuss the isotopic response of each record with regard to local climatology and the similarity of the records to local and regional forcing. Assessments will be made of the hydrographic factors at each site which contribute to, or detract from, the fidelity of each record. Secular trends in the records will also be examined, and it will be suggested that these trends can be largely explained by coral growth dynamics and not climate change.

SITE SELECTION

The eastern part of Indonesia is most favored by coral reef growth, and lies on the NW-SE monsoon axis that describes the seasonal movement of the Indonesian Low Pressure Cell over S.E Asia. The strategy in choosing coring sites was to develop a regional-scale network in E. Indonesia that

would provide multiple independent observations of local climate forcing by the Indonesian Low Pressure Cell. Five sites were selected which met the criteria of having a strong ENSO-related response in interannual precipitation variability, a unique hydrographic setting, and a reasonable degree of access within the limitations of the field program. These sites are representative of some of the major hydrographic features of the region. Stable isotope records have been developed from seven cores from four of these sites, as shown in Figure 1. A complete list of the cores collected is given in Appendix I.

Padang Bai, Bali (8°32'S, 115°32'E) - Core PDB

Padang Bai is a small bay on the southeast coast of E. Bali, in the arid section of the island lies on the west side of the Lombok Strait, as shown in Figure 2. A portion of the Pacific surface waters throughflow exits to the Indian Ocean via the Lombok Strait (Murray and Arief, 1988). The sill depth in the Lombok Strait is only 152m, and water movement tends to be fast and turbulent. The sampled reef is in a small bight on the open coast and has a number of large *Porites* colonies are growing at 10m depth. The largest of these is 4m tall; core PDB was collected from this colony during the first reconnaissance trip to E. Indonesia in 1989. A short stable isotope record was developed from this core for the period 1968-1986. It was first published in Cole et al., 1992, and is presented again here in a revised form at monthly resolution. In 1990, a 4.32 m core was recovered from this coral colony using the 3" hydraulic drill. This core (PDB1C) is estimated to date back 288 years, ca. 1702. Other long cores were also collected from this site. None of cores collected in 1990 have been analyzed.

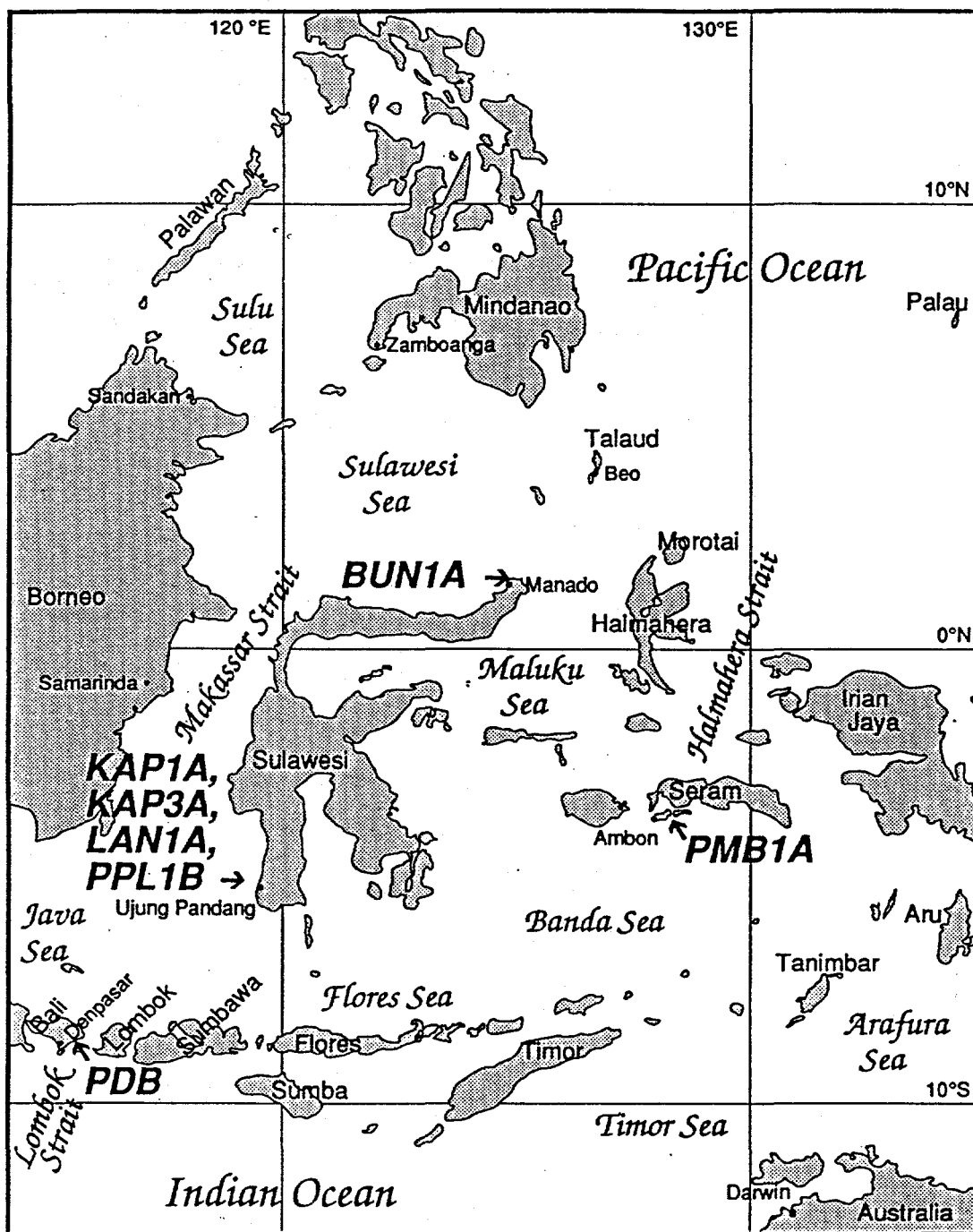


Figure 1. Map showing the locations and names of the E. Indonesian coral stable isotope records.

Core Sites in the Lombok Strait

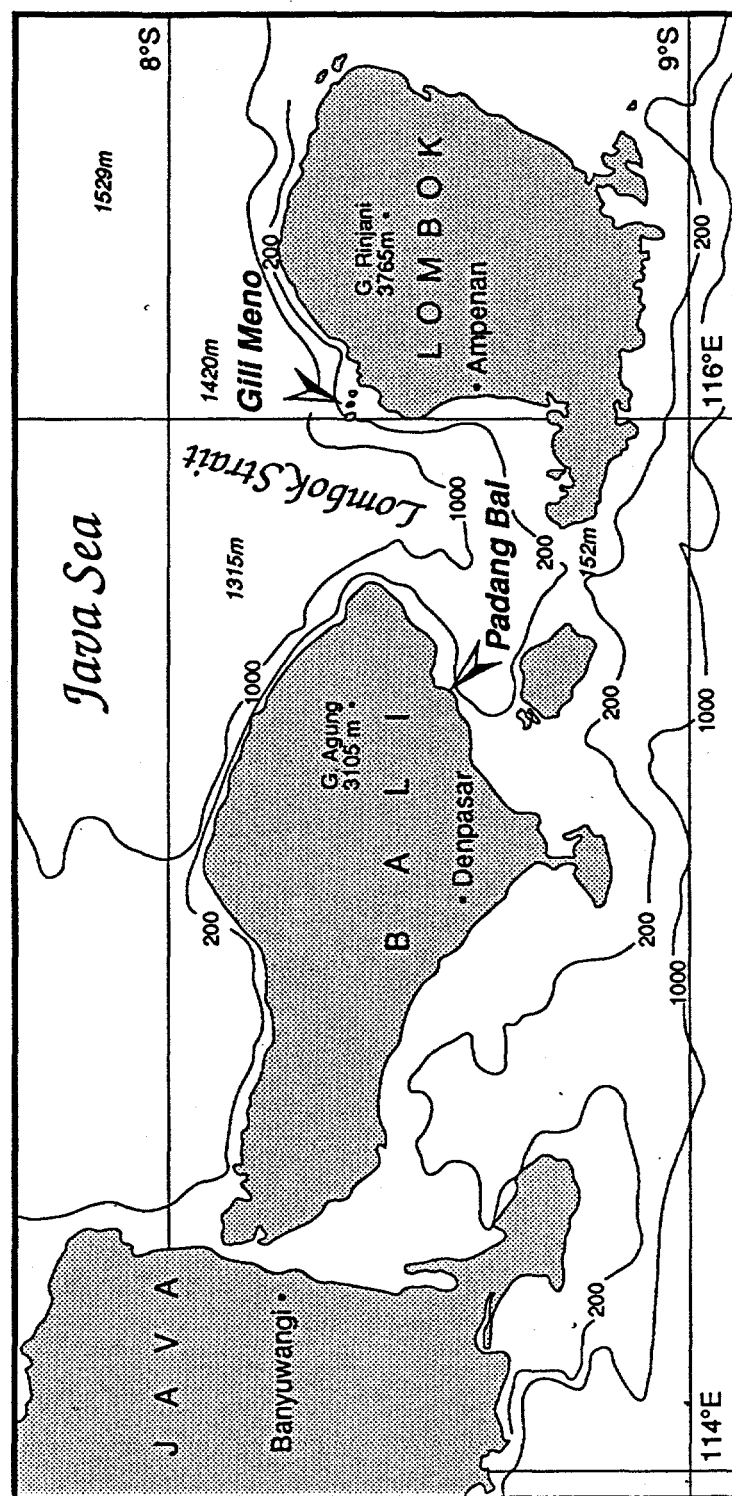


Figure 2. Map of the Lombok Strait, showing the locations of the Padang Bai and the Gili Meno core sites.

Bunaken Island, N. Sulawesi (1°38'N, 124°45'E) - Core BUN1A

Bunaken Island is located 7 km off of the mainland, at the extreme northern end of the long North Sulawesi peninsula, as shown in Figure 3. Bunaken Island is surrounded on all sides by deep water, and is bathed by the retroflecting east-bound surface waters of the Mindanao Current which feed the North Equatorial Countercurrent. This site is at the inlet of the Indonesian Seaway, and has the most open ocean character of all of the sites sampled. In 1990 a single core (BUN1A) was collected from a large *Porites* colony on the northeast corner of the island using the 3" hydraulic drill. This core measures 2.65m and is estimated to date back 145 years, ca. 1845. Additional cores were collected from a large, but still living, toppled colony at Tasik Ria, a fringing reef on the N. Sulawesi mainland.

Spermonde Bank, S. Sulawesi (4°40'-5°10'S, 118°50'-119°25'E)

Cores: KAP1A, KAP3A, LAN1A, PPL1B

The hydrography of the Makassar Strait and the setting of the Spermonde Bank was described in detail in earlier chapters. 13 cores were collected here in 1990. The stable isotope records from offshore sites at Kapoposang Island and Langkai will be further discussed, as well as a new stable isotope record from Podong Podong Lompo Island (PPL1B). Podong Podong Lompo Island is located on the mid-shelf in shallow water, as shown in Figure 4. It is sufficiently close to the mainland to be under direct influence of local river discharge. The sampled reef lies about 500m west of the island and has several large *Porites* colonies growing at 3m depth. Two cores were collected from the largest of these colonies: PPL1A (2.97m) and PPL1B (3.18m). These cores are estimated to date back 236 yr and 261 yr, respectively. Additional cores were collected from similar mid-shelf sites at

Core Sites in the Sulawesi Sea

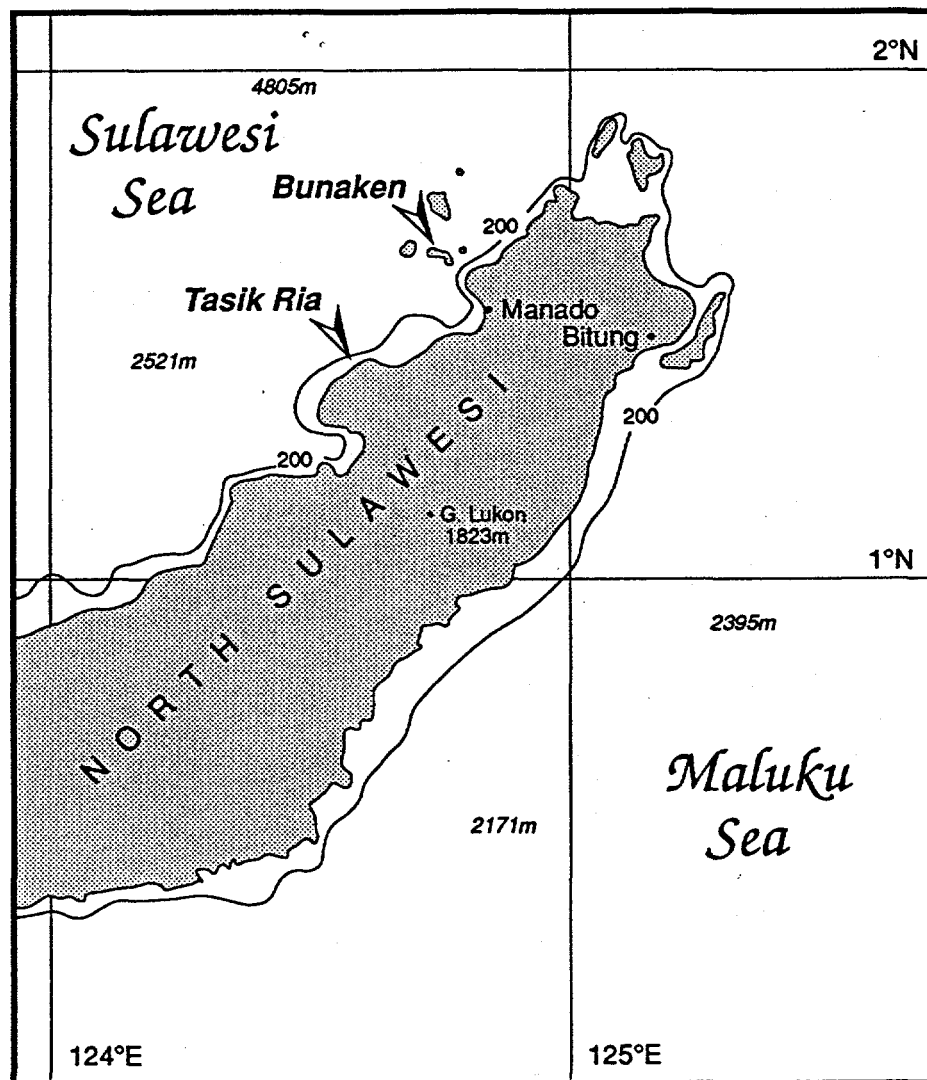


Figure 3. Map of N. Sulawesi, showing the locations of the Bunaken Is. and Tasik Ria core sites

Core Sites in the Spermonde Bank (Makassar Strait)

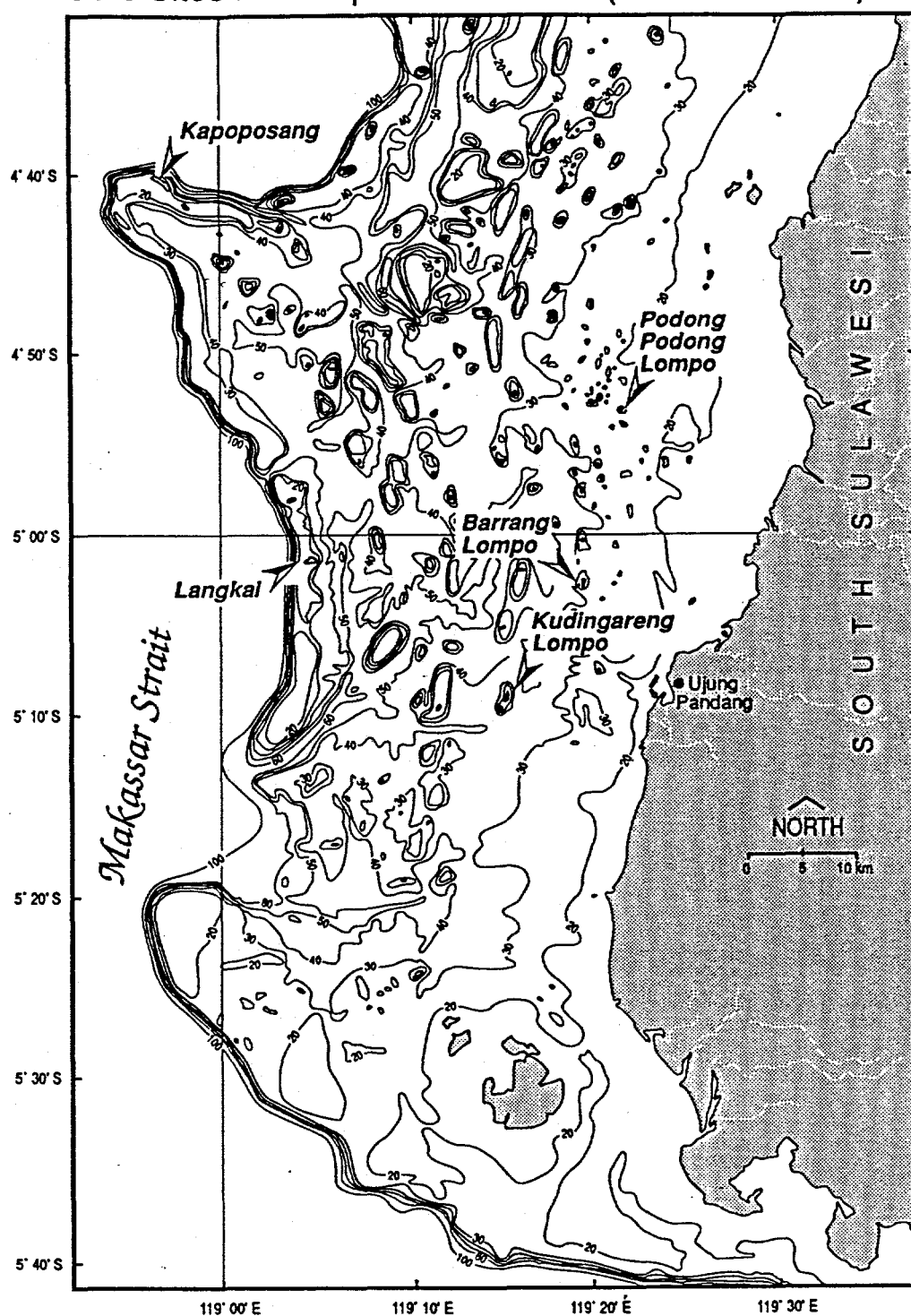


Figure 4. Map of the Spermonde Bank, S.W. Sulawesi, showing the locations of the offshore core sites (Kapotposang Is. and Langkai Is.) and the midshelf core sites (Podong Podong Lompo Is., Barrang Lompo Is., and Kudingareng Lompo Is.)

Barrang Lompo Island and Kudingareng Island (Figure 4), but none of this material has been analyzed.

Pombo Island, N. Banda Sea (3°32'S, 128°22'E)- Core PMB1A

Pombo Island lies between Ambon and Haraku, south of Seram, as shown in Figure 5. The site lies is bathed by surface waters of the Banda Sea and surface waters entering the Indonesian Seaway via the Halmahera Strait. Unlike the sites described above, which are characterized by a strong drought response during ENSO warm phase, the N. Banda Sea has an opposite response, with enhanced precipitation during ENSO warm phases. At the time this study was initiated, I had not established that a negative precipitation anomaly could be reliably captured by coral proxy records. Since the other ongoing studies in the Pacific were based on sites with large positive precipitation anomalies, it seemed wise to include a site with this style of response as well. A 2.53m core was collected from a large *Porites* colony growing at 12m depth on the west side of Pombo Island. The core is estimated to date back 199 yr. Additional cores were collected from dead *Porites* colonies found in the interior of Ambon Bay. The corals were found partially buried in mud, and had apparently been killed by high sedimentation rates. These cores have not been analyzed.

Site Network Dimensions

The site network is of sufficiently large dimension to be considered regional in scale. From the Spermonde Bank, it is 1060 km to Pombo, 965 km to Bunaken, and 560 km to Padang Bai. The distance from Padang Bai to Bunaken is 1540 km. The network domain has an average radius of 800 km comprising about $2.0 \times 10^6 \text{ km}^2$, as shown in Figure 6. This is an area roughly

Core Sites in the N. Banda Sea

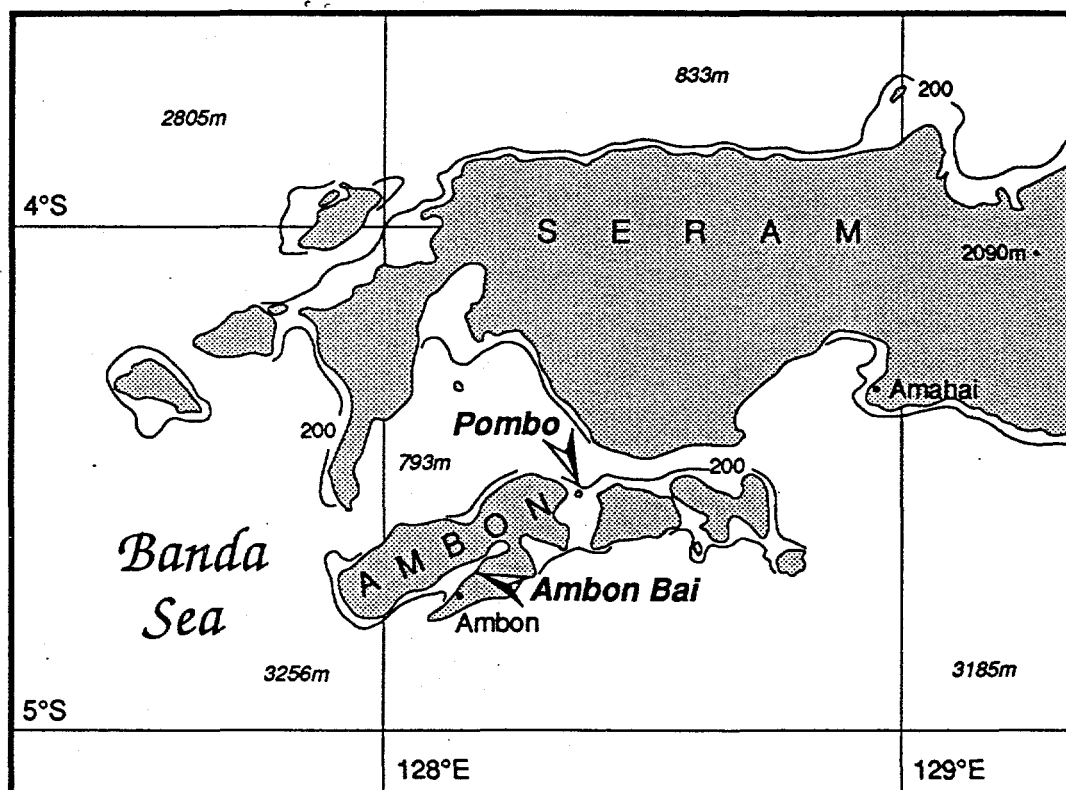


Figure 5. Map of the N. Banda Sea, showing the locations of the Pombo Is. and Ambon Bai core sites.

Site Network Dimensions

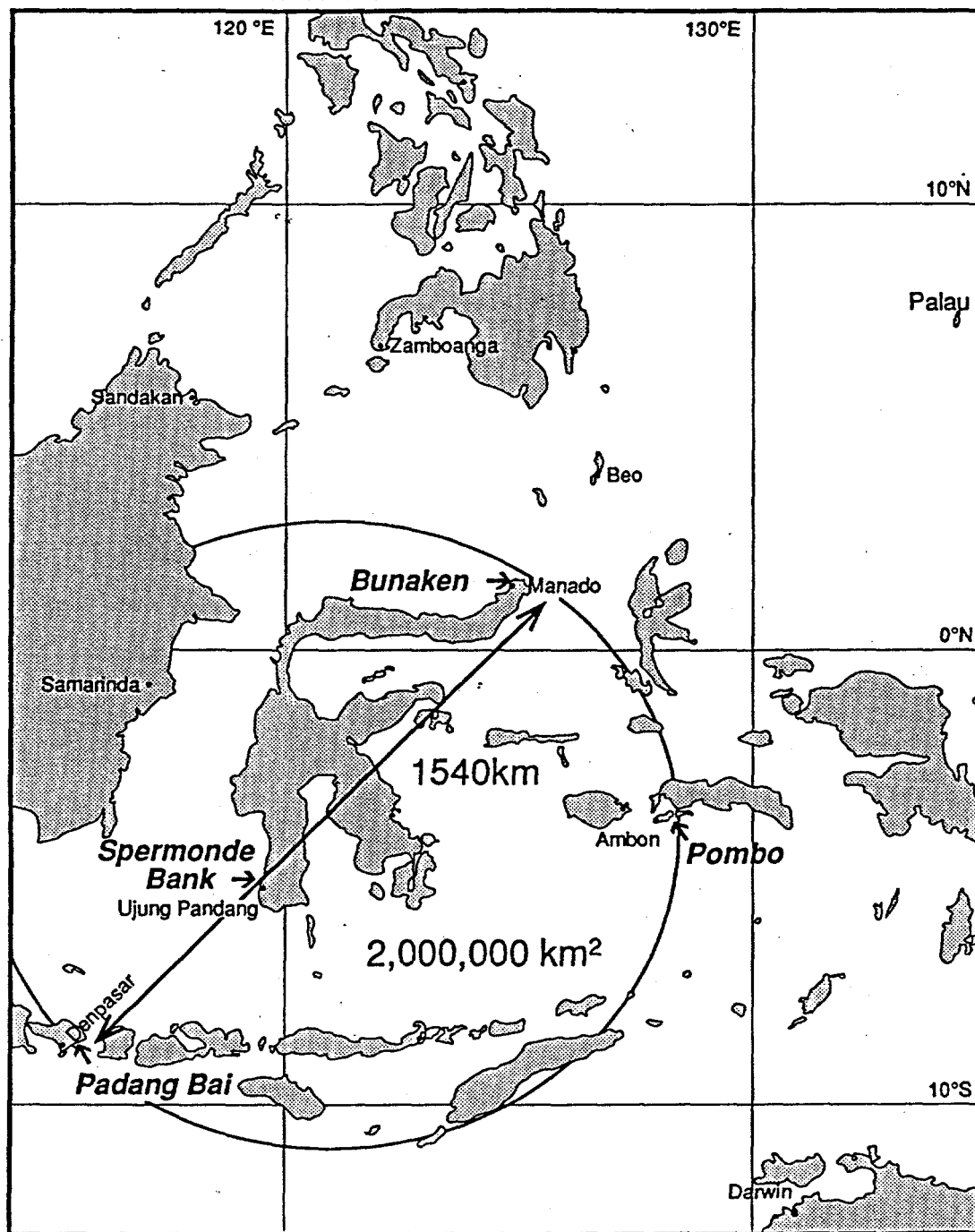


Figure 6. Area encompassed by the core site network.

the size of the western United States. The sites are well chosen to potentially capture surface water variability on the main Makassar Strait throughflow route, as the western section has sites in position to record the recirculation in the Sulawesi Sea, the throughflow in the Makassar Strait, and the discharge to the Indian Ocean via the Lombok Strait. The eastern section of the site network is weaker in this regard, as there are no sites at the Halmahera Strait throughflow entrance or at the Timor Strait exit. The following is a brief description of each of the sites.

METHODS

The core preparation, sub-sampling, gas-source mass spectrometry, and data reduction were as previously described in Chapter 2. The PDB and PPL1B cores were analyzed in the laboratory of Dr. Rick Fairbanks at Lamont-Doherty Geological Observatory, and the BUN1A and PMB1A cores were analyzed in the laboratory of Dr. Don DePaolo at the LBL Center for Isotope Geochemistry.

DATA SETS

Precipitation data is from the ASEAN Compendium of Climate Statistics (Ho Tong, 1982), a compilation of all available rainfall data for the ASEAN nations, and was supplemented by annual climate reports from the Indonesian Bureau of Geophysics and Meteorology. Monthly mean precipitation climatologies were computed from the nearest met station with the longest continuous record for each site.

The Global Ocean Surface Temperature Atlas (GOSTA) data set (Bottomley, et al., 1990), has $1^{\circ} \times 1^{\circ}$ gridded mean monthly SST values for E.

Indonesia. Monthly mean SST climatologies were developed for each site using the nearest $1^{\circ} \times 1^{\circ}$ grid box.

The Climatological Atlas of the World Ocean (Levitus, 1982) has $5^{\circ} \times 5^{\circ}$ gridded mean sea surface salinity values at quarterly resolution (February-April, May-July, August-October, November-January) covering most of the Indonesian Seaway. Seasonal salinity ranges for each of the sites was estimated using this data.

RESULTS

With over 80m of coral core in the collection, it was not conceivable that any more than a small portion of the cores could be analyzed at 1 mm resolution. In order to maximize the climatological data yield while conserving analytical resources, it was decided to develop 30-40 year long records from the core tops for each of the sites, and then proceed to the sections of core deposited around the turn of the century and develop records 10-20 years in length. This strategy allows for a diagnosis of the quality of the signal at each of the sites, as well as a check on the reproducibility of the secular trends seen in 128 yr KAP1A $\delta^{18}\text{O}$ record presented in Chapter 2. An alternative approach would have been to increase the sub-sample increment, thereby lowering the resolution of the time series, but this would have introduced substantial aliasing into the data.

The PDB stable isotope time series (1968-86) are presented in Figure 7. Re-examination of the original age model used by Cole et al, 1992 revealed an error in year-assignments that has been corrected in this interpretation. As mentioned earlier, no mid-core section from Padang Bai has been analyzed.

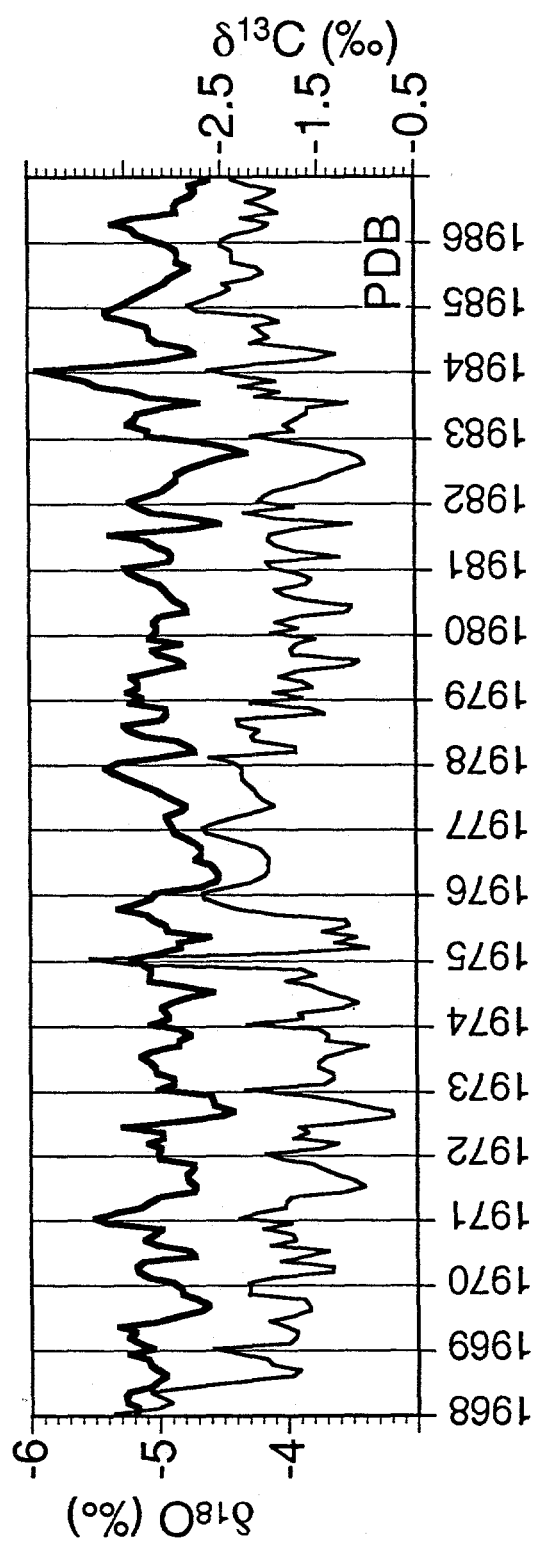


Figure 7. PDB stable isotope time series, 1968-1987. $\delta^{18}\text{O}$, heavy line; $\delta^{13}\text{C}$, light line. Y-axes reversed as per convention.

The $\delta^{18}\text{O}$ seasonality is low compared to the records from the Spermonde Bank. A large minima is seen in 1984, with values about 1‰ more negative than the mean.

The BUN1A stable isotope time series (1901-13, 1962-89) are presented in Figure 8. A feature of this time series are the occasional $\delta^{13}\text{C}$ spikes occurring mid-year (seen in 1903, 1963, 1965, 1979, and 1989), which are not reflected in the $\delta^{18}\text{O}$ time series. The seasonality of the $\delta^{18}\text{O}$ time series is weak, and interannual variability appears to be more dominant.

The PPL1B stable isotope time series (1974-86) are presented in Figure 9. This record has the same basic response style of the other records from the Spermonde Bank (KAP1A and 3A, LAN1A), with maxima marking the periods of low freshwater flux during ENSO warm-phase events (e.g. 1983). The record has a strong, even seasonality in both $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$.

The PMB1A stable isotope time series (1880-1904, 1960-1989) are presented in Figure 10. Note that the age model for this time series specifies that the $\delta^{13}\text{C}$ minima falls in June (rather than January), consistent with the local climatology. The $\delta^{13}\text{C}$ and the $\delta^{18}\text{O}$ time series are fairly regular during normal years and become erratic during strong ENSO warm event years (e.g. 1963, 1972-73, 1980, 1982-83). There is a obvious trend of about -0.5‰ in the $\delta^{18}\text{O}$ record during the period 1966-89.

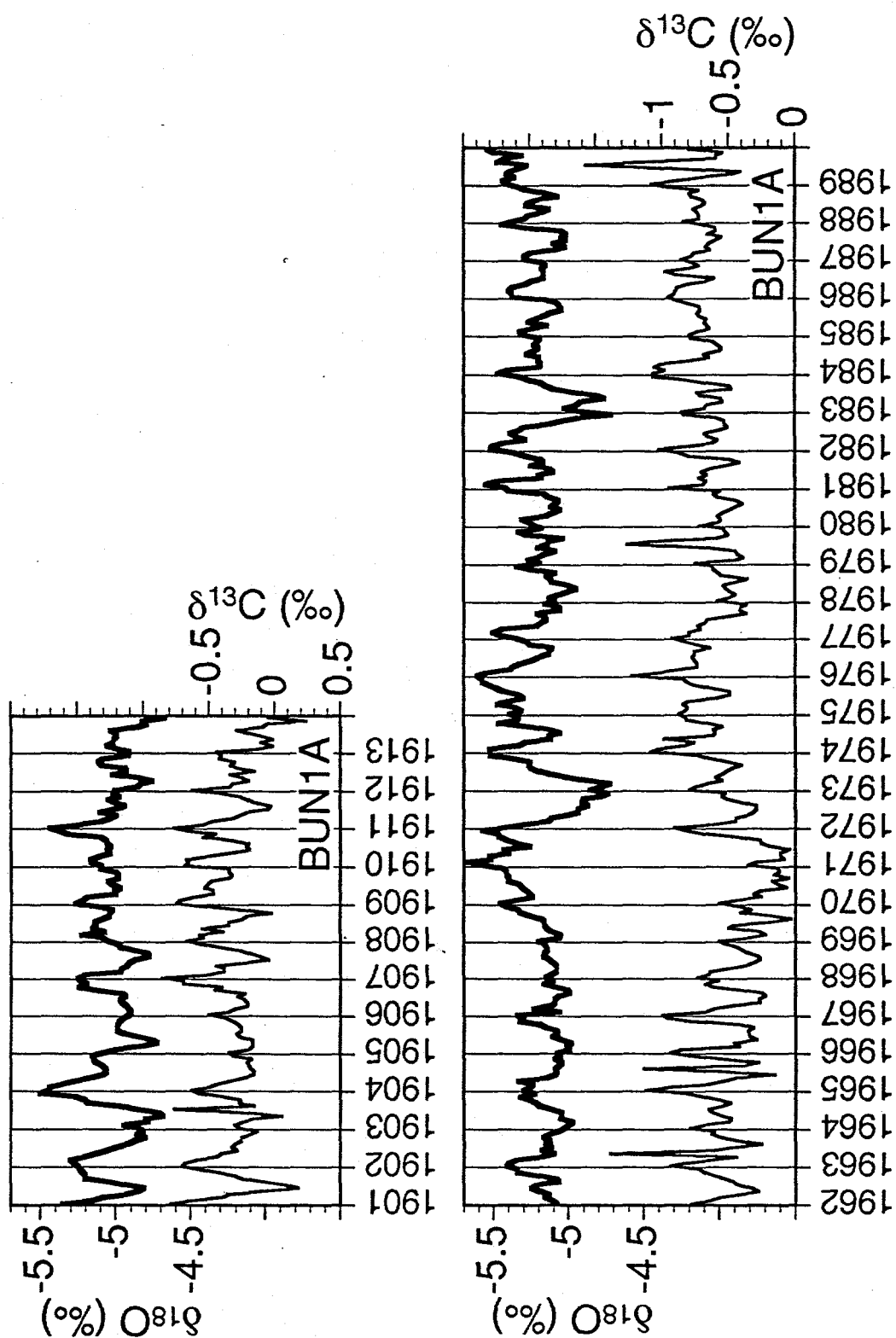


Figure 8. BUN1A stable isotope time series, 1901-13 and 1962-1989. $\delta^{18}\text{O}$, heavy line; $\delta^{13}\text{C}$, light line. Y-axes reversed as per convention.

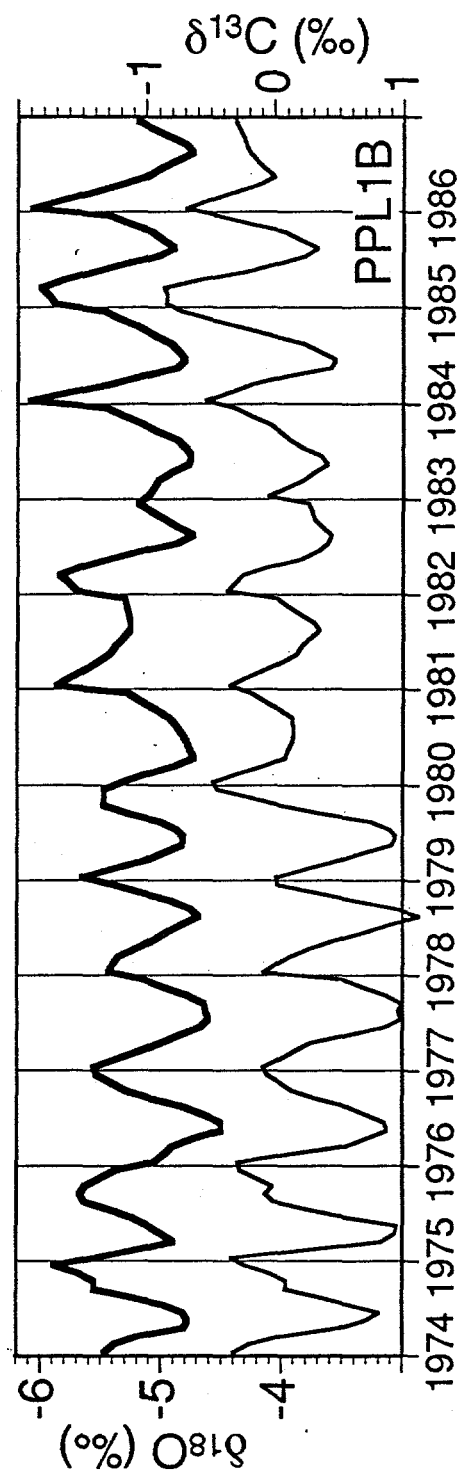


Figure 9. PPL1B stable isotope time series, 1974-86. $\delta^{18}\text{O}$, heavy line; $\delta^{13}\text{C}$, light line. Y-axes reversed as per convention.

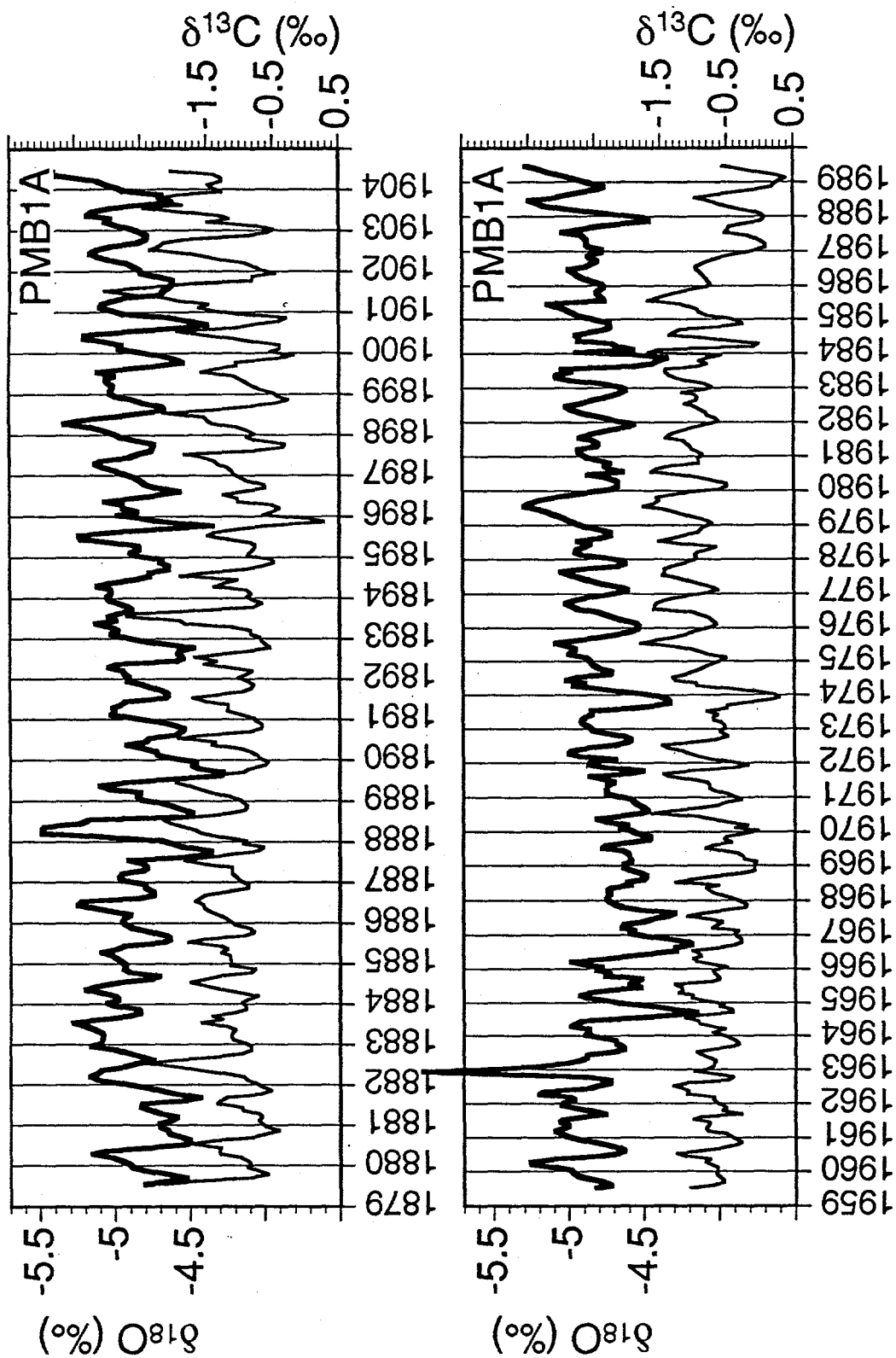


Figure 10. PMB1A stable isotope time series, 1879-1905 and 1959-1989. $\delta^{18}\text{O}$, heavy line; $\delta^{13}\text{C}$, light line. Y-axes reversed as per convention.

DISCUSSION

To assess the regional variability of the coral $\delta^{18}\text{O}$ records two basic tests were conducted. In the first test, the local precipitation record was cross-correlated to the Darwin SLP record. This yields a measure of the fidelity of the local fresh water flux to the regional-scale convective activity of the Indonesian Low Pressure Cell, and provides a baseline for how well a coral $\delta^{18}\text{O}$ record might be expected to perform as a climate proxy. In the second test, the coral $\delta^{18}\text{O}$ records were cross-correlated to both the local precipitation record and to the Darwin SLP record. The outcome of this analysis allows the site to be placed in the context of whether it is functioning as a recorder of local versus regional climate variability.

To illustrate this, one might conceive of the matrix shown below (Table I). The assumption here is that coral $\delta^{18}\text{O}$ is predominantly recording a freshwater flux signal. The case where coral $\delta^{18}\text{O}$ record correlates well to local precipitation and poorly to regional SLP suggests that the site is dominated by local freshwater flux and is insensitive to changes in regional-scale freshwater flux variability. This might be due to orographic rainfall effects, for example. The opposite case, where the coral $\delta^{18}\text{O}$ record correlates well to regional SLP and poorly to local precipitation, suggests that the site is dominated by regional freshwater flux variability and is insensitive to local effects. This might be due to strong surface currents in the region, for example.

Table I. Signal Assessment Matrix:

Coral $\delta^{18}\text{O}$ Fidelity:	Low r to Regional SLP	High r to Regional SLP
Low r to Local FWF	Confounded	Regional
High r to Local FWF	Local	Resonant

The case where high correlations are found to both local precipitation and regional SLP suggests a site where not only is the volume of freshwater flux responding linearly to regional climate variability, but the hydrography at the site serves to carry the freshwater flux signal without significant modification. This might be marine precipitation over a broad area of uniform surface water flow, for example. The term introduced here to describe this case is "resonant", in the sense that the local climate variability "echoes" (or has the same "beat" as) the regional climate variability. Proxy records from resonant sites have high value in paleoclimatic reconstructions for they allow the possibility of locally-calibrated records that scale to the regional climate forcing.

The last case, where no strong correlations to either local precipitation or regional SLP are found is indicative of a site where other processes have confounded the coral's $\delta^{18}\text{O}$ response. There are many reasons why an outcome like this is possible, even in a region with strong freshwater flux. For example, the site could have a large SST variability that is out-of-phase with freshwater flux, such that coolest SSTs (producing positive coral $\delta^{18}\text{O}$) occurs during the time of greatest isotopic dilution of the sea surface by rainwater (producing negative coral $\delta^{18}\text{O}$). The site could be dominated by strong SST variability due to local upwelling. The site could have large vertical mixing rates. The residence times of surface waters could be sufficiently long to buffer freshwater flux variability on monthly and interannual time scales. The paleoclimatic value of $\delta^{18}\text{O}$ records from confounded sites appears low.

Prior to computing cross-correlations, the data were detrended (when necessary) and monthly mean climatologies computed. The monthly mean climatologies were used to deseasonalize the records, and the resulting interannual residuals were smoothed by twice-applying a 13 point centered running mean. This is the same treatment used in Chapter 2, and it was applied to all of the time series used here. Cross-covariance functions were computed to ± 60 lags for Darwin SLP to local precipitation and for $\delta^{18}\text{O}$ to local precipitation and to Darwin SLP with the ARAND spectral analysis package.

Local Response: Padang Bai, Lombok Strait

The seasonal SST range for the GOSTA $1^\circ \times 1^\circ$ grid box containing the Padang Bai site ($8^\circ\text{--}9^\circ\text{S}$, $115^\circ\text{--}116^\circ\text{E}$) is about 2.5°C , with a maximum in November-March, as shown in upper panel of Figure 11. Mean precipitation at Denpasar during the rainy season is about 300 mm mo^{-1} through December-February. The dry season averages less than 100 mm mo^{-1} and last for seven months beginning in April. SST and precipitation climatologies are in-phase. The PDB $\delta^{18}\text{O}$ seasonality is shown in lower panel of Figure 11. The $\delta^{18}\text{O}$ minima in January corresponds to the precipitation maxima, but the minima is shouldered on both sides suggesting a convolved SST response. Similarly, the $\delta^{18}\text{O}$ maxima is not nearly as broad as the precipitation minima, and appears to incorporate a SST response through the months April-June. The seasonal range of $\delta^{18}\text{O}$ computed by maxima-minima differencing is 0.68‰ , which exceeds the expected coral SST fractionation response of 0.55‰ ($2.5^\circ\text{C} \times 0.22\text{‰}^\circ\text{C}^{-1}$) by 0.13‰ . Applying the Kapoposang $\delta w/\text{salinity}$ mixing line (determined in Chapter 1) yields an estimated salinity range of 0.48 psu ($0.13\text{‰} / 0.269\text{‰ psu}^{-1}$). Levitus (1982)

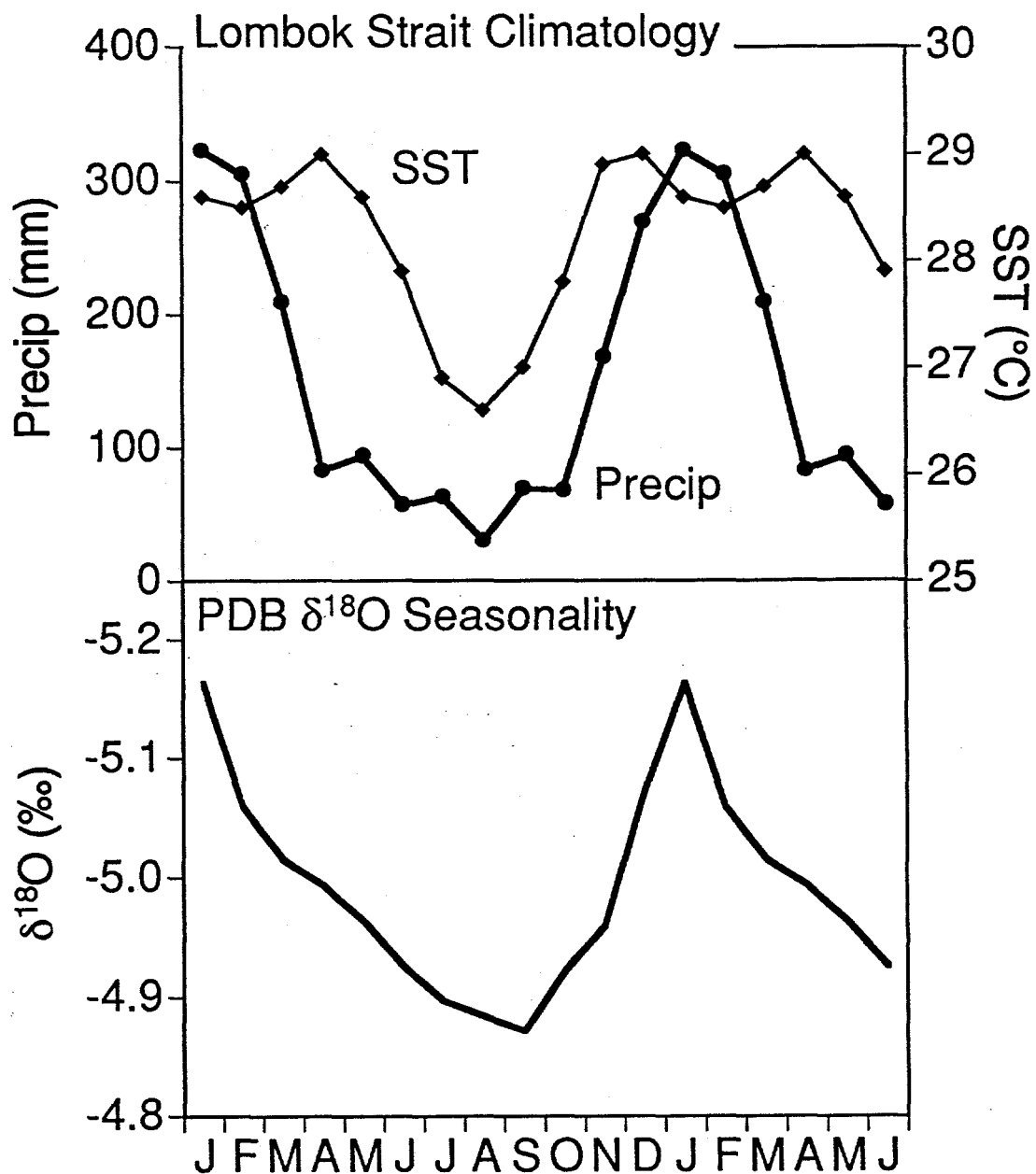


Figure 11. Lombok Strait SST and Denpasar precipitation climatology compared to the seasonality in the PDB $\delta^{18}\text{O}$ record. $\delta^{18}\text{O}$ y-axis reversed

gives the salinity range for the $5^{\circ}\times 5^{\circ}$ grid box containing the Java Sea and Lombok Strait and (5° - 10° S, 115° - 120° E) as 1.54 psu, about three times this estimate. The grid box due south in the Indian Ocean (10° - 15° S, 115° - 120° E) gives a salinity range of 0.31 psu, much closer to the estimated value of 0.48 psu. From this it can be concluded that the PDB $\delta^{18}\text{O}$ is capturing a relatively minor freshwater flux signal compared to that found in the Java Sea and Makassar Strait.

The zero-lag cross-correlation of the smoothed interannual residuals of Denpasar precipitation to Darwin SLP is -0.42 for the period 1968-87. The correlation is lower than expected: most E. Indonesian precipitation records typically post correlations in the -0.6 to -0.8 range. This suggests that the Bali climate is subject to forcings other than those strictly related to the Indonesian Low, such as convection stimulated by the Indian Ocean. The cross-covariance functions for Denpasar precipitation to PDB $\delta^{18}\text{O}$ yields $r = -0.76$ with a lag of -2 months (Figure 12), while Darwin SLP to PDB $\delta^{18}\text{O}$ yields $r = 0.42$ with a lag of -7 months (Figure 13). The sign of the lag indicates that the isotope record is leading the climate time series, which in the case of the Denpasar precipitation is an unlikely circumstance, and instead argues for the normal range of error in the age model. Correcting for this, then the lag in the cross-covariance function for Darwin SLP becomes -5 months.

The three time series are shown in Figure 14. The agreement between PDB $\delta^{18}\text{O}$ (lag-adjusted by 2 months) and Denpasar precipitation is very good. Neither record bears close resemblance to the Darwin SLP record, especially through the ENSO warm-phase events in 1972-73 and 1982-83. Therefore, it must be concluded that the PDB core site is locally dominated- the PDB $\delta^{18}\text{O}$

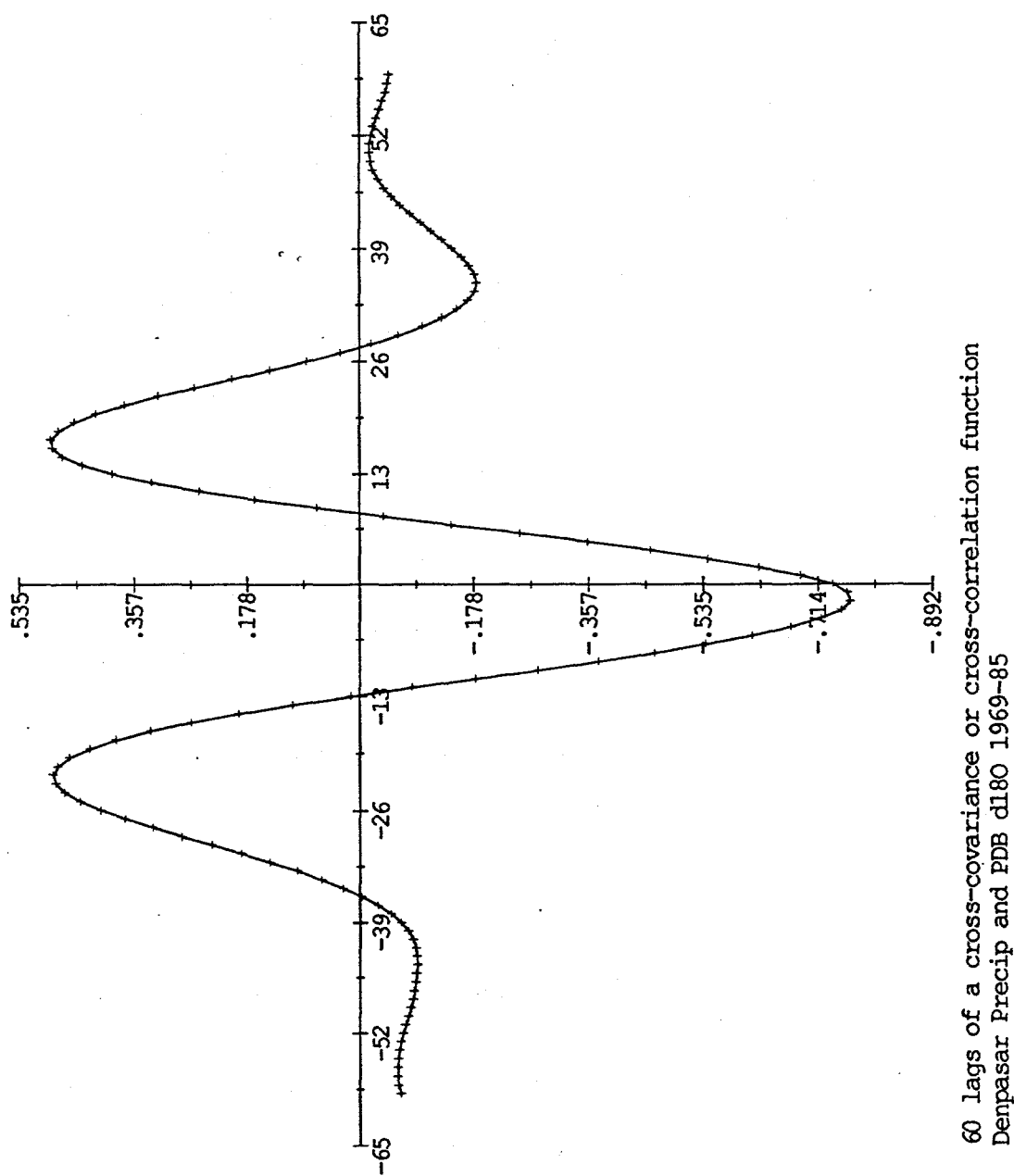
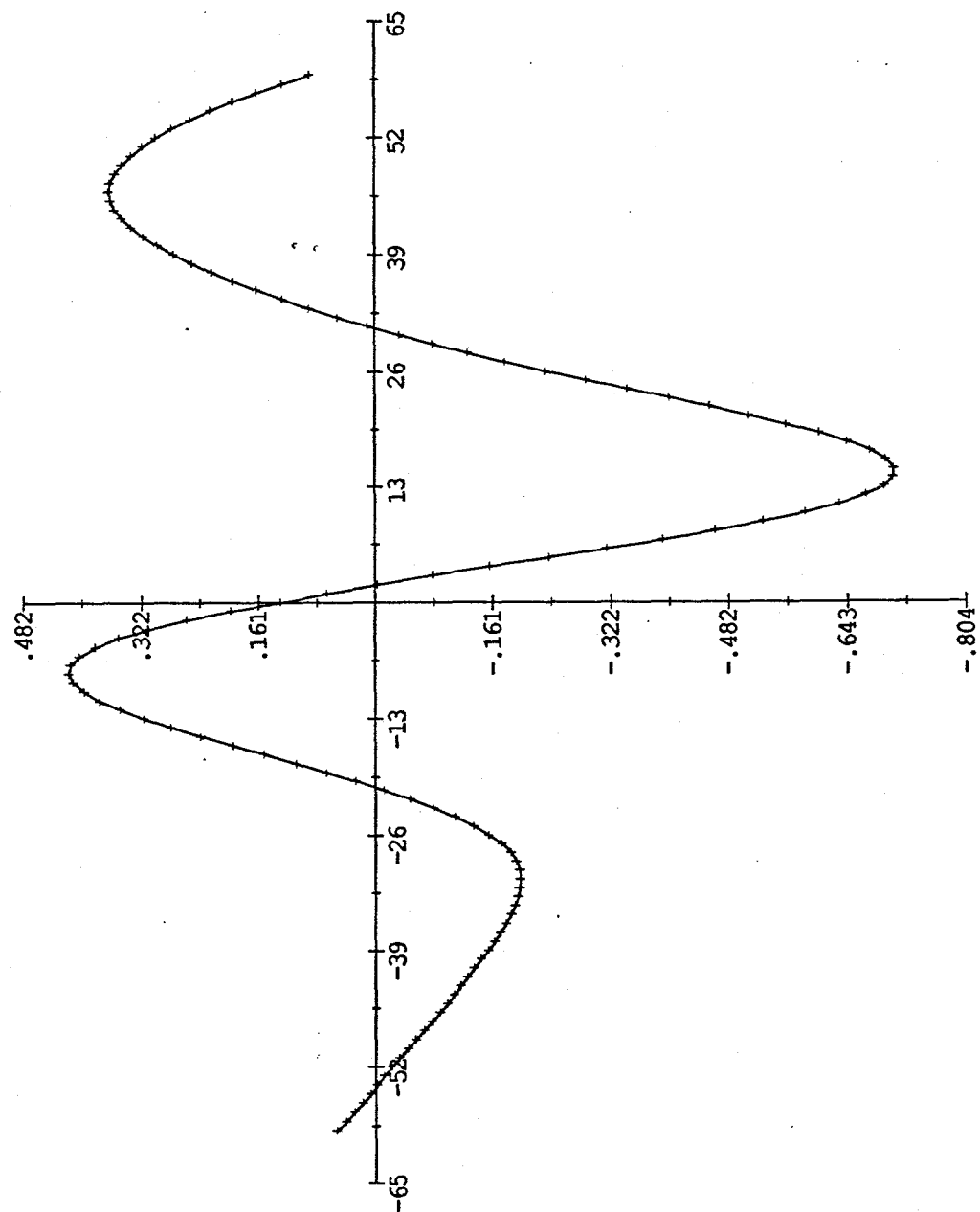


Figure 12. Cross-covariance function for Denpasar rainfall and PDB $\delta^{18}\text{O}$, $r = -0.76$, $m = -2$.



60 lags of a cross-covariance or cross-correlation function
 Darwin SLP and PDB d18O 1969-85

Figure 13. Cross-covariance function for Darwin SLP and PDB $\delta^{18}\text{O}$, $r = 0.42$, $m = -7$.

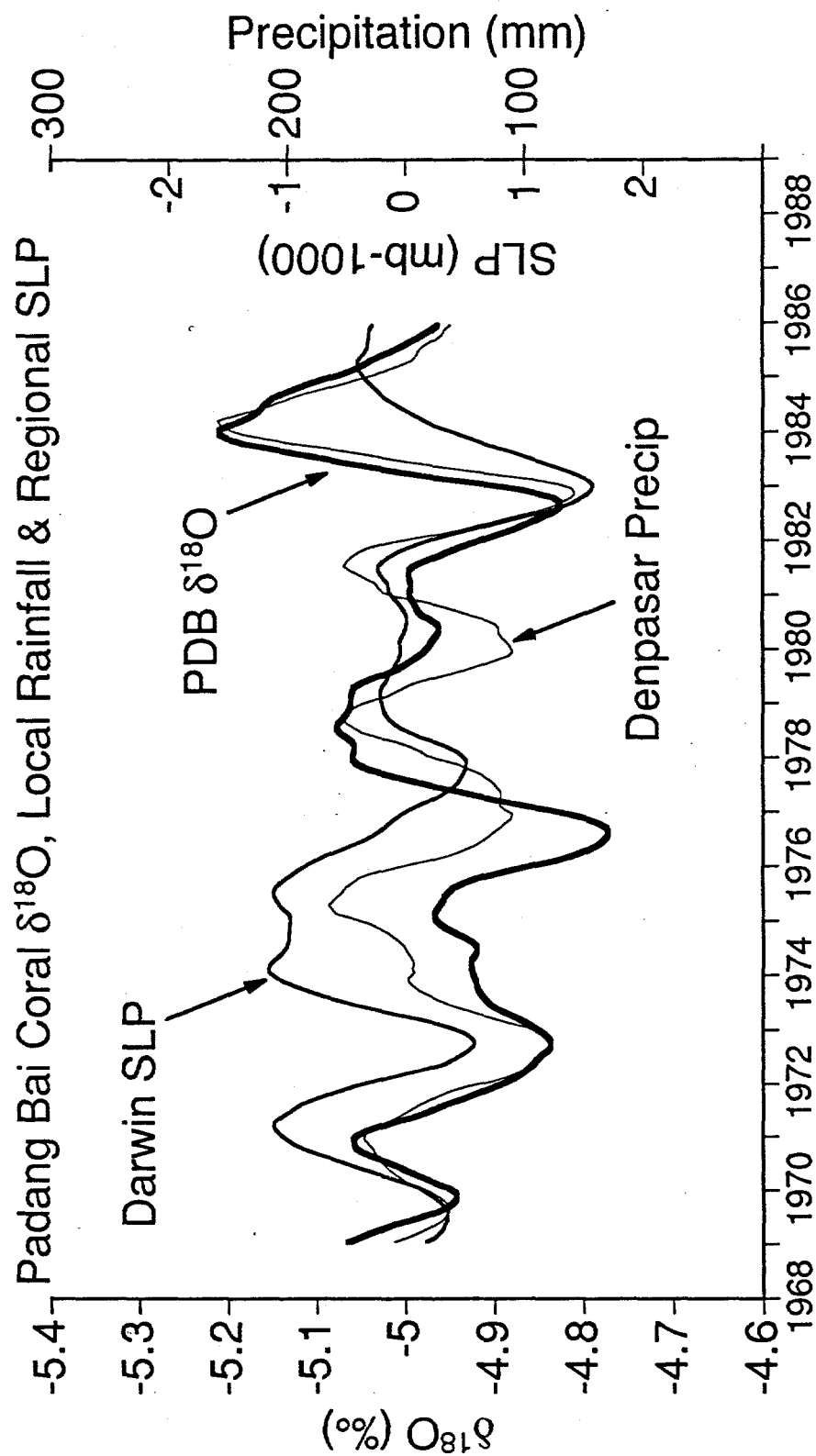


Figure 14. Interannual variability in Denpasar rainfall, Darwin SLP and PDB $\delta^{18}\text{O}$ (1968-87). $\delta^{18}\text{O}$ and SLP y-axes reversed..

record, while accurate, is clearly record of local freshwater flux rather than regional freshwater flux of the Indonesian Low. This conclusion also is supported by the seasonal salinity range estimate from above, which links the surface water variability at Padang Bai to the Indian Ocean.

What happened to the large freshwater flux signal expected from the Java Sea and the Makassar Strait? In the Wyrski (1961) plot of the February salinity (Chapter 2, Figure 1), a low salinity signal can be seen emanating from the southeast coast of Borneo and penetrating eastward to the Banda Sea. In contrast, there is a sharp salinity gradient south of the Lesser Sunda island chain (E. Java to Timor). This suggests mixing processes are strong the Lesser Sunda sills and that the low salinity signal in the Java Sea is being quickly mixed away as surface waters cross into the Indian Ocean. The effect of mixing would be even more pronounced on an interannual salinity anomaly, since it would have a smaller magnitude than a seasonal signal. In general, this would argue against choosing sites in close proximity to sills or other bathymetric features that promote turbulent mixing if the goal is to recover a regional-scale freshwater flux signal.

Regional Response: Spermonde Bank, Makassar Strait

The seasonal range of SST for the $1^{\circ} \times 1^{\circ}$ grid box adjacent to the Kapoposang and Langkai core sites (118° - 119° E, 4° - 5° S) is 1.5°C , as shown in the upper panel of Figure 15. There are two maxima in April and November, and a minima in August. Precipitation for Ujung Pandang during the rainy season is more than 650 mm mo^{-1} in January, and falls to less than 50 mm mo^{-1} during the peak of the dry season in July-September. The $\delta^{18}\text{O}$ seasonalities for all of the coral records from the Spermonde bank are shown

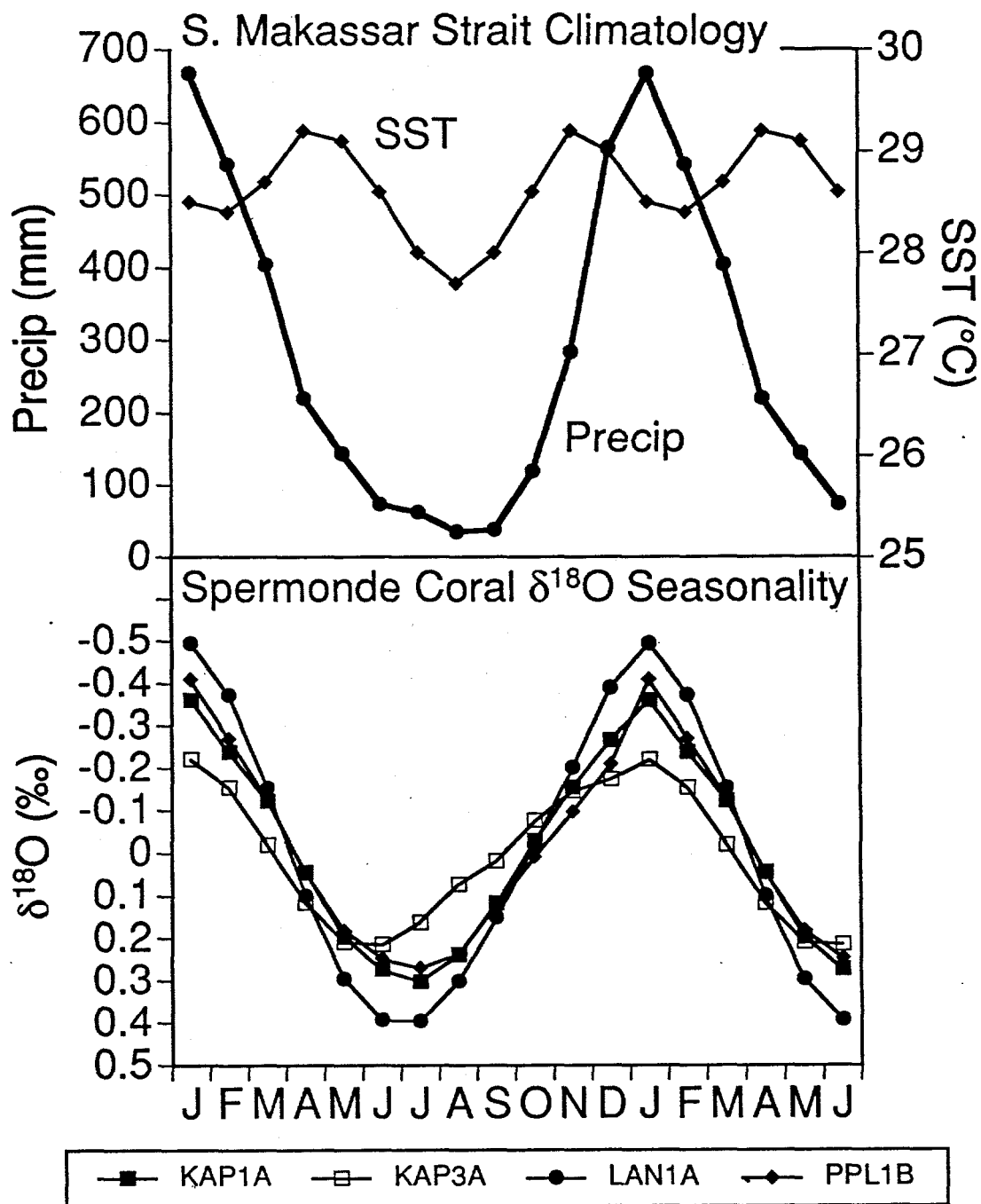


Figure 15. Makassar Strait SST and Ujung Pandang precipitation climatology compared to the seasonality in the Spermonde Bank $\delta^{18}\text{O}$ records. $\delta^{18}\text{O}$ means removed to facilitate comparison. $\delta^{18}\text{O}$ y-axis reversed.

in the lower panel of Figure 15, with the means removed to facilitate comparison. The $\delta^{18}\text{O}$ seasonality appears to be most closely related to the precipitation climatology, as there is no evidence of the double maxima characteristic of the SST climatology.

The average seasonal $\delta^{18}\text{O}$ range computed by maxima-minima differencing for the PPL1B record is 0.94‰, comparable to the seasonal range for the other records from shallow water depths (2.0-2.5m): 0.91‰ for KAP1A, and 1.10‰ for LAN1A. The deeper (4m) KAP3A record has a seasonal $\delta^{18}\text{O}$ range of 0.79‰. Ignoring the KAP3 record for the moment, the average seasonal $\delta^{18}\text{O}$ range for KAP1A, LAN1A and PPL1B is 0.98‰, which exceeds the expected coral SST fractionation response of 0.33‰ by 0.65‰. Applying the Kapoposang δw /salinity mixing line yields an estimated salinity range of 2.43 psu. This value is in close agreement with Wrytki's (1961) estimate of 2.4 psu in the vicinity of 6°S, 119°E, due south of the Spermonde Bank, and the Levitus (1982) estimate of 2.92 psu for the 5°x5° grid box at 0°-5°S, 115°-120°E. This site is clearly freshwater flux dominated, as has been argued in earlier chapters.

The smoothed interannual residuals for the KAP1A, KAP3A, LAN1A and PPL1B $\delta^{18}\text{O}$ time series are shown in Figure 16. The time series means have been removed to facilitate comparison. The reproducibility of the interannual residuals for KAP1A, KAP3A and LAN1A were discussed in detail in Chapter 2, and the same relationships are apparent here. The two offshore sites agree fairly well, and the PPL1B record matches both of the offshore records fairly well up until 1981, which is marked by a large $\delta^{18}\text{O}$ minima (0.25‰) not strongly present in the offshore records. In the period

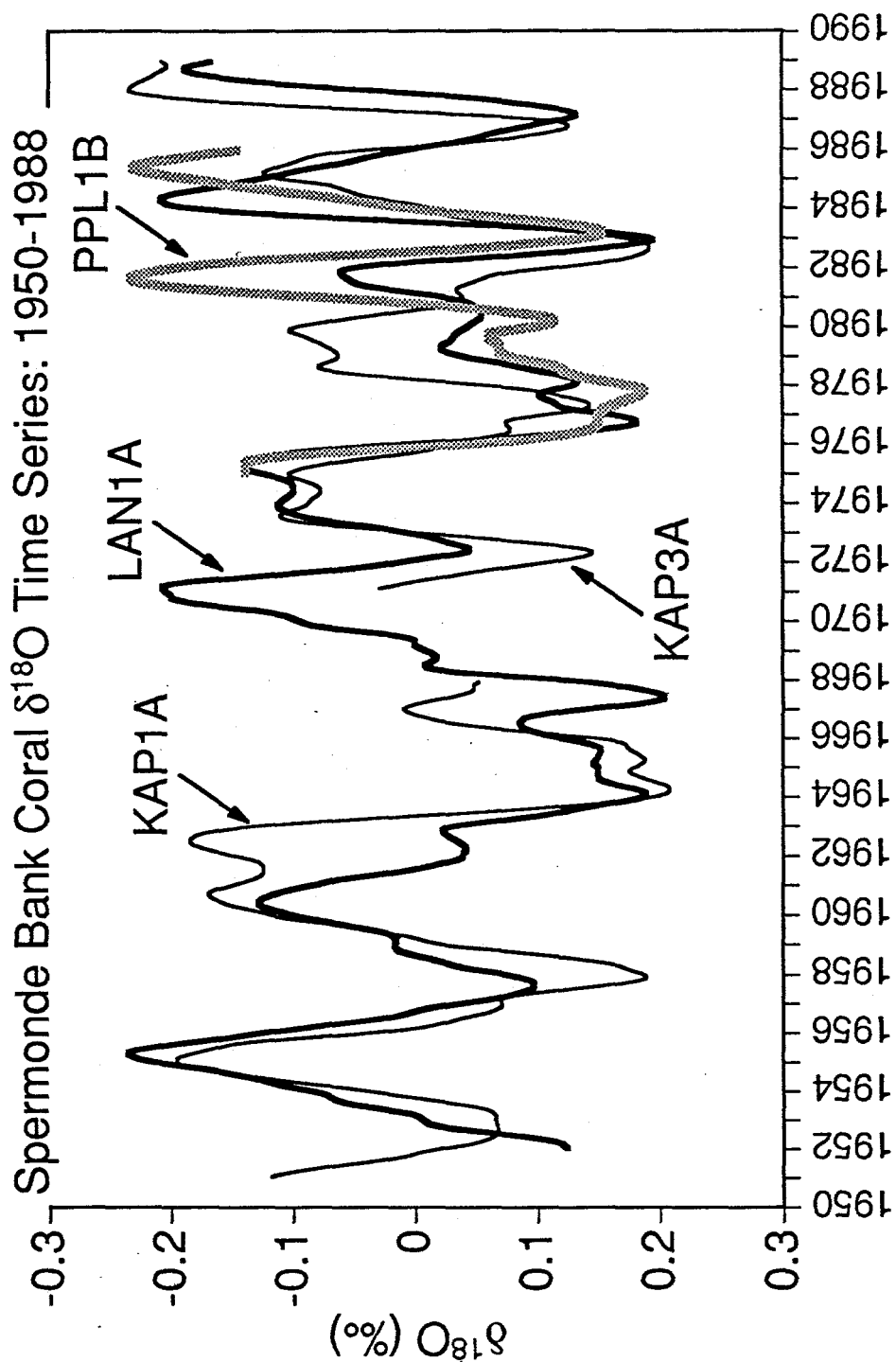


Figure 16. Interannual variability in Spermonde Bank $\delta^{18}\text{O}$ records (means removed). LAN1A, heavy line; KAP1A and KAP3A, light line; PPL1B shaded line. PPL1B has a larger freshwater spike in 1981, suggesting local influences.

1983-87 PPL1B resumes tracking the offshore records, with a lag of several months. The Podong Podong Lompo site is sufficiently close to the mainland that it could be under the direct influence of local discharge, and the large $\delta^{18}\text{O}$ minima may be evidence of this. For example, during the 1992-93 field season, local discharge plumes were observed approaching to within 1-2 km of Barrang Lompo Island.

These multiple $\delta^{18}\text{O}$ time series allow for a more accurate estimate of the surface water variability at Spermonde Bank site because they can be stacked (or averaged in time) to minimize the local, inter-site differences. Stacking of time series is an approach widely used in dendrochronology to minimize the differences between individual trees and maximize the accuracy of the climate reconstruction (Jacoby and Hornbeck, 1986). For example, most published tree ring records are actually composites of many records- typically thirty or more. Coral-based climate studies could certainly be improved by adopting this approach, but the high level of redundancy (while statistically desirable) is not really practical because of the high cost of the developing stable isotope time series. Operating in the favor of corals is the fact that the ocean environments are much more homogenous than terrestrial environments, which in theory, should allow a small number of coral records to adequately represent the variability over a large area of tropical sea surface.

Of the coral $\delta^{18}\text{O}$ records developed from the Spermonde Bank, the offshore records from Kapoposang and Langkai Islands are the best suited for stacking. The records already agree fairly well, and although there are some differences in bathymetry and presentation to weather, there is no reason to

believe the surface waters impinging on the two islands would have radically different properties on interannual timescales. The same cannot be said for the Podong Podong Lompo site, as it appears to be contaminated by some degree of local variability, which in this case, precludes it from further consideration.

The deseasonalized residuals for KAP1A (1950-1968) KAP3A (1970-1989) and LAN1A (1950-1989) were averaged and then smoothed by twice applying a 13-point centered running mean to produce a stacked interannual residual time series, hereinafter referred to as "Offshore Coral $\delta^{18}\text{O}$ ". Computing the cross-covariance function for Darwin SLP and Ujung Pandang precipitation yields $r = -0.76$ at lag -1 mo, as shown in Figure 17. The cross-covariance functions of the offshore coral $\delta^{18}\text{O}$ record to Ujung Pandang precipitation and Darwin SLP yields $r = -0.57$ at lag -3 mo and $r = 0.73$ at lag -5 mo, respectively (Figures 18 and 19).

The three time series are plotted in Figure 20. The offshore coral $\delta^{18}\text{O}$ record (lag adjusted) agrees well with the Darwin SLP record. Inspection of the Ujung Pandang precipitation record reveals that while it agrees for the most part to the regional SLP signal, there is a large anomaly in 1971 not reflected in the SLP record. From these comparisons, it can be concluded that the offshore coral $\delta^{18}\text{O}$ record is capturing the regional interannual climate variability fairly well, but not the local climate variability. This result, besides revealing the nature of the site response, supports usage of stacked records in coral-based climate reconstructions. The same analysis applied to KAP1A and LAN1A records in Chapter Two yielded individual correlations to Darwin SLP that did not exceed $r = 0.68$.

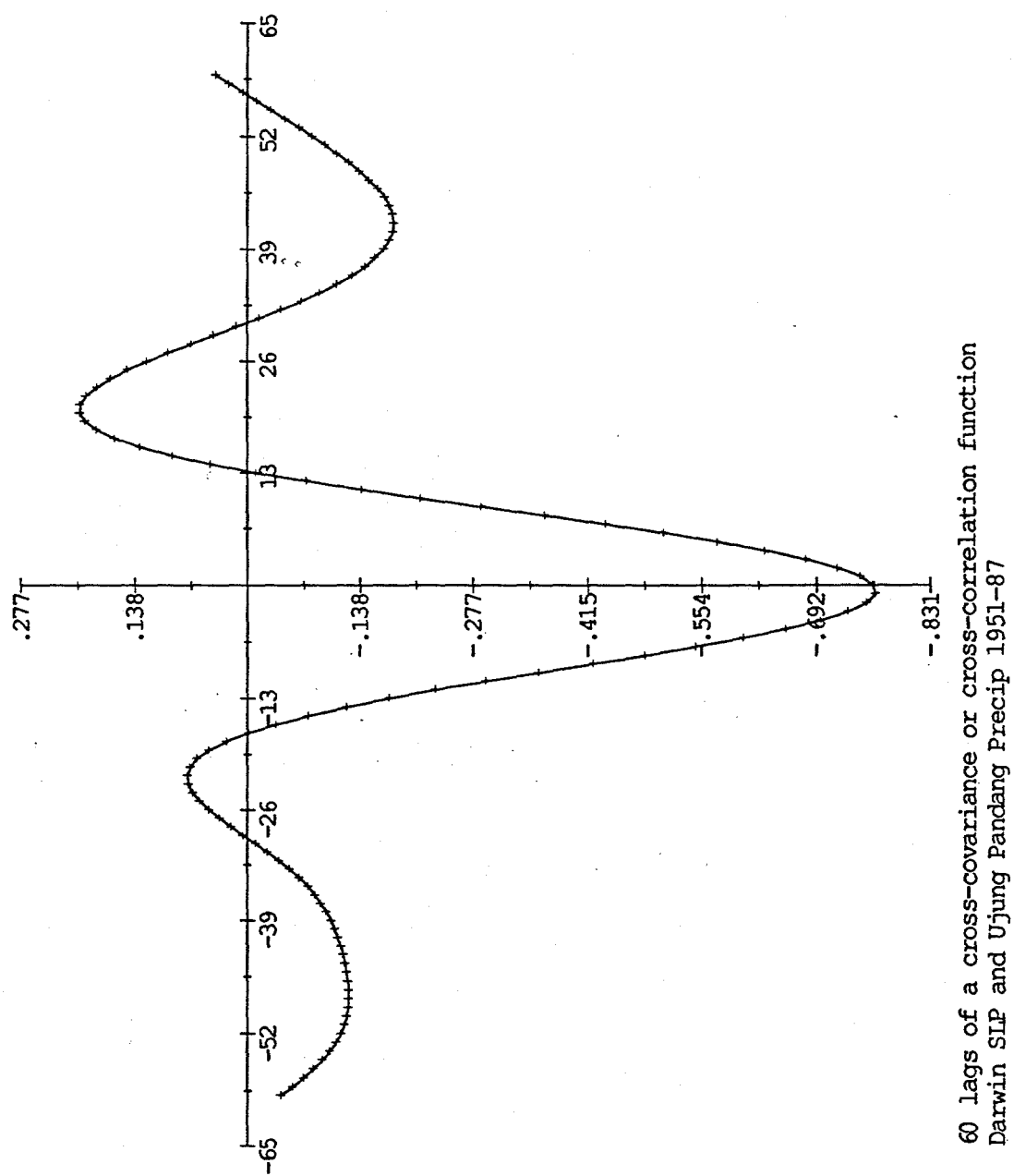
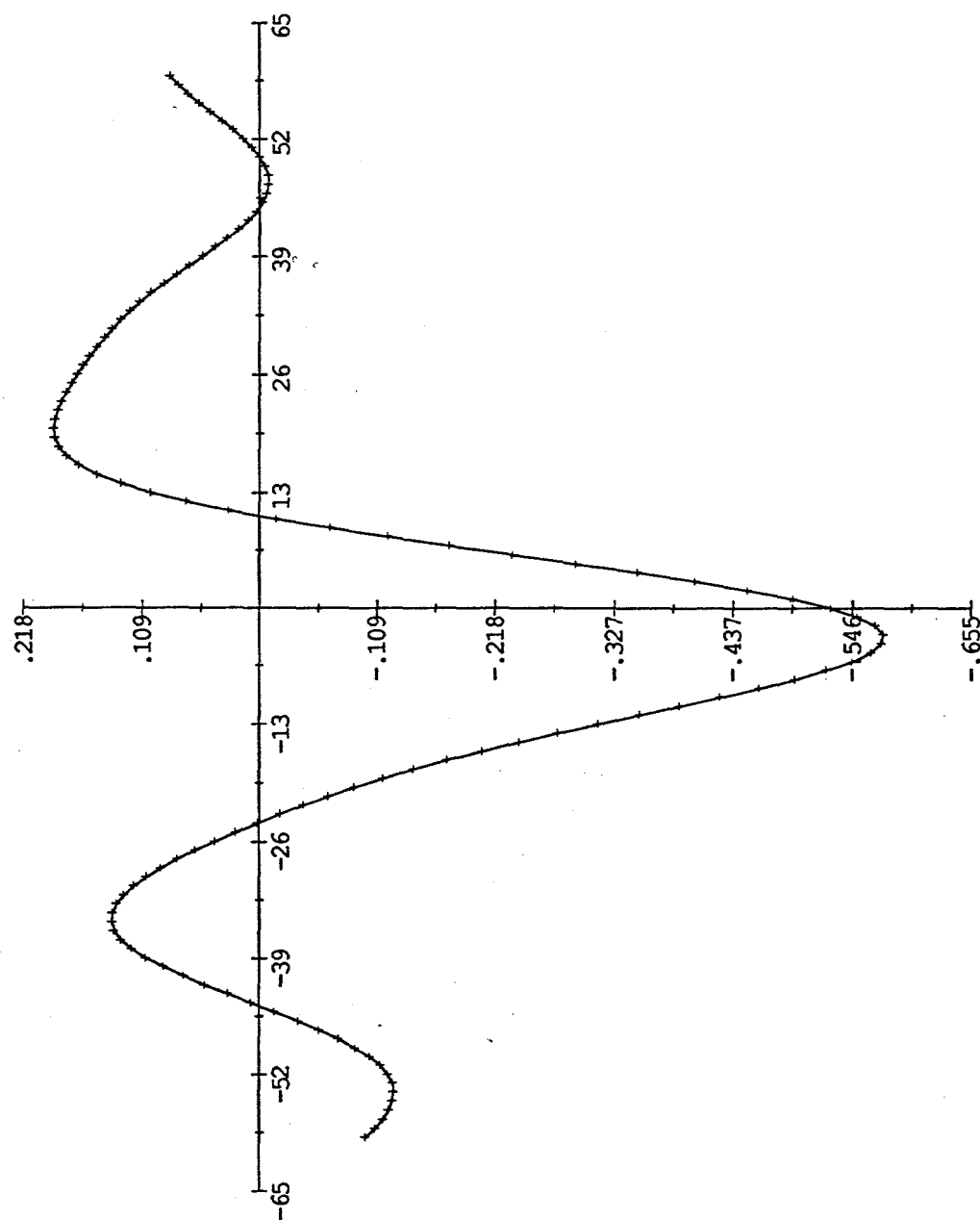


Figure 17. Cross-covariance function for Darwin SLP and Ujung Pandang rainfall, $r = -0.76$, $m = -1$.



60 lags of a cross-covariance or cross-correlation function
Ujung Pandang Precip and Offshore d18O 1951-87

Figure 18. Cross-covariance function for Ujung Pandang rainfall and the Spermonde Bank stacked offshore site $\delta^{18}\text{O}$ record, $r = -0.57$, $m = -3$.

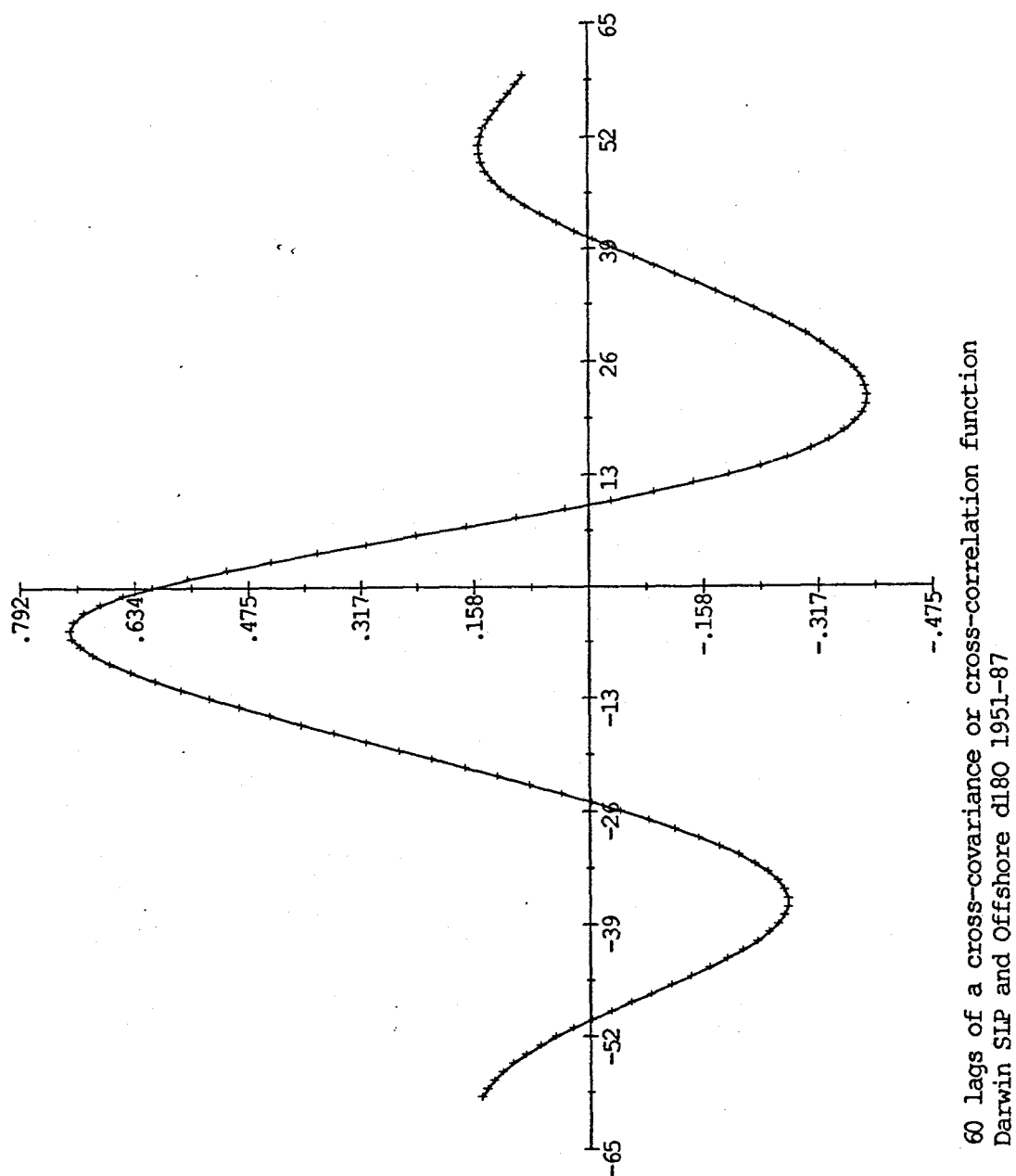


Figure 19. Cross-covariance function for Darwin SLP and the Spermonde Bank stacked offshore site $\delta^{18}\text{O}$ record, $r = 0.73$, $m = -5$.

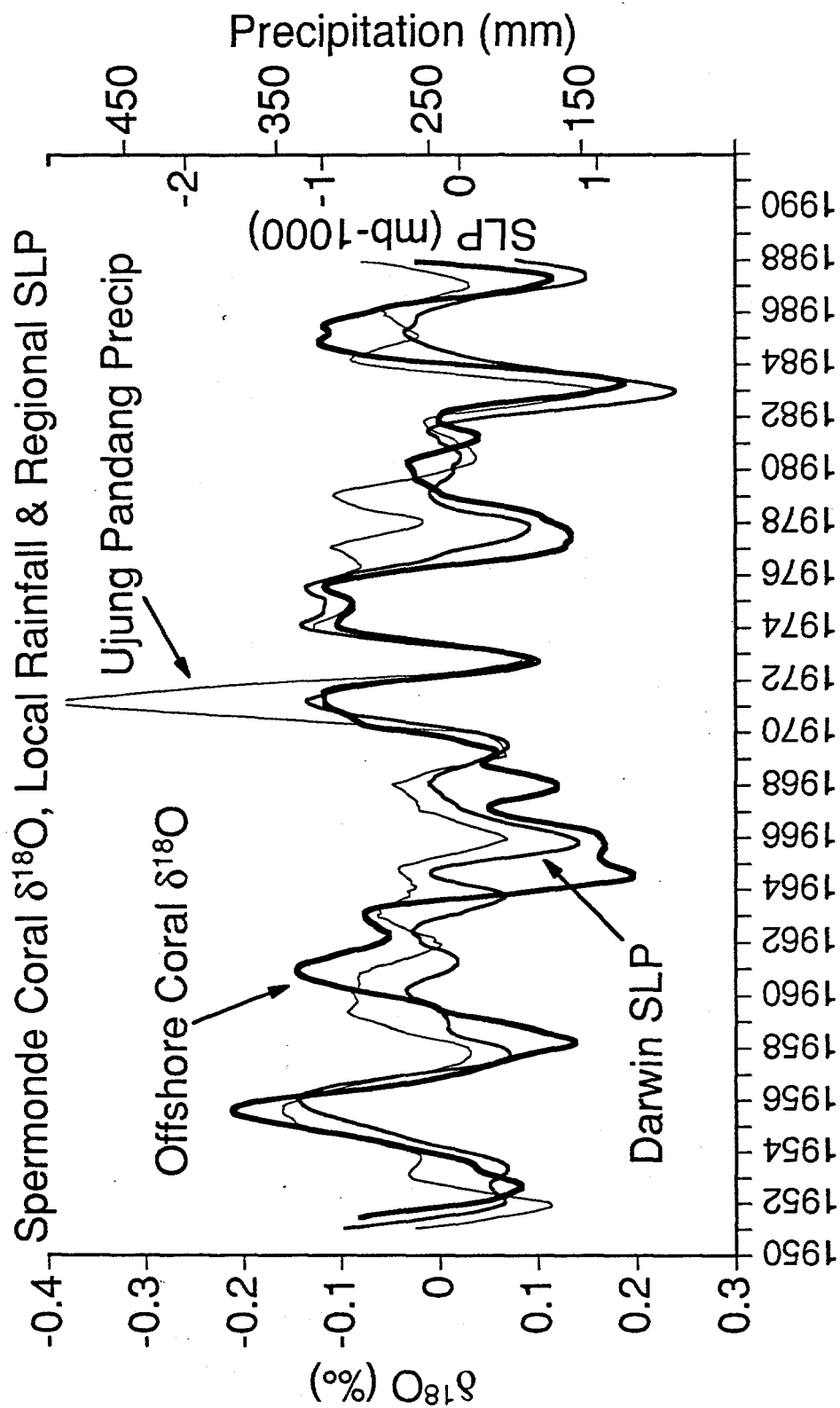


Figure 20. Interannual variability in Ujung Pandang rainfall, Darwin SLP and Offshore $\delta^{18}\text{O}$, 1951-1988. $\delta^{18}\text{O}$ and SLP y-axes reversed.

The unique circumstances of the Makassar Strait allow for the decoupling of the local and regional freshwater flux signals. The offshore sites are experiencing a substantial salinity seasonality, but the freshwater flux signal does not appear to be closely related to the local precipitation, as shown by the cross-covariance results. The high correlation to Darwin SLP suggests that the freshwater flux signal is more regional-scale, implying that the rapid south-flowing waters of the Makassar Strait are integrating this signal and carrying it past the Spermonde Bank.

To test this, it is necessary to have a time series estimate of the freshwater flux along the Makassar Strait throughflow route. Naturally, the accuracy of such an estimate is a function of the number of coastal meteorological stations on the throughflow route with complete rainfall records. The number of actively reporting stations in the vicinity of the Makassar Strait is relatively small. However, in the final decades of S.E. Asia's colonial experience, a large network of stations was established throughout Eastern Indonesia and the Southern Philippines in support of the expansion of plantation agriculture throughout the region. The most comprehensive and complete rainfall reporting in the Sulawesi Sea and Makassar Strait regions occurred during a 30-year period ending in 1940.

The quality of these records and their distribution along the principle throughflow route allows for an accurate assessment of the regional freshwater flux signal and its influence on the coral $\delta^{18}\text{O}$ signal in the S. Makassar Strait. Throughflowing surface waters enter at the northern Sulawesi Sea and move westward along the southern coast of Mindanao, then turn south at the sill separating the Sulu and Sulawesi Seas and enter

the Makassar Strait. Monthly rainfall records for 22 coastal stations in E. Borneo, W. Sulawesi, and the N. Sulawesi Sea (locations shown in Figure 21) were compiled and deseasonalized by subtracting each station's monthly climatology. The basic statistical features of the records are summarized in Table II. A grand mean was computed for each month to produce a time series of interannual coastal rainfall on the Makassar Strait throughflow route, hereinafter referred to as "TF Precip". Bias due to missing data is low since the number of stations reporting monthly data during 1911-39 climbs from 15 (of 22) stations in 1911 to more than 19 by 1918, as shown in Figure 22.

Table II. Rainfall on the Makassar Strait Throughflow Route: 1911-1939

Stations:	Mean Yearly	Seas. Max.	Seas. Min.	Seas. Range	Record Max.	Record Min.	Missing Values	Percent Missing
E. Borneo								
Samarinda	1964	208	96	112	575	2	0	0.0
Sandakan	3125	477	137	340	1116	4	120	52.6
Tanahgrogot	2365	354	101	253	694	0	81	30.3
Tanjungredep	2022	214	112	102	432	18	33	10.5
Tanjungselor	2583	247	178	69	531	11	5	1.5
Tarakan	3852	382	254	128	660	40	0	0.0
Tawao	1935	221	93	128	509	10	108	45.0
W. Sulawesi								
Donggala	1471	207	70	136	582	0	1	0.3
Majene	1675	235	54	180	1315	0	60	20.8
Ujung Pandang	2750	707	10	698	1424	0	0	0.0
Pangkajene	2348	446	30	416	994	0	13	3.9
Pare-Pare	2148	365	40	325	976	0	0	0.0
Polwali	2077	254	82	171	581	0	72	26.1
Sampaga	2753	279	163	116	662	0	87	33.3
Segeri	3265	685	25	661	1652	0	4	1.2
Tolitoli	2301	254	150	104	603	4	0	0.0
N. Sulawesi Sea								
Beo	3330	341	198	144	768	0	75	27.5
Davao City	1755	226	97	128	720	0	4	1.2
Dumaguete	1438	206	50	156	393	0	15	4.5
Tahuna	4032	498	199	299	1100	16	0	0.0
Yolo	2193	252	103	149	2103	0	7	2.1
Zamboanga	1195	160	53	107	918	0	6	1.8

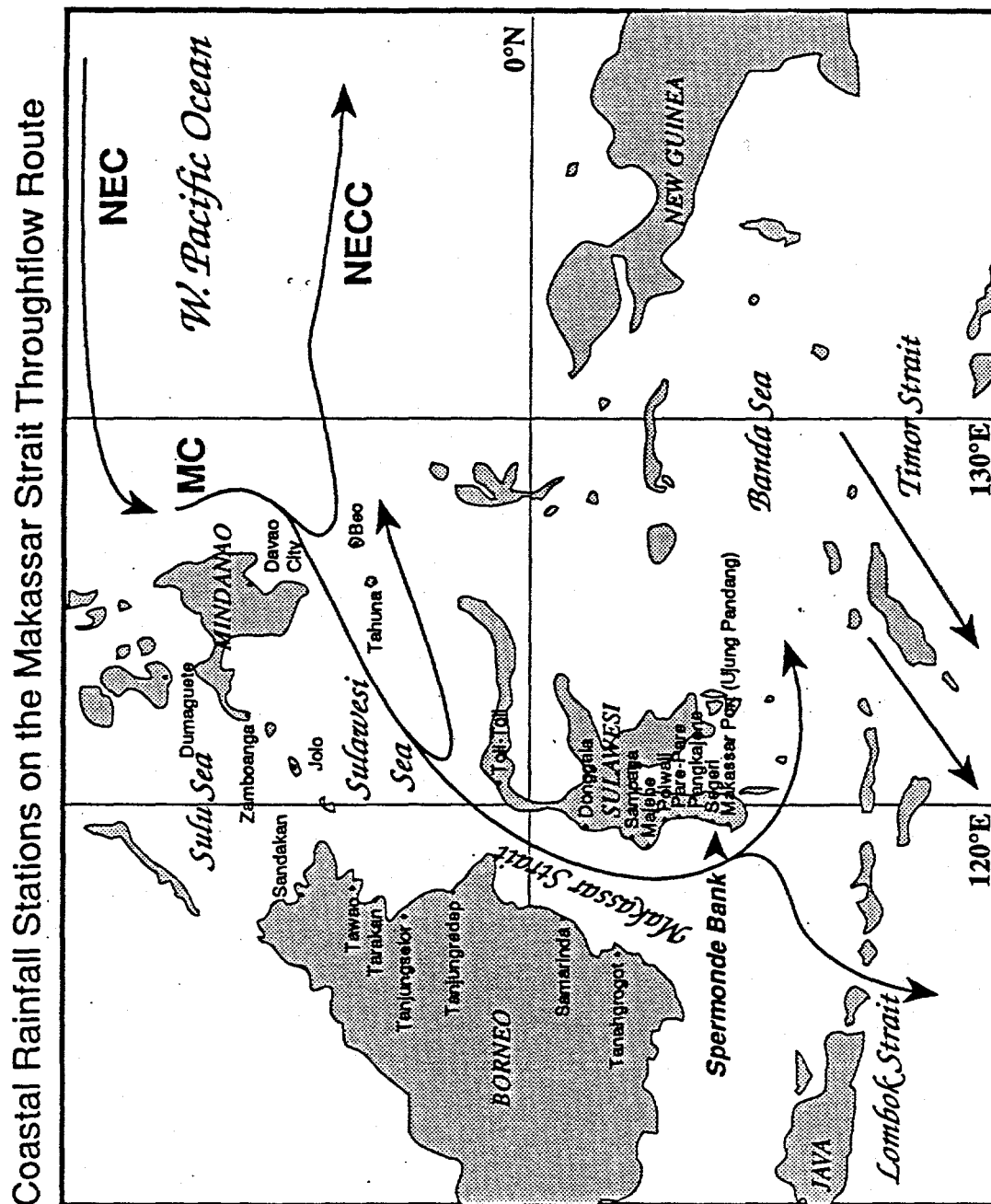


Figure 21. Map of coastal rainfall stations on the Makassar Strait throughflow route reporting during 1911-1939. Western boundary currents also shown: North Equatorial Current (NEC), Mindanao Current (MC), and the North Equatorial Countercurrent (NECC), after Ffield and Gordon, 1992.

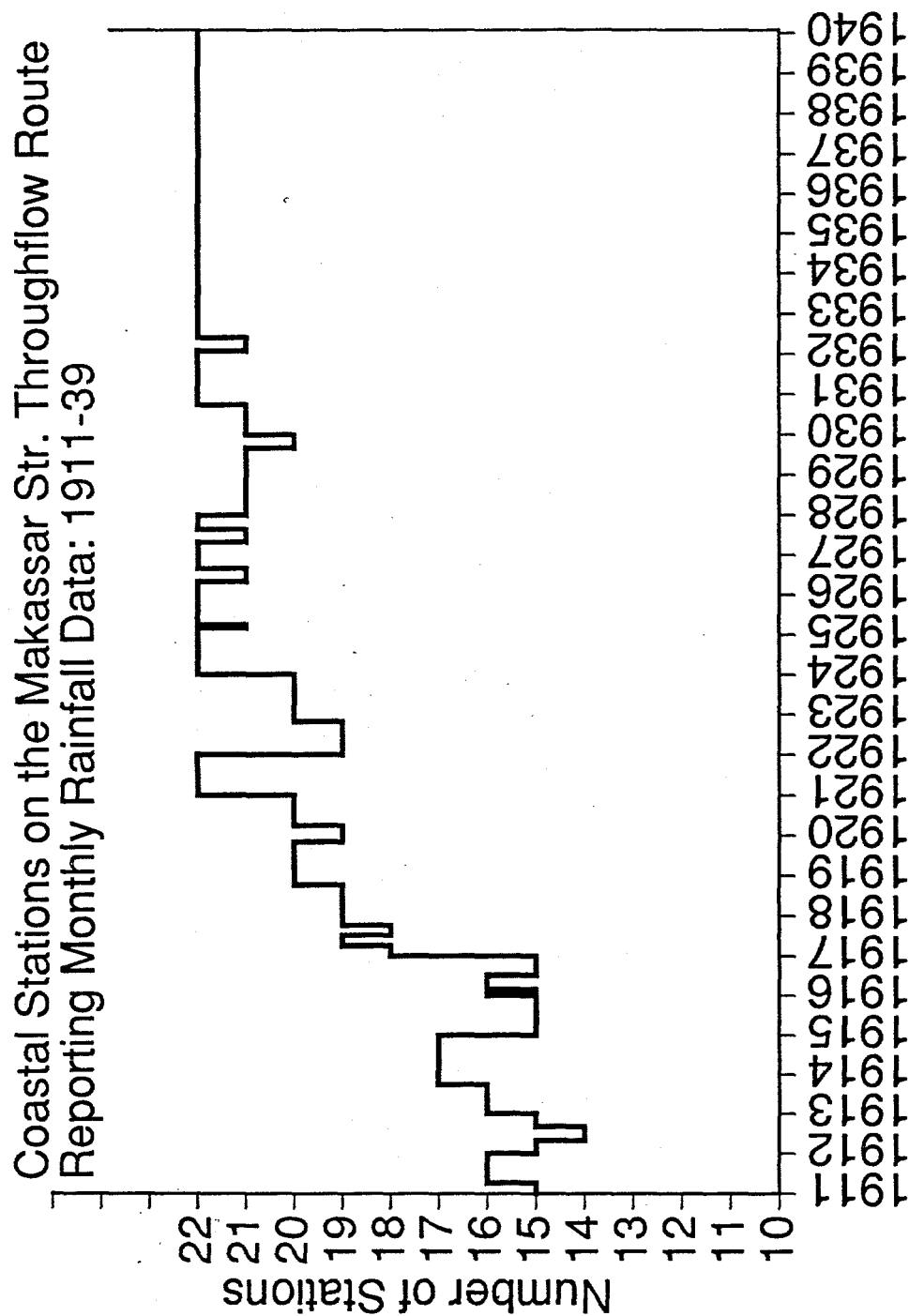


Figure 22. Number of coastal stations on the Makassar Strait throughflow route reporting monthly rainfall data during 1911-1939.

The TF Precip time series is a first-order observation of the regional freshwater flux to surface waters transiting the throughflow route. It is not areally averaged. From the perspective of the Spermonde Bank sites in the southern Makassar Strait, the TF Precip record represents the regionally integrated, "upcurrent" freshwater flux signal these sites capture. The record is shown in Figure 23, with the interannual component (smoothed by twice applying a 13 point centered running mean) compared to the Ujung Pandang rainfall record and the Darwin SLP record (both similarly deseasonalized and smoothed). TF Precip correlates much better to Darwin SLP ($r = -0.90$) than to local rainfall ($r = 0.80$). Recall that the offshore coral $\delta^{18}\text{O}$ curve correlates better to Darwin SLP ($r = 0.73$) than to local rainfall (Figure 20), suggesting a dominant regional influence on $\delta^{18}\text{O}$ variability. Here we see that the regional rainfall response is very closely tied to Darwin SLP, supporting this interpretation. Darwin SLP is an excellent surrogate for regional freshwater flux in the Makassar Strait and Sulawesi Sea, and is indeed a useful benchmark for describing the Indonesian Low.

The contemporaneous section of the KAP1A $\delta^{18}\text{O}$ record is compared to the TF Precip and the Ujung Pandang precipitation records in Figure 24. The correlations are low, but still are higher to the regional record than to the local record. However, for the period 1928-37 (highlighted by the gray box) the KAP1A $\delta^{18}\text{O}$ correlates exceptionally well to the TF Precip record. A blow-up of this ten-year period is shown in Figure 25. In this section, the correlation between the TF Precip and $\delta^{18}\text{O}$ is surprisingly good, with $r = -0.95$. This result suggests a circumstance, perhaps unique in the record, where the isotopic variability must have been close to 100% dominated by freshwater

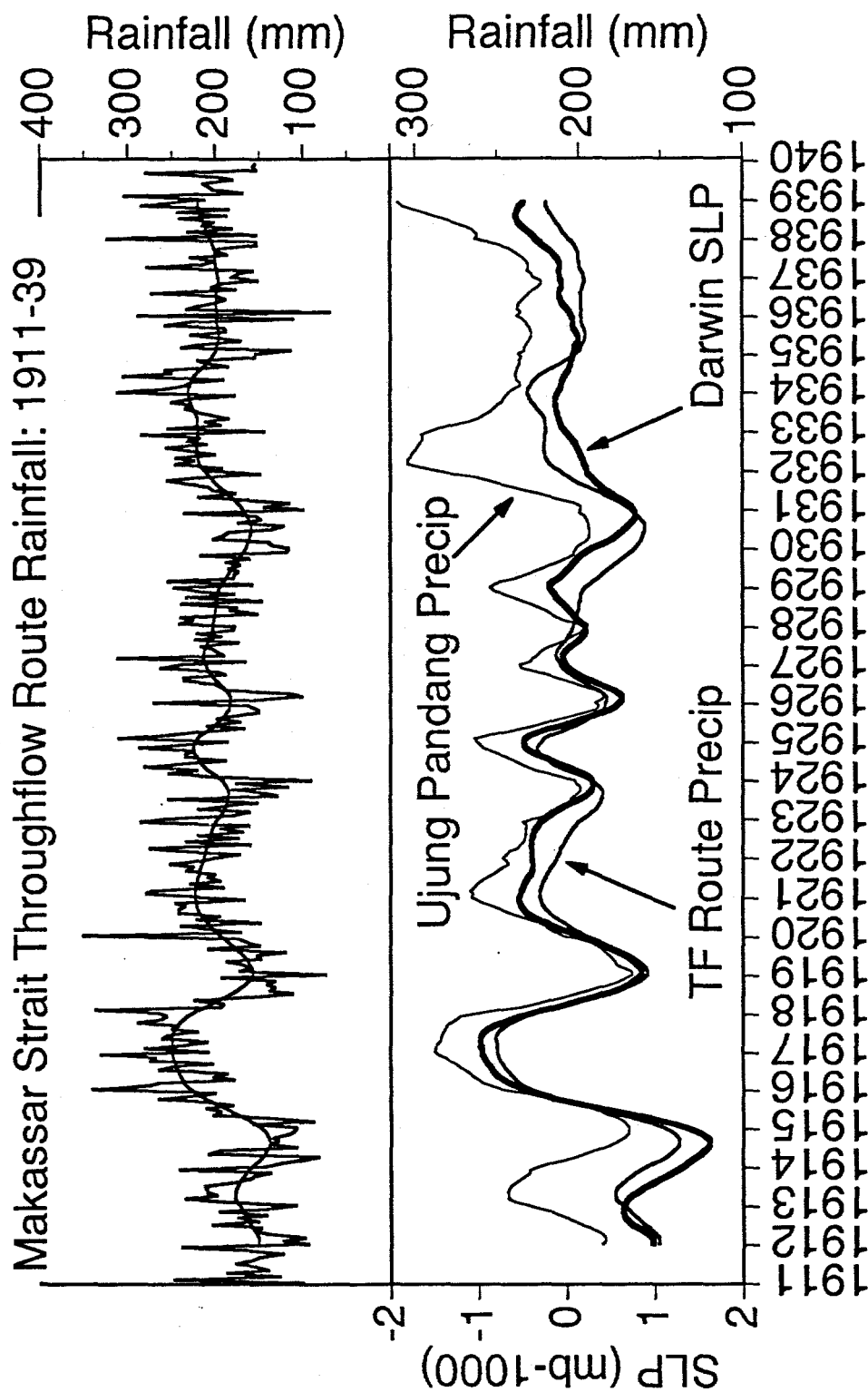


Figure 23. Throughflow route rainfall record (TF Precip) based on monthly ensemble averages for 22 coastal stations, 1911-39 (upper panel). Interannual variability in TF Precip, Ujung Pandang rainfall, and Darwin SLP (lower panel). SLP axis reversed.

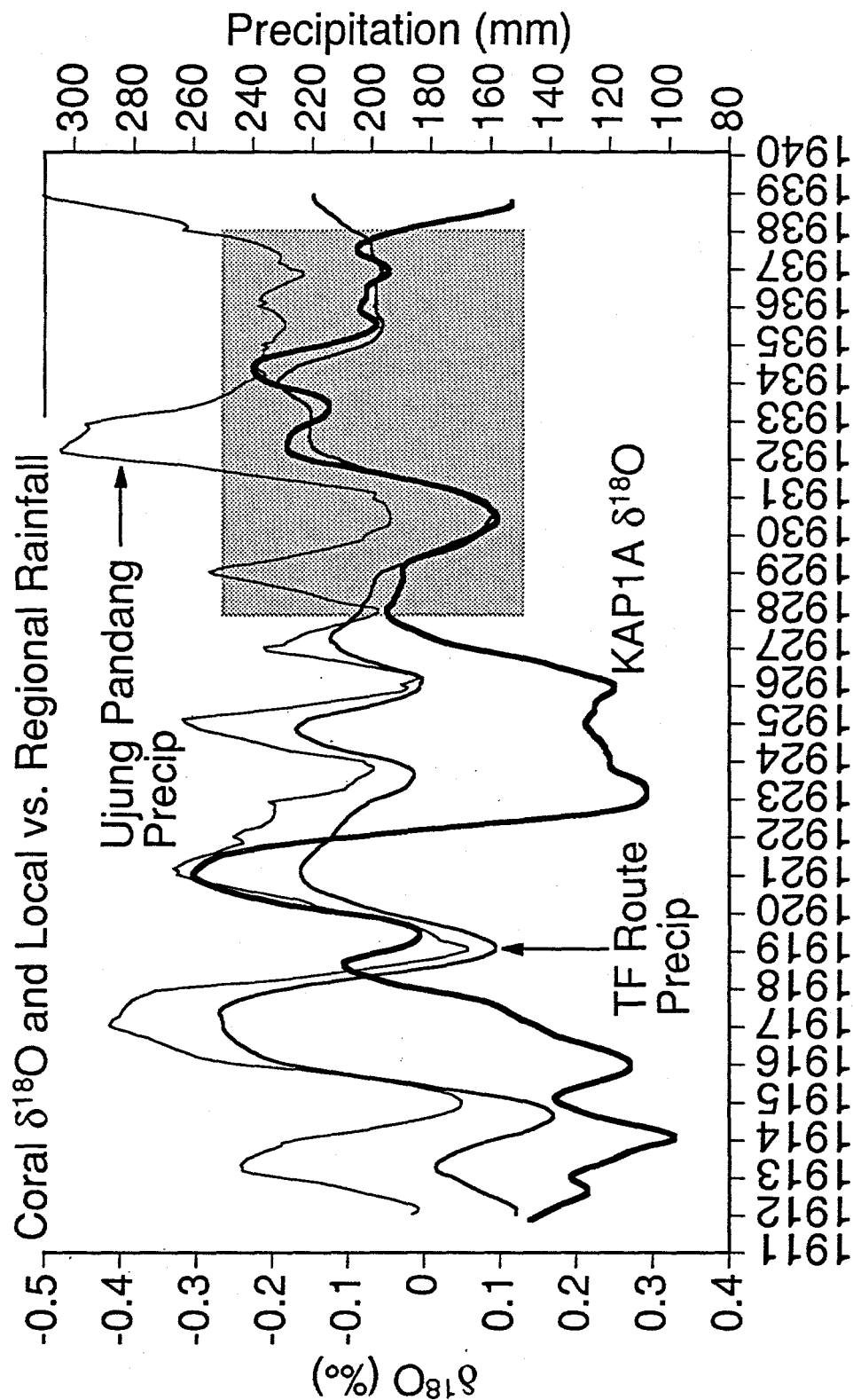


Figure 24. Interannual variability in Ujung Pandang rainfall, TF Precip and the KAP1A $\delta^{18}\text{O}$ record. $\delta^{18}\text{O}$ y-axis reversed. Shaded box is period of best agreement between TF Precip and KAP1A $\delta^{18}\text{O}$.

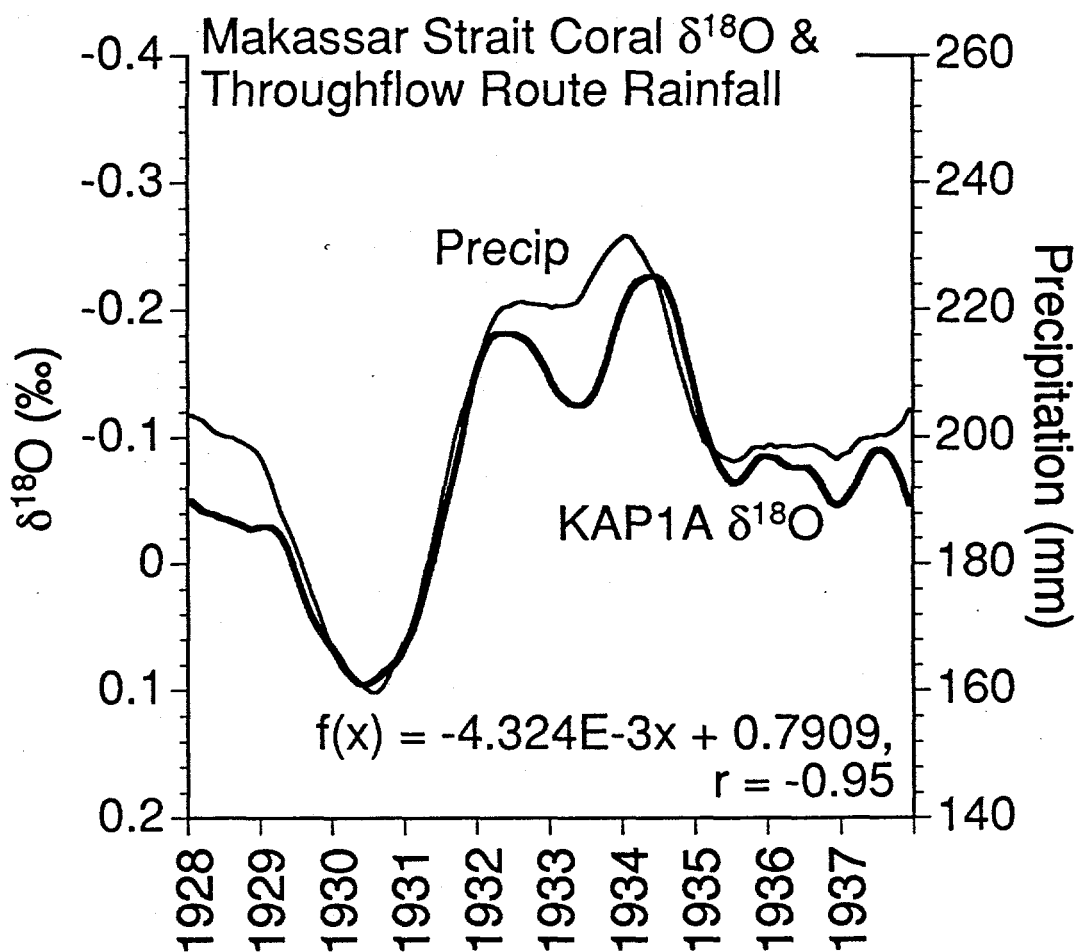


Figure 25. Comparison of interannual variability in TF Precip and KAP1A $\delta^{18}\text{O}$ during 1928-37, $r = -0.95$. $\delta^{18}\text{O}$ y-axis reversed.

flux effects; and hence, a period where there was little SST (or mixing) variability not linearly-related to the interannual variability of the monsoon.

This provides an opportunity to deconvolve the $\delta^{18}\text{O}$ signal into its freshwater flux and SST components. Linear regression of TF Precip on $\delta^{18}\text{O}$ for the period 1928-37 gives $f(x) = -0.00432x + 0.7909$ ($r = -0.95$). Applying this to the TF Precip record yields a time series estimate of the $\delta^{18}\text{O}$ variability due to freshwater flux. Subtracting this estimate from the KAP1A $\delta^{18}\text{O}$ record yields a residual $\delta^{18}\text{O}$ record, which represents the $\delta^{18}\text{O}$ variability due to temperature-dependent fractionation by the coral (Figure 26). This residual is an estimate of the interannual SST variability in the Makassar Strait, or more precisely, an estimate of the anomalous component of SST variability which does not scale directly to rainfall. The residual $\delta^{18}\text{O}$ time series shows anomalously positive $\delta^{18}\text{O}$ values in 1916-17 and in 1923-25 that correspond to large SST shifts of about -2.0°C and 1.5°C , respectively. Naturally, there is no SST variability during the 1928-37 calibration period.

What is the cause of these large SST anomalies? One might argue that they are a result of enhanced local upwelling, however, this argument can be dismissed by recognizing that interannual SST variability produced by changes in the local windfield would be closely linked to interannual changes in convection and would therefore scale to precipitation. This style of SST variability, if present, would already be subsumed in the regression relationship.

Another source of SST variability in the Makassar Strait is advected SST from the equatorial W. Pacific. Throughflowing surface waters carry a

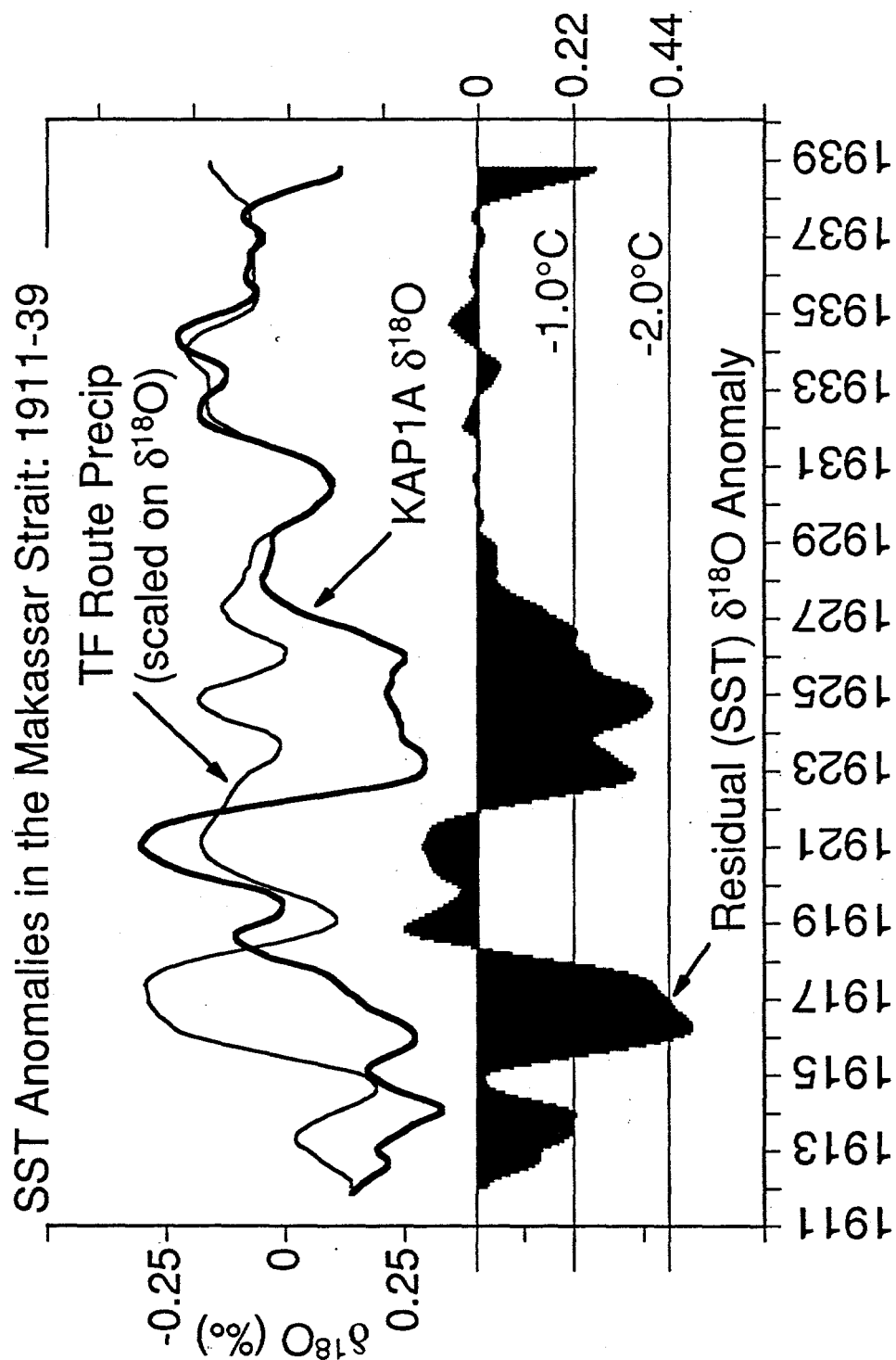


Figure 26. Interannual TF Precip time series converted to per mil units using the regression equation from Figure 25, compared to the interannual variability in KAP1A $\delta^{18}\text{O}$. Differencing the time series yields an estimate of the $\delta^{18}\text{O}$ variability in the KAP1A record not related to freshwater flux. This residual, interpreted as a SST signal, indicates SST anomalies of -1.0 to -2.0°C during this period.

seasonal SST signal into the Makassar Strait, easily apparent in the February and August maps of SST from the $1^\circ \times 1^\circ$ GOSTA data, shown in Figures 8 and 9 in Chapter 2. Wyrski (1961) describes the SST seasonality in the Java, Flores, and Banda Seas as the product of solar heating of the surface waters during the NW monsoon (Figure 8) and evaporative cooling during the SE Monsoon (Figure 9). In February, the 28° isotherm can be seen wrapping around the island of Mindanao as cool water enters the Sulawesi Sea from the east carried by the Mindanao current, and from the north across the Sulu Sill. This continues southward down the Makassar Strait, and can be seen spreading eastward into the Flores Sea, consistent with surface currents in this month (Wyrski, 1961). In August, the 28° isotherm lies just off of the Spermonde Bank. Warm water fills the Sulawesi Sea and the northern part of the Makassar Strait. Cool surface waters occur in the Java Sea, Flores Sea and Banda Sea. The SST maps show that SST regime at the Spermonde Bank in February is set by the interaction of warm water from the Java Sea mediated by cool water from the Sulawesi Sea, and in August by cool water from Flores Sea mediated by warm water from the Sulawesi Sea. Presumably this interaction accounts for the relatively minor SST seasonality (1.5°C) observed in the in southern Makassar Strait. Extending this line of reasoning to interannual time scales, it follows that even a small shift in the mean SST of W. Pacific surface waters entering the Indonesian Seaway, or the volume of W. Pacific surface water itself, would cause a discernible SST anomaly at this site.

Unfortunately, there are no time series of SST for any sites along the throughflow route, so a direct comparison between Makassar Strait or Sulawesi Sea SST observations and the residual (SST) $\delta^{18}\text{O}$ anomaly is not

possible. Monthly SST observations are available for the W. Pacific through the 1911-39 period. A time series of monthly SST anomalies in the region 10°N-10°S, 140°E-180°W was obtained courtesy of Dr. Tim Barnett (Climate Research Division, Scripps Institution of Oceanography). The time series is based on 2°x2° gridded monthly average SST observations drawn from the Combined Ocean-Atmosphere Data Set (COADS), and covers the period 1884-1987. This region, shown in Figure 27, comprises the central section of the W. Pacific warm pool and includes the South Equatorial Current (SEC) and the North Equatorial Counter Current (NECC), which is the recirculation of the North Equatorial Current (NEC) and the South Equatorial Current.

The comparison of the interannual W. Pacific SST anomaly (smoothed by twice applying a 13-point centered running mean) to the KAP1A residual (SST) $\delta^{18}\text{O}$ anomaly is shown in Figure 28. The $\delta^{18}\text{O}$ y-axis is scaled to correspond to SST shift in °C, as earlier. The W. Pacific SST anomaly record matches the $\delta^{18}\text{O}$ residual fairly well: both records show large negative anomaly in 1916-17, a positive anomaly in 1919-1922, and a negative anomaly in 1923-26. Cross-correlation gives $r = -0.54$. Although a better relationship might be found using SST data from the North Equatorial Current source water region, this result strongly suggests that interannual SST changes in the Makassar Strait are in-phase with and closely related to interannual SST changes in W. Pacific warm pool region. This relationship is suggestive of the advection of interannual SST variability into the Makassar Strait by throughflowing surface waters. It should also be pointed out that other processes may be modifying the $\delta^{18}\text{O}$ response, since the $\delta^{18}\text{O}$ anomalies in Figure 28 predict SST anomalies about 0.75°C larger than the W. Pacific SST

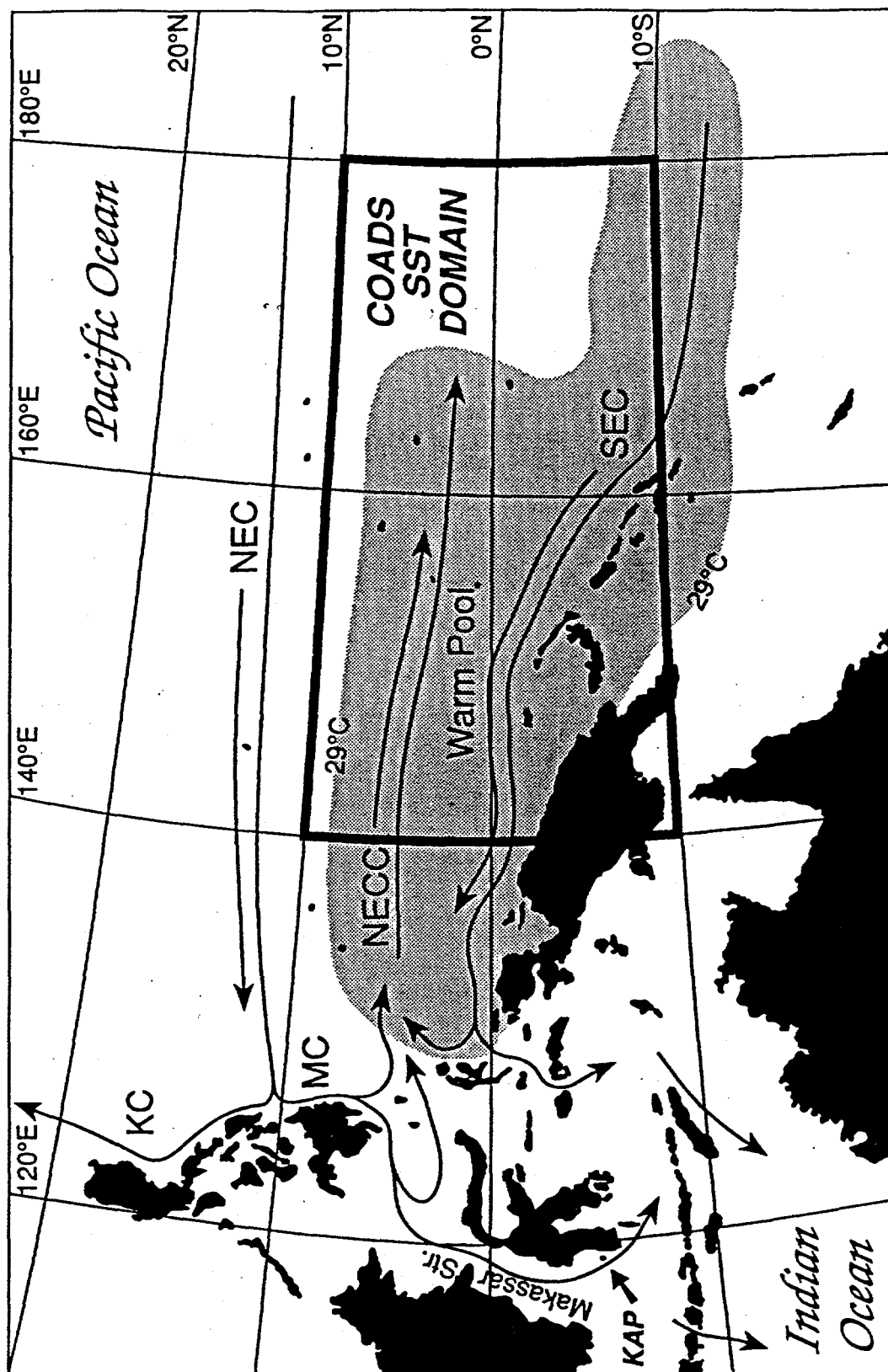


Figure 27. Domain of the W. Pacific COADS SST time series.

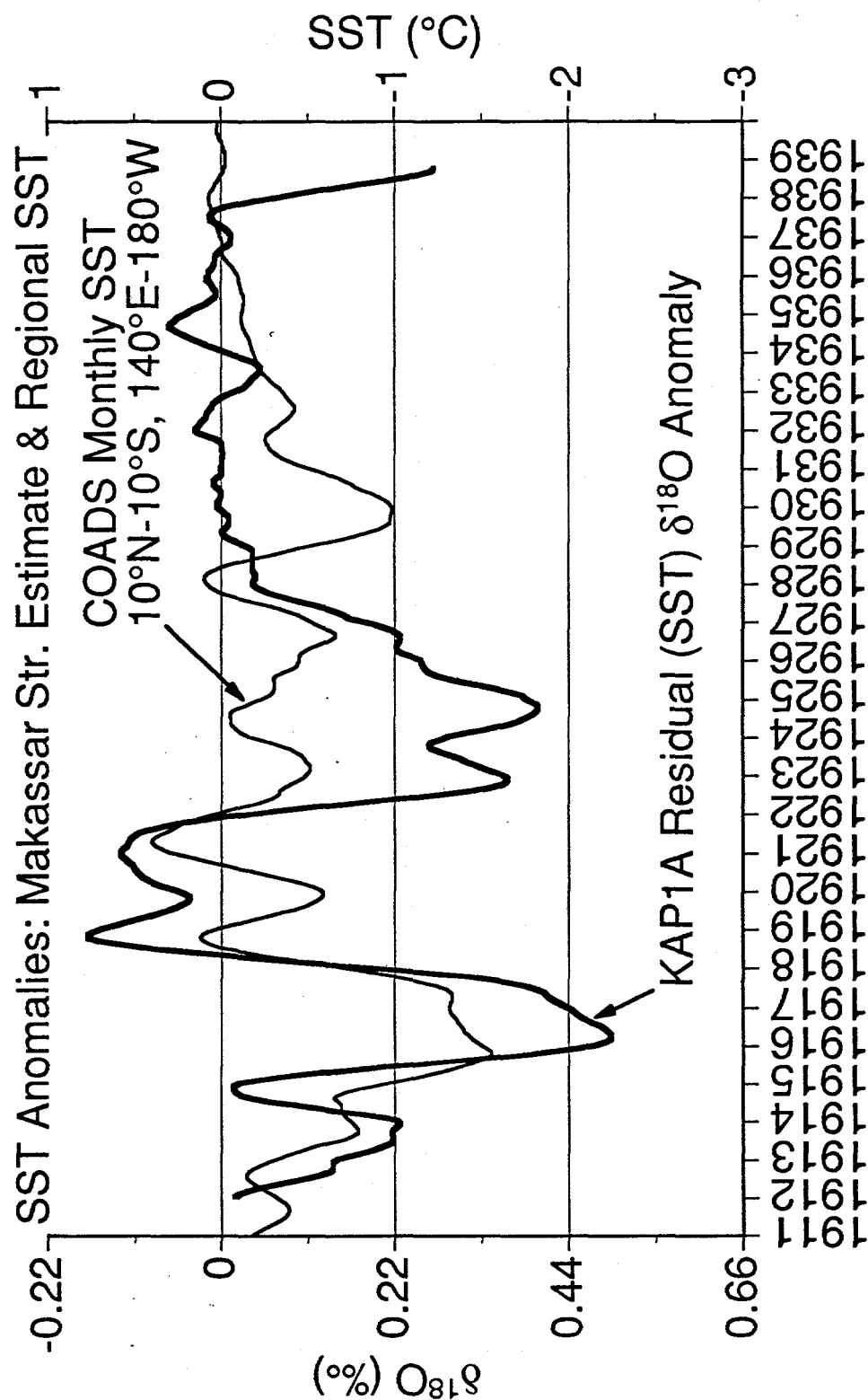


Figure 28. Interannual variability in Barnett's W. Pacific COADS SST time series and the KAP1A $\delta^{18}\text{O}$ SST residual, 1911-1939. $\delta^{18}\text{O}$ y-axis reversed and scaled by 1°C equivalent increments based on the Epstein (1953) slope.

response. As suggested in Chapter 3, interannual changes in mixing depth could produce an offset of this type.

By virtue of the hydrography of the Indonesian Seaway and the short residence times¹ of surface waters in the Makassar Strait, $\delta^{18}\text{O}$ variability in corals at the offshore Spermonde Bank sites (Kapoposang and Langkai) reflects two different regional-scale interannual climate signals: the SST variability of the surface waters of the equatorial W. Pacific and the isotopic dilution by freshwater flux to surface waters transiting the throughflow route. The regional freshwater flux signal swamps the advected SST signal, and may be complemented by local SST variability which is produced by the same convective processes that control regional precipitation (i.e. SST variability that scales directly to precipitation). To the degree that changes in the strength of the Indonesian Low are manifested as changes in the W. Pacific warm pool temperature, both signals capture ENSO variability. Unfortunately, because a deconvolution analysis requires good regional precipitation data (or SST data) and some statistical gymnastics, confidently deconvolving the coral $\delta^{18}\text{O}$ signal is generally not possible for most places in the tropics and not possible during pre-instrumental era.

¹ It is interesting to note that the residence time calculations by Ffield and Gordon (1992) assumed that regional precipitation was 1200mm annually, while the annual average for the 22 coastal stations on the Makassar Strait throughflow route during 1911-39 was 2390mm. Since their model basically mixes away the precipitation volume to produce the observed salinity profiles for the different Indonesian Seas, the fact that regional precipitation is double what they assume implies that the vertically diffusivity is twice as large, and hence the residence times are half of what they estimate. Residence times for the Sulawesi Sea may be as short as 1 month, and for the Makassar Strait as short as 2.5 months.

Resonant Response: Bunaken, Sulawesi Sea

At the eastern margin of the Sulawesi Sea, conditions approach those of the open waters of the W. Pacific. The SST regime is semiannual with maxima in May and November, the largest minimum in August and a subsidiary minimum in February. The seasonal SST range is small, only 0.9°C in the $1^{\circ}\times 1^{\circ}$ grid box containing the Bunaken Island site ($1^{\circ}\text{--}2^{\circ}\text{N}$, $124^{\circ}\text{--}125^{\circ}\text{E}$). Peak precipitation during the rainy season is about 400 mm mo^{-1} in January, with a dry season minimum of 150 mm mo^{-1} in August. SST and precipitation are phase-locked on the August minima (Figure 29). The $\delta^{18}\text{O}$ response agrees well with the precipitation climatology, with none of the semiannual character seen in the SST climatology.

Maxima-minima differencing gives a mean seasonal $\delta^{18}\text{O}$ range of 0.39‰ , which exceeds the expected coral SST fractionation response of 0.20‰ by 0.19‰ . Applying the Kapoposang $\delta w/\text{salinity}$ mixing line yields a estimated seasonal salinity range of 0.73 psu . This is about three times larger than the Levitus (1982) estimate of 0.26 psu for the $5^{\circ}\times 5^{\circ}$ grid box at $0^{\circ}\text{--}5^{\circ}\text{N}$, $120^{\circ}\text{--}125^{\circ}\text{E}$, which includes most of the Sulawesi Sea. The Wyrтки (1961) estimate for the seasonal salinity range in the Sulawesi Sea is 0.80 psu , in close agreement with the $\delta^{18}\text{O}$ estimate. The Wyrтки (1961) estimate is probably more accurate because it is based on monthly means that are less likely to underestimate the real salinity variability than are the Levitus (1982) quarterly means. Another reason to suspect the accuracy of the Levitus (1982) estimate is that the $5^{\circ}\times 5^{\circ}$ grid box averages across the entire Sulawesi Sea recirculation pattern, integrating the inbound, westward flow in the northern section with the outbound, eastward flow along the coast of N. Sulawesi (see Figure 21). It is reasonable to assume that the eastward flowing surface waters

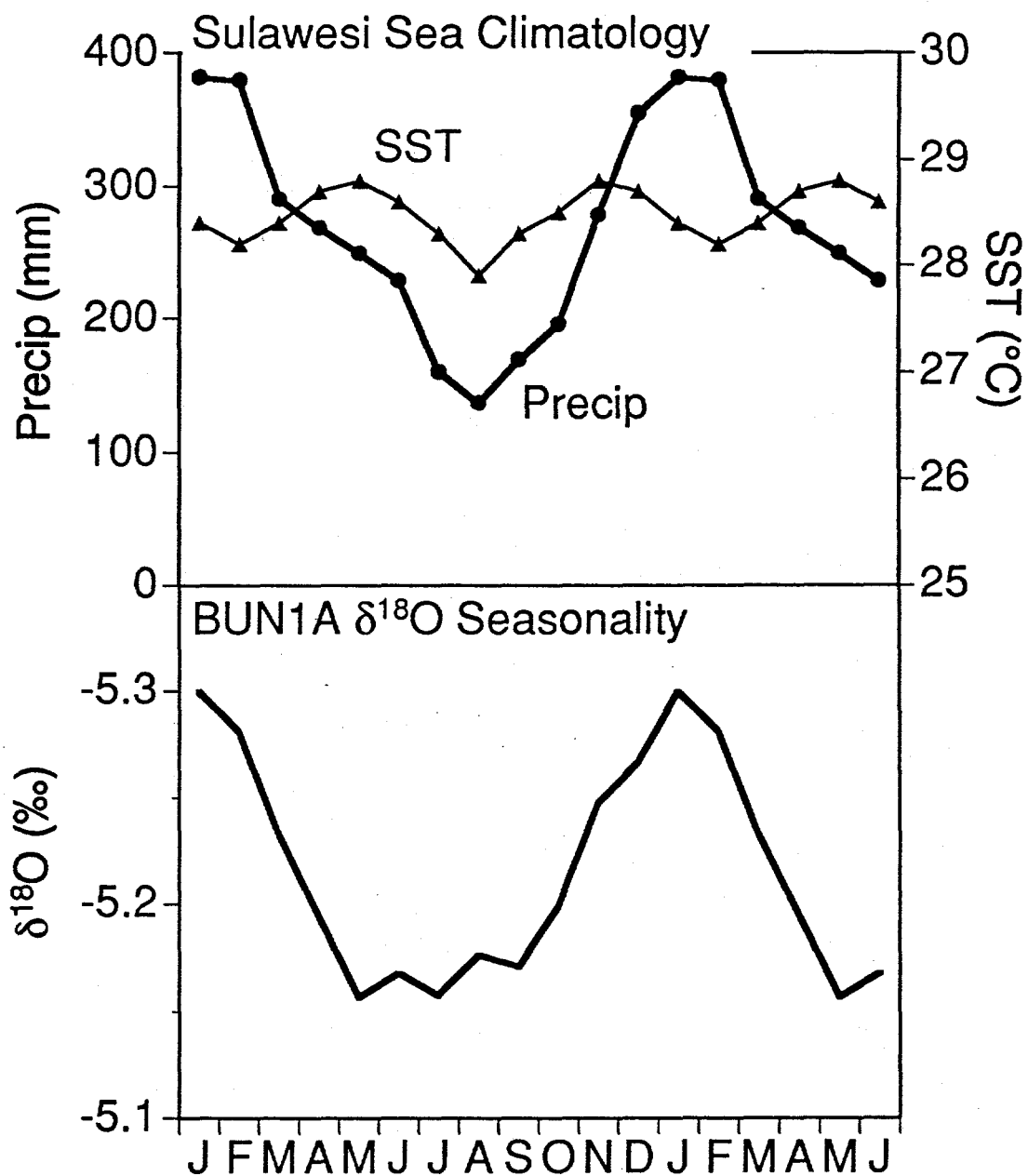
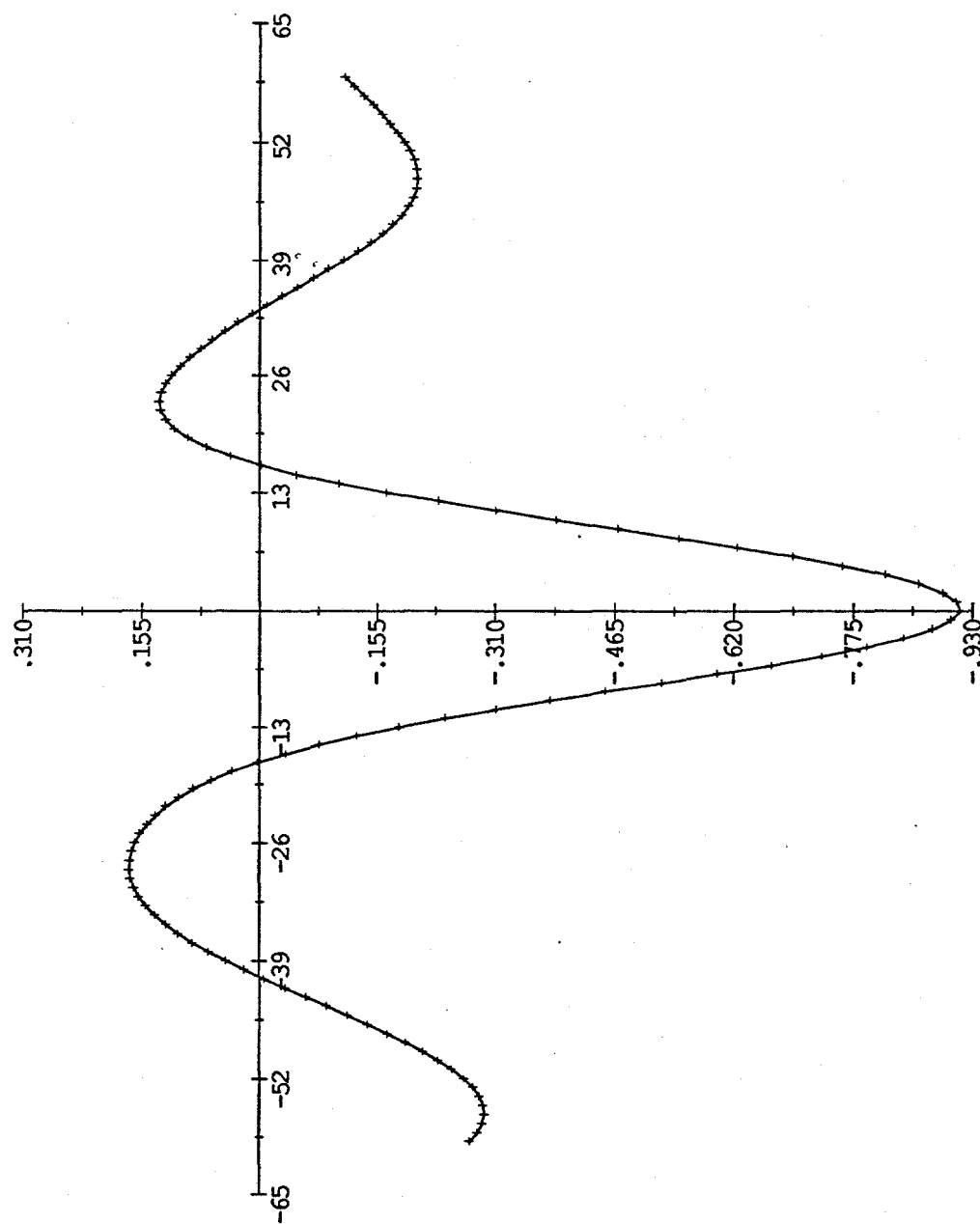


Figure 29. Sulawesi Sea SST and Manado precipitation climatology compared to the seasonality in the BUN1A $\delta^{18}\text{O}$ record. $\delta^{18}\text{O}$ y-axis reversed

will have a larger salinity signal than the westward flowing surface waters due to freshwater flux along the flow route. Wyrski (1961) apparently had enough well-distributed observations in the Sulawesi Sea to contour isopleths of salinity that indicate a seasonal range of 0.5-1.0 psu for the coast of N. Sulawesi (see Chapter 2, Figure 3), in agreement with the $\delta^{18}\text{O}$ salinity estimate. Despite the discrepancies in the atlas salinity estimates, it can be concluded that the coral $\delta^{18}\text{O}$ response at Bunaken is completely capturing the semiannual SST signal plus the seasonal freshwater flux signal, and that contribution of each to the coral $\delta^{18}\text{O}$ response is approximately equal.

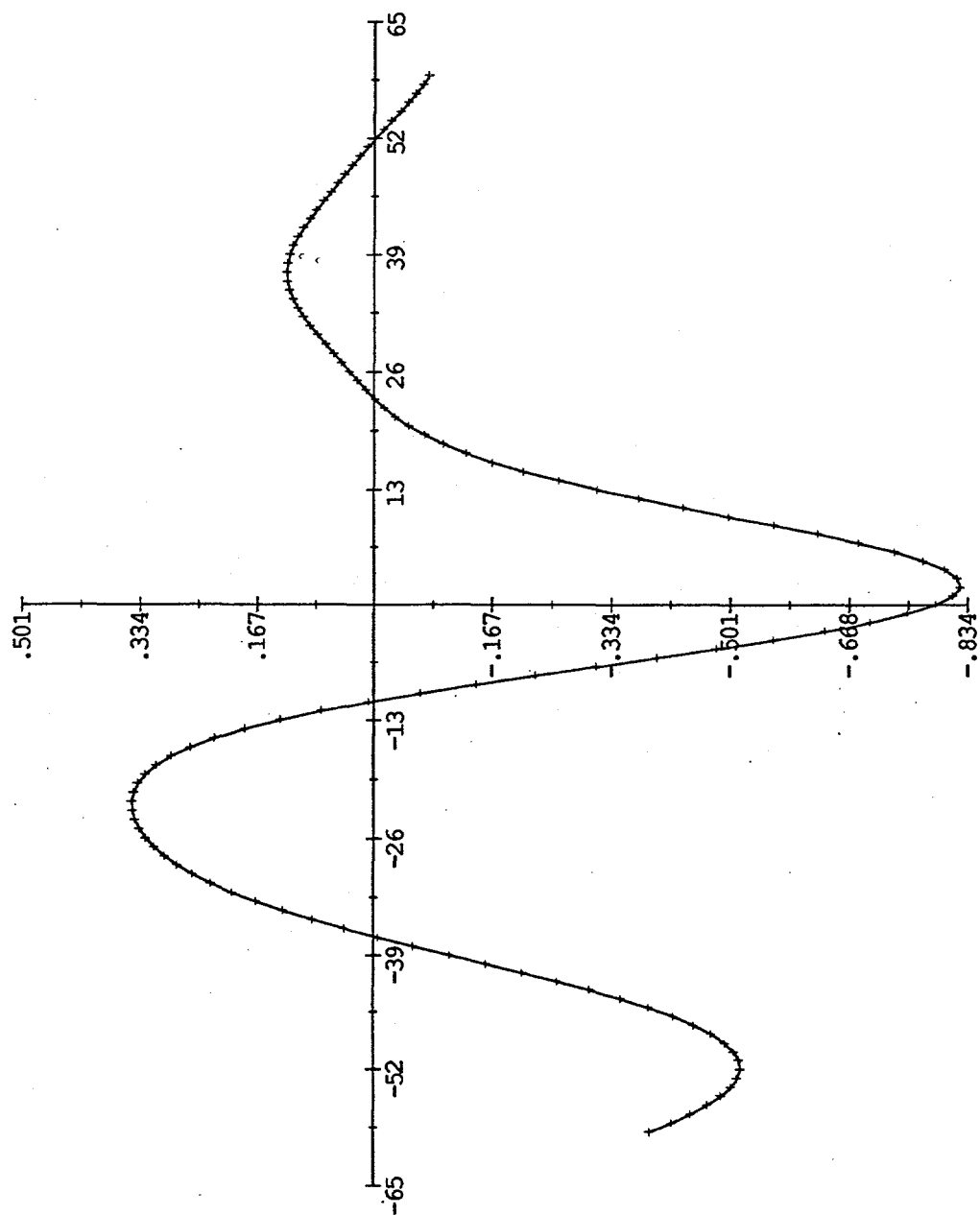
In comparison to the other sites in this study, N. Sulawesi has the strongest correlation between local precipitation variability and Darwin SLP on interannual time scales. The cross-covariance function for the smoothed, interannual Darwin SLP and Manado precipitation residuals yields $r = -0.91$ at lag 0 months, as shown in Figure 30. Precipitation variability at this single site is as accurate an observation of Darwin SLP variability as the 22 station TF Precip composite discussed in the previous section. Computing cross-covariance function for the smoothed interannual Manado precipitation and BUN1A $\delta^{18}\text{O}$ residuals yields $r = -0.82$ at lag 2 months, and for Darwin SLP and BUN1A $\delta^{18}\text{O}$ yields $r = 0.76$ at lag 2 months (Figures 31 and 32). The 0.76 correlation to Darwin SLP is the expected multiplicative error of linear estimation: $0.82 (\delta^{18}\text{O} \text{ to precipitation}) \times 0.91 (\text{precipitation to SLP}) = 0.75$.

The three time series are shown in Figure 33. The only significant discrepancy between the Darwin SLP and the Manado precipitation record is that the precipitation minima exceed the SLP maxima during ENSO warm-phase years (e.g. 1957-58, 1972-72, 1983). The agreement between the BUN1A



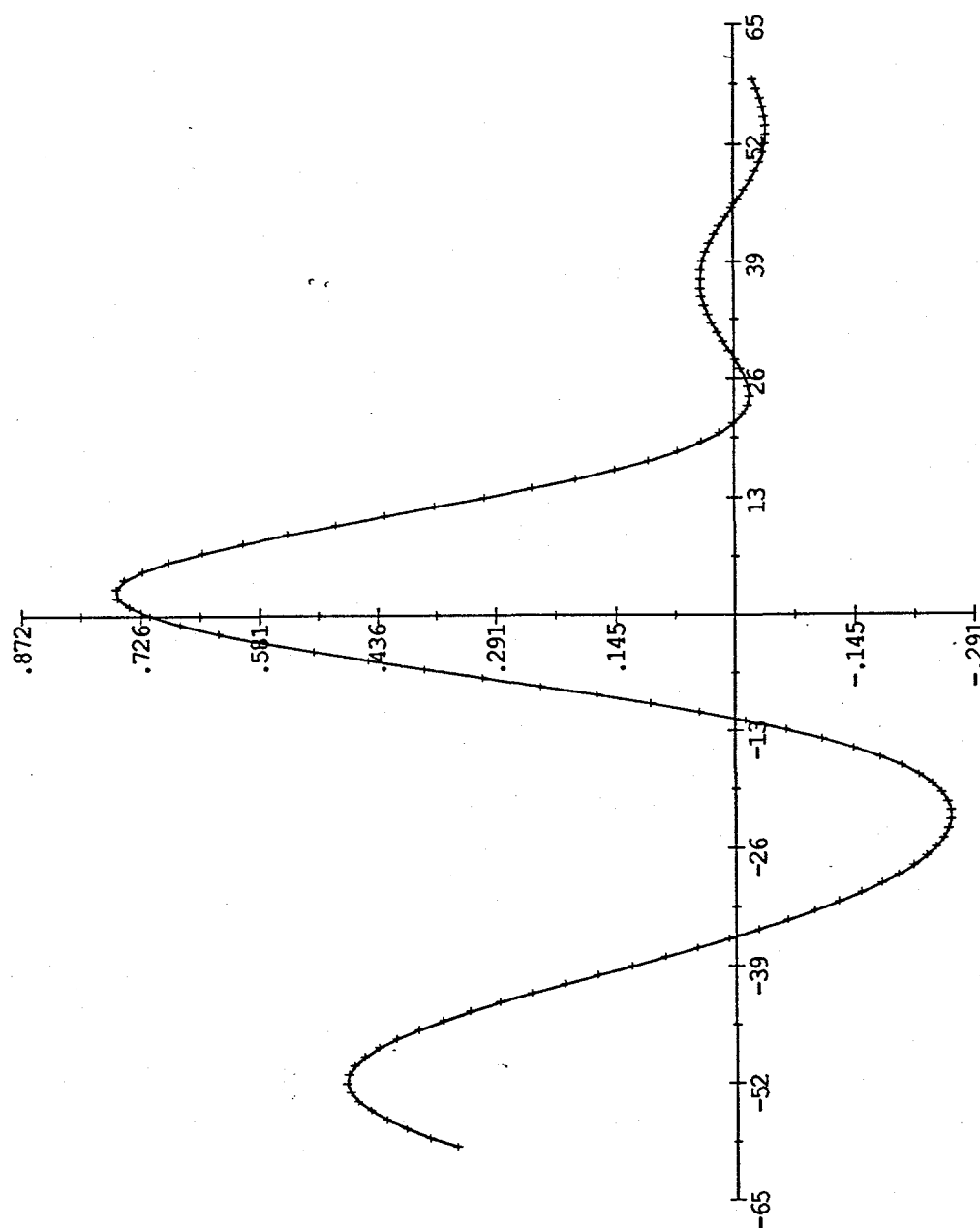
60 lags of a cross-covariance or cross-correlation function
Darwin SLP and Manado Precip 1963-87

Figure 30. Cross-covariance function for Manado rainfall and Darwin SLP, $r = -0.91$, $m = 0$.



60 lags of a cross-covariance or cross-correlation function
Manado Precip and BUN1A $\delta^{18}\text{O}$ 1963-87

Figure 31. Cross-covariance function for Manado rainfall and BUN1A $\delta^{18}\text{O}$, $r = -0.82$, $m = 2$.



60 lags of a cross-covariance or cross-correlation function
Darwin SLP and BUN1A $\delta^{18}\text{O}$ 1963-87

Figure 32. Cross-covariance function for Darwin SLP and BUN1A $\delta^{18}\text{O}$, $r = 0.76$, $m = 2$.

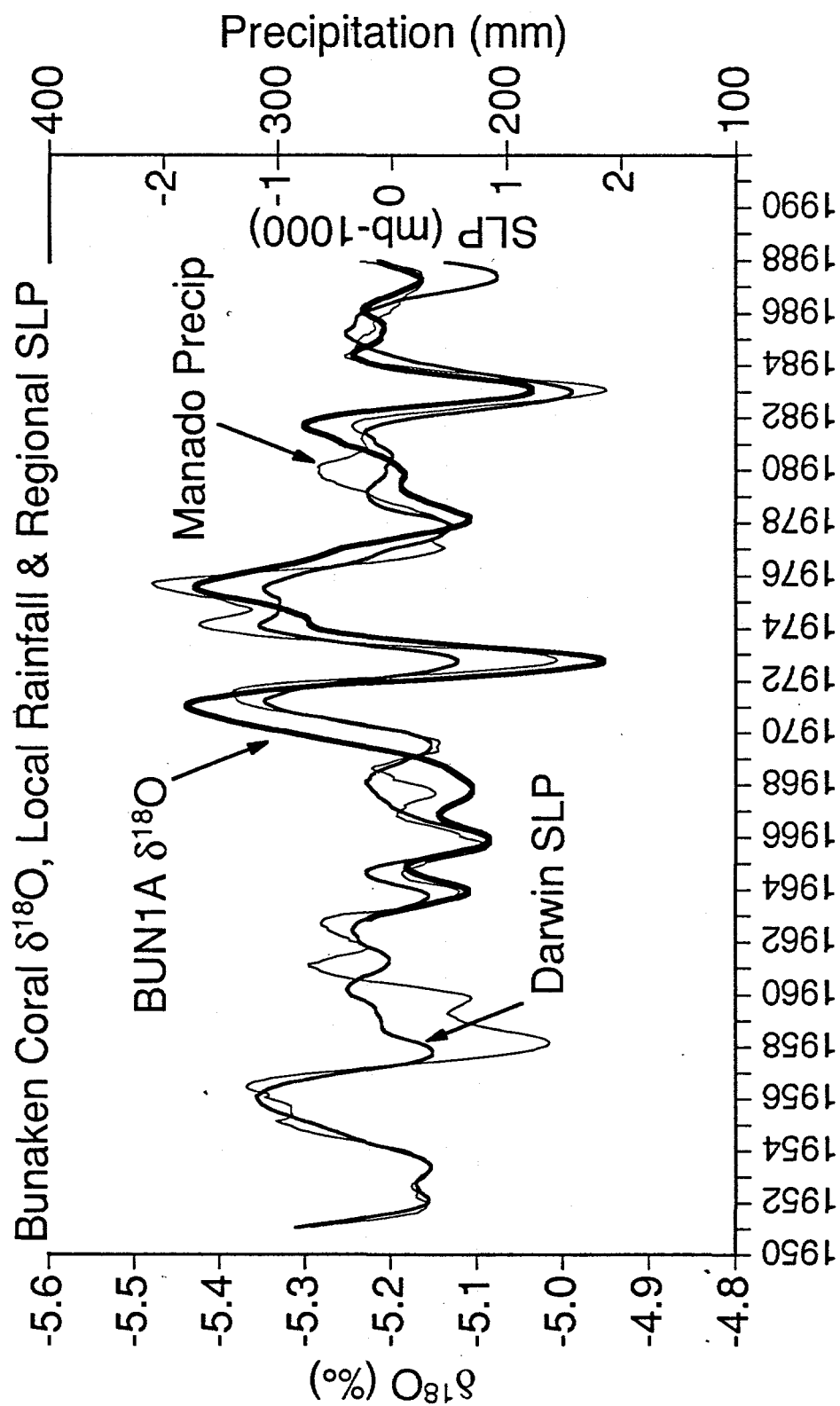


Figure 33. Interannual variability in Manado rainfall, Darwin SLP and the BUN1A $\delta^{18}\text{O}$ record, 1959-88. $\delta^{18}\text{O}$ and SLP y-axes reversed.

$\delta^{18}\text{O}$ and the Manado precipitation records is outstanding, in terms of both phasing and magnitude of the response. Inspection of the $\delta^{18}\text{O}$ times series reveals that there are no significant $\delta^{18}\text{O}$ anomalies which are not reflected in the precipitation record. However, it is known that cool SST anomalies are a typical expression of ENSO warm-phases in these waters. The fact that these SST anomalies, which are known to exist, cannot be resolved in the $\delta^{18}\text{O}$ time series suggests that most, if not all, of the interannual precipitation variability is scaling to interannual SST variability at this site

This implies that air-sea interactions around the N. Sulawesi Peninsula must play a strong role determining the interannual precipitation response. Wyrski (1961) calculates that low evaporative cooling of surface waters in the Sulawesi Sea gives rise to a year-round heat excess. This heat excess makes the Sulawesi Sea unique among the Indonesian seas, and is attributed to the completely equalized conditions found near the equator. Wyrski suggests that the heat excess is continuously removed by either surface currents, vertical mixing, or direct heating of the atmosphere. The tight agreement between the BUN1A $\delta^{18}\text{O}$ record and Manado precipitation indicates that the local precipitation is tracking the coupling between SST and convection, and supports the contention of direct heating of the atmosphere by surface waters.

These factors put the Bunaken site in the special class of "resonant" sites, where there exists an exceptionally strong relationship between the regional and local climate variability, and the physical setting is such that the coral $\delta^{18}\text{O}$ response to faithfully reproduces the full spectrum of local climate variability. One could have high confidence in pre-instrumental era

reconstructions of regional climate variability from stable isotope records from this site.

Confounded Response: Pombo, Banda Sea

The $1^{\circ} \times 1^{\circ}$ grid box containing the Pombo Island site (4° - 5° S, 128° - 129° E) in northern Banda Sea has a seasonal SST range of 2.2°C , with a maximum in November and a minimum in August (Figure 34). The rainfall record for Ambon indicates that precipitation exceeds 450 mm mo⁻¹ at the peak of the rainy season in June, and that during the prolonged dry season, precipitation averages 150 mm mo⁻¹ from October to April. This precipitation seasonality is opposite the normal seasonality, which typically has the peak of the rainy season occurring in January. SST and freshwater flux are thus completely out-of-phase. The seasonality of the PMB1A $\delta^{18}\text{O}$ record agrees with the precipitation climatology. Maxima-minima differencing of the PMB1A $\delta^{18}\text{O}$ time series yields a seasonal range of 0.48‰, which while agreeing exactly with the expected coral SST-fractionation value of 0.48‰, leaves no margin for freshwater flux. Levitus (1982) gives the seasonal salinity range for the $5^{\circ} \times 5^{\circ}$ grid box containing the site (0° - 5° S, 125° - 130° E) as 0.75 psu. Applying the Kapoposang δw /salinity mixing line to this value yield an estimate of the expected isotopic variability due to freshwater flux: 0.2‰. Wyrтки's (1961) estimate of the seasonal salinity range for the northern Banda Sea is 1.4 psu, equivalent to 0.38‰. On the basis of closure, one might be inclined to accept the Levitus salinity estimate, however the precipitation climatology suggests that the volume of rainfall is comparable to the other sites, and therefore must have contributed to dilution of the sea surface. If the magnitude of the dilution is as large as is suggested by the Wyrтки salinity estimate, then the situation is one where both SST and freshwater flux have similar

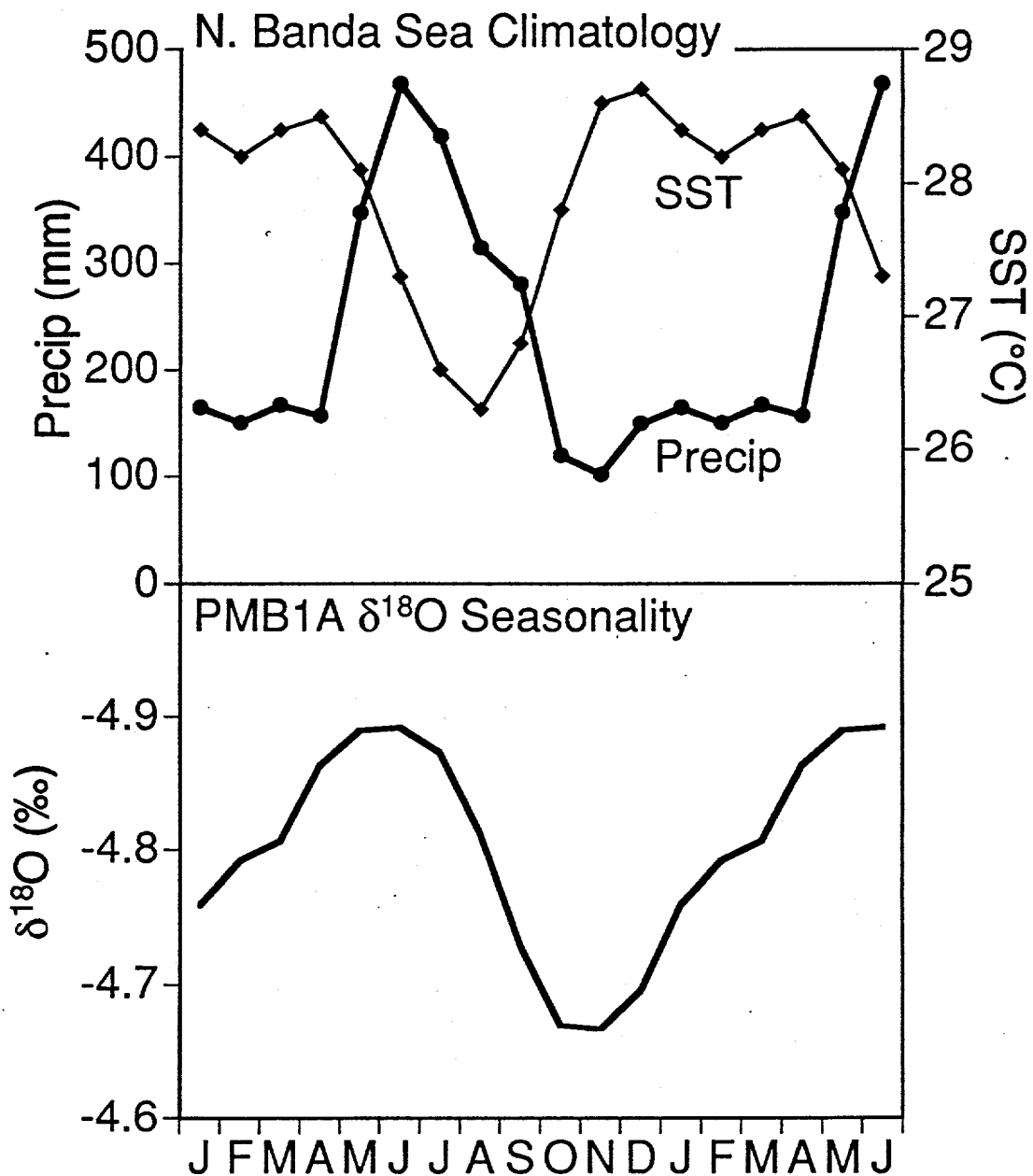


Figure 34. Banda Sea SST and Ambon precipitation climatology compared to the seasonality in the PMB1A $\delta^{18}\text{O}$ record. $\delta^{18}\text{O}$ y-axis reversed

contributions to the coral $\delta^{18}\text{O}$ response. If the contribution by SST and freshwater flux is similar, then their out-of-phase relationship should require that the two signals cancel, and the coral $\delta^{18}\text{O}$ seasonality should be negligible, however this is clearly not the case. If the Levitus value is accepted, then closure is achieved, and the signal can be assumed to be SST dominated. Unfortunately, this raises another problem: as with all of the stable isotope time series in this study, the $\delta^{13}\text{C}$ minima is interpreted to mark the month of maximum cloud cover, which is typically the month of maximum precipitation. For this site, that month is June, and the age model was set accordingly. If the site really is SST dominated, then $\delta^{18}\text{O}$ minima should fall in November, instead it is seen to fall in May-June.

Therefore, one is left with two equally unappealing possibilities: (1) The site is SST dominated: the Wyrski salinity estimate is too large, the local rainfall signal (which one might consider to be significant) is completely lost, and the $\delta^{13}\text{C}$ minima corresponds to the peak of the dry season. (2) The site is freshwater flux dominated: the precipitation record and the salinity range estimates are actually huge underestimates, and the freshwater flux at the site is large enough to produce a local salinity variability in excess of 3.5 psu, which is the value required to cancel the large out-of-phase SST signal and generate a May-June $\delta^{18}\text{O}$ minima of 0.48‰. Clearly, more data is required to understand the nature of the $\delta^{18}\text{O}$ at this site.

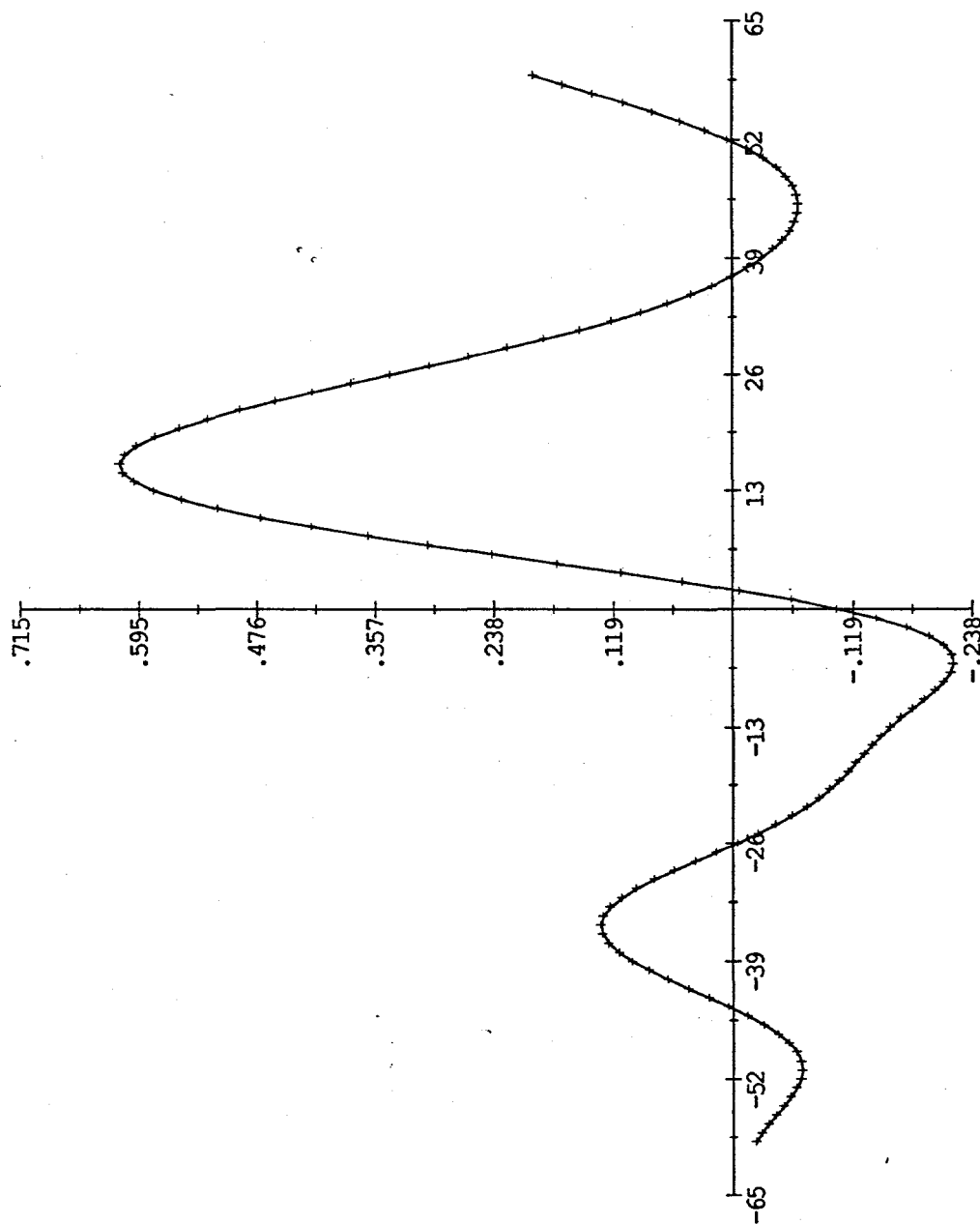
Computing the cross-covariance functions offers little insight. The cross-covariance function of the smoothed deseasonalized residuals for the Darwin SLP and Ambon precipitation time series yields $r = 0.21$ at lag -6 months, as shown in Figure 35. The cross-covariance functions for Darwin

SLP and PMB1A $\delta^{18}\text{O}$ yields $r = 0.30$ at lag 11 months, and for Ambon precipitation and PMB1A $\delta^{18}\text{O}$ yields $r = -0.15$ at lag 16 months, as shown in Figures 36 and 37.

The three time series have no strong relationship to each other, as shown in Figure 38. In some years the Ambon precipitation record can be seen leading Darwin SLP by a few months as suggested by the cross-covariance function. However, the PMB1A $\delta^{18}\text{O}$ record shows no evidence of any kind of a phase relationship to either of the other records, nor any common anomalies. From this it can be concluded that the Pombo site has a strong local variability that is not related to freshwater flux. In the absence of SST time series for the N. Banda Sea it is difficult to proceed much further.

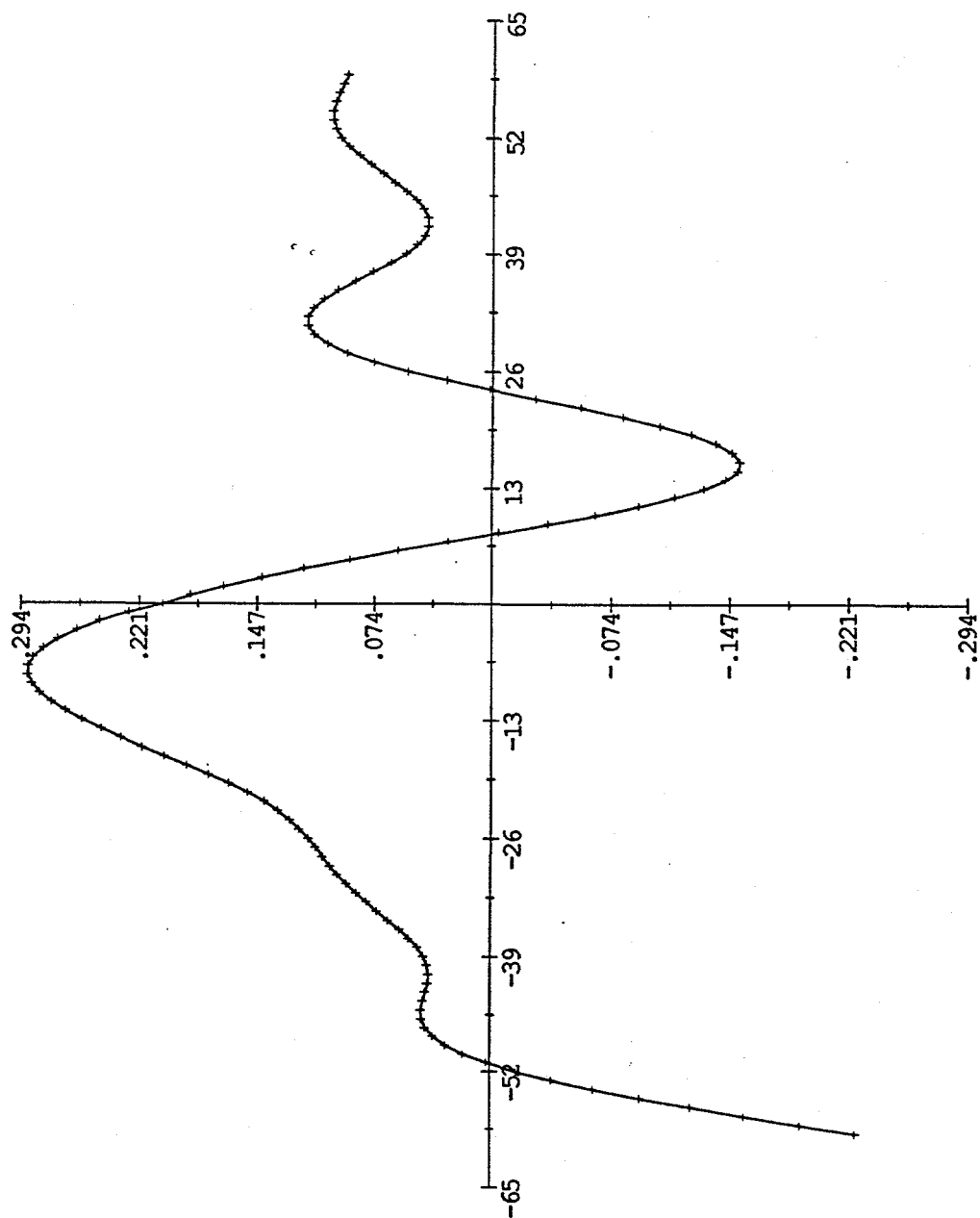
How can this site behave so poorly when the other sites from E. Indonesia are capturing, to varying degrees, the local and regional variability? The most obvious reason is that the precipitation seasonality is out of phase with large SST seasonality. The timing of the SST minimum at Ambon is completely consistent with the rest of E. Indonesia, and is a product of evaporative cooling of low humidity winds from Australia during the SE monsoon. This produces a dry season SST cooling of 2-3°C in the Flores and Banda Sea, as seen in the August GOSTA SST map (Chapter 2, Figure 9). For the precipitation seasonality to be phase-shifted indicates that the local convection is being controlled by something other than the monsoon regime or air-sea interactions in the Banda Sea.

The Banda Sea has the typical monsoon seasonality characteristic of E. Indonesia with NW monsoon rainy season in January-April, and the SE



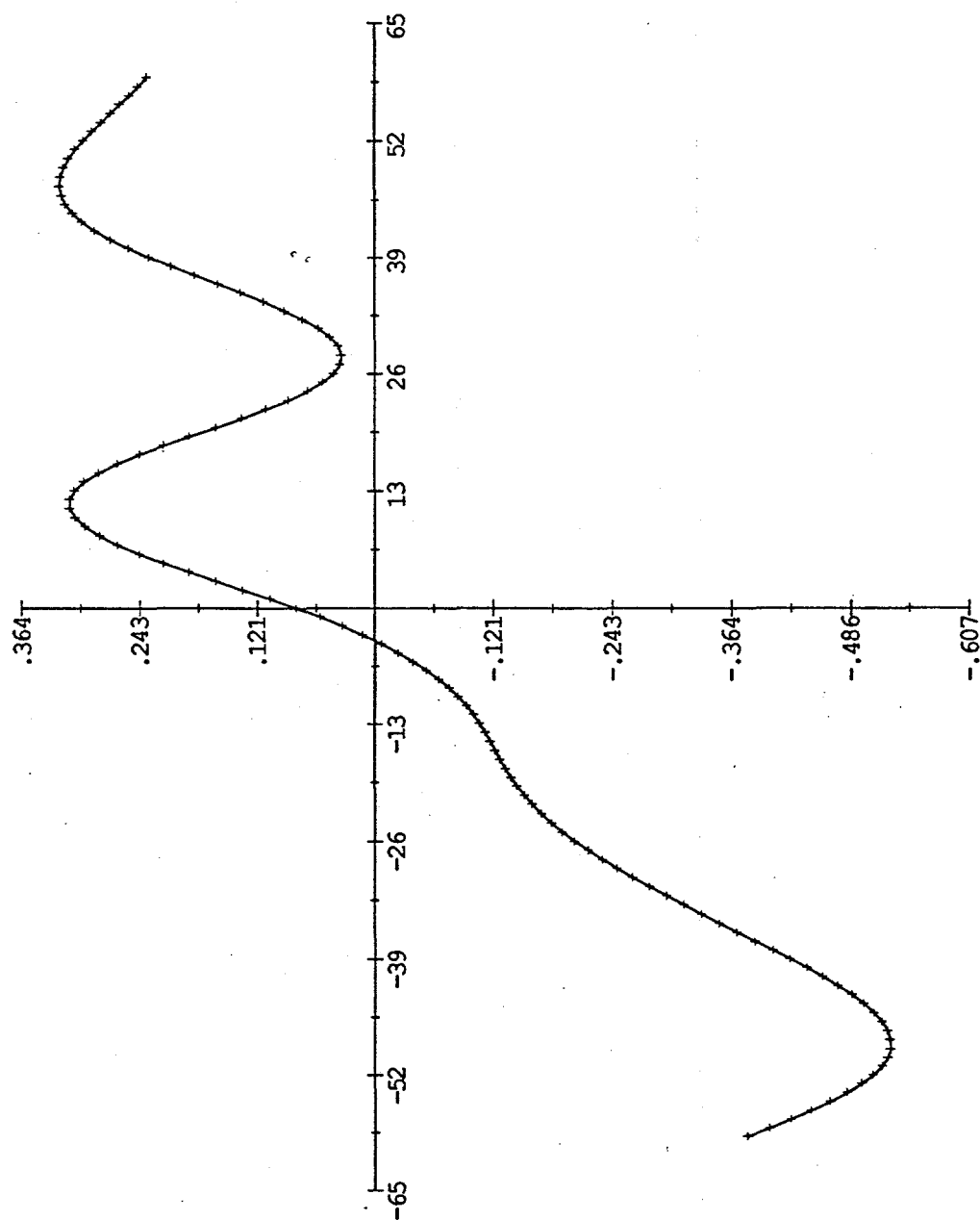
60 lags of a cross-covariance or cross-correlation function
 Darwin SLP and Ambon Precip 1961-87

Figure 35. Cross-covariance function for Ambon rainfall and Darwin SLP, $r = -0.21$, $m = -6$.



60 lags of a cross-covariance or cross-correlation function
Ambon Precip and PMB1A $\delta^{18}\text{O}$ 1961-87

Figure 36. Cross-covariance function for Ambon rainfall and PMB1A $\delta^{18}\text{O}$, $r = -0.15$, $m = 16$.



60 lags of a cross-covariance or cross-correlation function
 Darwin SLP and PMB1A $\delta^{18}\text{O}$ 1961-87

Figure 37. Cross-covariance function for Darwin SLP and PMB1A $\delta^{18}\text{O}$, $r = 0.30$, $m = 11$.

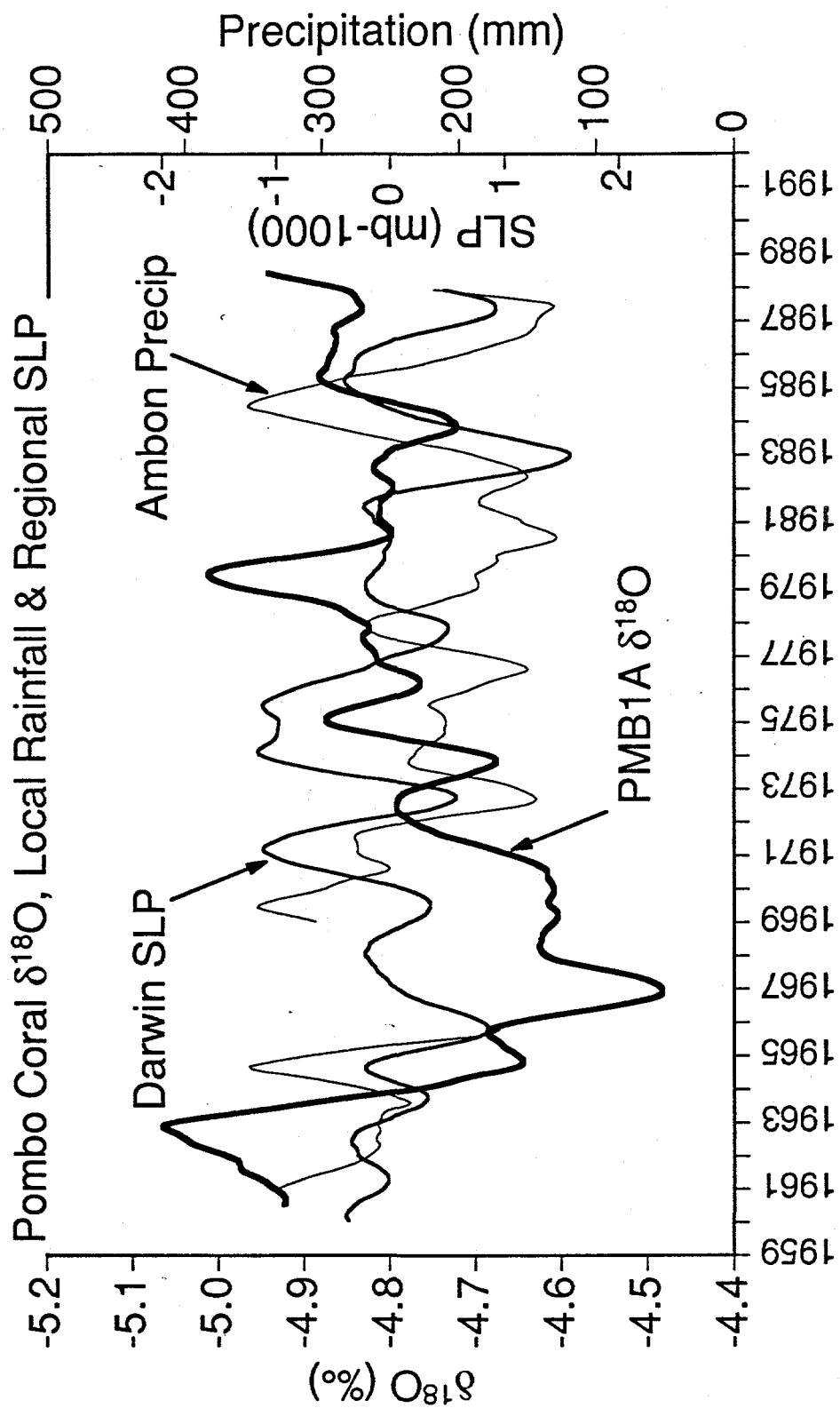


Figure 38. Interannual variability in Ambon rainfall, Darwin SLP, and the PMB1A $\delta^{18}\text{O}$ record, 1959-1988. $\delta^{18}\text{O}$ and SLP y-axes reversed.

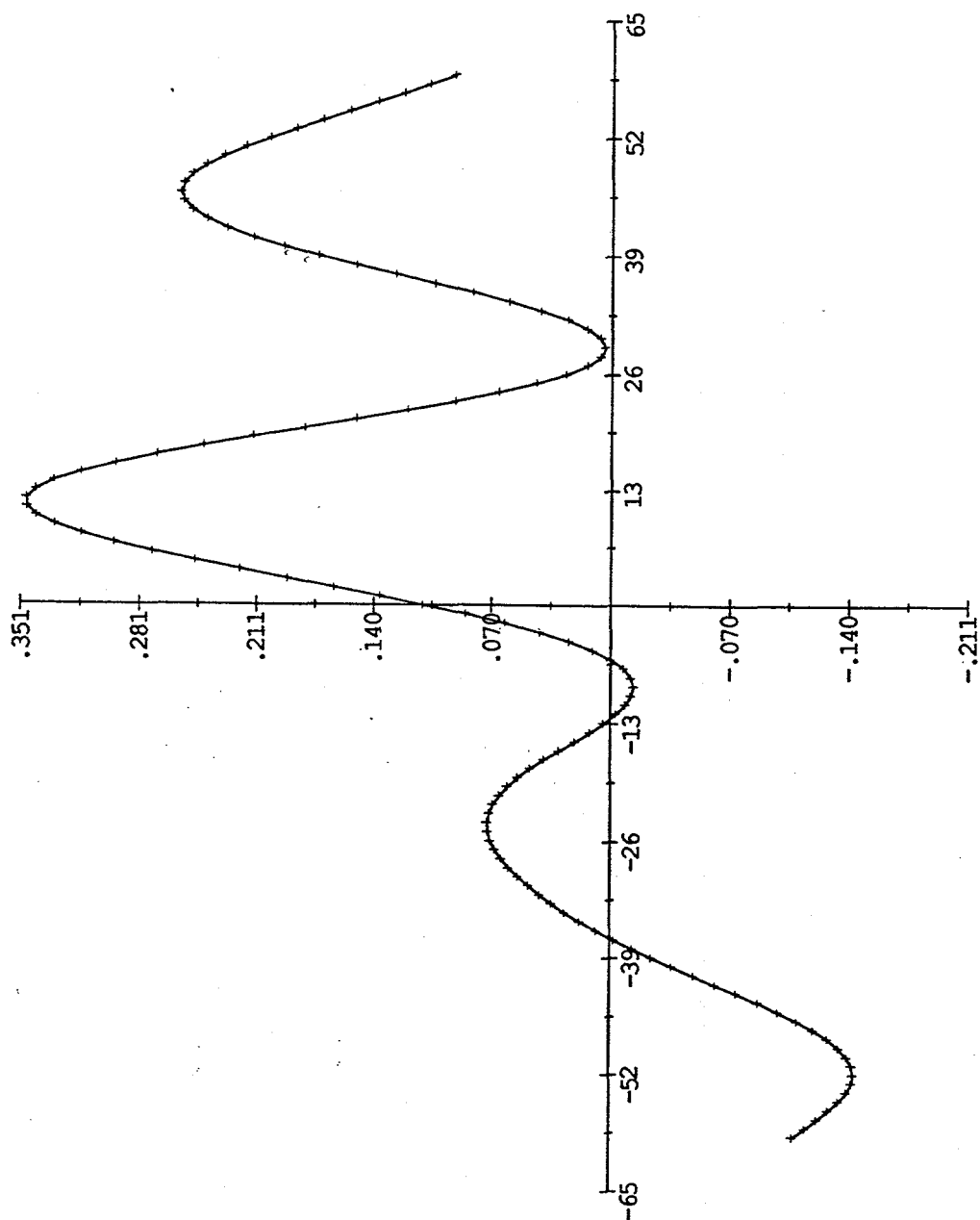
monsoon dry season in June-September. Inspection of rainfall records in the area north of Ambon reveals that sites on the east and west sides of the Halmahera Strait and the north coast of Irian Jaya (New Guinea) have peak precipitation occurring in June-August. This is the season of maximum throughflow via the Halmahera Strait: surface currents patterns for August show strong westward flow along the north coast of New Guinea and strong southward flow in Halmahera Strait. Wyrski (1961) suggests that, like the Sulawesi Sea, the surface waters north of New Guinea carry excess heat available for atmospheric heating. Since these surface waters are warmest in August, with SSTs in excess of 29°C (Chapter 2, Figure 9), the implication is that the precipitation seasonality in the vicinity of the Halmahera Strait is caused by strong air-sea interactions. The precipitation seasonality at Ambon places the site with this domain, which suggests that heat-laden surface waters are penetrating as far south as Seram. If this is the case, then perhaps the atlas data overestimates the seasonal SST range in the vicinity of Ambon, and the $\delta^{18}\text{O}$ response is freshwater flux dominated and the June placement of the $\delta^{13}\text{C}$ minima is correct.

From this it can be concluded that the Ambon site lies at the boundary between two conflicting seasonal regimes: the typical SST regime set by the monsoon circulation over the Banda Sea and the out-of-phase precipitation regime set by air-sea interactions associated with the presence of SEC water in the Halmahera Strait. On interannual time scale this situation is clearly confounding: for example, a strengthened SE monsoon during an ENSO warm-phase year would be expected to produce a cool SST anomaly in the Banda Sea, but also a stronger SEC supply in the Halmahera Strait and enhanced precipitation at Ambon. The two responses are competitive with

respect to coral $\delta^{18}\text{O}$, and it is difficult to predict which response would be the stronger on interannual timescales. It was determined above that there is no strong relationship between PMB1A $\delta^{18}\text{O}$ and the interannual monsoon variability. Though one might imagine that the site could be strongly influenced by W. Pacific warm pool SSTs advected by the SEC, this appears not be the case. Computing the cross-covariance function for the smoothed interannual residuals of Barnett's W. Pacific SST time series and PMB1A $\delta^{18}\text{O}$ yields $r = 0.35$ at lag 11 months (Figure 39), which is no better than the correlation to Darwin SLP.

To make matters worse, the Field and Gordon (1992) residence time estimate for surface waters in the Banda Sea is on the order of 4-5 years, which falls within the ENSO low frequency timescale of 2.75-7.0 years. This implies that, unlike the sites on the Makassar Strait throughflow route, interannual freshwater flux anomalies would persist across ENSO phase changes. It might be possible to recover useful information from a site with a long residence time, but the Ambon site is too complex to assess this fairly.

The seasonal and interannual $\delta^{18}\text{O}$ response at Ambon is strong evidence that an out-of-phase relationship between SST and precipitation is indeed cause for alarm. Besides signifying a complicated hydrography and a decoupling of the expected air-sea interactions, this kind of relationship does not provide much opportunity for recovering climatologically useful information on any timescale.



60 lags of a cross-covariance or cross-correlation function
WPAC SST and PMB1A $\delta^{18}\text{O}$ 1961-87

Figure 39. Cross-covariance function for Barnett's W. Pacific COADS SST record and the PMB1A $\delta^{18}\text{O}$ record, $r = 0.35$, $m = 11$.

Secular Trends in Coral $\delta^{18}\text{O}$

The ability to determine mean $\delta^{18}\text{O}$ values from biological carbonates and track their shifts over geological timescales is fundamental to paleoceanography. Researchers working on modern corals have extended this concept to the interpretation of $\delta^{18}\text{O}$ time series developed from individual, centuries-old coral colonies. For example, Dunbar and Cole (1993, p 1) state that "Coral records can thus be used to assess long-term climate trends as well as the range of natural variability in many tropical environments." The assumed climatic significance of long-term shifts in mean coral $\delta^{18}\text{O}$ values underlies conclusions such as: "(there is a) mean shift to lower $\delta^{18}\text{O}$ values (indicating rainier conditions) for the period between 1976 and 1988" (from Cole et al. 1993, p 1792), or " (the) long-term trend is ... a shift of -0.4‰ over the length of the record ... two mechanisms could account for this change: 1-2° reduction in SST or a reduction in precipitation" (from Linsley, et al. 1994, p 9990). However, little is known about the growth dynamics of corals on centennial timescales. Though widely assumed, there are no studies that conclusively demonstrate that the isotopic fractionation thresholds of long-lived corals will (or should) remain fixed over time. In Chapter 2, it was shown that the long term trends in the KAP1A and LAN1A time series were not reproducible. This section will investigate the secular trends in all of the Indonesian stable isotope time series and provide evidence that suggests that the long-term shifts in mean $\delta^{18}\text{O}$ values are attributable to biological effects, and not real climate change.

A low-pass binomial-spline filter with the 50% response set at 36 months was applied to the monthly KAP1A, KAP3A, LAN1A, PDB, BUN1A, and PMB1A stable isotope time series. The effect of this filter is to conserve

all of the low-frequency variance in the time series with periods longer than 3 years. The low-pass filtered BUN1A, LAN1A, KAP1A and PMB1A $\delta^{18}\text{O}$ time series are shown in Figure 40, and the corresponding $\delta^{13}\text{C}$ time series are shown in Figure 41. The percent conserved variance for each time series is indicated in parentheses. The filtered KAP1A record shows a trend of +5.5‰ in 130 years, while the BUN1A and LAN1A $\delta^{18}\text{O}$ time series have trends of -0.4‰ and -0.55‰ over the same period. The PMB1A $\delta^{18}\text{O}$ time series shows a small trend about +0.13‰. It is difficult to ascribe climatic significance to these trends. The PMB1A time series could perhaps be discounted because the site is confounded, and the BUN1A and LAN1A time series could be considered comparable. However, the KAP1A time series has a completely opposite trend of the same magnitude as the LAN1A time series, and the two sites are only 37 km apart. It stretches the imagination to propose that at Kapoposang Island SST cooled by 2°C, while at Langkai SST warmed by the same amount.

Examination of the $\delta^{13}\text{C}$ trends in Figure 41 reveals an interesting feature common to all of the time series. The KAP1A filtered $\delta^{13}\text{C}$ time series has a trend of +0.2‰ over 130 years, while the BUN1A and LAN1A $\delta^{13}\text{C}$ time series indicate trends of -0.7‰ and -1.25‰ over the same period. The PMB1A $\delta^{13}\text{C}$ time series indicates a trend of +0.6‰. Thus, all of the $\delta^{13}\text{C}$ trends are in the same direction as the $\delta^{18}\text{O}$ trends for each core. Linear estimates of the $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ slopes for each time series are given below in Table III. This observation, taken in conjunction with the irreproducibility of the $\delta^{18}\text{O}$ trends, suggests that the long term trends are under the influence of coral biology.

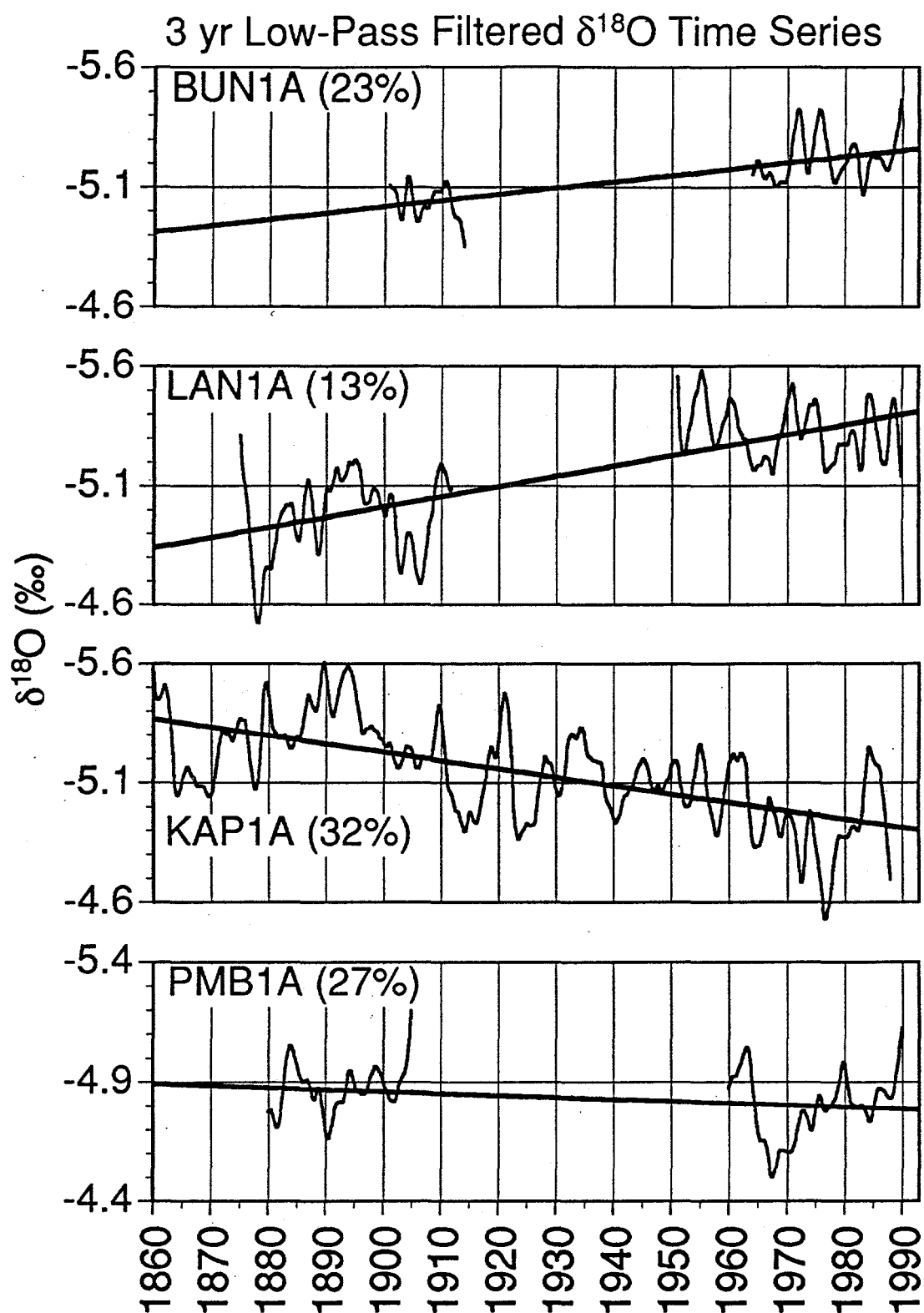


Figure 40. Inter-site comparison of secular trends in coral $\delta^{18}\text{O}$, 1860-1989. Percent variance retained by the 3 yr low-pass filter given in parentheses. $\delta^{18}\text{O}$ y-axis reversed.

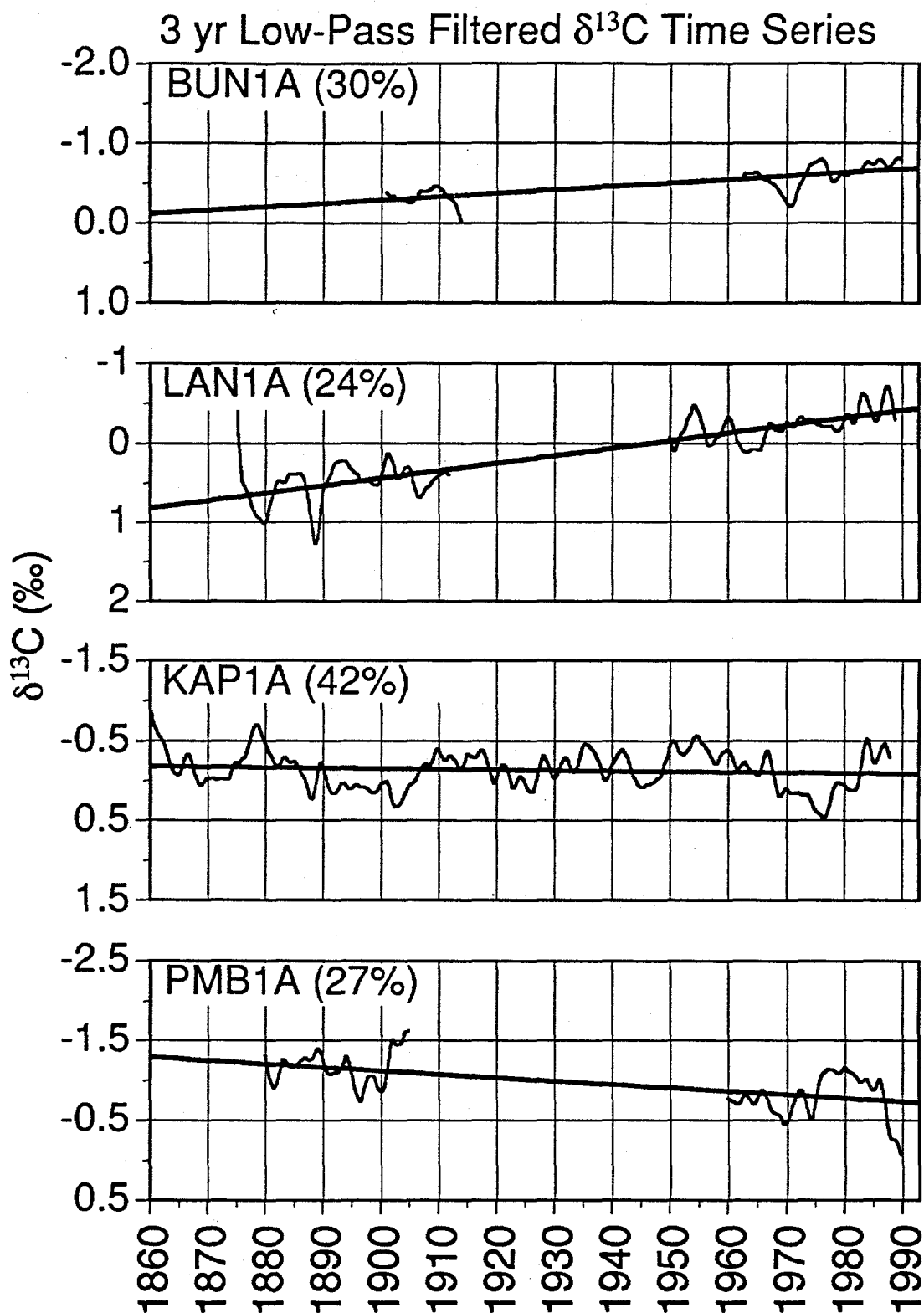


Figure 41. Inter-site comparison of secular trends in coral $\delta^{13}\text{C}$, 1860-1989. Percent variance retained by the 3 yr low-pass filter given in parentheses. $\delta^{13}\text{C}$ y-axis reversed.

Table III. Long-term Stable Isotope Trends

Core	$\delta^{13}\text{C}$ Slopes	$\delta^{18}\text{O}$ Slopes
BUN1A	-4.280E-3	-2.611E-3
LAN1A	-9.531E-3	-4.289E-3
KAP1A	+7.382E-4	+3.491E-3
PMB1A	+4.306E-3	+8.000E-4
PDB	-7.237E-3	-9.527E-4
KAP3A	-2.576E-2	-1.838E-3

As was discussed in Chapter 1, isotopic fractionation during the precipitation of biological carbonates causes skeletal $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values to be displaced from the predicted stable isotope values of carbonate precipitated in isotopic equilibrium with seawater. This isotopic "disequilibrium" is manifested in two patterns: "kinetic" displacements of $\delta^{13}\text{C}$ that correlate strongly to $\delta^{18}\text{O}$, and "metabolic" displacements of $\delta^{13}\text{C}$ independent of $\delta^{18}\text{O}$ displacements. Expected $\delta^{18}\text{O}$ values for aragonite precipitated in equilibrium with seawater can be estimated using the Friedman and O'Niell (1977) equation for the equilibrium partitioning of oxygen isotopes between calcite and H_2O :

$$(1) \quad 1000 \ln \alpha = 2.78(10^6 T^{-2}) - 2.89$$

where α is the ratio of $^{18}\text{O}/^{16}\text{O}(\text{CaCO}_3)$ to $^{18}\text{O}/^{16}\text{O}(\text{H}_2\text{O})$, and T is $^\circ\text{K}$. Eqn. (1) predicts α for a given temperature, and knowing the seawater $\delta^{18}\text{O}$ value (δ_w) the aragonite $\delta^{18}\text{O}$ value (δ_c) can be computed by solving:

$$(2) \quad \alpha = \frac{1000 + \delta_c}{1000 + \delta_w}$$

Eqn. (2) is valid when both δw and δc are given with respect to the same isotopic standard. Since δw is typically reported with respect to Standard Mean Ocean Water (SMOW) and δc is usually reported with respect to the Pee Dee Fm. Belemnite, the following conversion is useful:

$$(3) \quad \delta_{SMOW}^x = 1.03037 \delta_{PDB}^x + 30.37$$

During the NW Monsoon rainy season, δw at Kapoposang averages about -0.5‰ and SST is about 29°C, while during the SE Monsoon dry season, δw averages about 0.0‰ and SST is about 28°C. Solving equations (1) and (2) for each season, and using equation (3) to convert $\delta^{18}O_{SMOW}$ to $\delta^{18}O_{PDB}$ gives an expected $\delta^{18}O$ range for equilibrium aragonites of -2.82‰ to -2.12‰, with a mean value of -2.47‰. This mean value is considerably more positive than the average $\delta^{18}O$ of Indonesian corals, which is about -5.0‰. The difference, -2.53‰, is the displacement from the expected $\delta^{18}O$ value if the skeleton were precipitated in equilibrium with seawater (and is equivalent to a temperature offset of 11.5°C). The $\delta^{13}C$ displacement is usually observed to be about twice as large as the $\delta^{18}O$ displacement.

These $\delta^{18}O$ and $\delta^{13}C$ offsets are typical of "kinetic" disequilibria in biologically-precipitated carbonates, and are believed to be caused by discrimination against the heavy isotopes of carbon and oxygen during the hydration and hydroxylation of CO_2 (McConnaughey, 1989). This effect is particularly strong in non-photosynthetic corals. Among photosynthetic corals, an additional effect is superimposed in which the $\delta^{13}C$ is shifted to values more positive than predicted by the "kinetic" pattern. For example, a

photosynthetic coral and a non-photosynthetic coral growing in the same environment as will have the same $\delta^{18}\text{O}$, but the photosynthetic coral will have a more positive $\delta^{13}\text{C}$. This is the "metabolic" disequilibrium pattern, believed to be caused by the $\delta^{13}\text{C}$ value of the dissolved inorganic carbon pool involved in respiration and photosynthesis (McConnaughey, 1989).

McConnaughey (1989) surveyed stable isotope fractionation displacements from equilibrium values for a variety of non-photosynthetic organisms that precipitate calcite or aragonite, as shown in Figure 42. "E" represents the expected equilibrium value in $\delta^{13}\text{C}$ - $\delta^{18}\text{O}$ space. It is apparent that each of the groups generally fractionates $\delta^{13}\text{C}$ more than $\delta^{18}\text{O}$. Displacements for abyssal coral aragonites are distributed along a line with a slope of 0.5 (2:1), and have a wide range of values, with $\delta^{13}\text{C}$ as low as -10‰ and $\delta^{18}\text{O}$ values as low as -5‰. Since all of these organisms are non-photosynthetic, these displacements are the result of kinetic effects.

Here the following observation is made: if the long-term $\delta^{18}\text{O}$ trends are plotted against the long-term $\delta^{13}\text{C}$ trends for each the BUN1A, LAN1A, KAP1A, and PMB1A cores, as in Figure 43, the data describe a line with a slope of 0.48 ($r = 0.83$). This line implies that, for this population of corals, shifts in $\delta^{18}\text{O}$ over time are generally matched by shifts in $\delta^{13}\text{C}$ over time that are twice as large. This relationship strongly suggests that these corals have disequilibrium displacements that are drifting through $\delta^{13}\text{C}$ - $\delta^{18}\text{O}$ space, and that the average drift in displacements follows the basic proportionality of the kinetic pattern. LAN1A and BUN1A plot very near the 2:1 line, in the domain of negative $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ slopes, and KAP1A and PMB1A are farther off the 2:1 line in the domain of positive $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ slopes.

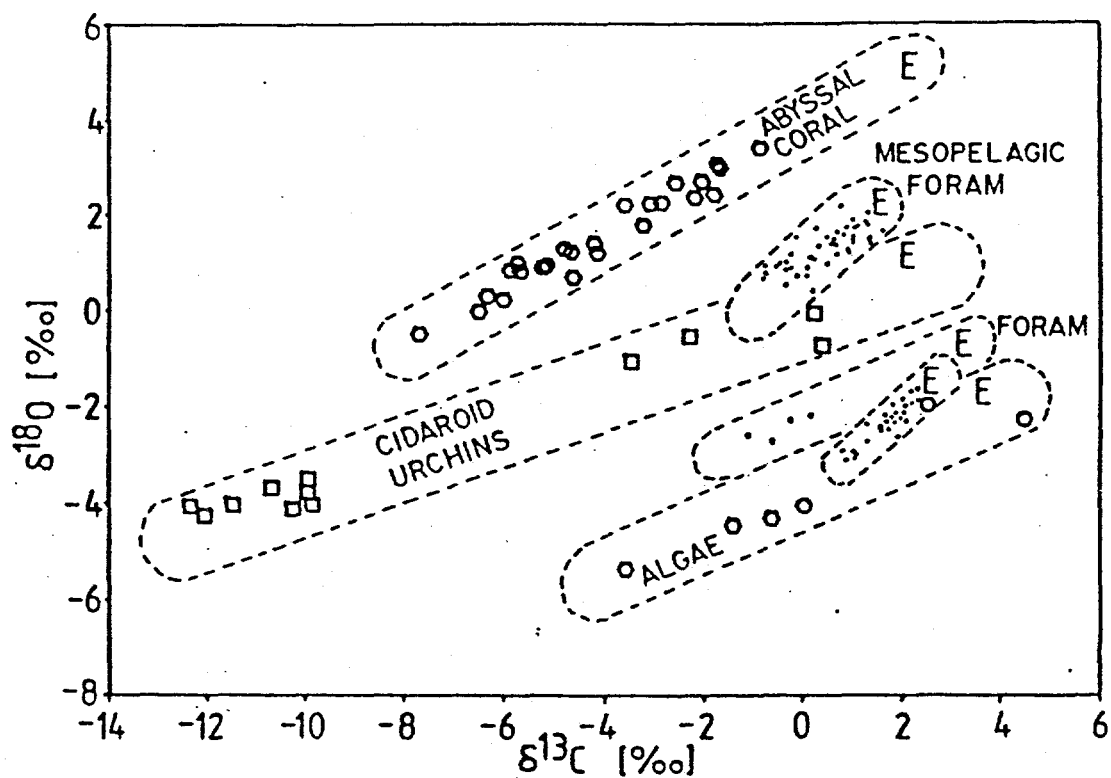


Figure 42. Kinetic disequilibria in various non-photosynthetic biological carbonates. "E" is expected equilibrium value for $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ for inorganically precipitated carbonate in isotopic equilibrium with seawater (after McConnaughey, 1989).

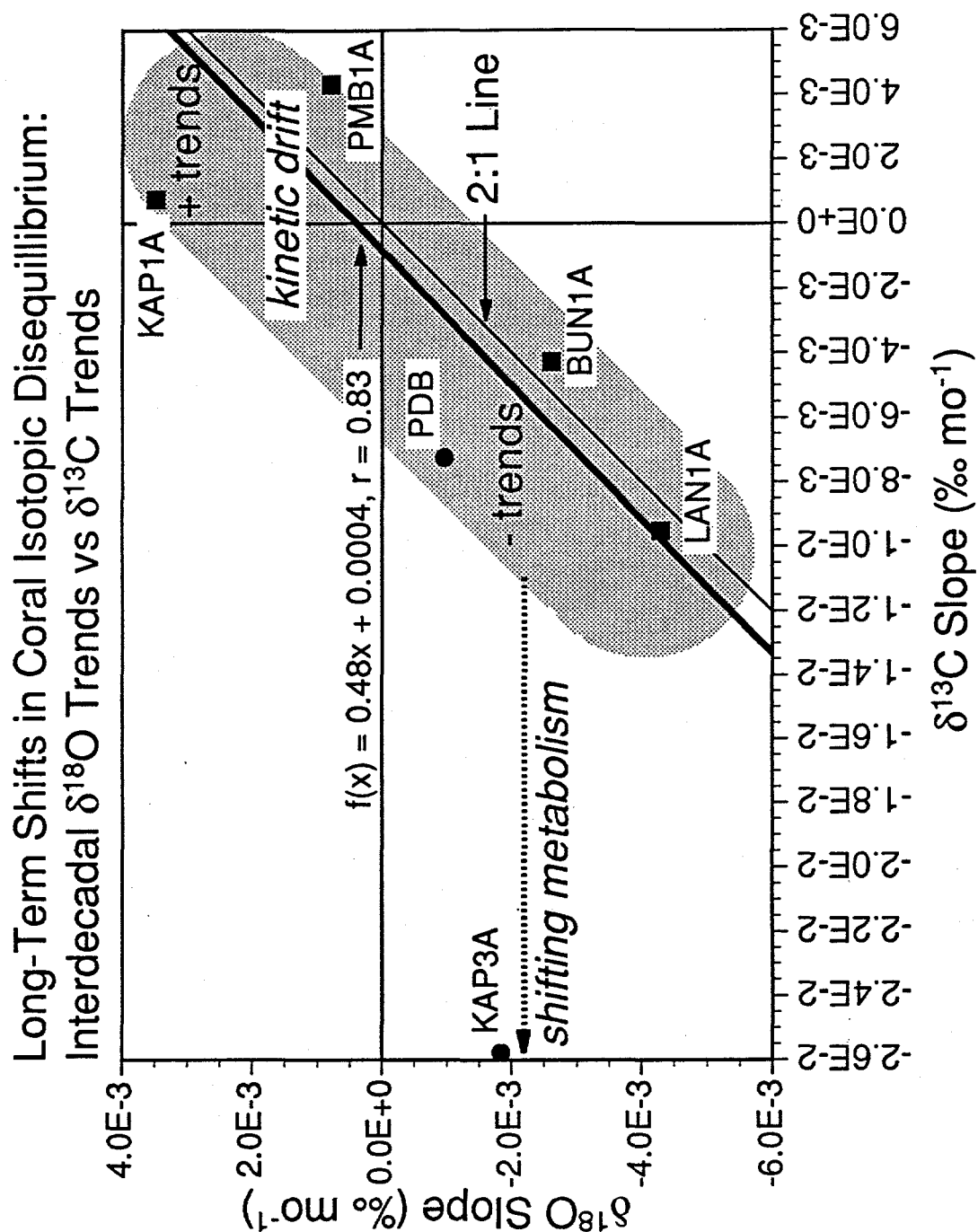


Figure 43. Plot of trends in $\delta^{18}\text{O}$ versus trends in $\delta^{13}\text{C}$ for Indonesian coral stable isotope records. Records from mature colonies are variously distributed about the 2:1 line, suggestive of slowly drifting fractionation thresholds, while the record from the juvenile KAP3A colony plots well off the 2:1 line, suggestive of a rapidly changing metabolism.

The slopes for the two shorter time series KAP3A and PDB are plotted as well. Note that the PDB slopes plot within the "kinetic drift" domain described by the slopes of the four longer time series, while KAP3A is far outside this domain. A significant difference between the KAP3A and the PDB time series is that the KAP3A colony was only about 45 cm tall with an age of about 22 years, while the PDB colony is 4.0 meters tall with an age of at least 288 years. PDB plots near the other mature colonies, while the juvenile KAP3A colony plots far off to the left. The reason KAP3A plots so far to the left is because its $\delta^{13}\text{C}$ slope is an order of magnitude larger than the others. Rapid skeletal growth is often associated with kinetic disequilibria (McConnaughey, 1989, Fairbanks and Dodge, 1979). The steep $\delta^{13}\text{C}$ slope of the KAP3A indicates this coral's metabolic rate was changing more rapidly over time compared to the older colonies with stabilized growth rates, and represents a shift in kinetic displacements away from the typical values for the mature corals.

These data, though strongly suggestive, are not sufficient to fully assess the validity of this hypothesis, as many more coral stable isotope time series will have to be examined to determine the true dimensions of the kinetic drift domain and growth history patterns. Nor does this preclude climate change, since a strong interdecadal $\delta^{18}\text{O}$ slope plotting well off of the 2:1 line would be suggestive of a real trend in SST or freshwater flux. These data can be used to estimate some possible boundaries for rates of $\delta^{18}\text{O}$ change over time. The y-intercepts for the upper and lower range of $\delta^{18}\text{O}$ slopes contained in the shaded kinetic drift domain were estimated (i.e. at $\delta^{13}\text{C}$ slope = 0.0, $\delta^{18}\text{O}$ slope = 0.0036 and -0.00175; see Figure 43) and plotted as functions of time in Figure 44. It can be seen that, in the absence of a $\delta^{13}\text{C}$ trend, one might expect

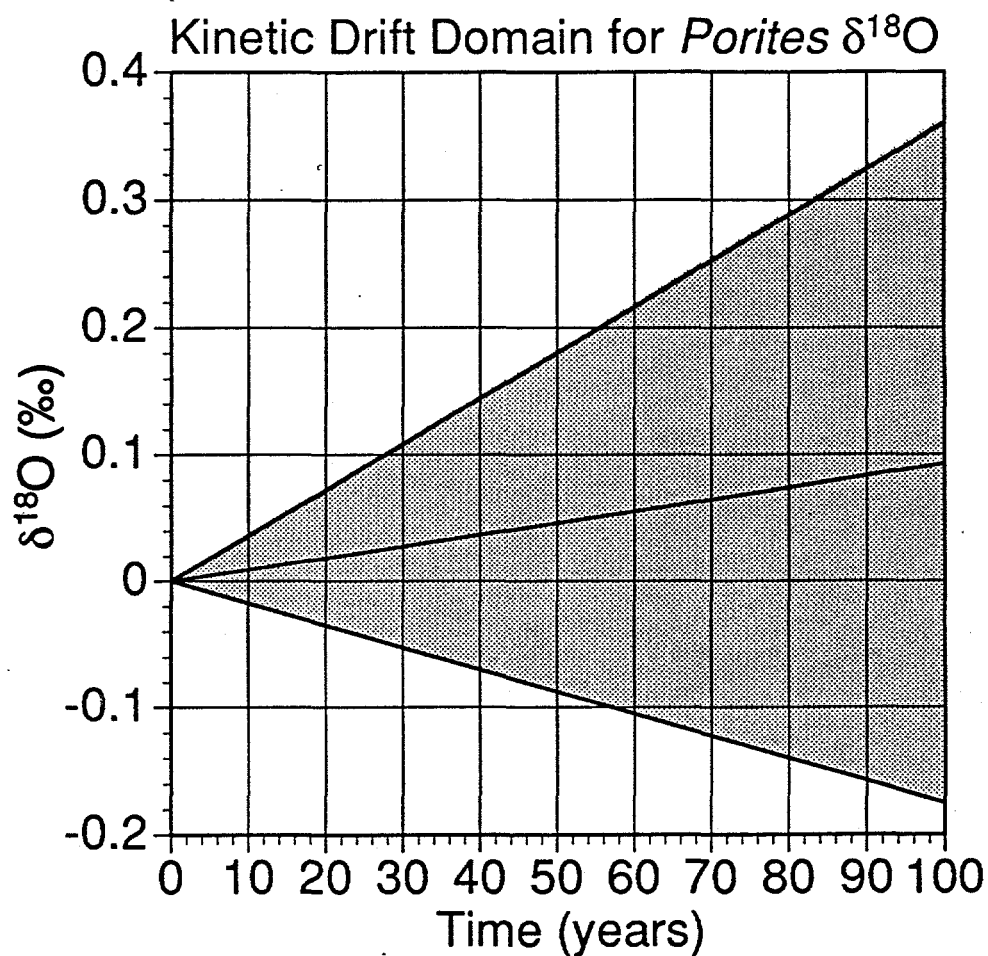


Figure 44. Shifts in $\delta^{18}\text{O}$ as a function of time predicted by the range of $\delta^{18}\text{O}$ slopes at slope $\delta^{13}\text{C} = 0.0$ (Figure 43). The variability in $\delta^{18}\text{O}$ trends describes a domain of kinetic disequilibrium drift that ranges from about -0.2 to $+0.35\text{‰}$ century⁻¹, large enough to preclude the use of secular trends in coral $\delta^{18}\text{O}$ for studies of recent climate change.

secular trends in $\delta^{18}\text{O}$ that describe shifts of -0.18‰ to $+0.36\text{‰}$ per century as a natural feature of coral growth dynamics. This large isotopic range (equivalent to $+0.8$ to -1.6°C 100 yr^{-1} SST) does not bode well for resolving real secular trends in SST that are thought to be on the order of $+0.5^\circ\text{C}$ 100 yr^{-1} (Houghton, 1990). Certainly published estimates of climate change based on secular trends in coral $\delta^{18}\text{O}$ that fall in this range should be treated with caution.

CONCLUSIONS

The regional variability of interannual coral $\delta^{18}\text{O}$ has been examined for several sites in the Indonesian Seaway. The data support the following conclusions.

1. The most useful coral proxy data comes from sites which have regional or resonant responses. Sites with a local response are less useful for regional analyses, but can provide relevant information in conjunction with other sites. Confounded sites can be diagnosed in advance, and should be avoided.
2. The stacking of stable isotope records appears to supply better correlations to regional climate forcing, and this technique should be more widely applied in future studies. Sites should be screened for the presence of complicated hydrography or strong local effects that might degrade the quality of the stacked $\delta^{18}\text{O}$ time series.
3. Through careful analysis it is possible to recover different modes of regional climate variability in the coral $\delta^{18}\text{O}$ records. The deconvolution analysis of the offshore Spermonde records reveals the advection of an

interannual SST signal from the W. Pacific into the Makassar Strait, which is perhaps amplified by additional interannual changes in vertical mixing.

4. As was seen in Chapters 2 and 3, the coral proxy records appear to be best suited for the recovery of paleoclimatic information on interannual timescales. The high correlations to local rainfall and regional SLP seen at Bunaken ($r = 0.76-0.83$) suggest that, in the right circumstances, coral records are as sensitive and accurate as single-site instrument observation.

5. Secular trends in the records are observed to conflict, even among nearby sites. Most of these long-term shifts in isotope mean values can be explained by slowly changing fractionation thresholds, which appear to produce an effect sufficiently large to preclude studies of long-term climate shifts in the tropics based on isotopic trends alone.

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APPENDIX I. CORAL CORES COLLECTED IN S.E. ASIA

Core Site	Core #	Length (m)	Hiatus (m)	Core Top	Date Collected	Age (yr)
<i>East Bali</i>						
<i>(Lombok Strait)</i>						
Padang Bai	1A	1.18		live	17-Jun-90	
Padang Bai	1B	3.78		live	18-Jun-90	260
Padang Bai	1C	4.32	3.92	live	22-Jun-90	288
Padang Bai	1D	0.61		live	12-Jun-90	
Padang Bai	2A	2.15		live	15-Jun-90	172
Padang Bai	2B	0.92		live	15-Jun-90	
Padang Bai	2C	1.45		live	18-Jun-90	
<i>Spermonde Bank</i>						
<i>(Makassar Strait)</i>						
Langkai	1A	2.3		live	3-Jul-90	141
Langkai	1B	1.9		live	3-Jul-90	
Langkai	2A	1.57	0.78	dead	4-Jul-90	
Langkai	2B	1.01		live	4-Jul-90	
Langkai	3A	2.05		dead	4-Jul-90	105
Barong Lompo	1A	3.15	3	live	8-Jul-90	
Barong Lompo	1B	2.85		live	8-Jul-90	174
Podong Podong	1A	2.97		live	9-Jul-90	236
Lompo						
Podong Podong	1B	3.18		dead	10-Jul-90	261
Lompo						
Kudingareng	1A	1.81		live	13-Jul-90	107
Lompo						
Kudingareng	2A	1.14	0.07	live	13-Jul-90	
Lompo						
Kudingareng	2B	1.64		live	17-Jul-90	
Lompo						
Kapoposang	1A	2.62		dead	16-Jul-90	245
<i>N. Sulawesi</i>						
<i>(Sulawesi Sea)</i>						
Bunaken	1A	2.65		live	20-Jul-90	145
Tasik Ria	1A	0.52		live	22-Jul-90	
Tasik Ria	1B	0.53		live	22-Jul-90	
Tasik Ria	1C	0.75		dead	22-Jul-90	
<i>Ambon</i>						
<i>(N. Banda Sea)</i>						
Ambon Bay	1A	1.72		live	7-Aug-90	
Ambon Bay	2A	2.41		dead	7-Aug-90	
Ambon Bay	3A	1.24		dead	7-Aug-90	
Pombo Island	1A	2.53		live	9-Aug-90	199

Core Site	Core #	Length (m)	Hiatus (m)	Core Top	Date Collected	Age (yr)
<i>W. Lombok</i>						
<i>(Lombok Strait)</i>						
Gili Meno	1A	2.23	1.75	live	14-Aug-90	
Gili Meno	3A	1.82		live	15-Aug-90	
Gili Meno	3B	0.97		live	15-Aug-90	
Gili Meno	4A	2.96	1.34	live	16-Aug-90	
Gili Meno	5A	3.3		live	17-Aug-90	168
<i>Koh Samui & Koh Phangan</i>						
<i>(Gulf of Siam)</i>						
Koh Tae Nai	1A	2.25		live	11-Jan-91	
Koh Tae Nai	1B	0.63		live	11-Jan-91	
Koh Tae Nai	1C	2.75		live	11-Jan-91	125
Koh Tae Nok	1A	0.58	0.23	live	13-Jan-91	
Koh Tae Nok	1B	0.54		live	13-Jan-91	
Koh Tae Nok	1C	0.12		live	13-Jan-91	
Koh Tae Nok	1D	2.97	1.98	live	13-Jan-91	
Koh Tae Nok	1E	3.04		live	13-Jan-91	195
Hat Lat	1B	2.87		live	14-Jan-91	139
Hat Lat	1C Center Axis	0.62		live	14-Jan-91	
Hat Lat	1D Midpoint-N	0.57		live	14-Jan-91	
Hat Lat	1E Midpoint-S	0.62		live	14-Jan-91	
Hat Lat	1A Midpoint-E	0.92		live	14-Jan-91	
Hat Lat	1F Midpoint-W	0.6		live	14-Jan-91	
Hat Lat	1G Circum-N	0.6		live	14-Jan-91	
Hat Lat	1H Circum-S	0.62		live	14-Jan-91	
Hat Lat	1I Circum-E	0.61		live	14-Jan-91	
Hat Lat	1J Circum-W	0.62		live	14-Jan-91	

Cores from Thailand were collected in the vicinity of Koh Samui (Gulf of Siam) and had not been analyzed at the time of this writing.

APPENDIX II.

KAP1A CORAL
STABLE ISOTOPE
DEPTH SERIES

m m	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
10	-0.175	-4.863
11	-0.195	-4.661
12	-0.177	-4.545
13	-0.652	-4.886
14	-0.721	-5.012
15	-0.775	-5.242
16	-0.516	-5.190
17	-0.382	-4.995
18	-0.201	-4.854
19	-0.353	-4.993
20	-0.356	-5.237
21	-0.523	-5.622
22	-0.481	-5.372
23	-0.440	-5.174
24	-0.046	-4.870
25	0.084	-4.918
26	-0.020	-5.151
27	-0.121	-5.408
28	-0.306	-5.341
29	-0.147	-5.050
30	0.009	-5.013
31	-0.278	-5.005
32	-0.459	-5.071
33	-0.990	-5.564
34	-1.394	-6.037
35	-0.596	-5.521
36	-0.524	-5.185
37	-0.111	-4.955
38	-0.373	-4.788
39	-0.385	-4.877
40	-0.171	-4.841
41	-0.456	-5.030
42	-0.203	-5.002
43	-0.167	-4.949
44	0.291	-4.870
45	0.328	-4.778
46	0.469	-4.652
47	-0.170	-5.025
48	-0.056	-5.244
49	0.000	-4.953
50	0.205	-4.983
51	0.084	-4.833
52	0.000	-5.005
53	0.181	-4.966
54	-0.114	-5.068

55	0.202	-4.867	109	0.035	-5.335
56	0.310	-4.729	110	0.177	-4.923
57	0.170	-4.787	111	0.207	-4.815
58	-0.018	-4.850	112	0.249	-4.779
59	-0.388	-5.011	113	-0.063	-4.892
60	0.063	-4.987	114	0.010	-5.255
61	0.118	-4.887	115	0.549	-5.026
62	0.277	-4.736	116	0.405	-4.884
63	0.282	-4.588	117	0.107	-4.766
64	-0.019	-4.952	118	0.196	-4.744
65	-0.382	-5.243	119	0.178	-4.931
66	-0.075	-5.063	120	-0.338	-4.929
67	0.106	-4.858	121	-0.301	-5.580
68	0.217	-4.638	122	-0.057	-5.116
69	0.144	-4.691	123	0.134	-5.035
70	-0.082	-4.943	124	0.393	-4.845
71	-0.131	-4.855	125	0.321	-4.595
72	-0.092	-4.842	126	-0.047	-4.805
73	0.243	-4.699	127	0.074	-4.720
74	0.642	-4.418	128	0.480	-4.876
75	0.513	-4.450	129	0.502	-4.743
76	0.235	-4.698	130	0.389	-4.740
77	0.230	-4.835	131	-0.086	-5.224
78	0.339	-4.638	132	-0.523	-5.337
79	0.922	-4.246	133	-0.398	-5.303
80	0.822	-4.115	134	-0.312	-5.347
81	0.183	-4.642	135	0.358	-4.569
82	0.034	-4.960	136	0.395	-4.469
83	0.182	-4.965	137	0.398	-4.549
84	0.411	-4.869	138	-0.013	-4.658
85	0.545	-4.702	139	-0.722	-5.151
86	0.624	-4.595	140	-0.803	-5.310
87	0.345	-4.990	141	-0.859	-5.624
88	0.098	-4.777	142	-0.706	-5.246
89	0.184	-4.700	143	-0.468	-5.419
90	0.674	-4.688	144	-0.700	-5.034
91	0.476	-4.836	145	-0.292	-4.753
92	0.382	-4.789	146	0.054	-4.637
93	0.213	-5.229	147	0.004	-4.851
94	-0.287	-5.420	148	-0.243	-5.107
95	-0.089	-5.003	149	-0.546	-5.008
96	0.022	-4.965	150	-0.407	-4.786
97	0.326	-5.016	151	-0.315	-4.810
98	0.210	-4.902	152	-0.177	-5.081
99	0.191	-5.110	153	-0.145	-4.967
100	0.191	-5.132	154	0.345	-4.661
101	0.410	-4.976	155	0.516	-4.571
102	0.170	-4.879	156	0.698	-4.502
103	0.160	-4.714	157	-0.080	-4.838
104	0.256	-4.240	158	-0.672	-4.999
105	0.235	-4.589	159	-0.474	-5.241
106	0.154	-4.476	160	-0.299	-5.206
107	-0.009	-4.635	161	-0.088	-4.899
108	0.232	-5.164	162	-0.217	-4.842

163	0.158	-4.698	217	-0.353	-5.222	271	-0.702	-5.462
164	0.286	-4.498	218	-0.501	-4.961	272	-0.717	-5.498
165	-0.279	-4.801	219	-0.395	-4.939	273	-0.592	-5.216
166	-0.403	-4.890	220	-0.250	-4.834	274	-0.602	-5.263
167	-0.484	-4.857	221	-0.234	-4.737	275	-0.294	-4.949
168	-0.207	-4.894	222	-0.130	-4.609	276	0.196	-4.614
169	-0.045	-4.865	223	0.043	-4.767	277	0.096	-4.619
170	0.011	-5.015	224	-0.018	-4.709	278	-0.004	-4.597
171	-0.040	-4.896	225	-0.128	-4.594	279	-0.176	-4.653
172	0.319	-4.515	226	-0.141	-4.804	280	-0.570	-5.065
173	0.423	-4.571	227	-0.098	-4.991	281	-0.436	-5.051
174	-0.080	-4.800	228	-0.146	-5.325	282	-0.882	-5.474
175	-0.482	-5.095	229	-0.069	-5.226	283	-0.771	-5.292
176	-0.635	-5.573	230	-0.306	-4.990	284	-0.413	-5.253
177	-0.726	-5.825	231	-0.205	-4.698	285	-0.542	-5.156
178	-0.642	-5.600	232	-0.004	-4.658	286	-0.531	-5.081
179	-0.550	-5.488	233	-0.105	-4.538	287	-0.240	-4.875
180	-0.357	-5.441	234	-0.222	-4.688	288	-0.126	-4.806
181	0.105	-5.009	235	-0.197	-4.804	289	0.047	-4.751
182	0.174	-4.850	236	-0.182	-5.000	290	0.186	-4.644
183	0.135	-4.893	237	-0.360	-5.386	291	-0.055	-4.767
184	0.033	-4.776	238	-0.431	-5.525	292	-0.515	-4.979
185	-0.382	-5.064	239	-0.601	-5.359	293	-0.601	-4.892
186	-0.642	-5.428	240	-0.519	-4.943	294	-0.463	-5.210
187	-0.656	-5.987	241	-0.256	-4.795	295	-0.634	-5.623
188	-0.374	-5.579	242	-0.199	-4.801	296	-0.558	-5.382
189	-0.225	-5.317	243	-0.358	-4.843	297	-0.617	-5.136
190	0.312	-4.913	244	-0.509	-4.999	298	-0.019	-4.888
191	0.573	-4.874	245	-0.691	-5.197	299	0.120	-4.791
192	0.427	-4.574	246	-0.643	-5.243	300	0.017	-4.825
193	-0.253	-4.958	247	-0.489	-5.387	301	-0.200	-4.855
194	-1.065	-5.704	248	-0.396	-5.472	302	-0.470	-5.018
195	-0.841	-5.782	249	-0.393	-5.525	303	-0.441	-5.111
196	-0.621	-5.745	250	-0.346	-5.328	304	-0.146	-5.419
197	-0.399	-5.445	251	-0.274	-5.007	305	-0.618	-5.795
198	-0.297	-5.056	252	-0.013	-4.779	306	-1.041	-5.750
199	-0.017	-4.859	253	0.034	-4.801	307	-0.935	-5.425
200	0.308	-4.840	254	-0.270	-5.083	308	-0.497	-4.983
201	-0.199	-4.846	255	-0.590	-5.336	309	0.033	-4.855
202	-0.820	-5.026	256	-0.809	-5.503	310	-0.159	-4.878
203	-1.013	-5.456	257	-0.900	-5.505	311	-0.746	-5.023
204	-0.722	-5.739	258	-0.861	-5.704	312	-0.698	-5.144
205	-0.609	-5.865	259	-0.667	-5.633	313	-0.531	-5.140
206	-0.482	-5.303	260	-0.684	-5.609	314	-0.431	-5.289
207	-0.067	-5.010	261	-0.601	-5.388	315	-0.816	-5.598
208	0.121	-4.928	262	-0.605	-5.155	316	-1.236	-5.574
209	0.233	-4.705	263	-0.490	-4.904	317	-0.970	-5.344
210	-0.080	-4.851	264	-0.430	-4.951	318	0.156	-4.870
211	-0.114	-4.649	265	-0.421	-4.897	319	0.438	-4.886
212	-0.365	-4.782	266	-0.506	-4.835	320	0.466	-4.655
213	-0.707	-5.061	267	-0.430	-4.837	321	-0.299	-5.047
214	-1.202	-5.509	268	-0.698	-5.066	322	-0.734	-5.451
215	-0.707	-5.584	269	-0.700	-5.150	323	-0.940	-5.633
216	-0.313	-5.393	270	-0.777	-5.451	324	-0.559	-5.382

325	-0.275	-5.120	379	-0.774	-5.153	433	0.237	-4.928
326	0.283	-4.796	380	-1.165	-5.326	434	0.438	-4.789
327	0.525	-4.624	381	-0.800	-5.487	435	0.297	-4.785
328	0.222	-4.649	382	-0.784	-5.473	436	-0.439	-4.968
329	0.468	-4.729	383	-0.665	-5.481	437	-0.639	-5.143
330	-0.018	-5.072	384	-0.307	-5.191	438	-0.670	-5.208
331	-0.651	-5.606	385	-0.772	-5.295	439	-0.729	-5.258
332	-0.340	-5.766	386	-0.444	-4.989	440	-0.609	-5.507
333	-0.553	-5.455	387	0.289	-4.621	441	-0.397	-5.539
334	-0.280	-5.164	388	0.010	-4.622	442	-0.531	-5.759
335	0.303	-4.925	389	0.065	-4.583	443	-0.513	-5.375
336	0.397	-4.785	390	0.052	-4.598	444	-0.600	-5.272
337	0.472	-4.664	391	0.227	-4.771	445	-0.348	-5.074
338	0.300	-4.870	392	-0.431	-4.831	446	0.039	-4.871
339	-0.675	-5.201	393	-1.129	-4.987	447	0.069	-4.797
340	-0.415	-5.576	394	-1.140	-5.417	448	0.060	-4.777
341	-0.142	-5.278	395	-0.270	-5.304	449	-0.030	-4.714
342	-0.133	-5.240	396	-0.093	-5.181	450	-0.205	-4.884
343	0.349	-4.842	397	-0.465	-5.140	451	-0.176	-5.099
344	0.688	-4.631	398	-0.448	-4.950	452	-0.208	-5.345
345	0.547	-4.768	399	0.050	-4.771	453	-0.530	-5.621
346	0.081	-4.965	400	0.082	-4.593	454	-0.896	-5.660
347	-0.233	-5.300	401	0.290	-4.548	455	-1.111	-5.783
348	-0.347	-5.717	402	0.423	-4.573	456	-0.927	-5.673
349	-0.478	-5.508	403	-0.074	-4.713	457	-0.947	-5.433
350	-0.420	-5.370	404	-0.734	-4.918	458	-0.636	-5.196
351	0.156	-5.053	405	-1.132	-5.096	459	0.088	-4.849
352	0.513	-4.889	406	-0.725	-5.407	460	0.256	-4.762
353	0.553	-4.840	407	-0.240	-5.642	461	0.264	-4.745
354	0.077	-5.188	408	-0.356	-5.318	462	0.127	-4.769
355	-0.114	-5.588	409	-0.365	-5.017	463	-0.308	-4.955
356	-0.072	-5.512	410	-0.314	-4.891	464	-0.762	-5.060
357	-0.129	-5.323	411	0.197	-4.731	465	-0.927	-5.120
358	-0.119	-5.152	412	0.531	-4.816	466	-1.017	-5.588
359	0.358	-4.971	413	0.603	-4.659	467	-1.035	-5.672
360	0.472	-4.910	414	0.384	-4.857	468	-0.920	-5.672
361	0.229	-4.936	415	-0.006	-5.053	469	-0.923	-5.751
362	-0.137	-5.257	416	-0.456	-5.423	470	-0.641	-5.542
363	-0.284	-5.575	417	-0.455	-5.695	471	-0.077	-5.194
364	-0.605	-5.502	418	-0.476	-5.352	472	0.421	-4.989
365	-0.296	-5.210	419	-0.469	-5.154	473	0.450	-5.005
366	0.101	-5.021	420	0.083	-4.870	474	0.178	-5.244
367	0.615	-4.681	421	0.455	-4.691	475	-0.186	-5.803
368	0.439	-4.819	422	0.507	-4.641	476	-0.396	-5.711
369	-0.458	-5.094	423	0.513	-4.822	477	-0.947	-5.709
370	-1.106	-5.484	424	0.315	-4.862	478	-0.405	-5.305
371	-0.405	-5.645	425	0.011	-5.105	479	-0.275	-5.134
372	-0.486	-5.231	426	-0.961	-5.466	480	0.058	-4.913
373	-0.611	-5.060	427	-1.189	-5.719	481	0.323	-4.888
374	-0.260	-4.937	428	-0.526	-5.646	482	0.327	-4.939
375	-0.082	-4.816	429	-0.310	-5.560	483	0.102	-5.148
376	0.182	-4.708	430	-0.359	-5.245	484	0.208	-5.209
377	0.564	-4.572	431	-0.490	-5.185	485	-0.292	-5.764
378	0.048	-4.833	432	-0.148	-5.113	486	-0.764	-5.834

487	-0.470	-5.587	541	-1.017	-5.713	595	-0.238	-5.037
488	-0.398	-5.229	542	-1.144	-5.586	596	-0.273	-5.152
489	-0.177	-5.129	543	-1.119	-5.443	597	0.410	-4.764
490	0.283	-4.927	544	-0.802	-5.312	598	0.855	-4.450
491	0.084	-4.827	545	0.350	-4.884	599	0.798	-4.534
492	0.122	-5.180	546	0.619	-4.690	600	0.222	-4.808
493	-0.367	-5.491	547	0.645	-4.614	601	-0.205	-5.116
494	-0.532	-5.594	548	0.190	-4.621	602	-0.262	-5.201
495	-0.783	-6.031	549	0.424	-4.705	603	-0.367	-5.864
496	-0.910	-5.660	550	0.302	-5.401	604	-0.757	-5.840
497	-0.668	-5.259	551	-0.216	-5.776	605	-0.531	-5.798
498	-0.641	-5.132	552	-0.717	-5.506	606	-0.531	-5.502
499	-0.240	-4.962	553	-0.825	-5.562	607	-0.529	-5.441
500	0.046	-5.009	554	-0.621	-5.182	608	0.103	-5.168
501	0.514	-4.781	555	-0.543	-5.093	609	0.374	-5.028
502	0.320	-4.790	556	0.527	-4.711	610	0.565	-5.059
503	-0.221	-4.885	557	0.833	-4.568	611	0.331	-5.241
504	-0.247	-4.911	558	0.912	-4.593	612	-0.169	-5.282
505	-0.239	-5.153	559	0.676	-4.608	613	-0.220	-5.846
506	-0.473	-5.455	560	-0.081	-5.050	614	-0.826	-5.969
507	-0.430	-5.270	561	-0.735	-5.134	615	-0.841	-5.873
508	-0.579	-5.265	562	-0.210	-5.216	616	-0.495	-5.670
509	-0.501	-5.183	563	-0.248	-5.356	617	-0.356	-5.491
510	-0.431	-5.142	564	0.027	-5.166	618	-0.663	-5.696
511	0.276	-4.835	565	-0.363	-5.030	619	0.031	-5.323
512	0.531	-4.764	566	0.565	-4.684	620	0.276	-5.306
513	0.380	-4.756	567	0.828	-4.384	621	0.351	-5.028
514	-0.012	-4.788	568	0.621	-4.471	622	0.242	-5.009
515	-0.110	-4.979	569	0.526	-4.686	623	0.271	-5.191
516	-0.088	-5.034	570	0.445	-4.891	624	-0.127	-5.315
517	-0.207	-5.321	571	0.055	-5.214	625	0.205	-5.411
518	-0.250	-5.388	572	-0.349	-5.464	626	-0.012	-5.454
519	-0.401	-5.411	573	-0.699	-5.230	627	-0.332	-5.526
520	-0.457	-5.344	574	-0.036	-5.147	628	-0.961	-5.537
521	-0.080	-4.886	575	-0.461	-5.036	629	-1.290	-5.345
522	0.501	-4.782	576	-0.154	-4.905	630	-0.560	-5.365
523	0.627	-4.683	577	0.250	-4.681	631	0.133	-5.270
524	0.588	-4.839	578	0.413	-4.640	632	0.913	-4.978
525	0.369	-5.052	579	0.287	-4.645	633	1.057	-4.837
526	-0.171	-5.279	580	0.013	-4.745	634	1.079	-4.618
527	-0.719	-5.638	581	0.073	-4.779	635	0.537	-4.888
528	-0.731	-5.735	582	-0.270	-5.166	636	-0.287	-5.103
529	-0.716	-5.477	583	-0.837	-5.566	637	-0.708	-5.201
530	-0.826	-5.332	584	-0.412	-5.227	638	-1.046	-5.604
531	-0.611	-5.290	585	-0.299	-5.054	639	-0.918	-6.114
532	0.026	-4.978	586	-0.323	-4.777	640	-0.495	-5.692
533	0.317	-4.819	587	-0.456	-4.584	641	-0.326	-5.468
534	0.413	-4.659	588	0.712	-4.658	642	0.052	-5.444
535	0.682	-4.572	589	0.555	-4.420	643	-0.010	-5.412
536	0.341	-4.860	590	0.154	-4.767	644	0.551	-4.929
537	-0.158	-4.900	591	0.090	-4.750	645	0.622	-4.874
538	-0.364	-5.143	592	0.071	-4.880	646	0.150	-4.692
539	-0.871	-5.721	593	-0.144	-5.130	647	-0.441	-5.098
540	-1.011	-5.936	594	0.088	-5.193	648	-0.232	-5.625

649	-0.578	-5.486	703	-0.672	-5.610	757	-0.555	-5.298
650	-0.685	-5.318	704	-0.674	-5.557	758	-0.323	-5.104
651	-0.801	-5.270	705	-0.682	-5.275	759	0.192	-4.856
652	-0.718	-5.123	706	-0.602	-5.042	760	0.325	-4.850
653	-0.322	-4.963	707	-0.417	-4.900	761	0.230	-4.891
654	-0.270	-4.951	708	-0.198	-4.762	762	-0.082	-4.974
655	-0.214	-4.836	709	0.209	-4.663	763	-0.170	-5.126
656	-0.298	-4.939	710	0.257	-4.644	764	-0.907	-5.784
657	-0.401	-4.963	711	-0.010	-4.691	765	-0.498	-5.928
658	-0.596	-5.064	712	-0.166	-4.697	766	-0.233	-5.573
659	-0.688	-5.468	713	-0.377	-4.980	767	-0.108	-5.397
660	-0.495	-5.381	714	-0.924	-5.374	768	-0.077	-5.244
661	-0.547	-5.320	715	-0.970	-5.794	769	0.015	-4.986
662	-0.434	-5.103	716	-0.402	-5.476	770	0.261	-4.907
663	-0.311	-4.894	717	-0.567	-5.311	771	0.362	-4.871
664	0.152	-4.642	718	-0.735	-5.185	772	0.182	-4.874
665	0.342	-4.570	719	-0.108	-4.977	773	-0.101	-4.720
666	0.387	-4.632	720	0.269	-4.674	774	-0.167	-5.407
667	0.084	-4.718	721	0.375	-4.532	775	-0.293	-5.574
668	0.124	-4.769	722	0.251	-4.626	776	-0.203	-5.329
669	-0.072	-4.978	723	-0.214	-4.995	777	-0.080	-5.252
670	-0.581	-4.875	724	-0.770	-5.283	778	0.067	-5.003
671	-0.863	-4.962	725	-0.599	-5.573	779	0.381	-4.937
672	-1.133	-4.947	726	-0.502	-5.675	780	0.477	-4.719
673	-1.014	-5.109	727	-0.122	-5.214	781	0.286	-4.877
674	0.072	-5.037	728	-0.426	-5.158	782	-0.218	-5.388
675	0.300	-4.872	729	-0.024	-4.990	783	-0.218	-5.600
676	0.193	-4.744	730	0.186	-5.027	784	-0.164	-5.647
677	0.178	-4.680	731	0.299	-5.058	785	-0.143	-5.657
678	-0.427	-5.089	732	-0.424	-5.416	786	-0.113	-5.450
679	-1.088	-5.385	733	-1.143	-5.923	787	0.085	-4.792
680	-1.155	-5.359	734	-1.033	-5.832	788	0.500	-4.921
681	-0.715	-5.120	735	-1.095	-6.088	789	0.612	-4.919
682	-0.534	-5.393	736	-0.599	-5.890	790	0.011	-5.434
683	-0.585	-5.283	737	-0.651	-5.561	791	-0.321	-5.720
684	-0.515	-4.849	738	-0.638	-5.381	792	-0.179	-5.741
685	-0.195	-4.713	739	-0.309	-5.237	793	0.351	-5.246
686	0.418	-4.566	740	-0.075	-5.014	794	0.475	-5.204
687	0.693	-4.285	741	0.201	-4.950	795	0.412	-4.912
688	0.580	-4.342	742	0.206	-5.073	796	0.512	-4.844
689	0.530	-4.343	743	-0.177	-5.403	797	0.455	-4.984
690	-0.192	-4.755	744	-0.481	-5.446	798	0.214	-5.483
691	-0.994	-5.413	745	-0.587	-5.794	799	0.019	-5.568
692	-0.414	-5.461	746	-0.470	-5.532	800	0.142	-5.246
693	-0.446	-5.216	747	-0.457	-5.282	801	0.002	-5.266
694	-0.671	-5.213	748	0.169	-5.016	802	0.156	-4.967
695	-0.348	-5.010	749	0.363	-4.858	803	0.607	-4.833
696	0.275	-4.737	750	0.158	-4.838	804	0.703	-4.803
697	0.281	-4.609	751	0.210	-4.990	805	0.485	-5.000
698	0.176	-4.562	752	0.019	-5.128	806	0.324	-5.263
699	0.123	-4.946	753	-0.422	-5.224	807	0.564	-5.582
700	0.145	-4.560	754	-0.923	-5.659	808	0.208	-5.456
701	-0.127	-5.003	755	-0.703	-5.645	809	-0.075	-5.543
702	-0.294	-5.293	756	-0.350	-5.320	810	0.482	-4.910

811	0.598	-4.745	865	0.204	-5.166	919	0.140	-5.851
812	0.403	-5.098	866	0.093	-5.417	920	0.295	-5.487
813	0.041	-5.045	867	-0.139	-5.600	921	0.286	-5.136
814	-0.031	-5.416	868	0.075	-5.645	922	0.637	-5.052
815	-0.197	-5.681	869	0.302	-5.956	923	0.231	-5.094
816	-0.395	-5.579	870	-0.042	-5.653	924	-0.501	-5.716
817	-0.542	-5.440	871	0.583	-5.104	925	-0.646	-5.952
818	-0.484	-5.374	872	0.255	-5.373	926	-0.106	-6.010
819	0.338	-5.030	873	-0.315	-5.736	927	-0.188	-5.764
820	0.571	-4.974	874	-0.092	-6.122	928	-0.217	-5.587
821	0.292	-5.059	875	-0.103	-5.915	929	-0.164	-5.406
822	0.090	-5.232	876	-0.292	-5.582	930	0.500	-5.132
823	-0.477	-5.385	877	0.444	-5.244	931	0.476	-5.109
824	-0.497	-5.625	878	0.344	-5.287	932	0.235	-5.188
825	0.055	-5.884	879	-0.104	-5.506	933	0.046	-5.081
826	-0.093	-5.566	880	-0.164	-5.592	934	-0.599	-5.362
827	-0.009	-5.062	881	-0.253	-5.593	935	-0.621	-5.651
828	0.325	-4.877	882	-0.003	-5.766	936	-0.071	-5.492
829	0.632	-4.793	883	-0.129	-5.903	937	-0.127	-5.493
830	0.642	-4.754	884	-0.045	-5.507	938	-0.239	-5.464
831	0.382	-5.180	885	0.370	-5.418	939	-0.548	-5.281
832	0.137	-5.795	886	0.454	-5.237	940	-0.043	-5.135
833	-0.306	-6.008	887	0.496	-5.274	941	0.332	-4.840
834	-0.079	-5.611	888	0.430	-5.336	942	0.327	-4.871
835	0.026	-5.305	889	0.275	-5.463	943	0.029	-4.921
836	-0.019	-5.220	890	-0.342	-5.933	944	-0.833	-5.221
837	0.502	-5.029	891	-0.163	-5.863	945	-0.657	-5.337
838	0.557	-4.925	892	-0.029	-5.546	946	-0.446	-5.700
839	0.247	-5.224	893	0.398	-5.231	947	-0.351	-5.697
840	0.077	-5.417	894	0.674	-4.830	948	-0.180	-5.631
841	-0.110	-5.687	895	0.017	-5.286	949	-0.574	-5.472
842	-0.095	-5.864	896	-0.368	-5.561	950	-0.015	-5.038
843	-0.086	-5.560	897	-0.190	-5.757	951	0.133	-4.865
844	-0.075	-5.248	898	-0.103	-5.690	952	-0.150	-4.974
845	0.164	-5.142	899	0.427	-5.360	953	-0.047	-5.701
846	0.354	-4.824	900	0.641	-5.059	954	0.016	-5.445
847	0.384	-5.212	901	0.395	-5.059	955	-0.393	-5.396
848	0.210	-5.192	902	-0.154	-5.338	956	-0.199	-5.207
849	-0.010	-5.417	903	-0.299	-5.373	957	-0.187	-5.079
850	-0.080	-5.195	904	-0.442	-5.607	958	-0.149	-5.011
851	-0.332	-5.745	905	-0.484	-5.868	959	-0.390	-4.892
852	0.041	-5.817	906	-0.449	-6.193	960	-0.616	-4.928
853	-0.041	-5.692	907	-0.382	-6.028	961	-0.629	-5.138
854	-0.038	-5.180	908	-0.163	-5.365	962	-0.586	-5.076
855	0.355	-5.031	909	-0.175	-5.423	963	-0.474	-4.961
856	0.637	-4.875	910	-0.226	-5.552	964	-0.403	-5.287
857	0.521	-4.859	911	-0.442	-5.664	965	-0.484	-5.868
858	0.084	-5.188	912	-0.199	-5.634	966	-0.630	-5.693
859	-0.535	-5.312	913	-0.312	-5.607	967	-0.734	-5.950
860	-0.252	-5.807	914	0.197	-5.117	968	-0.100	-5.581
861	-0.182	-6.082	915	0.751	-4.967	969	-0.125	-5.313
862	-0.053	-5.641	916	0.851	-5.041	970	-0.310	-5.263
863	0.052	-5.330	917	0.212	-5.460	971	0.202	-5.040
864	0.297	-4.960	918	0.017	-5.859	972	0.215	-4.889

973	0.088	-4.856	1027	-0.750	-5.878	1081	-0.529	-5.250
974	-0.237	-4.992	1028	-0.991	-5.975	1082	0.124	-4.967
975	-0.245	-5.222	1029	-1.101	-5.872	1083	0.219	-4.830
976	-0.485	-5.450	1030	-1.044	-5.569	1084	0.219	-4.856
977	-0.333	-5.512	1031	-0.954	-5.337	1085	0.234	-4.970
978	-0.267	-5.498	1032	-0.873	-5.224	1086	-0.284	-5.732
979	-0.285	-5.973	1033	-0.546	-5.151	1087	-0.537	-5.907
980	-0.138	-5.787	1034	-0.242	-4.909	1088	-0.327	-5.798
981	-0.332	-5.484	1035	-0.254	-4.876	1089	-0.369	-5.606
982	-0.026	-5.161	1036	-0.452	-4.763	1090	-0.496	-5.496
983	0.222	-4.898	1037	-0.701	-4.841	1091	-0.559	-5.409
984	0.086	-4.710	1038	-0.793	-4.988	1092	0.185	-4.897
985	0.053	-4.979	1039	-0.894	-4.975	1093	0.399	-4.875
986	0.177	-4.896	1040	-0.987	-4.862	1094	0.291	-4.927
987	0.065	-4.952	1041	-0.850	-4.990	1095	0.395	-5.180
988	0.011	-5.109	1042	-0.724	-5.077	1096	0.050	-5.530
989	-0.051	-5.433	1043	-0.877	-5.164	1097	-0.409	-5.904
990	-0.147	-5.367	1044	-0.863	-5.272	1098	-0.611	-5.451
991	-0.301	-5.573	1045	-0.779	-5.184	1099	-0.446	-5.522
992	-0.293	-5.774	1046	-0.790	-5.241	1100	0.214	-5.044
993	-0.519	-5.652	1047	-0.825	-5.198	1101	0.412	-4.926
994	-0.671	-5.481	1048	-0.560	-5.215	1102	0.186	-5.036
995	-0.170	-5.138	1049	-0.230	-4.983	1103	0.028	-5.152
996	0.169	-4.946	1050	-0.088	-4.830	1104	0.113	-5.169
997	0.122	-4.760	1051	-0.209	-4.757	1105	-0.206	-5.386
998	0.121	-4.857	1052	-0.074	-4.655	1106	-0.659	-5.993
999	0.241	-4.820	1053	-0.330	-4.692	1107	-0.405	-5.660
1000	-0.101	-5.142	1054	-0.558	-4.849	1108	0.002	-5.332
1001	-0.413	-5.461	1055	-0.712	-5.217	1109	0.427	-5.070
1002	-0.403	-5.491	1056	-0.743	-5.634	1110	0.444	-5.052
1003	-0.520	-5.895	1057	-0.948	-5.781	1111	0.218	-5.100
1004	-0.313	-5.913	1058	-1.020	-5.658	1112	-0.147	-5.299
1005	-0.648	-5.737	1059	-1.159	-5.496	1113	-0.500	-5.501
1006	-0.758	-5.519	1060	-0.590	-5.263	1114	-0.430	-5.577
1007	-0.851	-5.329	1061	0.395	-4.980	1115	0.092	-5.201
1008	-0.214	-5.191	1062	0.505	-4.748	1116	-0.449	-5.066
1009	0.112	-4.807	1063	0.080	-4.945	1117	0.073	-4.962
1010	-0.007	-5.037	1064	-0.286	-5.102	1118	0.453	-4.769
1011	-0.188	-4.992	1065	-0.375	-5.450	1119	0.406	-4.850
1012	-0.271	-5.108	1066	-0.424	-5.436	1120	0.419	-4.717
1013	-0.442	-5.242	1067	-0.983	-5.948	1121	-0.033	-4.848
1014	-0.436	-5.304	1068	-0.872	-5.945	1122	-0.681	-5.374
1015	-0.619	-5.348	1069	-0.777	-5.723	1123	-0.496	-5.539
1016	-0.569	-5.639	1070	-0.702	-5.482	1124	-0.111	-5.495
1017	-0.823	-6.040	1071	0.277	-4.985	1125	-0.408	-5.160
1018	-0.764	-5.897	1072	0.799	-4.730	1126	-0.249	-5.095
1019	-0.815	-5.735	1073	0.759	-4.712	1127	0.135	-4.802
1020	-0.453	-5.519	1074	0.491	-4.987	1128	0.336	-4.626
1021	-0.083	-5.203	1075	-0.072	-5.402	1129	0.225	-4.733
1022	0.004	-5.037	1076	-0.715	-5.913	1130	-0.064	-4.783
1023	-0.204	-5.255	1077	-0.986	-5.975	1131	-0.032	-4.863
1024	-0.198	-5.597	1078	-0.889	-5.665	1132	-0.072	-5.017
1025	-0.403	-5.794	1079	-0.864	-5.629	1133	-0.047	-5.059
1026	-0.630	-5.920	1080	-0.516	-5.387	1134	0.274	-5.154

1135	0.028	-5.656	1189	0.090	-4.783	1243	-0.428	-5.158
1136	-0.166	-5.538	1190	-0.109	-4.696	1244	-0.447	-5.148
1137	-0.139	-5.107	1191	-0.287	-4.808	1245	-0.411	-5.259
1138	0.429	-4.997	1192	-0.179	-5.006	1246	-0.791	-5.463
1139	0.444	-4.948	1193	-0.308	-5.367	1247	-1.054	-5.495
1140	0.314	-4.842	1194	-0.309	-5.719	1248	-0.876	-5.659
1141	0.021	-4.946	1195	-0.179	-5.432	1249	-0.869	-5.864
1142	0.096	-5.004	1196	-0.099	-5.050	1250	-1.009	-5.764
1143	0.096	-5.176	1197	-0.585	-4.904	1251	-1.107	-6.103
1144	-0.435	-5.419	1198	-0.184	-4.837			
1145	-0.489	-5.509	1199	0.063	-4.754			
1146	-0.023	-5.153	1200	0.236	-4.667			
1147	0.074	-4.918	1201	0.135	-4.977			
1148	0.331	-4.688	1202	-0.036	-4.798			
1149	0.196	-4.796	1203	-0.216	-5.081			
1150	0.136	-4.751	1204	-0.310	-5.447			
1151	-0.132	-4.818	1205	-0.285	-5.460			
1152	-0.196	-5.084	1206	-0.913	-5.947			
1153	-0.017	-5.128	1207	-0.541	-5.916			
1154	-0.304	-5.072	1208	-0.345	-5.871			
1155	-0.458	-5.339	1209	-0.451	-5.638			
1156	-0.298	-5.624	1210	-0.608	-5.278			
1157	-0.280	-5.255	1211	-0.340	-4.984			
1158	-0.641	-5.275	1212	-0.287	-5.155			
1159	-0.612	-5.142	1213	-0.176	-5.172			
1160	-0.501	-5.181	1214	-0.066	-5.127			
1161	-0.405	-5.010	1215	-0.213	-5.172			
1162	-0.296	-4.886	1216	-0.746	-5.351			
1163	-0.145	-5.009	1217	-0.706	-5.708			
1164	-0.083	-4.994	1218	-0.913	-6.042			
1165	-0.159	-4.960	1219	-1.022	-6.170			
1166	-0.222	-5.065	1220	-0.497	-5.890			
1167	-0.468	-5.035	1221	-0.582	-5.867			
1168	-0.780	-5.421	1222	-0.421	-5.652			
1169	-0.637	-5.438	1223	-0.575	-5.538			
1170	-0.384	-5.462	1224	-0.624	-5.429			
1171	-0.173	-5.619	1225	-0.198	-5.165			
1172	-0.316	-5.700	1226	-0.211	-5.093			
1173	-0.426	-5.326	1227	-0.431	-5.007			
1174	0.027	-4.990	1228	-0.234	-5.026			
1175	0.309	-4.651	1229	-0.108	-5.077			
1176	0.216	-4.641	1230	-0.368	-5.138			
1177	0.293	-4.774	1231	-0.619	-5.347			
1178	0.300	-4.937	1232	-0.655	-5.562			
1179	0.090	-5.065	1233	-0.846	-5.851			
1180	-0.030	-5.170	1234	-1.046	-6.117			
1181	0.066	-5.470	1235	-1.216	-6.123			
1182	0.130	-5.716	1236	-0.547	-5.773			
1183	-0.104	-5.397	1237	-0.755	-5.633			
1184	-0.337	-5.314	1238	-0.877	-5.413			
1185	-0.252	-5.296	1239	-0.543	-5.154			
1186	-0.031	-5.045	1240	-0.473	-4.916			
1187	0.046	-5.020	1241	-0.569	-4.755			
1188	0.184	-4.789	1242	-0.674	-5.029			

APPENDIX III.

KAP3A CORAL
STABLE ISOTOPE
DEPTH SERIES

m m	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
0	-2.022	-5.487
1	-2.067	-5.477
2	-2.000	-5.319
3	-1.853	-5.276
4	-1.621	-5.043
5	-1.834	-5.336
6	-1.942	-5.552
7	-1.526	-5.423
8	-1.188	-5.540
9	-1.468	-5.266
10	-1.821	-5.203
11	-1.727	-5.169
12	-1.626	-5.156
13	-1.584	-5.186
14	-1.771	-5.237
15	-2.044	-5.650
16	-2.098	-5.940
17	-2.366	-6.019
18	-1.956	-5.944
19	-1.962	-5.616
20	-1.898	-5.504
21	-1.886	-5.363
22	-1.793	-5.315
23	-2.078	-5.284
24	-2.123	-5.307
25	-1.767	-5.312
26	-1.864	-5.425
27	-1.842	-5.541
28	-1.687	-5.707
29	-1.919	-5.865
30	-2.154	-5.689
31	-1.845	-5.697
32	-1.652	-5.491
33	-1.645	-5.449
34	-1.733	-5.489
35	-1.642	-5.573
36	-1.842	-5.744
37	-1.887	-5.729
38	-1.882	-5.805
39	-1.994	-6.170
40	-2.078	-6.166
41	-1.889	-5.889
42	-2.006	-5.656
43	-1.810	-5.601
44	-1.687	-5.535

45	-1.769	-5.625	99	-1.395	-5.369
46	-1.914	-5.569	100	-1.273	-5.489
47	-2.072	-5.379	101	-1.389	-6.128
48	-1.820	-5.389	102	-0.891	-5.562
49	-2.003	-5.428	103	-1.389	-5.501
50	-1.998	-5.554	104	-1.350	-5.140
51	-2.025	-5.552	105	-1.476	-5.132
52	-2.115	-5.747	106	-1.720	-5.179
53	-2.199	-6.006	107	-1.591	-5.261
54	-2.097	-6.174	108	-1.551	-5.388
55	-2.047	-6.262	109	-1.468	-5.452
56	-2.019	-6.223	110	-0.900	-5.387
57	-1.821	-6.025	111	-1.298	-5.399
58	-1.725	-5.765	112	-1.503	-5.300
59	-1.769	-5.592	113	-1.365	-5.211
60	-1.854	-5.345	114	-1.309	-5.073
61	-2.023	-5.359	115	-1.381	-5.143
62	-1.992	-5.285	116	-1.772	-5.259
63	-1.817	-5.127	117	-1.519	-5.322
64	-2.029	-5.241	118	-1.343	-5.464
65	-1.833	-5.372	119	-1.436	-5.920
66	-1.349	-5.227	120	-1.418	-5.969
67	-1.263	-5.408	121	-1.176	-5.526
68	-1.130	-5.457	122	-1.221	-5.419
69	-1.508	-5.306	123	-1.072	-5.310
70	-1.943	-5.192	124	-1.104	-5.150
71	-1.629	-5.133	125	-1.402	-5.446
72	-1.655	-5.352	126	-1.506	-5.559
73	-1.692	-5.513	127	-1.401	-5.433
74	-1.765	-5.627	128	-1.549	-5.646
75	-1.739	-6.002	129	-1.266	-5.687
76	-1.680	-6.184	130	-0.958	-5.566
77	-1.734	-6.271	131	-1.493	-5.659
78	-1.608	-5.826	132	-1.772	-5.577
79	-1.740	-5.527	133	-1.550	-5.422
80	-1.782	-5.539	134	-1.489	-5.375
81	-1.846	-5.497	135	-1.122	-5.259
82	-1.851	-5.389	136	-1.347	-5.302
83	-1.655	-5.262	137	-1.437	-5.292
84	-1.442	-5.236	138	-1.491	-5.331
85	-1.454	-5.327	139	-1.341	-5.249
86	-1.512	-5.298	140	-1.569	-5.450
87	-1.536	-5.325	141	-1.503	-5.649
88	-1.825	-5.545	142	-2.061	-6.099
89	-1.806	-5.747	143	-1.953	-6.167
90	-1.671	-5.965	144	-1.748	-6.082
91	-1.828	-6.184	145	-1.443	-5.803
92	-2.013	-6.199	146	-1.664	-5.630
93	-1.633	-5.791	147	-1.709	-5.547
94	-1.760	-5.578	148	-1.749	-5.494
95	-1.550	-5.508	149	-1.373	-5.196
96	-1.660	-5.452	150	-1.291	-5.312
97	-1.349	-5.335	151	-1.719	-5.336
98	-1.200	-5.286	152	-1.759	-5.274

153	-1.987	-5.251	207	-0.927	-5.178	261	-1.099	-5.124
154	-2.185	-5.391	208	-0.975	-5.237	262	-1.098	-5.142
155	-2.013	-5.544	209	-0.615	-5.607	263	-1.170	-5.240
156	-1.899	-5.668	210	-1.264	-6.112	264	-1.139	-5.249
157	-1.624	-5.860	211	-1.796	-6.212	265	-1.177	-5.422
158	-1.272	-6.045	212	-1.595	-6.089	266	-1.252	-5.613
159	-1.231	-6.102	213	-1.465	-5.541	267	-1.646	-5.418
160	-1.509	-5.827	214	-1.453	-5.407	268	-1.795	-5.483
161	-1.263	-5.441	215	-1.078	-5.231	269	-2.046	-5.992
162	-1.145	-5.337	216	-1.006	-5.295	270	-2.261	-6.038
163	-1.308	-5.374	217	-0.983	-5.111	271	-1.913	-5.969
164	-1.580	-5.267	218	-1.066	-5.151	272	-2.246	-5.957
165	-1.697	-5.334	219	-1.112	-5.322	273	-2.199	-5.797
166	-1.515	-5.306	220	-1.040	-5.721	274	-2.037	-5.718
167	-1.644	-5.373	221	-1.511	-6.076	275	-1.660	-5.391
168	-1.498	-5.435	222	-2.006	-6.186	276	-1.646	-5.473
169	-1.095	-5.492	223	-1.332	-5.578	277	-1.417	-5.401
170	-0.904	-5.461	224	-1.265	-5.500	278	-1.319	-5.344
171	-0.846	-5.472	225	-1.167	-5.476	279	-1.385	-5.283
172	-0.883	-5.386	226	-0.973	-5.492	280	-1.414	-5.298
173	-0.769	-5.247	227	-1.056	-5.520	281	-1.503	-5.307
174	-1.066	-5.096	228	-1.117	-5.400	282	-1.557	-5.302
175	-1.084	-5.091	229	-1.161	-5.408	283	-1.598	-5.447
176	-1.126	-5.077	230	-1.481	-5.500	284	-1.598	-5.241
177	-1.425	-5.150	231	-1.579	-5.790	285		
178	-1.621	-5.252	232	-1.488	-5.831	286		-5.105
179	-1.866	-5.308	233	-1.966	-6.024	287	-1.441	-5.171
180	-1.957	-5.360	234	-1.527	-6.070	288	-1.656	-5.266
181	-1.821	-5.404	235	-1.553	-5.678	289	-1.813	-5.298
182	-1.723	-5.737	236	-0.850	-5.289	290	-1.863	-5.423
183	-1.806	-6.002	237	-0.895	-5.164	291	-1.876	-5.536
184	-1.838	-5.846	238	-1.127	-5.400	292	-2.091	-5.638
185	-1.862	-5.907	239	-0.997	-5.329	293	-2.181	-5.683
186	-1.701	-5.666	240	-0.813	-5.067	294	-2.117	-5.654
187	-1.633	-5.464	241	-0.807	-5.020	295	-2.337	-5.838
188	-1.990	-5.622	242	-0.868	-4.898	296	-2.386	-5.798
189	-1.790	-5.472	243	-0.777	-4.879	297	-2.531	-5.712
190	-1.419	-5.181	244	-0.984	-4.715	298	-2.669	-5.619
191	-1.512	-5.087	245	-0.957	-4.887	299	-2.875	-5.480
192	-1.513	-4.991	246	-0.934	-4.844	300	-3.162	-5.323
193	-1.641	-5.078	247	-1.015	-4.950	301	-3.149	-5.297
194	-1.301	-5.015	248	-1.055	-5.074	302	-2.787	-5.156
195	-1.110	-4.944	249	-0.922	-5.250	303	-2.378	-4.973
196	-1.151	-4.927	250	-0.841	-5.683			
197	-1.134	-5.146	251	-0.997	-5.972			
198	-1.287	-5.291	252	-1.411	-5.838			
199	-0.911	-5.693	253	-1.129	-5.738			
200	-1.128	-5.900	254	-1.243	-5.727			
201	-1.144	-6.003	255	-1.195	-5.835			
202	-1.268	-5.804	256	-0.969	-5.507			
203	-1.654	-5.813	257	-0.880	-5.318			
204	-0.771	-5.508	258	-0.862	-5.443			
205	-0.737	-5.332	259	-0.802	-5.230			
206	-0.894	-5.267	260	-0.905	-5.178			

APPENDIX IV.

LANIA CORAL
STABLE ISOTOPE
DEPTH SERIES

m m	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
0	-0.464	-4.905
1	-0.338	-5.015
2	-0.336	-5.099
3	-0.599	-5.557
4	-1.058	-5.683
5	-0.808	-5.360
6	-0.399	-5.116
7	-0.070	-5.033
8	-0.087	-4.959
9	-0.186	-4.890
10	-0.012	-5.023
11	-0.257	-5.286
12	-0.444	-5.396
13	-0.438	-5.671
14	-0.658	-5.861
15	-1.275	-5.903
16	-1.124	-5.734
17	-0.995	-5.657
18	-0.834	-5.571
19	-1.235	-5.563
20	-0.551	-5.431
21	-0.347	-5.145
22	-0.513	-5.232
23	-0.573	-5.159
24	-0.642	-5.015
25	-0.401	-4.973
26	-0.266	-5.293
27	-0.440	-5.447
28	-0.629	-5.730
29	-0.995	-5.859
30	-1.230	-6.067
31	-1.802	-6.307
32	-0.915	-5.559
33	-0.928	-5.321
34	-0.622	-5.074
35	-0.340	-4.869
36	-0.208	-4.833
37	-0.016	-4.694
38	0.012	-4.769
39	0.008	-4.801
40	0.121	-4.920
41	-0.569	-5.314
42	-0.869	-5.852
43	-0.443	-5.767
44	-0.500	-5.591

45	-0.096	-5.299	99	-0.321	-5.168
46	-0.082	-5.151	100	-0.459	-5.116
47	-0.146	-5.017	101	-0.816	-5.126
48	-0.200	-4.785	102	-0.459	-5.073
49	0.051	-4.697	103	-0.273	-5.041
50	-0.095	-4.781	104	-0.228	-5.118
51	-0.065	-5.025	105	-0.298	-5.328
52	-0.373	-5.227	106	-0.157	-5.230
53	-0.604	-5.634	107	-0.001	-5.116
54	-0.812	-5.858	108	0.012	-5.053
55	-0.753	-5.962	109	0.168	-5.037
56	-0.345	-5.705	110	0.358	-4.926
57	-0.234	-5.569	111	0.366	-4.726
58	-0.475	-5.388	112	0.423	-4.750
59	-0.467	-5.300	113	0.251	-4.848
60	-0.375	-5.067	114	0.032	-4.917
61	-0.101	-4.826	115	-0.670	-5.236
62	-0.269	-4.828	116	-0.772	-5.369
63	-0.086	-4.770	117	-0.612	-5.778
64	0.008	-4.889	118	-0.584	-5.877
65	-0.191	-5.127	119	-0.936	-6.041
66	-0.576	-5.333	120	-1.099	-5.996
67	-0.662	-5.714	121	-1.060	-5.826
68	-0.916	-5.964	122	-0.741	-5.542
69	-1.208	-6.062	123	-0.777	-5.418
70	-1.207	-5.979	124	-0.507	-5.287
71	-0.986	-5.822	125	-0.099	-5.049
72	-0.647	-5.605	126	-0.001	-5.058
73	-0.789	-5.472	127	0.080	-5.031
74	-0.301	-5.303	128	-0.198	-5.023
75	0.320	-5.109	129	0.139	-5.023
76	-0.021	-5.154	130	-0.158	-5.186
77	-0.278	-5.211	131	-0.406	-5.203
78	-0.208	-5.060	132	-0.453	-5.334
79	-0.019	-5.096	133	-0.441	-5.356
80	-0.023	-5.017	134	-0.429	-5.377
81	-0.318	-5.205	135	-0.364	-5.516
82	-0.793	-5.271	136	-0.309	-5.672
83	-1.055	-5.547	137	-0.881	-5.825
84	-1.616	-6.138	138	-0.866	-5.508
85	-1.809	-6.402	139	-1.072	-5.637
86	-1.582	-6.371	140	-0.382	-5.499
87	-1.453	-6.158	141	0.196	-5.202
88	-1.057	-5.780	142	0.169	-5.017
89	-0.798	-5.503	143	0.252	-5.012
90	-0.440	-5.479	144	0.123	-4.960
91	-0.322	-5.357	145	0.143	-4.814
92	-0.042	-5.233	146	0.026	-4.827
93	0.370	-4.899	147	-0.127	-4.877
94	0.282	-4.827	148	-0.187	-5.096
95	0.333	-4.753	149	-0.116	-5.331
96	0.267	-4.659	150	-0.143	-5.699
97	0.263	-4.784	151	-0.543	-5.897
98	-0.206	-4.930	152	-0.704	-5.818

153	-0.377	-5.594	207	-0.046	-4.551	261	-0.707	-5.346
154	-0.247	-5.485	208	-0.055	-4.796	262	-0.202	-5.309
155	-0.141	-5.335	209	-0.172	-4.808	263	-0.295	-5.281
156	0.083	-5.154	210	-0.300	-4.988	264	-0.418	-5.289
157	0.099	-4.955	211	-0.070	-5.089	265	0.244	-5.221
158	0.256	-4.891	212	0.032	-5.318	266	0.381	-5.104
159	0.506	-4.753	213	-0.304	-5.743	267	0.347	-4.932
160	0.318	-4.761	214	-1.001	-5.885	268	0.401	-4.860
161	0.084	-4.821	215	-0.633	-5.814	269	0.410	-4.674
162	-0.119	-4.852	216	-0.803	-5.845	270	0.382	-4.681
163	-0.243	-5.156	217	-0.770	-5.623	271	0.502	-4.699
164	-0.591	-5.347	218	-0.104	-5.470	272	0.316	-4.851
165	-0.346	-5.475	219	0.233	-5.301	273	-0.093	-5.442
166	-0.421	-5.794	220	0.160	-5.180	274	-0.264	-5.784
167	-0.305	-5.878	221	0.091	-5.056	275	-0.757	-5.854
168	-0.744	-5.804	222	-0.005	-5.029	276	-1.027	-5.986
169	-0.603	-5.819	223	-0.193	-5.146	277	-1.029	-5.913
170	-0.538	-5.552	224	-0.150	-5.088	278	-0.559	-5.691
171	-0.228	-5.215	225	-0.168	-5.318	279	-0.218	-5.334
172	0.015	-4.942	226	-0.247	-5.609	280	0.059	-5.149
173	0.176	-4.745	227	-0.619	-6.007	281	0.233	-4.945
174	0.141	-4.867	228	-0.816	-6.056	282	0.059	-5.074
175	0.051	-4.912	229	-1.175	-6.046	283	-0.056	-4.963
176	-0.271	-5.012	230	-0.662	-5.856	284	-0.174	-5.103
177	-0.272	-5.128	231	-0.181	-5.478	285	-0.293	-5.420
178	-0.443	-5.275	232	-0.351	-5.374	286	-0.251	-5.496
179	-0.597	-5.345	233	-0.550	-5.330	287	-0.598	-5.705
180	-0.478	-5.316	234	-0.101	-5.205	288	-0.329	-6.034
181	-0.507	-5.293	235	0.312	-5.121	289	-0.684	-6.071
182	-0.224	-5.297	236	0.309	-5.056	290	-0.953	-6.084
183	-0.099	-5.460	237	0.239	-4.891	291	-0.842	-5.924
184	-0.031	-5.556	238	0.280	-4.821	292	-0.518	-5.655
185	-0.431	-5.630	239	0.018	-4.997	293	-0.629	-5.657
186	-0.080	-5.407	240	-0.200	-5.136	294	-0.137	-5.481
187	0.153	-5.184	241	-0.230	-5.351	295	0.641	-5.251
188	0.411	-4.933	242	-0.167	-5.636	296	0.591	-5.157
189	0.355	-4.836	243	-0.512	-5.950	297	0.467	-5.083
190	0.313	-4.676	244	-1.060	-6.128	298	0.537	-4.920
191	0.275	-4.711	245	-1.056	-6.082	299	0.105	-5.032
192	0.193	-4.763	246	-0.405	-5.758	300	-0.074	-5.203
193	-0.334	-4.894	247	-0.791	-5.470	301	-0.408	-5.832
194	-0.548	-4.997	248	-0.327	-5.454	302	-0.822	-5.901
195	-0.494	-5.445	249	-0.003	-5.320	303	-0.530	-5.932
196	-0.321	-5.597	250	0.216	-5.171	304	-0.713	-5.964
197	-0.475	-5.895	251	0.141	-5.132	305	-0.638	-6.049
198	-0.637	-5.758	252	0.029	-4.924	306	-0.551	-5.807
199	-0.547	-5.713	253	-0.147	-4.968	307	-0.379	-5.566
200	-0.730	-5.682	254	-0.367	-5.125	308	-0.511	-5.416
201	-0.940	-5.432	255	-0.538	-5.243	309	-0.025	-5.234
202	-0.624	-5.307	256	-0.669	-5.551	310	0.238	-5.150
203	0.076	-5.039	257	-0.773	-5.645	311	0.337	-4.894
204	0.073	-4.948	258	-0.822	-5.863	312	0.281	-4.874
205	0.143	-4.733	259	-0.483	-5.732	313	-0.016	-4.811
206	0.118	-4.627	260	-0.718	-5.431	314	-0.229	-4.804

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 428 0.378 -4.881
 429 0.450 -4.786
 430 0.309 -4.797
 431 -0.069 -5.030
 432 -0.070 -5.140
 433 -0.073 -5.176
 434 0.169 -5.119
 435 -0.326 -5.758
 436 -0.520 -6.065
 437 -0.748 -5.795
 438 -0.329 -5.550
 439 -0.118 -5.447
 440 -0.033 -5.469
 441 -0.424 -5.256
 442 -0.366 -5.270
 443 -1.293 -5.279
 444 -0.025 -5.014
 445 -0.040 -4.827
 446 0.145 -4.709
 447 0.307 -4.668
 448 0.205 -4.781
 449 -0.089 -5.228
 450 -0.626 -5.800
 451 -0.776 -5.975
 452 -0.615 -5.817
 453 -0.471 -5.882
 454 -0.967 -5.881
 455 -0.948 -5.909
 456 -0.533 -5.593
 457 -0.361 -5.520
 458 -0.443 -5.533
 459 -0.339 -5.353
 460 -0.185 -5.186
 461 0.168 -5.018
 462 0.165 -5.050
 463 0.423 -5.017
 464 0.320 -5.030
 465 0.322 -5.037
 466 0.154 -5.195
 467 -0.022 -5.430
 468 -0.595 -5.849
 469 -0.627 -5.792
 470 -0.482 -5.897
 471 -0.709 -6.119
 472 -0.635 -6.114
 473 -0.359 -5.938
 474 -0.080 -5.701
 475 0.051 -5.494
 476 0.043 -5.430

477	0.079	-5.239	531	-0.095	-5.183	585	-1.312	-6.315
478	0.172	-5.119	532	-0.427	-5.351	586	-1.023	-6.155
479	-0.146	-5.027	533	-0.623	-5.451	587	-0.789	-5.836
480	0.285	-4.930	534	-0.706	-5.682	588	-0.956	-5.713
481	0.372	-4.841	535	-0.842	-6.011	589	-0.948	-5.551
482	0.466	-4.786	536	-0.713	-5.979	590	0.202	-5.177
483	0.244	-4.896	537	-0.712	-5.964	591	0.187	-5.120
484	0.413	-4.844	538	-0.227	-5.727	592	0.310	-5.052
485	0.416	-4.932	539	0.145	-5.475	593	0.549	-4.884
486	0.296	-5.042	540	-0.230	-5.368	594	0.387	-4.942
487	0.025	-5.233	541	-0.173	-5.189	595	0.617	-4.803
488	-0.245	-5.423	542	-0.033	-5.084	596	0.571	-4.878
489	-0.464	-5.550	543	0.140	-5.014	597	0.170	-5.041
490	-0.831	-5.976	544	0.276	-4.795	598	-0.248	-5.090
491	-0.835	-6.074	545	-0.027	-4.913	599	-0.204	-5.245
492	-0.808	-5.877	546	0.106	-4.773	600	-0.316	-5.446
493	-0.699	-5.829	547	0.048	-4.779	601	-0.539	-5.733
494	-0.573	-5.802	548	-0.065	-4.916	602	-0.724	-5.807
495	-0.384	-5.946	549	-0.151	-5.070	603	-0.894	-5.955
496	0.170	-5.739	550	-0.325	-5.142	604	-1.041	-5.943
497	-0.046	-5.402	551	-0.554	-5.366	605	-1.244	-5.968
498	0.204	-5.367	552	-0.381	-5.436	606	-0.830	-5.926
499	0.175	-5.159	553	-0.263	-5.572	607	-1.038	-5.750
500	0.272	-5.172	554	-0.227	-5.525	608	-1.082	-5.651
501	0.257	-5.086	555	-0.372	-5.473	609	-0.197	-5.586
502	0.579	-4.838	556	-0.544	-5.547	610	0.040	-5.532
503	0.602	-4.773	557	-0.522	-5.831	611	0.436	-5.519
504	0.621	-4.868	558	-0.636	-6.204	612	0.225	-5.331
505	0.417	-4.800	559	-0.940	-6.208	613	0.424	-5.219
506	0.426	-4.986	560	-0.791	-6.003	614	0.727	-4.886
507	0.330	-4.859	561	-0.833	-5.854	615	0.529	-4.809
508	0.258	-5.048	562	-0.621	-5.575	616	0.372	-4.837
509	-0.101	-5.084	563	-0.436	-5.462	617	0.267	-4.907
510	-0.186	-5.308	564	-0.284	-5.358	618	0.217	-4.929
511	-0.380	-5.586	565	-0.349	-5.312	619	0.294	-5.037
512	-0.386	-5.669	566	0.080	-5.142	620	0.372	-5.144
513	-0.349	-5.796	567	0.711	-4.956	621	0.153	-5.506
514	-0.255	-5.751	568	0.786	-4.921	622	-0.386	-5.687
515	-0.573	-5.830	569	0.433	-4.950	623	-0.890	-5.779
516	-0.751	-5.800	570	-0.016	-5.034	624	-0.733	-5.789
517	-0.293	-5.640	571	-0.177	-5.105	625	-0.841	-5.699
518	0.061	-5.458	572	-0.237	-5.233	626	-0.825	-5.858
519	-0.093	-5.379	573	-0.193	-5.244	627	-0.552	-5.937
520	0.354	-5.245	574	-0.541	-5.542	628	-0.644	-5.865
521	0.359	-5.227	575	-0.636	-5.669	629	-0.870	-5.859
522	0.453	-4.867	576	-0.672	-5.746	630	-0.516	-5.562
523	0.574	-4.837	577	-0.778	-5.872	631	-0.614	-5.371
524	0.495	-4.895	578	-0.850	-5.866	632	-0.365	-5.244
525	0.596	-4.735	579	-0.839	-5.782	633	0.064	-5.276
526	0.833	-4.770	580	-0.713	-5.759	634	-0.034	-5.113
527	0.515	-4.932	581	-0.696	-5.911	635	0.039	-5.062
528	0.137	-4.971	582	-0.865	-6.024	636	0.180	-4.994
529	0.186	-4.904	583	-1.003	-6.143	637	0.378	-4.855
530	0.095	-5.140	584	-1.151	-6.166	638	0.216	-4.769

639	0.427	-4.688
640	0.475	-4.857
641	0.427	-4.712
642	0.313	-4.795
643	0.159	-5.038
644	0.139	-5.302
645	0.001	-5.159
646	-0.009	-5.170
647	-0.129	-5.463
648	-0.250	-5.757
649	-0.128	-5.934
650	-0.269	-5.669
651	-0.174	-5.514
652	0.142	-5.344
653	0.538	-5.294
654	0.659	-5.065
655	0.472	-5.082
656	0.334	-4.922
657	0.430	-4.849
658	0.503	-4.815
659	0.596	-4.850
660	0.455	-4.806
661	0.307	-4.856
662	0.301	-4.978
663	0.245	-5.257
664	0.069	-5.165
665	-0.036	-5.270
666	-0.241	-5.588
667	-0.481	-6.078
668	-0.474	-6.173
669	-0.447	-6.008
670	-0.514	-5.954
671	-0.173	-5.630
672	-0.264	-5.389
673	-0.055	-5.254
674	0.328	-5.065

APPENDIX V.

LAN1A CORAL
STABLE ISOTOPE
DEPTH SERIES
(MID-CORE)

m m	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
0	0.091	-5.284
1	0.083	-5.531
2	0.138	-5.626
3	0.429	-5.346
4	0.529	-5.170
5	0.633	-4.874
6	0.604	-4.706
7	0.552	-4.492
8	0.502	-4.666
9	0.391	-4.914
10	0.145	-4.996
11	0.083	-5.142
12	0.172	-5.274
13	-0.035	-5.512
14	0.091	-5.762
15	0.006	-5.627
16	0.488	-5.276
17	0.718	-5.095
18	0.447	-5.044
19	0.486	-4.910
20	0.736	-4.849
21	0.762	-4.742
22	0.720	-4.786
23	0.479	-4.822
24	0.314	-4.985
25	0.254	-5.428
26	0.074	-5.851
27	0.036	-5.895
28	0.316	-5.587
29	0.279	-5.399
30	0.525	-5.275
31	0.785	-4.981
32	0.694	-4.797
33	0.504	-4.746
34	0.588	-4.756
35	0.618	-4.681
36	0.795	-4.807
37	0.531	-5.144
38	0.448	-5.221
39	0.413	-5.214
40	0.113	-5.292
41	-0.035	-5.734
42	-0.133	-5.725
43	0.145	-5.578

44	0.671	-5.174	98	0.120	-5.039
45	0.924	-4.894	99	0.021	-5.152
46	0.793	-4.742	100	0.076	-5.004
47	0.933	-4.570	101	-0.009	-5.120
48	0.797	-4.611	102	0.113	-5.170
49	0.644	-4.575	103	0.243	-5.165
50	0.848	-4.546	104	0.401	-5.137
51	0.800	-4.838	105	0.595	-4.956
52	0.333	-5.182	106	0.411	-4.982
53	-0.046	-5.468	107	0.428	-4.810
54	0.351	-5.456	108	0.628	-4.686
55	0.364	-5.459	109	0.904	-4.513
56	0.028	-5.360	110	1.004	-4.380
57	0.293	-5.034	111	0.687	-4.553
58	0.447	-4.975	112	0.255	-4.723
59	0.378	-4.992	113	0.085	-4.961
60	0.500	-4.779	114	0.014	-5.167
61	0.602	-4.562	115	-0.037	-5.370
62	0.702	-4.454	116	-0.119	-5.464
63	0.744	-4.435	117	0.037	-5.247
64	1.066	-4.360	118	0.268	-4.993
65	1.375	-4.185	119	0.236	-4.995
66	1.237	-4.438	120	0.407	-4.864
67	0.938	-4.836	121	0.534	-4.886
68	0.686	-5.422	122	0.528	-4.862
69	0.373	-5.439	123	0.657	-4.724
70	0.269	-5.364	124	0.651	-4.637
71	0.139	-5.075	125	0.601	-4.482
72	0.416	-4.787	126	0.454	-4.461
73	0.806	-4.588	127	0.360	-4.473
74	0.729	-4.622	128	0.332	-4.533
75	0.861	-4.553	129	0.495	-4.696
76	0.971	-4.455	130	0.510	-4.764
77	0.994	-4.460	131	0.525	-4.831
78	0.979	-4.298	132	0.459	-4.800
79	0.972	-4.353	133	0.584	-4.778
80	0.803	-4.398	134	0.844	-4.572
81	0.753	-4.505	135	0.779	-4.484
82	0.637	-4.560	136	0.612	-4.481
83	0.426	-4.781	137	0.430	-4.522
84	0.322	-4.867	138	0.332	-4.549
85	0.441	-5.115	139	0.289	-4.671
86	0.439	-5.144	140	0.116	-4.804
87	0.431	-4.937	141	0.074	-4.986
88	0.601	-4.840	142	0.050	-5.200
89	0.830	-4.786	143	-0.135	-5.607
90	0.848	-4.685	144	-0.057	-5.583
91	0.781	-4.560	145	0.014	-5.469
92	0.697	-4.540	146	-0.096	-5.379
93	0.660	-4.499	147	0.153	-5.266
94	0.609	-4.483	148	0.397	-5.091
95	0.520	-4.464	149	0.572	-4.867
96	0.504	-4.522	150	0.610	-4.789
97	0.403	-4.795	151	0.664	-4.703

152	0.718	-4.618	206	0.299	-5.538	260	0.104	-5.059
153	0.556	-4.599	207	0.234	-5.429	261	0.376	-5.051
154	0.481	-4.730	208	0.314	-5.348	262	0.371	-4.904
155	0.281	-4.807	209	0.619	-5.247	263	0.312	-4.851
156	0.131	-4.856	210	0.743	-4.893	264	0.446	-4.808
157	0.124	-4.874	211	0.822	-4.601	265	0.531	-4.855
158	0.079	-5.007	212	0.778	-4.540	266	0.740	-4.739
159	0.022	-5.328	213	0.865	-4.411	267	0.663	-4.806
160	-0.001	-5.571	214	0.623	-4.521	268	0.300	-4.976
161	-0.281	-5.605	215	0.482	-4.824	269	0.088	-4.991
162	-0.378	-5.520	216	0.300	-5.083	270	0.046	-5.248
163	-0.555	-5.460	217	0.138	-5.417	271	-0.127	-5.646
164	-0.591	-5.289	218	-0.209	-5.727	272	-0.240	-5.661
165	-0.420	-5.296	219	-0.190	-5.787	273	-0.297	-5.689
166	-0.204	-5.252	220	-0.144	-5.705	274	0.295	-5.517
167	0.221	-5.046	221	0.317	-5.409	275	0.171	-5.262
168	0.421	-4.920	222	1.137	-4.705	276	0.501	-5.088
169	0.601	-4.809	223	0.804	-4.762	277	0.858	-4.726
170	0.660	-4.674	224	0.691	-4.956	278	0.894	-4.760
171	0.684	-4.569	225	0.401	-5.154	279	0.651	-5.041
172	0.536	-4.576	226	0.169	-5.285	280	0.253	-5.191
173	0.601	-4.607	227	-0.179	-5.501	281	0.185	-5.405
174	0.436	-4.794	228	-0.231	-5.641	282	0.483	-5.265
175	0.238	-4.901	229	0.230	-5.471	283	0.539	-5.195
176	0.231	-4.996	230	0.092	-5.304	284	0.654	-4.997
177	0.293	-5.124	231	0.600	-5.159	285	0.550	-4.798
178	0.335	-5.485	232	0.436	-4.967	286	0.533	-4.697
179	0.571	-5.427	233	0.567	-4.798	287	0.571	-4.639
180	0.641	-5.450	234	0.684	-4.625	288	0.858	-4.644
181	0.780	-5.166	235	0.583	-4.679	289	1.136	-4.750
182	0.914	-4.816	236	0.554	-4.837	290	0.892	-4.888
183	0.693	-4.563	237	0.616	-5.110	291	0.589	-4.990
184	0.648	-4.523	238	0.343	-5.361	292	0.255	-5.194
185	0.697	-4.596	239	-0.489	-5.740	293	0.114	-5.452
186	0.497	-4.812	240	-0.795	-5.897	294	-0.160	-5.723
187	0.151	-5.108	241	-0.675	-5.913	295	-0.159	-5.732
188	-0.005	-5.725	242	-0.331	-5.651	296	0.147	-5.621
189	0.030	-5.701	243	0.267	-5.285	297	0.442	-5.291
190	0.576	-5.286	244	0.244	-5.137	298	0.643	-5.104
191	0.875	-5.060	245	0.507	-4.985	299	0.771	-4.872
192	0.958	-4.689	246	0.681	-4.829	300	0.984	-4.816
193	0.770	-4.719	247	0.702	-4.725	301	1.037	-4.693
194	0.703	-4.864	248	0.679	-4.700	302	1.687	-4.557
195	0.392	-4.999	249	0.552	-4.823	303	1.634	-4.646
196	0.177	-5.254	250	0.507	-4.865	304	1.158	-4.959
197	-0.016	-5.478	251	0.496	-4.983	305	1.103	-5.142
198	-0.178	-5.659	252	0.306	-5.029	306	1.267	-4.985
199	-0.153	-5.528	253	0.222	-5.115	307	1.563	-4.642
200	0.814	-4.913	254	-0.041	-5.156	308	2.042	-4.132
201	1.003	-4.602	255	-0.088	-5.315	309	1.354	-4.594
202	0.646	-4.728	256	-0.074	-5.519	310	0.862	-5.154
203	0.484	-4.753	257	-0.206	-5.554	311	0.771	-5.442
204	0.547	-4.759	258	-0.110	-5.408	312	0.792	-5.287
205	0.332	-5.120	259	0.325	-5.179	313	0.772	-5.102

314	0.834	-4.837	368	0.364	-4.950	422	1.535	-4.185
315	0.892	-4.597	369	0.536	-4.826	423	1.471	-4.266
316	0.799	-4.746	370	0.625	-4.749	424	0.871	-4.266
317	0.403	-5.044	371	0.803	-4.620	425	0.711	-4.362
318	0.054	-5.525	372	0.698	-4.553	426	0.766	-4.294
319	0.175	-5.690	373	0.332	-4.883	427	0.652	-4.515
320	0.227	-5.652	374	0.274	-5.006	428	0.742	-4.611
321	0.504	-5.504	375	0.418	-5.034	429	0.819	-4.561
322	0.723	-5.234	376	0.350	-5.113	430	0.733	-4.753
323	0.729	-5.003	377	-0.123	-5.180	431	0.744	-4.812
324	0.636	-4.855	378	0.328	-5.314	432	1.193	-4.292
325	0.565	-4.719	379	0.179	-5.358	433	0.691	-4.161
326	0.636	-4.702	380	-0.107	-5.487	434	0.761	-4.431
327	0.563	-4.765	381	0.156	-5.276	435	0.574	-4.975
328	0.388	-5.039	382	0.568	-4.941	436	0.311	-5.361
329	0.108	-5.385	383	0.873	-4.559	437	0.464	-5.083
330	0.038	-5.307	384	1.041	-4.333	438	0.701	-4.902
331	0.036	-5.414	385	0.904	-4.364	439	0.689	-4.676
332	0.037	-5.458	386	0.926	-4.429	440	0.439	-4.617
333	0.613	-5.129	387	0.935	-4.514	441	0.375	-4.827
334	0.723	-4.881	388	0.604	-4.879	442	0.228	-5.011
335	0.516	-4.776	389	0.521	-5.211	443	0.057	-5.511
336	0.539	-4.503	390	0.443	-5.345	444	0.007	-5.569
337	0.352	-4.394	391	0.332	-5.471	445	0.050	-5.372
338	0.381	-4.397	392	0.406	-5.153	446	0.067	-5.039
339	0.663	-4.477	393	0.532	-5.023	447	-0.240	-4.769
340	0.357	-4.656	394	0.899	-4.730	448	0.238	-4.511
341	0.340	-4.838	395	1.004	-4.607	449	-1.808	-5.353
342	0.207	-5.283	396	1.091	-4.490	450	-2.388	-5.863
343	0.162	-5.305	397	1.190	-4.115	451	-2.088	-5.631
344	0.352	-5.264	398	1.071	-4.479	452	-1.605	-5.287
345	0.662	-5.043	399	1.146	-4.477	453	-1.355	-5.337
346	0.519	-4.750	400	1.110	-4.610	454	-0.992	-5.136
347	0.631	-4.553	401	1.044	-4.651	455	-0.604	-4.713
348	0.566	-4.438	402	0.971	-4.832	456	-1.436	-4.893
349	0.683	-4.400	403	0.667	-5.153	457	-1.714	-4.862
350	0.745	-4.577	404	0.859	-5.195	458	-1.079	-4.501
351	0.279	-4.907	405	1.032	-4.949	459	-1.526	-4.649
352	-0.153	-5.544	406	1.289	-4.688			
353	-0.333	-5.784	407	1.291	-4.634			
354	-0.430	-5.722	408	1.318	-4.409			
355	0.032	-5.495	409	1.329	-4.373			
356	0.546	-5.206	410	1.358	-4.419			
357	0.743	-5.011	411	1.231	-4.590			
358	0.781	-4.696	412	0.969	-4.935			
359	0.796	-4.649	413	0.695	-5.290			
360	0.937	-4.493	414	0.476	-5.425			
361	0.946	-4.576	415	0.485	-5.309			
362	0.790	-4.652	416	0.475	-5.030			
363	0.702	-4.893	417	0.382	-4.915			
364	0.234	-5.396	418	0.644	-4.857			
365	0.028	-5.775	419	1.068	-4.761			
366	0.537	-5.456	420	1.318	-4.486			
367	0.411	-5.158	421	1.348	-4.331			

APPENDIX VI.

PPL1B CORAL
STABLE ISOTOPE
DEPTH SERIES

m m	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
15	0.422	-4.683
16	-0.065	-4.953
17	-0.286	-5.332
18	-4.110	-5.258
19	-0.306	-5.201
20	-0.210	-4.694
21	0.036	-5.173
22	-0.686	-6.078
23	-0.438	-5.440
24	0.133	-5.050
25	0.400	-4.848
26	-0.080	-5.472
27	-0.872	-6.021
28	-0.846	-5.891
29	-0.721	-5.478
30	-0.217	-5.159
31	0.314	-4.879
32	0.594	-4.764
33	-0.141	-5.362
34	-0.528	-6.093
35	-0.301	-5.460
36	-0.005	-5.129
37	0.138	-4.822
38	0.470	-4.720
39	0.252	-5.021
40	-0.045	-5.111
41	0.266	-5.196
42	0.315	-4.956
43	0.478	-4.673
44	0.315	-5.341
45	-0.239	-5.872
46	-0.365	-5.710
47	0.027	-5.309
48	0.381	-5.246
49	0.154	-5.454
50	-0.347	-5.874
51	-0.173	-5.281
52	0.147	-4.946
53	0.156	-4.809
54	0.084	-4.717
55	-0.476	-5.326
56	-0.440	-5.482
57	0.088	-5.494
58	0.914	-4.911
59	1.008	-4.766

60	0.533	-5.100
61	0.015	-5.659
62	0.027	-5.401
63	0.568	-4.956
64	1.249	-4.637
65	0.809	-4.901
66	0.380	-5.111
67	0.098	-5.380
68	-0.082	-5.440
69	0.541	-5.152
70	1.004	-4.649
71	1.022	-4.589
72	0.213	-5.041
73	-0.086	-5.567
74	-0.053	-5.545
75	0.151	-5.290
76	0.662	-4.720
77	0.957	-4.407
78	0.640	-4.900
79	-0.280	-5.063
80	-0.263	-5.385
81	0.003	-5.630
82	-0.110	-5.720
83	0.389	-5.316
84	1.112	-5.066
85	0.829	-4.873
86	-0.328	-5.544
87	-0.231	-5.892
88	0.102	-5.568
89	0.085	-5.563
90	0.542	-5.018
91	0.901	-4.779
92	0.564	-4.753
93	-0.143	-5.364
94	-0.314	-5.474
95	-0.264	-5.511
96	0.005	-5.690

APPENDIX VII.

PDB CORAL
STABLE ISOTOPE
DEPTH SERIES

m m	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
15	-1.746	-4.705
16	-1.713	-5.100
17	-1.974	-5.394
18	-1.679	-5.367
19	-1.775	-5.273
20	-2.074	-5.327
21	-1.995	-5.202
22	-2.400	-5.051
23	-2.388	-4.592
24	-2.178	-4.803
25	-2.219	-4.684
26	-1.893	-4.697
27	-1.996	-4.706
28	-2.116	-4.810
29	-2.263	-4.849
30	-2.051	-4.868
31	-2.022	-4.857
32	-1.847	-4.837
33	-2.340	-5.104
34	-2.083	-5.499
35	-1.937	-5.262
36	-2.060	-5.201
37	-2.360	-5.164
38	-2.383	-5.140
39	-2.484	-5.028
40	-2.506	-4.909
41	-2.345	-4.819
42	-2.446	-4.873
43	-2.102	-4.731
44	-2.005	-4.876
45	-2.487	-4.930
46	-2.377	-5.058
47	-2.613	-5.167
48	-2.848	-5.276
49	-2.741	-5.404
50	-2.179	-5.435
51	-1.839	-5.290
52	-1.900	-5.180
53	-2.163	-5.080
54	-2.083	-5.066
55	-2.074	-5.040
56	-1.972	-5.064
57	-2.274	-5.039
58	-1.874	-4.804
59	-1.538	-4.744

60	-1.298	-4.701	114	-1.724	-5.010
61	-1.381	-4.908	115	-2.057	-4.964
62	-1.947	-4.987	116	-1.736	-4.931
63	-2.294	-5.459	117	-1.528	-4.821
64	-2.641	-5.931	118	-1.592	-4.905
65	-2.334	-5.747	119	-1.141	-4.876
66	-2.123	-5.719	120	-1.719	-5.025
67	-1.936	-5.545	121	-2.061	-4.915
68	-2.295	-5.353	122	-1.998	-4.916
69	-2.316	-5.464	123	-1.875	-5.078
70	-2.106	-5.331	124	-1.987	-5.260
71	-1.895	-5.197	125	-1.732	-5.216
72	-2.429	-5.232	126	-1.477	-5.172
73	-2.141	-5.080	127	-1.680	-5.061
74	-1.477	-4.948	128	-1.618	-4.993
75	-1.196	-4.676	129	-1.888	-4.957
76	-1.708	-4.777	130	-2.071	-4.932
77	-1.604	-4.956	131	-1.812	-4.918
78	-1.466	-5.025	132	-1.807	-4.910
79	-1.612	-5.149	133	-1.193	-4.787
80	-1.619	-5.164	134	-1.126	-4.800
81	-1.734	-5.174	135	-1.130	-4.753
82	-1.789	-5.141	136	-1.492	-4.838
83	-1.850	-5.229	137	-1.868	-5.082
84	-1.817	-5.122	138	-1.969	-5.049
85	-1.744	-5.069	139	-1.767	-4.927
86	-1.921	-5.101	140	-1.654	-5.065
87	-2.191	-5.085	141	-1.993	-5.027
88	-1.826	-4.683	142	-1.535	-5.071
89	-1.213	-4.268	143	-1.519	-4.663
90	-0.950	-4.598	144	-1.997	-4.991
91	-1.310	-4.853	145	-1.759	-5.052
92	-1.550	-4.858	146	-2.004	-5.078
93	-2.003	-4.976	147	-1.400	-4.856
94	-2.127	-5.220	148	-1.008	-4.842
95	-1.750	-5.153	149	-1.047	-4.794
96	-1.478	-4.921	150	-1.494	-4.805
97	-2.063	-4.987	151	-1.836	-5.098
98	-2.405	-5.090	152	-1.903	-5.226
99	-2.233	-4.891	153	-1.946	-5.172
100	-2.089	-4.699	154	-1.523	-5.159
101	-1.581	-4.685	155	-1.522	-5.144
102	-1.348	-4.609	156	-1.987	-5.246
103	-1.134	-4.502	157	-1.961	-5.245
104	-1.402	-4.623	158	-1.670	-5.118
105	-1.484	-4.604	159	-2.199	-5.220
106	-1.972	-4.995	160	-2.165	-5.075
107	-2.048	-5.129	161	-1.872	-5.001
108	-2.039	-5.393	162	-1.431	-4.921
109	-1.838	-5.302	163	-1.253	-4.828
110	-1.990	-5.110	164	-1.433	-4.933
111		-5.085	165	-1.509	-4.971
112		-5.060	166	-1.487	-4.725
113	-2.105	-5.035	167	-2.437	-4.997

168	-2.950	-5.097	222	-3.881	-5.213	276	-2.031	-5.116
169	-2.416	-5.243	223	-3.466	-5.126	277	-1.698	-5.046
170	-2.252	-5.302	224	-2.181	-5.222	278	-2.100	-5.296
171	-2.117	-5.185	225	-1.488	-4.991	279	-2.342	-5.506
172	-2.185	-5.259	226	-1.537	-5.072	280	-1.797	-5.402
173	-1.849	-5.076	227	-1.534	-5.077	281	-1.898	-5.196
174	-2.004	-5.123	228	-1.836	-5.077	282	-2.096	-4.966
175	-2.253	-5.115	229	-1.943	-5.080	283	-2.066	-5.001
176	-1.952	-5.040	230	-1.553	-4.804	284	-2.020	-5.083
177	-2.149	-4.913	231	-1.485	-4.661	285	-1.629	-5.011
178	-2.211	-4.781	232	-1.417	-4.517	286	-1.217	-5.022
179	-1.942	-4.740	233	-1.307	-4.733	287	-1.862	-5.135
180	-1.754	-4.763	234	-1.202	-4.850	288	-2.193	-5.110
181	-1.709	-4.722	235	-1.086	-4.881	289	-2.029	-5.024
182	-1.597	-4.604	236	-1.321	-5.049	290	-1.873	-4.888
183	-1.790	-4.758	237	-1.246	-4.967	291	-1.417	-4.789
184	-2.156	-4.752	238	-1.742	-5.002	292	-1.374	-4.748
185	-2.681	-4.959	239	-1.725	-4.899	293	-1.565	-4.680
186	-2.681	-4.959	240	-1.614	-4.867	294	-1.703	-4.726
187	-2.681	-4.959	241	-1.797	-5.062	295	-1.754	-5.085
188	-2.681	-4.959	242	-2.249	-5.066	296	-1.937	-5.128
189	-2.303	-5.417	243	-1.513	-4.839	297	-1.550	-5.294
190	-2.311	-5.267	244	-1.397	-4.742	298	-1.401	-5.171
191	-2.186	-5.046	245	-1.465	-4.872	299	-1.215	-5.199
192	-2.131	-4.926	246	-0.794	-4.829	300	-1.220	-5.162
193	-1.923	-4.748	247	-1.481	-5.196	301	-1.541	-5.164
194	-2.406	-4.966	248	-1.415	-5.107	302	-2.105	-5.142
195	-2.715	-4.895	249	-1.607	-5.012	303	-1.944	-5.065
196	-2.667	-4.876	250	-1.363	-5.071	304	-2.205	-5.035
197	-2.424	-4.766	251	-1.355	-4.894	305	-2.250	-4.902
198	-2.163	-4.678	252	-1.367	-4.868	306	-2.218	-4.831
199	-2.084	-4.651	253	-2.272	-5.008	307	-2.212	-4.788
200	-2.016	-4.731	254	-1.720	-4.602	308	-2.287	-4.857
201	-2.037	-4.580	255	-1.492	-4.623	309	-1.662	-4.703
202	-2.024	-4.548	256	-0.922	-4.497	310	-1.674	-4.714
203	-2.090	-4.519	257	-1.158	-4.603	311	-1.606	-4.565
204	-2.367	-4.596	258	-0.780	-4.420	312	-1.593	-4.674
205	-2.717	-5.023	259	-0.599	-4.404	313	-1.671	-4.698
206	-2.698	-5.064	260	-0.894	-4.667	314	-1.831	-4.904
207	-2.645	-5.102	261	-1.189	-4.929	315	-2.039	-4.988
208	-2.407	-5.275	262	-1.793	-5.315	316	-2.050	-4.999
209	-2.360	-5.319	263	-1.460	-5.176	317	-1.818	-5.390
210	-2.070	-5.155	264	-1.727	-4.803	318	-1.721	-5.243
211	-1.774	-4.979	265	-1.788	-4.976	319	-1.772	-5.055
212	-1.120	-5.062	266	-1.292	-5.128	320	-1.762	-5.262
213	-1.017	-4.972	267	-1.308	-4.971	321	-1.721	-5.194
214	-1.643	-4.874	268	-1.613	-4.981	322	-1.927	-5.111
215	-1.430	-4.963	269	-2.059	-5.011	323	-2.609	-5.048
216	-1.013	-4.535	270	-1.896	-4.988	324	-2.339	-5.239
217	-1.547	-4.872	271	-1.494	-4.658	325	-2.069	-5.095
218	-1.256	-4.844	272	-1.444	-4.785	326	-2.075	-5.081
219	-0.979	-4.836	273	-1.203	-4.802	327	-1.727	-5.063
220	-1.106	-4.722	274	-1.016	-4.711	328	-1.627	-4.911
221	-2.549	-5.250	275	-1.241	-4.730	329	-2.059	-5.011

330	-2.539	-5.019
331	-3.033	-5.101
332	-3.422	-5.324
333	-3.069	-5.247
334	-3.036	-5.265
335	-3.189	-5.160
336	-3.640	-5.188
337	-3.459	-4.994
338	-2.633	-5.011
339	-3.173	-4.973
340	-2.884	-4.861
341	-2.455	-4.817
342	-2.386	-4.778
343	-2.059	-4.730
344	-1.969	-4.674
345	-2.075	-4.639
346	-1.713	-4.585
347	-2.108	-4.682
348	-2.446	-4.848
349	-2.516	-4.948
350	-2.535	-5.020

APPENDIX VIII.

BUNIA CORAL
STABLE ISOTOPE
DEPTH SERIES

m m	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
0	-0.910	-5.344
1	-0.815	-5.395
2	-0.566	-5.208
3	-0.911	-5.246
4	-0.914	-5.305
5	-0.847	-5.451
6	-0.952	-5.521
7	-0.976	-5.614
8	-0.796	-5.545
9	-0.545	-5.496
10	-0.594	-5.309
11	-0.600	-5.425
12	-1.140	-5.473
13	-1.571	-5.276
14	-1.005	-5.328
15	-0.405	-5.391
16	-0.471	-5.415
17	-0.700	-5.357
18	-0.880	-5.438
19	-1.077	-5.411
20	-0.958	-5.335
21	-0.643	-5.305
22	-0.819	-5.227
23	-0.882	-5.047
24	-0.653	-5.087
25	-0.682	-5.262
26	-0.676	-5.280
27	-0.698	-5.299
28	-0.806	-5.134
29	-0.690	-5.097
30	-0.706	-5.273
31	-0.759	-5.274
32	-0.685	-5.299
33	-0.836	-5.371
34	-0.695	-5.447
35	-0.608	-5.304
36	-0.580	-5.279
37	-0.575	-5.048
38	-0.742	-5.086
39	-0.696	-4.974
40	-0.482	-5.050
41	-0.617	-5.084
42	-0.598	-4.988
43	-0.655	-5.126
44	-0.664	-5.062

45	-0.684	-5.010	99	-0.717	-5.185
46	-0.584	-5.131	100	-0.481	-5.182
47	-0.597	-5.046	101	-0.281	-5.143
48	-0.784	-5.275	102	-0.458	-5.111
49	-0.720	-5.373	103	-0.624	-5.052
50	-0.789	-5.212	104	-0.790	-4.940
51	-0.852	-5.299	105	-0.748	-4.816
52	-0.773	-5.181	106	-0.583	-4.799
53	-0.714	-5.149	107	-0.548	-4.755
54	-0.669	-5.158	108	-0.498	-4.885
55	-0.889	-5.229	109	-0.518	-4.998
56	-1.118	-5.110	110	-0.688	-4.947
57	-0.857	-5.195	111	-0.637	-5.079
58	-0.546	-5.164	112	-0.659	-4.983
59	-0.668	-5.253	113	-0.850	-4.909
60	-0.779	-5.279	114	-0.833	-4.716
61	-0.881	-5.304	115	-0.600	-4.911
62	-0.924	-5.464	116	-0.545	-5.037
63	-0.879	-5.371	117	-0.423	-5.065
64	-0.909	-5.375	118	-0.548	-5.144
65	-0.953	-5.377	119	-0.488	-5.307
66	-0.904	-5.154	120	-0.458	-5.283
67	-0.861	-5.113	121	-0.648	-5.376
68	-0.713	-5.015	122	-0.737	-5.400
69	-0.721	-5.079	123	-0.654	-5.349
70	-0.691	-5.043	124	-0.565	-5.259
71	-0.793	-5.069	125	-0.604	-5.397
72	-0.665	-5.188	126	-0.603	-5.481
73	-0.733	-5.156	127	-0.829	-5.523
74	-0.650	-5.213	128	-1.024	-5.521
75	-0.600	-5.279	129	-0.870	-5.364
76	-0.758	-5.275	130	-0.897	-5.313
77	-0.652	-5.132	131	-0.501	-5.209
78	-0.621	-5.217	132	-0.397	-5.171
79	-0.635	-5.381	133	-0.347	-5.165
80	-0.787	-5.298	134	-0.532	-5.260
81	-0.794	-5.315	135	-0.474	-5.171
82	-0.783	-5.190	136	-0.716	-5.048
83	-0.601	-5.198	137	-0.793	-5.127
84	-0.532	-5.254	138	-0.616	-5.212
85	-0.667	-5.204	139	-0.774	-5.120
86	-0.465	-5.192	140	-0.647	-5.432
87	-0.485	-5.251	141	-0.617	-5.560
88	-0.723	-5.283	142	-0.684	-5.558
89	-0.605	-5.193	143	-0.944	-5.427
90	-0.758	-5.204	144	-0.561	-5.399
91	-0.949	-5.216	145	-0.485	-5.189
92	-1.117	-5.146	146	-0.694	-5.140
93	-1.056	-5.218	147	-0.593	-5.140
94	-0.932	-5.453	148	-0.453	-5.100
95	-1.070	-5.476	149	-0.346	-5.040
96	-1.063	-5.331	150	-0.410	-5.069
97	-0.800	-5.172	151	-0.384	-5.178
98	-0.815	-5.354	152	-0.432	-5.098

153	-0.482	-5.047	207	-0.604	-5.106	261	-0.475	-5.065
154	-0.322	-5.080	208	-0.839	-5.334	262	-1.104	-5.138
155	-0.550	-5.109	209	-0.675	-5.430	263	-0.638	-5.208
156	-0.585	-5.142	210	-0.756	-5.531	264	-0.688	-5.363
157	-0.555	-5.175	211	-0.842	-5.503	265	-0.701	-5.276
158	-0.558	-5.330	212	-0.774	-5.470	266	-0.968	-5.428
159	-0.549	-5.234	213	-0.744	-5.421	267	-1.038	-5.555
160	-0.560	-5.303	214	-0.923	-5.357	268	-0.983	-5.419
161	-0.717	-5.221	215	-0.838	-5.283	269	-1.084	-5.521
162	-0.545	-5.179	216	-0.795	-5.344	270	-0.730	-5.522
163	-0.544	-5.237	217	-0.720	-5.215	271	-0.527	-5.253
164	-0.482	-5.521	218	-0.622	-5.102	272	-0.393	-5.270
165	-0.506	-5.197	219	-0.574	-5.124	273	-0.214	-5.195
166	-0.531	-5.026	220	-0.770	-5.137	274	-0.574	-4.971
167	-0.861	-5.130	221	-0.804	-5.167	275	-0.669	-4.695
168	-1.409	-5.152	222	-0.643	-5.104	276	-0.794	-4.860
169	-1.276	-5.138	223	-0.800	-5.195	277	-0.525	-4.735
170	-0.692	-5.217	224	-0.781	-5.236	278	-0.545	-4.750
171	-0.373	-5.171	225	-0.753	-5.255	279	-0.571	-4.844
172	-0.355	-5.014	226	-0.721	-5.297	280	-0.511	-4.910
173	-0.455	-5.172	227	-0.762	-5.356	281	-0.388	-4.902
174	-0.364	-5.185	228	-0.718	-5.373	282	-0.234	-4.923
175	-0.348	-5.254	229	-0.817	-5.407	283	-0.286	-4.856
176	-0.388	-5.288	230	-0.896	-5.382	284	-0.245	-4.943
177	-0.754	-5.191	231	-0.979	-5.517	285	-0.258	-4.928
178	-0.627	-5.349	232	-1.107	-5.619	286	-0.321	-4.946
179	-0.665	-5.308	233	-1.226	-5.612	287	-0.380	-4.978
180	-0.626	-5.206	234	-0.838	-5.578	288	-0.367	-5.104
181	-0.546	-5.084	235	-0.817	-5.584	289	-0.245	-5.123
182	-0.762	-5.135	236	-0.751	-5.551	290	-0.475	-5.126
183	-0.470	-5.166	237	-0.801	-5.520	291	-0.444	-5.220
184	-0.306	-5.113	238	-0.597	-5.472	292	-0.603	-5.361
185	-0.382	-5.160	239	-0.492	-5.444	293	-0.905	-5.432
186	-0.484	-5.093	240	-0.473	-5.379	294	-0.832	-5.573
187	-0.537	-5.048	241	-0.508	-5.256	295	-0.711	-5.477
188	-0.584	-4.892	242	-0.577	-5.324	296	-0.685	-5.464
189	-0.498	-4.959	243	-0.834	-5.410	297	-0.440	-5.460
190	-0.538	-4.986	244	-0.854	-5.500	298	-0.343	-5.449
191	-0.537	-5.031	245	-0.797	-5.373	299	-0.207	-5.390
192	-0.391	-5.063	246	-0.792	-5.338	300	-0.278	-5.357
193	-0.559	-5.109	247	-0.841	-5.304	301	-0.153	-5.290
194	-0.448	-5.162	248	-0.875	-5.396	302	-0.209	-5.234
195	-0.586	-5.085	249	-0.823	-5.327	303	-0.017	-5.429
196	-0.360	-5.163	250	-0.786	-5.247	304	-0.074	-5.456
197	-0.274	-5.124	251	-0.834	-5.361	305	-0.125	-5.380
198	-0.451	-5.031	252	-0.717	-5.462	306	-0.155	-5.541
199	-0.386	-5.020	253	-0.667	-5.475	307	-0.038	-5.521
200	-0.396	-5.146	254	-0.446	-5.314	308	-0.083	-5.511
201	-0.356	-5.219	255	-0.521	-5.210	309	-0.286	-5.683
202	-0.412	-5.250	256	-0.605	-5.130	310	-0.301	-5.681
203	-0.576	-5.084	257	-0.690	-5.113	311	-0.352	-5.555
204	-0.671	-5.148	258	-0.579	-5.062	312	-0.130	-5.439
205	-0.659	-5.149	259	-0.588	-5.046	313	-0.086	-5.439
206	-0.699	-5.193	260	-0.656	-5.145	314	-0.187	-5.343

315	-0.145	-5.475	369	-0.367	-5.046	423	-0.564	-5.243
316	-0.015	-5.377	370	-0.238	-5.132	424	-0.625	-5.175
317	-0.168	-5.413	371	-0.257	-5.068	425	-0.531	-5.061
318	-0.189	-5.303	372	-0.240	-4.976	426	-0.452	-5.055
319	-0.038	-5.366	373	-0.500	-4.981	427	-0.539	-5.158
320	-0.057	-5.280	374	-0.325	-5.019	428	-0.354	-5.325
321	-0.278	-5.279	375	-0.182	-4.984	429	-0.213	-5.212
322	-0.328	-5.263	376	-0.755	-4.994	430	-0.234	-5.196
323	-0.247	-5.204	377	-0.935	-5.079	431	-0.432	-5.119
324	-0.240	-5.276	378	-0.797	-5.048	432	-0.537	-5.171
325	-0.509	-5.379	379	-0.603	-5.058	433	-0.604	-5.157
326	-0.570	-5.455	380	-0.285	-5.157	434	-0.641	-5.091
327	-0.418	-5.417	381	-0.236	-5.002	435	-0.779	-5.078
328	-0.313	-5.327	382	-0.109	-5.063	436	-0.692	-5.112
329	-0.435	-5.323	383	-0.043	-5.070			
330	-0.092	-5.230	384	-0.311	-5.126			
331	0.044	-5.146	385	-0.060	-5.068			
332	-0.360	-5.166	386	-0.111	-5.096			
333	-0.633	-5.155	387	-0.301	-5.086			
334	-0.284	-5.145	388	-0.585	-5.191			
335	-0.193	-5.049	389	-0.524	-5.354			
336	-0.318	-5.050	390	-0.624	-5.239			
337	-0.571	-5.204	391	-0.684	-5.218			
338	-0.522	-5.170	392	-1.034	-5.278			
339	-0.410	-5.204	393	-1.120	-5.301			
340	-0.377	-5.161	394	-0.813	-5.222			
341	-0.522	-5.209	395	-0.681	-5.331			
342	-0.667	-5.083	396	-0.515	-5.240			
343	-0.734	-5.154	397	-0.485	-5.214			
344	-0.574	-5.099	398	-0.456	-5.189			
345	-0.705	-5.206	399	-0.759	-5.061			
346	-0.643	-5.123	400	-0.591	-5.019			
347	-0.644	-5.088	401	-0.423	-5.095			
348	-0.290	-5.001	402	-0.400	-4.963			
349	-0.313	-5.006	403	-0.690	-5.000			
350	-0.283	-4.990	404	-0.784	-5.030			
351	-0.200	-5.041	405	-0.603	-5.071			
352	-0.222	-5.129	406	-0.646	-5.136			
353	-0.167	-5.083	407	-0.646	-5.110			
354	-0.282	-5.088	408	-0.530	-5.188			
355	-0.261	-5.103	409	-0.432	-5.115			
356	-0.448	-5.113	410	-0.306	-5.168			
357	-0.620	-5.236	411	-0.291	-5.153			
358	-0.567	-5.230	412	-0.106	-5.107			
359	-0.645	-4.906	413	-0.282	-5.191			
360	-0.995	-5.341	414	-0.035	-5.165			
361	-0.961	-5.298	415	-0.099	-5.034			
362	-0.985	-5.366	416	-0.440	-5.194			
363	-0.575	-5.285	417	-0.578	-5.334			
364	-0.372	-5.188	418	-0.647	-5.399			
365	-0.370	-5.167	419	-0.929	-5.401			
366	-0.326	-5.135	420	-0.936	-5.414			
367	-0.243	-5.062	421	-0.719	-5.339			
368	-0.435	-5.082	422	-0.715	-5.384			

APPENDIX IX.

BUN1A CORAL
STABLE ISOTOPE
DEPTH SERIES
(MID-CORE)

m m	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
0	-0.229	-4.903
1	-0.445	-4.851
2	-0.198	-4.878
3		
4	-0.095	-4.867
5	-0.035	-4.827
6	-0.087	-4.842
7	-0.089	-4.946
8	-0.133	-4.981
9	-0.111	-4.819
10	-0.249	-4.761
11	-0.269	-4.711
12	-0.307	-4.736
13	-0.048	-4.672
14	0.188	-4.814
15	0.260	-4.832
16	0.160	-4.744
17	-0.186	-4.817
18	-0.075	-4.869
19	-0.073	-4.830
20	-0.303	-5.056
21	-0.285	-5.017
22	-0.209	-4.989
23	-0.109	-5.109
24	-0.109	-4.981
25	-0.080	-5.044
26	0.021	-5.010
27	-0.064	-4.998
28	-0.157	-5.031
29	-0.026	-5.067
30	0.035	-5.060
31	-0.070	-4.965
32	-0.369	-5.084
33	-0.441	-4.909
34	-0.402	-4.916
35	-0.425	-5.037
36	-0.426	-5.108
37	-0.271	-5.140
38	-0.350	-5.056
39	-0.336	-5.100
40	-0.341	-4.996
41	-0.239	-4.886
42	-0.137	-4.899
43	-0.188	-5.059

44	-0.378	-5.021	98	-0.743	-5.270
45	-0.268	-4.862	99		
46	-0.215	-4.842	100	-0.376	-5.000
47	-0.177	-4.754	101	-0.159	-5.037
48	-0.343	-4.769	102	0.001	-5.041
49	-0.316	-4.863	103	-0.237	-5.051
50	-0.282	-4.796	104	-0.182	-5.034
51	-0.431	-4.957	105	-0.265	-5.111
52	-0.623	-5.006	106	-0.351	-5.123
53	-0.415	-5.021	107	-0.333	-5.192
54	-0.266	-4.949	108	-0.332	-5.100
55	-0.231	-5.059	109	-0.596	-5.200
56	-0.173	-5.043	136	-0.208	-4.968
57	-0.147	-4.971	137	-0.239	-4.939
58	0.028	-4.927	138	-0.305	-4.927
59	-0.050	-5.030	139	-0.247	-4.980
60	-0.211	-5.122	140	-0.177	-4.962
61	-0.255	-4.989	141	-0.218	-4.959
62	-0.281	-5.012	142	-0.227	-4.937
63	-0.346	-5.082	143	-0.144	-4.924
64	-0.543	-5.105	144	-0.314	-4.917
65	-0.549	-5.286	145	-0.380	-4.887
66	-0.766	-5.439	146	-0.315	-4.904
67	-0.671	-5.379	147	-0.500	-4.910
68	-0.415	-5.406	148	-0.374	-4.951
69	-0.464	-5.221	149	-0.319	-4.977
70	-0.548	-5.086	150	-0.295	-4.987
71	-0.456	-5.085	151	-0.242	-4.985
72	-0.076	-5.027	152	-0.261	-4.994
73	-0.208	-5.064	153	-0.246	-4.989
74	-0.222	-5.024	154	-0.289	-4.939
75	-0.196	-5.049	155	-0.277	-4.859
76	-0.172	-5.061	110	-0.372	-4.974
77	-0.327	-5.033	111	-0.369	-5.119
78	-0.408	-5.054	112	-0.578	-5.245
79	-0.558	-5.139	113	-0.558	-5.080
80	-0.672	-5.175	114	-0.504	-5.102
81	-0.627	-5.148	115	-0.663	-5.055
82	-0.659	-5.187	116	-0.562	-4.984
83	-0.683	-5.092	117	-0.454	-4.991
84	-0.339	-5.103	118	-0.249	-4.862
85	-0.337	-4.984	119	-0.279	-4.920
86	-0.381	-5.028	120	-0.126	-4.678
87	-0.267	-4.951	121	-0.107	-4.812
88	-0.357	-4.986	122	-0.029	-4.874
89	-0.470	-5.051	123	-0.203	-4.911
90	-0.486	-5.045	124	-0.466	-4.892
91	-0.536	-4.994	125	-0.406	-5.004
92	-0.525	-4.948	126	-0.335	-4.913
93	-0.454	-5.017	127	-0.407	-4.987
94	-0.440	-4.955	128	-0.509	-5.256
95	-0.560	-5.196	129	-0.856	-5.256
96	-0.700	-5.192	130	-0.688	-5.235
97	-0.727	-5.236	131	-0.709	-5.237

132	-0.696	-5.152	206	-0.702	-5.248
133	-0.391	-5.258	207	-0.582	-5.241
134	-0.403	-5.152	208	-0.545	-5.228
135	-0.500	-5.141	209	-0.345	-5.212
156	-0.162	-4.763	210	-0.308	-5.203
157	-0.130	-4.725	211	-0.280	-5.183
158	-0.222	-4.714	212	-0.229	-5.218
159	-0.124	-4.880	213	-0.091	-5.057
160	-0.198	-5.024	214	0.065	-4.958
161	-0.344	-5.076	215	0.091	-4.948
162	-0.312	-5.156	216	0.218	-4.800
163	-0.155	-5.153	217	0.126	-4.846
164	-0.223	-5.140	218	-0.156	-4.852
165	-0.192	-5.079	219	-0.358	-4.908
166	-0.187	-5.067	220	-0.345	-4.976
167	-0.117	-5.062	221	-0.402	-5.092
168	-0.194	-5.111	222	-0.595	-5.088
169	-0.308	-5.256	223		
170	-0.419	-5.339	224	-0.789	-5.352
171	-0.485	-5.442	225	-0.712	-5.365
172	-0.628	-5.439	226	-0.540	-5.283
173	-0.578	-5.502	227	-0.539	-5.370
174	-0.514	-5.418	228	-0.450	-5.253
175	-0.374	-5.233	229	-0.376	-5.147
176	-0.314	-5.258	230	-0.428	-5.182
177	-0.224	-5.176	231	-0.311	-5.158
178	-0.218	-5.225	232	-0.517	-5.142
179	-0.339	-5.159	233	-0.621	-5.076
180	-0.109	-4.983	234	-0.454	-4.915
181	-0.190	-4.951	235	-0.286	-4.944
182	-0.791	-4.878	236	-0.235	-4.940
183	-0.544	-4.828	237	-0.145	-4.936
184					
185	0.100	-4.595			
186	0.059	-4.718			
187	-0.080	-4.760			
188	-0.239	-4.844			
189	-0.228	-4.763			
190	-0.233	-4.798			
191	-0.321	-4.955			
192	-0.241	-4.919			
193	-0.262	-4.852			
194	-0.127	-4.815			
195	-0.178	-4.871			
196	-0.249	-4.782			
197	-0.243	-4.868			
198	-0.243	-4.886			
199	-0.404	-4.966			
200	-0.247	-5.040			
201	-0.290	-5.078			
202	-0.467	-5.145			
203	-0.418	-5.219			
204	-0.627	-5.321			
205	-0.690	-5.278			

APPENDIX X.

PMB1A CORAL
STABLE ISOTOPE
DEPTH SERIES

m m	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
0	0.203	-4.716
1	-0.046	-4.557
2	-0.631	-5.171
3	-0.553	-5.278
4	0.438	-5.020
5	0.174	-4.722
6	-0.971	-5.087
7	-0.791	-5.256
8	-0.494	-5.149
9	0.041	-4.773
10	0.128	-4.365
11	-0.470	-4.769
12	-0.522	-5.031
13	-0.184	-4.905
14	0.000	-4.863
15	0.153	-4.890
16	-0.084	-4.714
17	-0.570	-4.897
18	-0.789	-4.790
19	-0.967	-4.881
20	-0.954	-4.989
21	-0.819	-4.921
22	-0.691	-4.737
23	-1.329	-4.814
24	-1.688	-4.751
25	-1.205	-5.135
26	-0.950	-5.024
27	-0.919	-4.962
28	-0.340	-4.834
29	-0.188	-4.680
30	-1.305	-4.757
31	-1.362	-4.948
32	-0.802	-4.916
33	-0.454	-4.929
34	-0.018	-4.705
35	-0.093	-4.670
36	-1.532	-4.557
37	-1.686	-4.944
38	-0.581	-4.547
39	-0.795	-4.334
40	-0.930	-4.395
41	-0.803	-4.438
42	-0.949	-4.558
43	-1.426	-5.041
44	-1.426	-4.974

45	-1.346	-5.122	99	-0.842	-4.672
46	-1.178	-5.025	100	-1.425	-4.946
47	-0.814	-4.754	101	-1.589	-5.027
48	-0.630	-4.590	102	-1.602	-4.932
49	-1.214	-4.637	103	-1.038	-4.806
50	-0.938	-4.706	104	-0.757	-4.684
51	-0.930	-4.827	105	-0.626	-4.512
52	-1.134	-4.914	106	-0.959	-4.543
53	-1.001	-5.012	107	-1.297	-4.784
54	-0.834	-4.956	108	-1.803	-5.081
55	-0.802	-4.837	109	-1.316	-5.006
56	-0.563	-4.694	110	-0.946	-4.919
57	-0.843	-4.520	111	-0.873	-5.025
58	-1.102	-4.682	112	-0.480	-4.870
59	-1.361	-4.843	113	-0.651	-4.856
60	-1.419	-4.921	114	-0.794	-4.837
61	-1.156	-4.835	115	-0.932	-4.785
62	-1.067	-4.759	116	-1.069	-4.633
63	-1.038	-4.952	117	-1.319	-4.931
64	-0.837	-4.914	118	-1.281	-5.013
65	-0.981	-4.859	119	-0.939	-4.869
66	-0.860	-4.707	120	-0.965	-4.989
67	-1.552	-4.779	121	-0.333	-4.750
68	-1.644	-4.630	122	0.126	-4.577
69	-1.245	-4.867	123	0.253	-4.404
70	-0.774	-4.682	124	0.350	-4.360
71	-0.484	-4.657	125	-0.157	-4.291
72	-0.457	-4.664	126	-0.520	-4.382
73	-1.231	-4.898	127	-0.467	-4.539
74	-1.579	-5.095	128	-0.814	-4.847
75	-1.499	-5.242	129	-0.645	-4.838
76	-1.759	-5.291	130	-0.775	-4.906
77	-1.469	-5.204	131	-0.577	-4.916
78	-1.191	-5.101	132	-0.512	-4.858
79	-0.929	-5.027	133	-0.658	-4.835
80	-0.678	-4.965	134	-0.459	-4.637
81	-0.901	-4.868	135	-0.755	-4.553
82	-0.911	-4.714	136	-1.479	-4.690
83	-1.230	-4.704	137	-1.407	-4.856
84	-1.529	-4.934	138	-1.136	-4.949
85	-1.195	-4.848	139	-1.235	-5.078
86	-0.612	-4.890	140	-0.961	-4.926
87	-0.799	-4.951	141	-0.936	-4.936
88	-1.027	-4.950	142	-0.793	-4.663
89	-0.969	-4.887	143	-0.500	-4.844
90	-0.924	-4.656	144	-0.260	-4.892
91	-1.134	-4.626	145	-0.140	-4.852
92	-1.295	-4.596	146	-0.433	-4.746
93	-1.451	-4.872	147	-0.929	-4.508
94	-1.435	-5.052	148	-1.463	-4.428
95	-1.472	-4.988	149	-1.490	-4.787
96	-1.245	-4.916	150	-1.341	-4.890
97	-0.977	-4.811	151	-1.077	-4.770
98	-0.576	-4.575	152	-0.809	-4.689

153	-0.751	-4.757	207	-0.469	-4.212	261	-0.403	-4.933
154	-0.796	-4.722	208	-0.299	-4.119	262	-0.431	-4.867
155	-0.565	-4.784	209	-0.691	-4.358	263	-0.522	-4.690
156	-0.412	-4.671	210	-1.039	-4.278	264	-1.183	-4.723
157	-0.279	-4.566	211	-0.939	-4.428	265	-1.324	-4.805
158	-0.605	-4.558	212	-0.908	-4.596	266	-1.180	-4.867
159	-0.655	-4.517	213	-1.023	-4.736	267	-1.083	-5.165
160	-1.303	-4.449	214	-0.965	-4.983	268	-1.239	-5.242
161	-1.641	-4.528	215	-0.709	-4.898	269	-0.671	-5.010
162	-0.971	-4.661	216	-0.512	-4.776	270	-0.779	-4.958
163	-0.708	-4.807	217	-0.726	-4.813	271	-0.653	-4.961
164	-0.734	-4.827	218	-0.705	-4.724	272	-0.676	-5.136
165	-0.138	-4.577	219	-0.652	-4.757	273	-0.547	-4.984
166	-0.202	-4.611	220	-0.623	-4.509	274	-0.502	-4.944
167	-0.500	-4.681	221	-0.745	-4.548	275	-0.658	-4.831
168	-0.004	-4.574	222	-1.292	-4.595	276	-0.201	-4.734
169	-0.289	-4.550	223	-1.193	-4.517	277	-0.978	-4.918
170	-0.468	-4.445	224	-1.191	-4.699	278	-1.019	-5.033
171	-0.679	-4.462	225	-1.152	-4.755	279	-0.782	-5.062
172	-0.423	-4.456	226	-1.287	-4.895	280	-0.809	-4.972
173	-0.429	-4.638	227	-1.032	-4.925	281	-0.894	-5.105
174	-0.802	-4.772	228	-0.998	-4.918	282	-0.506	-5.056
175	-0.833	-4.772	229	-1.123	-4.794	283	-0.425	-4.985
176	-0.596	-4.640	230	-0.770	-4.717	284	-0.286	-4.847
177	-0.236	-4.587	231	-0.532	-4.665	285	-0.414	-4.731
178	-0.317	-4.596	232	-0.681	-4.500	286	-0.779	-4.598
179	-0.041	-4.572	233	-0.622	-4.404	287	-1.267	-4.683
180	-0.130	-4.664	234	-0.422	-4.295	288	-1.157	-4.801
181	-0.066	-4.596	235	-0.384	-4.100	289	-0.730	-5.128
182	-0.331	-4.503	236	-0.509	-4.245	290	-0.878	-5.292
183	-0.969	-4.451	237	-1.134	-4.326	291	-0.732	-5.241
184	-1.280	-4.607	238	-1.150	-4.539	292	-0.609	-5.009
185	-0.637	-4.581	239	-0.939	-4.909	293	-0.710	-4.968
186	-0.838	-4.726	240	-0.942	-4.929	294	-0.668	-4.968
187	-0.764	-4.746	241	-0.929	-5.047	295	-0.620	-4.896
188	-0.657	-4.710	242	-0.405	-4.897	296	-0.521	-4.796
189	-0.500	-4.755	243	-0.641	-4.832	297	-0.724	-4.707
190	-0.355	-4.747	244	-0.792	-4.872	298	-1.067	-4.820
191	-0.242	-4.698	245	-0.598	-4.894	299	-0.889	-4.899
192	-0.136	-4.668	246	-0.493	-4.806	300	-0.842	-5.086
193	-0.493	-4.568	247	-0.451	-4.719	301	-0.854	-5.167
194	-0.827	-4.280	248	-0.271	-4.604	302	-0.601	-5.160
195	-1.101	-4.346	249	-0.412	-4.779	303	-0.543	-5.191
196	-0.770	-4.442	250	-0.442	-4.576	304		
197	-0.526	-4.480	251	-0.791	-4.638	305		-4.783
198	-0.698	-4.578	252	-0.974	-4.703			
199	-0.645	-4.667	253	-0.894	-4.878			
200	-0.767	-4.644	254	-0.809	-4.875			
201	-0.329	-4.551	255	-0.676	-4.924			
202	-0.416	-4.600	256	-0.718	-4.954			
203	-0.408	-4.598	257	-0.756	-5.145			
204	-0.366	-4.441	258	-0.680	-5.314			
205	-0.292	-4.312	259	-0.961	-5.645			
206	-0.258	-4.208	260	-1.108	-6.288			

APPENDIX XI.

PMB1A CORAL
STABLE ISOTOPE
DEPTH SERIES
(MID-CORE)

m m	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
0	-0.997	-4.710
1	-1.919	-4.744
2	-1.901	-4.951
3	-1.759	-4.988
4	-2.282	-5.251
5	-2.033	-5.402
6	-1.387	-5.443
7	-1.268	-5.271
8	-1.262	-5.114
9	-1.472	-5.053
10	-1.399	-4.972
11	-1.264	-4.923
12	-1.935	-4.679
13	-2.248	-4.677
14	-2.076	-4.611
15	-1.866	-4.816
16	-2.456	-5.015
17	-1.862	-5.144
18	-1.296	-5.193
19	-0.941	-5.000
20	-1.753	-5.083
21	-0.751	-5.002
22	-0.478	-4.933
23	-0.231	-4.826
24	-0.440	-4.826
25	-1.054	-4.741
26	-2.174	-4.807
27	-2.167	-4.846
28	-2.216	-5.030
29	-2.354	-5.103
30	-1.783	-5.156
31	-1.396	-5.087
32	-0.847	-4.905
33	-0.731	-4.832
34	-0.314	-4.814
35	-0.582	-4.599
36	-2.152	-4.605
37	-3.041	-4.667
38	-2.620	-4.686
39	-2.156	-4.927
40	-1.912	-5.009
41	-1.470	-5.080
42	-1.624	-5.088
43	-1.379	-4.997

44	-1.014	-4.929	98	-1.043	-4.881
45	-0.285	-4.638	99	-1.041	-5.065
46	-0.404	-4.491	100	-0.519	-4.944
47	-0.812	-4.374	101	-0.394	-4.949
48	-1.085	-4.587	102	-0.525	-4.847
49	-1.955	-4.893	103	-0.646	-4.979
50	-1.539	-5.196	104	0.066	-4.814
51	-1.111	-5.200	105	0.277	-4.686
52	-0.798	-5.060	106	-0.597	-4.346
53	-0.386	-4.942	107	-1.020	-4.687
54	-0.391	-4.968	108	-1.385	-5.009
55	-0.541	-4.835	109	-1.495	-5.239
56	-0.172	-4.703	110	-1.186	-5.221
57	-0.450	-4.610	111	-0.713	-4.975
58	-1.059	-4.541	112	-0.685	-4.756
59	-1.050	-4.702	113	-0.890	-4.915
60	-1.371	-4.920	114	-0.937	-4.867
61	-1.576	-5.109	115	-0.486	-4.662
62	-1.103	-4.996	116	-0.236	-4.727
63	-0.938	-5.084	117	-0.602	-4.556
64	-0.860	-4.994	118	-1.449	-4.780
65	-0.680	-5.023	119	-1.911	-4.762
66	-0.361	-5.042	120	-1.050	-4.869
67	-0.149	-4.893	121	-1.212	-5.016
68	-0.325	-4.783	122	-1.516	-5.141
69	-1.098	-4.590	123	-0.796	-5.015
70	-2.173	-4.820	124	-0.872	-5.025
71	-1.539	-5.015	125	-0.802	-5.029
72	-1.499	-5.233	126	-1.008	-5.093
73	-1.411	-5.332	127	-0.757	-4.996
74	-1.052	-5.170	128	-0.468	-4.964
75	-0.882	-5.072	129	-0.768	-4.893
76	-0.780	-5.003	130	-1.687	-4.877
77	-0.904	-4.963	131	-2.680	-4.986
78	-0.771	-4.873	132	-2.726	-5.042
79	-0.315	-4.735	133	-1.920	-4.987
80	-0.347	-4.746	134	-2.016	-5.076
81	-0.765	-4.756	135	-1.670	-5.224
82	-1.836	-4.839	136	-0.820	-4.962
83	-1.539	-4.906	137	-0.861	-4.973
84	-1.372	-5.067	138	-0.920	-5.011
85	-1.410	-5.161	139	-0.800	-5.051
86	-1.308	-5.108	140	-0.668	-4.912
87	-1.182	-5.079	141	-0.706	-4.861
88	-1.121	-4.991	142	-0.677	-4.719
89	-1.150	-4.964	143	-0.621	-4.647
90	-1.082	-4.895	144	-0.511	-4.448
91	-0.915	-4.863	145	-0.777	-4.571
92	-0.917	-4.828	146	-1.097	-4.577
93	-0.664	-4.805	147	-1.417	-4.583
94	-0.476	-4.745	148	-1.700	-4.544
95	-0.404	-4.695	149	-1.361	-4.591
96	-1.025	-4.513	150	-1.607	-4.985
97	-1.254	-4.696	151	-1.283	-5.066

152	-0.631	-4.942	206	-1.710	-4.521	260	-1.324	-4.703
153	-0.864	-4.976	207	-2.184	-5.173	261	-1.535	-4.768
154	-1.115	-4.863	208	-2.064	-5.240	262	-1.764	-4.982
155	-0.992	-4.942	209	-1.857	-5.445	263	-1.508	-5.112
156	-0.846	-4.905	210	-1.875	-5.529	264	-1.318	-5.213
157	-0.702	-4.781	211	-1.640	-5.477	265	-1.270	-5.183
158	-0.872	-4.731	212	-1.616	-5.505	266	-0.905	-5.065
159	-0.981	-4.669	213	-1.561	-5.383	267	-0.727	-5.009
160	-1.384	-4.641	214	-0.760	-4.598	268	-0.597	-4.923
161	-1.731	-4.663	215	-0.859	-4.720	269	-1.106	-5.036
162	-1.529	-4.929	216	-1.062	-4.608	270	-0.978	-5.063
163	-1.117	-4.862	217	-0.500	-4.642	271	-0.936	-5.040
164	-1.228	-5.080	218	-0.485	-4.466	272	-0.959	-4.861
165	-1.182	-5.009	219	-0.761	-4.344	273	-0.823	-4.831
166	-1.244	-5.000	220	-1.063	-4.259	274	-1.118	-4.828
167	-1.189	-4.995	221	-1.327	-4.611	275	-1.500	-4.868
168	-0.936	-5.036	222	-1.566	-4.550	276	-1.358	-5.002
169	-0.759	-4.918	223	-1.862	-4.909	277	-1.134	-5.126
170	-0.835	-4.774	224	-1.566	-4.815	278	-1.598	-5.280
171	-0.731	-4.718	225	-1.108	-4.783	279	-1.232	-5.197
172	-0.690	-4.648	226	-1.137	-4.787	280	-1.013	-5.133
173	-0.515	-4.533	227	-1.167	-4.956	281	-1.160	-5.069
174	-0.689	-4.535	228	-0.997	-4.959	282	-1.211	-5.090
175	-0.843	-4.565	229	-1.123	-4.995	283	-0.936	-5.079
176	-0.998	-4.531	230	-0.932	-4.893	284	-0.810	-5.174
177	-1.879	-4.637	231	-0.794	-4.697	285	-0.874	-4.936
178	-1.951	-4.772	232	-0.858	-4.859	286	-0.919	-4.888
179	-1.383	-4.796	233	-1.306	-4.707	287	-1.939	-4.712
180	-1.586	-4.969	234	-1.606	-4.749	288	-2.456	-4.859
181	-1.175	-4.808	235	-1.626	-4.846	289	-1.928	-4.948
182	-0.688	-4.821	236	-1.688	-5.221	290	-1.754	-5.078
183	-0.881	-4.704	237	-1.571	-5.252	291	-1.479	-5.119
184	-0.712	-4.731	238	-1.570	-5.155	292	-1.184	-5.118
185	-0.843	-4.589	239	-1.488	-5.079	293	-0.957	-5.167
186	-0.642	-4.618	240	-1.446	-4.904	294	-0.915	-5.172
187	-0.388	-4.354	241	-1.261	-4.879	295	-0.914	-5.051
188	-0.611	-4.502	242	-1.211	-4.962	296	-0.716	-4.939
189	-0.935	-4.464	243	-1.144	-4.953	297	-0.738	-4.853
190	-0.681	-4.329	244	-1.121	-4.930	298	-0.512	-4.719
191	-1.041	-4.207	245	-0.826	-4.936	299	-0.423	-4.719
192	-1.621	-4.315	246	-0.801	-4.728	300	-0.685	-4.595
193	-1.919	-4.592	247	-0.866	-4.781	301	-1.242	-4.489
194	-1.989	-4.927	248	-0.839	-4.594	302	-1.248	-4.270
195	-1.810	-5.099	249	-1.677	-4.638	303	-1.340	-4.669
196	-1.666	-5.130	250	-1.795	-4.679	304	-1.366	-4.818
197	-1.563	-4.877	251	-1.316	-4.934	305	-1.000	-4.831
198	-1.395	-4.776	252	-1.199	-4.995	306	-0.974	-4.753
199	-1.077	-4.888	253	-1.297	-5.091	307	-0.715	-4.694
200	-1.002	-4.820	254	-1.175	-5.019	308	-0.461	-4.544
201	-0.962	-4.705	255	-1.161	-4.985	309	-0.804	-4.672
202	-0.860	-4.645	256	-1.148	-4.954	310	-0.648	-4.749
203	-0.991	-4.541	257	-1.165	-4.923	311	-0.583	-4.640
204	-0.785	-4.550	258	-0.770	-4.942	312	-0.249	-4.673
205	-1.276	-4.437	259	-0.848	-4.907	313	-0.254	-4.563

314	-1.430	-4.499
315	-1.768	-4.518
316	-1.307	-4.772
317	-1.298	-5.034
318	-1.486	-5.188
319	-1.102	-5.102
320	-0.801	-4.963
321	-0.942	-4.957
322	-0.835	-4.904
323	-0.928	-4.888
324	-0.829	-4.858
325	-0.466	-4.664
326	-0.484	-4.616
327	-0.898	-4.466
328	-1.846	-4.685
329	-2.217	-4.801
330	-1.672	-4.980

APPENDIX XII.

KAP1A CORAL
STABLE ISOTOPE
TIME SERIES (1860-1987)

Date	Depth	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$				
1860.00	1251.00	-1.107	-6.103	1863.75	1199.00	-0.005	-4.774
1860.09	1250.00	-0.959	-5.803	1863.84	1199.00	0.133	-4.724
1860.17	1248.00	-0.882	-5.712	1863.92	1198.00	-0.184	-4.837
1860.25	1247.00	-1.025	-5.492	1864.00	1197.00	-0.585	-4.904
1860.34	1246.00	-0.629	-5.368	1864.09	1196.00	-0.113	-5.087
1860.42	1244.00	-0.441	-5.171	1864.17	1195.00	-0.200	-5.479
1860.50	1243.00	-0.476	-5.131	1864.25	1194.00	-0.303	-5.614
1860.59	1241.00	-0.608	-4.885	1864.34	1193.00	-0.265	-5.240
1860.67	1240.00	-0.483	-4.903	1864.42	1192.00	-0.229	-4.918
1860.75	1239.00	-0.634	-5.225	1864.50	1190.00	-0.181	-4.752
1860.84	1237.00	-0.789	-5.551	1864.59	1189.00	0.015	-4.751
1860.92	1236.00	-0.547	-5.773	1864.67	1188.00	0.150	-4.791
1861.00	1235.00	-1.216	-6.123	1864.75	1187.00	0.071	-4.976
1861.09	1234.00	-0.972	-6.016	1864.84	1186.00	-0.025	-5.044
1861.17	1232.00	-0.712	-5.642	1864.92	1185.00	-0.252	-5.296
1861.25	1231.00	-0.593	-5.328	1865.00	1184.00	-0.337	-5.314
1861.34	1230.00	-0.260	-5.113	1865.09	1183.00	-0.025	-5.511
1861.42	1228.00	-0.218	-5.035	1865.17	1181.00	0.076	-5.531
1861.50	1227.00	-0.384	-5.023	1865.25	1180.00	-0.016	-5.162
1861.59	1225.00	-0.226	-5.135	1865.34	1179.00	0.181	-5.005
1861.67	1224.00	-0.583	-5.405	1865.42	1177.00	0.289	-4.804
1861.75	1223.00	-0.539	-5.571	1865.50	1176.00	0.234	-4.647
1861.84	1221.00	-0.524	-5.787	1865.59	1174.00	0.135	-4.840
1861.92	1220.00	-0.497	-5.890	1865.67	1173.00	-0.379	-5.296
1862.00	1219.00	-1.022	-6.170	1865.75	1172.00	-0.285	-5.670
1862.09	1218.00	-0.895	-6.010	1865.84	1170.00	-0.315	-5.522
1862.17	1217.00	-0.713	-5.644	1865.92	1169.00	-0.637	-5.438
1862.25	1216.00	-0.593	-5.306	1866.00	1168.00	-0.780	-5.421
1862.34	1215.00	-0.179	-5.158	1866.09	1167.00	-0.525	-5.112
1862.42	1214.00	-0.120	-5.149	1866.17	1166.00	-0.197	-5.015
1862.50	1212.00	-0.232	-5.157	1866.25	1166.00	-0.318	-5.056
1862.59	1211.00	-0.328	-5.052	1866.34	1165.00	-0.139	-4.973
1862.67	1210.00	-0.529	-5.204	1866.42	1164.00	-0.091	-4.994
1862.75	1209.00	-0.475	-5.571	1866.50	1163.00	-0.141	-5.006
1862.84	1208.00	-0.359	-5.848	1866.59	1162.00	-0.255	-4.922
1862.92	1207.00	-0.541	-5.916	1866.67	1161.00	-0.440	-5.069
1863.00	1206.00	-0.913	-5.947	1866.75	1161.00	-0.354	-4.960
1863.09	1205.00	-0.309	-5.456	1866.84	1160.00	-0.521	-5.171
1863.17	1205.00	-0.475	-5.602	1866.92	1159.00	-0.612	-5.142
1863.25	1204.00	-0.287	-5.374	1867.00	1158.00	-0.641	-5.275
1863.34	1203.00	-0.222	-5.113	1867.09	1157.00	-0.287	-5.290
1863.42	1202.00	0.026	-4.863	1867.17	1156.00	-0.326	-5.563
1863.50	1202.00	-0.101	-4.915	1867.25	1155.00	-0.405	-5.273
1863.59	1201.00	0.142	-4.945	1867.34	1154.00	-0.209	-5.096
1863.67	1200.00	0.211	-4.725	1867.42	1153.00	-0.108	-5.101
				1867.50	1151.00	-0.145	-4.939
				1867.59	1150.00	0.033	-4.782
				1867.67	1149.00	0.181	-4.780
				1867.75	1148.00	0.297	-4.711
				1867.84	1147.00	0.097	-4.898
				1867.92	1146.00	-0.023	-5.153
				1868.00	1145.00	-0.489	-5.509
				1868.09	1144.00	-0.432	-5.433
				1868.17	1143.00	0.073	-5.102

1868.25	1143.00	-0.105	-5.263	1872.75	1100.00	-0.039	-5.224
1868.34	1142.00	0.085	-4.989	1872.84	1100.00	0.248	-5.019
1868.42	1141.00	0.051	-4.937	1872.92	1099.00	-0.446	-5.522
1868.50	1140.00	0.286	-4.853	1873.00	1098.00	-0.611	-5.451
1868.59	1139.00	0.405	-4.920	1873.09	1097.00	-0.364	-5.865
1868.67	1138.00	0.213	-5.042	1873.17	1097.00	-0.493	-5.684
1868.75	1138.00	0.412	-4.973	1873.25	1096.00	0.102	-5.469
1868.84	1137.00	-0.128	-5.190	1873.34	1096.00	-0.112	-5.658
1868.92	1136.00	-0.166	-5.538	1873.42	1095.00	0.359	-5.113
1869.00	1135.00	0.028	-5.656	1873.50	1095.00	0.282	-5.278
1869.09	1134.00	0.238	-5.148	1873.59	1094.00	0.333	-4.912
1869.17	1133.00	-0.041	-5.050	1873.67	1094.00	0.312	-4.976
1869.25	1132.00	-0.065	-4.974	1873.75	1093.00	0.286	-4.885
1869.34	1131.00	-0.038	-4.836	1873.84	1093.00	0.386	-4.881
1869.42	1130.00	0.073	-4.758	1873.92	1092.00	0.185	-4.897
1869.50	1128.00	0.270	-4.678	1874.00	1091.00	-0.559	-5.409
1869.59	1127.00	0.197	-4.746	1874.09	1090.00	-0.472	-5.517
1869.67	1126.00	-0.145	-5.011	1874.17	1089.00	-0.363	-5.676
1869.75	1125.00	-0.365	-5.151	1874.25	1087.00	-0.439	-5.855
1869.84	1124.00	-0.144	-5.464	1874.34	1086.00	-0.336	-5.767
1869.92	1123.00	-0.496	-5.539	1874.42	1085.00	0.180	-5.043
1870.00	1122.00	-0.681	-5.374	1874.50	1084.00	0.222	-4.853
1870.09	1121.00	0.152	-4.800	1874.59	1083.00	0.177	-4.872
1870.17	1121.00	-0.212	-4.997	1874.67	1082.00	-0.174	-5.095
1870.25	1120.00	0.408	-4.742	1874.75	1080.00	-0.517	-5.338
1870.34	1119.00	0.407	-4.836	1874.84	1079.00	-0.801	-5.584
1870.42	1118.00	0.289	-4.844	1874.92	1078.00	-0.889	-5.665
1870.50	1118.00	0.430	-4.800	1875.00	1077.00	-0.986	-5.975
1870.59	1117.00	0.030	-4.970	1875.09	1076.00	-0.757	-5.919
1870.67	1116.00	-0.331	-5.046	1875.17	1075.00	0.171	-5.218
1870.75	1115.00	-0.093	-5.307	1875.25	1075.00	-0.301	-5.585
1870.84	1115.00	-0.162	-5.144	1875.34	1074.00	0.554	-4.916
1870.92	1114.00	-0.430	-5.577	1875.42	1073.00	0.757	-4.716
1871.00	1113.00	-0.500	-5.501	1875.50	1072.00	0.788	-4.730
1871.09	1112.00	-0.114	-5.281	1875.59	1071.00	0.388	-4.922
1871.17	1112.00	-0.306	-5.390	1875.67	1070.00	-0.706	-5.565
1871.25	1111.00	0.254	-5.093	1875.75	1070.00	-0.249	-5.255
1871.34	1111.00	0.082	-5.175	1875.84	1069.00	-0.800	-5.764
1871.42	1110.00	0.426	-5.059	1875.92	1068.00	-0.872	-5.945
1871.50	1110.00	0.376	-5.067	1876.00	1067.00	-0.983	-5.948
1871.59	1109.00	0.261	-5.170	1876.09	1066.00	-0.422	-5.443
1871.67	1109.00	0.417	-5.070	1876.17	1066.00	-0.642	-5.634
1871.75	1108.00	-0.179	-5.481	1876.25	1065.00	-0.382	-5.447
1871.84	1108.00	0.039	-5.309	1876.34	1064.00	-0.213	-5.077
1871.92	1107.00	-0.405	-5.660	1876.42	1064.00	-0.317	-5.258
1872.00	1106.00	-0.659	-5.993	1876.50	1063.00	0.263	-4.860
1872.09	1105.00	-0.130	-5.334	1876.59	1063.00	0.019	-4.973
1872.17	1105.00	-0.371	-5.613	1876.67	1062.00	0.482	-4.773
1872.25	1104.00	0.077	-5.191	1876.75	1061.00	0.008	-5.081
1872.34	1103.00	0.066	-5.129	1876.84	1061.00	0.390	-4.922
1872.42	1103.00	0.063	-5.160	1876.92	1060.00	-0.590	-5.263
1872.50	1102.00	0.279	-4.989	1877.00	1059.00	-1.159	-5.496
1872.59	1102.00	0.164	-5.056	1877.09	1058.00	-0.999	-5.689
1872.67	1101.00	0.386	-4.939	1877.17	1056.00	-0.838	-5.694

1877.25	1055.00	-0.717	-5.292	1881.75	997.20	0.127	-4.780
1877.34	1054.00	-0.536	-4.836	1881.84	996.10	0.160	-4.930
1877.42	1053.00	-0.246	-4.682	1881.92	995.00	-0.170	-5.138
1877.50	1051.00	-0.160	-4.721	1882.00	994.00	-0.671	-5.481
1877.59	1050.00	-0.100	-4.823	1882.09	992.90	-0.499	-5.662
1877.67	1049.00	-0.292	-5.024	1882.17	991.80	-0.298	-5.733
1877.75	1048.00	-0.673	-5.204	1882.25	990.70	-0.254	-5.521
1877.84	1046.00	-0.797	-5.229	1882.34	989.60	-0.116	-5.390
1877.92	1045.00	-0.779	-5.184	1882.42	988.50	-0.024	-5.281
1878.00	1044.00	-0.863	-5.272	1882.50	987.50	0.044	-5.028
1878.09	1043.00	-0.836	-5.141	1882.59	986.40	0.129	-4.921
1878.17	1041.00	-0.801	-5.028	1882.67	971.50	0.189	-4.961
1878.25	1040.00	-0.958	-4.888	1882.75	970.40	-0.117	-5.179
1878.34	1039.00	-0.885	-4.974	1882.83	969.20	-0.154	-5.305
1878.42	1038.00	-0.757	-4.933	1882.92	968.00	-0.100	-5.581
1878.50	1036.00	-0.541	-4.797	1883.00	967.00	-0.734	-5.950
1878.59	1035.00	-0.274	-4.865	1883.08	965.80	-0.603	-5.725
1878.67	1034.00	-0.303	-4.955	1883.17	964.60	-0.459	-5.646
1878.75	1033.00	-0.689	-5.181	1883.25	963.50	-0.446	-5.123
1878.84	1031.00	-0.929	-5.309	1883.33	962.30	-0.554	-5.048
1878.92	1030.00	-1.044	-5.569	1883.42	961.10	-0.625	-5.130
1879.00	1029.00	-1.101	-5.872	1883.50	959.90	-0.593	-4.927
1879.09	1028.00	-0.991	-5.975	1883.58	958.70	-0.330	-4.925
1879.17	1027.00	-0.750	-5.878	1883.67	957.50	-0.171	-5.041
1879.25	1026.00	-0.630	-5.920	1883.75	956.40	-0.202	-5.163
1879.34	1025.00	-0.403	-5.794	1883.83	955.20	-0.349	-5.360
1879.42	1024.00	-0.198	-5.597	1883.92	954.00	0.016	-5.445
1879.50	1023.00	-0.204	-5.255	1884.00	953.00	-0.047	-5.701
1879.59	1022.00	0.004	-5.037	1884.08	952.50	-0.088	-5.316
1879.67	1021.00	-0.083	-5.203	1884.17	951.90	-0.121	-4.969
1879.75	1020.00	-0.453	-5.519	1884.25	951.40	0.029	-4.915
1879.84	1019.00	-0.815	-5.735	1884.33	950.80	0.087	-4.9
1879.92	1018.00	-0.764	-5.897	1884.42	950.30	-0.002	-4.997
1880.00	1017.00	-0.823	-6.040	1884.50	949.70	-0.162	-5.158
1880.09	1016.00	-0.623	-5.712	1884.58	949.20	-0.456	-5.392
1880.17	1015.00	-0.534	-5.331	1884.67	948.60	-0.418	-5.524
1880.25	1015.00	-0.599	-5.459	1884.75	948.10	-0.219	-5.615
1880.34	1014.00	-0.441	-5.285	1884.83	947.50	-0.285	-5.661
1880.42	1013.00	-0.424	-5.229	1884.92	947.00	-0.351	-5.697
1880.50	1012.00	-0.287	-5.120	1885.00	946.00	-0.446	-5.7
1880.59	1011.00	-0.211	-5.028	1885.08	945.10	-0.641	-5.372
1880.67	1010.00	0.024	-4.956	1885.17	944.20	-0.781	-5.24
1880.75	1010.00	-0.085	-5.012	1885.25	943.30	-0.21	-5.005
1880.84	1009.00	0.042	-4.887	1885.33	942.40	0.195	-4.892
1880.92	1008.00	-0.214	-5.191	1885.42	941.50	0.319	-4.859
1881.00	1007.00	-0.851	-5.329	1885.50	940.50	0.142	-4.978
1881.09	1006.00	-0.746	-5.539	1885.58	939.60	-0.214	-5.185
1881.17	1005.00	-0.589	-5.768	1885.67	938.70	-0.448	-5.331
1881.25	1004.00	-0.379	-5.902	1885.75	937.80	-0.227	-5.467
1881.34	1003.00	-0.470	-5.748	1885.83	936.90	-0.121	-5.493
1881.42	1002.00	-0.408	-5.481	1885.92	936.00	-0.071	-5.492
1881.50	1000.00	-0.230	-5.280	1886.00	935.00	-0.621	-5.651
1881.59	999.40	0.100	-4.946	1886.08	934.20	-0.588	-5.413
1881.67	998.30	0.148	-4.847	1886.17	933.40	-0.194	-5.191

1886.25	932.50	0.117	-5.133	1890.75	898.50	0.141	-5.536
1886.33	931.70	0.307	-5.162	1890.83	897.70	-0.112	-5.704
1886.42	930.90	0.469	-5.113	1890.92	897.00	-0.190	-5.757
1886.50	930.10	0.483	-5.132	1891.00	896.00	-0.368	-5.561
1886.58	929.30	0.018	-5.332	1891.08	895.50	-0.177	-5.428
1886.67	928.50	-0.173	-5.502	1891.17	895.10	-0.011	-5.308
1886.75	927.60	-0.209	-5.653	1891.25	894.60	0.236	-5.130
1886.83	926.80	-0.171	-5.809	1891.33	894.20	0.531	-4.924
1886.92	926.00	-0.106	-6.010	1891.42	893.70	0.560	-4.954
1887.00	925.00	-0.646	-5.952	1891.50	893.30	0.446	-5.129
1887.08	924.50	-0.549	-5.814	1891.58	892.80	0.326	-5.284
1887.17	923.90	-0.429	-5.659	1891.67	892.40	0.137	-5.427
1887.25	923.40	-0.030	-5.326	1891.75	891.90	-0.038	-5.575
1887.33	922.80	0.282	-5.095	1891.83	891.50	-0.094	-5.720
1887.42	922.30	0.489	-5.070	1891.92	891.00	-0.163	-5.863
1887.50	921.70	0.526	-5.076	1892.00	890.00	-0.342	-5.933
1887.58	921.20	0.350	-5.124	1892.08	889.30	0.092	-5.597
1887.67	920.60	0.303	-5.269	1892.17	888.50	0.331	-5.411
1887.75	920.10	0.295	-5.456	1892.25	887.80	0.441	-5.324
1887.83	919.50	0.213	-5.651	1892.33	887.10	0.488	-5.279
1887.92	919.00	0.140	-5.851	1892.42	886.40	0.469	-5.255
1888.00	918.00	0.017	-5.859	1892.50	885.60	0.414	-5.304
1888.08	917.50	0.146	-5.639	1892.58	884.90	0.328	-5.426
1888.17	916.90	0.270	-5.423	1892.67	884.20	0.032	-5.495
1888.25	916.40	0.600	-5.199	1892.75	883.50	-0.075	-5.721
1888.33	915.80	0.802	-5.033	1892.83	882.70	-0.092	-5.856
1888.42	915.30	0.745	-4.992	1892.92	882.00	-0.003	-5.766
1888.50	914.70	0.590	-5.014	1893.00	881.00	-0.253	-5.593
1888.58	914.20	0.292	-5.096	1893.08	880.40	-0.201	-5.592
1888.67	913.60	0.025	-5.296	1893.17	879.70	-0.142	-5.566
1888.75	913.10	-0.259	-5.560	1893.25	879.10	-0.105	-5.513
1888.83	912.50	-0.242	-5.609	1893.33	878.50	0.147	-5.386
1888.92	912.00	-0.199	-5.634	1893.42	877.80	0.338	-5.284
1889.00	911.00	-0.442	-5.664	1893.50	877.20	0.393	-5.258
1889.08	910.50	-0.349	-5.614	1893.58	876.50	0.104	-5.403
1889.17	910.10	-0.248	-5.562	1893.67	875.90	-0.263	-5.611
1889.25	909.60	-0.211	-5.503	1893.75	875.30	-0.143	-5.822
1889.33	909.20	-0.185	-5.445	1893.83	874.60	-0.115	-5.989
1889.42	908.70	-0.176	-5.416	1893.92	874.00	-0.092	-6.122
1889.50	908.30	-0.173	-5.394	1894.00	873.00	-0.315	-5.736
1889.58	907.80	-0.206	-5.492	1894.08	872.50	-0.053	-5.569
1889.67	907.40	-0.304	-5.789	1894.17	872.10	0.205	-5.405
1889.75	906.90	-0.385	-6.038	1894.25	871.60	0.333	-5.287
1889.83	906.50	-0.412	-6.107	1894.33	871.20	0.487	-5.164
1889.92	906.00	-0.449	-6.193	1894.42	870.70	0.396	-5.266
1890.00	905.00	-0.484	-5.868	1894.50	870.30	0.136	-5.510
1890.08	904.30	-0.450	-5.677	1894.58	869.80	0.039	-5.700
1890.17	903.50	-0.378	-5.505	1894.67	869.40	0.183	-5.833
1890.25	902.80	-0.269	-5.367	1894.75	868.90	0.267	-5.924
1890.33	902.10	-0.162	-5.340	1894.83	868.50	0.146	-5.778
1890.42	901.40	0.195	-5.161	1894.92	868.00	0.075	-5.645
1890.50	900.60	0.462	-5.068	1895.00	867.00	-0.139	-5.600
1890.58	899.90	0.614	-5.088	1895.08	866.40	0.004	-5.483
1890.67	899.20	0.451	-5.308	1895.17	865.70	0.122	-5.347

1895.25	865.10	0.195	-5.188	1899.75	825.60	-0.049	-5.672
1895.33	864.50	0.243	-5.065	1899.83	824.80	-0.064	-5.831
1895.42	863.80	0.246	-5.034	1899.92	824.00	-0.497	-5.625
1895.50	863.20	0.096	-5.265	1900.00	823.00	-0.477	-5.385
1895.58	862.50	0.010	-5.472	1900.08	822.50	-0.233	-5.315
1895.67	861.90	-0.066	-5.681	1900.17	822.10	0.032	-5.246
1895.75	861.30	-0.147	-5.955	1900.25	821.60	0.158	-5.170
1895.83	860.60	-0.205	-5.969	1900.33	821.20	0.256	-5.091
1895.92	860.00	-0.252	-5.807	1900.42	820.70	0.366	-5.038
1896.00	859.00	-0.535	-5.312	1900.50	820.30	0.485	-4.999
1896.08	858.40	-0.145	-5.228	1900.58	819.80	0.508	-4.987
1896.17	857.70	0.194	-5.098	1900.67	819.40	0.391	-5.016
1896.25	857.10	0.477	-4.891	1900.75	818.90	0.256	-5.063
1896.33	856.50	0.564	-4.877	1900.83	818.50	-0.126	-5.223
1896.42	855.80	0.575	-4.903	1900.92	818.00	-0.484	-5.374
1896.50	855.20	0.397	-5.001	1901.00	817.00	-0.542	-5.440
1896.58	854.50	0.184	-5.105	1901.08	816.40	-0.447	-5.529
1896.67	853.90	-0.033	-5.229	1901.17	815.70	-0.340	-5.604
1896.75	853.30	-0.032	-5.551	1901.25	815.10	-0.215	-5.670
1896.83	852.60	-0.012	-5.729	1901.33	814.50	-0.112	-5.528
1896.92	852.00	0.041	-5.817	1901.42	813.80	-0.016	-5.352
1897.00	851.00	-0.332	-5.745	1901.50	813.20	0.034	-5.120
1897.08	850.20	-0.131	-5.308	1901.58	812.50	0.211	-5.068
1897.17	849.40	-0.034	-5.336	1901.67	811.90	0.415	-5.063
1897.25	848.50	0.095	-5.311	1901.75	811.30	0.531	-4.845
1897.33	847.70	0.252	-5.198	1901.83	810.60	0.546	-4.819
1897.42	846.90	0.378	-5.175	1901.92	810.00	0.482	-4.910
1897.50	846.10	0.354	-4.864	1902.00	809.00	-0.075	-5.543
1897.58	845.30	0.211	-5.060	1902.08	808.20	0.163	-5.476
1897.67	844.50	0.039	-5.197	1902.17	807.40	0.411	-5.531
1897.75	843.60	-0.072	-5.367	1902.25	806.50	0.444	-5.431
1897.83	842.80	-0.089	-5.614	1902.33	805.70	0.387	-5.194
1897.92	842.00	-0.095	-5.864	1902.42	804.90	0.502	-4.983
1898.00	841.00	-0.110	-5.687	1902.50	804.10	0.679	-4.823
1898.08	840.40	0.007	-5.518	1902.58	803.30	0.614	-4.828
1898.17	839.70	0.126	-5.363	1902.67	802.50	0.358	-4.911
1898.25	839.10	0.234	-5.240	1902.75	801.60	0.117	-5.075
1898.33	838.50	0.413	-5.065	1902.83	800.80	0.032	-5.257
1898.42	837.80	0.529	-4.950	1902.92	800.00	0.142	-5.246
1898.50	837.20	0.491	-5.014	1903.00	799.00	0.019	-5.568
1898.58	836.50	0.266	-5.113	1903.08	798.40	0.146	-5.505
1898.67	835.90	-0.007	-5.228	1903.17	797.70	0.278	-5.345
1898.75	835.30	0.020	-5.284	1903.25	797.10	0.431	-5.031
1898.83	834.60	-0.023	-5.421	1903.33	796.50	0.474	-4.917
1898.92	834.00	-0.079	-5.611	1903.42	795.80	0.493	-4.859
1899.00	833.00	-0.306	-6.008	1903.50	795.20	0.434	-4.904
1899.08	832.20	0.051	-5.828	1903.58	794.50	0.444	-5.043
1899.17	831.40	0.291	-5.401	1903.67	793.90	0.458	-5.207
1899.25	830.50	0.496	-4.998	1903.75	793.30	0.369	-5.238
1899.33	829.70	0.624	-4.772	1903.83	792.60	0.145	-5.436
1899.42	828.90	0.600	-4.800	1903.92	792.00	-0.179	-5.741
1899.50	828.10	0.351	-4.869	1904.00	791.00	-0.321	-5.720
1899.58	827.30	0.086	-5.018	1904.08	790.50	-0.125	-5.557
1899.67	826.50	-0.038	-5.341	1904.17	789.90	0.064	-5.388

1904.25	789.40	0.375	-5.115	1908.75	747.50	-0.169	-5.162
1904.33	788.80	0.566	-4.925	1908.83	746.70	-0.442	-5.350
1904.42	788.30	0.504	-4.920	1908.92	746.00	-0.470	-5.532
1904.50	787.70	0.386	-4.890	1909.00	745.00	-0.587	-5.794
1904.58	787.20	0.163	-4.826	1909.08	744.00	-0.481	-5.446
1904.67	786.60	0.023	-5.043	1909.17	743.00	-0.177	-5.403
1904.75	786.10	-0.092	-5.390	1909.25	742.00	0.206	-5.073
1904.83	785.50	-0.123	-5.531	1909.33	741.00	0.201	-4.950
1904.92	785.00	-0.143	-5.657	1909.42	740.00	-0.075	-5.014
1905.00	784.00	-0.164	-5.647	1909.50	739.00	-0.309	-5.237
1905.08	783.30	-0.206	-5.612	1909.58	738.00	-0.638	-5.381
1905.17	782.50	-0.203	-5.496	1909.67	737.00	-0.651	-5.561
1905.25	781.80	-0.120	-5.294	1909.75	736.00	-0.599	-5.890
1905.33	781.10	0.238	-4.925	1909.83	735.00	-1.095	-6.088
1905.42	780.40	0.390	-4.790	1909.92	734.00	-1.033	-5.832
1905.50	779.60	0.430	-4.800	1910.00	733.00	-1.143	-5.923
1905.58	778.90	0.351	-4.942	1910.08	732.30	-0.614	-5.555
1905.67	778.20	0.125	-4.993	1910.17	731.50	-0.121	-5.261
1905.75	777.50	-0.007	-5.140	1910.25	730.80	0.259	-5.056
1905.83	776.70	-0.115	-5.269	1910.33	730.10	0.192	-5.030
1905.92	776.00	-0.203	-5.329	1910.42	729.40	0.043	-5.007
1906.00	775.00	-0.293	-5.574	1910.50	728.60	-0.161	-5.052
1906.08	774.10	-0.180	-5.416	1910.58	727.90	-0.393	-5.163
1906.17	773.20	-0.109	-4.855	1910.67	727.20	-0.187	-5.210
1906.25	772.30	0.107	-4.839	1910.75	726.50	-0.346	-5.465
1906.33	771.40	0.285	-4.868	1910.83	725.70	-0.515	-5.636
1906.42	770.50	0.295	-4.893	1910.92	725.00	-0.599	-5.573
1906.50	769.50	0.150	-4.946	1911.00	724.00	-0.770	-5.283
1906.58	768.60	-0.012	-5.082	1911.08	723.30	-0.366	-5.071
1906.67	767.70	-0.086	-5.283	1911.17	722.50	-0.013	-4.830
1906.75	766.80	-0.134	-5.431	1911.25	721.80	0.264	-4.614
1906.83	765.90	-0.259	-5.606	1911.33	721.10	0.359	-4.543
1906.92	765.00	-0.498	-5.928	1911.42	720.40	0.300	-4.628
1907.00	764.00	-0.907	-5.784	1911.50	719.60	0.116	-4.786
1907.08	763.20	-0.321	-5.253	1911.58	718.90	-0.165	-4.995
1907.17	762.40	-0.118	-5.036	1911.67	718.20	-0.610	-5.145
1907.25	761.50	0.065	-4.936	1911.75	717.50	-0.627	-5.254
1907.33	760.70	0.245	-4.881	1911.83	716.70	-0.528	-5.357
1907.42	759.90	0.309	-4.851	1911.92	716.00	-0.402	-5.476
1907.50	759.10	0.198	-4.857	1912.00	715.00	-0.970	-5.794
1907.58	758.30	-0.186	-5.039	1912.08	714.20	-0.922	-5.451
1907.67	757.50	-0.428	-5.204	1912.17	713.40	-0.577	-5.124
1907.75	756.60	-0.482	-5.307	1912.25	712.50	-0.294	-4.858
1907.83	755.80	-0.428	-5.384	1912.33	711.70	-0.119	-4.699
1907.92	755.00	-0.703	-5.645	1912.42	710.90	0.014	-4.686
1908.00	754.00	-0.923	-5.659	1912.50	710.10	0.230	-4.648
1908.08	753.30	-0.559	-5.349	1912.58	709.30	0.205	-4.660
1908.17	752.50	-0.227	-5.185	1912.67	708.50	-0.016	-4.719
1908.25	751.80	0.045	-5.101	1912.75	707.60	-0.270	-4.813
1908.33	751.10	0.187	-5.002	1912.83	706.80	-0.451	-4.926
1908.42	750.40	0.182	-4.896	1912.92	706.00	-0.602	-5.042
1908.50	749.60	0.236	-4.850	1913.00	705.00	-0.682	-5.275
1908.58	748.90	0.336	-4.873	1913.08	703.80	-0.670	-5.562
1908.67	748.20	0.186	-4.989	1913.17	702.60	-0.531	-5.492

1913.25	701.50	-0.205	-5.129	1917.75	653.30	-0.315	-4.960
1913.33	700.30	0.065	-4.698	1917.83	652.60	-0.477	-5.025
1913.42	699.10	0.124	-4.907	1917.92	652.00	-0.718	-5.123
1913.50	697.90	0.186	-4.572	1918.00	651.00	-0.801	-5.270
1913.58	696.70	0.265	-4.643	1918.08	649.90	-0.674	-5.334
1913.67	695.50	-0.024	-4.864	1918.17	648.80	-0.518	-5.507
1913.75	694.40	-0.531	-5.134	1918.25	647.70	-0.294	-5.472
1913.83	693.20	-0.487	-5.217	1918.33	646.60	-0.204	-4.964
1913.92	692.00	-0.414	-5.461	1918.42	645.50	0.342	-4.780
1914.00	691.00	-0.994	-5.413	1918.50	644.50	0.546	-4.909
1914.08	690.10	-0.263	-4.816	1918.58	643.40	0.204	-5.236
1914.17	689.20	0.379	-4.426	1918.67	642.30	0.032	-5.430
1914.25	688.30	0.559	-4.343	1918.75	641.20	-0.259	-5.466
1914.33	687.40	0.647	-4.311	1918.83	640.10	-0.480	-5.673
1914.42	686.50	0.515	-4.443	1918.92	639.00	-0.918	-6.114
1914.50	685.50	0.137	-4.627	1919.00	638.00	-1.046	-5.604
1914.58	684.60	-0.298	-4.768	1919.08	637.30	-0.801	-5.317
1914.67	683.70	-0.528	-4.970	1919.17	636.50	-0.504	-5.160
1914.75	682.80	-0.576	-5.296	1919.25	635.80	-0.132	-5.060
1914.83	681.90	-0.553	-5.366	1919.33	635.10	0.461	-4.905
1914.92	681.00	-0.715	-5.120	1919.42	634.40	0.846	-4.726
1915.00	680.00	-1.155	-5.359	1919.50	633.60	1.052	-4.705
1915.08	679.40	-1.098	-5.371	1919.58	632.90	1.040	-4.849
1915.17	678.70	-0.896	-5.298	1919.67	632.20	0.919	-4.954
1915.25	678.10	-0.484	-5.113	1919.75	631.50	0.464	-5.138
1915.33	677.50	-0.120	-4.874	1919.83	630.70	-0.048	-5.292
1915.42	676.80	0.170	-4.699	1919.92	630.00	-0.560	-5.365
1915.50	676.20	0.187	-4.736	1920.00	629.00	-1.290	-5.345
1915.58	675.50	0.245	-4.802	1920.08	627.80	-0.846	-5.532
1915.67	674.90	0.270	-4.887	1920.17	626.60	-0.223	-5.500
1915.75	674.30	0.106	-4.991	1920.25	625.50	0.083	-5.430
1915.83	673.60	-0.349	-5.061	1920.33	624.30	-0.025	-5.341
1915.92	673.00	-1.014	-5.109	1920.42	623.10	0.231	-5.202
1916.00	672.00	-1.133	-4.947	1920.50	621.90	0.255	-5.013
1916.08	670.90	-0.836	-4.954	1920.58	620.70	0.323	-5.104
1916.17	669.80	-0.487	-4.894	1920.67	619.50	0.144	-5.316
1916.25	668.70	-0.034	-4.917	1920.75	618.40	-0.396	-5.556
1916.33	667.60	0.115	-4.755	1920.83	617.20	-0.411	-5.529
1916.42	666.50	0.222	-4.677	1920.92	616.00	-0.495	-5.670
1916.50	665.50	0.348	-4.600	1921.00	615.00	-0.841	-5.873
1916.58	664.40	0.210	-4.621	1921.08	614.10	-0.819	-5.960
1916.67	663.30	-0.181	-4.826	1921.17	613.20	-0.341	-5.861
1916.75	662.20	-0.408	-5.065	1921.25	612.30	-0.181	-5.442
1916.83	661.10	-0.536	-5.299	1921.33	611.40	0.156	-5.260
1916.92	660.00	-0.495	-5.381	1921.42	610.50	0.431	-5.139
1917.00	659.00	-0.688	-5.468	1921.50	609.50	0.469	-5.050
1917.08	658.40	-0.626	-5.216	1921.58	608.60	0.265	-5.083
1917.17	657.70	-0.542	-5.042	1921.67	607.70	-0.072	-5.242
1917.25	657.10	-0.420	-4.974	1921.75	606.80	-0.516	-5.450
1917.33	656.50	-0.347	-4.947	1921.83	605.90	-0.533	-5.531
1917.42	655.80	-0.284	-4.921	1921.92	605.00	-0.531	-5.798
1917.50	655.20	-0.232	-4.858	1922.00	604.00	-0.757	-5.840
1917.58	654.50	-0.241	-4.890	1922.08	603.40	-0.516	-5.840
1917.67	653.90	-0.276	-4.951	1922.17	602.70	-0.346	-5.681

1922.25	602.10	-0.274	-5.265	1926.75	555.30	-0.249	-4.987
1922.33	601.50	-0.223	-5.162	1926.83	554.60	-0.537	-5.119
1922.42	600.80	-0.117	-5.055	1926.92	554.00	-0.621	-5.182
1922.50	600.20	0.153	-4.862	1927.00	553.00	-0.825	-5.562
1922.58	599.50	0.471	-4.687	1927.08	552.10	-0.723	-5.515
1922.67	598.90	0.791	-4.529	1927.17	551.20	-0.303	-5.723
1922.75	598.30	0.811	-4.481	1927.25	550.30	0.152	-5.491
1922.83	597.60	0.676	-4.572	1927.33	549.40	0.352	-4.968
1922.92	597.00	0.410	-4.764	1927.42	548.50	0.312	-4.670
1923.00	596.00	-0.273	-5.152	1927.50	547.50	0.401	-4.617
1923.08	594.90	-0.209	-5.053	1927.58	546.60	0.612	-4.644
1923.17	593.80	0.036	-5.177	1927.67	545.70	0.526	-4.747
1923.25	592.70	-0.073	-5.061	1927.75	544.80	0.122	-4.963
1923.33	591.60	0.067	-4.839	1927.83	543.90	-0.819	-5.321
1923.42	590.50	0.131	-4.751	1927.92	543.00	-1.119	-5.443
1923.50	589.50	0.387	-4.585	1928.00	542.00	-1.144	-5.586
1923.58	588.40	0.584	-4.575	1928.08	541.00	-1.017	-5.713
1923.67	587.30	-0.141	-4.603	1928.17	540.00	-1.011	-5.936
1923.75	586.20	-0.335	-4.746	1928.25	539.00	-0.871	-5.721
1923.83	585.10	-0.305	-5.028	1928.33	538.00	-0.364	-5.143
1923.92	584.00	-0.412	-5.227	1928.42	537.00	-0.158	-4.900
1924.00	583.00	-0.837	-5.566	1928.50	536.00	0.341	-4.860
1924.08	582.20	-0.375	-5.237	1928.58	535.00	0.682	-4.572
1924.17	581.40	-0.071	-4.927	1928.67	534.00	0.413	-4.659
1924.25	580.50	0.045	-4.768	1928.75	533.00	0.317	-4.819
1924.33	579.70	0.097	-4.716	1928.83	532.00	0.026	-4.978
1924.42	578.90	0.293	-4.646	1928.92	531.00	-0.611	-5.290
1924.50	578.10	0.397	-4.641	1929.00	530.00	-0.826	-5.332
1924.58	577.30	0.284	-4.673	1929.08	529.20	-0.738	-5.453
1924.67	576.50	0.022	-4.805	1929.17	528.40	-0.730	-5.638
1924.75	575.60	-0.250	-4.950	1929.25	527.50	-0.714	-5.681
1924.83	574.80	-0.369	-5.056	1929.33	526.70	-0.558	-5.539
1924.92	574.00	-0.036	-5.147	1929.42	525.90	-0.125	-5.260
1925.00	573.00	-0.699	-5.230	1929.50	525.10	0.315	-5.073
1925.08	572.00	-0.349	-5.464	1929.58	524.30	0.518	-4.897
1925.17	571.00	0.055	-5.214	1929.67	523.50	0.604	-4.759
1925.25	570.00	0.445	-4.891	1929.75	522.60	0.566	-4.723
1925.33	569.00	0.526	-4.686	1929.83	521.80	0.383	-4.800
1925.42	568.00	0.621	-4.471	1929.92	521.00	-0.080	-4.886
1925.50	567.00	0.828	-4.384	1930.00	520.00	-0.457	-5.344
1925.58	566.00	0.565	-4.684	1930.08	519.00	-0.401	-5.411
1925.67	565.00	-0.363	-5.030	1930.17	518.00	-0.250	-5.388
1925.75	564.00	0.027	-5.166	1930.25	517.00	-0.207	-5.321
1925.83	563.00	-0.248	-5.356	1930.33	516.00	-0.088	-5.034
1925.92	562.00	-0.210	-5.216	1930.42	515.00	-0.110	-4.979
1926.00	561.00	-0.735	-5.134	1930.50	514.00	-0.012	-4.788
1926.08	560.40	-0.312	-5.071	1930.58	513.00	0.380	-4.756
1926.17	559.70	0.118	-4.929	1930.67	512.00	0.531	-4.764
1926.25	559.10	0.600	-4.651	1930.75	511.00	0.276	-4.835
1926.33	558.50	0.775	-4.608	1930.83	510.00	-0.431	-5.142
1926.42	557.80	0.893	-4.587	1930.92	509.00	-0.501	-5.183
1926.50	557.20	0.846	-4.573	1931.00	508.00	-0.579	-5.265
1926.58	556.50	0.658	-4.642	1931.08	507.00	-0.430	-5.270
1926.67	555.90	0.420	-4.747	1931.17	506.00	-0.473	-5.455

1931.25	505.00	-0.239	-5.153	1935.75	458.00	-0.636	-5.196
1931.33	504.00	-0.247	-4.911	1935.83	457.00	-0.947	-5.433
1931.42	503.00	-0.221	-4.885	1935.92	456.00	-0.927	-5.673
1931.50	502.00	0.320	-4.790	1936.00	455.00	-1.111	-5.783
1931.58	501.00	0.514	-4.781	1936.08	453.60	-0.759	-5.644
1931.67	500.00	0.046	-5.009	1936.17	452.30	-0.303	-5.419
1931.75	499.00	-0.240	-4.962	1936.25	450.90	-0.178	-5.079
1931.83	498.00	-0.641	-5.132	1936.33	449.50	-0.122	-4.811
1931.92	497.00	-0.668	-5.259	1936.42	448.20	0.040	-4.766
1932.00	496.00	-0.910	-5.660	1936.50	446.80	0.059	-4.812
1932.08	495.20	-0.803	-5.953	1936.58	445.50	-0.181	-4.984
1932.17	494.40	-0.627	-5.751	1936.67	444.10	-0.572	-5.252
1932.25	493.50	-0.448	-5.553	1936.75	442.70	-0.519	-5.479
1932.33	492.70	-0.237	-5.400	1936.83	441.40	-0.450	-5.614
1932.42	491.90	0.112	-5.150	1936.92	440.00	-0.609	-5.507
1932.50	491.10	0.090	-4.863	1937.00	439.00	-0.729	-5.258
1932.58	490.30	0.214	-4.906	1937.08	438.00	-0.670	-5.208
1932.67	489.50	0.015	-5.034	1937.17	437.00	-0.639	-5.143
1932.75	488.60	-0.243	-5.167	1937.25	436.00	-0.439	-4.968
1932.83	487.80	-0.410	-5.298	1937.33	435.00	0.297	-4.785
1932.92	487.00	-0.470	-5.587	1937.42	434.00	0.438	-4.789
1933.00	486.00	-0.764	-5.834	1937.50	433.00	0.237	-4.928
1933.08	485.30	-0.415	-5.773	1937.58	432.00	-0.148	-5.113
1933.17	484.50	-0.084	-5.514	1937.67	431.00	-0.490	-5.185
1933.25	483.80	0.178	-5.204	1937.75	430.00	-0.359	-5.245
1933.33	483.10	0.113	-5.154	1937.83	429.00	-0.310	-5.560
1933.42	482.40	0.250	-5.014	1937.92	428.00	-0.526	-5.646
1933.50	481.60	0.309	-4.925	1938.00	427.00	-1.189	-5.719
1933.58	480.90	0.296	-4.891	1938.08	426.40	-1.020	-5.556
1933.67	480.20	0.102	-4.911	1938.17	425.70	-0.695	-5.367
1933.75	479.50	-0.120	-5.036	1938.25	425.10	-0.085	-5.138
1933.83	478.70	-0.305	-5.179	1938.33	424.50	0.155	-4.979
1933.92	478.00	-0.405	-5.305	1938.42	423.80	0.351	-4.856
1934.00	477.00	-0.947	-5.709	1938.50	423.20	0.473	-4.828
1934.08	476.20	-0.504	-5.714	1938.58	422.50	0.503	-4.740
1934.17	475.40	-0.263	-5.760	1938.67	421.90	0.501	-4.648
1934.25	474.50	-0.016	-5.544	1938.75	421.30	0.460	-4.682
1934.33	473.70	0.244	-5.188	1938.83	420.60	0.307	-4.757
1934.42	472.90	0.441	-5.005	1938.92	420.00	0.083	-4.870
1934.50	472.10	0.416	-4.992	1939.00	419.00	-0.469	-5.154
1934.58	471.30	0.048	-5.142	1939.08	417.80	-0.473	-5.413
1934.67	470.50	-0.379	-5.384	1939.17	416.60	-0.448	-5.585
1934.75	469.60	-0.733	-5.613	1939.25	415.50	-0.202	-5.226
1934.83	468.80	-0.919	-5.734	1939.33	414.30	0.272	-4.910
1934.92	468.00	-0.920	-5.672	1939.42	413.10	0.579	-4.681
1935.00	467.00	-1.035	-5.672	1939.50	411.90	0.496	-4.806
1935.08	466.00	-1.017	-5.588	1939.58	410.70	0.060	-4.780
1935.17	465.00	-0.927	-5.120	1939.67	409.50	-0.325	-4.948
1935.25	464.00	-0.762	-5.060	1939.75	408.40	-0.354	-5.214
1935.33	463.00	-0.308	-4.955	1939.83	407.20	-0.271	-5.577
1935.42	462.00	0.127	-4.769	1939.92	406.00	-0.725	-5.407
1935.50	461.00	0.264	-4.745	1940.00	405.00	-1.132	-5.096
1935.58	460.00	0.256	-4.762	1940.08	404.10	-0.767	-4.934
1935.67	459.00	0.088	-4.849	1940.17	403.20	-0.192	-4.751

1940.25	402.30	0.266	-4.614	1944.75	359.10	0.362	-4.966
1940.33	401.40	0.319	-4.559	1944.83	358.50	0.130	-5.056
1940.42	400.50	0.188	-4.576	1944.92	358.00	-0.119	-5.152
1940.50	399.50	0.058	-4.676	1945.00	357.00	-0.129	-5.323
1940.58	398.60	-0.141	-4.836	1945.08	356.40	-0.097	-5.443
1940.67	397.70	-0.431	-5.001	1945.17	355.70	-0.084	-5.527
1940.75	396.80	-0.399	-5.146	1945.25	355.10	-0.109	-5.578
1940.83	395.90	-0.117	-5.193	1945.33	354.50	0.008	-5.363
1940.92	395.00	-0.270	-5.304	1945.42	353.80	0.162	-5.129
1941.00	394.00	-1.140	-5.417	1945.50	353.20	0.456	-4.909
1941.08	392.80	-0.991	-4.963	1945.58	352.50	0.508	-4.869
1941.17	391.60	-0.218	-4.808	1945.67	351.90	0.477	-4.904
1941.25	390.50	0.117	-4.677	1945.75	351.30	0.245	-5.011
1941.33	389.30	0.061	-4.591	1945.83	350.60	-0.060	-5.171
1941.42	388.10	0.022	-4.617	1945.92	350.00	-0.420	-5.370
1941.50	386.90	0.206	-4.658	1946.00	349.00	-0.478	-5.508
1941.58	385.70	-0.505	-5.065	1946.08	348.20	-0.372	-5.671
1941.67	384.50	-0.569	-5.249	1946.17	347.40	-0.271	-5.446
1941.75	383.40	-0.549	-5.377	1946.25	346.50	-0.080	-5.154
1941.83	382.20	-0.756	-5.472	1946.33	345.70	0.206	-4.912
1941.92	381.00	-0.800	-5.487	1946.42	344.90	0.552	-4.757
1942.00	380.00	-1.165	-5.326	1946.50	344.10	0.667	-4.646
1942.08	379.20	-0.837	-5.183	1946.58	343.30	0.425	-4.793
1942.17	378.40	-0.247	-4.947	1946.67	342.50	0.098	-5.054
1942.25	377.50	0.242	-4.723	1946.75	341.60	-0.128	-5.250
1942.33	376.70	0.434	-4.615	1946.83	340.80	-0.201	-5.337
1942.42	375.90	0.163	-4.717	1946.92	340.00	-0.415	-5.576
1942.50	375.10	-0.054	-4.806	1947.00	339.00	-0.675	-5.201
1942.58	374.30	-0.219	-4.905	1947.08	338.40	-0.082	-4.991
1942.67	373.50	-0.445	-5.004	1947.17	337.70	0.320	-4.819
1942.75	372.60	-0.554	-5.126	1947.25	337.10	0.448	-4.686
1942.83	371.80	-0.475	-5.309	1947.33	336.50	0.434	-4.735
1942.92	371.00	-0.405	-5.645	1947.42	335.80	0.374	-4.810
1943.00	370.00	-1.106	-5.484	1947.50	335.20	0.307	-4.900
1943.08	369.50	-0.801	-5.309	1947.58	334.50	0.026	-5.036
1943.17	369.10	-0.512	-5.130	1947.67	333.90	-0.298	-5.191
1943.25	368.60	-0.141	-4.996	1947.75	333.30	-0.462	-5.376
1943.33	368.20	0.263	-4.870	1947.83	332.60	-0.465	-5.568
1943.42	367.70	0.449	-4.788	1947.92	332.00	-0.340	-5.766
1943.50	367.30	0.529	-4.728	1948.00	331.00	-0.651	-5.606
1943.58	366.80	0.509	-4.748	1948.08	330.40	-0.245	-5.269
1943.67	366.40	0.277	-4.901	1948.17	329.70	0.092	-4.984
1943.75	365.90	0.068	-5.036	1948.25	329.10	0.409	-4.763
1943.83	365.50	-0.107	-5.119	1948.33	328.50	0.332	-4.689
1943.92	365.00	-0.296	-5.210	1948.42	327.80	0.288	-4.645
1944.00	364.00	-0.605	-5.502	1948.50	327.20	0.465	-4.631
1944.08	363.50	-0.437	-5.535	1948.58	326.50	0.379	-4.708
1944.17	362.90	-0.271	-5.543	1948.67	325.90	0.231	-4.826
1944.25	362.40	-0.187	-5.367	1948.75	325.30	-0.119	-5.032
1944.33	361.80	-0.066	-5.202	1948.83	324.60	-0.369	-5.214
1944.42	361.30	0.131	-5.029	1948.92	324.00	-0.559	-5.382
1944.50	360.70	0.285	-4.934	1949.00	323.00	-0.940	-5.633
1944.58	360.20	0.419	-4.917	1949.08	322.50	-0.825	-5.530
1944.67	359.60	0.412	-4.934	1949.17	321.90	-0.690	-5.412

1949.25	321.40	-0.439	-5.189	1953.75	273.00	-0.592	-5.216
1949.33	320.80	-0.166	-4.981	1953.83	272.00	-0.717	-5.498
1949.42	320.30	0.235	-4.775	1953.92	271.00	-0.702	-5.462
1949.50	319.70	0.430	-4.725	1954.00	270.00	-0.777	-5.451
1949.58	319.20	0.432	-4.843	1954.08	268.90	-0.699	-5.143
1949.67	318.60	0.319	-4.879	1954.17	267.80	-0.648	-5.023
1949.75	318.10	0.171	-4.874	1954.25	266.70	-0.458	-4.842
1949.83	317.50	-0.386	-5.098	1954.33	265.60	-0.470	-4.858
1949.92	317.00	-0.970	-5.344	1954.42	264.50	-0.430	-4.919
1950.00	316.00	-1.236	-5.574	1954.50	263.50	-0.465	-4.929
1950.08	315.20	-0.891	-5.589	1954.58	262.40	-0.561	-5.067
1950.17	314.40	-0.584	-5.400	1954.67	261.30	-0.603	-5.324
1950.25	313.50	-0.489	-5.228	1954.75	260.20	-0.667	-5.567
1950.33	312.70	-0.576	-5.141	1954.83	259.10	-0.670	-5.631
1950.42	311.90	-0.699	-5.132	1954.92	258.00	-0.861	-5.704
1950.50	311.10	-0.734	-5.033	1955.00	257.00	-0.900	-5.505
1950.58	310.30	-0.317	-4.919	1955.08	256.00	-0.809	-5.503
1950.67	309.50	-0.088	-4.868	1955.17	255.00	-0.590	-5.336
1950.75	308.60	-0.176	-4.907	1955.25	254.00	-0.270	-5.083
1950.83	307.80	-0.572	-5.067	1955.33	253.00	0.034	-4.801
1950.92	307.00	-0.935	-5.425	1955.42	252.00	-0.013	-4.779
1951.00	306.00	-1.041	-5.750	1955.50	251.00	-0.274	-5.007
1951.08	305.10	-0.653	-5.788	1955.58	250.00	-0.346	-5.328
1951.17	304.20	-0.249	-5.485	1955.67	249.00	-0.393	-5.525
1951.25	303.30	-0.368	-5.200	1955.75	248.00	-0.396	-5.472
1951.33	302.40	-0.443	-5.052	1955.83	247.00	-0.489	-5.387
1951.42	301.50	-0.320	-4.930	1955.92	246.00	-0.643	-5.243
1951.50	300.50	-0.106	-4.844	1956.00	245.00	-0.691	-5.197
1951.58	299.60	0.050	-4.813	1956.08	244.50	-0.610	-5.107
1951.67	298.70	0.067	-4.821	1956.17	244.10	-0.526	-5.017
1951.75	297.80	-0.132	-4.935	1956.25	243.60	-0.454	-4.944
1951.83	296.90	-0.603	-5.158	1956.33	243.20	-0.385	-4.873
1951.92	296.00	-0.558	-5.382	1956.42	242.70	-0.317	-4.833
1952.00	295.00	-0.634	-5.623	1956.50	242.30	-0.246	-4.813
1952.08	293.90	-0.478	-5.183	1956.58	241.80	-0.216	-4.801
1952.17	292.80	-0.577	-4.911	1956.67	241.40	-0.245	-4.800
1952.25	291.70	-0.385	-4.915	1956.75	240.90	-0.282	-4.810
1952.33	290.60	0.016	-4.729	1956.83	240.50	-0.404	-4.879
1952.42	289.50	0.112	-4.695	1956.92	240.00	-0.519	-4.943
1952.50	288.50	-0.043	-4.779	1957.00	239.00	-0.601	-5.359
1952.58	287.40	-0.204	-4.853	1957.08	238.30	-0.481	-5.476
1952.67	286.30	-0.450	-5.024	1957.17	237.50	-0.397	-5.453
1952.75	285.20	-0.532	-5.142	1957.25	236.80	-0.327	-5.315
1952.83	284.10	-0.430	-5.244	1957.33	236.10	-0.200	-5.036
1952.92	283.00	-0.771	-5.292	1957.42	235.40	-0.197	-4.880
1953.00	282.00	-0.882	-5.474	1957.50	234.60	-0.202	-4.761
1953.08	281.00	-0.436	-5.051	1957.58	233.90	-0.210	-4.675
1953.17	280.00	-0.570	-5.065	1957.67	233.20	-0.124	-4.569
1953.25	279.00	-0.176	-4.653	1957.75	232.50	-0.059	-4.607
1953.33	278.00	-0.004	-4.597	1957.83	231.70	-0.068	-4.666
1953.42	277.00	0.096	-4.619	1957.92	231.00	-0.205	-4.698
1953.50	276.00	0.196	-4.614	1958.00	230.00	-0.306	-4.990
1953.58	275.00	-0.294	-4.949	1958.08	228.60	-0.102	-5.254
1953.67	274.00	-0.602	-5.263	1958.17	227.30	-0.111	-5.082

1958.25	225.90	-0.138	-4.785	1962.75	179.60	-0.416	-5.452
1958.33	224.50	-0.076	-4.653	1962.83	178.80	-0.567	-5.511
1958.42	223.20	0.026	-4.752	1962.92	178.00	-0.642	-5.600
1958.50	221.80	-0.145	-4.637	1963.00	177.00	-0.726	-5.825
1958.58	220.50	-0.245	-4.789	1963.08	176.20	-0.651	-5.615
1958.67	219.10	-0.383	-4.928	1963.17	175.40	-0.532	-5.270
1958.75	217.70	-0.455	-5.036	1963.25	174.50	-0.288	-4.966
1958.83	216.40	-0.341	-5.329	1963.33	173.70	0.048	-4.738
1958.92	215.00	-0.707	-5.584	1963.42	172.90	0.402	-4.569
1959.00	214.00	-1.202	-5.509	1963.50	172.10	0.320	-4.525
1959.08	213.10	-0.754	-5.103	1963.58	171.30	0.067	-4.793
1959.17	212.20	-0.428	-4.834	1963.67	170.50	-0.004	-4.950
1959.25	211.30	-0.192	-4.694	1963.75	169.60	-0.018	-4.960
1959.33	210.40	-0.085	-4.774	1963.83	168.80	-0.076	-4.874
1959.42	209.50	0.085	-4.772	1963.92	168.00	-0.207	-4.894
1959.50	208.50	0.167	-4.813	1964.00	167.00	-0.484	-4.857
1959.58	207.60	0.049	-4.954	1964.08	166.30	-0.428	-4.880
1959.67	206.70	-0.183	-5.098	1964.17	165.50	-0.332	-4.842
1959.75	205.80	-0.498	-5.405	1964.25	164.80	-0.175	-4.747
1959.83	204.90	-0.620	-5.848	1964.33	164.10	0.228	-4.529
1959.92	204.00	-0.722	-5.739	1964.42	163.40	0.174	-4.633
1960.00	203.00	-1.013	-5.456	1964.50	162.60	0.031	-4.744
1960.08	202.30	-0.863	-5.147	1964.58	161.90	-0.201	-4.848
1960.17	201.50	-0.527	-4.951	1964.67	161.20	-0.114	-4.893
1960.25	200.80	-0.121	-4.846	1964.75	160.50	-0.214	-5.067
1960.33	200.10	0.249	-4.841	1964.83	159.70	-0.342	-5.210
1960.42	199.40	0.082	-4.854	1964.92	159.00	-0.474	-5.241
1960.50	198.60	-0.108	-4.936	1965.00	158.00	-0.672	-4.999
1960.58	197.90	-0.305	-5.092	1965.08	157.30	-0.228	-4.876
1960.67	197.20	-0.382	-5.375	1965.17	156.50	0.242	-4.690
1960.75	196.50	-0.523	-5.603	1965.25	155.80	0.638	-4.521
1960.83	195.70	-0.680	-5.751	1965.33	155.10	0.528	-4.566
1960.92	195.00	-0.841	-5.782	1965.42	154.40	0.400	-4.631
1961.00	194.00	-1.065	-5.704	1965.50	153.60	0.162	-4.776
1961.08	193.50	-0.622	-5.300	1965.58	152.90	-0.141	-4.974
1961.17	192.90	-0.196	-4.928	1965.67	152.20	-0.168	-5.053
1961.25	192.40	0.162	-4.733	1965.75	151.50	-0.257	-4.933
1961.33	191.80	0.437	-4.635	1965.83	150.70	-0.337	-4.810
1961.42	191.30	0.514	-4.792	1965.92	150.00	-0.407	-4.786
1961.50	190.70	0.487	-4.882	1966.00	149.00	-0.546	-5.008
1961.58	190.20	0.347	-4.909	1966.08	148.40	-0.354	-5.064
1961.67	189.60	0.116	-5.067	1966.17	147.70	-0.179	-5.032
1961.75	189.10	-0.173	-5.281	1966.25	147.10	-0.020	-4.873
1961.83	188.50	-0.279	-5.431	1966.33	146.50	0.018	-4.742
1961.92	188.00	-0.374	-5.579	1966.42	145.80	-0.019	-4.663
1962.00	187.00	-0.656	-5.987	1966.50	145.20	-0.238	-4.735
1962.08	186.20	-0.641	-5.532	1966.58	144.50	-0.462	-4.886
1962.17	185.40	-0.467	-5.198	1966.67	143.90	-0.674	-5.068
1962.25	184.50	-0.199	-4.941	1966.75	143.30	-0.534	-5.307
1962.33	183.70	0.051	-4.813	1966.83	142.60	-0.573	-5.345
1962.42	182.90	0.139	-4.887	1966.92	142.00	-0.706	-5.246
1962.50	182.10	0.171	-4.854	1967.00	141.00	-0.859	-5.624
1962.58	181.30	0.109	-4.974	1967.08	140.30	-0.822	-5.400
1962.67	180.50	-0.151	-5.242	1967.17	139.50	-0.752	-5.233

1967.25	138.80	-0.585	-5.059	1971.75	108.90	0.058	-5.314
1967.33	138.10	-0.078	-4.705	1971.83	108.50	0.155	-5.230
1967.42	137.40	0.224	-4.596	1971.92	108.00	0.232	-5.164
1967.50	136.60	0.392	-4.517	1972.00	107.00	-0.009	-4.635
1967.58	135.90	0.388	-4.482	1972.08	106.70	0.034	-4.597
1967.67	135.20	0.346	-4.565	1972.17	106.50	0.078	-4.557
1967.75	134.50	-0.015	-4.993	1972.25	106.20	0.123	-4.511
1967.83	133.70	-0.314	-5.318	1972.33	105.90	0.160	-4.487
1967.92	133.00	-0.398	-5.303	1972.42	105.60	0.180	-4.516
1968.00	132.00	-0.523	-5.337	1972.50	105.40	0.202	-4.544
1968.08	131.50	-0.320	-5.277	1972.58	105.10	0.226	-4.576
1968.17	131.10	-0.124	-5.230	1972.67	104.80	0.238	-4.517
1968.25	130.60	0.079	-5.049	1972.75	104.50	0.243	-4.419
1968.33	130.20	0.294	-4.832	1972.83	104.30	0.249	-4.327
1968.42	129.70	0.408	-4.752	1972.92	104.00	0.256	-4.240
1968.50	129.30	0.464	-4.751	1973.00	103.00	0.160	-4.714
1968.58	128.80	0.493	-4.765	1973.08	102.30	0.179	-4.832
1968.67	128.40	0.475	-4.823	1973.17	101.50	0.269	-4.923
1968.75	127.90	0.437	-4.859	1973.25	100.80	0.359	-5.005
1968.83	127.50	0.244	-4.785	1973.33	100.10	0.211	-5.117
1968.92	127.00	0.074	-4.720	1973.42	99.36	0.198	-5.111
1969.00	126.00	-0.047	-4.805	1973.50	98.64	0.201	-5.037
1969.08	125.50	0.113	-4.719	1973.58	97.91	0.220	-4.915
1969.17	125.10	0.284	-4.618	1973.67	97.18	0.295	-4.995
1969.25	124.60	0.330	-4.694	1973.75	96.45	0.152	-4.986
1969.33	124.20	0.368	-4.802	1973.83	95.73	0.001	-4.978
1969.42	123.70	0.316	-4.892	1973.92	95.00	-0.089	-5.003
1969.50	123.30	0.202	-4.978	1974.00	94.00	-0.287	-5.420
1969.58	122.80	0.102	-5.051	1974.08	93.55	-0.070	-5.326
1969.67	122.40	0.014	-5.092	1974.17	93.09	0.163	-5.243
1969.75	121.90	-0.080	-5.161	1974.25	92.64	0.262	-5.073
1969.83	121.50	-0.193	-5.377	1974.33	92.18	0.344	-4.875
1969.92	121.00	-0.301	-5.580	1974.42	91.73	0.413	-4.809
1970.00	120.00	-0.338	-4.929	1974.50	91.27	0.459	-4.825
1970.08	119.50	-0.073	-4.925	1974.58	90.82	0.506	-4.805
1970.17	118.90	0.172	-4.913	1974.67	90.36	0.581	-4.740
1970.25	118.40	0.173	-4.813	1974.75	89.91	0.616	-4.691
1970.33	117.80	0.184	-4.752	1974.83	89.45	0.377	-4.700
1970.42	117.30	0.142	-4.764	1974.92	89.00	0.184	-4.700
1970.50	116.70	0.199	-4.799	1975.00	88.00	0.098	-4.777
1970.58	116.20	0.355	-4.863	1975.08	87.55	0.215	-4.860
1970.67	115.60	0.433	-4.937	1975.17	87.09	0.325	-4.964
1970.75	115.10	0.524	-5.014	1975.25	86.64	0.438	-4.844
1970.83	114.50	0.278	-5.132	1975.33	86.18	0.564	-4.671
1970.92	114.00	0.010	-5.255	1975.42	85.73	0.590	-4.636
1971.00	113.00	-0.063	-4.892	1975.50	85.27	0.558	-4.681
1971.08	112.50	0.066	-4.844	1975.58	84.82	0.521	-4.730
1971.17	112.10	0.215	-4.791	1975.67	84.36	0.458	-4.806
1971.25	111.60	0.225	-4.794	1975.75	83.91	0.388	-4.877
1971.33	111.20	0.213	-4.809	1975.83	83.45	0.282	-4.921
1971.42	110.70	0.198	-4.849	1975.92	83.00	0.182	-4.965
1971.50	110.30	0.181	-4.901	1976.00	82.00	0.034	-4.960
1971.58	109.80	0.151	-4.999	1976.08	81.64	0.106	-4.838
1971.67	109.40	0.092	-5.181	1976.17	81.27	0.162	-4.721

1976.25	80.91	0.244	-4.595	1980.75	55.73	0.272	-4.771
1976.33	80.55	0.472	-4.410	1980.83	55.36	0.234	-4.820
1976.42	80.18	0.698	-4.219	1980.92	55.00	0.202	-4.867
1976.50	79.82	0.811	-4.152	1981.00	54.00	-0.114	-5.068
1976.58	79.45	0.828	-4.204	1981.08	53.45	0.027	-5.017
1976.67	79.09	0.897	-4.239	1981.17	52.91	0.159	-4.970
1976.75	78.73	0.741	-4.354	1981.25	52.36	0.062	-4.987
1976.83	78.36	0.530	-4.497	1981.33	51.82	0.025	-4.973
1976.92	78.00	0.339	-4.638	1981.42	51.27	0.071	-4.884
1977.00	77.00	0.230	-4.835	1981.50	50.73	0.109	-4.878
1977.08	76.55	0.242	-4.770	1981.58	50.18	0.174	-4.955
1977.17	76.09	0.239	-4.709	1981.67	49.64	0.124	-4.971
1977.25	75.64	0.344	-4.608	1981.75	49.09	0.019	-4.957
1977.33	75.18	0.465	-4.496	1981.83	48.55	-0.018	-5.094
1977.42	74.73	0.530	-4.449	1981.92	48.00	-0.056	-5.244
1977.50	74.27	0.584	-4.435	1982.00	47.00	-0.170	-5.025
1977.58	73.82	0.557	-4.472	1982.08	46.55	0.088	-4.866
1977.67	73.36	0.376	-4.598	1982.17	46.09	0.397	-4.691
1977.75	72.91	0.215	-4.710	1982.25	45.64	0.399	-4.706
1977.83	72.45	0.067	-4.773	1982.33	45.18	0.351	-4.758
1977.92	72.00	-0.092	-4.842	1982.42	44.73	0.318	-4.800
1978.00	71.00	-0.131	-4.855	1982.50	44.27	0.291	-4.843
1978.08	70.55	-0.102	-4.888	1982.58	43.82	0.199	-4.885
1978.17	70.09	-0.084	-4.932	1982.67	43.36	-0.003	-4.920
1978.25	69.64	0.002	-4.848	1982.75	42.91	-0.163	-4.954
1978.33	69.18	0.102	-4.737	1982.83	42.45	-0.170	-4.977
1978.42	68.73	0.156	-4.684	1982.92	42.00	-0.203	-5.002
1978.50	68.27	0.189	-4.660	1983.00	41.00	-0.456	-5.030
1978.58	67.82	0.193	-4.681	1983.08	40.45	-0.318	-4.933
1978.67	67.36	0.141	-4.781	1983.17	39.91	-0.196	-4.845
1978.75	66.91	0.089	-4.876	1983.25	39.36	-0.314	-4.863
1978.83	66.45	0.006	-4.968	1983.33	38.82	-0.372	-4.860
1978.92	66.00	-0.075	-5.063	1983.42	38.27	-0.361	-4.815
1979.00	65.00	-0.382	-5.243	1983.50	37.73	-0.310	-4.839
1979.08	64.55	-0.217	-5.107	1983.58	37.18	-0.173	-4.927
1979.17	64.09	-0.052	-4.977	1983.67	36.64	-0.276	-5.039
1979.25	63.64	0.083	-4.826	1983.75	36.09	-0.487	-5.165
1979.33	63.18	0.220	-4.661	1983.83	35.55	-0.541	-5.340
1979.42	62.73	0.269	-4.638	1983.92	35.00	-0.596	-5.521
1979.50	62.27	0.268	-4.701	1984.00	34.00	-1.394	-6.037
1979.58	61.82	0.247	-4.761	1984.08	33.55	-1.205	-5.820
1979.67	61.36	0.177	-4.829	1984.17	33.09	-1.024	-5.606
1979.75	60.91	0.115	-4.896	1984.25	32.64	-0.802	-5.390
1979.83	60.45	0.092	-4.941	1984.33	32.18	-0.563	-5.166
1979.92	60.00	0.063	-4.987	1984.42	31.73	-0.415	-5.060
1980.00	59.00	-0.388	-5.011	1984.50	31.27	-0.327	-5.028
1980.08	58.64	-0.259	-4.954	1984.58	30.82	-0.226	-5.006
1980.17	58.27	-0.125	-4.896	1984.67	30.36	-0.103	-5.010
1980.25	57.91	-0.003	-4.845	1984.75	29.91	-0.012	-5.017
1980.33	57.55	0.063	-4.822	1984.83	29.45	-0.092	-5.034
1980.42	57.18	0.135	-4.798	1984.92	29.00	-0.147	-5.050
1980.50	56.82	0.193	-4.777	1985.00	28.00	-0.306	-5.341
1980.58	56.45	0.239	-4.758	1985.08	27.45	-0.208	-5.371
1980.67	56.09	0.294	-4.736	1985.17	26.91	-0.113	-5.383

1985.25	26.36	-0.057	-5.241
1985.33	25.82	-0.002	-5.110
1985.42	25.27	0.052	-4.984
1985.50	24.73	0.037	-4.911
1985.58	24.18	-0.032	-4.885
1985.67	23.64	-0.190	-4.985
1985.75	23.09	-0.402	-5.147
1985.83	22.55	-0.447	-5.260
1985.92	22.00	-0.481	-5.372
1986.00	21.00	-0.523	-5.622
1986.08	20.55	-0.454	-5.449
1986.17	20.09	-0.374	-5.273
1986.25	19.64	-0.354	-5.151
1986.33	19.18	-0.350	-5.039
1986.42	18.73	-0.312	-4.959
1986.50	18.27	-0.249	-4.897
1986.58	17.82	-0.241	-4.883
1986.67	17.36	-0.323	-4.948
1986.75	16.91	-0.392	-5.013
1986.83	16.45	-0.451	-5.101
1986.92	16.00	-0.516	-5.190
1987.00	15.00	-0.775	-5.242
1987.08	14.55	-0.754	-5.141
1987.17	14.09	-0.727	-5.035
1987.25	13.64	-0.686	-4.963
1987.33	13.18	-0.655	-4.905
1987.42	12.73	-0.522	-4.794
1987.50	12.27	-0.315	-4.644
1987.58	11.82	-0.192	-4.574
1987.67	11.36	-0.200	-4.628
1987.75	10.91	-0.191	-4.679
1987.83	10.45	-0.178	-4.770
1987.92	10.00	-0.175	-4.863

APPENDIX XIII.

KAP3A CORAL
STABLE ISOTOPE
TIME SERIES (1970-1992)

Date	Depth	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
1970.00	300.00	-3.162	-5.323
1970.08	297.40	-2.581	-5.677
1970.17	294.70	-2.278	-5.787
1970.25	292.10	-2.094	-5.641
1970.33	289.50	-1.828	-5.356
1970.42	286.80	-1.449	-5.161
1970.50	284.20	-1.579	-5.231
1970.58	281.50	-1.529	-5.308
1970.67	278.90	-1.379	-5.289
1970.75	276.30	-1.571	-5.449
1970.83	273.60	-2.081	-5.742
1970.92	271.00	-1.913	-5.969
1971.00	270.00	-2.261	-6.038
1971.08	268.50	-1.917	-5.715
1971.17	266.90	-1.608	-5.436
1971.25	265.40	-1.224	-5.486
1971.33	263.80	-1.146	-5.248
1971.42	262.30	-1.122	-5.169
1971.50	260.70	-1.033	-5.139
1971.58	259.20	-0.840	-5.224
1971.67	257.60	-0.863	-5.394
1971.75	256.10	-0.969	-5.493
1971.83	254.50	-1.193	-5.781
1971.92	253.00	-1.129	-5.738
1972.00	252.00	-1.411	-5.838
1972.08	250.40	-0.934	-5.781
1972.17	248.70	-0.953	-5.207
1972.25	247.10	-1.014	-4.961
1972.33	245.50	-0.963	-4.864
1972.42	243.80	-0.947	-4.749
1972.50	242.20	-0.855	-4.895
1972.58	240.50	-0.839	-5.043
1972.67	238.90	-1.001	-5.333
1972.75	237.30	-0.941	-5.231
1972.83	235.60	-1.166	-5.433
1972.92	234.00	-1.527	-6.070
1973.00	233.00	-1.966	-6.024
1973.08	232.10	-1.548	-5.850
1973.17	231.20	-1.569	-5.795
1973.25	230.30	-1.482	-5.580
1973.33	229.40	-1.294	-5.445
1973.42	228.50	-1.157	-5.406
1973.50	227.50	-1.075	-5.454
1973.58	226.60	-1.046	-5.507
1973.67	225.70	-1.046	-5.489
1973.75	224.80	-1.175	-5.481
1973.83	223.90	-1.272	-5.507
1973.92	223.00	-1.332	-5.578
1974.00	222.00	-2.006	-6.186
1974.08	221.10	-1.552	-6.084
1974.17	220.20	-1.164	-5.783
1974.25	219.30	-1.110	-5.434
1974.33	218.40	-1.063	-5.217
1974.42	217.50	-1.033	-5.135
1974.50	216.50	-0.997	-5.194
1974.58	215.60	-1.057	-5.270
1974.67	214.70	-1.194	-5.283
1974.75	213.80	-1.438	-5.432
1974.83	212.90	-1.484	-5.594
1974.92	212.00	-1.595	-6.089
1975.00	211.00	-1.796	-6.212
1975.08	210.40	-1.424	-6.141
1975.17	209.70	-1.192	-5.970
1975.25	209.10	-0.751	-5.653
1975.33	208.50	-0.926	-5.413
1975.42	207.80	-0.924	-5.230
1975.50	207.20	-0.920	-5.192
1975.58	206.50	-0.915	-5.219
1975.67	205.90	-0.876	-5.273
1975.75	205.30	-0.791	-5.315
1975.83	204.60	-0.782	-5.398
1975.92	204.00	-0.771	-5.508
1976.00	203.00	-1.654	-5.813
1976.08	201.00	-1.144	-6.003
1976.17	199.00	-0.911	-5.693
1976.25	197.00	-1.134	-5.146
1976.33	195.00	-1.110	-4.944
1976.42	193.00	-1.641	-5.078
1976.50	191.00	-1.512	-5.087
1976.58	189.00	-1.790	-5.472
1976.67	187.00	-1.633	-5.464
1976.75	185.00	-1.862	-5.907
1976.83	183.00	-1.806	-6.002
1976.92	181.00	-1.821	-5.404
1977.00	180.00	-1.957	-5.360
1977.08	178.70	-1.796	-5.292
1977.17	177.50	-1.508	-5.196
1977.25	176.20	-1.191	-5.092
1977.33	174.90	-1.075	-5.092
1977.42	173.60	-0.981	-5.153
1977.50	172.40	-0.867	-5.334
1977.58	171.10	-0.849	-5.463
1977.67	169.80	-0.951	-5.467
1977.75	168.50	-1.286	-5.464
1977.83	167.30	-1.582	-5.390
1977.92	166.00	-1.515	-5.306
1978.00	165.00	-1.697	-5.334
1978.08	164.10	-1.586	-5.275
1978.17	163.20	-1.358	-5.354

1978.25	162.30	-1.209	-5.346	1982.75	108.60	-1.452	-5.426
1978.33	161.40	-1.252	-5.410	1982.83	107.80	-1.566	-5.365
1978.42	160.50	-1.371	-5.654	1982.92	107.00	-1.591	-5.261
1978.50	159.50	-1.370	-5.946	1983.00	106.00	-1.720	-5.179
1978.58	158.60	-1.294	-6.076	1983.08	105.50	-1.588	-5.152
1978.67	157.70	-1.379	-5.994	1983.17	104.90	-1.472	-5.135
1978.75	156.80	-1.667	-5.826	1983.25	104.40	-1.426	-5.146
1978.83	155.90	-1.907	-5.657	1983.33	103.80	-1.346	-5.207
1978.92	155.00	-2.013	-5.544	1983.42	103.30	-1.335	-5.398
1979.00	154.00	-2.185	-5.391	1983.50	102.70	-1.297	-5.519
1979.08	153.00	-1.987	-5.251	1983.58	102.20	-1.063	-5.558
1979.17	152.00	-1.759	-5.274	1983.67	101.60	-1.175	-5.767
1979.25	151.00	-1.719	-5.336	1983.75	101.10	-1.354	-6.071
1979.33	150.00	-1.291	-5.312	1983.83	100.50	-1.268	-5.815
1979.42	149.00	-1.373	-5.196	1983.92	100.00	-1.273	-5.489
1979.50	148.00	-1.749	-5.494	1984.00	99.00	-1.395	-5.369
1979.58	147.00	-1.709	-5.547	1984.08	98.45	-1.311	-5.326
1979.67	146.00	-1.664	-5.630	1984.17	97.91	-1.227	-5.292
1979.75	145.00	-1.443	-5.803	1984.25	97.36	-1.331	-5.320
1979.83	144.00	-1.748	-6.082	1984.33	96.82	-1.401	-5.356
1979.92	143.00	-1.953	-6.167	1984.42	96.27	-1.554	-5.420
1980.00	142.00	-2.061	-6.099	1984.50	95.73	-1.622	-5.466
1980.08	141.20	-1.640	-5.734	1984.58	95.18	-1.579	-5.497
1980.17	140.40	-1.547	-5.523	1984.67	94.64	-1.641	-5.535
1980.25	139.50	-1.469	-5.362	1984.75	94.09	-1.739	-5.573
1980.33	138.70	-1.406	-5.275	1984.83	93.55	-1.676	-5.677
1980.42	137.90	-1.478	-5.326	1984.92	93.00	-1.633	-5.791
1980.50	137.10	-1.440	-5.296	1985.00	92.00	-2.013	-6.199
1980.58	136.30	-1.354	-5.299	1985.08	90.45	-1.759	-6.062
1980.67	135.50	-1.268	-5.280	1985.17	88.91	-1.801	-5.728
1980.75	134.60	-1.297	-5.303	1985.25	87.36	-1.649	-5.408
1980.83	133.80	-1.477	-5.382	1985.33	85.82	-1.496	-5.303
1980.92	133.00	-1.550	-5.422	1985.42	84.27	-1.460	-5.261
1981.00	132.00	-1.772	-5.577	1985.50	82.73	-1.701	-5.297
1981.08	130.60	-1.349	-5.625	1985.58	81.18	-1.841	-5.477
1981.17	129.30	-1.238	-5.655	1985.67	79.64	-1.762	-5.537
1981.25	127.90	-1.530	-5.627	1985.75	78.09	-1.627	-5.802
1981.33	126.50	-1.463	-5.494	1985.83	76.55	-1.702	-6.223
1981.42	125.20	-1.404	-5.461	1985.92	75.00	-1.739	-6.002
1981.50	123.80	-1.123	-5.185	1986.00	74.00	-1.765	-5.627
1981.58	122.50	-1.142	-5.365	1986.08	73.18	-1.708	-5.534
1981.67	121.10	-1.189	-5.519	1986.17	72.36	-1.663	-5.408
1981.75	119.70	-1.399	-5.944	1986.25	71.55	-1.668	-5.256
1981.83	118.40	-1.392	-5.632	1986.33	70.73	-1.716	-5.154
1981.92	117.00	-1.519	-5.322	1986.42	69.91	-1.887	-5.202
1982.00	116.00	-1.772	-5.259	1986.50	69.09	-1.541	-5.296
1982.08	115.20	-1.468	-5.164	1986.58	68.27	-1.281	-5.414
1982.17	114.40	-1.354	-5.103	1986.67	67.45	-1.223	-5.424
1982.25	113.50	-1.345	-5.138	1986.75	66.64	-1.299	-5.345
1982.33	112.70	-1.401	-5.234	1986.83	65.82	-1.461	-5.258
1982.42	111.90	-1.470	-5.309	1986.92	65.00	-1.833	-5.372
1982.50	111.10	-1.299	-5.389	1987.00	64.00	-2.029	-5.241
1982.58	110.30	-1.110	-5.391	1987.08	63.09	-1.846	-5.140
1982.67	109.50	-1.284	-5.422	1987.17	62.18	-1.964	-5.257

1987.25	61.27	-2.000	-5.335	1991.75	8.82	-1.442	-5.316
1987.33	60.36	-1.915	-5.354	1991.83	7.91	-1.239	-5.526
1987.42	59.45	-1.813	-5.482	1991.92	7.00	-1.526	-5.423
1987.50	58.55	-1.754	-5.670	1992.00	6.00	-1.942	-5.552
1987.58	57.64	-1.772	-5.861	1992.08	5.64	-1.892	-5.470
1987.67	56.73	-1.874	-6.077	1992.17	5.27	-1.852	-5.391
1987.75	55.82	-2.018	-6.228	1992.25	4.91	-1.817	-5.311
1987.83	54.91	-2.053	-6.253	1992.33	4.55	-1.756	-5.211
1987.92	54.00	-2.097	-6.174	1992.42	4.18	-1.677	-5.103
1988.00	53.00	-2.199	-6.006	1992.50	3.82	-1.681	-5.091
1988.08	51.91	-2.107	-5.730	1992.58	3.46	-1.767	-5.176
1988.17	50.82	-2.024	-5.554	1992.67	3.09	-1.835	-5.255
1988.25	49.73	-1.992	-5.518	1992.75	2.73	-1.883	-5.282
1988.33	48.64	-1.948	-5.416	1992.83	2.36	-1.937	-5.298
1988.42	47.55	-1.944	-5.387	1992.92	2.00	-2.000	-5.319
1988.50	46.45	-1.967	-5.484				
1988.58	45.36	-1.828	-5.600				
1988.67	44.27	-1.718	-5.561				
1988.75	43.18	-1.797	-5.589				
1988.83	42.09	-1.983	-5.652				
1988.92	41.00	-1.889	-5.889				
1989.00	40.00	-2.078	-6.166				
1989.08	39.18	-2.007	-6.164				
1989.17	38.36	-1.927	-5.938				
1989.25	37.55	-1.890	-5.778				
1989.33	36.73	-1.865	-5.731				
1989.42	35.91	-1.824	-5.727				
1989.50	35.09	-1.667	-5.589				
1989.58	34.27	-1.709	-5.514				
1989.67	33.45	-1.676	-5.468				
1989.75	32.64	-1.663	-5.467				
1989.83	31.82	-1.693	-5.530				
1989.92	31.00	-1.845	-5.697				
1990.00	30.00	-2.154	-5.689				
1990.08	28.91	-1.902	-5.849				
1990.17	27.82	-1.729	-5.678				
1990.25	26.73	-1.831	-5.510				
1990.33	25.64	-1.845	-5.385				
1990.42	24.55	-1.942	-5.311				
1990.50	23.45	-2.066	-5.295				
1990.58	22.36	-1.914	-5.304				
1990.67	21.27	-1.867	-5.352				
1990.75	20.18	-1.895	-5.478				
1990.83	19.09	-1.956	-5.607				
1990.92	18.00	-1.956	-5.944				
1991.00	17.00	-2.366	-6.019				
1991.08	16.09	-2.128	-5.946				
1991.17	15.18	-2.049	-5.699				
1991.25	14.27	-1.841	-5.355				
1991.33	13.36	-1.669	-5.209				
1991.42	12.45	-1.617	-5.169				
1991.50	11.55	-1.677	-5.163				
1991.58	10.64	-1.747	-5.181				
1991.67	9.73	-1.704	-5.223				

APPENDIX XIV.

LANIA CORAL
STABLE ISOTOPE
TIME SERIES (1951-1989)

Date	Depth	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
1951.00	670.00	-0.514	-5.954
1951.08	668.30	-0.464	-6.127
1951.17	666.50	-0.378	-5.853
1951.25	664.80	-0.016	-5.254
1951.33	663.10	0.230	-5.246
1951.42	661.40	0.302	-4.904
1951.50	659.60	0.510	-4.822
1951.58	657.90	0.496	-4.819
1951.67	656.20	0.349	-4.911
1951.75	654.50	0.578	-5.075
1951.83	652.70	0.432	-5.305
1951.92	651.00	-0.174	-5.514
1952.00	650.00	-0.269	-5.669
1952.08	647.60	-0.214	-5.649
1952.17	645.30	-0.004	-5.169
1952.25	642.90	0.171	-5.017
1952.33	640.50	0.450	-4.776
1952.42	638.20	0.248	-4.756
1952.50	635.80	0.152	-5.005
1952.58	633.50	0.027	-5.200
1952.67	631.10	-0.598	-5.360
1952.75	628.70	-0.827	-5.857
1952.83	626.40	-0.727	-5.883
1952.92	624.00	-0.733	-5.789
1953.00	623.00	-0.890	-5.779
1953.08	621.50	-0.088	-5.583
1953.17	619.90	0.367	-5.136
1953.25	618.40	0.242	-4.969
1953.33	616.80	0.286	-4.893
1953.42	615.30	0.483	-4.818
1953.50	613.70	0.653	-4.978
1953.58	612.20	0.250	-5.311
1953.67	610.60	0.299	-5.521
1953.75	609.10	-0.168	-5.581
1953.83	607.50	-1.098	-5.697
1953.92	606.00	-0.830	-5.926
1954.00	605.00	-1.244	-5.968
1954.08	603.30	-0.934	-5.949
1954.17	601.50	-0.641	-5.772
1954.25	599.80	-0.291	-5.411
1954.33	598.10	-0.248	-5.105
1954.42	596.40	0.432	-4.936
1954.50	594.60	0.530	-4.854
1954.58	592.90	0.532	-4.901
1954.67	591.20	0.199	-5.105

1954.75	589.50	-0.439	-5.383
1954.83	587.70	-0.899	-5.749
1954.92	586.00	-1.023	-6.155
1955.00	585.00	-1.312	-6.315
1955.08	582.70	-0.966	-6.109
1955.17	580.50	-0.697	-5.830
1955.25	578.20	-0.851	-5.850
1955.33	575.90	-0.668	-5.740
1955.42	573.60	-0.414	-5.435
1955.50	571.40	-0.203	-5.150
1955.58	569.10	0.391	-4.958
1955.67	566.80	0.602	-4.992
1955.75	564.50	-0.324	-5.332
1955.83	562.30	-0.569	-5.547
1955.92	560.00	-0.791	-6.003
1956.00	559.00	-0.940	-6.208
1956.08	556.90	-0.524	-5.807
1956.17	554.80	-0.343	-5.484
1956.25	552.70	-0.292	-5.533
1956.33	550.60	-0.481	-5.284
1956.42	548.50	-0.111	-4.998
1956.50	546.50	0.088	-4.782
1956.58	544.40	0.166	-4.841
1956.67	542.30	0.012	-5.063
1956.75	540.20	-0.231	-5.334
1956.83	538.10	-0.188	-5.705
1956.92	536.00	-0.713	-5.979
1957.00	535.00	-0.842	-6.011
1957.08	533.40	-0.654	-5.539
1957.17	531.70	-0.337	-5.306
1957.25	530.10	0.079	-5.142
1957.33	528.50	0.153	-4.945
1957.42	526.80	0.579	-4.902
1957.50	525.20	0.641	-4.746
1957.58	523.50	0.532	-4.864
1957.67	521.90	0.443	-4.901
1957.75	520.30	0.366	-5.238
1957.83	518.60	-0.046	-5.407
1957.92	517.00	-0.293	-5.640
1958.00	516.00	-0.751	-5.800
1958.08	513.80	-0.265	-5.760
1958.17	511.60	-0.388	-5.638
1958.25	509.50	-0.144	-5.192
1958.33	507.30	0.313	-4.916
1958.42	505.10	0.416	-4.818
1958.50	502.90	0.601	-4.781
1958.58	500.70	0.255	-5.105
1958.67	498.50	0.193	-5.254
1958.75	496.40	0.100	-5.620
1958.83	494.20	-0.545	-5.829
1958.92	492.00	-0.808	-5.877
1959.00	491.00	-0.835	-6.074
1959.08	489.30	-0.566	-5.669
1959.17	487.50	-0.126	-5.334

1959.25	485.80	0.320	-5.023	1963.75	406.10	0.537	-5.279
1959.33	484.10	0.416	-4.854	1963.83	404.50	-0.082	-5.357
1959.42	482.40	0.386	-4.826	1963.92	403.00	-0.071	-5.298
1959.50	480.60	0.346	-4.873	1964.00	402.00	-0.306	-5.260
1959.58	478.90	-0.124	-5.035	1964.08	400.80	-0.223	-5.250
1959.67	477.20	0.100	-5.219	1964.17	399.60	-0.069	-5.236
1959.75	475.50	0.050	-5.465	1964.25	398.50	0.553	-4.985
1959.83	473.70	-0.154	-5.765	1964.33	397.30	0.672	-4.738
1959.92	472.00	-0.635	-6.114	1964.42	396.10	0.140	-4.923
1960.00	471.00	-0.709	-6.119	1964.50	394.90	0.093	-5.040
1960.08	469.50	-0.540	-5.855	1964.58	393.70	0.193	-5.166
1960.17	468.10	-0.606	-5.841	1964.67	392.50	0.076	-5.253
1960.25	466.60	0.053	-5.350	1964.75	391.40	0.048	-5.331
1960.33	465.20	0.294	-5.068	1964.83	390.20	0.105	-5.300
1960.42	463.70	0.350	-5.026	1964.92	389.00	-0.236	-5.459
1960.50	462.30	0.232	-5.040	1965.00	388.00	-0.270	-5.560
1960.58	460.80	0.109	-5.051	1965.08	386.50	-0.045	-5.622
1960.67	459.40	-0.288	-5.293	1965.17	384.90	0.173	-5.267
1960.75	457.90	-0.437	-5.530	1965.25	383.40	0.040	-5.006
1960.83	456.50	-0.443	-5.565	1965.33	381.80	0.087	-4.871
1960.92	455.00	-0.948	-5.909	1965.42	380.30	0.246	-4.773
1961.00	454.00	-0.967	-5.881	1965.50	378.70	0.226	-4.813
1961.08	453.10	-0.521	-5.855	1965.58	377.20	0.373	-4.824
1961.17	452.20	-0.764	-5.960	1965.67	375.60	0.315	-5.085
1961.25	451.30	-0.436	-5.588	1965.75	374.10	0.047	-5.294
1961.33	450.40	0.156	-4.867	1965.83	372.50	0.030	-5.280
1961.42	449.50	0.270	-4.681	1965.92	371.00	-0.282	-5.530
1961.50	448.50	-0.005	-4.796	1966.00	370.00	-0.700	-5.751
1961.58	447.60	-0.270	-5.062	1966.08	368.60	-0.277	-5.686
1961.67	446.70	-0.744	-5.269	1966.17	367.30	0.025	-5.263
1961.75	445.80	-0.397	-5.276	1966.25	365.90	0.336	-5.107
1961.83	444.90	-0.063	-5.455	1966.33	364.50	0.236	-4.998
1961.92	444.00	-0.329	-5.550	1966.42	363.20	0.102	-4.844
1962.00	443.00	-0.748	-5.795	1966.50	361.80	0.416	-4.822
1962.08	441.00	-0.442	-5.911	1966.58	360.50	0.705	-4.928
1962.17	439.00	0.130	-5.182	1966.67	359.10	0.651	-5.246
1962.25	437.00	-0.080	-5.158	1966.75	357.70	0.347	-5.424
1962.33	435.00	-0.075	-5.048	1966.83	356.40	-0.171	-5.614
1962.42	433.00	0.356	-4.799	1966.92	355.00	-0.026	-5.677
1962.50	431.00	0.397	-4.855	1967.00	354.00	-0.880	-5.917
1962.58	429.00	0.303	-4.996	1967.08	352.80	-0.324	-5.715
1962.67	427.00	0.044	-5.245	1967.17	351.60	0.043	-5.153
1962.75	425.00	-0.094	-5.449	1967.25	350.50	0.136	-4.903
1962.83	423.00	0.287	-5.586	1967.33	349.30	0.064	-4.680
1962.92	421.00	-0.142	-6.000	1967.42	348.10	-0.014	-4.587
1963.00	420.00	-0.466	-6.006	1967.50	346.90	0.100	-4.654
1963.08	418.50	-0.353	-5.705	1967.58	345.70	0.246	-4.674
1963.17	416.90	-0.327	-5.355	1967.67	344.50	0.073	-4.818
1963.25	415.40	-0.085	-4.948	1967.75	343.40	-0.039	-4.946
1963.33	413.80	0.135	-4.700	1967.83	342.20	-0.093	-5.094
1963.42	412.30	0.100	-4.758	1967.92	341.00	-0.249	-5.236
1963.50	410.70	0.254	-4.947	1968.00	340.00	-0.825	-5.403
1963.58	409.20	0.495	-5.131	1968.08	338.50	-0.589	-5.656
1963.67	407.60	0.329	-5.247	1968.17	337.10	-0.720	-5.957

1968.25	335.60	-0.535	-5.656	1972.75	262.30	-0.209	-5.302
1968.33	334.20	-0.477	-5.524	1972.83	260.60	-0.732	-5.380
1968.42	332.70	-0.399	-5.389	1972.92	259.00	-0.483	-5.732
1968.50	331.30	-0.157	-5.195	1973.00	258.00	-0.822	-5.863
1968.58	329.80	-0.028	-4.956	1973.08	256.80	-0.755	-5.628
1968.67	328.40	-0.023	-4.963	1973.17	255.60	-0.622	-5.438
1968.75	326.90	-0.008	-5.058	1973.25	254.50	-0.447	-5.181
1968.83	325.50	-0.021	-5.318	1973.33	253.30	-0.207	-5.010
1968.92	324.00	-0.301	-5.472	1973.42	252.10	0.014	-4.931
1969.00	323.00	-0.427	-5.587	1973.50	250.90	0.149	-5.134
1969.08	321.20	0.215	-5.572	1973.58	249.70	0.161	-5.215
1969.17	319.40	-0.078	-5.686	1973.67	248.50	-0.141	-5.377
1969.25	317.50	-0.341	-5.240	1973.75	247.40	-0.650	-5.467
1969.33	315.70	0.136	-4.965	1973.83	246.20	-0.468	-5.708
1969.42	313.90	-0.214	-4.805	1973.92	245.00	-1.056	-6.082
1969.50	312.10	0.256	-4.867	1974.00	244.00	-1.060	-6.128
1969.58	310.30	0.267	-5.080	1974.08	242.70	-0.409	-5.863
1969.67	308.50	-0.304	-5.335	1974.17	241.50	-0.196	-5.482
1969.75	306.60	-0.432	-5.656	1974.25	240.20	-0.210	-5.177
1969.83	304.80	-0.653	-6.030	1974.33	238.90	0.043	-4.981
1969.92	303.00	-0.530	-5.932	1974.42	237.60	0.270	-4.853
1970.00	302.00	-0.822	-5.901	1974.50	236.40	0.280	-4.995
1970.08	301.00	-0.408	-5.832	1974.58	235.10	0.315	-5.115
1970.17	300.00	-0.074	-5.203	1974.67	233.80	-0.189	-5.228
1970.25	299.00	0.105	-5.032	1974.75	232.50	-0.478	-5.349
1970.33	298.00	0.537	-4.920	1974.83	231.30	-0.212	-5.454
1970.42	297.00	0.467	-5.083	1974.92	230.00	-0.662	-5.856
1970.50	296.00	0.591	-5.157	1975.00	229.00	-1.175	-6.046
1970.58	295.00	0.641	-5.251	1975.08	227.70	-0.762	-6.039
1970.67	294.00	-0.137	-5.481	1975.17	226.50	-0.415	-5.788
1970.75	293.00	-0.629	-5.657	1975.25	225.20	-0.179	-5.372
1970.83	292.00	-0.518	-5.655	1975.33	223.90	-0.154	-5.095
1970.92	291.00	-0.842	-5.924	1975.42	222.60	-0.129	-5.101
1971.00	290.00	-0.953	-6.084	1975.50	221.40	0.060	-5.051
1971.08	288.90	-0.650	-6.067	1975.58	220.10	0.153	-5.169
1971.17	287.80	-0.374	-5.972	1975.67	218.80	0.182	-5.332
1971.25	286.70	-0.517	-5.652	1975.75	217.50	-0.417	-5.541
1971.33	285.60	-0.255	-5.467	1975.83	216.30	-0.809	-5.782
1971.42	284.50	-0.246	-5.273	1975.92	215.00	-0.633	-5.814
1971.50	283.50	-0.107	-5.036	1976.00	214.00	-1.001	-5.885
1971.58	282.40	0.014	-5.030	1976.08	212.90	-0.269	-5.703
1971.67	281.30	0.191	-4.983	1976.17	211.80	0.021	-5.281
1971.75	280.20	0.095	-5.114	1976.25	210.70	-0.137	-5.061
1971.83	279.10	-0.192	-5.318	1976.33	209.60	-0.262	-4.924
1971.92	278.00	-0.559	-5.691	1976.42	208.50	-0.114	-4.801
1972.00	277.00	-1.029	-5.913	1976.50	207.50	-0.052	-4.664
1972.08	275.40	-0.869	-5.902	1976.58	206.40	0.058	-4.605
1972.17	273.70	-0.213	-5.684	1976.67	205.30	0.141	-4.706
1972.25	272.10	0.279	-4.908	1976.75	204.20	0.082	-4.908
1972.33	270.50	0.437	-4.688	1976.83	203.10	0.082	-5.032
1972.42	268.80	0.410	-4.710	1976.92	202.00	-0.624	-5.307
1972.50	267.20	0.356	-4.919	1977.00	201.00	-0.940	-5.432
1972.58	265.50	0.335	-5.155	1977.08	199.10	-0.560	-5.709
1972.67	263.90	-0.417	-5.288	1977.17	197.20	-0.509	-5.865

1977.25	195.30	-0.445	-5.483	1981.75	124.30	-0.393	-5.223
1977.33	193.40	-0.426	-4.936	1981.83	122.60	-0.764	-5.465
1977.42	191.50	0.248	-4.736	1981.92	121.00	-1.060	-5.826
1977.50	189.50	0.331	-4.751	1982.00	120.00	-1.099	-5.996
1977.58	187.60	0.321	-5.027	1982.08	118.40	-0.707	-5.937
1977.67	185.70	-0.185	-5.466	1982.17	116.70	-0.656	-5.665
1977.75	183.80	-0.032	-5.539	1982.25	115.10	-0.689	-5.247
1977.83	181.90	-0.249	-5.298	1982.33	113.50	0.163	-4.884
1977.92	180.00	-0.478	-5.316	1982.42	111.80	0.416	-4.749
1978.00	179.00	-0.597	-5.345	1982.50	110.20	0.361	-4.890
1978.08	178.10	-0.458	-5.281	1982.58	108.50	0.092	-5.044
1978.17	177.20	-0.299	-5.155	1982.67	106.90	-0.013	-5.127
1978.25	176.30	-0.277	-5.044	1982.75	105.30	-0.265	-5.296
1978.33	175.40	-0.068	-4.950	1982.83	103.60	-0.238	-5.095
1978.42	174.50	0.106	-4.886	1982.92	102.00	-0.459	-5.073
1978.50	173.50	0.159	-4.815	1983.00	101.00	-0.816	-5.126
1978.58	172.60	0.122	-4.824	1983.08	99.64	-0.401	-5.132
1978.67	171.70	-0.049	-5.017	1983.17	98.27	-0.248	-4.994
1978.75	170.80	-0.285	-5.277	1983.25	96.91	0.268	-4.773
1978.83	169.90	-0.547	-5.576	1983.33	95.55	0.296	-4.706
1978.92	169.00	-0.603	-5.819	1983.42	94.18	0.288	-4.812
1979.00	168.00	-0.744	-5.804	1983.50	92.82	0.302	-4.962
1979.08	166.60	-0.341	-5.842	1983.58	91.45	-0.205	-5.297
1979.17	165.30	-0.360	-5.563	1983.67	90.09	-0.427	-5.467
1979.25	163.90	-0.567	-5.328	1983.75	88.73	-0.869	-5.584
1979.33	162.50	-0.179	-5.021	1983.83	87.36	-1.314	-6.019
1979.42	161.20	0.045	-4.828	1983.92	86.00	-1.582	-6.371
1979.50	159.80	0.356	-4.762	1984.00	85.00	-1.809	-6.402
1979.58	158.50	0.376	-4.828	1984.08	83.64	-1.418	-5.922
1979.67	157.10	0.111	-4.950	1984.17	82.27	-0.864	-5.354
1979.75	155.70	0.025	-5.202	1984.25	80.91	-0.288	-5.188
1979.83	154.40	-0.211	-5.430	1984.33	79.55	-0.013	-5.055
1979.92	153.00	-0.377	-5.594	1984.42	78.18	-0.174	-5.068
1980.00	152.00	-0.704	-5.818	1984.50	76.82	-0.239	-5.197
1980.08	150.90	-0.508	-5.877	1984.58	75.45	0.182	-5.135
1980.17	149.80	-0.130	-5.632	1984.67	74.09	-0.241	-5.286
1980.25	148.70	-0.137	-5.269	1984.75	72.73	-0.757	-5.509
1980.33	147.60	-0.169	-5.018	1984.83	71.36	-0.855	-5.743
1980.42	146.50	-0.059	-4.857	1984.92	70.00	-1.207	-5.979
1980.50	145.50	0.095	-4.823	1985.00	69.00	-1.208	-6.062
1980.58	144.40	0.127	-4.908	1985.08	67.73	-0.842	-5.892
1980.67	143.30	0.220	-4.995	1985.17	66.45	-0.619	-5.508
1980.75	142.20	0.182	-5.018	1985.25	65.18	-0.262	-5.165
1980.83	141.10	0.198	-5.186	1985.33	63.91	0.002	-4.880
1980.92	140.00	-0.382	-5.499	1985.42	62.64	-0.160	-4.792
1981.00	139.00	-1.072	-5.637	1985.50	61.36	-0.158	-4.830
1981.08	137.40	-0.892	-5.708	1985.58	60.09	-0.350	-5.046
1981.17	135.70	-0.307	-5.631	1985.67	58.82	-0.471	-5.315
1981.25	134.10	-0.424	-5.390	1985.75	57.55	-0.366	-5.471
1981.33	132.50	-0.448	-5.341	1985.83	56.27	-0.303	-5.669
1981.42	130.80	-0.366	-5.201	1985.92	55.00	-0.753	-5.962
1981.50	129.20	0.098	-5.054	1986.00	54.00	-0.812	-5.858
1981.58	127.50	-0.082	-5.027	1986.08	53.00	-0.604	-5.634
1981.67	125.90	-0.010	-5.058	1986.17	52.00	-0.373	-5.227

1986.25	51.00	-0.065	-5.025
1986.33	50.00	-0.095	-4.781
1986.42	49.00	0.051	-4.697
1986.50	48.00	-0.200	-4.785
1986.58	47.00	-0.146	-5.017
1986.67	46.00	-0.082	-5.151
1986.75	45.00	-0.096	-5.299
1986.83	44.00	-0.500	-5.591
1986.92	43.00	-0.443	-5.767
1987.00	42.00	-0.869	-5.852
1987.08	41.09	-0.604	-5.364
1987.17	40.18	0.005	-4.996
1987.25	39.27	0.047	-4.838
1987.33	38.36	0.005	-4.779
1987.42	37.45	0.003	-4.732
1987.50	36.55	-0.102	-4.759
1987.58	35.64	-0.256	-4.845
1987.67	34.73	-0.412	-4.929
1987.75	33.82	-0.681	-5.119
1987.83	32.91	-0.931	-5.343
1987.92	32.00	-0.915	-5.559
1988.00	31.00	-1.802	-6.307
1988.08	29.64	-1.138	-5.993
1988.17	28.27	-0.728	-5.763
1988.25	26.91	-0.424	-5.434
1988.33	25.55	-0.316	-5.149
1988.42	24.18	-0.604	-5.011
1988.50	22.82	-0.562	-5.170
1988.58	21.45	-0.422	-5.189
1988.67	20.09	-0.522	-5.405
1988.75	18.73	-1.153	-5.565
1988.83	17.36	-0.920	-5.627
1988.92	16.00	-1.124	-5.734
1989.00	15.00	-1.275	-5.903
1989.08	14.09	-0.710	-5.864
1989.17	13.18	-0.470	-5.703
1989.25	12.27	-0.444	-5.474
1989.33	11.36	-0.333	-5.325
1989.42	10.45	-0.113	-5.141
1989.50	9.55	-0.088	-4.969
1989.58	8.64	-0.159	-4.918
1989.67	7.73	-0.075	-4.978
1989.75	6.82	-0.124	-5.049
1989.83	5.91	-0.436	-5.139
1989.92	5.00	-0.808	-5.360

APPENDIX XV.

LANIA CORAL
STABLE ISOTOPE
TIME SERIES (1875-1911)

Date	Depth	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$				
1875.00	450.00	-2.388	-5.863	1878.75	420.20	1.328	-4.460
1875.08	449.50	-2.007	-5.620	1878.83	419.10	1.099	-4.735
1875.17	449.10	-1.809	-5.394	1878.92	418.00	0.644	-4.857
1875.25	448.60	0.248	-5.059	1879.00	417.00	0.382	-4.915
1875.33	448.20	0.942	-4.679	1879.08	415.80	0.492	-5.082
1875.42	447.70	1.892	-4.602	1879.17	414.60	0.453	-5.346
1875.50	447.30	1.512	-4.711	1879.25	413.50	0.550	-5.345
1875.58	446.80	0.866	-4.814	1879.33	412.30	0.894	-5.030
1875.67	446.40	1.695	-4.938	1879.42	411.10	1.210	-4.623
1875.75	445.90	0.533	-5.070	1879.50	409.90	1.358	-4.416
1875.83	445.50	1.126	-5.223	1879.58	408.70	1.325	-4.387
1875.92	445.00	0.050	-5.372	1879.67	407.50	1.302	-4.511
1876.00	444.00	0.007	-5.569	1879.75	406.40	1.306	-4.669
1876.08	443.40	-0.169	-5.522	1879.83	405.20	1.079	-4.903
1876.17	442.70	-0.080	-5.372	1879.92	404.00	0.859	-5.195
1876.25	442.10	0.166	-5.058	1880.00	403.00	0.667	-5.153
1876.33	441.50	0.354	-4.915	1880.08	402.00	0.971	-4.832
1876.42	440.80	0.385	-4.788	1880.17	401.00	1.044	-4.651
1876.50	440.20	0.400	-4.657	1880.25	400.00	1.110	-4.610
1876.58	439.50	0.524	-4.652	1880.33	399.00	1.146	-4.477
1876.67	438.90	0.711	-4.697	1880.42	398.00	1.071	-4.479
1876.75	438.30	0.744	-4.841	1880.50	397.00	1.190	-4.115
1876.83	437.60	0.640	-4.966	1880.58	396.00	1.091	-4.490
1876.92	437.00	0.464	-5.083	1880.67	395.00	1.004	-4.607
1877.00	436.00	0.311	-5.361	1880.75	394.00	0.899	-4.730
1877.08	435.50	0.422	-5.181	1880.83	393.00	0.532	-5.023
1877.17	435.10	0.546	-5.008	1880.92	392.00	0.406	-5.153
1877.25	434.60	0.687	-4.778	1881.00	391.00	0.332	-5.471
1877.33	434.20	0.769	-4.532	1881.08	389.80	0.466	-5.320
1877.42	433.70	0.709	-4.366	1881.17	388.60	0.517	-5.086
1877.50	433.30	0.629	-4.244	1881.25	387.50	0.773	-4.685
1877.58	432.80	0.728	-4.192	1881.33	386.30	0.955	-4.455
1877.67	432.40	0.991	-4.256	1881.42	385.10	0.895	-4.370
1877.75	431.90	1.192	-4.342	1881.50	383.90	1.040	-4.356
1877.83	431.50	1.039	-4.582	1881.58	382.70	0.804	-4.664
1877.92	431.00	0.744	-4.812	1881.67	381.50	0.386	-5.092
1878.00	430.00	0.733	-4.753	1881.75	380.40	0.523	-5.404
1878.08	428.90	0.821	-4.567	1881.83	379.20	0.490	-5.381
1878.17	427.80	0.711	-4.589	1881.92	378.00	0.328	-5.314
1878.25	426.70	0.668	-4.457	1882.00	377.00	-0.123	-5.180
1878.33	425.60	0.764	-4.322	1882.08	376.00	0.350	-5.113
1878.42	424.50	0.706	-4.316	1882.17	375.00	0.418	-5.034
1878.50	423.50	1.181	-4.266	1882.25	374.00	0.274	-5.006
1878.58	422.40	1.556	-4.217	1882.33	373.00	0.332	-4.883
1878.67	421.30	1.389	-4.293	1882.42	372.00	0.698	-4.553
				1882.50	371.00	0.803	-4.620
				1882.58	370.00	0.625	-4.749
				1882.67	369.00	0.536	-4.826
				1882.75	368.00	0.364	-4.950
				1882.83	367.00	0.411	-5.158
				1882.92	366.00	0.537	-5.456
				1883.00	365.00	0.028	-5.775
				1883.08	364.10	0.148	-5.429
				1883.17	363.20	0.595	-4.987

1883.25	362.30	0.787	-4.724	1887.75	313.10	0.774	-5.077
1883.33	361.40	0.884	-4.603	1887.83	312.50	0.771	-5.185
1883.42	360.50	0.973	-4.536	1887.92	312.00	0.792	-5.287
1883.50	359.50	0.867	-4.565	1888.00	311.00	0.771	-5.442
1883.58	358.60	0.775	-4.667	1888.08	310.50	0.783	-5.307
1883.67	357.70	0.782	-4.786	1888.17	310.10	0.841	-5.178
1883.75	356.80	0.738	-5.044	1888.25	309.60	0.982	-4.944
1883.83	355.90	0.521	-5.233	1888.33	309.20	1.226	-4.692
1883.92	355.00	0.032	-5.495	1888.42	308.70	1.555	-4.483
1884.00	354.00	-0.430	-5.722	1888.50	308.30	1.892	-4.279
1884.08	353.10	-0.342	-5.777	1888.58	307.80	1.987	-4.239
1884.17	352.20	-0.191	-5.581	1888.67	307.40	1.760	-4.469
1884.25	351.30	0.153	-5.083	1888.75	306.90	1.523	-4.669
1884.33	350.40	0.587	-4.704	1888.83	306.50	1.370	-4.820
1884.42	349.50	0.724	-4.485	1888.92	306.00	1.267	-4.985
1884.50	348.50	0.623	-4.422	1889.00	305.00	1.103	-5.142
1884.58	347.60	0.591	-4.481	1889.08	304.10	1.136	-4.974
1884.67	346.70	0.600	-4.609	1889.17	303.20	1.542	-4.705
1884.75	345.80	0.543	-4.804	1889.25	302.30	1.729	-4.588
1884.83	344.90	0.640	-5.062	1889.33	301.40	1.229	-4.646
1884.92	344.00	0.352	-5.264	1889.42	300.50	0.972	-4.757
1885.00	343.00	0.162	-5.305	1889.50	299.50	0.904	-4.844
1885.08	342.00	0.207	-5.283	1889.58	298.60	0.711	-4.959
1885.17	341.00	0.340	-4.838	1889.67	297.70	0.613	-5.155
1885.25	340.00	0.357	-4.656	1889.75	296.80	0.397	-5.352
1885.33	339.00	0.663	-4.477	1889.83	295.90	0.118	-5.629
1885.42	338.00	0.381	-4.397	1889.92	295.00	-0.159	-5.732
1885.50	337.00	0.352	-4.394	1890.00	294.00	-0.160	-5.723
1885.58	336.00	0.539	-4.503	1890.08	292.90	0.172	-5.429
1885.67	335.00	0.516	-4.776	1890.17	291.80	0.252	-5.158
1885.75	334.00	0.723	-4.881	1890.25	290.70	0.682	-4.963
1885.83	333.00	0.613	-5.129	1890.33	289.60	1.008	-4.837
1885.92	332.00	0.037	-5.458	1890.42	288.50	1.050	-4.704
1886.00	331.00	0.036	-5.414	1890.50	287.50	0.653	-4.644
1886.08	329.90	0.042	-5.314	1890.58	286.40	0.522	-4.677
1886.17	328.80	0.156	-5.317	1890.67	285.30	0.524	-4.772
1886.25	327.70	0.440	-4.969	1890.75	284.20	0.652	-4.962
1886.33	326.60	0.594	-4.746	1890.83	283.10	0.550	-5.176
1886.42	325.50	0.604	-4.712	1890.92	282.00	0.483	-5.265
1886.50	324.50	0.599	-4.795	1891.00	281.00	0.185	-5.405
1886.58	323.40	0.697	-4.950	1891.08	280.20	0.233	-5.231
1886.67	322.30	0.730	-5.173	1891.17	279.40	0.502	-5.093
1886.75	321.20	0.547	-5.454	1891.25	278.50	0.771	-4.913
1886.83	320.10	0.250	-5.638	1891.33	277.70	0.892	-4.760
1886.92	319.00	0.175	-5.690	1891.42	276.90	0.829	-4.761
1887.00	318.00	0.054	-5.525	1891.50	276.10	0.536	-5.054
1887.08	317.50	0.214	-5.266	1891.58	275.30	0.242	-5.213
1887.17	316.90	0.436	-5.018	1891.67	274.50	0.250	-5.403
1887.25	316.40	0.668	-4.857	1891.75	273.60	0.085	-5.576
1887.33	315.80	0.846	-4.723	1891.83	272.80	-0.310	-5.682
1887.42	315.30	0.898	-4.645	1891.92	272.00	-0.240	-5.661
1887.50	314.70	0.884	-4.669	1892.00	271.00	-0.127	-5.646
1887.58	314.20	0.849	-4.796	1892.08	269.80	0.055	-5.205
1887.67	313.60	0.804	-4.931	1892.17	268.60	0.156	-4.987

1892.25	267.50	0.500	-4.881	1896.75	209.80	0.729	-4.956
1892.33	266.30	0.730	-4.763	1896.83	208.90	0.604	-5.254
1892.42	265.10	0.549	-4.843	1896.92	208.00	0.314	-5.348
1892.50	263.90	0.434	-4.813	1897.00	207.00	0.234	-5.429
1892.58	262.70	0.322	-4.866	1897.08	206.30	0.313	-5.500
1892.67	261.50	0.386	-4.970	1897.17	205.50	0.264	-5.340
1892.75	260.40	0.189	-5.055	1897.25	204.80	0.341	-5.059
1892.83	259.20	0.291	-5.159	1897.33	204.10	0.537	-4.795
1892.92	258.00	-0.110	-5.408	1897.42	203.40	0.515	-4.760
1893.00	257.00	-0.206	-5.554	1897.50	202.60	0.461	-4.740
1893.08	255.50	-0.250	-5.424	1897.58	201.90	0.674	-4.717
1893.17	254.10	0.238	-5.172	1897.67	201.20	0.952	-4.630
1893.25	252.60	0.322	-5.083	1897.75	200.50	1.018	-4.784
1893.33	251.20	0.461	-4.990	1897.83	199.70	0.621	-5.084
1893.42	249.70	0.496	-4.854	1897.92	199.00	-0.153	-5.528
1893.50	248.30	0.650	-4.735	1898.00	198.00	-0.178	-5.659
1893.58	246.80	0.704	-4.745	1898.08	197.20	0.125	-5.511
1893.67	245.40	0.620	-4.929	1898.17	196.40	0.326	-5.334
1893.75	243.90	0.230	-5.151	1898.25	195.50	0.250	-5.140
1893.83	242.50	0.375	-5.486	1898.33	194.70	0.467	-4.964
1893.92	241.00	-0.675	-5.913	1898.42	193.90	0.721	-4.850
1894.00	240.00	-0.795	-5.897	1898.50	193.10	0.761	-4.732
1894.08	239.00	-0.489	-5.740	1898.58	192.30	0.912	-4.706
1894.17	238.00	0.343	-5.361	1898.67	191.50	0.952	-4.894
1894.25	237.00	0.616	-5.110	1898.75	190.60	0.806	-5.140
1894.33	236.00	0.554	-4.837	1898.83	189.80	0.503	-5.365
1894.42	235.00	0.583	-4.679	1898.92	189.00	0.030	-5.701
1894.50	234.00	0.684	-4.625	1899.00	188.00	-0.005	-5.725
1894.58	233.00	0.567	-4.798	1899.08	187.00	0.151	-5.108
1894.67	232.00	0.436	-4.967	1899.17	186.00	0.497	-4.812
1894.75	231.00	0.600	-5.159	1899.25	185.00	0.697	-4.596
1894.83	230.00	0.092	-5.304	1899.33	184.00	0.648	-4.523
1894.92	229.00	0.230	-5.471	1899.42	183.00	0.693	-4.563
1895.00	228.00	-0.231	-5.641	1899.50	182.00	0.914	-4.816
1895.08	227.20	-0.052	-5.525	1899.58	181.00	0.780	-5.166
1895.17	226.40	0.349	-5.364	1899.67	180.00	0.641	-5.450
1895.25	225.50	0.373	-5.226	1899.75	179.00	0.571	-5.427
1895.33	224.70	0.469	-5.099	1899.83	178.00	0.335	-5.485
1895.42	223.90	0.705	-4.938	1899.92	177.00	0.293	-5.124
1895.50	223.10	0.773	-4.779	1900.00	176.00	0.231	-4.996
1895.58	222.30	1.104	-4.736	1900.08	175.00	0.238	-4.901
1895.67	221.50	0.606	-5.096	1900.17	174.00	0.436	-4.794
1895.75	220.60	0.085	-5.505	1900.25	173.00	0.601	-4.607
1895.83	219.80	-0.036	-5.719	1900.33	172.00	0.536	-4.576
1895.92	219.00	-0.190	-5.787	1900.42	171.00	0.684	-4.569
1896.00	218.00	-0.209	-5.727	1900.50	170.00	0.660	-4.674
1896.08	217.10	0.167	-5.445	1900.58	169.00	0.601	-4.809
1896.17	216.20	0.314	-5.145	1900.67	168.00	0.421	-4.920
1896.25	215.30	0.433	-4.894	1900.75	167.00	0.221	-5.046
1896.33	214.40	0.555	-4.633	1900.83	166.00	-0.204	-5.252
1896.42	213.50	0.771	-4.470	1900.92	165.00	-0.420	-5.296
1896.50	212.50	0.842	-4.471	1901.00	164.00	-0.591	-5.289
1896.58	211.60	0.778	-4.563	1901.08	162.20	-0.408	-5.509
1896.67	210.70	0.818	-4.686	1901.17	160.40	-0.101	-5.579

1901.25	158.50	0.044	-5.184	1905.75	90.36	0.829	-4.641
1901.33	156.70	0.125	-4.870	1905.83	89.18	0.851	-4.767
1901.42	154.90	0.300	-4.800	1905.92	88.00	0.601	-4.840
1901.50	153.10	0.548	-4.612	1906.00	87.00	0.431	-4.937
1901.58	151.30	0.682	-4.680	1906.08	85.64	0.466	-5.126
1901.67	149.50	0.592	-4.834	1906.17	84.27	0.314	-4.937
1901.75	147.60	0.311	-5.153	1906.25	82.91	0.442	-4.760
1901.83	145.80	-0.082	-5.395	1906.33	81.55	0.714	-4.538
1901.92	144.00	-0.057	-5.583	1906.42	80.18	0.783	-4.418
1902.00	143.00	-0.135	-5.607	1906.50	78.82	0.986	-4.344
1902.08	142.10	0.163	-5.239	1906.58	77.45	0.984	-4.387
1902.17	141.20	0.201	-5.026	1906.67	76.09	0.976	-4.456
1902.25	140.30	-0.038	-4.854	1906.75	74.73	0.803	-4.569
1902.33	139.40	0.170	-4.720	1906.83	73.36	0.803	-4.603
1902.42	138.50	0.349	-4.606	1906.92	72.00	0.416	-4.787
1902.50	137.50	0.337	-4.538	1907.00	71.00	0.139	-5.075
1902.58	136.60	0.485	-4.507	1907.08	69.45	0.321	-5.403
1902.67	135.70	0.663	-4.483	1907.17	67.91	0.710	-5.365
1902.75	134.80	0.809	-4.502	1907.25	66.36	1.128	-4.587
1902.83	133.90	0.835	-4.592	1907.33	64.82	1.325	-4.223
1902.92	133.00	0.584	-4.778	1907.42	63.27	0.824	-4.411
1903.00	132.00	0.459	-4.800	1907.50	61.73	0.677	-4.486
1903.08	130.60	0.525	-4.805	1907.58	60.18	0.520	-4.741
1903.17	129.30	0.529	-4.713	1907.67	58.64	0.401	-4.982
1903.25	127.90	0.306	-4.529	1907.75	57.09	0.312	-5.031
1903.33	126.50	0.390	-4.468	1907.83	55.55	0.170	-5.399
1903.42	125.20	0.580	-4.481	1907.92	54.00	0.351	-5.456
1903.50	123.80	0.662	-4.652	1908.00	53.00	-0.046	-5.468
1903.58	122.50	0.573	-4.799	1908.08	52.09	0.276	-5.208
1903.67	121.10	0.536	-4.883	1908.17	51.18	0.724	-4.900
1903.75	119.70	0.295	-4.900	1908.25	50.27	0.893	-4.632
1903.83	118.40	0.274	-4.996	1908.33	49.36	0.679	-4.569
1903.92	117.00	0.037	-5.247	1908.42	48.45	0.671	-4.591
1904.00	116.00	-0.119	-5.464	1908.50	47.55	0.900	-4.595
1904.08	114.70	-0.214	-5.313	1908.58	46.64	0.874	-4.636
1904.17	113.50	-0.124	-5.054	1908.67	45.73	0.808	-4.783
1904.25	112.20	0.138	-4.767	1908.75	44.82	0.922	-4.948
1904.33	110.90	0.729	-4.538	1908.83	43.91	0.632	-5.211
1904.42	109.60	1.011	-4.435	1908.92	43.00	0.145	-5.578
1904.50	108.40	0.725	-4.621	1909.00	42.00	-0.133	-5.725
1904.58	107.10	0.435	-4.800	1909.08	40.73	-0.152	-5.611
1904.67	105.80	0.431	-4.976	1909.17	39.45	0.164	-5.257
1904.75	104.50	0.550	-5.041	1909.25	38.18	0.470	-5.219
1904.83	103.30	0.265	-5.155	1909.33	36.91	0.549	-5.112
1904.92	102.00	0.113	-5.170	1909.42	35.64	0.758	-4.769
1905.00	101.00	-0.009	-5.120	1909.50	34.36	0.591	-4.729
1905.08	99.82	-0.086	-5.033	1909.58	33.09	0.493	-4.747
1905.17	98.64	-0.742	-5.104	1909.67	31.82	0.739	-4.833
1905.25	97.45	0.175	-4.904	1909.75	30.55	0.703	-5.113
1905.33	96.27	0.520	-4.600	1909.83	29.27	0.258	-5.364
1905.42	95.09	0.513	-4.471	1909.92	28.00	0.316	-5.587
1905.50	93.91	0.618	-4.485	1910.00	27.00	0.036	-5.895
1905.58	92.73	0.667	-4.510	1910.08	25.82	0.105	-5.770
1905.67	91.55	0.730	-4.550	1910.17	24.64	0.279	-5.271

1910.25	23.45	0.398	-4.902
1910.33	22.27	0.658	-4.795
1910.42	21.09	0.759	-4.747
1910.50	19.91	0.715	-4.854
1910.58	18.73	0.464	-4.947
1910.67	17.55	0.572	-5.066
1910.75	16.36	0.591	-5.216
1910.83	15.18	0.083	-5.562
1910.92	14.00	0.091	-5.762
1911.00	13.00	-0.035	-5.512
1911.08	12.00	0.172	-5.274
1911.17	11.00	0.083	-5.142
1911.25	10.00	0.145	-4.996
1911.33	9.00	0.391	-4.914
1911.42	8.00	0.502	-4.666
1911.50	7.00	0.552	-4.492
1911.58	6.00	0.604	-4.706
1911.67	5.00	0.633	-4.874
1911.75	4.00	0.529	-5.170
1911.83	3.00	0.429	-5.346
1911.92	2.00	0.138	-5.626

APPENDIX XVI.

PPL1B CORAL
STABLE ISOTOPE
TIME SERIES (1974-1986)

Date	Depth	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
1974.00	94.00	-0.314	-5.474
1974.08	93.36	-0.186	-5.391
1974.17	92.73	0.057	-5.197
1974.25	92.09	0.498	-4.813
1974.33	91.45	0.707	-4.781
1974.42	90.82	0.815	-4.825
1974.50	90.18	0.592	-4.981
1974.58	89.55	0.349	-5.263
1974.67	88.91	0.091	-5.560
1974.75	88.27	0.096	-5.566
1974.83	87.64	-0.036	-5.695
1974.92	87.00	-0.231	-5.892
1975.00	86.00	-0.328	-5.544
1975.08	85.45	0.275	-5.196
1975.17	84.91	0.832	-4.897
1975.25	84.36	0.940	-5.006
1975.33	83.82	0.953	-5.111
1975.42	83.27	0.565	-5.250
1975.50	82.73	0.276	-5.426
1975.58	82.18	0.000	-5.643
1975.67	81.64	-0.063	-5.677
1975.75	81.09	-0.010	-5.636
1975.83	80.55	-0.135	-5.518
1975.92	80.00	-0.263	-5.385
1976.00	79.00	-0.280	-5.063
1976.08	78.55	0.119	-4.979
1976.17	78.09	0.548	-4.910
1976.25	77.64	0.719	-4.726
1976.33	77.18	0.876	-4.506
1976.42	76.73	0.853	-4.512
1976.50	76.27	0.722	-4.650
1976.58	75.82	0.569	-4.822
1976.67	75.36	0.342	-5.078
1976.75	74.91	0.137	-5.311
1976.83	74.45	0.051	-5.423
1976.92	74.00	-0.053	-5.545
1977.00	73.00	-0.086	-5.567
1977.08	72.64	0.044	-5.375
1977.17	72.27	0.155	-5.184
1977.25	71.91	0.286	-5.002
1977.33	71.55	0.563	-4.843
1977.42	71.18	0.854	-4.677
1977.50	70.82	0.981	-4.610
1977.58	70.45	0.958	-4.637
1977.67	70.09	0.991	-4.649
1977.75			
1977.83			
1977.92			
1978.00			
1978.08			
1978.17			
1978.25			
1978.33			
1978.42			
1978.50			
1978.58			
1978.67			
1978.75			
1978.83			
1978.92			
1979.00			
1979.08			
1979.17			
1979.25			
1979.33			
1979.42			
1979.50			
1979.58			
1979.67			
1979.75			
1979.83			
1979.92			
1980.00			
1980.08			
1980.17			
1980.25			
1980.33			
1980.42			
1980.50			
1980.58			
1980.67			
1980.75			
1980.83			
1980.92			
1981.00			
1981.08			
1981.17			
1981.25			
1981.33			
1981.42			
1981.50			
1981.58			
1981.67			
1981.75			
1981.83			
1981.92			
1982.00			
1982.08			
1982.17			

1982.25	44.64	-0.035	-5.665	1986.75	19.55	-0.241	-4.944
1982.33	44.18	0.210	-5.430	1986.83	19.27	-0.272	-5.075
1982.42	43.73	0.338	-5.170	1986.92	19.00	-0.306	-5.201
1982.50	43.27	0.414	-4.872				
1982.58	42.82	0.444	-4.737				
1982.67	42.36	0.373	-4.866				
1982.75	41.91	0.313	-4.975				
1982.83	41.45	0.294	-5.081				
1982.92	41.00	0.266	-5.196				
1983.00	40.00	-0.045	-5.111				
1983.08	39.55	0.093	-5.064				
1983.17	39.09	0.226	-5.027				
1983.25	38.64	0.313	-4.913				
1983.33	38.18	0.414	-4.778				
1983.42	37.73	0.366	-4.757				
1983.50	37.27	0.224	-4.802				
1983.58	36.82	0.118	-4.879				
1983.67	36.36	0.051	-5.019				
1983.75	35.91	-0.035	-5.159				
1983.83	35.45	-0.174	-5.310				
1983.92	35.00	-0.301	-5.460				
1984.00	34.00	-0.528	-6.093				
1984.08	33.55	-0.334	-5.760				
1984.17	33.09	-0.168	-5.428				
1984.25	32.64	0.107	-5.156				
1984.33	32.18	0.436	-4.883				
1984.42	31.73	0.476	-4.808				
1984.50	31.27	0.361	-4.857				
1984.58	30.82	0.219	-4.930				
1984.67	30.36	-0.022	-5.058				
1984.75	29.91	-0.263	-5.188				
1984.83	29.45	-0.491	-5.334				
1984.92	29.00	-0.721	-5.478				
1985.00	28.00	-0.846	-5.891				
1985.08	27.55	-0.837	-5.940				
1985.17	27.09	-0.860	-6.005				
1985.25	26.64	-0.572	-5.809				
1985.33	26.18	-0.222	-5.565				
1985.42	25.73	0.025	-5.311				
1985.50	25.27	0.241	-5.032				
1985.58	24.82	0.333	-4.897				
1985.67	24.36	0.207	-4.990				
1985.75	23.91	0.079	-5.085				
1985.83	23.45	-0.183	-5.262				
1985.92	23.00	-0.438	-5.440				
1986.00	22.00	-0.686	-6.078				
1986.08	21.73	-0.512	-5.834				
1986.17	21.45	-0.327	-5.588				
1986.25	21.18	-0.120	-5.340				
1986.33	20.91	0.002	-5.135				
1986.42	20.64	-0.077	-5.018				
1986.50	20.36	-0.137	-4.890				
1986.58	20.09	-0.191	-4.746				
1986.67	19.82	-0.219	-4.800				

APPENDIX XVII.

PDB CORAL
STABLE ISOTOPE
TIME SERIES (1968-1986)

Date	Depth	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
1968.00	336.00	-0.640	-5.188
1968.08	334.90	-0.177	-5.170
1968.17	333.80	-0.046	-5.261
1968.25	332.70	-0.164	-5.267
1968.33	331.60	-0.269	-5.239
1968.42	330.50	0.190	-5.069
1968.50	329.50	0.724	-5.012
1968.58	328.40	1.207	-4.951
1968.67	327.30	1.289	-5.022
1968.75	326.20	0.993	-5.076
1968.83	325.10	0.930	-5.095
1968.92	324.00	0.661	-5.239
1969.00	323.00	0.391	-5.048
1969.08	321.50	1.174	-5.158
1969.17	319.90	1.238	-5.242
1969.25	318.40	1.259	-5.183
1969.33	316.80	1.140	-5.316
1969.42	315.30	0.964	-4.995
1969.50	313.70	1.211	-4.849
1969.58	312.20	1.392	-4.677
1969.67	310.60	1.373	-4.622
1969.75	309.10	1.330	-4.705
1969.83	307.50	0.760	-4.822
1969.92	306.00	0.782	-4.831
1970.00	305.00	0.750	-4.902
1970.08	302.70	1.011	-5.087
1970.17	300.50	1.621	-5.164
1970.25	298.20	1.634	-5.179
1970.33	295.90	1.084	-5.125
1970.42	293.60	1.351	-4.718
1970.50	291.40	1.586	-4.775
1970.58	289.10	0.986	-5.011
1970.67	286.80	1.249	-5.113
1970.75	284.50	1.204	-5.042
1970.83	282.30	0.916	-4.981
1970.92	280.00	1.203	-5.402
1971.00	279.00	0.658	-5.506
1971.08	278.20	0.862	-5.332
1971.17	277.40	1.138	-5.145
1971.25	276.50	1.155	-5.075
1971.33	275.70	1.199	-5.006
1971.42	274.90	1.770	-4.733
1971.50	274.10	1.957	-4.715
1971.58	273.30	1.844	-4.776
1971.67	272.50	1.670	-4.787
1971.75	271.60	1.537	-4.743
1971.83	270.80	1.426	-4.725
1971.92	270.00	1.104	-4.988
1972.00	269.00	0.941	-5.011
1972.08	267.60	1.494	-4.981
1972.17	266.30	1.689	-5.083
1972.25	264.90	1.224	-4.963
1972.33	263.50	1.380	-4.981
1972.42	262.20	1.277	-5.281
1972.50	260.80	1.856	-4.884
1972.58	259.50	2.261	-4.526
1972.67	258.10	2.230	-4.422
1972.75	256.70	1.907	-4.572
1972.83	255.40	1.704	-4.579
1972.92	254.00	1.280	-4.602
1973.00	253.00	0.728	-5.008
1973.08	252.10	1.542	-4.882
1973.17	251.20	1.638	-4.893
1973.25	250.30	1.634	-5.020
1973.33	249.40	1.488	-5.032
1973.42	248.50	1.495	-5.070
1973.50	247.50	1.567	-5.138
1973.58	246.60	1.757	-5.062
1973.67	245.70	1.996	-4.847
1973.75	244.80	1.563	-4.846
1973.83	243.90	1.588	-4.754
1973.92	243.00	1.487	-4.839
1974.00	242.00	0.751	-5.066
1974.08	240.30	1.329	-4.922
1974.17	238.50	1.281	-4.943
1974.25	236.80	1.732	-4.982
1974.33	235.10	1.891	-4.897
1974.42	233.40	1.733	-4.770
1974.50	231.60	1.561	-4.576
1974.58	229.90	1.410	-4.830
1974.67	228.20	1.152	-5.076
1974.75	226.50	1.463	-5.071
1974.83	224.70	1.304	-5.057
1974.92	223.00	-0.466	-5.126
1975.00	222.00	-0.881	-5.213
1975.08	220.50	1.083	-5.013
1975.17	219.10	2.002	-4.827
1975.25	217.60	1.652	-4.848
1975.33	216.20	1.879	-4.607
1975.42	214.70	1.531	-4.928
1975.50	213.30	1.807	-4.950
1975.58	211.80	1.758	-5.047
1975.67	210.40	1.042	-5.095
1975.75	208.90	0.637	-5.313
1975.83	207.50	0.462	-5.182
1975.92	206.00	0.302	-5.064
1976.00	205.0	0.283	-5.023
1976.08	204.2	0.569	-4.679
1976.17	203.4	0.805	-4.554

1976.25	202.5	0.935	-4.532	1980.75	127.9	1.375	-5
1976.33	201.7	0.973	-4.559	1980.83	126.5	1.428	-5.121
1976.42	200.9	0.965	-4.594	1980.92	125.0	1.268	-5.216
1976.50	200.1	0.981	-4.716	1981.00	124.0	1.013	-5.26
1976.58	199.3	0.934	-4.672	1981.08	121.4	0.968	-4.921
1976.67	198.5	0.870	-4.67	1981.17	118.7	1.720	-4.886
1976.75	197.6	0.739	-4.711	1981.25	116.1	1.279	-4.921
1976.83	196.8	0.533	-4.786	1981.33	113.5	1.060	-5.023
1976.92	196.0	0.333	-4.876	1981.42	110.8	0.981	-5.091
1977.00	195.0	0.285	-4.895	1981.50	108.2	0.998	-5.371
1977.08	194.5	0.461	-4.925	1981.58	105.5	1.248	-4.82
1977.17	193.9	0.637	-4.945	1981.67	102.9	1.841	-4.514
1977.25	193.4	0.890	-4.832	1981.75	100.3	1.052	-4.697
1977.33	192.8	1.031	-4.786	1981.83	97.6	0.734	-5.047
1977.42	192.3	0.921	-4.881	1981.92	95.0	1.250	-5.153
1977.50	191.7	0.859	-4.957	1982.00	94.0	0.873	-5.22
1977.58	191.2	0.825	-5.025	1982.08	93.5	0.949	-5.089
1977.67	190.6	0.767	-5.128	1982.17	92.9	1.040	-4.967
1977.75	190.1	0.701	-5.247	1982.25	92.4	1.283	-4.905
1977.83	189.5	0.696	-5.333	1982.33	91.8	1.491	-4.857
1977.92	189.0	0.697	-5.417	1982.42	91.3	1.627	-4.852
1978.00	188.0	0.602	-5.302	1982.50	90.7	1.785	-4.776
1978.08	185.4	0.363	-4.998	1982.58	90.2	1.977	-4.639
1978.17	182.7	1.258	-4.715	1982.67	89.6	1.935	-4.488
1978.25	180.1	1.250	-4.758	1982.75	89.1	1.805	-4.304
1978.33	177.5	0.833	-4.854	1982.83	88.6	1.504	-4.475
1978.42	174.8	0.801	-5.115	1982.92	88.0	1.174	-4.683
1978.50	172.2	0.879	-5.223	1983.00	87.0	0.809	-5.085
1978.58	169.5	0.666	-5.270	1983.08	85.0	1.256	-5.069
1978.67	166.9	0.647	-4.973	1983.17	83.0	1.150	-5.229
1978.75	164.3	1.553	-4.937	1983.25	81.0	1.266	-5.174
1978.83	161.6	1.406	-4.949	1983.33	79.0	1.388	-5.149
1978.92	159.0	0.801	-5.220	1983.42	77.0	1.396	-4.956
1979.00	158.0	1.330	-5.118	1983.50	75.0	1.804	-4.676
1979.08	156.5	1.040	-5.242	1983.58	73.0	0.859	-5.08
1979.17	155.1	1.434	-5.154	1983.67	71.0	1.105	-5.197
1979.25	153.6	1.324	-5.164	1983.75	69.0	0.684	-5.464
1979.33	152.2	1.092	-5.215	1983.83	67.0	1.064	-5.545
1979.42	150.7	1.264	-5.019	1983.92	65.0	0.666	-5.747
1979.50	149.3	1.825	-4.801	1984.00	64.00	0.359	-5.931
1979.58	147.8	1.912	-4.846	1984.08	62.64	0.836	-5.293
1979.67	146.4	1.231	-4.996	1984.17	61.27	1.459	-4.930
1979.75	144.9	1.216	-5.046	1984.25	59.91	1.679	-4.707
1979.83	143.5	1.268	-4.82	1984.33	58.55	1.304	-4.774
1979.92	142.0	1.465	-5.071	1984.42	57.18	0.808	-4.995
1980.00	141.0	1.007	-5.027	1984.50	55.82	1.002	-5.060
1980.08	139.5	1.285	-5.004	1984.58	54.45	0.922	-5.054
1980.17	138.1	1.051	-5.039	1984.67	53.09	0.847	-5.079
1980.25	136.6	1.273	-4.991	1984.75	51.73	1.108	-5.210
1980.33	135.2	1.798	-4.772	1984.83	50.36	0.937	-5.380
1980.42	133.7	1.848	-4.797	1984.92	49.00	0.259	-5.404
1980.50	132.3	1.365	-4.876	1985.00	48.00	0.152	-5.276
1980.58	130.8	1.137	-4.921	1985.08	47.27	0.326	-5.197
1980.67	129.4	1.056	-4.948	1985.17	46.55	0.487	-5.117

1985.25	45.82	0.603	-5.035
1985.33	45.09	0.527	-4.943
1985.42	44.36	0.819	-4.893
1985.50	43.64	0.942	-4.826
1985.58	42.91	0.868	-4.746
1985.67	42.18	0.622	-4.846
1985.75	41.45	0.612	-4.841
1985.83	40.73	0.604	-4.848
1985.92	40.00	0.494	-4.909
1986.00	39.00	0.516	-5.028
1986.08	37.55	0.631	-5.150
1986.17	36.09	0.912	-5.197
1986.25	34.64	1.002	-5.344
1986.33	33.18	0.718	-5.173
1986.42	31.73	1.093	-4.846
1986.50	30.27	0.956	-4.864
1986.58	28.82	0.769	-4.841
1986.67	27.36	0.961	-4.745
1986.75	25.91	1.075	-4.696
1986.83	24.45	0.807	-4.746
1986.92	23.00	0.612	-4.592

APPENDIX XVIII.

BUN1A CORAL
STABLE ISOTOPE
TIME SERIES (1962-1989)

Date	Depth	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$				
1962.00	435.00	-0.779	-5.078	1965.75	380.70	-0.272	-5.046
1962.08	433.70	-0.640	-5.110	1965.83	379.40	-0.554	-5.092
1962.17	432.50	-0.561	-5.162	1965.92	378.00	-0.797	-5.048
1962.25	431.20	-0.430	-5.130	1966.00	377.00	-0.935	-5.079
1962.33	429.90	-0.274	-5.197	1966.08	375.50	-0.854	-4.992
1962.42	428.60	-0.328	-5.252	1966.17	374.10	-0.415	-5.015
1962.50	427.40	-0.433	-5.216	1966.25	372.60	-0.456	-4.981
1962.58	426.10	-0.467	-5.065	1966.33	371.20	-0.285	-5.052
1962.67	424.80	-0.533	-5.082	1966.42	369.70	-0.343	-5.108
1962.75	423.50	-0.613	-5.206	1966.50	368.30	-0.343	-5.072
1962.83	422.30	-0.683	-5.344	1966.58	366.80	-0.351	-5.077
1962.92	421.00	-0.719	-5.339	1966.67	365.40	-0.312	-5.154
1963.00	420.00	-0.936	-5.414	1966.75	363.90	-0.417	-5.197
1963.08	418.60	-0.830	-5.400	1966.83	362.50	-0.796	-5.327
1963.17	417.30	-0.615	-5.350	1966.92	361.00	-0.961	-5.298
1963.25	415.90	-0.440	-5.180	1967.00	360.00	-0.995	-5.341
1963.33	414.50	-1.388	-5.097	1967.08	358.50	-0.666	-5.061
1963.42	413.20	-0.606	-5.183	1967.17	357.10	-0.604	-5.233
1963.50	411.80	-0.483	-5.117	1967.25	355.60	-0.461	-5.111
1963.58	410.50	-0.253	-5.158	1967.33	354.20	-0.259	-5.090
1963.67	409.10	-0.428	-5.121	1967.42	352.70	-0.275	-5.095
1963.75	407.70	-0.561	-5.165	1967.50	351.30	-0.223	-5.064
1963.83	406.40	-0.628	-5.127	1967.58	349.80	-0.251	-4.993
1963.92	405.00	-0.603	-5.071	1967.67	348.40	-0.436	-5.004
1964.00	404.00	-0.784	-5.030	1967.75	346.90	-0.619	-5.091
1964.08	403.10	-0.682	-5.002	1967.83	345.50	-0.679	-5.167
1964.17	402.20	-0.499	-4.973	1967.92	344.00	-0.574	-5.099
1964.25	401.30	-0.479	-5.057	1968.00	343.00	-0.734	-5.154
1964.33	400.40	-0.557	-5.045	1968.08	342.50	-0.644	-5.116
1964.42	399.50	-0.625	-5.046	1968.17	341.90	-0.637	-5.083
1964.50	398.50	-0.647	-5.118	1968.25	341.40	-0.498	-5.079
1964.58	397.60	-0.549	-5.196	1968.33	340.80	-0.366	-5.083
1964.67	396.70	-0.486	-5.223	1968.42	340.30	-0.301	-5.107
1964.75	395.80	-0.566	-5.256	1968.50	339.70	-0.259	-5.134
1964.83	394.90	-0.688	-5.319	1968.58	339.20	-0.272	-5.168
1964.92	394.00	-0.813	-5.222	1968.67	338.60	-0.343	-5.164
1965.00	393.00	-1.120	-5.301	1968.75	338.10	-0.392	-5.140
1965.08	391.60	-0.924	-5.256	1968.83	337.50	-0.440	-5.151
1965.17	390.30	-0.649	-5.237	1968.92	337.00	-0.536	-5.163
1965.25	388.90	-0.537	-5.337	1969.00	337.00	-0.571	-5.204
1965.33	387.50	-0.444	-5.147	1969.08	336.10	-0.342	-5.065
1965.42	386.20	-0.151	-5.094	1969.17	335.20	-0.219	-5.052
1965.50	384.80	-0.568	-5.079	1969.25	334.30	-0.272	-5.118
1965.58	383.50	-1.136	-5.095	1969.33	333.40	-0.498	-5.150
1965.67	382.10	-0.373	-5.063	1969.42	332.50	-0.464	-5.161
				1969.50	331.50	-0.189	-5.158
				1969.58	330.60	-0.028	-5.179
				1969.67	329.70	-0.181	-5.254
				1969.75	328.80	-0.406	-5.323
				1969.83	327.90	-0.327	-5.336
				1969.92	327.00	-0.418	-5.417
				1970.00	326.00	-0.570	-5.455
				1970.08	324.70	-0.435	-5.350
				1970.17	323.50	-0.254	-5.239

1970.25	322.20	-0.312	-5.253	1974.75	252.60	-0.662	-5.467
1970.33	320.90	-0.257	-5.279	1974.83	250.80	-0.813	-5.341
1970.42	319.60	-0.061	-5.310	1974.92	249.00	-0.823	-5.327
1970.50	318.40	-0.133	-5.328	1975.00	248.00	-0.875	-5.396
1970.58	317.10	-0.167	-5.402	1975.08	246.70	-0.829	-5.315
1970.67	315.80	-0.045	-5.395	1975.17	245.50	-0.806	-5.359
1970.75	314.50	-0.156	-5.414	1975.25	244.20	-0.845	-5.475
1970.83	313.30	-0.116	-5.414	1975.33	242.90	-0.807	-5.403
1970.92	312.00	-0.130	-5.439	1975.42	241.60	-0.590	-5.302
1971.00	311.00	-0.352	-5.555	1975.50	240.40	-0.490	-5.336
1971.08	309.50	-0.288	-5.677	1975.58	239.10	-0.495	-5.437
1971.17	307.90	-0.082	-5.514	1975.67	237.80	-0.635	-5.481
1971.25	306.40	-0.111	-5.529	1975.75	236.50	-0.763	-5.534
1971.33	304.80	-0.115	-5.397	1975.83	235.30	-0.808	-5.575
1971.42	303.30	-0.041	-5.431	1975.92	234.00	-0.838	-5.578
1971.50	301.70	-0.190	-5.254	1976.00	233.00	-1.226	-5.612
1971.58	300.20	-0.253	-5.344	1976.08	231.40	-1.029	-5.552
1971.67	298.60	-0.262	-5.411	1976.17	229.70	-0.870	-5.391
1971.75	297.10	-0.433	-5.459	1976.25	228.10	-0.736	-5.376
1971.83	295.50	-0.693	-5.471	1976.33	226.50	-0.737	-5.323
1971.92	294.00	-0.832	-5.573	1976.42	224.80	-0.758	-5.252
1972.00	293.00	-0.905	-5.432	1976.50	223.20	-0.775	-5.201
1972.08	291.50	-0.601	-5.296	1976.58	221.50	-0.755	-5.134
1972.17	290.10	-0.448	-5.135	1976.67	219.90	-0.755	-5.136
1972.25	288.60	-0.442	-5.114	1976.75	218.30	-0.638	-5.110
1972.33	287.20	-0.347	-5.002	1976.83	216.60	-0.743	-5.260
1972.42	285.70	-0.309	-4.941	1976.92	215.00	-0.838	-5.283
1972.50	284.30	-0.288	-4.937	1977.00	214.00	-0.923	-5.357
1972.58	282.80	-0.285	-4.870	1977.08	212.40	-0.788	-5.452
1972.67	281.40	-0.402	-4.909	1977.17	210.70	-0.799	-5.509
1972.75	279.90	-0.512	-4.903	1977.25	209.10	-0.705	-5.439
1972.83	278.50	-0.548	-4.794	1977.33	207.50	-0.732	-5.214
1972.92	277.00	-0.525	-4.735	1977.42	205.80	-0.672	-5.183
1973.00	276.00	-0.794	-4.860	1977.50	204.20	-0.666	-5.147
1973.08	275.50	-0.747	-4.780	1977.58	202.50	-0.513	-5.161
1973.17	274.90	-0.650	-4.723	1977.67	200.90	-0.364	-5.212
1973.25	274.40	-0.547	-4.876	1977.75	199.30	-0.413	-5.056
1973.33	273.80	-0.600	-5.009	1977.83	197.60	-0.410	-5.065
1973.42	273.30	-0.549	-5.131	1977.92	196.00	-0.360	-5.163
1973.50	272.70	-0.511	-5.212	1978.00	195.00	-0.586	-5.085
1973.58	272.20	-0.465	-5.254	1978.08	193.50	-0.498	-5.131
1973.67	271.60	-0.399	-5.266	1978.17	191.90	-0.444	-5.060
1973.75	271.10	-0.510	-5.256	1978.25	190.40	-0.495	-5.003
1973.83	270.50	-0.644	-5.381	1978.33	188.80	-0.524	-4.948
1973.92	270.00	-0.730	-5.522	1978.42	187.30	-0.538	-5.006
1974.00	269.00	-1.084	-5.521	1978.50	185.70	-0.445	-5.111
1974.08	267.20	-1.030	-5.529	1978.58	184.20	-0.358	-5.122
1974.17	265.40	-0.833	-5.337	1978.67	182.60	-0.556	-5.152
1974.25	263.50	-0.757	-5.289	1978.75	181.10	-0.582	-5.090
1974.33	261.70	-0.986	-5.119	1978.83	179.50	-0.614	-5.251
1974.42	259.90	-0.618	-5.135	1978.92	178.00	-0.627	-5.349
1974.50	258.10	-0.596	-5.061	1979.00	177.00	-0.754	-5.191
1974.58	256.30	-0.618	-5.126	1979.08	175.60	-0.442	-5.273
1974.67	254.50	-0.547	-5.268	1979.17	174.30	-0.384	-5.206

1979.25	172.90	-0.432	-5.157	1983.75	99.09	-0.689	-5.187
1979.33	171.50	-0.446	-5.090	1983.83	97.55	-0.824	-5.270
1979.42	170.20	-0.686	-5.206	1983.92	96.00	-1.063	-5.331
1979.50	168.80	-1.260	-5.142	1984.00	95.00	-1.070	-5.476
1979.58	167.50	-1.103	-5.137	1984.08	93.82	-0.972	-5.409
1979.67	166.10	-0.588	-5.037	1984.17	92.64	-1.055	-5.197
1979.75	164.70	-0.501	-5.281	1984.25	91.45	-1.013	-5.184
1979.83	163.40	-0.527	-5.337	1984.33	90.27	-0.804	-5.206
1979.92	162.00	-0.545	-5.179	1984.42	89.09	-0.644	-5.195
1980.00	161.00	-0.717	-5.221	1984.50	87.91	-0.685	-5.279
1980.08	159.50	-0.576	-5.267	1984.58	86.73	-0.567	-5.236
1980.17	157.90	-0.558	-5.314	1984.67	85.55	-0.548	-5.200
1980.25	156.40	-0.581	-5.156	1984.75	84.36	-0.580	-5.234
1980.33	154.80	-0.544	-5.104	1984.83	83.18	-0.618	-5.208
1980.42	153.30	-0.484	-5.057	1984.92	82.00	-0.783	-5.190
1980.50	151.70	-0.449	-5.118	1985.00	81.00	-0.794	-5.315
1980.58	150.20	-0.389	-5.088	1985.08	79.64	-0.733	-5.327
1980.67	148.60	-0.439	-5.063	1985.17	78.27	-0.638	-5.260
1980.75	147.10	-0.583	-5.136	1985.25	76.91	-0.661	-5.146
1980.83	145.50	-0.613	-5.165	1985.33	75.55	-0.683	-5.273
1980.92	144.00	-0.561	-5.399	1985.42	74.18	-0.665	-5.225
1981.00	143.00	-0.944	-5.427	1985.50	72.82	-0.722	-5.162
1981.08	141.70	-0.690	-5.556	1985.58	71.45	-0.736	-5.122
1981.17	140.50	-0.665	-5.484	1985.67	70.09	-0.705	-5.047
1981.25	139.20	-0.724	-5.182	1985.75	68.73	-0.720	-5.062
1981.33	137.90	-0.657	-5.202	1985.83	67.36	-0.816	-5.079
1981.42	136.60	-0.703	-5.102	1985.92	66.00	-0.904	-5.154
1981.50	135.40	-0.633	-5.129	1986.00	65.00	-0.953	-5.377
1981.58	134.10	-0.515	-5.250	1986.08	63.82	-0.908	-5.375
1981.67	132.80	-0.414	-5.168	1986.17	62.64	-0.898	-5.403
1981.75	131.50	-0.490	-5.189	1986.25	61.45	-0.886	-5.375
1981.83	130.30	-0.796	-5.285	1986.33	60.27	-0.808	-5.288
1981.92	129.00	-0.870	-5.364	1986.42	59.09	-0.671	-5.254
1982.00	128.00	-1.024	-5.521	1986.50	57.91	-0.608	-5.167
1982.08	126.70	-0.787	-5.511	1986.58	56.73	-0.896	-5.172
1982.17	125.50	-0.623	-5.433	1986.67	55.55	-0.978	-5.165
1982.25	124.20	-0.581	-5.287	1986.75	54.36	-0.792	-5.182
1982.33	122.90	-0.657	-5.353	1986.83	53.18	-0.718	-5.152
1982.42	121.60	-0.672	-5.389	1986.92	52.00	-0.773	-5.181
1982.50	120.40	-0.562	-5.319	1987.00	51.00	-0.852	-5.299
1982.58	119.10	-0.501	-5.304	1987.08	49.45	-0.776	-5.300
1982.67	117.80	-0.529	-5.132	1987.17	47.91	-0.758	-5.255
1982.75	116.50	-0.527	-5.051	1987.25	46.36	-0.636	-5.100
1982.83	115.30	-0.593	-4.943	1987.33	44.82	-0.670	-5.023
1982.92	114.00	-0.833	-4.716	1987.42	43.27	-0.650	-5.104
1983.00	113.00	-0.850	-4.909	1987.50	41.73	-0.597	-5.018
1983.08	111.50	-0.683	-5.031	1987.58	40.18	-0.552	-5.054
1983.17	109.90	-0.665	-4.953	1987.67	38.64	-0.658	-5.015
1983.25	108.40	-0.545	-4.922	1987.75	37.09	-0.600	-5.053
1983.33	106.80	-0.559	-4.765	1987.83	35.55	-0.594	-5.287
1983.42	105.30	-0.709	-4.812	1987.92	34.00	-0.695	-5.447
1983.50	103.70	-0.732	-4.969	1988.00	33.00	-0.836	-5.371
1983.58	102.20	-0.474	-5.100	1988.08	31.82	-0.714	-5.295
1983.67	100.60	-0.488	-5.156	1988.17	30.64	-0.718	-5.271

1988.25	29.45	-0.730	-5.177
1988.33	28.27	-0.759	-5.129
1988.42	27.09	-0.708	-5.283
1988.50	25.91	-0.673	-5.278
1988.58	24.73	-0.694	-5.212
1988.67	23.55	-0.777	-5.075
1988.75	22.36	-0.793	-5.162
1988.83	21.18	-0.722	-5.289
1988.92	20.00	-0.958	-5.335
1989.00	19.00	-1.077	-5.411
1989.08	18.00	-0.880	-5.438
1989.17	17.00	-0.700	-5.357
1989.25	16.00	-0.471	-5.415
1989.33	15.00	-0.405	-5.391
1989.42	14.00	-1.005	-5.328
1989.50	13.00	-1.571	-5.276
1989.58	12.00	-1.140	-5.473
1989.67	11.00	-0.600	-5.425
1989.75	10.00	-0.594	-5.309
1989.83	9.00	-0.545	-5.496
1989.92	8.00	-0.796	-5.545

APPENDIX XIX.

BUNIA CORAL
STABLE ISOTOPE
TIME SERIES (1901-1913)

Date	Depth	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
1901.00	224.00	-0.789	-5.352
1901.08	222.50	-0.636	-5.151
1901.17	220.90	-0.399	-5.080
1901.25	219.40	-0.349	-4.934
1901.33	217.80	-0.106	-4.851
1901.42	216.30	0.182	-4.816
1901.50	214.70	0.086	-4.948
1901.58	213.20	-0.065	-5.041
1901.67	211.60	-0.245	-5.203
1901.75	210.10	-0.305	-5.201
1901.83	208.50	-0.437	-5.220
1901.92	207.00	-0.582	-5.241
1902.00	206.00	-0.702	-5.248
1902.08	204.90	-0.683	-5.282
1902.17	203.80	-0.590	-5.301
1902.25	202.70	-0.435	-5.200
1902.33	201.60	-0.396	-5.121
1902.42	200.50	-0.283	-5.061
1902.50	199.50	-0.327	-4.998
1902.58	198.40	-0.299	-4.917
1902.67	197.30	-0.247	-4.871
1902.75	196.20	-0.246	-4.800
1902.83	195.10	-0.184	-4.862
1902.92	194.00	-0.127	-4.815
1903.00	193.00	-0.262	-4.852
1903.08	191.20	-0.304	-4.945
1903.17	189.40	-0.234	-4.781
1903.25	187.50	-0.163	-4.804
1903.33	185.70	0.062	-4.685
1903.42	183.90	-0.251	-4.721
1903.50	182.10	-0.759	-4.874
1903.58	180.30	-0.152	-4.976
1903.67	178.50	-0.267	-5.190
1903.75	176.60	-0.256	-5.206
1903.83	174.80	-0.401	-5.269
1903.92	173.00	-0.578	-5.502
1904.00	172.00	-0.628	-5.439
1904.08	171.10	-0.499	-5.441
1904.17	170.20	-0.431	-5.358
1904.25	169.30	-0.337	-5.278
1904.33	168.40	-0.235	-5.164
1904.42	167.50	-0.157	-5.087
1904.50	166.50	-0.151	-5.065
1904.58	165.60	-0.187	-5.072
1904.67	164.70	-0.200	-5.096
1904.75	163.80	-0.210	-5.142
1904.83	162.90	-0.173	-5.153
1904.92	162.00	-0.312	-5.156
1905.00	161.00	-0.344	-5.076
1905.08	159.80	-0.188	-4.996
1905.17	158.60	-0.160	-4.822
1905.25	157.50	-0.169	-4.723
1905.33	156.30	-0.159	-4.753
1905.42	155.10	-0.266	-4.850
1905.50	153.90	-0.285	-4.943
1905.58	152.70	-0.251	-4.990
1905.67	151.50	-0.253	-4.990
1905.75	150.40	-0.276	-4.986
1905.83	149.20	-0.315	-4.979
1905.92	148.00	-0.374	-4.951
1906.00	147.00	-0.500	-4.910
1906.08	145.50	-0.354	-4.895
1906.17	143.90	-0.299	-4.917
1906.25	142.40	-0.200	-4.933
1906.33	140.80	-0.212	-4.960
1906.42	139.30	-0.230	-4.974
1906.50	137.70	-0.283	-4.931
1906.58	136.20	-0.223	-4.965
1906.67	134.60	-0.453	-5.144
1906.75	133.10	-0.397	-5.247
1906.83	131.50	-0.693	-5.194
1906.92	130.00	-0.688	-5.235
1907.00	129.00	-0.856	-5.256
1907.08	127.80	-0.495	-5.205
1907.17	126.60	-0.382	-4.967
1907.25	125.50	-0.379	-4.960
1907.33	124.30	-0.441	-4.923
1907.42	123.10	-0.226	-4.909
1907.50	121.90	-0.038	-4.868
1907.58	120.70	-0.112	-4.779
1907.67	119.50	-0.194	-4.790
1907.75	118.40	-0.262	-4.882
1907.83	117.20	-0.418	-4.968
1907.92	116.00	-0.562	-4.984
1908.00	115.00	-0.663	-5.055
1908.08	113.50	-0.534	-5.095
1908.17	112.10	-0.573	-5.229
1908.25	110.60	-0.384	-5.073
1908.33	109.20	-0.547	-5.156
1908.42	107.70	-0.343	-5.128
1908.50	106.30	-0.343	-5.141
1908.58	104.80	-0.253	-5.096
1908.67	103.40	-0.209	-5.046
1908.75	101.90	-0.020	-5.041
1908.83	100.50	-0.275	-5.019
1908.92	99.00	-0.560	-5.135
1909.00	98.00	-0.743	-5.270
1909.08	96.73	-0.718	-5.225
1909.17	95.45	-0.621	-5.190

1909.25	94.18	-0.464	-5.002	1913.75	16.64	-0.053	-4.793
1909.33	92.91	-0.461	-5.009	1913.83	14.82	0.244	-4.826
1909.42	91.64	-0.526	-4.968	1913.92	13.00	-0.048	-4.672
1909.50	90.36	-0.505	-5.025				
1909.58	89.09	-0.471	-5.050				
1909.67	87.82	-0.344	-4.981				
1909.75	86.55	-0.320	-4.985				
1909.83	85.27	-0.347	-4.997				
1909.92	84.00	-0.339	-5.103				
1910.00	83.00	-0.683	-5.092				
1910.08	81.55	-0.647	-5.168				
1910.17	80.09	-0.667	-5.172				
1910.25	78.64	-0.506	-5.108				
1910.33	77.18	-0.340	-5.038				
1910.42	75.73	-0.184	-5.057				
1910.50	74.27	-0.215	-5.032				
1910.58	72.82	-0.188	-5.057				
1910.67	71.36	-0.323	-5.064				
1910.75	69.91	-0.540	-5.100				
1910.83	68.45	-0.445	-5.319				
1910.92	67.00	-0.671	-5.379				
1911.00	66.00	-0.766	-5.439				
1911.08	64.82	-0.550	-5.254				
1911.17	63.64	-0.468	-5.099				
1911.25	62.45	-0.316	-5.042				
1911.33	61.27	-0.262	-4.999				
1911.42	60.09	-0.214	-5.109				
1911.50	58.91	-0.046	-5.021				
1911.58	57.73	-0.023	-4.941				
1911.67	56.55	-0.154	-5.003				
1911.75	55.36	-0.210	-5.050				
1911.83	54.18	-0.261	-4.971				
1911.92	53.00	-0.415	-5.021				
1912.00	52.00	-0.623	-5.006				
1912.08	50.36	-0.341	-4.858				
1912.17	48.73	-0.319	-4.834				
1912.25	47.09	-0.194	-4.757				
1912.33	45.45	-0.246	-4.854				
1912.42	43.82	-0.338	-5.024				
1912.50	42.18	-0.151	-4.929				
1912.58	40.55	-0.282	-4.938				
1912.67	38.91	-0.337	-5.095				
1912.75	37.27	-0.298	-5.117				
1912.83	35.64	-0.420	-5.082				
1912.92	34.00	-0.402	-4.916				
1913.00	33.00	-0.441	-4.909				
1913.08	31.18	-0.126	-4.988				
1913.17	29.36	-0.009	-5.062				
1913.25	27.55	-0.107	-5.016				
1913.33	25.73	-0.010	-5.018				
1913.42	23.91	-0.110	-4.994				
1913.50	22.09	-0.200	-5.000				
1913.58	20.27	-0.290	-5.040				
1913.67	18.45	-0.088	-4.855				

APPENDIX XX.

PMB1A CORAL
STABLE ISOTOPE
TIME SERIES (1960-1989)

Date	Depth	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$				
1960.00	298.00	-1.067	-4.820	1963.75	255.20	-0.687	-4.930
1960.08	297.10	-0.756	-4.719	1963.83	254.10	-0.797	-4.880
1960.17	296.20	-0.565	-4.781	1963.92	253.00	-0.894	-4.878
1960.25	295.30	-0.595	-4.868	1964.00	252.00	-0.974	-4.703
1960.33	294.40	-0.650	-4.940	1964.08	250.80	-0.729	-4.629
1960.42	293.50	-0.687	-4.967	1964.17	249.60	-0.436	-4.649
1960.50	292.50	-0.665	-4.991	1964.25	248.50	-0.340	-4.682
1960.58	291.60	-0.662	-5.095	1964.33	247.30	-0.404	-4.691
1960.67	290.70	-0.766	-5.250	1964.42	246.10	-0.488	-4.798
1960.75	289.80	-0.851	-5.259	1964.50	244.90	-0.615	-4.891
1960.83	288.90	-0.776	-5.097	1964.58	243.70	-0.739	-4.862
1960.92	288.00	-1.157	-4.801	1964.67	242.50	-0.554	-4.866
1961.00	287.00	-1.267	-4.683	1964.75	241.40	-0.743	-4.988
1961.08	286.30	-0.914	-4.626	1964.83	240.20	-0.934	-4.950
1961.17	285.50	-0.619	-4.662	1964.92	239.00	-0.939	-4.909
1961.25	284.80	-0.398	-4.751	1965.00	238.00	-1.150	-4.539
1961.33	284.10	-0.302	-4.837	1965.08	236.60	-0.905	-4.297
1961.42	283.40	-0.374	-4.934	1965.17	235.30	-0.429	-4.146
1961.50	282.60	-0.459	-5.010	1965.25	233.90	-0.442	-4.303
1961.58	281.90	-0.544	-5.060	1965.33	232.50	-0.639	-4.450
1961.67	281.20	-0.819	-5.093	1965.42	231.20	-0.564	-4.634
1961.75	280.50	-0.838	-5.033	1965.50	229.80	-0.831	-4.732
1961.83	279.70	-0.807	-5.002	1965.58	228.50	-1.048	-4.860
1961.92	279.00	-0.782	-5.062	1965.67	227.10	-1.033	-4.924
1962.00	278.00	-1.019	-5.033	1965.75	225.70	-1.244	-4.856
1962.08	276.90	-0.908	-4.902	1965.83	224.40	-1.181	-4.719
1962.17	275.80	-0.308	-4.756	1965.92	223.00	-1.193	-4.517
1962.25	274.70	-0.596	-4.860	1966.00	222.00	-1.292	-4.595
1962.33	273.60	-0.532	-4.960	1966.08	221.00	-0.745	-4.548
1962.42	272.50	-0.600	-5.050	1966.17	220.00	-0.623	-4.509
1962.50	271.50	-0.667	-5.038	1966.25	219.00	-0.652	-4.757
1962.58	270.40	-0.726	-4.962	1966.33	218.00	-0.705	-4.724
1962.67	269.30	-0.716	-5.000	1966.42	217.00	-0.726	-4.813
1962.75	268.20	-1.131	-5.198	1966.50	216.00	-0.512	-4.776
1962.83	267.10	-1.096	-5.169	1966.58	215.00	-0.709	-4.898
1962.92	266.00	-1.180	-4.867	1966.67	214.00	-0.965	-4.983
1963.00	265.00	-1.324	-4.805	1966.75	213.00	-1.023	-4.736
1963.08	263.90	-1.121	-4.722	1966.83	212.00	-0.908	-4.596
1963.17	262.80	-0.516	-4.721	1966.92	211.00	-0.939	-4.428
1963.25	261.70	-0.433	-4.900	1967.00	210.00	-1.039	-4.278
1963.33	260.60	-0.669	-5.432	1967.08	208.70	-0.594	-4.292
1963.42	259.50	-1.016	-5.970	1967.17	207.50	-0.394	-4.175
1963.50	258.50	-0.819	-5.479	1967.25	206.20	-0.297	-4.209
1963.58	257.40	-0.732	-5.204	1967.33	204.90	-0.298	-4.324
1963.67	256.30	-0.725	-5.009	1967.42	203.60	-0.382	-4.497
				1967.50	202.40	-0.406	-4.595
				1967.58	201.10	-0.345	-4.557
				1967.67	199.80	-0.735	-4.646
				1967.75	198.50	-0.671	-4.625
				1967.83	197.30	-0.578	-4.508
				1967.92	196.00	-0.770	-4.442
				1968.00	195.00	-1.101	-4.346
				1968.08	194.10	-0.852	-4.290
				1968.17	193.20	-0.551	-4.516

1968.25	192.30	-0.245	-4.637	1972.75	139.50	-1.083	-4.996
1968.33	191.40	-0.213	-4.688	1972.83	138.30	-1.165	-4.981
1968.42	190.50	-0.301	-4.725	1972.92	137.00	-1.407	-4.856
1968.50	189.50	-0.423	-4.749	1973.00	136.00	-1.479	-4.690
1968.58	188.60	-0.556	-4.739	1973.08	135.40	-1.026	-4.607
1968.67	187.70	-0.686	-4.721	1973.17	134.70	-0.691	-4.581
1968.75	186.80	-0.775	-4.741	1973.25	134.10	-0.494	-4.631
1968.83	185.90	-0.817	-4.712	1973.33	133.50	-0.567	-4.743
1968.92	185.00	-0.637	-4.581	1973.42	132.80	-0.625	-4.837
1969.00	184.00	-1.280	-4.607	1973.50	132.20	-0.538	-4.853
1969.08	183.30	-1.045	-4.498	1973.58	131.50	-0.554	-4.885
1969.17	182.50	-0.679	-4.479	1973.67	130.90	-0.594	-4.914
1969.25	181.80	-0.296	-4.520	1973.75	130.30	-0.715	-4.907
1969.33	181.10	-0.097	-4.588	1973.83	129.60	-0.719	-4.881
1969.42	180.40	-0.103	-4.635	1973.92	129.00	-0.645	-4.838
1969.50	179.60	-0.102	-4.630	1974.00	128.00	-0.814	-4.847
1969.58	178.90	-0.070	-4.575	1974.08	127.10	-0.505	-4.568
1969.67	178.20	-0.262	-4.592	1974.17	126.20	-0.507	-4.412
1969.75	177.50	-0.273	-4.591	1974.25	125.30	-0.242	-4.319
1969.83	176.70	-0.350	-4.603	1974.33	124.40	0.145	-4.336
1969.92	176.00	-0.596	-4.640	1974.42	123.50	0.281	-4.386
1970.00	175.00	-0.833	-4.772	1974.50	122.50	0.193	-4.485
1970.08	173.80	-0.731	-4.745	1974.58	121.60	-0.059	-4.641
1970.17	172.60	-0.445	-4.574	1974.67	120.70	-0.499	-4.813
1970.25	171.50	-0.555	-4.461	1974.75	119.80	-0.952	-4.964
1970.33	170.30	-0.522	-4.452	1974.83	118.90	-0.976	-4.885
1970.42	169.10	-0.301	-4.540	1974.92	118.00	-1.281	-5.013
1970.50	167.90	-0.057	-4.584	1975.00	117.00	-1.319	-4.931
1970.58	166.70	-0.396	-4.658	1975.08	116.30	-1.140	-4.724
1970.67	165.50	-0.206	-4.603	1975.17	115.50	-1.009	-4.708
1970.75	164.40	-0.514	-4.736	1975.25	114.80	-0.907	-4.792
1970.83	163.20	-0.711	-4.807	1975.33	114.10	-0.807	-4.832
1970.92	162.00	-0.971	-4.661	1975.42	113.40	-0.698	-4.848
1971.00	161.00	-1.641	-4.528	1975.50	112.60	-0.600	-4.864
1971.08	160.20	-1.356	-4.466	1975.58	111.90	-0.521	-4.884
1971.17	159.40	-0.904	-4.494	1975.67	111.20	-0.800	-4.994
1971.25	158.50	-0.639	-4.534	1975.75	110.50	-0.909	-4.966
1971.33	157.70	-0.513	-4.561	1975.83	109.70	-1.057	-4.948
1971.42	156.90	-0.298	-4.577	1975.92	109.00	-1.316	-5.006
1971.50	156.10	-0.402	-4.662	1976.00	108.00	-1.803	-5.081
1971.58	155.30	-0.525	-4.750	1976.08	107.50	-1.577	-4.946
1971.67	154.50	-0.687	-4.750	1976.17	107.10	-1.345	-4.811
1971.75	153.60	-0.774	-4.736	1976.25	106.60	-1.175	-4.699
1971.83	152.80	-0.765	-4.742	1976.33	106.20	-1.020	-4.589
1971.92	152.00	-0.809	-4.689	1976.42	105.70	-0.873	-4.540
1972.00	151.00	-1.077	-4.770	1976.50	105.30	-0.726	-4.526
1972.08	149.70	-1.379	-4.855	1976.58	104.80	-0.659	-4.545
1972.17	148.50	-1.463	-4.596	1976.67	104.40	-0.721	-4.623
1972.25	147.20	-1.023	-4.500	1976.75	103.90	-0.783	-4.694
1972.33	145.90	-0.410	-4.754	1976.83	103.50	-0.911	-4.749
1972.42	144.60	-0.196	-4.866	1976.92	103.00	-1.038	-4.806
1972.50	143.40	-0.415	-4.856	1977.00	102.00	-1.602	-4.932
1972.58	142.10	-0.766	-4.684	1977.08	101.50	-1.594	-4.981
1972.67	140.80	-0.942	-4.930	1977.17	100.90	-1.571	-5.018

1977.25	100.40	-1.474	-4.970	1981.75	62.27	-1.057	-4.814
1977.33	99.82	-1.315	-4.895	1981.83	61.64	-1.103	-4.794
1977.42	99.27	-1.000	-4.747	1981.92	61.00	-1.156	-4.835
1977.50	98.73	-0.787	-4.653	1982.00	60.00	-1.419	-4.921
1977.58	98.18	-0.640	-4.599	1982.08	59.36	-1.377	-4.870
1977.67	97.64	-0.734	-4.665	1982.17	58.73	-1.288	-4.797
1977.75	97.09	-0.942	-4.789	1982.25	58.09	-1.125	-4.696
1977.83	96.55	-1.092	-4.854	1982.33	57.45	-0.958	-4.600
1977.92	96.00	-1.245	-4.916	1982.42	56.82	-0.797	-4.556
1978.00	95.00	-1.472	-4.988	1982.50	56.18	-0.624	-4.664
1978.08	94.09	-1.439	-5.045	1982.58	55.55	-0.680	-4.757
1978.17	93.18	-1.446	-4.901	1982.67	54.91	-0.802	-4.848
1978.25	92.27	-1.336	-4.677	1982.75	54.27	-0.823	-4.923
1978.33	91.36	-1.191	-4.618	1982.83	53.64	-0.901	-4.975
1978.42	90.45	-1.023	-4.645	1982.92	53.00	-1.001	-5.012
1978.50	89.55	-0.952	-4.763	1983.00	52.00	-1.134	-4.914
1978.58	88.64	-0.985	-4.905	1983.08	51.27	-0.987	-4.850
1978.67	87.73	-0.958	-4.950	1983.17	50.55	-0.948	-4.772
1978.75	86.82	-0.773	-4.939	1983.25	49.82	-0.985	-4.694
1978.83	85.91	-0.674	-4.886	1983.33	49.09	-1.180	-4.643
1978.92	85.00	-1.195	-4.848	1983.42	48.36	-0.847	-4.610
1979.00	84.00	-1.529	-4.934	1983.50	47.64	-0.725	-4.655
1979.08	83.36	-1.336	-4.792	1983.58	46.91	-0.846	-4.779
1979.17	82.73	-1.148	-4.712	1983.67	46.18	-1.108	-4.975
1979.25	82.09	-0.944	-4.715	1983.75	45.45	-1.265	-5.071
1979.33	81.45	-0.904	-4.799	1983.83	44.73	-1.367	-5.078
1979.42	80.82	-0.860	-4.884	1983.92	44.00	-1.426	-4.974
1979.50	80.18	-0.725	-4.946	1984.00	43.00	-1.426	-5.041
1979.58	79.55	-0.805	-4.993	1984.08	42.00	-0.949	-4.558
1979.67	78.91	-0.951	-5.034	1984.17	41.00	-0.803	-4.438
1979.75	78.27	-1.118	-5.081	1984.25	40.00	-0.930	-4.395
1979.83	77.64	-1.293	-5.139	1984.33	39.00	-0.795	-4.334
1979.92	77.00	-1.469	-5.204	1984.42	38.00	-0.581	-4.547
1980.00	76.00	-1.759	-5.291	1984.50	37.00	-1.686	-4.944
1980.08	75.36	-1.603	-5.258	1984.58	36.00	-1.532	-4.557
1980.17	74.73	-1.524	-5.200	1984.67	35.00	-0.093	-4.670
1980.25	74.09	-1.571	-5.108	1984.75	34.00	-0.018	-4.705
1980.33	73.45	-1.369	-4.985	1984.83	33.00	-0.454	-4.929
1980.42	72.82	-1.093	-4.857	1984.92	32.00	-0.802	-4.916
1980.50	72.18	-0.610	-4.710	1985.00	31.00	-1.362	-4.948
1980.58	71.55	-0.495	-4.665	1985.08	30.45	-1.299	-4.845
1980.67	70.91	-0.511	-4.659	1985.17	29.91	-1.201	-4.752
1980.75	70.27	-0.699	-4.677	1985.25	29.36	-0.614	-4.714
1980.83	69.64	-0.950	-4.753	1985.33	28.82	-0.252	-4.711
1980.92	69.00	-1.245	-4.867	1985.42	28.27	-0.335	-4.794
1981.00	68.00	-1.644	-4.630	1985.50	27.73	-0.492	-4.867
1981.08	67.36	-1.567	-4.719	1985.58	27.18	-0.804	-4.937
1981.17	66.73	-1.366	-4.759	1985.67	26.64	-0.921	-4.984
1981.25	66.09	-0.931	-4.715	1985.75	26.09	-0.947	-5.019
1981.33	65.45	-0.937	-4.792	1985.83	25.55	-1.076	-5.076
1981.42	64.82	-0.950	-4.867	1985.92	25.00	-1.205	-5.135
1981.50	64.18	-0.866	-4.904	1986.00	24.00	-1.688	-4.751
1981.58	63.55	-0.936	-4.927	1986.08	23.64	-1.548	-4.770
1981.67	62.91	-1.038	-4.933	1986.17	23.27	-1.417	-4.793

1986.25	22.91	-1.272	-4.807
1986.33	22.55	-1.051	-4.781
1986.42	22.18	-0.819	-4.754
1986.50	21.82	-0.729	-4.774
1986.58	21.45	-0.778	-4.840
1986.67	21.09	-0.811	-4.904
1986.75	20.73	-0.851	-4.936
1986.83	20.36	-0.900	-4.961
1986.92	20.00	-0.954	-4.989
1987.00	19.00	-0.967	-4.881
1987.08	18.45	-0.871	-4.838
1987.17	17.91	-0.767	-4.800
1987.25	17.36	-0.642	-4.853
1987.33	16.82	-0.479	-4.862
1987.42	16.27	-0.217	-4.768
1987.50	15.73	-0.034	-4.768
1987.58	15.18	0.098	-4.858
1987.67	14.64	0.087	-4.875
1987.75	14.09	0.012	-4.865
1987.83	13.55	-0.082	-4.885
1987.92	13.00	-0.184	-4.905
1988.00	12.00	-0.522	-5.031
1988.08	11.55	-0.479	-4.905
1988.17	11.09	-0.466	-4.790
1988.25	10.64	-0.254	-4.632
1988.33	10.18	0.010	-4.450
1988.42	9.73	0.074	-4.492
1988.50	9.27	0.038	-4.672
1988.58	8.82	-0.060	-4.836
1988.67	8.36	-0.300	-5.005
1988.75	7.91	-0.517	-5.157
1988.83	7.46	-0.648	-5.204
1988.92	7.00	-0.791	-5.256
1989.00	6.00	-0.971	-5.087
1989.08	5.73	-0.672	-4.997
1989.17	5.46	-0.367	-4.902
1989.25	5.18	-0.049	-4.799
1989.33	4.91	0.180	-4.754
1989.42	4.64	0.216	-4.841
1989.50	4.36	0.284	-4.919
1989.58	4.09	0.392	-4.995
1989.67	3.82	0.229	-5.064
1989.75	3.55	-0.054	-5.133
1989.83	3.27	-0.310	-5.205
1989.92	3.00	-0.553	-5.278

APPENDIX XXI.

PMB1A CORAL
STABLE ISOTOPE
TIME SERIES (1880-1904)

Date	Depth	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$
1880.00	329.00	-2.217	-4.801
1880.08	327.80	-1.680	-4.647
1880.17	326.60	-0.839	-4.526
1880.25	325.50	-0.585	-4.642
1880.33	324.30	-0.755	-4.805
1880.42	323.10	-0.902	-4.884
1880.50	321.90	-0.851	-4.909
1880.58	320.70	-0.902	-4.959
1880.67	319.50	-1.011	-5.029
1880.75	318.40	-1.311	-5.152
1880.83	317.20	-1.331	-5.059
1880.92	316.00	-1.307	-4.772
1881.00	315.00	-1.768	-4.518
1881.08	314.10	-1.428	-4.501
1881.17	313.20	-0.818	-4.553
1881.25	312.30	-0.636	-4.640
1881.33	311.40	-0.422	-4.653
1881.42	310.50	-0.617	-4.700
1881.50	309.50	-0.686	-4.708
1881.58	308.60	-0.728	-4.630
1881.67	307.70	-0.672	-4.589
1881.75	306.80	-0.739	-4.703
1881.83	305.90	-0.969	-4.761
1881.92	305.00	-1.000	-4.831
1882.00	304.00	-1.366	-4.818
1882.08	302.60	-1.316	-4.530
1882.17	301.30	-1.208	-4.435
1882.25	299.90	-0.696	-4.607
1882.33	298.50	-0.541	-4.719
1882.42	297.20	-0.677	-4.829
1882.50	295.80	-0.774	-4.960
1882.58	294.50	-0.892	-5.115
1882.67	293.10	-0.962	-5.167
1882.75	291.70	-1.266	-5.119
1882.83	290.40	-1.648	-5.091
1882.92	289.00	-1.928	-4.948
1883.00	288.00	-2.456	-4.859
1883.08	287.20	-2.004	-4.745
1883.17	286.40	-1.388	-4.824
1883.25	285.50	-0.991	-4.911
1883.33	284.70	-0.837	-5.002
1883.42	283.90	-0.838	-5.163
1883.50	283.10	-0.939	-5.088
1883.58	282.30	-1.123	-5.088
1883.67	281.50	-1.149	-5.079
1883.75	280.60	-1.128	-5.094
1883.83	279.80	-1.079	-5.144
1883.92	279.00	-1.232	-5.197
1884.00	278.00	-1.598	-5.280
1884.08	276.60	-1.268	-5.081
1884.17	275.30	-1.426	-4.906
1884.25	273.90	-1.108	-4.828
1884.33	272.50	-0.913	-4.848
1884.42	271.20	-0.931	-5.006
1884.50	269.80	-0.985	-5.057
1884.58	268.50	-0.903	-4.977
1884.67	267.10	-0.736	-5.001
1884.75	265.70	-1.017	-5.098
1884.83	264.40	-1.290	-5.199
1884.92	263.00	-1.508	-5.112
1885.00	262.00	-1.764	-4.982
1885.08	261.00	-1.535	-4.768
1885.17	260.00	-1.324	-4.703
1885.25	259.00	-0.848	-4.907
1885.33	258.00	-0.770	-4.942
1885.42	257.00	-1.165	-4.923
1885.50	256.00	-1.148	-4.954
1885.58	255.00	-1.161	-4.985
1885.67	254.00	-1.175	-5.019
1885.75	253.00	-1.297	-5.091
1885.83	252.00	-1.199	-4.995
1885.92	251.00	-1.316	-4.934
1886.00	250.00	-1.795	-4.679
1886.08	248.80	-1.548	-4.632
1886.17	247.60	-0.949	-4.662
1886.25	246.50	-0.799	-4.753
1886.33	245.30	-0.863	-4.879
1886.42	244.10	-1.089	-4.930
1886.50	242.90	-1.154	-4.953
1886.58	241.70	-1.228	-4.939
1886.67	240.50	-1.348	-4.895
1886.75	239.40	-1.468	-5.015
1886.83	238.20	-1.554	-5.141
1886.92	237.00	-1.571	-5.252
1887.00	236.00	-1.688	-5.221
1887.08	234.90	-1.623	-4.839
1887.17	233.80	-1.534	-4.743
1887.25	232.70	-1.202	-4.748
1887.33	231.60	-0.886	-4.799
1887.42	230.50	-0.879	-4.793
1887.50	229.50	-1.011	-4.943
1887.58	228.40	-1.056	-4.973
1887.67	227.30	-1.129	-4.954
1887.75	226.20	-1.128	-4.819
1887.83	225.10	-1.127	-4.784
1887.92	224.00	-1.566	-4.815
1888.00	223.00	-1.862	-4.909
1888.08	221.60	-1.481	-4.572
1888.17	220.30	-1.131	-4.358

1888.25	218.90	-0.741	-4.354	1892.75	151.20	-1.212	-5.043
1888.33	217.50	-0.649	-4.543	1892.83	150.10	-1.558	-4.989
1888.42	216.20	-0.965	-4.617	1892.92	149.00	-1.361	-4.591
1888.50	214.80	-0.912	-4.701	1893.00	148.00	-1.700	-4.544
1888.58	213.50	-1.268	-5.034	1893.08	146.60	-1.300	-4.581
1888.67	212.10	-1.600	-5.490	1893.17	145.30	-0.859	-4.569
1888.75	210.70	-1.705	-5.491	1893.25	143.90	-0.548	-4.469
1888.83	209.40	-1.863	-5.472	1893.33	142.50	-0.626	-4.677
1888.92	208.00	-2.064	-5.240	1893.42	141.20	-0.691	-4.834
1889.00	207.00	-2.184	-5.173	1893.50	139.80	-0.712	-4.938
1889.08	205.80	-1.625	-4.515	1893.58	138.50	-0.850	-5.026
1889.17	204.60	-1.169	-4.477	1893.67	137.10	-0.853	-4.976
1889.25	203.50	-0.940	-4.545	1893.75	135.70	-1.143	-5.034
1889.33	202.30	-0.897	-4.617	1893.83	134.40	-1.844	-5.125
1889.42	201.10	-0.957	-4.700	1893.92	133.00	-1.920	-4.987
1889.50	199.90	-1.015	-4.825	1894.00	132.00	-2.726	-5.042
1889.58	198.70	-1.177	-4.856	1894.08	130.90	-2.578	-4.976
1889.67	197.50	-1.455	-4.830	1894.17	129.80	-1.554	-4.882
1889.75	196.40	-1.630	-5.035	1894.25	128.70	-0.801	-4.912
1889.83	195.20	-1.786	-5.101	1894.33	127.60	-0.669	-4.976
1889.92	194.00	-1.989	-4.927	1894.42	126.50	-0.816	-5.039
1890.00	193.00	-1.919	-4.592	1894.50	125.50	-0.911	-5.057
1890.08	191.70	-1.453	-4.291	1894.58	124.40	-0.836	-5.027
1890.17	190.50	-0.965	-4.277	1894.67	123.30	-0.914	-5.021
1890.25	189.20	-0.880	-4.439	1894.75	122.20	-1.392	-5.116
1890.33	187.90	-0.629	-4.489	1894.83	121.10	-1.234	-5.026
1890.42	186.60	-0.582	-4.454	1894.92	120.00	-1.050	-4.869
1890.50	185.40	-0.712	-4.598	1895.00	119.00	-1.911	-4.762
1890.58	184.10	-0.745	-4.717	1895.08	118.20	-1.509	-4.771
1890.67	182.80	-0.847	-4.727	1895.17	117.40	-0.961	-4.644
1890.75	181.50	-1.023	-4.816	1895.25	116.50	-0.681	-4.637
1890.83	180.30	-1.434	-4.922	1895.33	115.70	-0.491	-4.706
1890.92	179.00	-1.383	-4.796	1895.42	114.90	-0.533	-4.683
1891.00	178.00	-1.951	-4.772	1895.50	114.10	-0.884	-4.849
1891.08	176.50	-1.519	-4.592	1895.58	113.30	-0.861	-4.895
1891.17	175.10	-0.869	-4.562	1895.67	112.50	-0.793	-4.833
1891.25	173.60	-0.684	-4.537	1895.75	111.60	-0.761	-4.844
1891.33	172.20	-0.667	-4.627	1895.83	110.80	-0.838	-5.018
1891.42	170.70	-0.761	-4.734	1895.92	110.00	-1.186	-5.221
1891.50	169.30	-0.792	-4.880	1896.00	109.00	-1.495	-5.239
1891.58	167.80	-0.978	-5.027	1896.08	108.00	-1.385	-5.009
1891.67	166.40	-1.202	-4.999	1896.17	107.00	-1.020	-4.687
1891.75	164.90	-1.187	-5.015	1896.25	106.00	-0.597	-4.346
1891.83	163.50	-1.193	-4.961	1896.33	105.00	0.277	-4.686
1891.92	162.00	-1.529	-4.929	1896.42	104.00	0.066	-4.814
1892.00	161.00	-1.731	-4.663	1896.50	103.00	-0.646	-4.979
1892.08	159.90	-1.352	-4.644	1896.58	102.00	-0.525	-4.847
1892.17	158.80	-0.975	-4.680	1896.67	101.00	-0.394	-4.949
1892.25	157.70	-0.837	-4.745	1896.75	100.00	-0.519	-4.944
1892.33	156.60	-0.798	-4.827	1896.83	99.00	-1.041	-5.065
1892.42	155.50	-0.907	-4.917	1896.92	98.00	-1.043	-4.881
1892.50	154.50	-1.037	-4.902	1897.00	97.00	-1.254	-4.696
1892.58	153.40	-0.913	-4.934	1897.08	95.73	-0.943	-4.567
1892.67	152.30	-0.825	-4.952	1897.17	94.45	-0.610	-4.719

1897.25	93.18	-0.636	-4.794	1901.75	40.00	-1.912	-5.009
1897.33	91.91	-0.908	-4.831	1901.83	39.00	-2.156	-4.927
1897.42	90.64	-0.996	-4.875	1901.92	38.00	-2.620	-4.686
1897.50	89.36	-1.107	-4.938	1902.00	37.00	-3.041	-4.667
1897.58	88.09	-1.126	-4.989	1902.08	36.36	-2.429	-4.627
1897.67	86.82	-1.208	-5.084	1902.17	35.73	-1.839	-4.607
1897.75	85.55	-1.342	-5.131	1902.25	35.09	-0.812	-4.602
1897.83	84.27	-1.389	-5.090	1902.33	34.45	-0.803	-4.716
1897.92	83.00	-1.539	-4.906	1902.42	33.82	-0.456	-4.814
1898.00	82.00	-1.836	-4.839	1902.50	33.18	-0.667	-4.827
1898.08	81.00	-0.765	-4.756	1902.58	32.55	-0.778	-4.869
1898.17	80.00	-0.347	-4.746	1902.67	31.91	-0.922	-4.922
1898.25	79.00	-0.315	-4.735	1902.75	31.27	-1.275	-5.036
1898.33	78.00	-0.771	-4.873	1902.83	30.64	-1.515	-5.109
1898.42	77.00	-0.904	-4.963	1902.92	30.00	-1.783	-5.156
1898.50	76.00	-0.780	-5.003	1903.00	29.00	-2.354	-5.103
1898.58	75.00	-0.882	-5.072	1903.08	27.91	-2.216	-5.013
1898.67	74.00	-1.052	-5.170	1903.17	26.82	-2.152	-4.841
1898.75	73.00	-1.411	-5.332	1903.25	25.73	-1.863	-4.790
1898.83	72.00	-1.499	-5.233	1903.33	24.64	-0.916	-4.773
1898.92	71.00	-1.539	-5.015	1903.42	23.55	-0.577	-4.826
1899.00	70.00	-2.173	-4.820	1903.50	22.45	-0.488	-4.886
1899.08	69.27	-1.405	-4.662	1903.58	21.36	-0.762	-4.977
1899.17	68.55	-0.898	-4.683	1903.67	20.27	-1.477	-5.057
1899.25	67.82	-0.468	-4.801	1903.75	19.18	-1.158	-5.018
1899.33	67.09	-0.264	-4.883	1903.83	18.09	-1.301	-5.175
1899.42	66.36	-0.435	-4.986	1903.92	17.00	-1.862	-5.144
1899.50	65.64	-0.482	-5.031	1904.00	16.00	-2.456	-5.015
1899.58	64.91	-0.686	-5.021	1904.08	15.00	-1.866	-4.816
1899.67	64.18	-0.811	-5.002	1904.17	14.00	-2.076	-4.611
1899.75	63.45	-0.904	-5.042	1904.25	13.00	-2.248	-4.677
1899.83	62.73	-0.993	-5.056	1904.33	12.00	-1.935	-4.679
1899.92	62.00	-1.103	-4.996	1904.42	11.00	-1.264	-4.923
1900.00	61.00	-1.576	-5.109	1904.50	10.00	-1.399	-4.972
1900.08	60.00	-1.371	-4.920	1904.58	9.00	-1.472	-5.053
1900.17	59.00	-1.050	-4.702	1904.67	8.00	-1.262	-5.114
1900.25	58.00	-1.059	-4.541	1904.75	7.00	-1.268	-5.271
1900.33	57.00	-0.450	-4.610	1904.83	6.00	-1.387	-5.443
1900.42	56.00	-0.172	-4.703	1904.92	5.00	-2.033	-5.402
1900.50	55.00	-0.541	-4.835				
1900.58	54.00	-0.391	-4.968				
1900.67	53.00	-0.386	-4.942				
1900.75	52.00	-0.798	-5.060				
1900.83	51.00	-1.111	-5.200				
1900.92	50.00	-1.539	-5.196				
1901.00	49.00	-1.955	-4.893				
1901.08	48.00	-1.085	-4.587				
1901.17	47.00	-0.812	-4.374				
1901.25	46.00	-0.404	-4.491				
1901.33	45.00	-0.285	-4.638				
1901.42	44.00	-1.014	-4.929				
1901.50	43.00	-1.379	-4.997				
1901.58	42.00	-1.624	-5.088				
1901.67	41.00	-1.470	-5.080				

APPENDIX XXII.

WEEKLY SALINITY MEASUREMENTS AT KAPOPOSANG ISLAND 1992-93

250ml water samples collected on SCUBA. Conductivity measured with a SPER Scientific high-precision conductivity meter calibrated against KCL and working sea water standards (precision = 0.08 s). Practical salinity computed using algorithms supplied in Fofonoff and Millard, 1983.

Fofonoff, N.P., and Millard, R.C., 1983. Algorithms for the Computation of Fundamental Properties of Seawater, UNESCO Technical Papers in Marine Science, No. 44, pp. 53.

Week	Date	pS 1m	pS 3m	pS 10m	pS 20m
1	8/26/92	35.71			
2	9/1/92	35.58	35.58		
3	9/8/92	35.62	35.62	35.62	35.82
4	9/14/92	35.48	35.54	35.56	
5	9/20/92	35.66	35.64	35.65	35.65
6					
7	10/4/92	35.48	35.48	35.55	
8	10/11/92	35.44	35.35	35.42	35.43
9	10/18/92	35.55	35.68	35.53	35.61
10	10/25/09	35.54	35.69	35.55	35.63
11	11/1/92	35.41	35.48	35.42	35.49
12	11/6/92	35.41	35.42	35.49	35.44
13	11/15/09	35.15	35.15	35.23	
14	11/22/09	35.06	35.00	34.93	35.02
15	11/29/09	35.09	35.07	35.07	35.09
16	12/4/92	34.80	34.90	34.80	34.87
17	12/13/09	34.04	33.99	34.12	34.25
18	12/20/09	34.19	34.33	34.19	34.32
19	12/27/92	34.10	34.10	34.03	34.10
20	1/3/93	33.96	33.89	33.96	33.96
21	1/10/93	33.12	33.12	33.12	33.40
22	1/17/93	33.20	33.41	34.52	34.60
23					
24					
25	2/10/93	33.45	33.44	33.45	33.61
26	2/15/93	33.58	33.63	33.52	33.58
27	2/21/93	33.12	33.38	33.63	
28	2/28/93	33.13	33.12	33.03	33.07
29	3/7/93	32.26	32.27	32.40	32.27
30	3/14/93	32.59	32.85	34.15	34.22
31	3/21/93	32.66	32.66	32.59	32.72

Week	Date	pS 1m	pS 3m	pS 10m	pS 20m
32	3/30/93	33.70	32.92	33.14	33.83
33	4/6/93	33.27	33.12	33.52	34.00
34	4/15/93	33.60	33.52	33.70	33.79
35	4/20/93	33.26	33.26	33.51	34.21
36	4/26/93	33.52	33.72	34.86	35.08
37	5/1/93	33.92	34.13	33.86	33.92
38	5/11/93	34.52	34.62		34.69
39	5/18/93	34.92	34.81	34.85	34.97
40	5/24/93	34.43	34.52	34.68	34.88
41	6/1/93	35.24	35.1	35.11	35.24
42					
43					
44	6/22/93	35.04		35.12	35.11
45					
46	7/9/93	35.39	35.29	35.30	35.55
47					
48					
49	7/25/93	35.29	35.25	35.18	35.21
50	8/1/93	35.26	35.33	35.32	35.30

APPENDIX XXIII.

SEAWATER $\delta^{18}\text{O}$ (δ_w) MEASUREMENTS AT 3m FROM KAPOPOSANG IS.

Week	Date	Sample	δ_w
1	8/26/92	KAP 1.3	-0.058
2	9/1/92	KAP 2.3	0.088
4	9/14/92	KAP 4.3	-0.106
5	9/20/92	KAP 5.3	0.114
6	10/4/92	KAP 6.3	-0.096
8	10/11/92	KAP 8.3	-0.003
10	10/25/09	KAP 10.3	0.021
12	11/6/92	KAP 12.3	-0.147
13	11/15/09	KAP 13.3	-0.060
14	11/22/09	KAP 14.3	-0.233
15	11/29/09	KAP 15.3	0.086
16	12/4/92	KAP 16.3	-0.079
17	12/13/09	KAP 17.3	-0.239
18	12/20/09	KAP 18.3	-0.199
20	1/3/93	KAP 20.3	-0.392
21	1/10/93	KAP 21.3	-0.658
22	1/17/93	KAP 22.3	-0.541

Seawater $\delta^{18}\text{O}$ measured on a VG Prism gas-source mass spectrometer after 8 hours of CO_2 equilibration (after Epstein and Mayeda, 1953) at the UCB/LBL Center for Isotope Geochemistry. Measured values corrected against the TW-1 laboratory standard. Precision on the measurement of TW-1 for this analysis is $\pm 0.11\text{‰}$.

APPENDIX XXIV.

2-HOURLY SST MEASUREMENTS AT 4m DEPTH AT KAPOPOSANG IS.

Measurements made with a Ryan Instruments Tempmentor data-logging thermometer (Redmond, WA). Precision on SST is $\pm 0.01^{\circ}\text{C}$. Time series is in three deployments, with the date and time of the first measurement in the series as:

SST#1: 8/26/92, 10:00

SST#2: 1/17/93, 15:00

SST#3: 5/18/93, 14:00

Series given in vertical columns, arranged left to right in each page.

	27.3	28.1	26.5	26.5	27.8	27.7	28.5
#1	27.1	27.6	26.7	26.7	27.7	27.6	27.9
33.8	27.6	26.7	26.7	26.8	27.6	27.9	27.7
35.6	27.5	28.1	26.9	26.9	27.5	27.7	28.0
27.3	27.5	28.1	26.7	26.9	27.6	28.1	27.4
26.9	27.6	28.1	26.6	27.0	27.3	28.2	27.3
27.0	27.0	27.9	26.6	27.0	27.4	28.4	27.7
26.5	27.7	27.7	26.7	27.0	27.3	28.8	27.8
26.2	27.6	27.4	26.5	27.0	27.3	28.9	27.9
26.9	27.5	27.6	26.3	27.2	27.3	29.3	27.7
26.3	27.1	27.7	26.2	27.2	27.6	29.3	28.5
26.9	27.1	27.6	26.4	27.3	27.3	29.0	28.1
26.9	27.6	28.0	26.3	27.3	27.5	29.0	28.0
26.9	27.5	27.3	26.0	27.3	27.3	28.9	27.9
27.1	27.7	26.5	25.7	27.3	27.3	28.9	27.7
27.7	27.7	25.4	25.7	27.3	27.2	28.8	27.7
28.3	27.3	25.6	25.4	27.3	26.7	28.8	27.8
28.3	27.8	25.8	25.9	27.3	25.9	28.8	27.7
28.5	27.3	26.0	25.8	27.3	25.9	28.8	27.7
28.3	27.2	26.6	25.9	27.3	26.0	28.5	27.9
28.1	27.3	26.5	25.8	27.3	26.7	28.5	28.0
28.1	27.3	25.7	26.0	27.3	26.7	28.7	28.1
27.6	27.3	25.8	25.8	27.3	26.9	28.5	28.1
27.6	26.9	26.2	26.0	27.6	27.6	28.1	28.1
28.2	27.5	26.4	26.1	27.7	26.9	28.0	28.4
28.3	27.9	26.8	26.3	27.7	27.3	28.3	27.7
28.7	28.0	26.5	26.3	27.6	27.5	27.9	27.8
27.8	28.0	26.3	26.3	27.5	27.3	28.0	27.4
28.3	27.3	26.5	26.1	27.6	27.3	28.1	27.7
29.6	27.7	25.8	26.1	27.6	27.1	27.9	27.7
28.8	27.7	26.4	26.2	27.6	27.3	27.7	26.9
28.5	27.6	26.3	26.1	27.6	27.2	28.0	27.6
28.5	27.3	26.3	26.1	27.3	27.3	28.1	27.3
28.3	27.6	26.2	26.2	27.6	27.4	28.0	27.1
27.3	27.5	26.2	26.3	27.6	27.7	28.5	26.6
27.0	27.8	26.3	26.5	27.6	27.7	28.4	26.8
27.0	28.0	26.5	26.7	27.7	27.7	28.4	26.8

27.3	27.3	27.4	28.9	27.9	28.5	27.3	28.0
27.6	27.3	27.2	29.1	28.3	28.4	27.3	27.8
26.9	27.8	27.2	28.9	27.8	28.4	27.3	28.1
26.7	28.0	27.3	28.3	28.0	28.7	27.3	28.0
26.7	27.7	27.2	27.5	28.0	28.8	27.3	28.1
26.7	27.5	27.3	27.3	28.1	28.8	27.3	27.9
26.9	27.5	27.7	27.6	28.2	28.8	27.2	27.6
27.3	27.8	27.5	27.7	28.2	28.8	27.3	27.4
27.0	27.7	27.5	27.7	27.9	28.4	26.9	27.7
26.7	27.7	27.3	28.0	28.1	28.6	26.9	27.7
26.9	27.5	27.2	27.9	27.9	28.7	26.7	27.6
26.9	27.7	26.8	27.9	28.1	28.6	26.8	27.6
26.9	28.0	27.2	28.2	28.1	28.7	26.9	26.9
26.9	28.4	26.9	28.5	28.1	28.9	27.0	27.9
26.9	28.7	26.8	28.5	28.2	29.3	27.0	28.1
26.9	28.4	26.8	28.4	28.2	29.3	27.0	28.0
26.9	28.3	27.3	27.7	28.3	29.1	26.9	27.8
26.9	28.2	27.6	27.5	28.4	28.9	27.1	27.7
26.7	28.1	27.0	27.3	28.3	28.8	27.2	27.7
27.0	28.0	27.3	27.3	28.3	28.6	27.3	28.0
27.0	27.8	27.1	27.3	28.3	28.4	27.3	28.0
26.9	28.1	26.9	27.7	28.2	28.5	27.4	27.9
26.7	28.1	27.3	27.7	28.6	28.4	27.6	27.8
26.8	28.2	26.8	27.7	28.2	28.4	27.5	27.8
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26.9	28.2	26.4	28.1	28.5	28.4	27.7	27.8
26.7	28.1	26.6	27.9	28.9	27.9	27.7	27.9
26.8	28.2	26.7	27.9	29.0	27.7	27.6	28.1
26.9	28.2	27.6	27.7	29.0	28.8	27.7	27.2
26.9	28.1	27.3	27.3	29.1	28.1	27.8	27.3
27.0	28.3	26.9	27.8	29.1	27.9	27.9	26.8
27.0	28.3	27.1	28.2	28.9	28.0	28.1	26.9
27.1	28.1	26.9	28.1	29.1	27.9	28.0	27.7
26.9	28.1	27.0	28.1	29.1	27.8	28.0	27.3
26.9	27.9	27.1	28.1	28.9	28.0	27.6	27.7
26.7	28.1	27.1	28.2	28.9	28.2	27.9	27.7
26.9	28.5	27.2	28.2	28.9	28.5	28.1	27.8
26.9	28.4	26.8	28.4	28.9	28.4	27.9	27.8
26.9	28.4	26.9	28.2	28.7	28.4	27.7	27.7
26.9	28.4	27.0	28.2	28.9	28.2	27.7	27.8
27.0	28.3	26.9	28.2	28.8	28.7	28.0	28.1
27.0	28.1	27.3	28.2	29.4	28.3	27.7	27.8
26.9	28.2	27.2	28.3	28.9	28.3	28.1	27.8
26.7	27.9	27.5	28.2	29.3	28.3	28.1	28.0
26.7	27.5	28.5	28.3	28.9	28.3	28.0	27.8
26.7	27.8	28.2	28.2	28.9	28.2	28.0	27.8
26.7	27.9	27.9	28.2	28.9	28.1	28.0	27.8
26.6	27.7	27.5	28.4	28.9	28.3	27.8	28.1
26.6	27.8	28.5	28.5	28.9	27.8	27.9	28.3
26.5	28.0	28.5	28.4	28.9	27.9	27.8	28.4
26.6	27.8	28.5	28.2	28.7	28.0	27.7	28.2
26.9	27.3	28.4	28.2	28.8	28.0	27.7	28.1
27.0	28.5	28.2	28.5	28.7	27.1	27.7	28.1

28.1	29.3	28.8	29.1	29.3	29.3	30.1	29.5
28.0	29.4	28.6	29.2	29.3	29.4	30.0	29.7
28.1	29.4	28.9	29.3	28.3	29.4	29.7	29.5
28.1	29.4	28.6	29.1	28.8	29.6	29.7	29.6
28.1	29.3	28.8	29.8	29.3	29.3	29.9	29.6
28.1	29.2	28.7	29.1	28.9	29.4	29.7	29.7
28.8	29.0	28.7	29.3	29.3	29.4	29.8	29.6
29.0	29.0	28.9	29.1	29.3	29.4	29.7	29.4
28.5	29.0	28.9	29.1	29.6	29.4	29.7	29.5
28.8	29.0	29.0	29.1	29.6	29.5	29.7	29.3
28.8	28.9	29.0	29.1	29.9	29.3	29.9	29.0
28.7	28.9	29.0	29.2	29.4	29.4	29.9	29.3
28.9	29.1	28.9	29.1	29.1	29.7	29.9	29.7
28.7	29.1	28.9	29.1	29.3	29.8	29.8	29.8
28.4	29.1	29.0	29.3	29.3	29.7	29.7	29.8
28.2	29.3	28.9	30.1	29.4	29.7	29.7	29.9
28.2	29.1	28.9	29.4	29.4	29.9	29.7	30.1
28.2	29.1	28.9	29.3	29.4	29.6	29.7	29.9
28.1	29.1	29.0	29.4	29.7	29.7	29.7	29.3
28.7	28.9	29.1	29.1	29.8	29.7	29.8	29.4
27.5	28.9	29.0	29.3	29.7	29.6	29.8	29.3
28.9	28.9	29.1	29.3	29.7	29.5	29.8	29.3
29.1	28.9	28.9	29.2	29.6	29.5	29.7	29.3
28.9	28.7	28.9	29.2	29.7	29.4	29.9	29.3
28.7	28.8	28.9	29.2	29.7	29.5	29.8	29.3
28.7	28.9	28.8	29.1	29.4	29.8	29.8	29.5
28.6	28.9	28.9	29.3	29.5	29.9	29.4	29.8
28.5	28.9	28.9	29.5	29.6	30.1	29.3	29.4
28.6	29.0	28.9	29.5	29.6	29.9	29.7	29.5
28.5	28.9	28.9	29.3	29.4	29.9	29.8	29.9
28.6	28.8	29.1	29.2	29.6	29.8	29.9	29.4
29.1	28.8	29.3	29.1	29.6	29.6	29.9	29.7
29.0	28.8	29.4	28.8	29.9	29.7	29.9	29.4
29.0	28.8	29.6	29.3	29.8	29.4	30.1	29.3
29.2	28.7	29.6	29.2	29.5	29.6	29.8	28.7
29.1	28.7	28.9	28.9	29.7	29.7	29.9	29.4
28.9	28.9	29.1	29.3	29.6	29.7	29.9	29.7
29.0	28.9	28.9	29.1	29.5	29.6	29.8	29.8
28.6	28.6	29.0	29.3	29.4	29.7	29.6	29.7
28.9	28.9	28.9	29.6	29.5	30.0	29.7	29.7
28.7	28.9	28.9	29.6	29.3	30.1	29.4	29.5
28.6	28.9	29.0	29.5	29.3	29.9	29.7	29.7
28.7	29.0	29.1	29.3	29.4	29.8	29.7	29.7
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29.6	28.9	29.1	29.1	29.7	29.6	29.9	29.2
29.4	28.9	29.1	29.1	29.7	29.7	29.7	29.2
28.9	29.0	29.1	29.3	29.6	29.7	29.6	29.5
29.4	28.9	29.0	29.3	29.4	29.7	29.6	29.6
29.4	28.8	29.1	28.9	29.4	29.7	29.6	29.6
29.5	28.7	29.0	28.9	29.3	29.7	29.4	29.6
29.3	28.5	28.9	28.9	29.3	29.7	29.3	29.4
29.3	28.5	28.9	29.5	29.4	30.3	29.4	29.4

29.5	29.0	29.6	29.3	29.3	29.4	29.6	29.0
29.6	29.1	29.3	29.3	29.3	29.4	29.4	28.9
29.6	29.2	29.2	29.6	29.3	29.6	29.3	28.9
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29.5	29.1	29.1	29.5	29.3	29.6	29.3	29.0
29.3	29.2	29.3	29.6	29.3	29.6	29.1	28.9
29.2	29.3	29.3	29.4	29.3	29.6	29.3	28.9
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29.3	29.3	29.3	29.3	29.4	29.3	29.3	28.9
29.5	29.1	29.4	29.3	29.6	29.3	29.3	28.9
29.6	29.1	29.6	29.2	29.6	29.1	29.1	29.0
29.5	29.1	29.4	29.2	29.6	29.1	29.1	28.9
29.5	29.2	29.5	29.3	29.6	29.3	29.3	28.9
29.5	29.1	29.3	29.6	29.4	29.3	29.3	28.9
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29.3	29.1	29.3	29.6	29.4	29.3	29.3	28.9
29.3	29.2	29.1	29.4	29.3	29.3	28.9	29.0
29.1	29.1	29.3	29.3	29.4	29.3	28.9	28.9
29.3	29.1	29.3	29.3	29.4	29.3	29.1	29.1
29.3	28.9	29.5	29.3	29.6	29.1	29.1	29.0
29.3	28.8	29.6	29.3	29.6	29.1	29.1	29.0
29.4	28.9	29.6	29.3	29.7	29.3	29.3	28.9
29.4	29.0	29.4	29.2	29.8	28.9	29.1	28.9
29.3	29.1	29.4	29.0	29.3	29.2	28.9	28.9
29.3	29.1	29.4	29.0	29.7	29.1	29.1	29.1
29.2	29.1	29.3	29.2	29.6	29.1	29.1	28.9
29.3	29.2	29.3	29.3	29.4	29.1	28.9	29.1
29.2	29.3	29.3	29.3	29.4	29.4	28.9	29.1
29.1	29.3	28.9	29.3	29.3	29.4	28.9	29.1
29.3	29.3	29.3	29.3	29.4	29.3	28.9	29.1
29.2	29.3	29.3	29.3	29.4	29.3	29.0	28.9
29.2	29.2	29.5	29.3	29.4	29.3	29.3	29.0
29.3	29.2	29.5	29.2	29.6	29.3	29.2	28.9
29.5	29.0	29.5	29.2	29.6	29.1	29.1	28.9
29.3	29.2	29.6	29.0	29.4	28.9	29.1	28.9
29.3	29.1	29.6	29.1	29.4	29.3	28.9	28.9
29.3	29.0	29.4	28.9	29.4	29.1	28.9	29.1
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29.2	29.0	29.4	29.3	29.2	29.3	28.9	29.1
29.1	28.9	29.3	29.3	29.3	29.3	29.1	29.1
29.1	28.9	28.8	29.3	29.4	29.4	28.9	29.1
29.1	29.0	28.8	29.3	29.4	29.4	28.8	29.1
29.2	28.9	28.9	29.3	29.4	29.4	29.1	29.1
29.3	28.9	29.0	29.3	29.6	29.3	29.3	29.1
29.2	28.8	29.3	29.3	29.6	29.3	29.1	29.1
29.1	28.6	29.3	29.2	29.6	29.3	29.1	29.1
29.1	28.6	29.5	29.3	29.3	28.9	29.2	29.1
29.1	28.9	29.3	29.2	29.3	29.2	28.9	29.1
29.0	28.9	29.3	29.2	29.4	29.3	29.0	29.1
29.0	29.3	29.3	29.3	29.4	29.3	29.1	29.3
29.0	29.7	29.3	29.3	29.3	29.3	29.1	29.3
28.8	29.7	29.3	29.5	28.9	29.6	29.1	29.4
29.0	29.6	29.2	29.4	29.3	29.7	29.0	29.3
29.0	29.3	29.1	29.3	29.3	29.7	28.5	29.3

29.3	29.5	29.2	28.5	28.7	28.5	29.0	28.5
29.3	28.6	29.3	28.5	28.5	28.7	28.8	28.4
29.3		29.3	28.4	28.5	28.5	28.5	28.4
29.3		29.2	28.5	28.5	28.5	28.4	28.2
29.1	#2	29.2	28.5	28.5	28.5	28.4	28.4
29.3	29.6	29.1	28.5	28.5	28.5	28.5	28.3
29.3	29.6	29.1	28.5	28.5	28.5	28.4	28.4
29.4	29.7	29.0	28.8	28.5	28.5	28.2	28.5
29.7	29.4	29.1	28.8	28.5	28.5	28.4	28.4
29.5	29.6	29.1	28.3	28.5	28.5	28.5	28.1
29.4	29.5	28.9	28.5	28.7	28.4	28.5	28.4
29.4	29.5	29.2	28.6	28.8	28.4	28.7	28.4
29.3	29.3	29.1	28.7	28.8	28.5	29.1	28.4
29.2	29.2	29.0	28.5	28.8	28.4	28.8	28.3
29.1	29.4	29.2	28.5	28.8	28.4	28.7	28.2
29.1	29.4	29.0	28.5	28.7	28.5	28.5	28.1
29.3	29.5	28.9	28.5	28.7	28.5	28.7	28.2
29.1	29.5	28.9	28.7	28.8	28.7	28.5	28.1
29.1	29.6	28.9	28.7	28.5	28.9	28.5	28.2
29.3	29.3	28.9	28.8	28.5	28.7	28.4	28.4
29.3	29.4	28.9	28.7	28.2	28.5	28.4	28.2
29.5	29.2	28.8	28.6	28.5	28.5	28.5	28.1
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29.3	29.3	28.8	28.5	28.8	28.4	28.7	28.2
29.3	29.3	28.7	28.5	28.9	28.3	29.0	28.2
29.3	29.2	28.8	28.5	28.8	28.4	28.9	28.4
29.2	29.3	28.8	28.5	28.8	28.4	28.7	28.2
29.3	29.3	28.8	28.5	28.7	28.4	28.4	28.2
29.3	29.3	28.7	28.5	28.7	28.4	28.4	28.2
29.3	29.3	28.8	28.5	28.8	28.3	28.4	28.3
29.3	29.3	28.7	28.5	28.7	28.1	28.5	28.2
29.5	29.3	28.7	28.5	28.7	28.1	28.2	28.3
29.7	29.1	28.7	28.5	28.7	28.1	28.5	28.2
29.7	29.1	28.7	28.5	28.8	28.2	28.5	28.1
30.2	29.0	28.7	28.5	28.8	28.1	28.7	28.2
29.9	29.0	28.7	28.4	28.8	28.1	28.7	28.2
29.4	29.0	28.7	28.5	28.8	27.8	28.8	28.2
29.4	29.0	28.8	28.5	28.7	28.1	28.7	28.4
29.4	29.2	28.7	28.4	28.7	28.2	28.7	28.3
29.3	29.3	28.7	28.5	28.7	28.4	28.5	28.2
29.3	29.5	28.7	28.5	28.7	28.5	28.5	28.3
29.3	29.3	28.5	28.5	28.6	28.1	28.5	28.3
29.4	29.3	28.5	28.5	28.6	28.1	28.5	28.2
29.5	29.3	28.7	28.5	28.6	28.2	28.4	28.2
29.7	29.3	28.5	28.5	28.8	28.1	28.4	28.2
29.7	29.2	28.6	28.4	28.6	28.1	28.5	28.2
29.5	29.2	28.8	28.4	28.6	28.2	28.5	28.4
29.4	29.1	28.7	28.4	28.6	28.0	28.7	28.2
29.3	29.1	28.8	28.5	28.8	27.9	28.7	28.2
29.3	29.1	28.7	28.5	28.7	28.1	28.5	28.2
29.2	29.1	28.6	28.4	28.7	28.2	28.4	28.2
29.0	29.1	28.7	28.5	28.5	28.2	28.5	28.3
29.3		28.6	28.6	28.7	28.4	28.4	28.4

28.5	28.4	29.2	28.9	28.9	28.9	29.4	29.4
28.5	28.4	29.0	28.7	28.8	28.9	29.3	29.4
28.5	28.4	29.0	28.6	28.8	28.9	29.7	29.6
28.5	28.4	28.9	28.7	28.8	28.9	29.7	29.8
28.4	28.5	29.0	28.7	28.8	29.1	29.6	29.6
28.3	28.8	29.0	28.7	28.8	29.4	29.3	29.7
28.2	29.1	29.0	28.7	28.7	28.9	29.4	29.9
28.4	29.1	28.8	28.7	28.7	29.3	29.4	30.5
28.4	28.6	28.6	28.7	28.6	29.4	29.6	30.2
28.4	28.8	28.7	28.7	28.7	29.3	29.7	30.5
28.5	28.9	28.8	28.7	28.9	29.2	29.7	30.2
28.5	28.6	28.7	28.7	28.9	28.9	30.1	29.9
28.5	28.5	28.7	28.7	29.0	28.9	30.1	29.8
28.5	28.4	28.7	28.7	28.9	28.7	30.1	29.3
28.5	28.5	28.5	28.6	28.9	28.6	29.7	29.6
28.5	28.5	28.6	28.7	28.9	28.9	29.8	29.7
28.5	28.8	28.6	28.7	28.9	28.9	29.8	29.9
28.5	28.7	28.6	28.7	28.8	29.1	29.7	29.9
28.5	29.2	28.5	28.7	28.8	28.3	29.7	30.0
28.5	29.2	28.5	28.8	28.6	28.9	29.6	30.8
28.5	29.0	28.2	28.8	28.7	29.6	29.4	30.2
28.5	29.3	28.6	28.7	28.7	29.5	29.3	30.4
28.6	29.1	28.8	28.7	28.9	29.5	30.0	30.3
28.5	28.9	29.1	28.7	28.9	29.3	29.6	29.9
28.7	28.8	29.3	28.6	29.0	29.1	29.6	30.1
28.5	28.5	29.6	28.5	29.6	28.2	29.7	29.9
28.7	28.5	29.1	28.7	28.9	28.7	29.4	29.8
28.7	28.9	29.3	28.7	29.4	28.9	29.6	29.8
28.7	28.9	29.3	28.9	29.3	29.3	29.7	29.8
28.6	29.0	29.3	29.2	29.1	28.8	29.6	30.0
28.1	28.8	29.3	29.1	29.0	28.9	29.6	30.5
28.2	29.0	28.9	29.0	29.0	29.7	29.3	30.8
28.7	28.8	28.8	29.1	29.1	30.0	29.3	30.1
28.6	28.8	28.8	28.9	29.0	29.7	29.4	29.8
28.9	28.7	28.8	28.9	28.9	29.6	29.6	29.3
29.1	28.8	29.0	29.1	29.1	28.5	29.6	29.3
29.2	28.8	29.0	28.9	29.3	29.2	29.9	30.1
29.2	28.5	29.4	28.8	29.3	28.5	29.9	29.5
29.0	28.6	29.3	28.9	29.8	29.3	29.8	29.7
29.0	28.7	29.1	28.8	29.1	29.4	29.4	29.7
29.0	28.8	28.9	28.9	29.1	29.6	29.3	30.0
28.8	29.0	29.0	29.1	29.0	29.6	29.3	30.3
28.8	29.2	28.8	29.3	29.2	29.3	29.3	30.8
28.8	29.2	28.8	29.2	28.9	29.7	29.1	31.0
28.7	29.2	28.7	29.1	29.3	29.8	29.3	30.4
28.7	29.0	28.8	29.1	28.9	29.6	29.3	30.6
28.6	29.0	28.8	28.9	29.1	29.6	29.4	30.5
28.6	29.0	28.8	28.9	29.0	29.4	29.4	30.4
28.6	28.8	28.8	28.9	29.3	29.3	29.5	30.1
28.5	28.8	28.7	28.8	29.3	29.4	30.0	29.9
28.5	28.3	28.7	28.9	29.3	29.3	29.4	30.1
28.5	28.7	28.6	28.9	29.1	29.3	29.4	30.0
28.5	28.8	28.7	28.9	29.1	29.6	29.6	30.1
28.5	29.0	28.6	28.8	29.1	29.6	29.4	30.1

30.5	29.7	29.3	28.2	29.0	29.5	30.8	27.6
30.8	28.7	29.6	28.9	28.9	29.3	29.6	28.5
30.8	28.5	28.9	29.3	28.9	29.4	30.0	28.9
30.2	29.4	29.1	29.3	29.0	29.3	29.3	29.1
30.2	29.7	29.3	29.3	28.9	29.3	28.9	29.3
30.3	30.1	29.3	29.5	28.9	29.4	28.9	29.3
30.1	29.8	29.2	27.3	28.4	29.5	28.9	29.3
30.0	28.5	29.1	30.1	28.8	29.3	28.9	29.7
30.1	29.4	29.1	30.1	28.5	29.4	28.9	29.6
30.0	29.9	28.9	30.1	28.8	29.3	29.1	29.6
30.0	29.9	29.2	29.9	28.8	29.3	29.2	29.6
29.9	29.8	29.6	29.6	28.8	29.2	29.2	29.6
29.9	29.3	29.7	29.8	28.9	29.1	28.9	29.6
30.0	28.8	29.6	29.3	28.6	29.3	29.3	27.8
30.0	28.8	29.3	29.5	28.6	29.3	29.4	29.4
29.8	29.3	29.3	29.2	28.6	29.2	29.3	29.6
29.7	29.7	29.3	29.3	28.9	29.3	29.0	29.9
29.8	29.8	29.2	29.3	28.9	29.4	29.0	29.9
29.9	29.9	28.9	29.6	28.8	29.3	28.9	29.7
29.7	28.6	29.1	29.8	28.8	29.6	28.8	29.7
29.6	29.2	29.1	30.5	28.6	29.5	28.6	29.6
29.6	29.8	29.3	29.4	28.8	29.3	29.0	29.8
29.9	30.0	28.8	29.4	28.9	28.9	29.4	29.9
30.0	29.8	29.4	29.0	29.1	29.3	28.9	29.9
29.9	29.7	29.4	29.0	28.9	29.2	29.9	29.7
30.3	29.5	29.9	29.2	29.0	29.1	29.9	29.6
30.2	29.5	29.9	28.9	28.9	29.2	29.8	29.5
29.9	29.6	29.7	28.9	28.9	29.3	29.9	29.3
29.7	29.7	29.7	29.3	28.8	29.4	29.6	29.4
29.7	29.4	29.4	29.3	28.6	29.6	29.6	29.3
29.6	29.4	28.9	29.2	28.8	29.7	29.4	29.6
29.5	29.3	29.1	29.3	29.0	29.9	29.3	29.6
29.5	29.3	29.1	28.9	28.7	29.6	29.4	29.5
29.7	28.9	29.2	28.9	28.8	29.6	29.4	29.7
29.7	29.3	29.3	28.9	28.9	29.5	29.5	29.7
30.3	29.3	28.4	28.9	29.3	29.3	29.0	29.6
29.7	29.1	28.9	28.9	29.3	29.3	29.0	29.6
28.7	29.1	29.3	29.1	29.3	29.3	28.9	29.3
30.0	28.9	29.3	28.9	29.1	29.3	29.3	29.3
30.1	28.9	29.3	28.5	29.0	29.3	28.9	29.7
29.9	28.9	29.3	28.7	28.9	29.3	28.2	29.9
29.9	29.3	29.4	28.8	29.1	29.5	27.7	29.7
29.6	29.1	29.5	28.9	29.1	29.3	28.6	29.9
28.6	29.1	28.9	28.9	28.9	29.6	28.9	29.6
29.6	29.1	29.1	28.8	29.0	29.3	28.8	29.7
29.5	29.1	29.3	28.7	29.2	29.3	29.2	29.6
29.7	29.1	29.2	28.9	29.5	29.1	29.3	29.6
29.4	29.0	29.7	28.9	29.8	29.2	28.9	29.6
29.5	28.8	30.2	28.9	29.6	29.1	27.3	29.5
29.2	28.8	30.2	28.8	29.4	29.2	29.4	29.5
29.8	28.9	29.9	28.8	29.7	29.1	29.7	29.1
29.8	28.9	29.8	28.6	29.6	28.8	29.3	27.5
29.9	29.1	29.8	28.8	29.6	29.0	29.3	28.9
29.7	29.1	26.2	28.9	29.6	29.3	28.9	29.9

30.0	29.6	29.1	29.3		29.3	29.1	28.0
29.7	29.6	29.2	29.2		29.3	28.8	28.0
29.7	29.3	29.2	28.9	#3	29.0	29.3	28.0
29.3	29.6	29.3	28.6	29.6	28.7	29.0	28.4
29.3	29.6	29.3	28.7	29.5	28.8	29.0	28.6
29.7	30.1	29.2	29.0	29.4	28.1	29.1	28.7
29.3	29.7	29.2	28.8	28.6	28.1	28.8	28.7
29.3	29.7	28.9	29.1	28.2	28.3	28.8	28.5
29.0	29.8	29.3	28.7	27.7	28.4	28.2	28.7
29.1	29.7	29.9	28.7	28.5	28.3	28.1	28.7
28.9	29.7	29.5	28.7	28.4	28.5	28.1	28.7
29.5	29.7	29.5	28.8	28.7	28.4	28.3	28.8
29.5	29.6	29.1	28.8	27.7	28.4	28.1	28.2
29.5	29.6	29.6	29.1	27.5	28.4	28.2	28.2
29.3	29.5	29.6	29.1	27.3	28.4	28.1	28.8
29.6	29.4	29.6	29.3	27.6	28.2	27.7	28.2
29.6	29.6	29.3	29.0	28.2	28.2	27.7	28.4
29.2	28.9	29.1	29.9	28.5	28.2	28.4	28.2
29.0	29.1	28.7	29.3	28.1	28.2	28.1	28.0
28.7	29.3	28.8	29.2	27.3	28.2	28.5	28.0
28.6	29.4	28.8	29.0	27.3	29.1	27.6	28.6
28.4	29.4	29.2	28.9	27.2	29.3	27.7	28.9
28.7	29.3	29.3	28.8	27.3	29.3	27.8	28.9
29.3	28.7	29.4	28.8	27.3	29.3	27.3	28.9
29.1	29.3	29.3	28.9	27.3	29.7	27.3	28.9
28.9	29.3	29.6	28.9	27.3	29.5	27.3	28.6
28.9	29.3	28.7	28.9	27.3	29.5	27.3	28.7
28.9	29.4	29.4	29.0	27.3	29.2	27.5	28.5
28.9	29.6	29.4	29.0	27.3	29.0	27.8	28.3
29.0	29.1	29.3	29.3	27.8	29.2	27.7	28.5
29.1	29.1	29.3	29.1	28.4	28.9	27.2	28.5
28.6	29.3	28.5	29.2	27.7	29.0	27.3	29.0
28.9	29.2	28.5	29.0	28.1	29.2	27.3	28.9
28.9	29.7	28.3	28.8	27.9	29.7	27.2	29.0
29.2	28.9	29.0	28.8	27.6	29.6	27.2	29.3
29.2	28.7	29.3	28.6	27.9	29.6	27.3	29.4
29.7	28.6	29.1	28.9	28.1	29.6	27.4	29.3
29.2	29.0	29.1	28.9	27.6	29.6	27.3	29.2
28.8	28.7	28.9	28.9	27.7	29.6	27.3	29.1
28.9	29.1	29.3	29.1	28.1	29.6	28.0	29.1
28.8	29.1	29.2	29.3	28.3	29.4	28.0	29.1
28.6	29.3	29.2	29.2	28.1	29.4	28.0	29.2
28.7	29.3	28.9	29.3	28.8	29.3	27.9	29.0
28.7	29.9	29.1	29.3	28.5	29.2	27.9	29.0
28.6	29.4	29.2	29.3	28.5	29.1	27.8	29.2
28.8	29.2	29.3	29.0	28.4	29.1	27.7	29.0
28.9	29.3	29.3	29.0	28.1	29.1	27.8	28.8
29.9	28.7	28.9	29.0	28.1	28.9	28.0	29.1
30.4	28.5	29.6	29.1	28.1	29.0	28.0	29.3
30.6	28.1	29.5	29.1	27.8	28.8	28.0	29.1
30.0	28.3	29.4	28.9	28.1	28.9	27.3	29.0
30.0	28.9	29.4	29.0	28.3	29.1	27.8	29.0
29.9	28.9	29.4	29.1	28.6	29.2	28.1	28.9
29.7	29.0	29.3			29.0	28.1	28.9

28.9	28.1	27.9	28.8	27.6	27.5	26.9	28.3
28.9	28.1	28.2	28.8	28.2	27.5	27.0	28.1
28.7	28.1	28.1	28.9	27.9	27.5	27.0	28.1
28.7	28.1	28.4	28.7	28.1	27.5	27.2	27.4
28.5	27.0	28.7	28.7	28.1	27.3	27.2	26.9
28.6	26.7	28.8	28.7	27.9	27.3	27.3	27.2
28.8	26.9	28.7	28.6	27.7	27.7	27.2	27.3
29.3	27.1	28.7	28.8	27.8	27.5	27.0	27.7
29.2	26.9	28.6	28.6	27.7	27.5	26.9	27.7
28.8	26.6	28.5	28.6	28.0	27.7	26.9	27.7
28.5	27.5	28.4	28.8	27.8	27.7	27.0	27.8
28.5	27.7	28.6	29.0	27.9	27.5	27.2	27.8
28.4	28.5	28.8	28.8	27.6	27.5	27.2	27.7
28.7	28.5	28.7	28.9	27.7	27.3	27.3	27.6
28.7	28.4	28.8	28.7	27.3	27.5	27.3	27.3
28.8	28.5	28.7	28.7	27.5	27.5	28.7	27.7
29.1	28.5	28.9	28.7	28.1	27.2	29.2	27.5
29.3	28.4	28.7	28.7	27.7	27.3	29.3	27.3
29.3	28.5	28.7	28.7	27.2	27.3	29.4	27.3
28.9	28.2	28.5	28.6	27.3	27.3	28.9	27.6
28.6	28.6	28.4	28.7	28.1	27.3	28.1	27.3
28.9	28.6	28.5	28.7	27.8	27.3	28.2	27.7
28.2	28.5	28.7	28.8	27.6	27.2	28.2	27.3
28.1	27.3	28.5	28.7	27.7	27.2	28.1	27.4
28.5	28.5	28.5	28.7	27.7	27.2	27.9	27.2
28.5	28.6	28.2	28.7	27.9	27.0	28.1	27.0
28.2	28.9	28.4	28.6	27.8	27.0	28.6	26.9
28.7	27.3	28.5	28.5	27.9	27.2	29.2	26.9
28.0	27.0	28.9	28.4	27.9	27.3	29.4	27.3
28.9	27.2	28.9	28.4	28.1	27.3	29.4	25.0
28.9	27.2	28.7	28.5	27.3	27.3	29.3	26.9
28.8	27.2	28.6	28.7	27.3	27.3	28.9	27.0
27.7	28.5	29.0	28.4	27.3	27.3	28.9	27.2
28.2	29.1	28.5	28.5	27.3	27.2	28.7	27.2
28.2	29.1	28.5	28.7	27.2	27.5	28.5	27.4
27.7	28.8	28.6	28.9	27.9	27.4	28.2	27.7
28.1	28.8	28.5	28.1	27.6	27.1	28.1	27.4
28.2	28.9	28.5	28.7	27.3	27.0	28.1	27.3
28.3	28.7	28.7	28.5	27.3	26.8	28.2	27.2
28.4	28.8	28.7	28.7	27.3	27.0	28.2	27.3
28.3	28.8	28.7	28.5	27.5	27.0	28.1	27.2
28.4	28.6	28.7	28.6	27.6	27.2	28.1	27.3
28.4	28.6	28.9	28.5	27.7	27.2	28.2	25.4
28.3	28.6	28.7	28.5	27.7	27.2	27.9	26.7
28.3	27.7	28.6	28.5	27.7	27.3	28.2	27.2
28.1	28.8	28.6	28.8	27.3	27.3	28.4	27.3
28.1	28.7	28.7	28.9	27.0	27.3	28.1	27.5
28.1	28.8	28.5	28.7	27.3	27.3	28.1	27.6
28.1	28.6	28.5	29.1	27.3	27.3	27.7	27.6
28.1	28.5	28.6	28.9	27.3	27.0	27.9	27.3
28.6	28.1	28.7	28.7	27.5	26.9	28.1	27.3
28.1	28.5	28.7	28.4	27.5	27.0	28.5	27.3
28.0	28.5	28.9	28.1	27.5	27.0	28.4	27.3
28.2	27.7	28.9	27.5	27.7	27.0	28.6	27.2

26.2	27.0	27.7	28.7	28.1	27.9	26.7	26.5
23.7	27.0	27.5	28.5	28.0	27.9	26.8	26.5
26.7	27.3	27.8	28.3	27.6	27.8	26.9	26.5
26.9	27.2	27.7	28.4	27.8	27.8	26.7	26.6
27.2	27.2	27.7	28.3	27.9	27.8	26.9	26.5
27.2	27.1	27.8	28.1	28.8	27.6	26.4	26.5
27.3	27.2	27.7	28.1	28.9	27.4	26.5	26.5
27.3	27.0	27.5	28.2	28.7	28.1	26.2	26.7
26.1	26.7	27.9	28.2	28.5	28.0	26.2	26.5
27.0	27.0	27.9	28.1	28.2	28.0	26.4	26.2
26.5	27.2	27.0	28.2	28.1	27.8	26.2	26.3
26.1	27.2	26.9	28.1	28.3	28.1	26.2	26.3
26.7	26.9	27.2	28.5	28.3	28.1	26.1	26.2
26.1	26.7	27.5	28.3	28.2	27.7	26.2	26.2
25.9	26.7	27.1	28.6	28.3	27.8	26.5	26.5
26.0	26.3	27.0	28.5	28.5	27.7	26.5	26.5
26.5	26.6	26.8	28.5	28.3	27.3	26.7	26.6
26.6	26.6	27.2	28.3	28.3	27.5	26.1	26.3
26.5	26.7	27.3	28.2	28.2	27.4	26.5	26.5
26.8	26.6	27.3	28.1	28.2	27.6	26.5	26.5
26.9	26.6	27.3	28.3	28.1	27.7	26.8	26.3
27.1	26.9	27.3	28.2	28.0	28.0	26.4	26.9
26.9	27.0	27.2	28.2	28.0	27.7	26.6	26.4
27.0	26.9	26.9	28.4	28.0	27.9	26.7	26.7
26.4	26.9	26.6	28.0	28.0	27.7	26.7	26.1
26.8	26.3	26.9	28.1	28.1	27.5	26.7	25.8
27.0	26.5	26.9	28.5	27.3	27.6	26.9	25.7
27.0	26.7	27.0	28.4	27.3	27.7	26.9	25.8
26.7	26.8	27.0	28.5	27.4	27.5	26.9	25.8
26.7	26.7	26.7	28.0	27.9	27.2	27.0	25.8
26.7	26.7	26.8	28.0	28.1	27.3	27.0	25.8
26.7	26.7	27.0	28.2	27.8	27.3	26.9	25.9
26.7	26.9	27.0	28.2	27.7	27.3	27.0	26.2
26.7	26.9	27.0	28.5	27.4	27.4	27.0	26.1
26.7	26.9	27.1	28.7	27.7	27.0	26.9	26.2
26.7	27.0	27.2	28.9	27.7	27.6	26.7	26.1
26.8	27.0	27.1	28.5	27.7	27.7	26.9	26.0
26.8	27.0	27.5	28.5	27.7	27.5	26.9	26.1
27.0	27.0	27.7	28.6	28.1	27.2	27.2	26.0
27.2	27.0	28.1	28.7	28.1	27.2	27.3	25.8
27.2	26.9	27.9	28.5	28.2	27.2	27.2	26.0
27.0	26.9	28.1	28.5	28.2	26.9	27.1	26.1
27.0	26.9	27.9	28.5	27.8	27.0	26.4	26.1
27.0	26.9	27.8	28.5	27.7	27.1	26.6	26.1
27.2	26.9	27.7	28.5	27.7	27.2	26.9	26.3
27.0	27.7	27.3	28.5	27.8	27.3	26.7	26.4
27.0	28.0	27.5	28.5	27.7	27.3	26.9	26.5
26.7	28.2	27.5	28.3	27.7	27.2	26.9	26.4
26.8	28.1	27.3	28.3	27.8	27.0	26.6	26.4
26.7	28.1	27.3	28.2	27.8	27.0	26.5	26.5
26.9	28.1	27.7	28.1	28.1	26.7	26.5	26.3
27.0	28.4	27.1	28.1	28.0	26.9	26.9	26.4
27.0	27.8	27.1	28.0	28.0	27.0	26.7	26.4
26.9	27.4	28.0	27.9	28.0	26.9	26.7	26.5

26.6	26.7	28.2	28.7	27.3	29.1	27.9	27.8
26.7	26.6	28.3	28.7	27.3	29.1	27.9	26.9
26.9	26.5	28.5	28.7	27.6	28.7	28.1	27.3
27.0	26.3	28.5	28.7	27.6	28.7	27.8	26.9
27.1	26.4	28.4	28.7	27.6	28.8	28.2	27.2
27.7	26.3	28.3	28.5	27.9	28.7	27.8	26.9
27.9	26.1	28.2	28.3	27.7	28.5	27.7	27.3
28.0	26.1	27.9	28.4	27.7	28.6	26.6	27.3
27.8	26.6	28.0	28.5	27.6	28.8	26.2	27.3
28.1	26.5	27.9	28.5	27.7	28.9	27.3	27.1
27.7	26.4	28.0	28.6	27.7	28.9	27.5	27.3
28.0	26.6	28.1	28.5	27.2	28.8	27.3	26.5
28.1	26.5	28.0	28.3	27.3	28.9	27.3	27.3
28.0	26.5	28.0	28.3	27.2	29.0	27.3	27.3
27.8	26.6	28.2	28.2	27.1	28.8	27.7	27.1
27.9	26.1	28.8	28.2	27.3	28.8	27.8	26.9
27.8	26.2	28.4	28.3	27.5	28.8	27.8	27.1
28.3	26.1	28.4	28.2	26.6	28.7	27.8	27.6
28.2	26.1	28.5	28.0	27.0	28.7	27.4	27.5
28.1	26.3	28.2	28.3	26.9	28.5	27.3	27.3
28.0	26.4	28.1	28.3	27.2	28.7	27.6	
27.9	26.4	27.9	28.4	27.3	28.9	27.3	
27.7	26.3	27.8	28.4	27.2	28.7	27.3	
28.0	26.3	27.6	28.2	26.9	28.6	27.3	
27.9	26.1	28.0	28.1	27.2	28.3	27.3	
27.8	26.3	28.0	28.0	27.5	28.5	27.3	
27.3	26.3	28.1	27.8	27.5	28.3	27.3	
26.8	26.0	28.3	28.0	27.6	28.5	27.6	
27.3	26.2	28.3	28.0	27.1	28.4	27.6	
27.3	26.1	28.3	28.0	27.7	28.4	27.5	
27.1	25.7	28.2	27.8	27.6	28.3	27.3	
27.3	26.0	28.3	28.0	27.7	28.2	27.3	
26.7	26.1	28.3	28.0	27.7	28.5	27.3	
26.4	26.1	28.2	28.1	27.2	28.7	27.3	
26.5	26.2	28.1	28.2	27.3	28.6	27.3	
26.4	26.4	28.1	28.2	27.1	28.5	27.3	
26.5	27.3	28.0	28.0	26.9	26.9	27.2	
27.0	27.5	28.3	27.9	27.1	28.5	27.3	
26.9	27.7	28.5	27.3	27.3	28.3	27.3	
26.7	27.1	28.7	27.4	27.2	26.7	27.6	
26.3	27.3	28.5	26.8	27.2	27.7	27.6	
27.0	27.3	28.5	26.8	27.2	28.0	27.6	
26.7	27.3	28.5	27.1	27.3	27.6	27.5	
26.7	27.3	28.9	27.3	27.3	27.8	27.5	
26.7	27.3	28.7	27.3	27.5	28.1	27.5	
26.7	27.2	28.7	27.3	27.3	28.1	27.0	
26.3	27.3	28.4	27.2	27.2	28.0	27.2	
26.1	27.5	28.5	27.0	26.3	28.0	27.3	
26.2	27.7	28.5	27.3	27.2	28.0	27.0	
26.5	27.7	28.4	27.9	28.5	27.8	27.0	
26.7	27.8	28.4	27.3	28.9	27.7	27.3	
26.4	27.8	28.5	27.7	28.8	27.9	27.6	
26.7	27.7	28.5	27.6	28.7	28.0	27.3	
27.0	28.0	28.7	27.5	28.7	27.8	26.9	

APPENDIX XXV.

MEASUREMENTS OF CORAL FLUORESCENCE

Corals growing in highly seasonal climates have yellow-green fluorescent bands superimposed on their annual growth bands. The fluorescent bands are created by variations in the concentration of fulvic and humic acids, thought to be derived from decomposing vegetation in tropical drainage basins and carried to coastal reefs during seasonal monsoon discharge (Boto and Isdale, 1985).

Although the first reports of fluorescence as a precipitation/river discharge proxy were published by Isdale in 1984, no major papers detailing the mechanics of the system have been forthcoming. Several short accounts have been published (Boto and Isdale, 1985; Klein et al., 1990), and a descriptive account by Scoffin et al. (1989) noted good results in Papua New Guinea but poor results in West Java. Fluorescence banding has the potential to be a fast, inexpensive, low-latitude climate proxy. However, in the absence of basic research on the causal relationships that produce seasonally varying fluorescence in corals, the true potentials and limitations of this system are unclear.

Time-resolved laser-induced fluorescence spectrometry was used to measure interannual variation in fluorescence intensity along the growth axis of the slabs at the Nuclear Chemistry Division of Lawrence Livermore National Laboratory. Polished slabs were mounted on a horizontal translation stage and intersect the beam path at a 45 degree angle. Fluorescence was excited by a Nd/YAG laser (tuned to 354 nm) with the beam

intensity reduced by 90% by a neutral density filter and then clipped with a 1 mm slit, and intensity of the emission spectra is recorded by a time-gated spectrophotometer. Maximum separation between on-band and off-band spectra occurs at 550 nm, while peak intensity is at 640 nm.

With this laboratory apparatus, it was possible to record the basic seasonality of the coral fluorescence as well as some interannual variability. However, due to the lack of fiber optics in the laser system, surface irregularities of the polished the slab caused variations in position of the laser beam entering the spectrophotometer collimator slit. This introduced artifacts in the data and thus it was not clear how much of the interannual variability was real. Furthermore, it was also determined that the level of reproducibility of the fluorescence scans was low with this system. These factors, combined with the problems in characterizing the production rates of natural humics by tropical drainage basins and potential for non-linear response to rainfall (e.g. a basin could be flushed clean of accumulated humics by heavy rainfall) led me to concentrate on developing stable isotope records in lieu of further work with fluorescence as a climate proxy.

Boto, K. and Isdale P., Fluorescent bands in massive corals result from terrestrial fulvic acid inputs to nearshore zone, *Nature*, 315:396-397, 1985.

Isdale, P., Fluorescent bands in massive corals record centuries of coastal rainfall, *Nature*, 310:578-579, 1984.

Scoffin, T.P., Tudhope, A.W., and Brown, B.E., Fluorescent and skeletal density banding in *Porites lutea* from Papua New Guinea and Indonesia, *Coral Reefs* 7: 169-178, 1989.

Fluorescence scan of the top 2803mm of the PPL1B core.
R is the ratio of photomultiplier tube voltage to photodiode voltage at 550nm.

		24.48	2.634	49.98	2.547	75.48	2.477
m m	R	24.99	2.660	50.49	2.392	75.99	2.425
0.00	2.599	25.50	2.388	51.00	3.391	76.50	1.910
0.51	2.307	26.01	2.576	51.51	3.644	77.01	2.076
1.02	2.430	26.52	3.013	52.02	3.703	77.52	1.790
1.53	2.479	27.03	2.377	52.53	3.614	78.03	1.761
2.04	2.036	27.54	2.277	53.04	2.809	78.54	1.636
2.55	2.267	28.05	2.677	53.55	2.582	79.05	1.597
3.06	2.133	28.56	2.795	54.06	2.395	79.56	1.338
3.57	2.162	29.07	2.867	54.57	1.828	80.07	1.709
4.08	2.169	29.58	3.324	55.08	2.064	80.58	1.463
4.59	2.978	30.09	3.458	55.59	2.278	81.09	1.437
5.10	3.824	30.60	4.218	56.10	2.340	81.60	1.146
5.61	3.938	31.11	3.959	56.61	2.525	82.11	1.414
6.12	2.766	31.62	3.632	57.12	1.748	82.62	1.467
6.63	2.587	32.13	2.973	57.63	1.706	83.13	1.713
7.14	2.671	32.64	2.436	58.14	1.993	83.64	1.825
7.65	2.315	33.15	2.333	58.65	2.401	84.15	1.872
8.16	2.438	33.66	2.280	59.16	2.573	84.66	1.397
8.67	2.368	34.17	2.386	59.67	3.189	85.17	1.204
9.18	2.199	34.68	2.428	60.18	3.781	85.68	1.184
9.69	2.371	35.19	2.232	60.69	4.191	86.19	1.404
10.20	2.169	35.70	2.675	61.20	3.186	86.70	1.438
10.71	2.291	36.21	3.735	61.71	2.832	87.21	1.465
11.22	1.773	36.72	3.829	62.22	2.381	87.72	1.946
11.73	1.763	37.23	4.090	62.73	2.275	88.23	2.019
12.24	1.121	37.74	4.645	63.24	2.628	88.74	1.660
12.75	0.533	38.25	4.042	63.75	1.851	89.25	1.752
13.26	0.265	38.76	3.174	64.26	2.047	89.76	1.311
13.77	0.440	39.27	3.220	64.77	2.012	90.27	1.303
14.28	0.630	39.78	2.947	65.28	2.541	90.78	1.822
14.79	0.911	40.29	2.917	65.79	3.177	91.29	2.893
15.30	0.975	40.80	2.587	66.30	3.867	91.80	3.531
15.81	1.107	41.31	2.610	66.81	4.092	92.31	4.127
16.32	2.491	41.82	2.707	67.32	3.229	92.82	3.040
16.83	4.171	42.33	1.908	67.83	2.896	93.33	3.303
17.34	4.031	42.84	2.418	68.34	2.674	93.84	3.164
17.85	3.459	43.35	2.563	68.85	2.737	94.35	2.120
18.36	3.115	43.86	3.077	69.36	2.598	94.86	1.901
18.87	2.922	44.37	3.082	69.87	1.891	95.37	1.457
19.38	2.964	44.88	2.765	70.38	1.782	95.88	1.270
19.89	2.891	45.39	3.093	70.89	1.610	96.39	1.003
20.40	2.713	45.90	3.297	71.40	1.942	96.90	1.055
20.91	3.062	46.41	2.637	71.91	2.025	97.41	1.219
21.42	2.382	46.92	2.544	72.42	1.669	97.92	1.877
21.93	2.598	47.43	2.272	72.93	1.330	98.43	2.873
22.44	2.731	47.94	2.192	73.44	1.566	98.94	3.858
22.95	3.051	48.45	2.021	73.95	1.973	99.45	3.781
23.46	3.211	48.96	2.052	74.46	2.503	99.96	3.573
23.97	2.852	49.47	1.981	74.97	2.182	100.47	2.579

100.98	2.376	128.52	1.507	156.06	2.127	183.60	3.011
101.49	1.982	129.03	1.658	156.57	2.109	184.11	3.295
102.00	1.561	129.54	2.083	157.08	2.266	184.62	2.486
102.51	1.904	130.05	2.789	157.59	2.249	185.13	2.442
103.02	1.694	130.56	2.661	158.10	1.743	185.64	1.888
103.53	1.439	131.07	3.243	158.61	1.672	186.15	1.986
104.04	1.064	131.58	2.997	159.12	1.531	186.66	1.812
104.55	0.976	132.09	2.336	159.63	1.560	187.17	1.913
105.06	1.019	132.60	2.554	160.14	1.802	187.68	2.349
105.57	1.163	133.11	2.385	160.65	1.682	188.19	2.049
106.08	1.184	133.62	1.936	161.16	1.449	188.70	2.453
106.59	1.819	134.13	1.597	161.67	1.684	189.21	2.702
107.10	1.483	134.64	1.295	162.18	1.907	189.72	2.709
107.61	1.452	135.15	1.383	162.69	2.684	190.23	2.899
108.12	1.067	135.66	1.563	163.20	3.313	190.74	3.045
108.63	1.207	136.17	1.571	163.71	2.973	191.25	3.457
109.14	1.207	136.68	1.616	164.22	2.724	191.76	3.321
109.65	1.246	137.19	1.644	164.73	2.994	192.27	2.968
110.16	1.065	137.70	1.705	165.24	2.469	192.78	2.704
110.67	0.869	138.21	1.417	165.75	2.287	193.29	2.398
111.18	0.943	138.72	1.321	166.26	2.068	193.80	2.152
111.69	1.003	139.23	1.279	166.77	1.943	194.31	2.318
112.20	0.980	139.74	1.577	167.28	1.744	194.82	1.915
112.71	0.788	140.25	2.105	167.79	1.813	195.33	2.238
113.22	1.214	140.76	1.853	168.30	1.428	195.84	1.969
113.73	1.272	141.27	2.335	168.81	2.255	196.35	1.950
114.24	1.560	141.78	2.335	169.32	2.939	196.86	1.643
114.75	2.023	142.29	2.947	169.83	3.007	197.37	1.659
115.26	2.497	142.80	2.426	170.34	3.149	197.88	1.713
115.77	2.104	143.31	2.130	170.85	2.805	198.39	2.102
116.28	2.050	143.82	1.856	171.36	2.732	198.90	2.395
116.79	2.193	144.33	1.618	171.87	2.244	199.41	2.620
117.30	1.604	144.84	1.433	172.38	2.212	199.92	3.017
117.81	1.595	145.35	1.420	172.89	2.005	200.43	3.391
118.32	1.981	145.86	1.615	173.40	2.334	200.94	2.749
118.83	1.630	146.37	2.351	173.91	2.140	201.45	2.260
119.34	1.874	146.88	2.597	174.42	2.525	201.96	1.876
119.85	2.220	147.39	2.390	174.93	2.221	202.47	1.909
120.36	1.976	147.90	2.507	175.44	1.976	202.98	1.867
120.87	1.623	148.41	2.540	175.95	2.135	203.49	1.813
121.38	2.144	148.92	2.511	176.46	3.452	204.00	2.038
121.89	2.733	149.43	2.314	176.97	3.395	204.51	2.379
122.40	3.438	149.94	2.434	177.48	3.466	205.02	1.947
122.91	3.330	150.45	1.783	177.99	2.888	205.53	1.687
123.42	3.304	150.96	1.478	178.50	2.946	206.04	1.793
123.93	3.063	151.47	1.644	179.01	2.213	206.55	2.066
124.44	2.188	151.98	1.544	179.52	2.051	207.06	1.736
124.95	2.435	152.49	1.080	180.03	1.781	207.57	2.069
125.46	2.046	153.00	1.082	180.54	2.458	208.08	2.780
125.97	1.880	153.51	0.876	181.05	2.226	208.59	2.991
126.48	2.281	154.02	0.884	181.56	2.638	209.10	3.535
126.99	1.680	154.53	1.048	182.07	2.137	209.61	2.890
127.50	1.732	155.04	1.433	182.58	2.657	210.12	2.292
128.01	1.576	155.55	2.091	183.09	2.852	210.63	2.253

211.14	1.747	238.68	2.292	266.22	1.739	293.76	1.916
211.65	1.779	239.19	1.875	266.73	1.792	294.27	2.088
212.16	1.939	239.70	2.623	267.24	2.783	294.78	1.870
212.67	1.792	240.21	2.366	267.75	4.191	295.29	2.086
213.18	1.418	240.72	2.715	268.26	4.073	295.80	1.974
213.69	1.794	241.23	2.635	268.77	3.577	296.31	1.521
214.20	2.356	241.74	3.425	269.28	2.622	296.82	1.259
214.71	2.226	242.25	2.805	269.79	3.112	297.33	1.322
215.22	2.396	242.76	2.758	270.30	2.608	297.84	1.162
215.73	2.471	243.27	2.389	270.81	2.228	298.35	1.403
216.24	2.370	243.78	2.320	271.32	1.792	298.86	1.557
216.75	2.227	244.29	2.118	271.83	1.981	299.37	1.331
217.26	2.193	244.80	1.896	272.34	2.231	299.88	1.744
217.77	1.953	245.31	2.151	272.85	1.654	300.39	1.616
218.28	2.231	245.82	2.250	273.36	1.591	300.90	1.442
218.79	2.090	246.33	1.967	273.87	1.913	301.41	1.564
219.30	2.270	246.84	1.879	274.38	1.500	301.92	1.551
219.81	2.411	247.35	1.968	274.89	1.746	302.43	1.575
220.32	2.399	247.86	1.752	275.40	1.795	302.94	1.517
220.83	2.180	248.37	1.726	275.91	2.002	303.45	2.234
221.34	2.290	248.88	1.809	276.42	2.056	303.96	2.318
221.85	2.637	249.39	1.862	276.93	2.269	304.47	2.360
222.36	2.844	249.90	1.638	277.44	2.345	304.98	2.787
222.87	2.788	250.41	2.523	277.95	2.637	305.49	2.709
223.38	3.171	250.92	2.860	278.46	1.867	306.00	2.521
223.89	3.540	251.43	2.861	278.97	1.979	306.51	2.117
224.40	3.644	251.94	2.879	279.48	1.616	307.02	2.103
224.91	3.403	252.45	2.591	279.99	1.947	307.53	2.152
225.42	2.813	252.96	2.473	280.50	1.747	308.04	2.068
225.93	2.551	253.47	2.742	281.01	1.482	308.55	2.068
226.44	2.078	253.98	1.883	281.52	1.677	309.06	1.833
226.95	2.289	254.49	2.115	282.03	1.752	309.57	1.584
227.46	1.856	255.00	2.023	282.54	2.182	310.08	1.665
227.97	2.169	255.51	1.782	283.05	2.619	310.59	1.430
228.48	1.947	256.02	1.694	283.56	2.648	311.10	1.416
228.99	2.351	256.53	1.166	284.07	3.146	311.61	1.286
229.50	2.081	257.04	1.124	284.58	3.423	312.12	1.291
230.01	1.933	257.55	1.384	285.09	3.708	312.63	1.056
230.52	2.428	258.06	1.943	285.60	3.497	313.14	1.075
231.03	2.011	258.57	2.204	286.11	2.669	313.65	1.201
231.54	1.642	259.08	2.360	286.62	2.336	314.16	1.363
232.05	2.026	259.59	2.662	287.13	2.471	314.67	1.148
232.56	2.199	260.10	3.491	287.64	2.245	315.18	1.292
233.07	2.089	260.61	3.141	288.15	1.850	315.69	1.262
233.58	1.993	261.12	3.338	288.66	1.778	316.20	1.143
234.09	2.031	261.63	3.119	289.17	1.738	316.71	1.220
234.60	1.863	262.14	3.232	289.68	2.173	317.22	1.280
235.11	1.831	262.65	2.429	290.19	2.245	317.73	1.503
235.62	1.539	263.16	2.251	290.70	1.749	318.24	1.358
236.13	2.067	263.67	1.711	291.21	1.522	318.75	0.924
236.64	1.997	264.18	1.827	291.72	1.406	319.26	1.125
237.15	1.982	264.69	2.028	292.23	1.666	319.77	1.359
237.66	2.178	265.20	2.075	292.74	1.807	320.28	1.551
238.17	1.949	265.71	1.890	293.25	2.078	320.79	1.477

321.30	1.282	348.84	2.111	376.38	2.223	403.92	2.438
321.81	1.581	349.35	1.903	376.89	2.088	404.43	2.379
322.32	1.762	349.86	1.542	377.40	2.200	404.94	2.676
322.83	1.648	350.37	1.606	377.91	1.929	405.45	2.079
323.34	1.492	350.88	1.679	378.42	1.907	405.96	2.354
323.85	1.435	351.39	2.137	378.93	2.419	406.47	2.623
324.36	1.271	351.90	1.397	379.44	2.573	406.98	2.185
324.87	1.824	352.41	2.245	379.95	3.026	407.49	2.186
325.38	1.493	352.92	2.475	380.46	3.364	408.00	2.587
325.89	1.646	353.43	1.897	380.97	4.316	408.51	3.328
326.40	1.827	353.94	1.907	381.48	2.689	409.02	2.840
326.91	2.001	354.45	2.383	381.99	2.702	409.53	3.121
327.42	1.587	354.96	2.517	382.50	2.436	410.04	4.843
327.93	1.535	355.47	2.144	383.01	2.450	410.55	4.713
328.44	1.783	355.98	1.886	383.52	2.251	411.06	4.840
328.95	1.778	356.49	2.145	384.03	1.972	411.57	3.509
329.46	1.831	357.00	1.878	384.54	1.803	412.08	3.220
329.97	2.099	357.51	2.042	385.05	1.425	412.59	2.908
330.48	1.791	358.02	1.781	385.56	1.870	413.10	2.682
330.99	1.787	358.53	1.662	386.07	1.790	413.61	2.758
331.50	1.697	359.04	1.854	386.58	1.703	414.12	2.799
332.01	1.725	359.55	1.647	387.09	2.183	414.63	2.819
332.52	2.004	360.06	2.189	387.60	2.108	415.14	2.804
333.03	2.528	360.57	2.257	388.11	1.914	415.65	2.830
333.54	2.631	361.08	2.895	388.62	2.144	416.16	2.245
334.05	2.596	361.59	2.381	389.13	2.264	416.67	2.642
334.56	2.725	362.10	3.422	389.64	2.540	417.18	2.518
335.07	2.237	362.61	4.306	390.15	3.172	417.69	3.217
335.58	2.208	363.12	4.387	390.66	2.622	418.20	3.178
336.09	1.824	363.63	4.192	391.17	2.398	418.71	4.096
336.60	1.750	364.14	3.223	391.68	2.033	419.22	4.038
337.11	1.633	364.65	3.629	392.19	1.979	419.73	3.917
337.62	1.727	365.16	2.766	392.70	2.007	420.24	4.339
338.13	2.249	365.67	2.781	393.21	1.572	420.75	5.473
338.64	2.210	366.18	2.440	393.72	1.770	421.26	5.020
339.15	1.727	366.69	2.280	394.23	2.442	421.77	4.654
339.66	1.741	367.20	2.200	394.74	1.958	422.28	4.050
340.17	1.611	367.71	1.754	395.25	1.713	422.79	3.433
340.68	1.565	368.22	2.114	395.76	2.325	423.30	3.121
341.19	1.698	368.73	2.024	396.27	2.204	423.81	2.856
341.70	1.689	369.24	2.421	396.78	2.504	424.32	3.145
342.21	1.526	369.75	2.115	397.29	2.511	424.83	3.159
342.72	1.594	370.26	1.892	397.80	3.136	425.34	2.972
343.23	1.608	370.77	2.331	398.31	3.506	425.85	2.651
343.74	1.800	371.28	2.296	398.82	3.657	426.36	2.549
344.25	2.013	371.79	2.553	399.33	4.619	426.87	2.892
344.76	1.989	372.30	2.902	399.84	3.926	427.38	2.978
345.27	1.760	372.81	3.183	400.35	3.933	427.89	3.415
345.78	1.637	373.32	3.225	400.86	4.058	428.40	4.632
346.29	1.762	373.83	3.078	401.37	3.368	428.91	4.179
346.80	1.622	374.34	2.527	401.88	3.228	429.42	4.313
347.31	2.265	374.85	3.210	402.39	2.538	429.93	3.386
347.82	1.930	375.36	2.075	402.90	2.837	430.44	3.244
348.33	2.091	375.87	2.074	403.41	2.144	430.95	3.049

431.46	2.410	459.00	2.238	486.54	2.278	514.08	2.582
431.97	2.641	459.51	2.137	487.05	2.162	514.59	2.555
432.48	2.525	460.02	2.307	487.56	2.537	515.10	2.664
432.99	2.790	460.53	2.334	488.07	2.882	515.61	2.328
433.50	2.434	461.04	2.022	488.58	3.479	516.12	2.245
434.01	2.091	461.55	2.180	489.09	3.361	516.63	2.323
434.52	2.405	462.06	2.358	489.60	3.856	517.14	2.476
435.03	1.906	462.57	2.826	490.11	3.950	517.65	2.497
435.54	2.791	463.08	2.482	490.62	3.214	518.16	2.530
436.05	3.106	463.59	2.696	491.13	3.482	518.67	2.618
436.56	4.144	464.10	2.483	491.64	3.008	519.18	2.327
437.07	5.345	464.61	1.983	492.15	2.549	519.69	2.062
437.58	5.457	465.12	1.859	492.66	3.078	520.20	2.167
438.09	5.479	465.63	2.103	493.17	2.379	520.71	2.285
438.60	5.408	466.14	2.005	493.68	2.141	521.22	2.700
439.11	5.057	466.65	1.961	494.19	2.005	521.73	3.156
439.62	4.860	467.16	2.285	494.70	2.598	522.24	3.605
440.13	3.785	467.67	2.346	495.21	2.512	522.75	3.172
440.64	3.386	468.18	1.983	495.72	2.004	523.26	3.205
441.15	3.324	468.69	2.717	496.23	2.005	523.77	3.323
441.66	2.789	469.20	2.628	496.74	2.334	524.28	2.822
442.17	2.855	469.71	2.858	497.25	1.866	524.79	2.934
442.68	2.939	470.22	2.569	497.76	2.084	525.30	2.765
443.19	2.899	470.73	2.265	498.27	1.941	525.81	2.365
443.70	2.773	471.24	2.338	498.78	1.893	526.32	1.894
444.21	2.621	471.75	2.332	499.29	1.895	526.83	2.317
444.72	2.790	472.26	2.389	499.80	2.101	527.34	2.554
445.23	2.762	472.77	2.452	500.31	2.426	527.85	1.977
445.74	2.450	473.28	2.062	500.82	2.966	528.36	2.035
446.25	1.858	473.79	1.922	501.33	2.723	528.87	1.969
446.76	2.266	474.30	2.260	501.84	2.476	529.38	2.183
447.27	2.378	474.81	1.891	502.35	2.274	529.89	1.914
447.78	2.573	475.32	2.347	502.86	2.337	530.40	2.080
448.29	3.564	475.83	2.565	503.37	2.747	530.91	1.968
448.80	3.789	476.34	3.607	503.88	2.128	531.42	1.822
449.31	4.113	476.85	4.695	504.39	2.588	531.93	1.939
449.82	3.472	477.36	4.600	504.90	2.181	532.44	1.887
450.33	3.254	477.87	4.284	505.41	2.802	532.95	2.049
450.84	3.562	478.38	3.800	505.92	2.304	533.46	2.113
451.35	2.789	478.89	3.774	506.43	2.518	533.97	2.287
451.86	3.008	479.40	3.423	506.94	2.401	534.48	1.981
452.37	2.356	479.91	2.531	507.45	2.385	534.99	2.052
452.88	2.740	480.42	2.629	507.96	2.530	535.50	2.515
453.39	2.474	480.93	2.666	508.47	2.299	536.01	2.242
453.90	2.782	481.44	2.526	508.98	2.425	536.52	2.491
454.41	2.839	481.95	2.361	509.49	3.138	537.03	2.461
454.92	2.370	482.46	2.111	510.00	3.434	537.54	2.284
455.43	2.060	482.97	2.182	510.51	3.318	538.05	2.080
455.94	2.101	483.48	2.170	511.02	3.766	538.56	2.329
456.45	1.806	483.99	1.911	511.53	3.779	539.07	2.002
456.96	1.914	484.50	2.027	512.04	4.030	539.58	1.812
457.47	1.985	485.01	2.042	512.55	3.541	540.09	2.133
457.98	2.077	485.52	2.182	513.06	3.490	540.60	2.490
458.49	2.165	486.03	2.024	513.57	3.475	541.11	2.011

541.62	2.081	569.16	2.475	596.70	2.893	624.24	2.101
542.13	2.079	569.67	2.337	597.21	2.770	624.75	2.158
542.64	2.348	570.18	2.501	597.72	2.678	625.26	2.074
543.15	2.321	570.69	2.652	598.23	2.721	625.77	1.870
543.66	1.637	571.20	2.424	598.74	2.418	626.28	2.130
544.17	2.049	571.71	2.409	599.25	2.788	626.79	2.270
544.68	2.182	572.22	2.647	599.76	2.338	627.30	2.524
545.19	2.152	572.73	3.427	600.27	2.539	627.81	2.311
545.70	2.120	573.24	3.051	600.78	2.353	628.32	2.576
546.21	1.536	573.75	3.725	601.29	1.990	628.83	2.595
546.72	2.051	574.26	4.145	601.80	2.368	629.34	2.796
547.23	2.229	574.77	4.666	602.31	2.505	629.85	3.007
547.74	2.996	575.28	4.376	602.82	2.492	630.36	3.472
548.25	2.415	575.79	3.561	603.33	2.127	630.87	3.324
548.76	2.547	576.30	2.978	603.84	2.947	631.38	3.435
549.27	2.100	576.81	2.791	604.35	3.001	631.89	4.409
549.78	1.972	577.32	2.877	604.86	2.519	632.40	4.309
550.29	2.079	577.83	2.416	605.37	2.973	632.91	4.215
550.80	2.083	578.34	2.798	605.88	3.310	633.42	3.998
551.31	1.716	578.85	2.170	606.39	3.423	633.93	3.379
551.82	2.144	579.36	2.576	606.90	3.193	634.44	3.414
552.33	2.107	579.87	2.370	607.41	3.330	634.95	3.204
552.84	2.547	580.38	2.397	607.92	3.452	635.46	2.794
553.35	1.839	580.89	2.482	608.43	3.183	635.97	2.897
553.86	2.075	581.40	1.985	608.94	3.493	636.48	2.360
554.37	2.177	581.91	1.983	609.45	3.870	636.99	2.764
554.88	2.323	582.42	2.422	609.96	3.968	637.50	2.411
555.39	2.467	582.93	2.469	610.47	4.287	638.01	2.530
555.90	2.277	583.44	2.116	610.98	3.566	638.52	2.703
556.41	2.156	583.95	2.224	611.49	4.430	639.03	2.225
556.92	2.290	584.46	2.167	612.00	4.018	639.54	2.232
557.43	3.407	584.97	2.556	612.51	3.877	640.05	2.450
557.94	4.366	585.48	2.471	613.02	3.479	640.56	2.489
558.45	4.937	585.99	2.299	613.53	2.999	641.07	2.799
558.96	4.826	586.50	2.555	614.04	2.971	641.58	3.199
559.47	4.933	587.01	2.320	614.55	3.155	642.09	2.927
559.98	3.906	587.52	2.538	615.06	2.871	642.60	2.704
560.49	4.217	588.03	3.001	615.57	2.606	643.11	2.552
561.00	3.338	588.54	3.112	616.08	2.609	643.62	2.700
561.51	2.806	589.05	4.186	616.59	2.809	644.13	3.151
562.02	3.057	589.56	4.366	617.10	2.788	644.64	3.476
562.53	2.573	590.07	4.693	617.61	2.646	645.15	3.962
563.04	2.027	590.58	4.665	618.12	2.525	645.66	3.692
563.55	2.242	591.09	3.787	618.63	2.196	646.17	4.540
564.06	1.927	591.60	3.412	619.14	2.284	646.68	4.128
564.57	2.013	592.11	3.099	619.65	2.170	647.19	3.035
565.08	2.547	592.62	2.851	620.16	1.926	647.70	2.943
565.59	2.335	593.13	2.810	620.67	2.341	648.21	3.333
566.10	2.125	593.64	2.390	621.18	2.182	648.72	2.992
566.61	2.089	594.15	2.328	621.69	2.137	649.23	2.737
567.12	2.204	594.66	2.533	622.20	2.509	649.74	2.913
567.63	2.518	595.17	2.902	622.71	2.361	650.25	2.471
568.14	2.207	595.68	2.458	623.22	2.499	650.76	2.540
568.65	2.644	596.19	2.641	623.73	2.092	651.27	2.781

651.78	2.469	679.32	2.709	706.86	2.441	734.40	2.528
652.29	2.754	679.83	2.947	707.37	2.869	734.91	2.441
652.80	3.013	680.34	2.158	707.88	2.555	735.42	2.565
653.31	2.869	680.85	2.524	708.39	2.480	735.93	2.276
653.82	2.484	681.36	2.260	708.90	2.270	736.44	2.347
654.33	2.546	681.87	2.611	709.41	2.116	736.95	2.230
654.84	2.763	682.38	2.302	709.92	1.948	737.46	2.691
655.35	2.750	682.89	2.756	710.43	2.401	737.97	2.592
655.86	3.387	683.40	2.011	710.94	2.946	738.48	2.589
656.37	3.465	683.91	2.258	711.45	2.731	738.99	2.650
656.88	3.620	684.42	2.091	711.96	2.651	739.50	3.341
657.39	3.272	684.93	2.504	712.47	2.608	740.01	3.359
657.90	4.032	685.44	2.551	712.98	2.955	740.52	3.750
658.41	3.797	685.95	2.697	713.49	3.033	741.03	3.347
658.92	3.922	686.46	2.847	714.00	3.101	741.54	2.664
659.43	4.428	686.97	2.354	714.51	3.336	742.05	2.801
659.94	4.337	687.48	2.820	715.02	3.325	742.56	2.620
660.45	4.016	687.99	2.644	715.53	3.201	743.07	2.261
660.96	3.463	688.50	2.336	716.04	2.796	743.58	2.033
661.47	2.975	689.01	2.028	716.55	3.136	744.09	2.110
661.98	2.969	689.52	2.566	717.06	2.616	744.60	2.637
662.49	2.560	690.03	2.217	717.57	2.478	745.11	2.639
663.00	2.689	690.54	2.468	718.08	2.226	745.62	2.648
663.51	2.915	691.05	2.760	718.59	2.318	746.13	2.577
664.02	2.687	691.56	2.224	719.10	2.305	746.64	2.938
664.53	2.523	692.07	2.455	719.61	2.163	747.15	2.720
665.04	2.089	692.58	2.206	720.12	1.854	747.66	2.147
665.55	2.747	693.09	2.011	720.63	2.335	748.17	2.471
666.06	2.696	693.60	2.591	721.14	2.316	748.68	2.808
666.57	2.343	694.11	2.278	721.65	2.580	749.19	2.090
667.08	2.557	694.62	1.935	722.16	2.512	749.70	2.201
667.59	2.326	695.13	1.838	722.67	2.140	750.21	2.641
668.10	2.237	695.64	2.146	723.18	2.334	750.72	2.944
668.61	2.873	696.15	1.884	723.69	2.295	751.23	2.594
669.12	2.688	696.66	2.020	724.20	2.658	751.74	2.839
669.63	2.845	697.17	2.037	724.71	3.251	752.25	2.583
670.14	3.001	697.68	2.012	725.22	3.047	752.76	3.117
670.65	3.235	698.19	2.066	725.73	3.220	753.27	3.480
671.16	4.092	698.70	2.242	726.24	3.974	753.78	3.536
671.67	4.080	699.21	2.176	726.75	3.233	754.29	3.140
672.18	5.123	699.72	2.677	727.26	3.117	754.80	2.707
672.69	4.945	700.23	2.847	727.77	2.330	755.31	3.290
673.20	4.640	700.74	2.910	728.28	2.652	755.82	2.902
673.71	4.167	701.25	3.353	728.79	2.782	756.33	2.974
674.22	4.059	701.76	3.876	729.30	2.779	756.84	2.456
674.73	4.537	702.27	4.120	729.81	2.336	757.35	2.593
675.24	4.547	702.78	4.371	730.32	2.076	757.86	2.285
675.75	4.383	703.29	3.569	730.83	2.645	758.37	2.339
676.26	3.809	703.80	3.162	731.34	2.510	758.88	2.208
676.77	3.068	704.31	2.799	731.85	2.725	759.39	2.840
677.28	2.797	704.82	2.671	732.36	2.176	759.90	2.726
677.79	2.540	705.33	3.095	732.87	2.742	760.41	2.291
678.30	2.552	705.84	2.649	733.38	2.290	760.92	2.252
678.81	1.970	706.35	2.645	733.89	2.872	761.43	2.528

761.94	2.259	789.48	3.134	817.02	3.461	844.56	4.762
762.45	2.239	789.99	3.075	817.53	3.823	845.07	5.005
762.96	2.128	790.50	3.545	818.04	3.611	845.58	4.922
763.47	1.922	791.01	4.081	818.55	3.810	846.09	3.291
763.98	2.392	791.52	3.587	819.06	2.920	846.60	3.227
764.49	1.860	792.03	3.971	819.57	2.831	847.11	3.350
765.00	2.168	792.54	3.248	820.08	2.817	847.62	3.515
765.51	2.766	793.05	3.085	820.59	3.024	848.13	2.450
766.02	3.088	793.56	2.778	821.10	2.880	848.64	2.699
766.53	3.005	794.07	3.065	821.61	2.332	849.15	2.842
767.04	3.052	794.58	2.598	822.12	2.694	849.66	2.429
767.55	3.258	795.09	2.745	822.63	2.785	850.17	2.385
768.06	2.886	795.60	2.507	823.14	2.491	850.68	2.611
768.57	2.830	796.11	2.578	823.65	2.698	851.19	2.472
769.08	3.349	796.62	3.008	824.16	2.658	851.70	2.736
769.59	2.352	797.13	2.588	824.67	2.940	852.21	2.581
770.10	1.971	797.64	2.510	825.18	2.429	852.72	2.603
770.61	1.896	798.15	2.349	825.69	2.501	853.23	2.424
771.12	2.476	798.66	2.921	826.20	3.008	853.74	2.446
771.63	2.256	799.17	2.841	826.71	2.455	854.25	2.465
772.14	2.482	799.68	2.483	827.22	2.859	854.76	2.099
772.65	2.180	800.19	2.372	827.73	3.202	855.27	2.264
773.16	2.729	800.70	2.623	828.24	2.931	855.78	1.858
773.67	2.622	801.21	2.679	828.75	3.555	856.29	2.000
774.18	2.187	801.72	2.405	829.26	3.341	856.80	2.350
774.69	2.641	802.23	2.914	829.77	3.579	857.31	2.850
775.20	2.275	802.74	3.293	830.28	3.581	857.82	2.920
775.71	2.943	803.25	3.169	830.79	3.603	858.33	3.877
776.22	2.975	803.76	3.554	831.30	3.457	858.84	3.899
776.73	3.229	804.27	3.628	831.81	3.469	859.35	3.542
777.24	3.423	804.78	3.448	832.32	3.292	859.86	3.154
777.75	4.544	805.29	3.005	832.83	2.816	860.37	3.056
778.26	5.052	805.80	3.083	833.34	2.950	860.88	2.681
778.77	6.617	806.31	2.312	833.85	2.716	861.39	2.568
779.28	5.978	806.82	2.632	834.36	2.708	861.90	2.517
779.79	5.627	807.33	2.256	834.87	2.301	862.41	2.361
780.30	4.433	807.84	2.478	835.38	2.506	862.92	2.590
780.81	3.789	808.35	2.136	835.89	2.871	863.43	2.683
781.32	3.526	808.86	2.745	836.40	2.517	863.94	2.307
781.83	3.214	809.37	2.004	836.91	2.402	864.45	2.347
782.34	3.151	809.88	2.664	837.42	2.186	864.96	2.073
782.85	2.731	810.39	2.337	837.93	2.386	865.47	2.155
783.36	2.417	810.90	2.597	838.44	2.253	865.98	2.757
783.87	2.556	811.41	2.168	838.95	2.898	866.49	2.471
784.38	2.362	811.92	3.078	839.46	2.622	867.00	2.527
784.89	2.510	812.43	2.503	839.97	3.002	867.51	2.555
785.40	2.472	812.94	2.093	840.48	2.419	868.02	2.759
785.91	2.674	813.45	2.255	840.99	2.395	868.53	2.836
786.42	2.710	813.96	1.977	841.50	2.734	869.04	2.370
786.93	2.588	814.47	2.602	842.01	3.226	869.55	2.328
787.44	2.596	814.98	3.038	842.52	4.195	870.06	2.553
787.95	2.330	815.49	2.914	843.03	4.685	870.57	2.773
788.46	2.550	816.00	3.169	843.54	4.764	871.08	2.358
788.97	2.905	816.51	3.201	844.05	5.174	871.59	3.065

872.10	3.223	899.64	2.631	927.18	2.410	954.72	2.520
872.61	3.222	900.15	2.730	927.69	2.781	955.23	3.195
873.12	3.031	900.66	2.493	928.20	3.107	955.74	2.928
873.63	3.693	901.17	2.417	928.71	2.913	956.25	2.883
874.14	4.426	901.68	2.533	929.22	2.711	956.76	2.613
874.65	4.487	902.19	2.464	929.73	2.700	957.27	2.835
875.16	3.397	902.70	2.999	930.24	2.746	957.78	2.956
875.67	3.171	903.21	3.342	930.75	2.932	958.29	2.904
876.18	3.031	903.72	3.829	931.26	2.905	958.80	2.546
876.69	3.199	904.23	4.377	931.77	3.325	959.31	3.155
877.20	2.883	904.74	4.373	932.28	3.852	959.82	2.697
877.71	2.513	905.25	4.356	932.79	4.158	960.33	2.774
878.22	2.630	905.76	4.066	933.30	4.061	960.84	2.199
878.73	2.356	906.27	3.426	933.81	4.024	961.35	2.804
879.24	2.537	906.78	3.365	934.32	3.719	961.86	2.840
879.75	2.491	907.29	3.695	934.83	2.692	962.37	2.900
880.26	2.397	907.80	3.023	935.34	3.116	962.88	2.608
880.77	2.681	908.31	2.941	935.85	3.141	963.39	2.838
881.28	2.539	908.82	3.016	936.36	2.761	963.90	2.705
881.79	2.786	909.33	2.393	936.87	2.620	964.41	3.015
882.30	2.695	909.84	2.474	937.38	2.677	964.92	3.240
882.81	2.731	910.35	2.702	937.89	3.188	965.43	3.668
883.32	2.266	910.86	2.522	938.40	3.015	965.94	3.656
883.83	2.414	911.37	2.365	938.91	2.944	966.45	3.074
884.34	2.193	911.88	2.128	939.42	2.822	966.96	3.377
884.85	2.064	912.39	2.479	939.93	2.603	967.47	2.735
885.36	2.259	912.90	2.123	940.44	2.507	967.98	3.219
885.87	2.240	913.41	2.520	940.95	2.532	968.49	3.004
886.38	1.985	913.92	2.134	941.46	2.758	969.00	2.642
886.89	1.964	914.43	2.738	941.97	2.835	969.51	2.850
887.40	2.630	914.94	2.504	942.48	2.885	970.02	2.370
887.91	2.572	915.45	2.744	942.99	2.962	970.53	2.469
888.42	2.438	915.96	2.523	943.50	3.372	971.04	2.617
888.93	2.554	916.47	2.875	944.01	3.653	971.55	2.466
889.44	2.810	916.98	2.922	944.52	3.279	972.06	2.735
889.95	3.559	917.49	2.343	945.03	4.027	972.57	2.575
890.46	3.394	918.00	3.147	945.54	4.258	973.08	2.405
890.97	3.078	918.51	3.245	946.05	4.938	973.59	2.289
891.48	3.313	919.02	3.437	946.56	4.740	974.10	2.532
891.99	3.461	919.53	2.750	947.07	5.206	974.61	2.817
892.50	3.501	920.04	2.557	947.58	4.850	975.12	2.724
893.01	2.666	920.55	2.883	948.09	5.000	975.63	2.373
893.52	2.390	921.06	2.682	948.60	4.629	976.14	2.041
894.03	2.590	921.57	2.453	949.11	5.225	976.65	2.412
894.54	2.354	922.08	2.654	949.62	4.496	977.16	2.826
895.05	1.935	922.59	2.633	950.13	4.126	977.67	2.849
895.56	2.348	923.10	2.442	950.64	4.015	978.18	2.506
896.07	2.682	923.61	2.286	951.15	3.853	978.69	2.568
896.58	2.226	924.12	2.611	951.66	3.884	979.20	2.561
897.09	2.593	924.63	2.964	952.17	3.665	979.71	2.706
897.60	2.165	925.14	2.639	952.68	3.359	980.22	2.532
898.11	2.239	925.65	2.220	953.19	3.079	980.73	2.676
898.62	2.099	926.16	2.568	953.70	3.050	981.24	2.643
899.13	2.381	926.67	3.057	954.21	2.657	981.75	2.368

982.26	2.982	1009.80	3.885	1037.34	2.701	1064.88	3.405
982.77	3.976	1010.31	4.026	1037.85	2.665	1065.39	3.310
983.28	4.329	1010.82	4.104	1038.36	3.456	1065.90	3.261
983.79	4.107	1011.33	4.242	1038.87	3.265	1066.41	3.463
984.30	4.021	1011.84	3.948	1039.38	3.866	1066.92	3.831
984.81	4.306	1012.35	3.672	1039.89	5.016	1067.43	3.845
985.32	3.835	1012.86	3.915	1040.40	4.279	1067.94	5.126
985.83	2.960	1013.37	3.508	1040.91	3.939	1068.45	5.104
986.34	2.886	1013.88	3.063	1041.42	4.552	1068.96	5.201
986.85	2.896	1014.39	2.789	1041.93	4.002	1069.47	5.311
987.36	3.102	1014.90	2.975	1042.44	3.634	1069.98	4.836
987.87	2.618	1015.41	2.697	1042.95	3.219	1070.49	4.015
988.38	2.878	1015.92	2.623	1043.46	3.458	1071.00	3.568
988.89	2.888	1016.43	2.679	1043.97	3.473	1071.51	3.207
989.40	2.817	1016.94	2.662	1044.48	3.364	1072.02	3.270
989.91	2.986	1017.45	2.980	1044.99	2.654	1072.53	3.298
990.42	2.682	1017.96	2.641	1045.50	2.918	1073.04	3.438
990.93	2.796	1018.47	3.018	1046.01	3.219	1073.55	3.229
991.44	2.639	1018.98	3.013	1046.52	3.174	1074.06	3.240
991.95	2.670	1019.49	2.393	1047.03	3.124	1074.57	3.864
992.46	2.311	1020.00	2.476	1047.54	3.214	1075.08	2.975
992.97	2.595	1020.51	2.850	1048.05	2.768	1075.59	3.405
993.48	2.398	1021.02	3.042	1048.56	2.564	1076.10	3.096
993.99	2.689	1021.53	2.971	1049.07	2.715	1076.61	3.334
994.50	2.490	1022.04	2.578	1049.58	2.880	1077.12	3.213
995.01	2.595	1022.55	2.708	1050.09	2.457	1077.63	3.288
995.52	2.754	1023.06	3.488	1050.60	2.913	1078.14	3.336
996.03	3.154	1023.57	3.279	1051.11	3.181	1078.65	3.138
996.54	4.084	1024.08	3.516	1051.62	2.894	1079.16	2.898
997.05	4.945	1024.59	4.074	1052.13	3.234	1079.67	3.366
997.56	5.673	1025.10	3.887	1052.64	3.017	1080.18	3.065
998.07	5.783	1025.61	3.930	1053.15	2.944	1080.69	3.009
998.58	6.503	1026.12	4.123	1053.66	2.811	1081.20	
999.09	5.969	1026.63	3.874	1054.17	2.757	1081.71	0.244
999.60	5.253	1027.14	2.774	1054.68	3.258	1082.22	0.421
1000.11	5.135	1027.65	2.753	1055.19	3.306	1082.73	0.672
1000.62	4.428	1028.16	3.077	1055.70	3.646	1083.24	0.812
1001.13	3.692	1028.67	2.429	1056.21	4.231	1083.75	0.833
1001.64	3.582	1029.18	2.165	1056.72	5.040	1084.26	1.001
1002.15	3.314	1029.69	2.112	1057.23	4.883	1084.77	0.916
1002.66	3.328	1030.20	2.449	1057.74	4.306	1085.28	0.917
1003.17	3.059	1030.71	2.453	1058.25	3.998	1085.79	1.153
1003.68	2.917	1031.22	2.752	1058.76	4.226	1086.30	0.980
1004.19	3.127	1031.73	2.605	1059.27	3.902	1086.81	0.827
1004.70	3.132	1032.24	2.060	1059.78	3.641	1087.32	0.669
1005.21	2.891	1032.75	2.154	1060.29	3.359	1087.83	0.834
1005.72	2.713	1033.26	1.917	1060.80	3.536	1088.34	0.938
1006.23	2.995	1033.77	1.994	1061.31	3.324	1088.85	1.044
1006.74	2.424	1034.28	2.007	1061.82	3.285	1089.36	1.046
1007.25	2.723	1034.79	2.562	1062.33	3.270	1089.87	0.947
1007.76	2.846	1035.30	2.292	1062.84	2.987	1090.38	0.859
1008.27	3.283	1035.81	2.193	1063.35	2.847	1090.89	0.971
1008.78	3.052	1036.32	2.609	1063.86	2.852	1091.40	1.095
1009.29	3.284	1036.83	2.816	1064.37	2.653	1091.91	1.268

1092.42	1.285	1119.96	1.502	1147.50	1.932	1175.04	2.045
1092.93	1.239	1120.47	1.561	1148.01	2.343	1175.55	1.606
1093.44	1.221	1120.98	1.588	1148.52	2.021	1176.06	2.122
1093.95	1.696	1121.49	1.649	1149.03	2.036	1176.57	1.776
1094.46	1.494	1122.00	1.676	1149.54	2.022	1177.08	1.905
1094.97	1.537	1122.51	1.403	1150.05	1.931	1177.59	1.848
1095.48	1.986	1123.02	1.524	1150.56	1.624	1178.10	1.568
1095.99	2.138	1123.53	1.440	1151.07	1.620	1178.61	1.544
1096.50	1.992	1124.04	1.569	1151.58	1.662	1179.12	1.734
1097.01	1.793	1124.55	1.406	1152.09	1.729	1179.63	2.055
1097.52	1.921	1125.06	1.488	1152.60	1.807	1180.14	1.701
1098.03	1.560	1125.57	1.427	1153.11	1.569	1180.65	1.759
1098.54	1.447	1126.08	1.499	1153.62	1.757	1181.16	2.144
1099.05	1.662	1126.59	1.535	1154.13	1.814	1181.67	2.335
1099.56	1.345	1127.10	1.719	1154.64	1.853	1182.18	2.568
1100.07	1.431	1127.61	1.999	1155.15	1.885	1182.69	2.731
1100.58	1.239	1128.12	2.041	1155.66	1.935	1183.20	2.774
1101.09	1.119	1128.63	2.313	1156.17	1.962	1183.71	2.676
1101.60	1.434	1129.14	2.089	1156.68	2.063	1184.22	3.147
1102.11	1.354	1129.65	2.867	1157.19	2.113	1184.73	2.942
1102.62	1.306	1130.16	2.854	1157.70	2.491	1185.24	2.333
1103.13	1.737	1130.67	3.004	1158.21	2.552	1185.75	1.962
1103.64	1.523	1131.18	3.072	1158.72	2.839	1186.26	2.202
1104.15	1.476	1131.69	3.249	1159.23	2.862	1186.77	2.209
1104.66	1.450	1132.20	2.620	1159.74	2.615	1187.28	1.876
1105.17	1.351	1132.71	2.233	1160.25	2.511	1187.79	2.016
1105.68	1.526	1133.22	2.382	1160.76	1.918	1188.30	2.038
1106.19	1.223	1133.73	2.173	1161.27	1.897	1188.81	2.098
1106.70	1.506	1134.24	2.532	1161.78	1.574	1189.32	1.420
1107.21	1.469	1134.75	2.638	1162.29	1.779	1189.83	1.918
1107.72	1.443	1135.26	1.976	1162.80	1.655	1190.34	1.742
1108.23	1.282	1135.77	2.087	1163.31	1.900	1190.85	1.337
1108.74	1.278	1136.28	2.098	1163.82	1.965	1191.36	1.690
1109.25	1.295	1136.79	1.799	1164.33	1.738	1191.87	1.363
1109.76	1.303	1137.30	2.104	1164.84	1.576	1192.38	1.715
1110.27	1.397	1137.81	2.110	1165.35	2.113	1192.89	1.536
1110.78	1.411	1138.32	1.778	1165.86	1.833	1193.40	1.794
1111.29	2.047	1138.83	1.793	1166.37	1.702	1193.91	1.674
1111.80	2.206	1139.34	1.776	1166.88	1.695	1194.42	1.770
1112.31	2.630	1139.85	1.475	1167.39	1.850	1194.93	1.699
1112.82	2.801	1140.36	1.798	1167.90	1.776	1195.44	1.855
1113.33	2.721	1140.87	2.336	1168.41	1.535	1195.95	2.009
1113.84	2.554	1141.38	1.900	1168.92	1.843	1196.46	1.869
1114.35	2.657	1141.89	2.013	1169.43	1.982	1196.97	2.322
1114.86	1.982	1142.40	2.430	1169.94	2.120	1197.48	1.929
1115.37	2.400	1142.91	2.676	1170.45	2.531	1197.99	1.718
1115.88	2.343	1143.42	2.851	1170.96	3.251	1198.50	2.099
1116.39	2.122	1143.93	3.221	1171.47	3.093	1199.01	1.853
1116.90	2.267	1144.44	3.226	1171.98	3.382	1199.52	2.091
1117.41	2.268	1144.95	2.316	1172.49	3.698	1200.03	1.455
1117.92	1.755	1145.46	2.662	1173.00	3.103	1200.54	1.545
1118.43	1.717	1145.97	2.436	1173.51	2.353	1201.05	1.755
1118.94	1.738	1146.48	2.200	1174.02	2.252	1201.56	1.854
1119.45	1.548	1146.99	2.406	1174.53	2.006	1202.07	1.705

1202.58	1.634	1230.12	1.401	1257.66	1.801	1285.20	1.967
1203.09	1.472	1230.63	1.696	1258.17	1.533	1285.71	1.533
1203.60	1.394	1231.14	1.714	1258.68	1.344	1286.22	1.818
1204.11	1.880	1231.65	1.582	1259.19	1.861	1286.73	1.788
1204.62	1.340	1232.16	1.755	1259.70	1.660	1287.24	1.994
1205.13	1.229	1232.67	1.729	1260.21	1.646	1287.75	2.027
1205.64	1.646	1233.18	1.644	1260.72	1.424	1288.26	2.483
1206.15	1.694	1233.69	1.900	1261.23	1.677	1288.77	2.861
1206.66	1.502	1234.20	1.654	1261.74	1.923	1289.28	2.758
1207.17	2.383	1234.71	1.510	1262.25	1.636	1289.79	2.613
1207.68	2.186	1235.22	1.787	1262.76	1.528	1290.30	2.498
1208.19	2.799	1235.73	2.049	1263.27	1.670	1290.81	2.130
1208.70	2.271	1236.24	1.687	1263.78	1.738	1291.32	2.183
1209.21	2.243	1236.75	2.260	1264.29	2.027	1291.83	1.808
1209.72	2.253	1237.26	2.258	1264.80	1.874	1292.34	1.640
1210.23	2.090	1237.77	2.447	1265.31	2.813	1292.85	1.861
1210.74	1.904	1238.28	2.272	1265.82	2.955	1293.36	1.690
1211.25	1.676	1238.79	2.248	1266.33	3.167	1293.87	1.782
1211.76	1.741	1239.30	1.766	1266.84	2.744	1294.38	1.361
1212.27	1.991	1239.81	1.992	1267.35	2.383	1294.89	1.921
1212.78	1.742	1240.32	1.839	1267.86	1.806	1295.40	1.657
1213.29	1.600	1240.83	1.696	1268.37	1.718	1295.91	2.024
1213.80	1.786	1241.34	1.986	1268.88	1.527	1296.42	1.428
1214.31	1.898	1241.85	1.946	1269.39	1.613	1296.93	1.460
1214.82	1.815	1242.36	1.524	1269.90	1.634	1297.44	1.388
1215.33	1.593	1242.87	1.817	1270.41	1.673	1297.95	1.585
1215.84	1.300	1243.38	1.721	1270.92	1.685	1298.46	1.517
1216.35	1.631	1243.89	1.691	1271.43	1.534	1298.97	1.395
1216.86	1.699	1244.40	1.920	1271.94	1.704	1299.48	1.497
1217.37	1.516	1244.91	1.485	1272.45	1.534	1299.99	1.657
1217.88	1.538	1245.42	1.527	1272.96	1.496	1300.50	1.666
1218.39	1.307	1245.93	1.341	1273.47	1.625	1301.01	1.641
1218.90	1.458	1246.44	1.682	1273.98	1.482	1301.52	1.571
1219.41	1.423	1246.95	1.618	1274.49	1.494	1302.03	1.690
1219.92	1.676	1247.46	1.899	1275.00	1.327	1302.54	1.834
1220.43	1.506	1247.97	1.520	1275.51	1.638	1303.05	2.108
1220.94	1.833	1248.48	1.522	1276.02	1.401	1303.56	2.238
1221.45	1.606	1248.99	1.642	1276.53	1.637	1304.07	2.411
1221.96	1.827	1249.50	1.484	1277.04	1.685	1304.58	2.580
1222.47	3.076	1250.01	1.552	1277.55	2.091	1305.09	2.370
1222.98	3.840	1250.52	1.573	1278.06	2.311	1305.60	3.259
1223.49	3.423	1251.03	2.242	1278.57	1.755	1306.11	3.029
1224.00	3.359	1251.54	2.493	1279.08	2.227	1306.62	3.307
1224.51	3.585	1252.05	2.723	1279.59	1.991	1307.13	2.869
1225.02	2.674	1252.56	2.413	1280.10	1.573	1307.64	3.053
1225.53	2.657	1253.07	2.416	1280.61	1.800	1308.15	3.103
1226.04	2.313	1253.58	2.400	1281.12	2.039	1308.66	2.970
1226.55	1.724	1254.09	2.017	1281.63	2.181	1309.17	3.055
1227.06	1.727	1254.60	1.805	1282.14	1.826	1309.68	2.435
1227.57	1.658	1255.11	1.492	1282.65	1.593	1310.19	2.477
1228.08	1.753	1255.62	1.715	1283.16	2.194	1310.70	2.372
1228.59	1.769	1256.13	1.570	1283.67	1.860	1311.21	1.821
1229.10	1.722	1256.64	1.595	1284.18	1.524	1311.72	1.700
1229.61	1.417	1257.15	1.443	1284.69	1.756	1312.23	1.714

1312.74	1.742	1340.28	0.958	1367.82	0.956	1395.36	1.474
1313.25	1.614	1340.79	1.296	1368.33	1.172	1395.87	1.727
1313.76	1.786	1341.30	1.168	1368.84	1.343	1396.38	1.480
1314.27	1.598	1341.81	1.235	1369.35	0.972	1396.89	1.265
1314.78	1.466	1342.32	1.237	1369.86	1.115	1397.40	1.258
1315.29	1.893	1342.83	1.283	1370.37	1.009	1397.91	1.670
1315.80	1.689	1343.34	1.380	1370.88	1.227	1398.42	1.825
1316.31	1.727	1343.85	1.557	1371.39	1.281	1398.93	1.477
1316.82	1.959	1344.36	1.156	1371.90	1.133	1399.44	1.510
1317.33	1.660	1344.87	1.418	1372.41	1.410	1399.95	1.582
1317.84	1.588	1345.38	1.292	1372.92	1.394	1400.46	1.501
1318.35	2.123	1345.89	1.176	1373.43	1.579	1400.97	1.559
1318.86	2.073	1346.40	1.351	1373.94	1.571	1401.48	1.598
1319.37	2.487	1346.91	1.481	1374.45	1.625	1401.99	1.422
1319.88	3.091	1347.42	1.435	1374.96	1.935	1402.50	1.695
1320.39	2.841	1347.93	1.864	1375.47	1.849	1403.01	1.553
1320.90	2.728	1348.44	1.740	1375.98	1.801	1403.52	1.998
1321.41	2.959	1348.95	1.901	1376.49	2.112	1404.03	2.012
1321.92	3.217	1349.46	2.226	1377.00	2.011	1404.54	2.147
1322.43	2.436	1349.97	1.716	1377.51	2.258	1405.05	1.976
1322.94	2.265	1350.48	1.456	1378.02	1.850	1405.56	1.871
1323.45	2.376	1350.99	1.381	1378.53	2.178	1406.07	1.870
1323.96	1.913	1351.50	1.162	1379.04	2.042	1406.58	1.727
1324.47	1.844	1352.01	1.118	1379.55	2.036	1407.09	1.435
1324.98	1.779	1352.52	1.133	1380.06	1.905	1407.60	1.355
1325.49	1.771	1353.03	1.183	1380.57	2.030	1408.11	1.703
1326.00	1.679	1353.54	0.888	1381.08	1.859	1408.62	1.483
1326.51	1.677	1354.05	1.069	1381.59	1.723	1409.13	1.262
1327.02	1.918	1354.56	1.053	1382.10	1.738	1409.64	1.514
1327.53	1.776	1355.07	1.107	1382.61	1.485	1410.15	1.449
1328.04	1.401	1355.58	1.266	1383.12	1.650	1410.66	1.647
1328.55	1.734	1356.09	1.332	1383.63	1.595	1411.17	1.551
1329.06	1.663	1356.60	1.015	1384.14	1.709	1411.68	1.552
1329.57	1.509	1357.11	1.341	1384.65	1.756	1412.19	1.415
1330.08	1.529	1357.62	1.262	1385.16	1.859	1412.70	1.474
1330.59	1.618	1358.13	1.165	1385.67	1.786	1413.21	1.695
1331.10	1.369	1358.64	1.237	1386.18	1.761	1413.72	1.591
1331.61	1.420	1359.15	1.225	1386.69	1.287	1414.23	1.523
1332.12	1.390	1359.66	1.052	1387.20	1.497	1414.74	1.776
1332.63	1.559	1360.17	1.348	1387.71	1.641	1415.25	1.512
1333.14	1.726	1360.68	1.490	1388.22	1.585	1415.76	1.699
1333.65	2.025	1361.19	1.338	1388.73	1.679	1416.27	1.384
1334.16	1.961	1361.70	1.388	1389.24	1.714	1416.78	1.760
1334.67	2.166	1362.21	1.523	1389.75	1.563	1417.29	1.922
1335.18	1.952	1362.72	1.852	1390.26	1.770	1417.80	1.800
1335.69	2.083	1363.23	1.401	1390.77	1.764	1418.31	1.778
1336.20	1.940	1363.74	1.412	1391.28	2.013	1418.82	1.756
1336.71	1.983	1364.25	1.677	1391.79	1.881	1419.33	1.542
1337.22	1.729	1364.76	1.154	1392.30	2.163	1419.84	1.625
1337.73	1.433	1365.27	1.258	1392.81	1.278	1420.35	1.644
1338.24	1.323	1365.78	1.141	1393.32	1.987	1420.86	1.670
1338.75	1.224	1366.29	1.185	1393.83	1.721	1421.37	1.468
1339.26	1.034	1366.80	1.210	1394.34	1.402	1421.88	1.665
1339.77	1.392	1367.31	1.082	1394.85	1.276	1422.39	1.414

1422.90	1.181	1450.44	1.601	1477.98	1.464	1505.52	1.369
1423.41	1.531	1450.95	1.651	1478.49	1.568	1506.03	1.661
1423.92	1.250	1451.46	1.828	1479.00	1.471	1506.54	1.249
1424.43	1.576	1451.97	1.640	1479.51	1.353	1507.05	1.541
1424.94	1.593	1452.48	2.174	1480.02	1.667	1507.56	1.772
1425.45	1.462	1452.99	1.524	1480.53	1.660	1508.07	1.601
1425.96	1.676	1453.50	1.437	1481.04	1.810	1508.58	2.289
1426.47	1.591	1454.01	1.468	1481.55	1.445	1509.09	1.874
1426.98	1.737	1454.52	1.850	1482.06	1.453	1509.60	1.839
1427.49	1.373	1455.03	1.648	1482.57	1.446	1510.11	2.382
1428.00	1.365	1455.54	1.903	1483.08	1.854	1510.62	2.051
1428.51	1.733	1456.05	1.637	1483.59	1.843	1511.13	2.526
1429.02	1.502	1456.56	1.694	1484.10	1.989	1511.64	2.397
1429.53	1.783	1457.07	1.456	1484.61	2.074	1512.15	2.231
1430.04	2.260	1457.58	1.504	1485.12	2.015	1512.66	1.909
1430.55	2.351	1458.09	1.652	1485.63	1.856	1513.17	2.067
1431.06	2.469	1458.60	1.409	1486.14	1.900	1513.68	1.959
1431.57	2.753	1459.11	1.563	1486.65	1.379	1514.19	1.602
1432.08	2.474	1459.62	1.713	1487.16	1.220	1514.70	1.757
1432.59	2.727	1460.13	1.581	1487.67	1.220	1515.21	1.802
1433.10	2.746	1460.64	1.564	1488.18	1.240	1515.72	1.642
1433.61	3.123	1461.15	1.827	1488.69	1.397	1516.23	1.714
1434.12	2.472	1461.66	1.868	1489.20	1.268	1516.74	1.763
1434.63	2.457	1462.17	1.673	1489.71	2.049	1517.25	1.671
1435.14	2.271	1462.68	1.840	1490.22	1.896	1517.76	1.832
1435.65	2.449	1463.19	1.898	1490.73	2.524	1518.27	1.760
1436.16	2.137	1463.70	2.073	1491.24	2.685	1518.78	1.514
1436.67	2.043	1464.21	2.183	1491.75	2.359	1519.29	1.659
1437.18	2.039	1464.72	2.629	1492.26	2.796	1519.80	1.352
1437.69	1.740	1465.23	2.278	1492.77	2.521	1520.31	1.723
1438.20	2.218	1465.74	2.566	1493.28	2.574	1520.82	1.722
1438.71	1.433	1466.25	2.501	1493.79	2.083	1521.33	1.681
1439.22	1.806	1466.76	2.235	1494.30	2.068	1521.84	1.794
1439.73	1.640	1467.27	2.383	1494.81	1.701	1522.35	1.592
1440.24	1.809	1467.78	2.262	1495.32	1.901	1522.86	1.564
1440.75	1.726	1468.29	2.215	1495.83	2.033	1523.37	1.635
1441.26	1.548	1468.80	2.180	1496.34	1.734	1523.88	2.151
1441.77	1.626	1469.31	1.954	1496.85	1.710	1524.39	2.072
1442.28	1.652	1469.82	2.083	1497.36	1.751	1524.90	1.959
1442.79	1.481	1470.33	1.928	1497.87	1.438	1525.41	2.532
1443.30	1.417	1470.84	1.443	1498.38	1.963	1525.92	2.385
1443.81	1.799	1471.35	1.725	1498.89	1.561	1526.43	2.138
1444.32	1.560	1471.86	1.512	1499.40	1.351	1526.94	2.197
1444.83	1.563	1472.37	1.625	1499.91	1.315	1527.45	1.818
1445.34	1.535	1472.88	1.531	1500.42	1.559	1527.96	1.498
1445.85	1.524	1473.39	1.430	1500.93	1.622	1528.47	1.694
1446.36	1.965	1473.90	1.553	1501.44	1.385	1528.98	1.505
1446.87	1.552	1474.41	1.430	1501.95	1.585	1529.49	1.545
1447.38	1.663	1474.92	1.477	1502.46	1.540	1530.00	1.421
1447.89	1.792	1475.43	1.548	1502.97	1.630	1530.51	1.531
1448.40	1.404	1475.94	1.377	1503.48	1.379	1531.02	1.710
1448.91	1.767	1476.45	1.413	1503.99	1.615	1531.53	1.663
1449.42	2.178	1476.96	1.563	1504.50	1.379	1532.04	1.420
1449.93	1.865	1477.47	1.462	1505.01	1.601	1532.55	1.720

1533.06	1.517	1560.60	1.812	1588.14	1.601	1615.68	1.652
1533.57	1.591	1561.11	2.015	1588.65	1.529	1616.19	1.475
1534.08	1.425	1561.62	1.978	1589.16	1.650	1616.70	1.743
1534.59	1.839	1562.13	1.663	1589.67	1.382	1617.21	1.671
1535.10	1.642	1562.64	1.733	1590.18	1.403	1617.72	1.589
1535.61	2.076	1563.15	1.589	1590.69	1.211	1618.23	1.519
1536.12	1.885	1563.66	1.714	1591.20	1.411	1618.74	1.435
1536.63	2.054	1564.17	1.713	1591.71	1.670	1619.25	1.432
1537.14	2.025	1564.68	2.137	1592.22	1.553	1619.76	1.322
1537.65	1.928	1565.19	1.738	1592.73	1.170	1620.27	1.548
1538.16	2.508	1565.70	1.780	1593.24	1.196	1620.78	1.548
1538.67	2.359	1566.21	1.580	1593.75	1.576	1621.29	1.937
1539.18	3.177	1566.72	1.584	1594.26	1.565	1621.80	1.543
1539.69	2.756	1567.23	1.550	1594.77	1.500	1622.31	1.703
1540.20	3.012	1567.74	1.542	1595.28	1.501	1622.82	1.769
1540.71	2.475	1568.25	1.786	1595.79	1.556	1623.33	1.569
1541.22	2.850	1568.76	1.537	1596.30	1.578	1623.84	1.767
1541.73	3.078	1569.27	1.788	1596.81	2.273	1624.35	1.330
1542.24	2.557	1569.78	1.824	1597.32	2.198	1624.86	1.511
1542.75	2.075	1570.29	2.280	1597.83	2.512	1625.37	1.146
1543.26	1.842	1570.80	1.805	1598.34	2.469	1625.88	1.408
1543.77	1.927	1571.31	2.194	1598.85	2.477	1626.39	1.650
1544.28	1.936	1571.82	2.491	1599.36	1.988	1626.90	1.690
1544.79	1.838	1572.33	2.526	1599.87	2.299	1627.41	1.397
1545.30	1.839	1572.84	2.516	1600.38	1.869	1627.92	1.504
1545.81	2.188	1573.35	2.584	1600.89	1.638	1628.43	1.896
1546.32	1.530	1573.86	2.999	1601.40	1.371	1628.94	2.035
1546.83	1.873	1574.37	2.435	1601.91	1.453	1629.45	1.702
1547.34	1.773	1574.88	1.856	1602.42	1.242	1629.96	2.185
1547.85	1.715	1575.39	2.016	1602.93	1.449	1630.47	2.181
1548.36	2.068	1575.90	1.777	1603.44	1.353	1630.98	2.289
1548.87	1.902	1576.41	1.514	1603.95	1.546	1631.49	2.125
1549.38	1.772	1576.92	1.226	1604.46	1.329	1632.00	2.362
1549.89	2.086	1577.43	1.652	1604.97	1.521	1632.51	2.649
1550.40	1.819	1577.94	1.791	1605.48	1.335	1633.02	2.511
1550.91	1.715	1578.45	1.478	1605.99	1.331	1633.53	2.160
1551.42	1.907	1578.96	1.408	1606.50	1.561	1634.04	1.856
1551.93	1.884	1579.47	1.821	1607.01	1.138	1634.55	2.108
1552.44	2.235	1579.98	1.557	1607.52	1.436	1635.06	2.152
1552.95	2.912	1580.49	1.710	1608.03	1.415	1635.57	1.843
1553.46	2.872	1581.00	1.499	1608.54	1.178	1636.08	1.975
1553.97	2.440	1581.51	1.954	1609.05	1.584	1636.59	1.621
1554.48	2.688	1582.02	2.168	1609.56	1.638	1637.10	1.857
1554.99	2.836	1582.53	2.755	1610.07	1.304	1637.61	1.540
1555.50	2.772	1583.04	2.302	1610.58	1.309	1638.12	1.431
1556.01	2.316	1583.55	2.514	1611.09	1.181	1638.63	1.590
1556.52	2.439	1584.06	2.690	1611.60	1.451	1639.14	1.652
1557.03	2.552	1584.57	2.415	1612.11	1.644	1639.65	1.581
1557.54	2.167	1585.08	2.111	1612.62	1.406	1640.16	2.084
1558.05	2.434	1585.59	2.388	1613.13	1.668	1640.67	1.829
1558.56	2.103	1586.10	1.690	1613.64	1.521	1641.18	1.981
1559.07	1.994	1586.61	1.391	1614.15	1.902	1641.69	1.487
1559.58	1.779	1587.12	1.391	1614.66	2.162	1642.20	1.864
1560.09	1.504	1587.63	1.389	1615.17	1.711	1642.71	1.303

1643.22	1.550	1670.76	1.686	1698.30	2.027	1725.84	1.930
1643.73	1.439	1671.27	2.099	1698.81	1.911	1726.35	2.055
1644.24	1.697	1671.78	1.718	1699.32	1.666	1726.86	1.851
1644.75	1.751	1672.29	1.721	1699.83	2.012	1727.37	1.820
1645.26	1.961	1672.80	2.020	1700.34	2.440	1727.88	1.977
1645.77	1.949	1673.31	1.710	1700.85	2.077	1728.39	2.506
1646.28	2.161	1673.82	2.088	1701.36	2.211	1728.90	1.941
1646.79	3.028	1674.33	1.793	1701.87	1.945	1729.41	2.426
1647.30	2.251	1674.84	2.042	1702.38	1.873	1729.92	1.811
1647.81	2.414	1675.35	2.146	1702.89	2.204	1730.43	2.224
1648.32	1.850	1675.86	1.829	1703.40	2.637	1730.94	1.790
1648.83	1.775	1676.37	2.090	1703.91	2.796	1731.45	1.657
1649.34	1.597	1676.88	1.960	1704.42	2.396	1731.96	1.779
1649.85	1.771	1677.39	2.105	1704.93	2.397	1732.47	1.846
1650.36	1.686	1677.90	1.650	1705.44	2.892	1732.98	1.554
1650.87	1.856	1678.41	1.925	1705.95	2.275	1733.49	1.946
1651.38	1.548	1678.92	1.826	1706.46	2.039	1734.00	1.860
1651.89	1.359	1679.43	2.318	1706.97	2.494	1734.51	1.809
1652.40	1.404	1679.94	1.944	1707.48	2.323	1735.02	2.098
1652.91	1.421	1680.45	1.873	1707.99	2.168	1735.53	1.625
1653.42	1.741	1680.96	2.062	1708.50	2.026	1736.04	1.988
1653.93	1.506	1681.47	2.301	1709.01	2.052	1736.55	1.966
1654.44	1.846	1681.98	2.879	1709.52	2.066	1737.06	1.353
1654.95	1.832	1682.49	2.872	1710.03	2.524	1737.57	2.145
1655.46	1.830	1683.00	2.801	1710.54	2.438	1738.08	2.081
1655.97	1.671	1683.51	2.774	1711.05	2.528	1738.59	1.765
1656.48	1.921	1684.02	2.825	1711.56	2.407	1739.10	1.763
1656.99	1.589	1684.53	2.720	1712.07	2.498	1739.61	1.731
1657.50	1.778	1685.04	2.211	1712.58	2.494	1740.12	1.947
1658.01	2.121	1685.55	2.931	1713.09	2.041	1740.63	1.988
1658.52	1.780	1686.06	2.128	1713.60	2.161	1741.14	2.357
1659.03	1.805	1686.57	2.429	1714.11	2.919	1741.65	2.318
1659.54	1.772	1687.08	2.410	1714.62	2.637	1742.16	2.588
1660.05	2.081	1687.59	2.323	1715.13	2.529	1742.67	3.011
1660.56	2.011	1688.10	2.454	1715.64	2.729	1743.18	3.020
1661.07	1.901	1688.61	2.116	1716.15	3.068	1743.69	2.434
1661.58	2.232	1689.12	2.071	1716.66	2.953	1744.20	2.548
1662.09	3.067	1689.63	2.111	1717.17	3.186	1744.71	2.410
1662.60	2.960	1690.14	1.956	1717.68	3.187	1745.22	1.739
1663.11	2.945	1690.65	2.023	1718.19	3.477	1745.73	2.006
1663.62	2.667	1691.16	2.032	1718.70	3.313	1746.24	1.741
1664.13	3.192	1691.67	1.853	1719.21	3.197	1746.75	2.067
1664.64	2.860	1692.18	1.610	1719.72	3.000	1747.26	2.004
1665.15	2.534	1692.69	2.132	1720.23	2.713	1747.77	1.854
1665.66	2.495	1693.20	2.186	1720.74	2.834	1748.28	1.845
1666.17	2.348	1693.71	2.153	1721.25	2.791	1748.79	1.766
1666.68	2.401	1694.22	2.185	1721.76	2.603	1749.30	1.746
1667.19	2.016	1694.73	2.089	1722.27	2.360	1749.81	1.977
1667.70	2.113	1695.24	2.316	1722.78	2.642	1750.32	2.229
1668.21	2.054	1695.75	2.019	1723.29	2.162	1750.83	2.041
1668.72	2.000	1696.26	2.057	1723.80	2.286	1751.34	1.766
1669.23	1.903	1696.77	2.085	1724.31	2.305	1751.85	2.214
1669.74	1.663	1697.28	2.299	1724.82	2.284	1752.36	2.244
1670.25	1.953	1697.79	2.358	1725.33	2.242	1752.87	2.620

1753.38	2.382	1780.92	1.783	1808.46	1.977	1836.00	2.317
1753.89	2.728	1781.43	1.912	1808.97	2.347	1836.51	2.944
1754.40	3.209	1781.94	2.213	1809.48	2.300	1837.02	2.798
1754.91	2.876	1782.45	2.421	1809.99	2.376	1837.53	3.183
1755.42	2.877	1782.96	2.608	1810.50	2.630	1838.04	2.459
1755.93	3.216	1783.47	3.093	1811.01	2.889	1838.55	2.802
1756.44	2.979	1783.98	3.008	1811.52	2.295	1839.06	2.448
1756.95	3.265	1784.49	2.775	1812.03	1.972	1839.57	2.778
1757.46	2.678	1785.00	2.455	1812.54	2.133	1840.08	2.314
1757.97	2.512	1785.51	2.290	1813.05	2.069	1840.59	1.951
1758.48	2.060	1786.02	2.116	1813.56	1.908	1841.10	2.150
1758.99	2.376	1786.53	1.890	1814.07	1.592	1841.61	1.559
1759.50	2.046	1787.04	1.847	1814.58	2.050	1842.12	1.894
1760.01	1.900	1787.55	1.798	1815.09	2.021	1842.63	1.939
1760.52	2.008	1788.06	2.107	1815.60	2.014	1843.14	1.816
1761.03	1.901	1788.57	1.912	1816.11	1.587	1843.65	1.716
1761.54	1.450	1789.08	1.761	1816.62	1.647	1844.16	1.852
1762.05	1.707	1789.59	1.677	1817.13	1.983	1844.67	1.863
1762.56	1.584	1790.10	1.545	1817.64	1.686	1845.18	1.783
1763.07	1.440	1790.61	1.570	1818.15	1.613	1845.69	1.813
1763.58	1.633	1791.12	1.676	1818.66	1.753	1846.20	1.783
1764.09	1.473	1791.63	1.686	1819.17	1.791	1846.71	2.038
1764.60	1.547	1792.14	1.821	1819.68	1.734	1847.22	1.564
1765.11	1.689	1792.65	2.262	1820.19	1.626	1847.73	1.840
1765.62	1.838	1793.16	1.906	1820.70	2.497	1848.24	2.239
1766.13	1.891	1793.67	1.645	1821.21	2.056	1848.75	2.120
1766.64	2.094	1794.18	1.768	1821.72	2.665	1849.26	1.778
1767.15	1.918	1794.69	2.028	1822.23	3.281	1849.77	1.890
1767.66	1.797	1795.20	2.592	1822.74	3.219	1850.28	1.811
1768.17	2.047	1795.71	2.506	1823.25	3.116	1850.79	2.245
1768.68	2.300	1796.22	3.076	1823.76	3.303	1851.30	2.404
1769.19	2.355	1796.73	2.890	1824.27	3.016	1851.81	2.257
1769.70	2.442	1797.24	3.147	1824.78	2.217	1852.32	1.830
1770.21	2.319	1797.75	4.158	1825.29	2.617	1852.83	1.681
1770.72	2.119	1798.26	3.617	1825.80	2.408	1853.34	1.607
1771.23	1.780	1798.77	3.145	1826.31	2.110	1853.85	1.914
1771.74	1.735	1799.28	3.204	1826.82	2.564	1854.36	1.818
1772.25	1.919	1799.79	2.461	1827.33	2.195	1854.87	1.913
1772.76	1.636	1800.30	2.320	1827.84	1.959	1855.38	1.668
1773.27	1.564	1800.81	2.226	1828.35	2.393	1855.89	2.083
1773.78	1.783	1801.32	1.860	1828.86	1.941	1856.40	1.896
1774.29	1.596	1801.83	1.694	1829.37	1.643	1856.91	1.986
1774.80	1.547	1802.34	1.985	1829.88	1.966	1857.42	2.046
1775.31	2.056	1802.85	1.726	1830.39	1.773	1857.93	2.419
1775.82	2.031	1803.36	2.068	1830.90	1.794	1858.44	2.102
1776.33	1.453	1803.87	2.058	1831.41	1.717	1858.95	1.940
1776.84	1.503	1804.38	1.447	1831.92	2.334	1859.46	1.687
1777.35	1.625	1804.89	1.492	1832.43	1.561	1859.97	1.796
1777.86	1.635	1805.40	1.624	1832.94	1.825	1860.48	2.254
1778.37	1.436	1805.91	1.560	1833.45	1.555	1860.99	2.194
1778.88	1.312	1806.42	2.074	1833.96	1.561	1861.50	2.518
1779.39	1.508	1806.93	1.948	1834.47	1.928	1862.01	2.890
1779.90	1.420	1807.44	1.900	1834.98	2.069	1862.52	2.683
1780.41	1.454	1807.95	2.016	1835.49	2.042	1863.03	2.376

1863.54	2.533	1891.08	2.451	1918.62	3.144	1946.16	2.798
1864.05	2.846	1891.59	2.167	1919.13	2.623	1946.67	2.037
1864.56	2.646	1892.10	1.913	1919.64	3.254	1947.18	2.503
1865.07	2.571	1892.61	1.778	1920.15	2.182	1947.69	2.337
1865.58	2.490	1893.12	1.601	1920.66	2.953	1948.20	2.426
1866.09	2.086	1893.63	1.606	1921.17	2.970	1948.71	2.363
1866.60	1.784	1894.14	2.133	1921.68	2.669	1949.22	2.589
1867.11	2.132	1894.65	1.798	1922.19	2.785	1949.73	2.099
1867.62	2.193	1895.16	1.636	1922.70	2.556	1950.24	1.880
1868.13	2.018	1895.67	1.576	1923.21	2.918	1950.75	2.612
1868.64	1.586	1896.18	1.516	1923.72	2.735	1951.26	2.105
1869.15	1.955	1896.69	1.570	1924.23	2.898	1951.77	2.300
1869.66	2.085	1897.20	1.755	1924.74	2.500	1952.28	2.419
1870.17	2.391	1897.71	1.800	1925.25	2.383	1952.79	2.125
1870.68	2.482	1898.22	1.455	1925.76	2.768	1953.30	1.710
1871.19	2.549	1898.73	2.201	1926.27	2.469	1953.81	2.287
1871.70	2.385	1899.24	2.353	1926.78	2.420	1954.32	2.006
1872.21	2.084	1899.75	3.072	1927.29	2.575	1954.83	1.844
1872.72	2.168	1900.26	2.641	1927.80	2.377	1955.34	2.096
1873.23	2.114	1900.77	2.110	1928.31	2.127	1955.85	2.899
1873.74	1.765	1901.28	2.340	1928.82	2.218	1956.36	3.208
1874.25	1.633	1901.79	2.413	1929.33	2.011	1956.87	3.117
1874.76	2.138	1902.30	2.379	1929.84	2.563	1957.38	3.146
1875.27	2.485	1902.81	2.832	1930.35	2.223	1957.89	3.041
1875.78	2.211	1903.32	2.175	1930.86	2.250	1958.40	3.333
1876.29	3.047	1903.83	2.500	1931.37	2.336	1958.91	2.937
1876.80	3.302	1904.34	2.427	1931.88	2.259	1959.42	2.706
1877.31	3.255	1904.85	2.314	1932.39	1.989	1959.93	2.760
1877.82	2.779	1905.36	2.352	1932.90	2.207	1960.44	2.428
1878.33	2.545	1905.87	1.985	1933.41	2.169	1960.95	2.989
1878.84	2.375	1906.38	1.874	1933.92	2.199	1961.46	2.157
1879.35	2.517	1906.89	2.570	1934.43	1.895	1961.97	2.435
1879.86	2.149	1907.40	2.236	1934.94	1.634	1962.48	1.861
1880.37	2.070	1907.91	1.809	1935.45	1.891	1962.99	2.467
1880.88	2.142	1908.42	2.041	1935.96	1.764	1963.50	2.074
1881.39	1.971	1908.93	1.844	1936.47	1.897	1964.01	1.930
1881.90	1.923	1909.44	1.815	1936.98	1.790	1964.52	2.402
1882.41	2.258	1909.95	1.542	1937.49	2.056	1965.03	2.225
1882.92	2.177	1910.46	1.666	1938.00	2.175	1965.54	2.134
1883.43	2.169	1910.97	1.740	1938.51	2.229	1966.05	1.913
1883.94	2.428	1911.48	1.991	1939.02	2.166	1966.56	2.118
1884.45	2.169	1911.99	2.400	1939.53	2.014	1967.07	2.424
1884.96	1.704	1912.50	2.955	1940.04	2.323	1967.58	2.171
1885.47	2.375	1913.01	2.539	1940.55	2.221	1968.09	1.958
1885.98	2.297	1913.52	2.807	1941.06	1.814	1968.60	1.828
1886.49	2.433	1914.03	2.639	1941.57	1.986	1969.11	2.054
1887.00	2.680	1914.54	3.054	1942.08	2.848	1969.62	2.130
1887.51	2.611	1915.05	2.933	1942.59	2.894	1970.13	2.006
1888.02	2.739	1915.56	2.744	1943.10	3.821	1970.64	1.937
1888.53	2.509	1916.07	2.547	1943.61	3.480	1971.15	2.131
1889.04	3.257	1916.58	2.769	1944.12	2.974	1971.66	2.228
1889.55	2.740	1917.09	3.055	1944.63	3.513	1972.17	2.636
1890.06	2.639	1917.60	2.567	1945.14	3.112	1972.68	2.763
1890.57	2.457	1918.11	2.848	1945.65	2.822	1973.19	3.170

1973.70	3.365	2001.24	3.628	2028.78	2.474	2056.32	2.187
1974.21	2.612	2001.75	4.395	2029.29	2.296	2056.83	2.258
1974.72	2.553	2002.26	3.419	2029.80	3.175	2057.34	2.658
1975.23	2.641	2002.77	3.674	2030.31	2.676	2057.85	2.355
1975.74	2.407	2003.28	3.291	2030.82	2.458	2058.36	2.226
1976.25	2.316	2003.79	3.462	2031.33	2.830	2058.87	2.711
1976.76	2.358	2004.30	2.723	2031.84	2.588	2059.38	2.568
1977.27	2.405	2004.81	2.661	2032.35	2.329	2059.89	2.151
1977.78	2.269	2005.32	2.534	2032.86	2.378	2060.40	2.141
1978.29	2.268	2005.83	2.892	2033.37	2.728	2060.91	2.389
1978.80	2.214	2006.34	3.082	2033.88	2.920	2061.42	2.469
1979.31	2.619	2006.85	2.705	2034.39	2.677	2061.93	2.856
1979.82	2.342	2007.36	2.724	2034.90	2.189	2062.44	3.026
1980.33	2.397	2007.87	3.363	2035.41	2.486	2062.95	2.546
1980.84	2.146	2008.38	3.093	2035.92	2.467	2063.46	2.747
1981.35	2.099	2008.89	3.310	2036.43	2.831	2063.97	3.336
1981.86	2.519	2009.40	3.294	2036.94	3.039	2064.48	2.825
1982.37	2.566	2009.91	2.293	2037.45	3.393	2064.99	2.603
1982.88	2.259	2010.42	2.672	2037.96	3.101	2065.50	2.445
1983.39	2.302	2010.93	2.223	2038.47	3.750	2066.01	2.543
1983.90	2.648	2011.44	2.782	2038.98	3.711	2066.52	1.957
1984.41	2.802	2011.95	3.112	2039.49	2.950	2067.03	2.304
1984.92	2.894	2012.46	3.280	2040.00	2.676	2067.54	1.788
1985.43	3.129	2012.97	3.151	2040.51	2.955	2068.05	2.002
1985.94	3.124	2013.48	4.673	2041.02	2.409	2068.56	2.070
1986.45	2.795	2013.99	4.050	2041.53	2.418	2069.07	1.922
1986.96	3.059	2014.50	4.056	2042.04	2.790	2069.58	1.988
1987.47	2.326	2015.01	4.247	2042.55	2.526	2070.09	1.673
1987.98	2.275	2015.52	3.393	2043.06	2.650	2070.60	1.712
1988.49	1.953	2016.03	2.780	2043.57	2.732	2071.11	1.881
1989.00	1.745	2016.54	2.719	2044.08	2.554	2071.62	1.697
1989.51	2.165	2017.05	2.780	2044.59	2.708	2072.13	1.917
1990.02	2.458	2017.56	2.966	2045.10	2.931	2072.64	2.293
1990.53	2.133	2018.07	2.750	2045.61	2.271	2073.15	2.545
1991.04	2.384	2018.58	2.626	2046.12	2.962	2073.66	2.797
1991.55	2.071	2019.09	2.848	2046.63	2.478	2074.17	2.541
1992.06	2.263	2019.60	3.163	2047.14	2.434	2074.68	2.856
1992.57	1.922	2020.11	3.148	2047.65	2.850	2075.19	2.837
1993.08	2.084	2020.62	3.080	2048.16	2.865	2075.70	3.136
1993.59	2.436	2021.13	2.798	2048.67	2.942	2076.21	2.786
1994.10	2.543	2021.64	2.766	2049.18	3.491	2076.72	2.500
1994.61	2.477	2022.15	2.726	2049.69	3.967	2077.23	1.903
1995.12	2.533	2022.66	3.036	2050.20	4.015	2077.74	2.067
1995.63	2.622	2023.17	2.489	2050.71	3.852	2078.25	2.100
1996.14	2.537	2023.68	2.759	2051.22	2.945	2078.76	2.059
1996.65	3.003	2024.19	3.224	2051.73	3.495	2079.27	1.976
1997.16	2.709	2024.70	3.524	2052.24	3.478	2079.78	1.717
1997.67	2.396	2025.21	3.904	2052.75	2.878	2080.29	2.335
1998.18		2025.72	4.382	2053.26	2.770	2080.80	1.763
1998.69	2.245	2026.23	4.352	2053.77	2.536	2081.31	1.893
1999.20	2.610	2026.74	3.946	2054.28	2.408	2081.82	2.085
1999.71	2.603	2027.25	3.590	2054.79	3.063	2082.33	2.018
2000.22	3.579	2027.76	3.092	2055.30	2.744	2082.84	2.290
2000.73	3.375	2028.27	2.524	2055.81	2.270	2083.35	2.126

2083.86	2.765	2111.40	2.408	2138.94	2.559	2166.48	3.604
2084.37	2.832	2111.91	3.033	2139.45	2.803	2166.99	3.531
2084.88	3.301	2112.42	2.649	2139.96	3.012	2167.50	3.623
2085.39	3.322	2112.93	2.565	2140.47	2.265	2168.01	3.023
2085.90	3.550	2113.44	2.494	2140.98	2.345	2168.52	2.377
2086.41	3.652	2113.95	2.356	2141.49	2.562	2169.03	1.934
2086.92	3.879	2114.46	2.051	2142.00	2.455	2169.54	1.515
2087.43	3.954	2114.97	2.414	2142.51	2.850	2170.05	1.443
2087.94	4.124	2115.48	2.204	2143.02	2.927	2170.56	1.715
2088.45	3.679	2115.99	2.174	2143.53	2.975	2171.07	2.093
2088.96	3.537	2116.50	2.094	2144.04	3.056	2171.58	2.008
2089.47	2.867	2117.01	2.127	2144.55	3.270	2172.09	2.120
2089.98	2.871	2117.52	2.128	2145.06	3.373	2172.60	3.328
2090.49	2.840	2118.03	2.225	2145.57	3.804	2173.11	3.509
2091.00	2.964	2118.54	2.219	2146.08	3.641	2173.62	3.504
2091.51	2.818	2119.05	2.080	2146.59	3.301	2174.13	3.474
2092.02	2.386	2119.56	2.184	2147.10	3.218	2174.64	3.360
2092.53	2.471	2120.07	2.187	2147.61	3.303	2175.15	3.084
2093.04	2.236	2120.58	2.229	2148.12	3.021	2175.66	3.503
2093.55	2.503	2121.09	2.755	2148.63	3.323	2176.17	2.621
2094.06	1.798	2121.60	3.513	2149.14	2.907	2176.68	2.718
2094.57	2.377	2122.11	3.672	2149.65	3.199	2177.19	2.170
2095.08	1.854	2122.62	3.459	2150.16	3.071	2177.70	2.548
2095.59	2.034	2123.13	3.703	2150.67	2.145	2178.21	2.635
2096.10	2.020	2123.64	3.455	2151.18	2.514	2178.72	2.352
2096.61	2.155	2124.15	2.816	2151.69	2.186	2179.23	2.453
2097.12	1.763	2124.66	2.780	2152.20	2.356	2179.74	2.410
2097.63	2.136	2125.17	2.249	2152.71	2.495	2180.25	2.432
2098.14	2.451	2125.68	2.534	2153.22	2.308	2180.76	2.267
2098.65	2.849	2126.19	2.477	2153.73	1.929	2181.27	2.437
2099.16	3.143	2126.70	2.718	2154.24	2.770	2181.78	2.794
2099.67	4.013	2127.21	2.836	2154.75	2.611	2182.29	3.073
2100.18	2.862	2127.72	2.439	2155.26	2.724	2182.80	3.747
2100.69	2.828	2128.23	2.551	2155.77	2.852	2183.31	3.553
2101.20	2.818	2128.74	2.216	2156.28	4.003	2183.82	3.510
2101.71	2.553	2129.25	2.712	2156.79	4.923	2184.33	2.956
2102.22	2.841	2129.76	2.492	2157.30	4.815	2184.84	2.770
2102.73	2.064	2130.27	2.447	2157.81	4.587	2185.35	2.963
2103.24	2.244	2130.78	2.415	2158.32	5.230	2185.86	3.196
2103.75	2.397	2131.29	2.984	2158.83	4.611	2186.37	2.965
2104.26	2.267	2131.80	3.809	2159.34	3.919	2186.88	3.087
2104.77	2.541	2132.31	3.726	2159.85	4.204	2187.39	2.970
2105.28	2.060	2132.82	3.690	2160.36	3.950	2187.90	3.165
2105.79	2.138	2133.33	3.927	2160.87	4.092	2188.41	2.981
2106.30	2.231	2133.84	3.713	2161.38	4.172	2188.92	2.508
2106.81	2.180	2134.35	3.598	2161.89	4.082	2189.43	2.223
2107.32	1.988	2134.86	3.660	2162.40	4.247	2189.94	2.799
2107.83	2.107	2135.37	3.798	2162.91	4.642	2190.45	2.735
2108.34	2.047	2135.88	3.279	2163.42	4.259	2190.96	3.004
2108.85	2.405	2136.39	2.781	2163.93	4.075	2191.47	2.990
2109.36	2.839	2136.90	2.731	2164.44	4.318	2191.98	3.549
2109.87	2.377	2137.41	2.939	2164.95	3.917	2192.49	4.250
2110.38	2.657	2137.92	2.795	2165.46	3.663	2193.00	3.923
2110.89	2.824	2138.43	2.508	2165.97	3.835	2193.51	4.806

2194.02	4.175	2221.56	2.552	2249.10	3.148	2276.64	2.115
2194.53	4.558	2222.07	2.492	2249.61	2.772	2277.15	1.906
2195.04	3.783	2222.58	2.222	2250.12	2.870	2277.66	2.085
2195.55	4.358	2223.09	1.898	2250.63	2.295	2278.17	2.111
2196.06	3.943	2223.60	2.051	2251.14	2.400	2278.68	2.160
2196.57	3.693	2224.11	2.145	2251.65	1.925	2279.19	1.970
2197.08	3.737	2224.62	2.354	2252.16	2.132	2279.70	1.821
2197.59	4.573	2225.13	2.982	2252.67	1.946	2280.21	1.992
2198.10	4.014	2225.64	4.148	2253.18	1.927	2280.72	1.782
2198.61	3.528	2226.15	4.367	2253.69	2.006	2281.23	2.174
2199.12	4.132	2226.66	4.436	2254.20	1.933	2281.74	2.058
2199.63	3.192	2227.17	3.736	2254.71	1.980	2282.25	2.151
2200.14	3.829	2227.68	3.792	2255.22	1.955	2282.76	1.977
2200.65	4.449	2228.19	3.194	2255.73	1.597	2283.27	2.186
2201.16	4.503	2228.70	3.213	2256.24	2.063	2283.78	2.387
2201.67	4.214	2229.21	2.561	2256.75	1.534	2284.29	2.496
2202.18	4.244	2229.72	2.961	2257.26	1.908	2284.80	2.822
2202.69	4.702	2230.23	2.134	2257.77	2.129	2285.31	3.388
2203.20	4.402	2230.74	2.197	2258.28	2.105	2285.82	2.969
2203.71	4.995	2231.25	2.327	2258.79	2.500	2286.33	3.188
2204.22	4.628	2231.76	2.130	2259.30	2.437	2286.84	3.434
2204.73	5.260	2232.27	2.014	2259.81	2.847	2287.35	2.661
2205.24	5.041	2232.78	2.474	2260.32	3.036	2287.86	2.671
2205.75	5.906	2233.29	2.119	2260.83	2.699	2288.37	2.160
2206.26	6.077	2233.80	2.300	2261.34	2.457	2288.88	2.433
2206.77	5.613	2234.31	1.877	2261.85	2.744	2289.39	2.137
2207.28	4.883	2234.82	2.012	2262.36	2.258	2289.90	2.642
2207.79	4.603	2235.33	2.691	2262.87	2.044	2290.41	2.178
2208.30	4.740	2235.84	2.627	2263.38	2.377	2290.92	1.918
2208.81	4.233	2236.35	2.734	2263.89	2.083	2291.43	1.846
2209.32	4.278	2236.86	2.685	2264.40	2.154	2291.94	2.272
2209.83	4.780	2237.37	2.655	2264.91	1.758	2292.45	2.117
2210.34	4.379	2237.88	2.747	2265.42	2.297	2292.96	2.114
2210.85	4.259	2238.39	2.181	2265.93	2.015	2293.47	1.975
2211.36	3.552	2238.90	2.500	2266.44	1.805	2293.98	1.865
2211.87	3.373	2239.41	1.844	2266.95	1.972	2294.49	2.111
2212.38	3.512	2239.92	1.850	2267.46	2.105	2295.00	2.118
2212.89	3.656	2240.43	1.753	2267.97	2.295	2295.51	2.227
2213.40	3.958	2240.94	2.154	2268.48	2.199	2296.02	2.434
2213.91	3.375	2241.45	1.978	2268.99	2.501	2296.53	2.433
2214.42	3.267	2241.96	1.888	2269.50	2.322	2297.04	2.597
2214.93	3.391	2242.47	1.928	2270.01	2.199	2297.55	2.581
2215.44	3.314	2242.98	1.711	2270.52	2.185	2298.06	2.720
2215.95	3.782	2243.49	1.908	2271.03	2.738	2298.57	3.393
2216.46	3.869	2244.00	1.489	2271.54	3.582	2299.08	3.500
2216.97	3.734	2244.51	1.700	2272.05	3.227	2299.59	3.017
2217.48	3.552	2245.02	2.006	2272.56	3.917	2300.10	2.795
2217.99	4.046	2245.53	1.753	2273.07	3.543	2300.61	2.685
2218.50	3.504	2246.04	2.067	2273.58	3.094	2301.12	2.800
2219.01	3.445	2246.55	2.336	2274.09	2.926	2301.63	2.721
2219.52	3.102	2247.06	2.144	2274.60	2.487	2302.14	2.458
2220.03	3.221	2247.57	2.600	2275.11	2.612	2302.65	2.518
2220.54	2.546	2248.08	2.905	2275.62	2.211	2303.16	2.179
2221.05	2.442	2248.59	3.386	2276.13	2.298	2303.67	2.193

2304.18	2.248	2331.72	2.010	2359.26	2.150	2386.80	2.094
2304.69	1.972	2332.23	2.043	2359.77	2.372	2387.31	1.404
2305.20	2.159	2332.74	1.876	2360.28	2.181	2387.82	1.914
2305.71	2.126	2333.25	1.695	2360.79	1.558	2388.33	1.622
2306.22	2.350	2333.76	1.708	2361.30	1.886	2388.84	1.611
2306.73	2.617	2334.27	1.789	2361.81	1.472	2389.35	2.048
2307.24	2.773	2334.78	1.415	2362.32	1.911	2389.86	2.057
2307.75	3.603	2335.29	1.656	2362.83	1.705	2390.37	2.283
2308.26	3.670	2335.80	1.597	2363.34	2.093	2390.88	2.279
2308.77	4.022	2336.31	1.464	2363.85	1.822	2391.39	2.615
2309.28	4.322	2336.82	1.649	2364.36	1.876	2391.90	3.199
2309.79	3.941	2337.33	2.157	2364.87	2.229	2392.41	3.781
2310.30	3.021	2337.84	2.142	2365.38	2.280	2392.92	3.439
2310.81	2.585	2338.35	3.020	2365.89	2.577	2393.43	3.211
2311.32	2.597	2338.86	3.979	2366.40	3.460	2393.94	3.044
2311.83	2.912	2339.37	5.145	2366.91	2.643	2394.45	2.834
2312.34	2.477	2339.88	4.660	2367.42	2.859	2394.96	2.185
2312.85	2.395	2340.39	4.544	2367.93	2.848	2395.47	2.497
2313.36	2.373	2340.90	3.792	2368.44	2.772	2395.98	2.135
2313.87	2.409	2341.41	3.023	2368.95	2.692	2396.49	1.610
2314.38	1.843	2341.92	2.659	2369.46	2.810	2397.00	1.890
2314.89	1.740	2342.43	2.827	2369.97	2.989	2397.51	2.509
2315.40	1.787	2342.94	2.607	2370.48	2.340	2398.02	1.763
2315.91	2.095	2343.45	2.569	2370.99	2.360	2398.53	2.527
2316.42	2.285	2343.96	2.335	2371.50	2.192	2399.04	2.277
2316.93	2.336	2344.47	2.164	2372.01	2.412	2399.55	2.138
2317.44	3.220	2344.98	2.424	2372.52	2.036	2400.06	2.503
2317.95	3.464	2345.49	2.664	2373.03	1.824	2400.57	2.118
2318.46	3.222	2346.00	2.352	2373.54	1.511	2401.08	2.219
2318.97	2.700	2346.51	2.085	2374.05	1.953	2401.59	2.060
2319.48	2.887	2347.02	2.172	2374.56	2.103	2402.10	2.097
2319.99	2.905	2347.53	2.018	2375.07	2.007	2402.61	2.299
2320.50	3.837	2348.04	2.034	2375.58	2.007	2403.12	2.141
2321.01	3.407	2348.55	1.782	2376.09	1.764	2403.63	2.368
2321.52	2.638	2349.06	2.111	2376.60	1.636	2404.14	2.816
2322.03	2.465	2349.57	1.906	2377.11	1.909	2404.65	3.101
2322.54	2.398	2350.08	2.537	2377.62	1.519	2405.16	3.028
2323.05	2.145	2350.59	2.271	2378.13	1.751	2405.67	2.777
2323.56	2.506	2351.10	2.400	2378.64	1.884	2406.18	2.666
2324.07	1.955	2351.61	2.932	2379.15	1.913	2406.69	3.156
2324.58	1.971	2352.12	2.743	2379.66	2.645	2407.20	2.788
2325.09	2.110	2352.63	3.201	2380.17	2.670	2407.71	2.676
2325.60	2.186	2353.14	3.413	2380.68	3.239	2408.22	2.170
2326.11	2.227	2353.65	3.329	2381.19	2.978	2408.73	2.532
2326.62	1.747	2354.16	4.019	2381.70	3.415	2409.24	2.272
2327.13	1.784	2354.67	3.448	2382.21	2.906	2409.75	2.568
2327.64	2.232	2355.18	3.143	2382.72	2.816	2410.26	2.154
2328.15	2.418	2355.69	3.192	2383.23	2.573	2410.77	1.785
2328.66	3.160	2356.20	2.348	2383.74	2.272	2411.28	1.725
2329.17	3.458	2356.71	2.140	2384.25	2.373	2411.79	1.697
2329.68	3.165	2357.22	2.604	2384.76	1.694	2412.30	1.798
2330.19	2.762	2357.73	1.716	2385.27	1.912	2412.81	1.684
2330.70	2.497	2358.24	1.491	2385.78	1.946	2413.32	1.837
2331.21	2.505	2358.75	1.985	2386.29	1.783	2413.83	1.753

2414.34	1.803	2441.88	1.580	2469.42	2.604	2496.96	3.371
2414.85	1.757	2442.39	2.214	2469.93	2.573	2497.47	2.909
2415.36	1.792	2442.90	2.326	2470.44	3.064	2497.98	3.472
2415.87	1.585	2443.41	2.234	2470.95	4.096	2498.49	3.378
2416.38	1.759	2443.92	2.362	2471.46	4.032	2499.00	3.028
2416.89	1.675	2444.43	2.589	2471.97	3.892	2499.51	3.061
2417.40	1.651	2444.94	2.406	2472.48	4.219	2500.02	3.057
2417.91	2.236	2445.45	2.139	2472.99	4.175	2500.53	2.956
2418.42	2.627	2445.96	2.123	2473.50	3.637	2501.04	3.013
2418.93	2.910	2446.47	1.829	2474.01	3.786	2501.55	2.609
2419.44	2.875	2446.98	1.719	2474.52	3.417	2502.06	2.949
2419.95	2.830	2447.49	1.994	2475.03	3.843	2502.57	2.426
2420.46	2.775	2448.00	1.896	2475.54	4.088	2503.08	2.448
2420.97	2.662	2448.51	1.996	2476.05	3.434	2503.59	2.097
2421.48	2.365	2449.02	1.988	2476.56	3.193	2504.10	2.093
2421.99	2.202	2449.53	1.907	2477.07	3.260	2504.61	1.884
2422.50	2.121	2450.04	1.764	2477.58	2.832	2505.12	1.638
2423.01	1.882	2450.55	1.569	2478.09	2.948	2505.63	1.929
2423.52	1.647	2451.06	1.694	2478.60	2.462	2506.14	2.294
2424.03	1.596	2451.57	1.758	2479.11	2.125	2506.65	2.706
2424.54	1.481	2452.08	1.410	2479.62	2.439	2507.16	2.636
2425.05	1.609	2452.59	1.523	2480.13	2.311	2507.67	3.400
2425.56	1.746	2453.10	1.929	2480.64	2.394	2508.18	3.324
2426.07	1.698	2453.61	2.097	2481.15	2.728	2508.69	2.974
2426.58	1.607	2454.12	1.957	2481.66	2.292	2509.20	2.544
2427.09	1.584	2454.63	2.110	2482.17	2.231	2509.71	2.265
2427.60	1.636	2455.14	2.082	2482.68	2.303	2510.22	2.924
2428.11	1.508	2455.65	2.522	2483.19	2.680	2510.73	2.545
2428.62	1.887	2456.16	2.785	2483.70	2.234	2511.24	1.735
2429.13	2.076	2456.67	2.832	2484.21	2.304	2511.75	2.005
2429.64	1.860	2457.18	3.148	2484.72	2.213	2512.26	2.236
2430.15	1.990	2457.69	3.675	2485.23	2.912	2512.77	2.397
2430.66	2.192	2458.20	3.640	2485.74	2.622	2513.28	2.412
2431.17	2.592	2458.71	3.528	2486.25	3.163	2513.79	2.790
2431.68	2.322	2459.22	3.067	2486.76	3.147	2514.30	3.191
2432.19	2.543	2459.73	3.243	2487.27	3.415	2514.81	3.538
2432.70	2.064	2460.24	3.355	2487.78	2.554	2515.32	4.105
2433.21	2.040	2460.75	2.888	2488.29	3.069	2515.83	4.162
2433.72	1.734	2461.26	2.571	2488.80	2.945	2516.34	4.046
2434.23	1.874	2461.77	2.918	2489.31	2.546	2516.85	4.045
2434.74	1.627	2462.28	2.282	2489.82	2.748	2517.36	3.115
2435.25	1.691	2462.79	2.207	2490.33	2.596	2517.87	3.183
2435.76	1.627	2463.30	2.202	2490.84	2.371	2518.38	3.310
2436.27	1.524	2463.81	2.117	2491.35	2.556	2518.89	3.144
2436.78	1.982	2464.32	2.038	2491.86	2.500	2519.40	2.841
2437.29	1.873	2464.83	2.117	2492.37	2.015	2519.91	2.690
2437.80	1.825	2465.34	1.804	2492.88	2.173	2520.42	2.374
2438.31	1.939	2465.85	1.888	2493.39	1.669	2520.93	2.080
2438.82	1.610	2466.36	1.969	2493.90	2.001	2521.44	2.022
2439.33	1.617	2466.87	2.071	2494.41	2.076	2521.95	2.292
2439.84	1.527	2467.38	1.903	2494.92	2.007	2522.46	1.800
2440.35	1.814	2467.89	2.380	2495.43	2.164	2522.97	1.780
2440.86	1.730	2468.40	2.209	2495.94	2.515	2523.48	1.785
2441.37	1.848	2468.91	2.597	2496.45	2.548	2523.99	2.023

2524.50	1.831	2552.04	2.134	2579.58	1.982	2607.12	3.332
2525.01	1.859	2552.55	2.279	2580.09	2.252	2607.63	3.423
2525.52	2.168	2553.06	2.403	2580.60	2.378	2608.14	3.009
2526.03	2.465	2553.57	1.694	2581.11	2.383	2608.65	2.685
2526.54	2.372	2554.08	1.780	2581.62	2.427	2609.16	2.288
2527.05	2.739	2554.59	1.811	2582.13	2.710	2609.67	2.479
2527.56	2.935	2555.10	1.700	2582.64	2.751	2610.18	2.789
2528.07	2.862	2555.61	1.592	2583.15	3.003	2610.69	2.033
2528.58	2.959	2556.12	1.433	2583.66	2.560	2611.20	2.266
2529.09	3.434	2556.63	1.515	2584.17	2.041	2611.71	2.376
2529.60	3.611	2557.14	1.414	2584.68	1.862	2612.22	1.910
2530.11	3.509	2557.65	2.120	2585.19	1.469	2612.73	1.892
2530.62	3.368	2558.16	2.048	2585.70	1.958	2613.24	1.606
2531.13	3.309	2558.67	1.817	2586.21	1.669	2613.75	1.680
2531.64	2.794	2559.18	1.713	2586.72	1.891	2614.26	1.585
2532.15	2.734	2559.69	2.402	2587.23	2.109	2614.77	1.884
2532.66	2.448	2560.20	2.786	2587.74	1.417	2615.28	2.194
2533.17	2.451	2560.71	2.332	2588.25	1.692	2615.79	2.981
2533.68	2.316	2561.22	2.042	2588.76	1.397	2616.30	2.093
2534.19	2.312	2561.73	2.342	2589.27	1.474	2616.81	2.518
2534.70	2.468	2562.24	2.255	2589.78	1.807	2617.32	3.036
2535.21	2.082	2562.75	2.034	2590.29	1.650	2617.83	2.930
2535.72	1.760	2563.26	1.836	2590.80	1.614	2618.34	3.232
2536.23	1.703	2563.77	1.696	2591.31	1.731	2618.85	3.264
2536.74	1.965	2564.28	1.879	2591.82	2.017	2619.36	2.618
2537.25	2.132	2564.79	1.777	2592.33	1.987	2619.87	2.718
2537.76	2.288	2565.30	2.138	2592.84	2.209	2620.38	3.290
2538.27	2.864	2565.81	1.781	2593.35	3.108	2620.89	2.578
2538.78	3.594	2566.32	1.925	2593.86	2.386	2621.40	2.069
2539.29	4.525	2566.83	1.794	2594.37	2.726	2621.91	2.232
2539.80	4.121	2567.34	2.128	2594.88	2.331	2622.42	2.081
2540.31	3.965	2567.85	2.656	2595.39	2.232	2622.93	2.090
2540.82	3.622	2568.36	2.266	2595.90	2.754	2623.44	2.145
2541.33	3.249	2568.87	2.492	2596.41	2.781	2623.95	1.862
2541.84	3.254	2569.38	2.416	2596.92	2.679	2624.46	1.876
2542.35	2.884	2569.89	2.201	2597.43	2.596	2624.97	2.717
2542.86	2.524	2570.40	2.258	2597.94	2.382	2625.48	2.861
2543.37	2.675	2570.91	2.377	2598.45	2.655	2625.99	3.854
2543.88	2.080	2571.42	2.384	2598.96	2.224	2626.50	4.050
2544.39	2.488	2571.93	2.792	2599.47	2.003	2627.01	3.508
2544.90	1.598	2572.44	2.351	2599.98	2.020	2627.52	3.612
2545.41	1.896	2572.95	1.920	2600.49	2.187	2628.03	2.792
2545.92	2.048	2573.46	2.264	2601.00	2.147	2628.54	2.276
2546.43	1.789	2573.97	2.277	2601.51	2.075	2629.05	2.724
2546.94	1.596	2574.48	2.621	2602.02	2.002	2629.56	2.444
2547.45	1.664	2574.99	2.223	2602.53	1.667	2630.07	2.551
2547.96	1.814	2575.50	1.909	2603.04	1.858	2630.58	2.141
2548.47	1.776	2576.01	1.981	2603.55	1.916	2631.09	2.059
2548.98	1.656	2576.52	1.942	2604.06	2.020	2631.60	1.689
2549.49	1.944	2577.03	1.891	2604.57	1.920	2632.11	1.935
2550.00	1.971	2577.54	2.270	2605.08	2.167	2632.62	2.304
2550.51	2.103	2578.05	2.220	2605.59	2.264	2633.13	2.680
2551.02	2.366	2578.56	2.505	2606.10	2.684	2633.64	2.879
2551.53	2.058	2579.07	2.121	2606.61	3.277	2634.15	2.969

2634.66	3.515	2662.20	2.755	2689.74	3.898	2717.28	5.375
2635.17	3.196	2662.71	2.356	2690.25	3.477	2717.79	5.358
2635.68	2.686	2663.22	2.642	2690.76	2.734	2718.30	5.182
2636.19	1.921	2663.73	2.619	2691.27	2.994	2718.81	4.905
2636.70	2.326	2664.24	2.587	2691.78	3.074	2719.32	5.201
2637.21	1.889	2664.75	2.768	2692.29	3.632	2719.83	5.228
2637.72	2.180	2665.26	2.742	2692.80	2.753	2720.34	4.835
2638.23	2.422	2665.77	3.515	2693.31	3.119	2720.85	4.372
2638.74	2.244	2666.28	3.722	2693.82	3.119	2721.36	4.813
2639.25	2.435	2666.79	3.576	2694.33	3.413	2721.87	4.265
2639.76	2.237	2667.30	3.632	2694.84	3.332	2722.38	4.383
2640.27	2.351	2667.81	3.682	2695.35	3.562	2722.89	4.216
2640.78	2.331	2668.32	2.988	2695.86	3.526	2723.40	4.362
2641.29	2.583	2668.83	3.069	2696.37	3.481	2723.91	4.359
2641.80	2.113	2669.34	2.682	2696.88	3.777	2724.42	3.787
2642.31	2.056	2669.85	2.921	2697.39	3.880	2724.93	4.042
2642.82	2.619	2670.36	1.969	2697.90	3.544	2725.44	4.623
2643.33	3.142	2670.87	1.886	2698.41	3.373	2725.95	3.913
2643.84	2.840	2671.38	2.457	2698.92	3.459	2726.46	3.811
2644.35	2.573	2671.89	2.064	2699.43	3.320	2726.97	3.774
2644.86	2.469	2672.40	2.571	2699.94	3.115	2727.48	3.957
2645.37	3.253	2672.91	2.419	2700.45	3.795	2727.99	3.628
2645.88	3.377	2673.42	2.427	2700.96	3.459	2728.50	4.150
2646.39	2.681	2673.93	2.475	2701.47	3.014	2729.01	4.708
2646.90	2.510	2674.44	2.954	2701.98	2.917	2729.52	5.272
2647.41	2.508	2674.95	2.890	2702.49	2.926	2730.03	5.148
2647.92	2.276	2675.46	3.683	2703.00	3.220	2730.54	5.775
2648.43	2.094	2675.97	4.013	2703.51	3.440	2731.05	5.136
2648.94	2.321	2676.48	4.169	2704.02	3.291	2731.56	5.648
2649.45	1.890	2676.99	4.305	2704.53	2.851	2732.07	4.842
2649.96	2.086	2677.50	4.129	2705.04	3.657	2732.58	4.525
2650.47	2.104	2678.01	3.792	2705.55	4.488	2733.09	4.773
2650.98	1.928	2678.52	3.781	2706.06	5.788	2733.60	4.121
2651.49	2.113	2679.03	2.783	2706.57	5.293	2734.11	4.434
2652.00	2.408	2679.54	2.129	2707.08	6.073	2734.62	3.970
2652.51	2.186	2680.05	2.108	2707.59	5.708	2735.13	3.757
2653.02	2.388	2680.56	2.075	2708.10	4.867	2735.64	3.125
2653.53	2.566	2681.07	2.968	2708.61	5.140	2736.15	4.054
2654.04	2.522	2681.58	3.091	2709.12	4.897	2736.66	4.054
2654.55	3.036	2682.09	3.134	2709.63	4.554	2737.17	3.995
2655.06	3.689	2682.60	3.630	2710.14	4.598	2737.68	3.660
2655.57	3.685	2683.11	3.113	2710.65	3.737	2738.19	4.636
2656.08	4.591	2683.62	3.834	2711.16	4.184	2738.70	4.091
2656.59	4.312	2684.13	3.450	2711.67	4.168	2739.21	3.531
2657.10	4.441	2684.64	3.327	2712.18	4.125	2739.72	4.427
2657.61	3.808	2685.15	4.192	2712.69	4.295	2740.23	3.829
2658.12	3.685	2685.66	4.030	2713.20	3.642	2740.74	4.302
2658.63	3.819	2686.17	4.047	2713.71	4.140	2741.25	4.254
2659.14	3.234	2686.68	3.985	2714.22	4.030	2741.76	3.907
2659.65	3.365	2687.19	3.581	2714.73	4.298	2742.27	4.290
2660.16	2.812	2687.70	4.478	2715.24	4.446	2742.78	4.227
2660.67	3.210	2688.21	4.703	2715.75	4.769	2743.29	4.489
2661.18	3.072	2688.72	5.074	2716.26	5.131	2743.80	4.894
2661.69	2.707	2689.23	4.115	2716.77	4.967	2744.31	4.398

2744.82	5.130	2772.36	3.608	2799.90	1.622
2745.33	5.399	2772.87	3.790	2800.41	2.448
2745.84	5.107	2773.38	3.534	2800.92	3.734
2746.35	4.867	2773.89	3.563	2801.43	3.358
2746.86	5.379	2774.40	3.731	2801.94	3.751
2747.37	4.323	2774.91	4.257	2802.45	4.589
2747.88	3.946	2775.42	3.867	2802.96	4.448
2748.39	3.974	2775.93	4.186	2803.47	4.522
2748.90	4.083	2776.44	4.773	2803.98	2.853
2749.41	3.363	2776.95	5.455		
2749.92	3.729	2777.46	7.112		
2750.43	3.070	2777.97	6.767		
2750.94	2.368	2778.48	6.128		
2751.45	3.377	2778.99	7.375		
2751.96	4.296	2779.50	7.540		
2752.47	4.516	2780.01	6.382		
2752.98	4.600	2780.52	7.506		
2753.49	4.088	2781.03	5.831		
2754.00	4.017	2781.54	5.155		
2754.51	3.600	2782.05	5.183		
2755.02	3.619	2782.56	3.655		
2755.53	2.246	2783.07	3.672		
2756.04	2.471	2783.58	3.514		
2756.55	2.916	2784.09	3.271		
2757.06	3.715	2784.60	3.188		
2757.57	3.943	2785.11	3.097		
2758.08	4.902	2785.62	3.561		
2758.59	4.731	2786.13	2.970		
2759.10	5.244	2786.64	3.224		
2759.61	4.763	2787.15	3.210		
2760.12	5.026	2787.66	3.347		
2760.63	5.503	2788.17	3.460		
2761.14	6.033	2788.68	3.037		
2761.65	6.482	2789.19	4.006		
2762.16	6.558	2789.70	4.086		
2762.67	6.114	2790.21	4.806		
2763.18	6.055	2790.72	4.356		
2763.69	6.129	2791.23	4.651		
2764.20	6.203	2791.74	4.438		
2764.71	6.581	2792.25	3.193		
2765.22	6.728	2792.76	3.147		
2765.73	6.290	2793.27	2.912		
2766.24	5.970	2793.78	2.235		
2766.75	4.777	2794.29	1.577		
2767.26	5.081	2794.80	1.657		
2767.77	5.014	2795.31	1.615		
2768.28	4.402	2795.82	1.530		
2768.79	4.281	2796.33	1.726		
2769.30	4.033	2796.84	1.554		
2769.81	3.772	2797.35	1.608		
2770.32	3.733	2797.86	1.482		
2770.83	3.745	2798.37	1.327		
2771.34	3.528	2798.88	1.223		
2771.85	4.618	2799.39	1.752		