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Sea Level Variations at Monterey, California

Dale Emil Bretschneider and Douglas R. McLain

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U.S. DEPARTMENT OF COMMERCE

Malcolm Baldridge, Secretary

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John V. Byrne, Administrator

National Marine Fisheries Service

William G. Gordon, Assistant Administrator for Fisheries

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Sea Level Variations at Monterey, California

DALE EMIL BRETSCHNEIDER and DOUGLAS R. McLAIN[1]

ABSTRACT

Sea level data from Monterey, Calif., during the period 1963 through 1976 were compared with data from coastal stations from Peru to Alaska. Sea level fluctuations at Monterey were correlated with data from these stations, particularly those to the south. The causes of sea level fluctuations at Monterey were investigated by correlation, regression, and spectral analysis of sea level with atmospheric pressure, zonal and meridional wind stress, Ekman and Sverdrup transport, surface temperature and salinity, and dynamic height data from nearby locations. Of these variables, dynamic height was the best predictor of sea level fluctuations. Atmospheric pressure, surface temperature, and meridional wind stress were of secondary importance. The prediction was better during the Davidson Current period than during the upwelling period.

INTRODUCTION

Sea level and its fluctuations have interested man for centuries. Historical sea level time-series data are unique among marine data sources in that they have been obtained continuously and inexpensively over periods of decades or longer at many coastal and island locations worldwide. Sea level records include not only periodic fluctuations due to astronomic tides but also nontidal, low frequency fluctuations resulting from various oceanic and atmospheric processes. The nontidal components can be isolated by filtering out the astronomic tides, thus making measurements of sea level useful as a spacially integrated index of nearshore and offshore ocean changes.

This paper examines the character of sea level anomalies at Monterey, Calif., and the relative importance of the large-scale atmospheric and ocean processes which may cause nontidal, low frequency fluctuations. An understanding of these processes will allow the use of the abundant historical records of sea level data to reconstruct changes in the past oceanographic environment of the California Current system, which, in turn, may aid in understanding past changes in distribution, abundance, and availability of marine fish populations. In particular, the study was designed to examine the utility of sea level data for identification of anomalous environmental periods and for monitoring of changes in coastal oceanographic conditions.

EARLIER STUDIES ON SEA LEVEL VARIATIONS

Sea level variations along the Pacific coast and their relationship to various environmental phenomena have been examined from a number of different points of view. In addition to the well-understood astronomically induced periodicities, it is widely recognized that coastal sea level measurements are influenced by: 1) wind waves and swell, 2) wind set-up or set-down against the coast due to storms, 3) changes in atmospheric pressure over the ocean surface, 4) redistribution of water mass due to wind stress, 5) changes in average density of the seawater column, 6) long period astronomic tides, 7) subsidence or uplift of the land upon which the tide gage is located, and 8) changes in total mass of water in the oceans associated with the glacial ice budget. These physical processes are discussed by Montgomery (1938). LaFond (1939) found close agreement between weekly mean sea level measured at La Jolla, Calif., and offshore geopotential topography, thus directly relating ocean currents to sea level. Jacobs (1939) suggested that the relationships observed by LaFond were not entirely due to changes in the density of surface water but rather to actual slopes induced by wind-driven water transport along the coast. Pattullo et al. (1955) found that south of lat. 40°N in the North Pacific Ocean, the seasonal variation of steric elevation and sea level are in phase, both having a maximum elevation in late summer or early fall and a minimum elevation in winter. This they took as a consequence of seasonal heating and cooling. These investigators further found that seasonal variations in sea level north of lat. 40°N along the northwest coast of the United States could not be explained by steric considerations alone, suggesting that nonisostatic processes such as wind and currents can lead to appreciable regional deviations. Roden (1960) used autocorrelation and spectral techniques to examine the relationship between monthly mean sea level pressure, wind, and sea surface temperature (SST) at several stations along the Pacific coast. He found good coherence between anomalies of sea level and atmospheric pressure, moderate to poor coherence between SST and sea level depending on the location of the station, and moderate coherence between anomalies of sea level and north-south component of the geostrophic wind. Sturges (1974) found high correlations between occasional steric observations and 3-d mean sea levels at Neah Bay, Wash., and San Diego, Calif. Reid and Mantyla (1976) demonstrated that the winter increase in seasonal sea level elevation along the northern North Pacific coast results from increased overall flow in the North Pacific subarctic cyclonic gyre.[2]

OCEAN AND ATMOSPHERIC PROCESSES NEAR MONTEREY

Monterey Bay is located along the central California coast, about 120 km south of San Francisco. The bay, which is bisected by a deep submarine canyon, is a large, semi-elliptical coastal feature measuring about 37 km wide at the mouth and about 19 km from the mouth to the innermost point.

The bay lies inshore of the broad, diffuse, southward flowing California Current. The strength of the Current is affected by the winds over the Current which, in turn, are controlled by the strength and location of the Aleutian low-pressure cell located over the Aleutian

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[2]After this paper was completed, the thesis of Chelton (1980) became available. The reader is referred to it for additional information on processes affecting sea level along the coast.

Islands, the Pacific high-pressure cell located east of the Hawaiian Islands, and the thermal low-pressure cell located in summer over the western United States. During spring and summer the Aleutian low normally weakens and the Pacific high intensifies and moves northward. Winds over the Current during this period are mainly from the northwest and are strongest when the Pacific high and thermal low-pressure cells are closest together and relatively intense. Winds weaken or change direction as this pressure gradient decreases. The seasonal change in strength and location of these pressure cells thus causes seasonal changes in the winds (Reid et al. 1958).

Skogsberg (1936) described three distinct phases or periods in the seasonal hydrography of Monterey Bay. The calendar year opens in the countercurrent or Davidson Current phase. In late fall and early winter of most years, winds are weak and variable and intermittent southerly winds occur. A northward flowing countercurrent is present at the surface close inshore off central California. The general north-northwest to south-southeast trend of the coastline and Ekman transport of surface water to the right of the wind cause onshore transport of surface waters and piling up against the coast. Minimal solar radiation and strong vertical mixing of surface waters by winter storms decrease SST's to a seasonal minimum during January or February. While SST's decline during the Davidson Current period, temperatures at deeper levels slowly increase due to advection of warm waters from the south. For example, temperatures at 50 m depth reach a seasonal maximum during December and January (Skogsberg 1936; Bolin and Abbott 1963). The end of the Davidson Current period is variable and difficult to pinpoint. About March, the offshore high pressure cell intensifies and northwest winds become frequent. The resulting Ekman transport causes offshore transport of surface water and, in the nearshore region, some of this water is replaced by cold, nutrient-rich subsurface water upwelled from the upper hundred or so meters. Upwelling is strongest when northerly winds are strongest, and near Monterey usually reaches a maximum in May or June (Bakun 1975). By August, northerly winds begin to slacken and the strong solar radiation of late spring and summer results in a steady rise in SST that usually continues through September. A period of calmer winds that Skogsberg (1936) called the oceanic period occurs in September and October. With a slackening of wind stress, the cool, upwelled water begins to sink and is replaced by warmer surface water from offshore. Coastal SST's rise to their highest seasonal values and strong vertical temperature gradients form (Bolin and Abbott 1963).

Thus the oceanographic regime off Monterey is marked by three distinct periods: the Davidson Current period, occurring during November through February, has weak northerly winds, strong winter storm events, northward current flow, and onshore transport of surface water. The upwelling period, occurring in March through August, has strong northwest winds, southward current flow, offshore transport of surface water, and upwelling of cool, nutrient-rich water. The oceanic period, occurring during September and October, is a period of calm between the northerly winds of the upwelling period and the southerly winds of winter. During this period, highest surface temperatures and strongest vertical temperature gradients occur. Although these are the average seasonal characteristics in the meteorological and oceanic regimes affecting Monterey Bay, there are marked year-to-year differences in both timing and intensity of the events.

DESCRIPTION OF DATA

Recorded tide data from the tide station at Monterey, Calif. were chosen for analysis because the tide gage lies along the biologically productive upwelling region off central California and is exposed to open ocean conditions with no nearby river discharge that may affect sea level measurements (such as at San Francisco or Crescent City, Calif.). The Monterey gage is the only primary tide station maintained by the National Ocean Survey (NOS) between San Francisco and Avila, and thus fills a large data gap along the central California coast. The Monterey station has been operated continuously since 1963 by the Naval Postgraduate School (NPS) but the time-series data have not been fully analyzed. The tide station is located along the southern edge of the bay near the end of Monterey Municipal Wharf No. 2 where the water has a depth of approximately 6.8 m. Because of the open shape of the bay and the narrow width of the continental shelf, tide measurements obtained here are presumed to approximate those of the open coast.

In addition to sea level data, meteorological and oceanographic data representative of the Monterey area, including surface atmospheric pressure data, geostrophic wind data, surface salinity and temperature data, and deep hydrocast data were used in this study. The geographic proximity of the various data sources allowed direct comparison of variables with minimal problems resulting from spatial distortion. Figure 1 shows the location from which each of the data sources was derived, along with bathymetric contours.

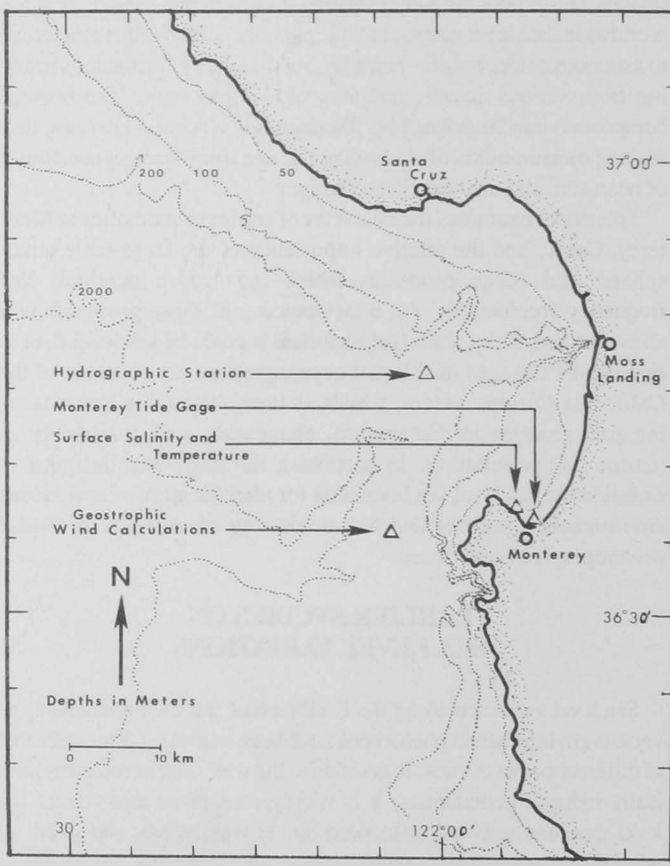

Figure 1.—Map of Monterey Bay, Calif., region showing location of data sources.

Monterey Sea Level Data

Tide Gages.—A standard recording tide gage, which traces tide heights continuously on a strip chart, was installed at the Monterey tide station by NPS personnel in June 1963. This analog system is entirely mechanical and is highly dependable when maintained properly. A drum-mounted strip chart is rotated by a spring-driven clock mechanism, and a pencil records sea level changes by means of a float-pulley system. A second instrument, a Fisher-Porter digital tide gage, was installed adjacent to the analog gage by the NOS in November 1973. This is an electrically operated system which punches digital data on foil tape. Both gages use the same 21.6 cm diameter float and have operated simultaneously since November 1973. The stilling well, which serves as a low pass filter for oscillations with periods greater than a minute, consists of a 30.5 cm diameter steel pipe with a 2.5 cm diameter orifice at the bottom. Both gages are checked for accuracy of time and height and are annotated about five times per week.

Data Processing and Reduction.—Continuous tide traces obtained from the analog gage during the period 20 July 1963 through 31 December 1974 were manually digitized for use in this study by Ocean Data Systems, Inc., Monterey, Calif. Datums were reviewed and data were reduced to hourly sea level heights using standard NOS procedures (Coast and Geodetic Survey 1965). Data from the digital gage for the period 1 January 1974 through 31 September 1976 were processed for hourly heights by the NOS and provided for use in this study. Data from both gages were recorded in feet and in this study converted to centimeters. The hourly heights from both analog and digital gages are accurate to about 0.1 ft (3.0 cm) and times of observation (Pacific Standard Time) are accurate to within 6 min. A small percentage of the hourly sea level data was missing, either rejected as erroneous or lost due to equipment malfunctions. As a result, some monthly means contain less than a full month of data. Missing data of duration of a day or longer are listed in Appendix A.

All hourly heights were measured relative to the station datum established by the NOS in November 1973. Mean sea level for the period 1963 through 1978 lies at 184.4 cm and the National Geodetic Vertical Datum lies 182.88 cm above the station datum.

Merging of Analog and Digital Tide Data.—To obtain the longest possible continuous tide record, it was necessary to merge the older analog data with the more recent digital data. Before the data sets were combined, the response of the two gauges was analyzed by comparing the hourly heights from both tide records for the calendar year 1974. The correlation coefficient between the analog and digital data sets exceeds 0.99, as anticipated.

The differences (digital-analog) between the two sets of hourly sea levels for the calendar year 1974 had a mean value of -0.06 cm. The frequency distribution of the differences (Fig. 2) resembles a normal distribution, with a standard deviation of 3.7 cm. Nearly all of the differences can be attributed to the fact that the digital data were recorded as instantaneous values, which can include short-term sea level fluctuations such as long period waves and seiches, whereas in the analog data, these short-term fluctuations were filtered out by manually smoothing the tidal curve before digitizing.

It was concluded that differences between the two data sets were negligible, and that the analog and digital data could be combined without significant error. Thus, analog data from the period 20 July 1963 through 31 December 1974 were combined with digital data from the period 1 January 1975 through 31 August 1976 to form a 13-yr time series containing 107,954 hourly observations.

Long Period Sea Level Changes.—Tide gages monitor the height of the sea level relative to land. Thus, changes in mean sea level over periods of years or decades can result from the addition or removal of water from the oceans due to global climatic variations, from subsidence or emergence of the land upon which the gage is located, or from long-period astronomic tides. For example, some long-period trends in sea level records, such as the rise in sea level in Panama described by Roden (1963) or the drop in sea level in the Juneau, Alaska, area described by Hicks (1973), clearly result from local or regional land subsidence or uplift.

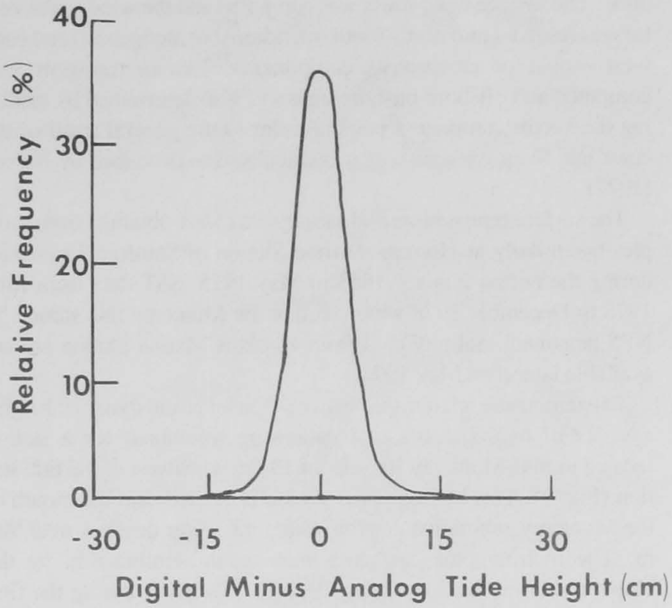

Figure 2.—Comparison of hourly tide measurements in Monterey Bay, Calif., from digital and analog gages for calendar year 1974. Total number of observations was 107,954.

To determine trends in the Monterey sea level record during the period 1963 through 1978, a least-squares linear fit was made to the time-series on monthly mean values. The fit showed a relative rise in sea level of about 0.01 cm/yr. The variability in sea level due to oceanographic and meteorological processes greatly exceeds this trend and thus the effects of long term trends were neglected in this study.

Of the long-period astronomic tides, the nodal tidal constituent, which results from the changing declination of the moon over a period of 18.61 yr, has the greatest amplitude. The theoretical amplitude of this constituent varies with latitude, with maximum effects at the Equator and the poles and minimum effects near lat. 35°N and 35°S (Lisitzin 1974). A second significant long period constituent, the annual solar tide, has an amplitude approximately one-fifth of the nodal tide component. The effects of this tidal constituent vary with latitude in a manner similar to that of the nodal tide. Monterey, located near lat. 36°N, is in a region where the ranges of both of these long period tides are about 1 cm, so these effects were neglected in this study.

Ocean and Atmospheric Data

The atmospheric pressure and wind data used in this study were derived from 6-h synoptic surface pressure fields prepared by Fleet Numerical Oceanography Center (FNOC). The pressure fields, interpolated onto a grid with a mesh length of 3° latitude and longitude, were used to compute geostrophic winds, from which wind stress, Ekman transport, and Sverdrup transport estimates were calculated at a deep water site approximately 14 km west of Monterey (Fig. 1). A description of the methods and computations used in these calculations is given by Bakun (1975). Briefly, the geostrophic wind was computed for the point lat. 36.6°N, long. 122.1°W and an estimate of the wind near the sea surface was made by rotating the geostrophic wind vector 15° to the left and reducing its magnitude by

30%. The surface wind stress was computed and the wind stress vector was resolved into north-south (meridional or alongcoast) and east-west (zonal or crosscoast) components. Ekman transport was computed and offshore-onshore transport was determined by resolving the vector component perpendicular to the general trend of the coastline. Sverdrup transport was calculated as described by Nelson (1977).

The surface temperature and salinity data were obtained from samples taken daily at Hopkins Marine Station of Stanford University during the period January 1963 to May 1975. SST data from June 1975 to December 1978 were taken at the Monterey tide station by NPS personnel. Salinity data from Hopkins Marine Station are not available later than May 1975.

To examine the relationship between sea level and dynamic height, a series of hydrographic cast data were assembled for a station located in mid-Monterey Bay, about 19 km northwest of the tide station (Fig. 1). This hydrographic station is located near the mouth of the Monterey submarine canyon where the water depth is over 900 m. The hydrographic cast data were taken semimonthly by the Hopkins Marine Station during 1963-73. Sampling during the first years of the program was limited to the upper 50 m of the water column but in 1968 the sampling depth was increased to over 500 m.[3] Sampling was discontinued by Hopkins in December 1973 and was resumed by Moss Landing Marine Laboratory from July 1974 to June 1978.[4]

The Hopkins and Moss Landing hydrographic data were keypunched and profiles of temperature and salinity and temperature-salinity curves were plotted for each station. Using these plots, obvious errors in the data were eliminated.

The time series of hydrographic stations had a gap in early 1974 between the end of Hopkins sampling and the beginning of Moss Landing sampling. Several expendable bathythermograph (XBT) drops taken during this period by NPS are available for the mid-bay location. To be able to utilize these XBT data, it was necessary to estimate a salinity value for each temperature value. A density value was calculated for each pair of temperature-salinity observations in the hydrographic cast data and correlation analysis was made. Density was found to be better correlated with temperature ($r = 0.98$) than was salinity with temperature ($r = 0.96$). Thus a density value was computed for each temperature in the XBT profiles and then a companion salinity value was calculated for each temperature and density pair. This procedure also allowed estimation of salinity for some of the hydrographic casts where temperature but not salinity values were recorded. The hydrographic data were then checked for density instabilities and finally, dynamic height was calculated for each profile for the 0/200, 0/400, and 200/400 db (decabars) levels. The depth of maximum calculation was limited by the XBT profiles which extended to only 460 m. The final time series contained 202 profiles to at least 400 m in the 10-yr period April 1968 to June 1978.

Monthly means and anomalies of sea level, and of the ocean and atmospheric data described in the above sections, are presented graphically and in tabular form in Appendix B.

SEA LEVEL AT MONTEREY

Although the time series of hourly sea levels contains much valuable information on the occurrence, amplitude, and duration of anomalous short period sea level fluctuations, it was decided for this study to concentrate on variations of sea level of monthly period and longer and on their atmospheric and oceanographic causes. Weekly and 6-h sea level data are discussed but in a more limited way as are the statistical characteristics of hourly deviations from the predicted sea level. Readers interested in short period fluctuations are referred to Maixner (1973) who examined Monterey sea level data during the year 1971.

Means and Variations

Hourly Sea Level.—To analyze nontidal sea level variations, which are small compared with the normal tide range in this area, the tidal signal must first be removed. Three methods for this are averaging, filtering, or subtracting predicted tides from the observed. The Tide Predictions Branch of the NOS performed a harmonic analysis of 365 d of hourly Monterey tide height values and isolated 37 harmonic constituents (Maixner 1973). Using the 20 constituents whose amplitudes were >0.61 cm, the NOS computed predicted hourly tide heights for the period of record, 1963 through 1976. Predicted hourly heights were then subtracted from the 13 yr of observed hourly heights to yield nonastronomic residuals. The frequency of occurrence of these sea level differences (observed minus predicted), which total nearly 108,000 values, approximates a normal or Gaussian distribution (Fig. 3). Of the observations, 94.5% lie within 15.2 cm (0.5 ft) of the predicted tide and 99.9% lie within 30.5 cm (1.0 ft). The maximum observed difference was 39.6 cm. The standard deviation of the differences was 8.7 cm, skewness -0.02, and kurtosis 3.2.

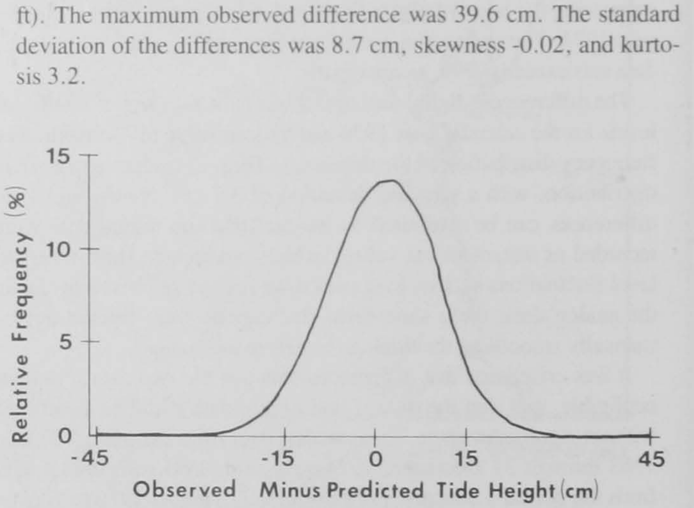

Figure 3—Frequency of occurrence of differences between observed and predicted hourly tide heights at Monterey, Calif., 1963-76.

The distribution of hourly differences describes nontidal sea level variations over a 13-yr period but gives no information about seasonal variations of the frequency distribution. Are distributions for winter months the same as those for summer? To define the seasonal

[3]Hopkins Marine Station. CalCOFI Hydrographic Data, collected on approximately bi-weekly cruises on Monterey Bay, California. Annual reports for years 1968 to 1973 (mineogr.). Hopkins Marine Station, Pacific Grove, CA 93950.

[4]Broenkow, W. W., S. R. Lasley, and G. C. Schrader. 1975. CalCOFI Hydrogrphic Data Report, Monterey Bay, July to December 1974. Tech. Publ. 75-1. Moss Landing Mar. Lab., Moss Landing, CA 95039.

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Lasley, S. R. 1976. CalCOFI Hydrographic Data Report, Monterey Bay, January to December 1976. Tech. Publ. 77-1. Moss Landing Mar. Lab., Moss Landing, CA 95039.

Chinburg, S. J., and S. R. Lasley. 1977. CalCOFI Hydrographic Data Report, Monterey Bay, January to December 1977. Tech. Publ. 78-1. Moss Landing Mar. Lab., Moss Landing, CA 95039.

Chinburg, S. J. 1979. CalCOFI Hydrographic Data Report, Monterey Bay, January to June 1978. Tech. Publ. 79-1. Moss Landing Mar. Lab., Moss Landing, CA 95039.

change, curves were generated using data from 8,200 to 9,800 observations for each of the 12 mo of the year (Fig. 4). The frequency distribution of nontidal sea level fluctuations changes seasonally. In April, for example, 73% of the observed sea levels were lower than predicted, but in September, 81% of the observed data were greater than predicted. From March through May, observed sea levels tend to be lower than predicted sea levels, probably due to offshore Ekman transport, low water temperature, and atmospheric pressure effects as discussed later. From July through January, observed sea levels are higher than predicted due to atmospheric pressure and thermal expansion effects during summer and fall, and to onshore transport, pressure, and thermal effects during the Davidson Current period in December and January. It is not clear why these seasonal differences occur since one would expect seasonal effects to have been included in the harmonic constituents. Perhaps the differences occur because of variations in the frequency of occurrence of events in different years. Thus harmonics generated from measurements in only a single year may not be typical of other years.

The distributions of differences for winter months are wider and less peaked than those of summer months, indicating greater variability and larger nontidal events such as winter storms. In contrast, the distributions for July and August are narrow and more peaked.

Monthly Mean Sea Level.—Averaging of hourly sea level values over intervals of weeks to months removes the effects of the principal diurnal, semi-diurnal, and other short-term tidal components from the data to reduce the quantities of data to manageable size and to emphasize the longer time scales.

Monthly means of the hourly values were calculated for the period July 1963 through August 1976 and were updated for the period September 1976 through December 1978 with monthly mean values provided by the NOS. Figure 7 shows the long-term monthly means, standard deviations, and extremes of the monthly means of sea level at Monterey and other stations along the coast. Mean sea level at Monterey is lowest in April and highest in September, with a mean annual range of 13.6 cm. Variability is highest during winter months, with monthly standard deviations during winter being almost double those for summer. The range between maximum and minimum monthly values reaches a high of 21.0 cm in January and a low of 8.5 cm in August.

Anomalies of monthly sea level were calculated as differences between the monthly mean and the long-term mean for the same month. Calculation of anomalies in this manner removes the annual cycle from the data and allows examination of processes of nonannual periods. Monthly mean sea levels and their anomalies are shown in tabular and graphical form in Appendix B. In these figures extreme monthly sea level anomalies are shown to range from -10.8 cm in December 1975 to +10.7 cm in January 1978. Periods of anomalously high sea level occurred during 1969, 1972-73, 1976-77, and early 1978, and periods of anomalously low sea level occurred in 1964, 1970, 1971, 1973, 1975-76, and 1977.

To statistically define the persistence of anomalous periods, the autocorrelation function was used. This function describes the decay of the correlation coefficient of the data series with itself as the date series is time shifted relative to itself an increasing number of lag periods (months). The autocorrelation function of monthly Monterey sea level anomalies (Fig. 5) shows that sea level anomalies are correlated at the 5% level of significance for lags of up to 5 mo, indicating that anomalies persist over a period of several months. The autocorrelation function of the sea level series appears to decay exponentially for the first 8 mo or so, with significant negative autocorrelation coefficients occurring from lags of 11 to 18 and 23 to 26 mo.

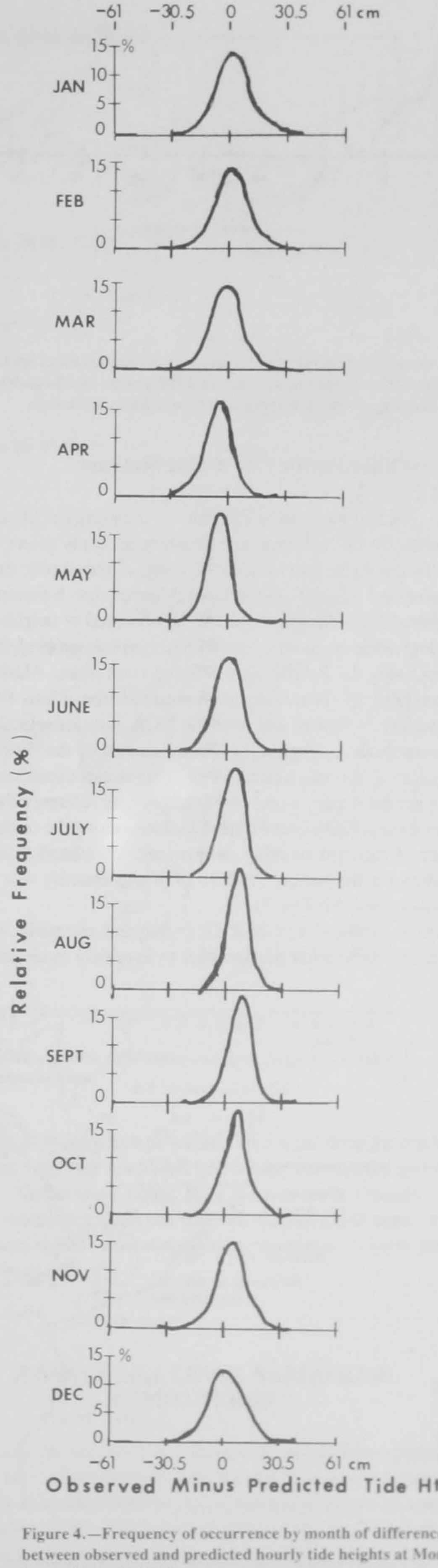


Figure 4.—Frequency of occurrence by month of differences between observed and predicted hourly tide heights at Monterey, Calif., 1963-76.

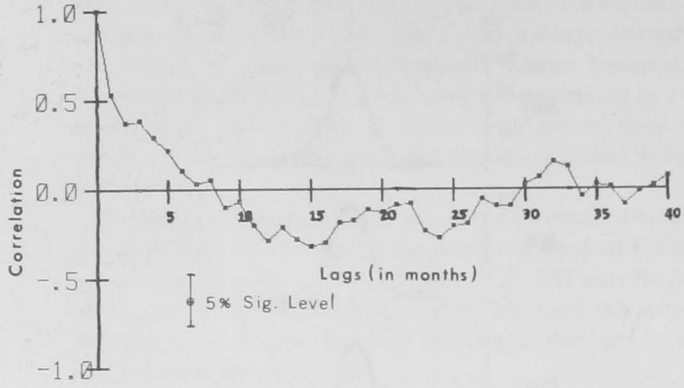


Figure 5.—Autocorrelation function for anomaly of monthly mean sea level at Monterey, Calif. The number of data points is 180 and the significance level is computed assuming a normal distribution of correlation coefficients.

Relation to Other Pacific Coast Tide Stations

We have seen that mean monthly sea level anomalies at Monterey tend to persist for up to 5 mo. The question naturally arises as to whether these anomalies are of local or regional geographic extent. To determine the spacial and temporal coherence between the monthly anomalies at Monterey and those observed at neighboring tide recording stations, monthly mean data were assembled for 15 tide stations along the Pacific coast ranging from Sitka, Alaska, to Callao, Peru (Fig. 6). These data were obtained from Klaus Wyrtki of the University of Hawaii and from the NOS. Stations selected for analysis were those having the best combination of the following characteristics: 1) representativeness of open ocean conditions, 2) long and continuous data record, 3) a constant tidal reference datum, and 4) suitable spacing between station locations along the coast. For each station, long-term monthly means were calculated from the available data for the period 1963 to 1978 and monthly sea level anomalies were derived (Fig. 7).

For stations north of Crescent City, frequent energetic winter storms cause the time series of anomalies to have only moderate persistence whereas stations south of San Francisco have much greater persistence of anomalies. Perhaps the most striking feature of the time series is the high visual correlation of anomalies along the coast (Bretschneider and McLain 1979; Enfield and Allen 1980). The periods of anomalously high sea level at Monterey during 1969, 1972-73, 1976-77, and 1978 were common to most stations where data are available. Similarly, the periods of anomalously low sea level seen at Monterey in 1964, 1970, 1971, 1973, 1975-76, and 1977 occurred at most of the other stations.

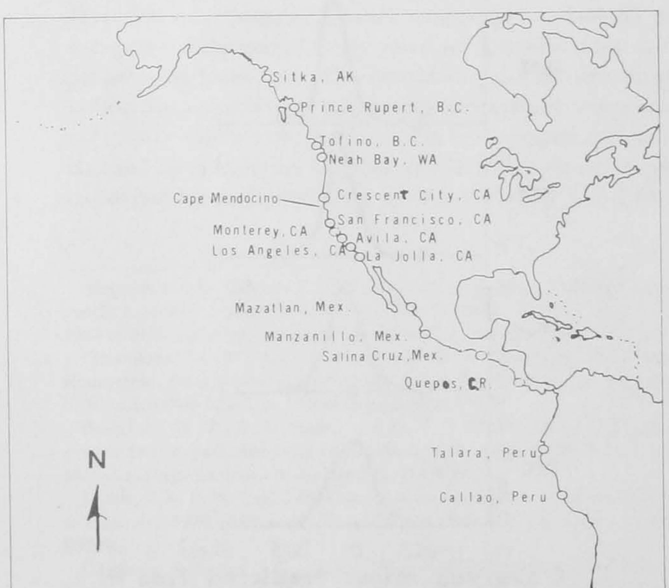


Figure 6.—Location of 15 tide stations along the west coasts of North and South America whose data were used in this study (see text).

Correlations of the monthly sea level anomalies between stations were calculated using the BMDP8D statistical program (Dixon 1975) and are tabulated in Table 1. The correlation of the selected tide stations relative to Monterey is shown graphically in Figure 8. Correlation of the Monterey anomalies is seen to be highest with San Francisco ($r = 0.85$) and lowest with Sitka ($r = 0.15$). Note also that the correlation coefficient drops off more rapidly with distance to the north of Monterey than to the south, due to the different space scales of the processes affecting sea level to the north and south.

Osmer and Huyer (1978) suggested the existence of two domains of coastal sea level fluctuations, with a boundary located south of San Francisco in winter and north of Crescent City in the spring and summer. The general location of their break-point is in agreement with the findings of Zee (1975), who suggested that sea level anomalies at stations from San Francisco southward to the Equator were related to nonseasonal vertical movements of the thermocline. That an oceanographic gradient or boundary may exist between northern and southern stations is further suggested by Nelson (1977) who showed that the area off northern California near Cape Mendocino is one of marked change in the seasonal surface wind stress field. The mean seasonal wind stress field over the coastal ocean south of Cape Mendocino is alongshore (southward) all year while the stress field north of Cape Mendocino is strongly onshore in winter and alongshore (southward) in summer.

The geographic coherence of sea level anomalies observed at Monterey with the neighboring tide stations along the coast was further examined in a time-distance domain. The monthly anomalies from the series of 15 coastal stations from Sitka, Alaska, to Callao, Peru, were plotted and contoured at 5 cm intervals for the period 1963 to 1974 (Fig. 9). Data for the years 1975-78 were not available for several of the stations so plots for these years are not included. The monthly anomalies have recognizable patterns which are coherent in both time and space. For example, large negative anomalies can be seen in January 1963 extending from Crescent City to Sitka and large positive anomalies in the same region occur in the subsequent fall and winter.

Anomalies of greater magnitude and stronger gradients in time and space occur northward of a boundary zone lying between Crescent City and Monterey, than to the south. Anomalous events north of this zone tend to occur simultaneously along the coast and persist for 1 or 2 mo. Anomaly magnitudes and gradients are also generally larger southward of a second, less well-defined boundary zone lying approximately between Manzanillo and Quepos. Between these boundary zones, gradients of the anomaly field are relatively weak. Southward of the zone between Crescent City and Monterey, sea level anomalies are of relatively long duration, as was noted earlier.

A particularly interesting event is the anomalously high sea level during the period October 1972 through February 1973 between Callao and San Francisco. This was a period of strong El Niño activity in the eastern tropical Pacific. During El Niño occurrences warm advection occurs into the eastern tropical Pacific Ocean and high SST's are observed. Sea level rapidly rises in the eastern tropical Pacific and falls slowly in the western Pacific (Wyrtki 1977). A peak sea level anomaly

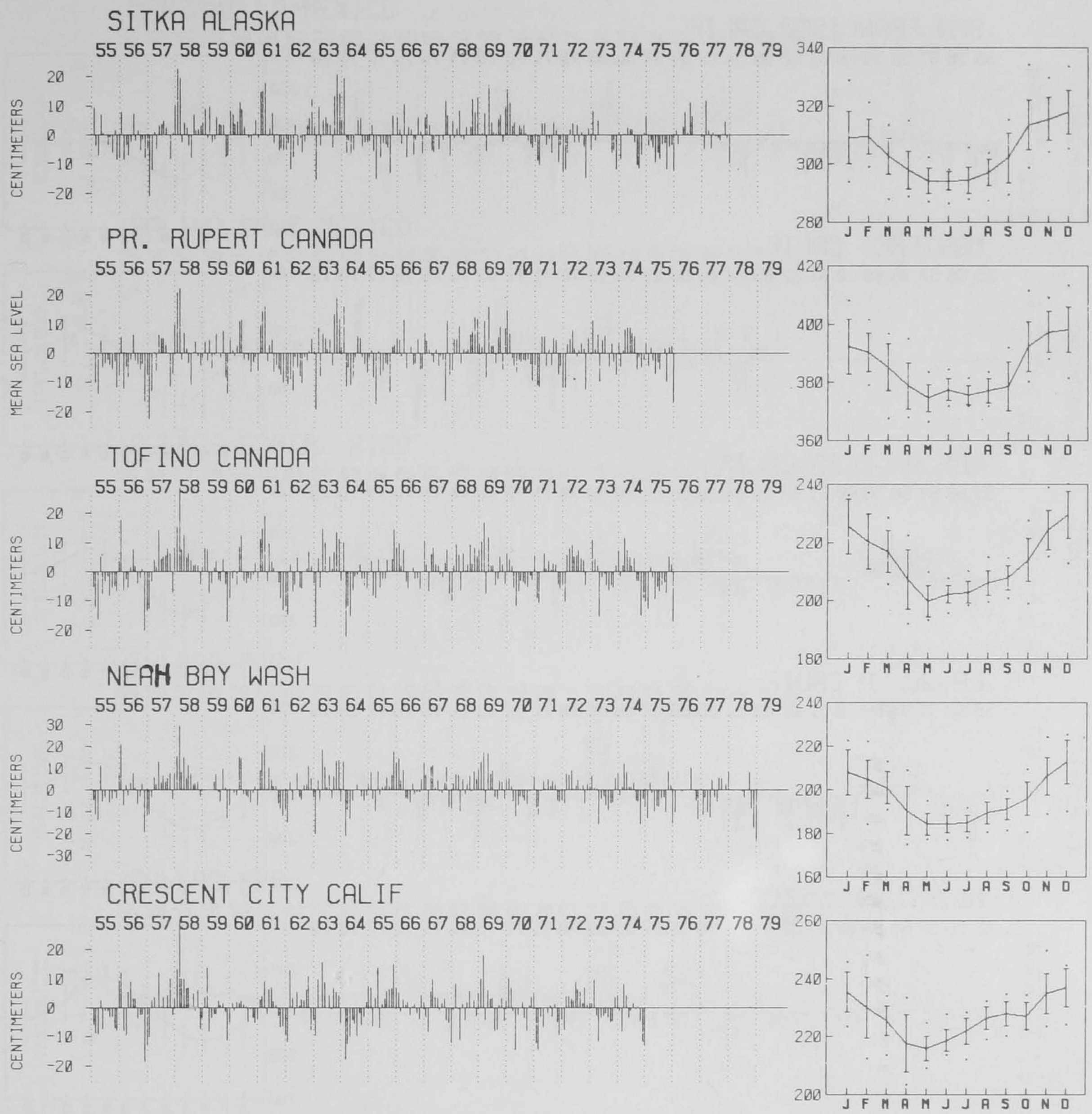


Figure 7.—Time series of monthly sea level anomalies for selected west coast tide stations. Inserts show mean annual cycle with standard deviations as vertical bars and monthly extremes as dots.

of 25 cm occurred at Manzanillo in December 1972, where the occurrence of high sea levels preceeded those observed at more northern stations by a month or more. At Monterey, sea levels were higher than average during the winter of 1972-73 (see also Fig. 7). During the El Niño period (see time-series plots in Appendix B), atmospheric pressures at Monterey were less than average and wind stress was negligible except during February 1973 when anomalous southerly winds resulted in onshore transport of surface waters and downwelling.

The strong alongcoast correlation of monthly sea level anomalies shows that sea level changes at Monterey are related to large-scale influences rather than to strictly local events. Table 1 shows that the anomalies at Monterey are correlated, at the 5% level of significance, with anomalies recorded at stations from Prince Rupert, Canada, to Callao, Peru, but are more closely related to events affecting sea levels in the group of stations from Crescent City to Quepos, Costa Rica. Processes producing the El Niño phenomenon in the eastern tropical Pacific also apparently affect sea level at Monterey. Recent theories (e.g., McCreary 1976) predict a deepening of the thermocline associated with the El Niño, which propagates northward along the coast as a Kelvin wave, and that northward geostrophic currents are produced behind the Kelvin wave fronts. Such currents cause changes in the cross shelf sea surface slope and northward advection of warm water. Both processes would cause anomalous increases in sea level at stations along the coast.

CAUSES OF SEA LEVEL VARIATIONS AT MONTEREY

The effects on sea level of changes in atmospheric pressure, changes in sea surface slopes due to changes in alongcoast currents, and changes in average density of the water column are all interrelated. A change in the distribution of atmospheric pressure over the ocean surface will generally change the horizontal gradient of pressure, resulting in a change in the geostrophic and other wind compo-

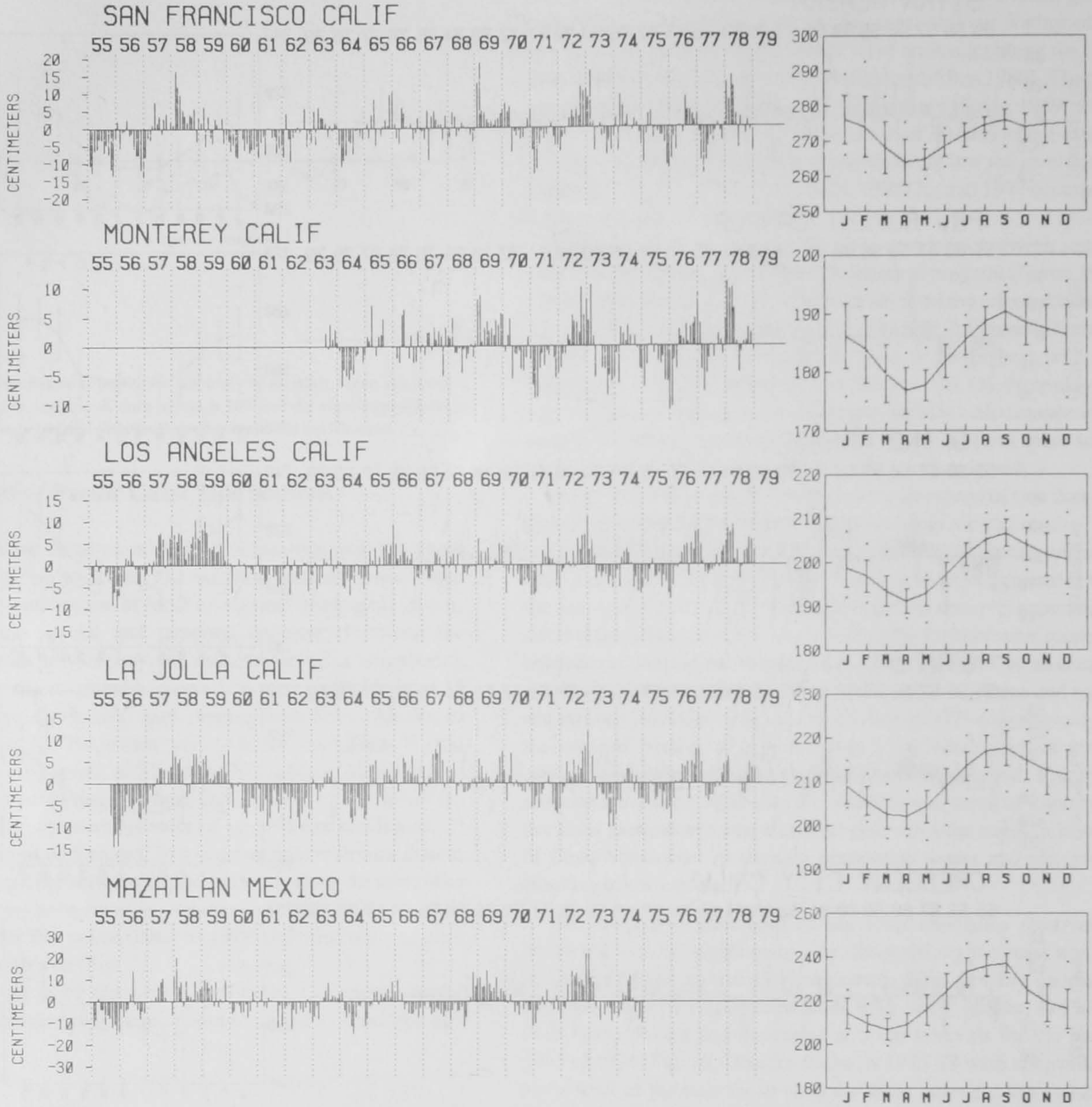


Figure 7.—*Continued.*

nents, and thus in wind stress. A change in wind stress will change the wind-driven current, redistribute the mass, and change the average density of the water column. Wind stress changes also alter wind-induced set-up or set-down against the coast. All of these processes combine with effects of a northward propagating wave from the tropics to affect sea level at Monterey.

Records of SST and salinity changes reflect changes in oceanographic conditions at the sea surface and may also be indicative of changes in the subsurface density distribution. Dynamic height calculations, however, provide a direct measure of the subsurface density field and its changes, and therefore reflect large scale changes in ocean circulation. If a strong relationship between sea level and dynamic height were found, it would allow use of inexpensive tide gage data to monitor changes in coastal circulation. The time series of frequent hydrographic stations taken in mid-Monterey Bay during 1968 to 1978 provide a unique opportunity to test for such a relation.

Correlation, regression, and spectral analysis techniques were used to study the causes of the sea level variations. These variations occur on various time scales and the analysis techniques used were chosen as appropriate for the time scale and character of the data to be analyzed. Thus, this section is organized generally by time-sampling and specifically by analysis procedures.

Correlation Analysis

Long term monthly means and anomalies for the period 1963-78 were calculated for the following oceanic and atmospheric variables: surface atmospheric pressure, meridional component of wind stress, zonal wind stress, offshore component of Ekman transport, Sverdrup transport, salinity, SST, and 0/400 db dynamic height. The data are presented numerically and graphically in Appendix B. Correlations between these variables and the monthly sea level anomalies at Monterey were calculated using the BMDP8D statistical program (Dixon 1975) and the results are given in Table 2. The correlation analysis measures the strength of the linear relationship between two random variables. However, the variables dealt with here are not random and may be mutually dependent on some third but unmeasured variable. Thus care must be used in interpretation of the statistical results. In

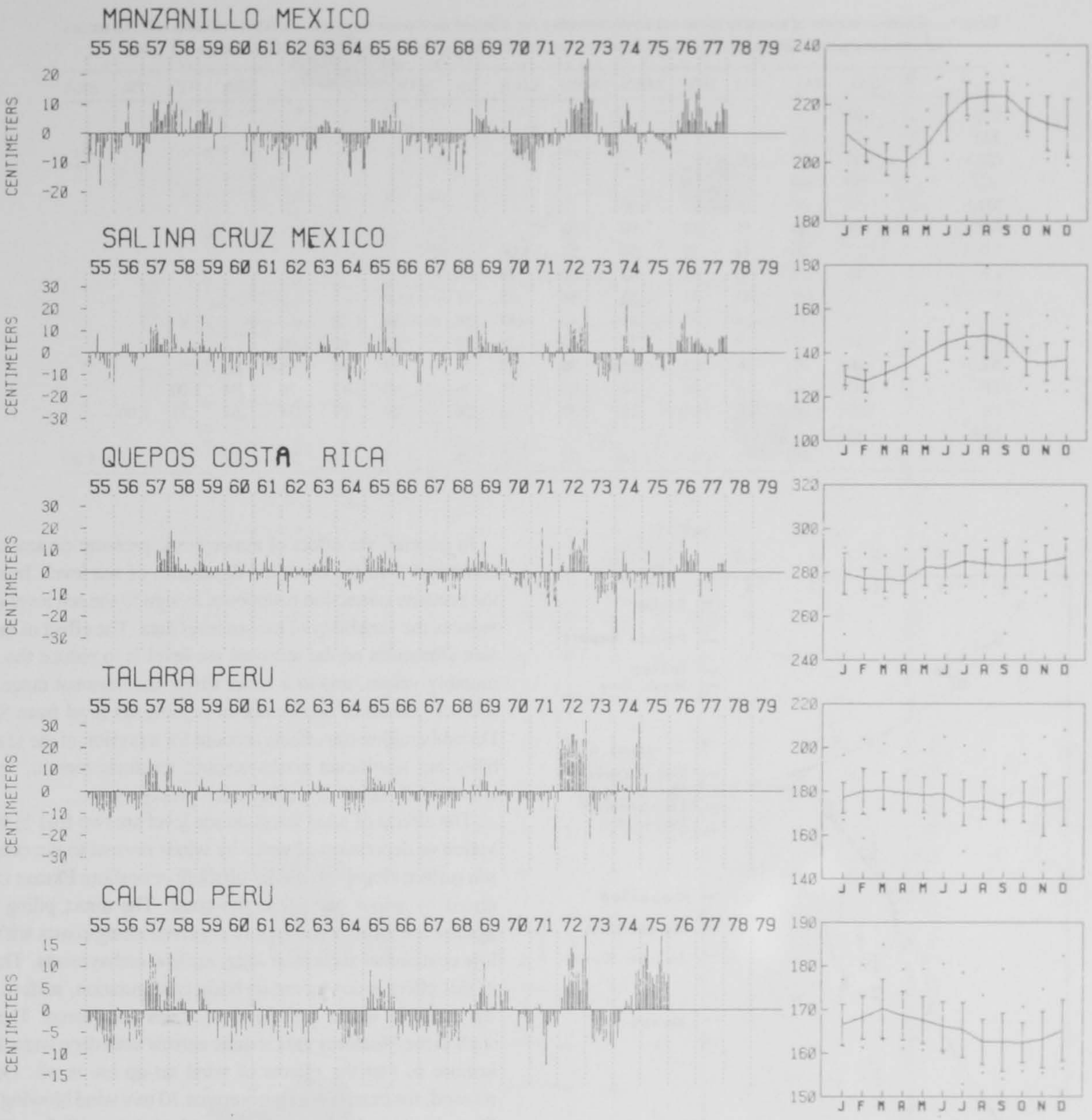


Figure 7.—*Continued.*

the following paragraphs each variable will be treated in turn and the results of the correlation analysis will be discussed.

The effect on sea level of changes in atmospheric pressure over the oceans has been examined by a number of authors (Patullo et al. 1955; Saur 1962; Roden 1960). An increase (decrease) in atmospheric pressure results in a decrease (increase) in sea level. The pressure effect can be quite large in some areas, particularly in the Gulf of Alaska where winter storms are intense or along the Gulf or Atlantic coasts of the United States during the passage of hurricanes.

The isostatic contribution of atmospheric pressure variations to variations in sea level is computed from the hydrostatic equation $\Delta p = -\rho g \Delta h$ where Δp is the change in atmospheric pressure in millibars (mb), ρ is the density of water in g/cm^3, g is the acceleration of gravity in cm/s^2, and Δh is the change in sea level in centimeters. Applying this equation to seawater of density 1.025 g/cm^3 and using 980.7 cm/s^2 as the acceleration of gravity, we find that an increase in atmospheric pressure of 1 mb will result in a 0.995 cm depression of sea level.

The annual seasonal range of monthly mean atmospheric pressure at Monterey during the period 1963-78 was 7.3 mb, but pressure changes several times greater than this are not uncommon during the passage of intense winter storms. Thus, the effect of atmospheric pressure is expected to account for a significant portion of sea level variability near Monterey.

Maixner (1973) examined hourly data recorded from the Monterey tide gage during the year 1971 and concluded that sea level responds rapidly (within several hours) to pressure changes in an approximately hydrostatic manner. The coefficient of correlation between monthly mean sea level anomalies and pressure anomalies, based on 180 mo of simultaneous data from the period July 1963 through December 1978, was found in the present study to be -0.69 (Table 2). The relatively large negative correlation indicates a significant response of sea level to pressure.

It is desirable to remove the static effects of atmospheric pressure from the monthly sea level data so that the influence on sea level of other variables can be readily examined. To accomplish this, monthly

Table 1.—Intercorrelation of monthly mean sea level anomalies for selected west coast tide stations. Abbreviations refer to names of stations shown in Figure 6. Correlation coefficients enclosed in parentheses are not significant at the 5% level.

	CAL	TAL	QPO	SCZ	MAN	MZN	LJLA	LA	MTRY	SF	CC	NEA	TF	PR	SKA
CAL	1.00														
TAL	.71	1.00													
QPO	.49	.57	1.00												
SCZ	.50	.44	.55	1.00											
MAN	.54	.49	.56	.72	1.00										
MZN	.64	.43	.55	.68	.90	1.00									
LJLA	.22	.26	.43	.42	.56	.51	1.00								
LA	.19	.27	.50	.48	.63	.63	.79	1.00							
MTRY	.23	.21	.43	.43	.53	.56	.75	.75	1.00						
SF	.25	.17	.36	.31	.41	.49	.57	.58	.84	1.00					
CC	.24	(.13)	.31	.33	.33	.37	.35	.38	.62	.67	1.00				
NEA	(.00)	(.05)	.26	.23	.21	.36	.15	.21	.32	.43	.75	1.00			
TF	(.02)	(.04)	.24	.26	.32	.41	.27	.36	.40	.47	.76	.94	1.00		
PR	(.03)	(.00)	.16	(.08)	.28	.37	.16	.24	.21	.27	.34	.67	.73	1.00	
SKA	(-.10)	(-.10)	.21	(.01)	(.12)	.22	.17	.15	(.15)	.17	.20	.49	.55	.81	1.00

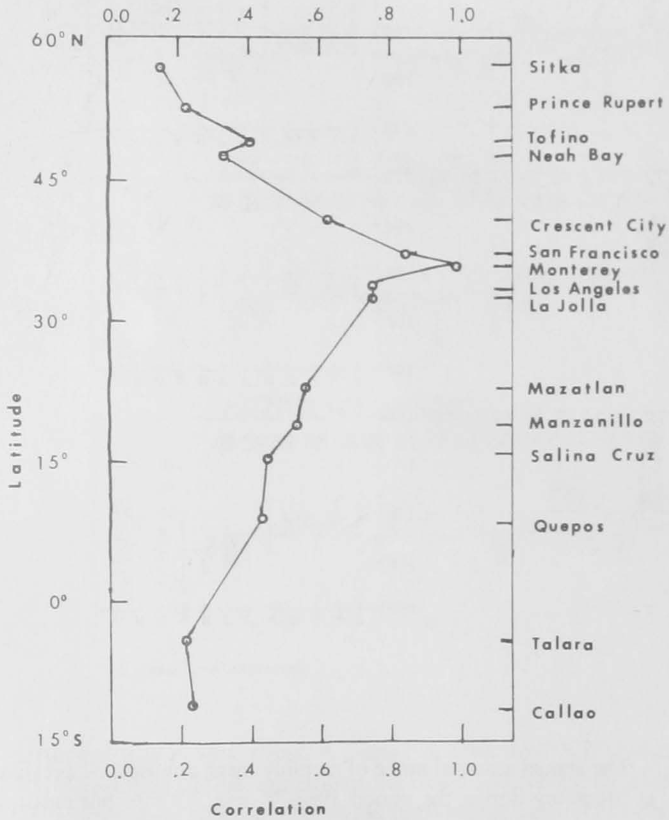


Figure 8.—Correlation of monthly sea level anomalies at selected west coast tide stations relative to Monterey, Calif.

mean sea levels were adjusted for monthly pressure effects by increasing (decreasing) sea level 1.00 cm for every 1.00 mb increase (decrease) of atmospheric pressure. The use of the more accurate value of 0.995 cm/mb was not warranted in this study. The magnitude of the pressure correction was determined by subtracting the long term mean pressure for the period January 1963 through December 1978 (1,016.85 mb) from the monthly mean atmospheric pressures. This method removes the effects of seasonal and interannual pressure changes. Mean monthly sea levels and sea level anomalies from which the hydrostatic effect associated with monthly pressure anomalies have been removed are referred to in this paper as adjusted sea levels.

In general, the effect of atmospheric pressure on sea level is small compared with the observed departures of sea level. In most months the pressure correction is opposite in sign to the sea level anomaly and reduces the variability of the sea level data. The effect of the static pressure correction on the seasonal sea level is to reduce the range of the monthly values, and to a lesser extent the seasonal range, but also to shift the month of occurrence of highest sea level from September to December. Pressure effects account for a portion of the sea level variability but significant nonbarometric residuals remain, indicating the effects of dynamic as well as static processes.

The effects of wind stress on sea level are two fold 1) the direct elevation or depression of water by winds normal to the coast and 2) the sea surface slopes created by offshore or onshore Ekman transport produced by winds parallel to the coast. The direct piling up of water against the shore is commonly observed along coasts with wide, shallow continental shelves or long, narrow embayments. The magnitude of this effect is dependent on basin configuration, surface wind velocity, depth of water, and the time scales considered. The continental shelf in the Monterey area is quite narrow with deep water located close inshore so that the effects of wind set-up are small. Defant (1961) showed, for example, that a constant 10 m/s wind blowing over a basin 50 m deep would produce a sea surface slope of 6.6 cm/100 km. The 50 m contour near Monterey is <1.6 km offshore (Fig. 1), and the magnitude of direct piling of water by the wind is thus less than the range of error in tide measurements. In addition, monthly anomalies of zonal (east/west) wind stress were found not to be significantly correlated with monthly sea level anomalies at the 5% level of significance (Table 2). Accordingly, elevation or depression of sea level by cross shore wind stress is neglected in this analysis.

The second effect of wind stress is that of sea surface slopes produced by offshore or onshore Ekman transport due to winds parallel to the coast. According to conventional Ekman transport theory, net transport is directed 90° to the right of the wind in the Northern Hemisphere. In this study, offshore/onshore Ekman transport was found to be significantly correlated with sea level ($r = -0.42$ in Table 2). The inverse correlation indicates that offshore transport results in decreased sea level and onshore transport in increased sea level. Meridional wind stress is also significantly correlated with sea level ($r = 0.43$), as expected. Monthly anomalies of Sverdrup transport were found not to be significantly correlated with monthly sea level anomalies at the 5% level.

Sea surface temperature and surface salinity are both significantly correlated with monthly sea level anomalies (with correlation coefficients of 0.61 and -0.35). The signs of the correlations indicate that

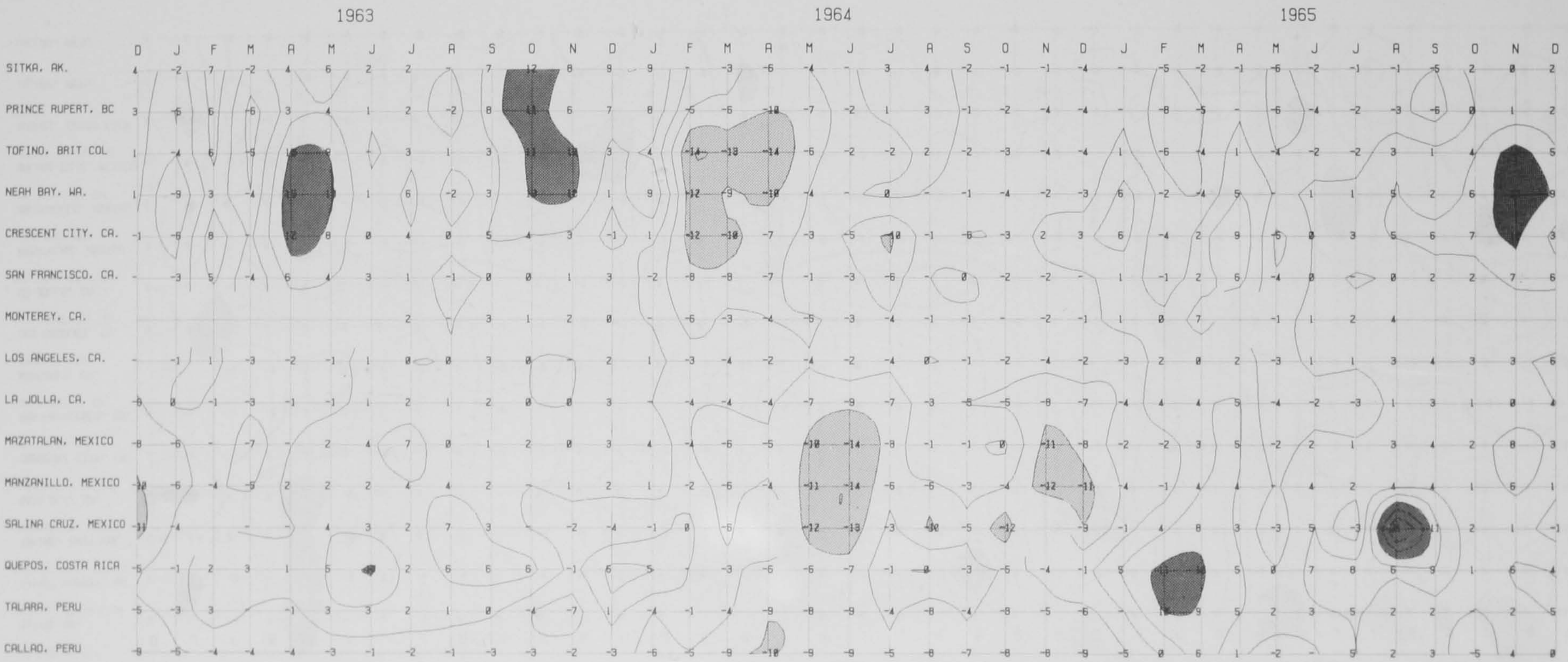
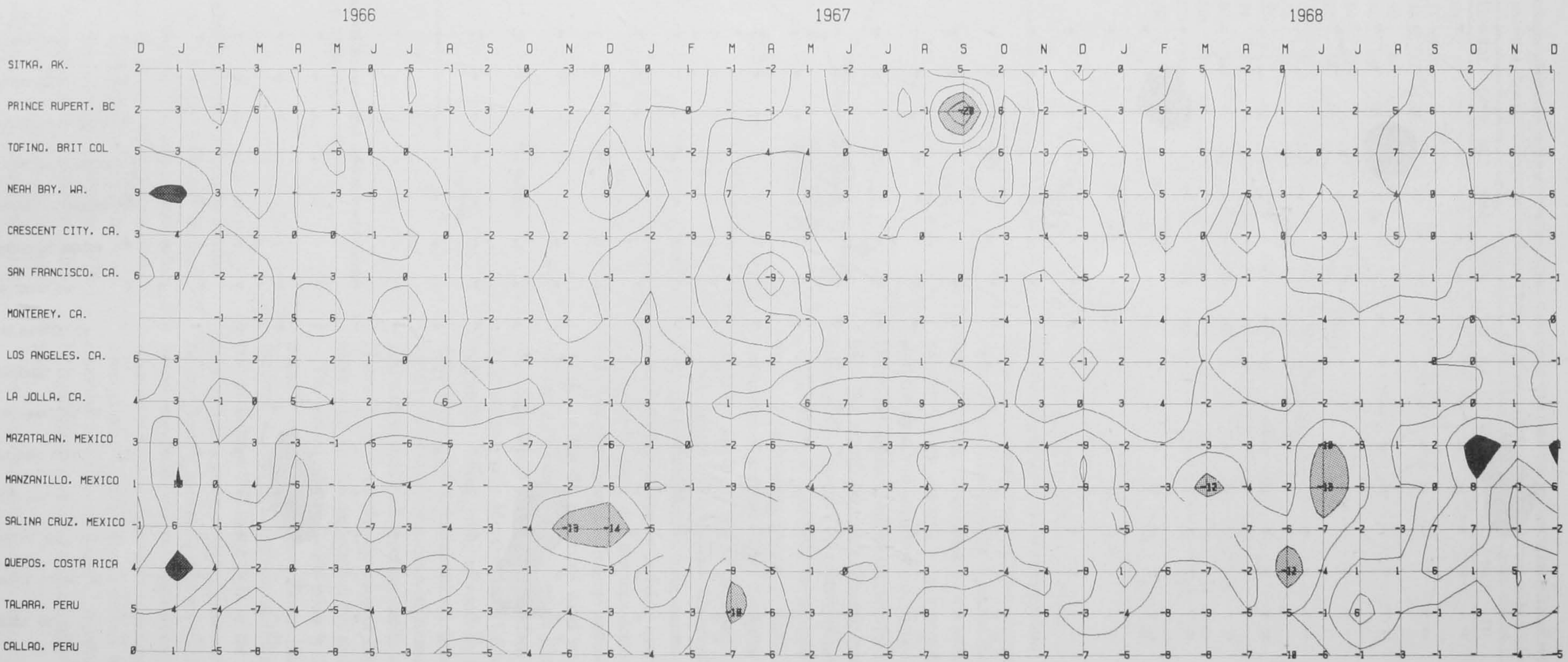


Figure 9.—Time-distance contour plot of monthly mean anomalies of sea level in centimeters from 1962-74 mean at selected west cost tide stations. The contour interval is 5 cm with areas greater than +10 cm shaded dark and areas less than -10 cm shaded light.



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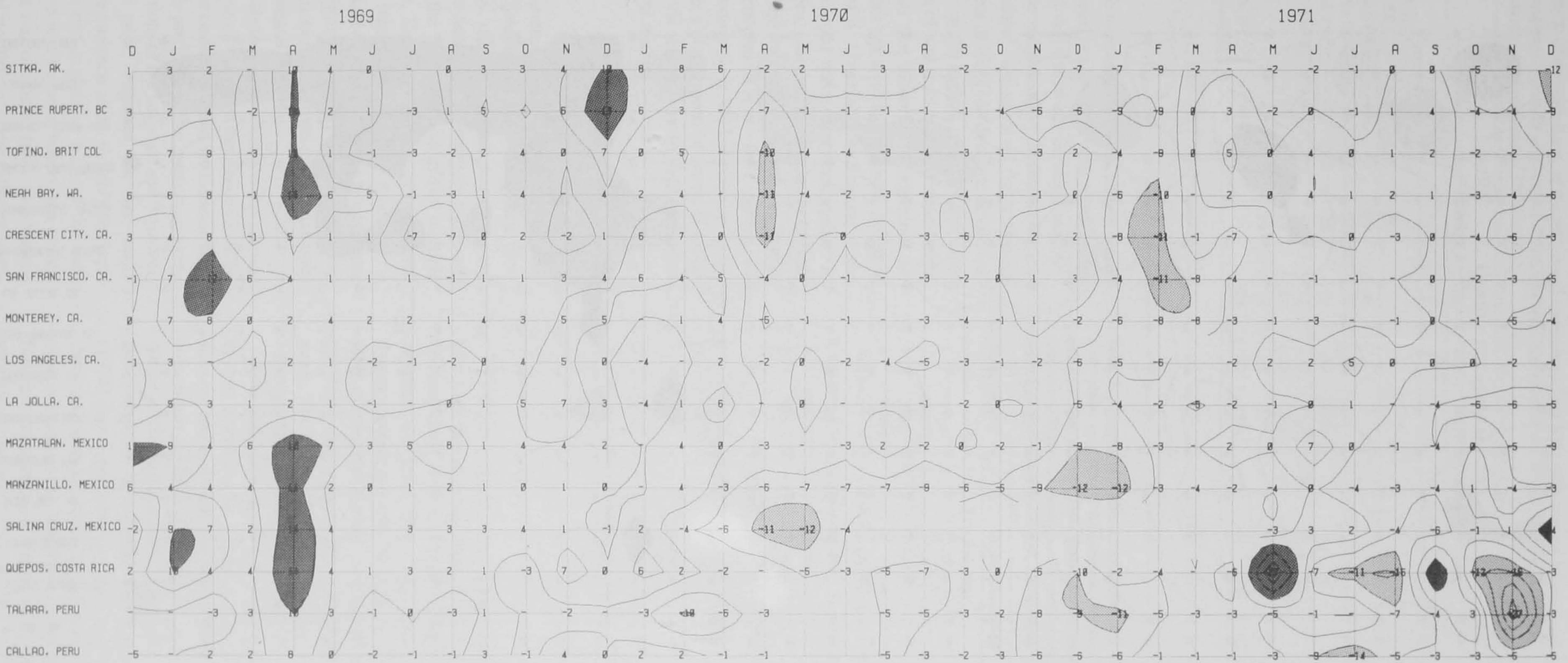

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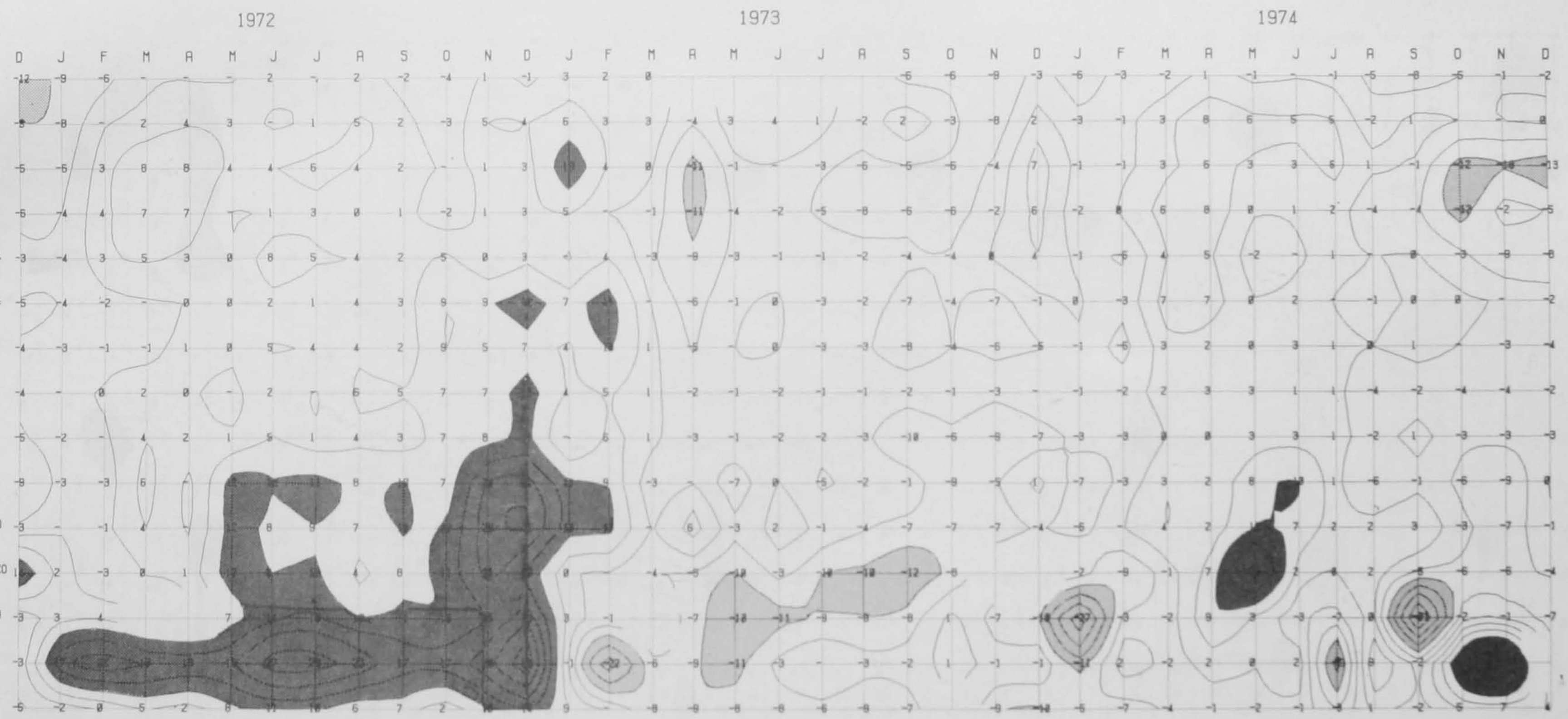

Figure 9.—*Continued.*

Table 2.—Intercorrelation of monthly mean anomalies of sea level with various oceanic and atmospheric variables at Monterey, Calif. (see text). Correlation coefficients enclosed in parentheses are not significant at 5% level.

	SL	ADJ SL	PRESS	MERID WS	ZONAL WS	EKM TSPT	SVP TSPT	SAL	SST	DYN HT
SL	1.00									
ADJ SL	.96	1.00								
PRESS	-.70	-.46	1.00							
MERID WS	.43	.42	-.28	1.00						
ZONAL WS	(-.14)	-.18	(-.03)	-.48	1.00					
EKM TSPT	-.42	-.42	.26	-.99	.59	1.00				
SVP TSPT	(.01)	(.07)	-.18	-.33	.15	.32	1.00			
SAL	-.35	-.31	.29	-.31	(.07)	.30	.20	1.00		
SST	.61	.65	-.29	.38	-.17	-.37	(-.05)	-.37	1.00	
DYN HT	.79	.79	-.46	.25	(-.08)	-.25	(.00)	-.44	.65	1.00

increases in SST are associated with increased sea levels and increased salinities are associated with decreased sea levels. These relationships are consistent with basic considerations of seawater density changes.

Dynamic height (0/400 db) at the mid-Monterey hydrographic station was found to be strongly correlated with sea level fluctuations at Monterey. The correlation coefficient of 0/400 db dynamic height was 0.79 with Monterey sea level and was the highest of any of the variables tested. The higher correlation of sea level with dynamic height than with SST ($r = 0.61$) suggests that subsurface fluctuations are important in causing changes of both sea level and dynamic height at Monterey. A possible cause of such subsurface fluctuations is the northward propagating coastally trapped wave mentioned earlier. To examine this, sea level at Talara, Peru, was used as an index of El Niño conditions and was lagged 0 to 10 mo for correlation with sea level at Monterey. The correlation coefficient peaked at $r = 0.37$ at a lag of 6 mo. A wave propagating the approximately 6,300 km between Talara and Monterey in 6 mo would have a phase speed of about 34 km/d. This is somewhat lower than speeds reported by Enfield and Allen (1980) but not inconsistent with their results.

Regression Analysis

We have seen that the monthly anomalies of sea level at Monterey are significantly correlated with dynamic height, atmospheric pressure, SST, meridional wind stress, offshore Ekman transport, and surface salinity. To quantify these relationships, a multiple regression analysis was performed using the BMDP2R stepwise multiple regression program (Dixon 1975). Since fluctuations of meridional wind stress and offshore Ekman transport are closely related ($r = 0.99$ in Table 2), use of both variables in a regression would cause instabilities in the computation. Ekman transport was omitted from the regressions and only the meridional wind stress considered since the wind stress is the more fundamental variable.

The results of the regression analysis for the entire year, presented in Table 3 (Part A), show that dynamic height is the major predictor of sea level, with atmospheric pressure, SST, and meridional wind stress as second, third, and fourth predictors. The remaining variables explained only negligible portions of the variance and their coefficients are not included in the table. Together, the four major predictors explain over 76% of the variance of the monthly sea level anomalies with dynamic height alone explaining 62% of the variance. Considering that the sea level was recorded hourly in a consistent fashion while dynamic height was computed from observations taken at scattered times by several institutions using different methods, the strength of the relation seems very good.

Table 3.—Results of multiple regression analysis of sea level at Monterey, Calif., with various oceanic and atmospheric variables for entire year, Davidson Current, and upwelling periods. Data series are sea level (SL) in centimeters, atmospheric pressure (PRESS) in millibars, sea surface temperature (SST) in °C, meridional wind stress (MWS) in dynes/cm², and dynamic height (DYN HT) in centimeters.

Step	Variable	Explained variance	Increase in explained variance
A. Entire year (Jan.-Dec., 77 mo of data)			
1	DYN HT	.62	.62
2	PRESS	.70	.08
3	SST	.74	.04
4	MWS	.76	.02
Sea level = -0.057 + 0.470 DYN HT - 0.894 PRESS + 1.208 SST + 4.491 MWS			
B. Davidson Current period (Oct.-Feb., 31 mo of data)			
1	DYN HT	.76	.76
2	MWS	.82	.06
Sea level = -0.0653 + 0.732 DYN HT + 15.402 MWS			
C. Upwelling period (Apr.-Aug., 33 mo of data)			
1	DYN HT	.36	.36
2	MWS	.52	.16
3	PRESS	.60	.08
4	SST	.66	.06
Sea level = -0.108 - 0.935 PRESS + 0.256 DYN HT + 4.256 MWS + 1.271 SST			

The relationship between sea level and dynamic height was further examined in a seasonal sense. There is good agreement in both phase and amplitude of the long term monthly means of dynamic height and adjusted sea level (Fig. 10). The observed seasonal cycle for dynamic height is somewhat more variable than that of sea level, possibly as a result of limited sampling (there were only 12 or 13 stations per month during winter but up to 24 stations per month the rest of the year). The figure shows that both sea level and dynamic height near Monterey are highest in winter and lowest in spring.

Reid and Mantyla (1976), showed that south of lat. 40°N in the eastern North Pacific Ocean sea levels are typically highest in late summer and early fall and lowest in late winter as a result of annual solar heating. North of lat. 40°N, however, sea levels are highest in winter and lowest in summer; this pattern cannot be explained by the steric response to seasonal heating and cooling. Using Sturges' (1974) data from Neah Bay, Reid and Mantyla further demonstrated that maximum sea levels occur in winter when inshore northward flow is strongest and minimum sea levels occur during summer when flow is southward, thus relating seasonal changes in sea level to geostrophically balanced flow. Monterey lies at lat. 36°N and has a seasonal cycle that is intermediate between these regimes.

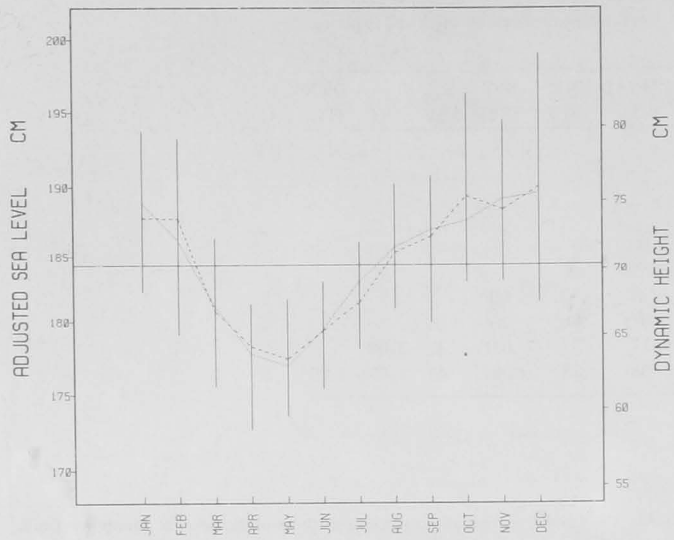

Figure 10.—Seasonal cycle of sea level and dynamic height near Monterey, Calif. Sea level data are for 1963-78 and shown as dotted line and dynamic height data are for 1968-77 and shown as dashed line. Ranges of monthly sea levels are shown by vertical bars.

Sea level and dynamic height are also in good agreement in a time series sense. Figure 11 shows the time series of weekly mean sea level, calculated from the hourly data, and individual dynamic height calculations relative to 200 and 400 db. The figure shows that both sea levels and dynamic heights were higher than normal during 1969–70, 1972–73, and 1976, which were periods of El Niño activity in the eastern tropical Pacific. Sea levels and dynamic heights were both also near or below normal during anti-El Niño periods. Because of the close agreement between seasonal cycles of sea level and dynamic height, and because of the high correlation of sea level at Monterey with that at adjacent stations, dynamic height and sea level variations may both reflect variations in the alongshore geostrophic current flow. To show this, one would have to show that fluctuations of sea level were correlated with fluctuations of slope of dynamic height normal to the coastline. Suitable data for this may be available but this was felt to be beyond the scope of this report.

The regression formula indicates that the response of sea level to changes in atmospheric pressure is -1.67 cm/mb whereas a purely hydrostatic response would be -1.00 cm/mb. This higher than theoretical pressure response coefficient is poorly understood but is possibly due to reinforcement of the local pressure effect by a larger scale, dynamic aspect of the atmospheric pressure systems themselves. Saur (1962) and Roden (1960) analyzed monthly tide data from stations to the north and south of Monterey and found similar larger than expected pressure response coefficients.

Because of the significant seasonal changes in the oceanic and atmospheric regimes near Monterey, we might expect to observe seasonal changes in the processes affecting sea level. To define these seasonal changes, the ocean and atmospheric variables were analyzed separately for the two major periods, the Davidson Current and the upwelling periods (Table 3).

Sea level changes during the Davidson Current period were analyzed using data from 5 mo, October through February, for the years 1963-78. The results of multiple regression analysis indicate that dynamic height and meridional wind stress are major predictors of sea level during this period, explaining 82% of the variance of monthly sea level anomalies. During this period, dynamic height and sea level are strongly correlated, $r = 0.87$.

The second period analyzed was centered during the upwelling period and covered 6 mo, April through August, during the years 1964-78. During this period, dynamic height remains the primary predictor but at weaker correlation, $r = 0.60$. Atmospheric pressure, SST, and meridional wind stress are secondary predictors and in total account for 66% of the variability of monthly sea level.

Thus, some seasonal change in the processes affecting sea level is indicated, with dynamic height accounting for most of the sea level variability in both the upwelling and Davidson Current periods. Meridional wind stress is also important during both periods but more so during the upwelling than Davidson Current period. Atmospheric pressure and SST explain an additional portion of the sea level variability during the upwelling period. The greater amount of explained variance in winter than summer suggests that conditions in winter are dominated by changes in the structure of the water column whereas upwelling in summer causes complicated effects on sea level.

Spectral Analysis

In the previous section, it was shown that most of the variance of monthly sea level anomalies can be explained by monthly anomalies of dynamic height, surface atmospheric pressure, SST, and meridional wind stress. However, important variations in these processes occur on time scales shorter than a month. To determine how the variance of sea level is distributed with frequency over time-periods of days to weeks, auto- and cross-spectra were calculated for 6-h observations of sea level, atmospheric pressure, and meridional wind stress. Spectra of dynamic height and SST were not computed because the required data were too sparse.

To prepare these data for spectral analysis, it was necessary to subsample the hourly sea level series at the 6-h period of the available surface atmospheric pressure and meridional wind stress data. Atmospheric pressure and meridional wind stress were calculated as described previously on a 6-h basis for the period 1 January 1967 through 31 August 1976 for a point approximately 14 km west of the Monterey tide station (Fig. 1). Hourly sea level data for the same time period were low-pass filtered to remove the diurnal, semidiurnal, and other short-term tidal components and were subsampled at 6-h intervals. A complete description of the low-pass filter used is given by Godin (1966). All data series were then detrended by subtracting their 30-d running mean to produce band-passed series. The response function for the 30-d running mean is shown in Figure 12.

Atmospheric pressure, wind stress, and sea level data (unadjusted for pressure effects) were analyzed during the winter storm season (1 November to 8 March) and the upwelling period (1 April to 8 August) for the years 1967-76. The definition of these periods is somewhat arbitrary but was based on visual interpretation of time series of sea level and wind stress and on the requirement that the number of data points used in the spectral analysis be a power of 2. Since the periods are normally 3-4 mo long, 512 data points (128 d) were used. A fast Fourier transform spectrum analysis with a triangular data window was used and the spectra were averaged for all available years. The frequency bandwidth is 0.04 cycles per day (cpd) and the number of degrees of freedom is 90 for the winter period and 100 for the upwelling period.

The spectral relationships between sea level and atmospheric pressure are discussed first. In the low frequency region, the winter period spectra (Fig. 13) are three to four times more energetic than the upwelling period spectra (Fig. 14), indicating the effects of intense winter storm events. The largest sea level and pressure fluctuations

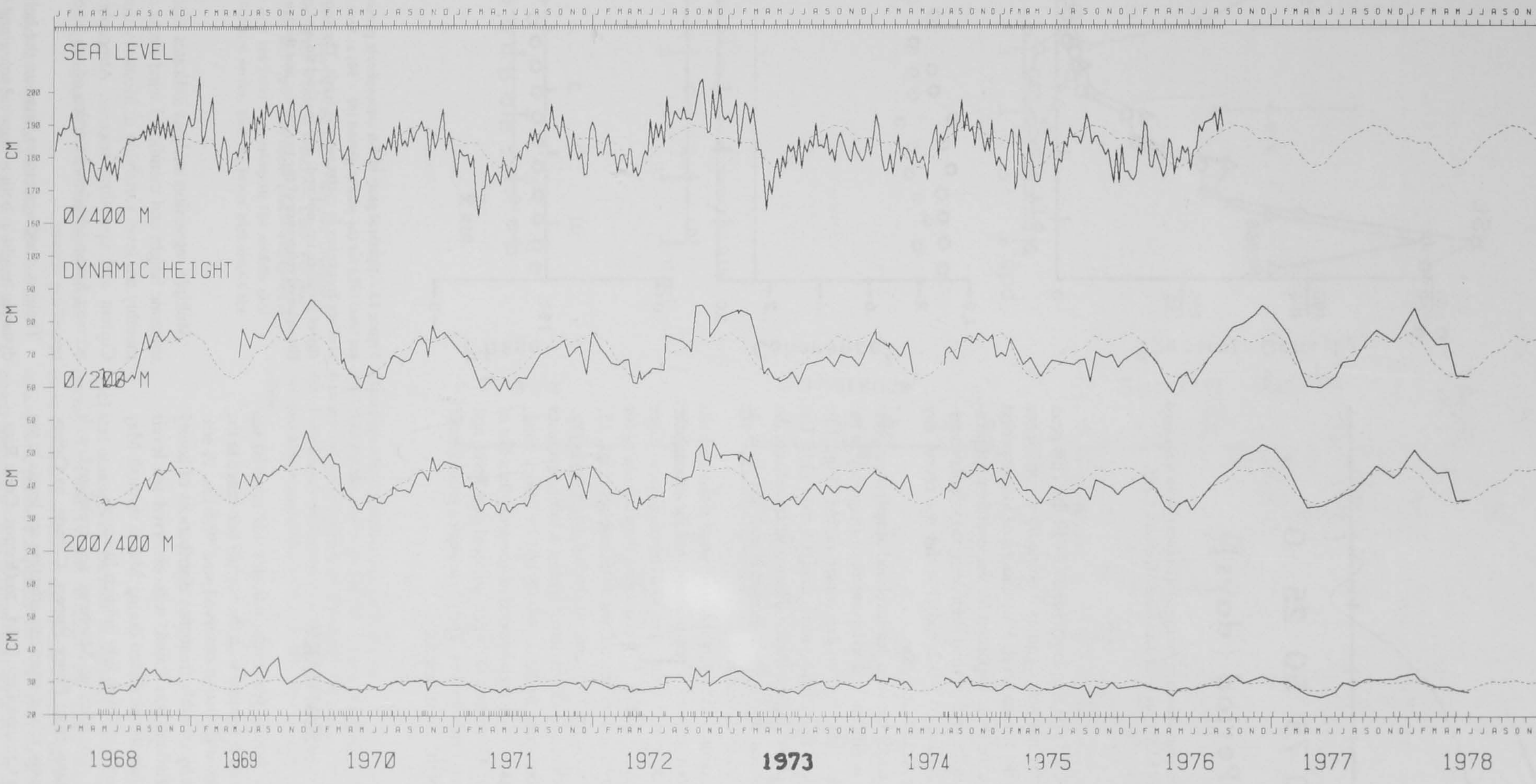

Figure 11.—Time series of weekly mean sea level at Monterey, Calif., and dynamic height computed from frequent hydrographic stations in mid-Monterey Bay. The mean annual cycles are shown as dotted lines.

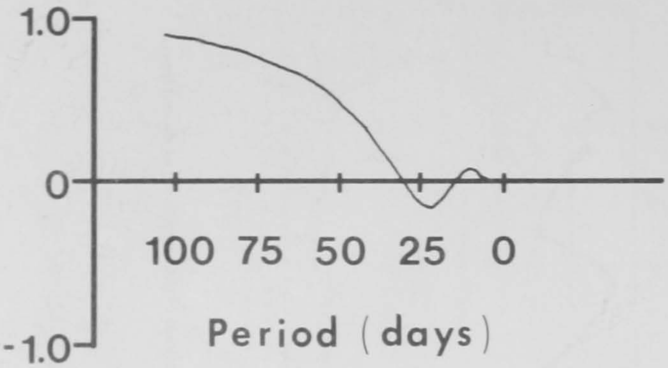

Figure 12.—Amplitude response function for the 30-d running mean filter used to low pass filter hourly sea level data from Monterey, Calif.

occurred in the 0.04-0.08 cpd frequency band (24-12 d). This peak was present in all series and was significant at the 95% confidence level for pressure but not for sea level. Fluctuations of longer period than this peak appear to be more important for sea level than for pressure. The filters used in the analysis had been designed to isolate variations with periods 2-10 d (0.5-0.2 cpd) but did not reveal any significant spectral peaks in that region.

The coherence (squared) between sea level and atmospheric pressure was found to be significant and independent of frequency in the upwelling period (Fig. 14), but in the winter period (Fig. 13), decreased in magnitude at frequencies greater than 0.5 cpd (<2d). The nearly constant 180° phase angle between the two series reflects the inverse response between atmospheric pressure and sea level as expected from the hydrostatic equation.

In order to better examine the relationship of wind stress and sea level, the low-passed 6-h sea level series was adjusted for atmospheric pressure effects and detrended using the 30-d running mean filter described previously. Auto- and cross-spectra were then calculated for the 6-h adjusted sea level and meridional wind stress series (Figs. 15, 16). Like the atmospheric pressure and unadjusted sea level series, meridional wind stress had a concentration of energy at low frequencies with large variations occurring in the 0.04-0.08 cpd frequency band, and the winter season power spectra contained more energy than that of the upwelling season. Coherence between adjusted sea level and meridional wind stress is generally low. The phase angles provide little information because of the low coherence.

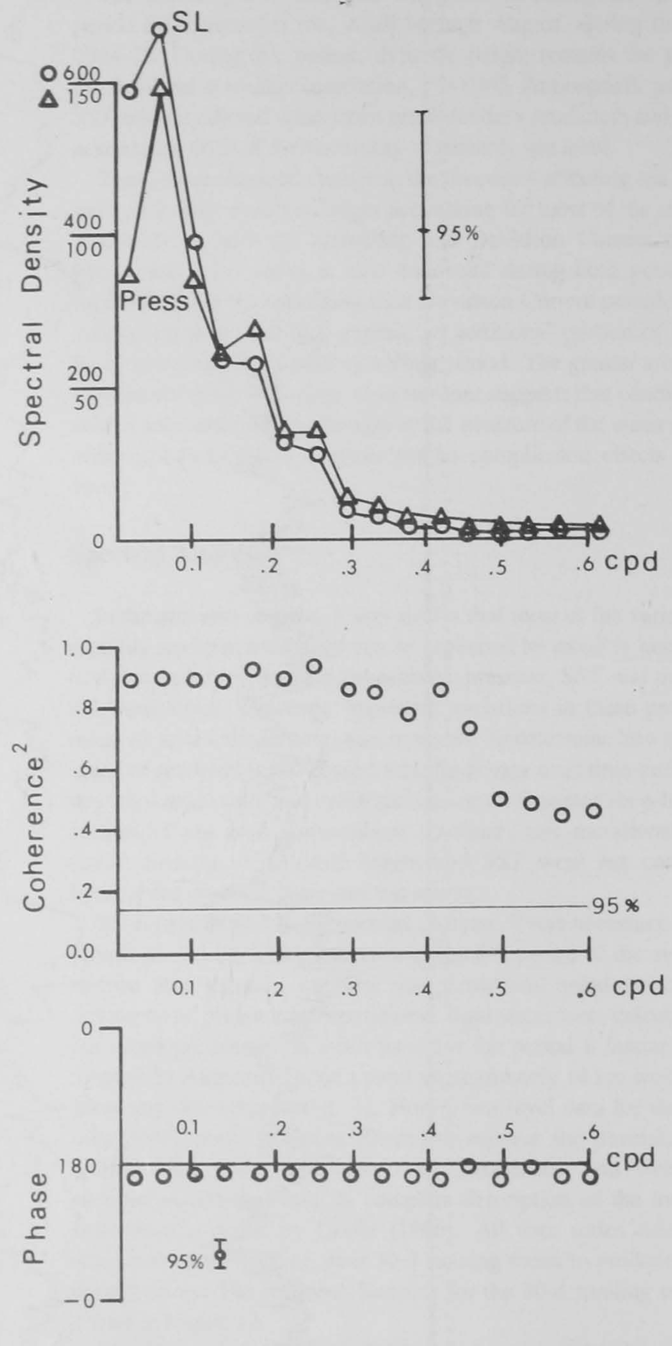

Figure 13.—Spectral plots of 6-h atmospheric pressure (Press) and unadjusted sea level (SL) for the winter period (df = 90) at Monterey, Calif. The horizontal axes are frequency in cycles per day (cpd). The upper plot shows spectral density of pressure (in mb²/cpd) and sea level (in cm²/cpd); the middle plot shows the squared coherence of the two series; and the lower plot shows the phase.

SUMMARY

Analysis of 13 yr of hourly sea levels indicates that nontidal sea level variations are small compared with the normal tide range in the area. The largest nontidal deviation observed was 39.6 cm. A seasonal change revealed by monthly frequency distributions of hourly nontidal sea level variations was found, with observed sea levels being generally less than the predicted during March through May and greater than the predicted from July through January.

Monthly sea level anomalies at Monterey are correlated with anomalies at tide stations from Prince Rupert, Canada, to Callao, Peru, but are most closely related to events affecting sea levels in the group of stations from Crescent City, Calif., to Quepos, Costa Rica. Processes producing the El Niño phenomenon in the eastern tropical Pacific affect sea level at Monterey with a lag of about 6 mo.

Multiple regression analysis indicates that monthly anomalies of dynamic height and meridional wind stress account for most of the monthly sea level variability at Monterey during both the Davidson Current and upwelling seasons. Atmospheric pressure and SST account for an additional portion of sea level variability during the upwelling season.

There is good agreement between the behavior of sea level and dynamic height in both a seasonal sense and in interyear variability. The close agreement between sea level and dynamic height, and the high correlation of sea level at Monterey with that at adjacent tide sta-

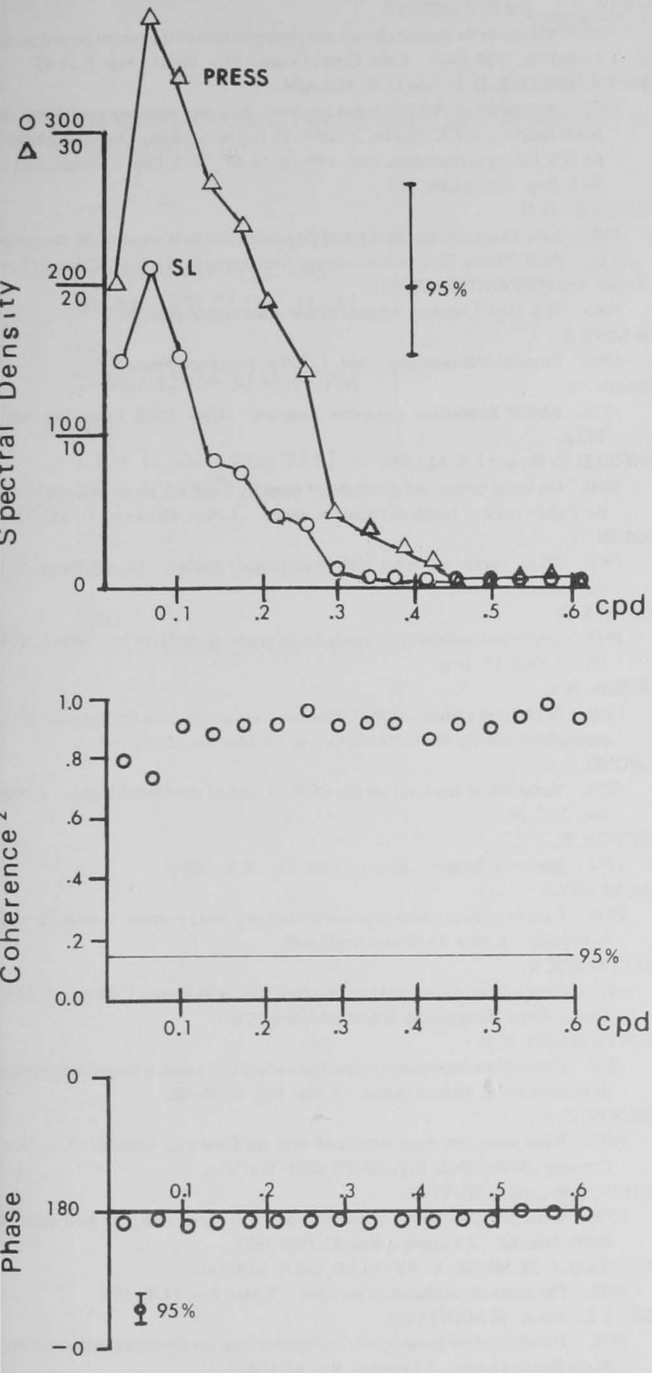

Figure 14.—Spectral plots of 6-h atmospheric pressure (Press) and unadjusted sea level (SL) for the upwelling period (df = 100) at Monterey, Calif. The horizontal axes are frequency in cycles per day (cpd). The upper plot shows spectral density of pressure (in mb²/cpd) and sea level (in cm²/cpd); the middle plot shows the squared coherence of the two series; and the lower plot shows the phase.

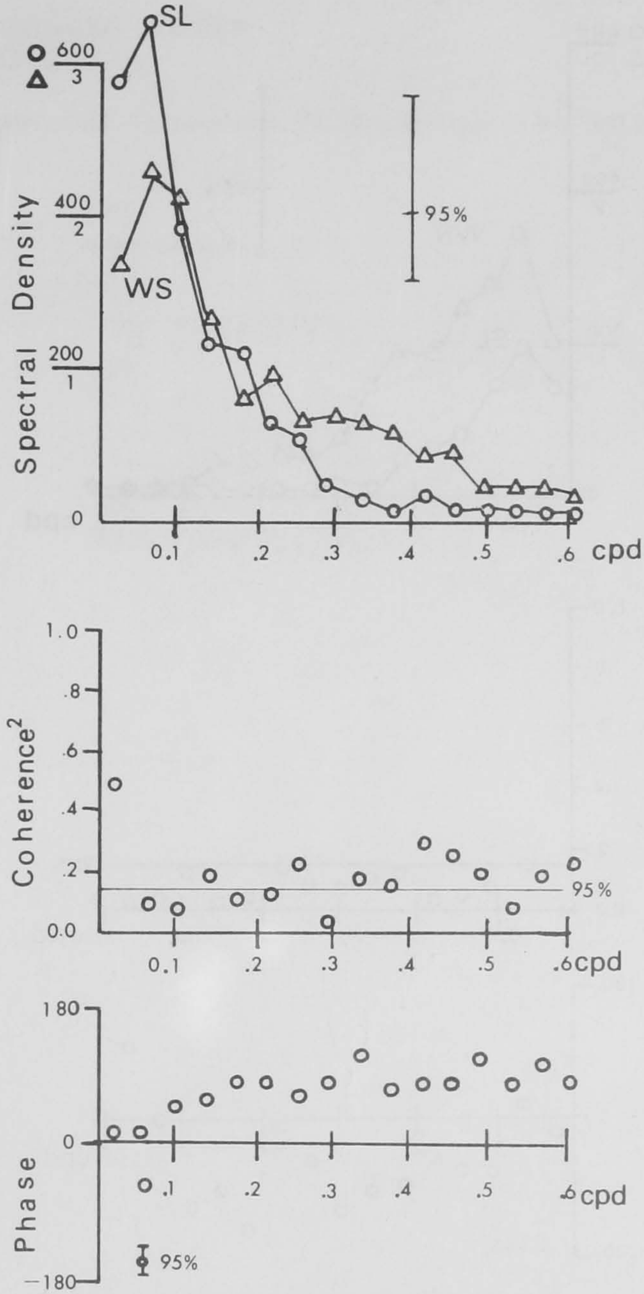

Figure 15.—Spectral plots of 6-h meridional wind stress (WS) and adjusted sea level (SL) for the winter period (df = 90) at Monterey, Calif. The horizontal axes are frequency in cycles per day (cpd). The upper plot shows spectral density of wind stress (in (dynes/cm²)²/cpd) and sea level (in cm²/cpd); the middle plot shows the squared coherence of the two series; and the lower plot shows the phase.

tions along the coast are both thought to result from variations in coastal current flow.

Analysis of 6-h sea level and atmospheric pressure observations shows that the power spectra in the winter season are more energetic than those of the upwelling season, and that most of the energy occurs at low frequencies (periods longer than 12 d). Coherence between sea level and atmospheric pressure is significant and independent of frequency. This and a nearly constant 180° phase relationship between these 6-h data sets reflects the inverse response between sea level and atmospheric pressure expected from the hydrostatic relationship. The power spectra for 6-h meridional wind stress also show a concentration of energy at low frequencies and are most energetic in winter; however, coherence between the local wind stress and sea level is generally low.

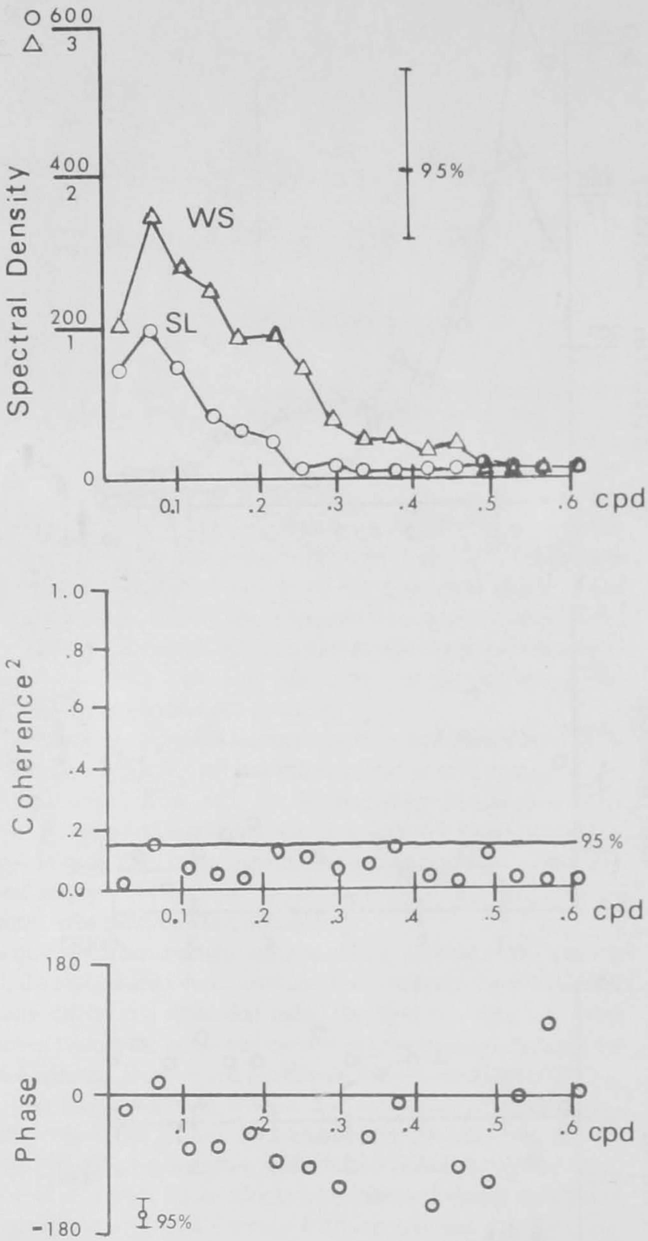

Figure 16.—Spectral plot of 6-h meridional wind stress (WS) and adjusted sea level (SL) for the upwelling period (df = 100) at Monterey, Calif. The horizontal axes are frequency in cycles per day (cpd). The upper plot shows spectral density of wind stress (in (dynes/cm²)²/cpd) and sea level (in cm²/cpd); the middle plot shows the squared coherence of the two series; and the lower plot shows the phase.

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APPENDIX A.—MISSING HOURLY SEA LEVEL DATA

The dates and times of missing hourly sea level observations at Monterey, Calif., are listed below. The data series began 21 July 1963 and ended 31 August 1976.

1963
25 Aug. 12AM-4 Sept. 11PM
28 Sept. 4AM-3 Oct. 6PM
16 Oct. 9AM-21 Oct. 11AM

1964
28 Mar. 12AM-30 Mar. 7PM

1965
1 Apr. 12AM-1 May 9AM
1 Sept. 12AM-31 Dec. 11PM

1966
1 Jan. 12AM-3 Feb. 3PM

1969
20 Sept. 12PM-23 Sept. 3PM

1970
6 Oct. 10PM-8 Oct. 3PM

1971
20 Jan. 7PM-23 Jan. 2PM

1975
14 Feb. 1PM-18 Feb. 3PM
22 Oct. 2AM-28 Oct. 11PM
7 Nov. 1AM-19 Nov. 11PM

1976
25 May 1AM-26 May 11PM

APPENDIX B.—MONTHLY MEAN OCEANIC AND ATMOSPHERIC OBSERVATIONS

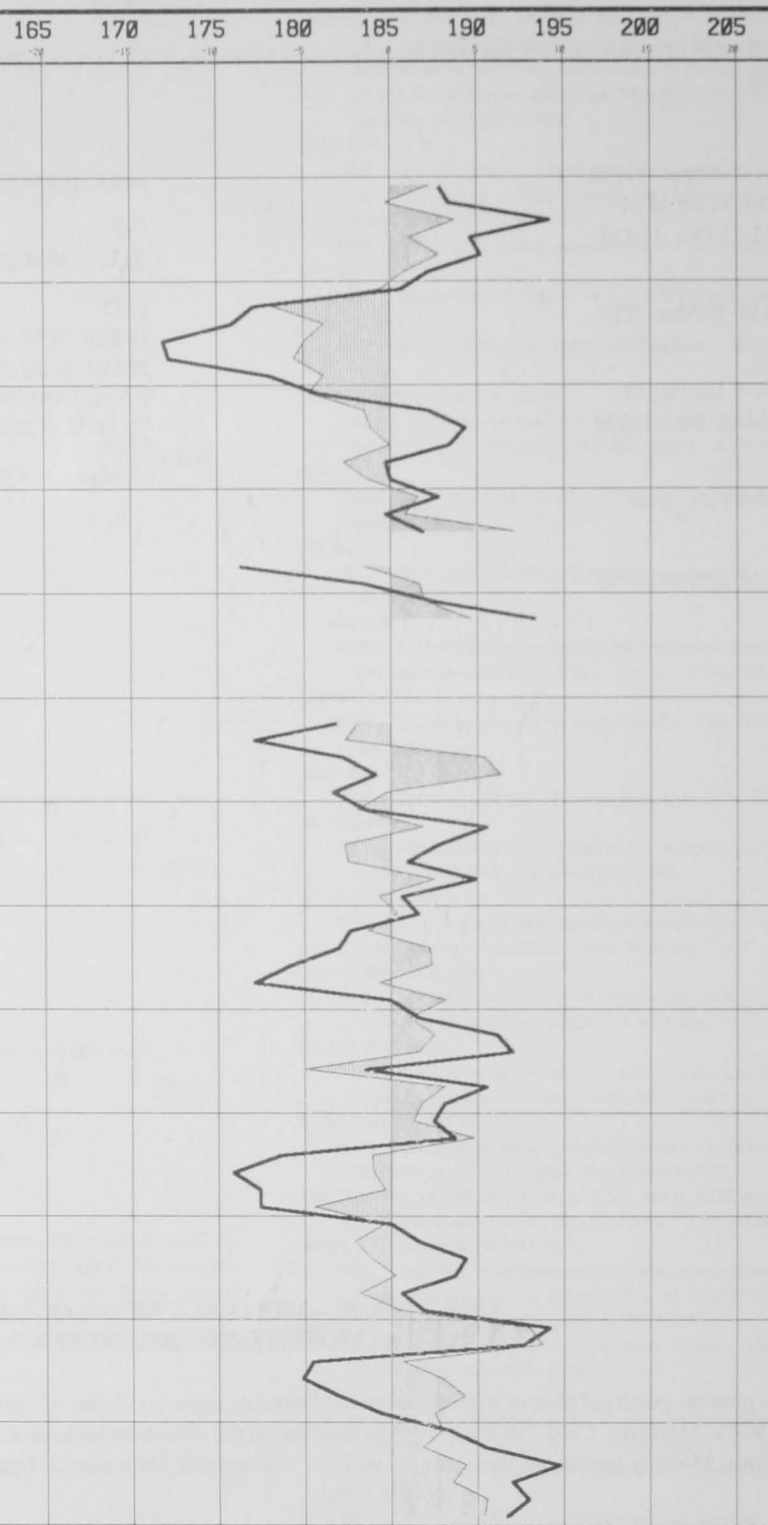
This appendix presents graphical plots of monthly means and monthly mean anomalies of various oceanic and atmospheric observations for the period 1960 to 1978 at Monterey, Calif. Anomalies were calculated as the difference between a monthly mean and the long term mean (1963-78) for the same month. Monthly means are shown as heavy lines and monthly anomalies as light lines. The data are presented in the following sequence:

1) sea level (cm),
2) adjusted sea level (cm),
3) surface atmospheric pressure (mb),
4) meridional wind stress (dynes/cm^2; positive northward),
5) zonal wind stress (dynes/cm^2; positive eastward),
6) offshore/onshore Ekman transport (t/s per 100 m of coastline; positive offshore),
7) Sverdrup transport (t/s per km; positive northward),
8) surface salinity (parts per thousand),
9) sea surface temperature (°C), and
10) dynamic height (cm).

NOAA-NMFS, PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

SEA LEVEL MONTEREY, CA BY MONTH

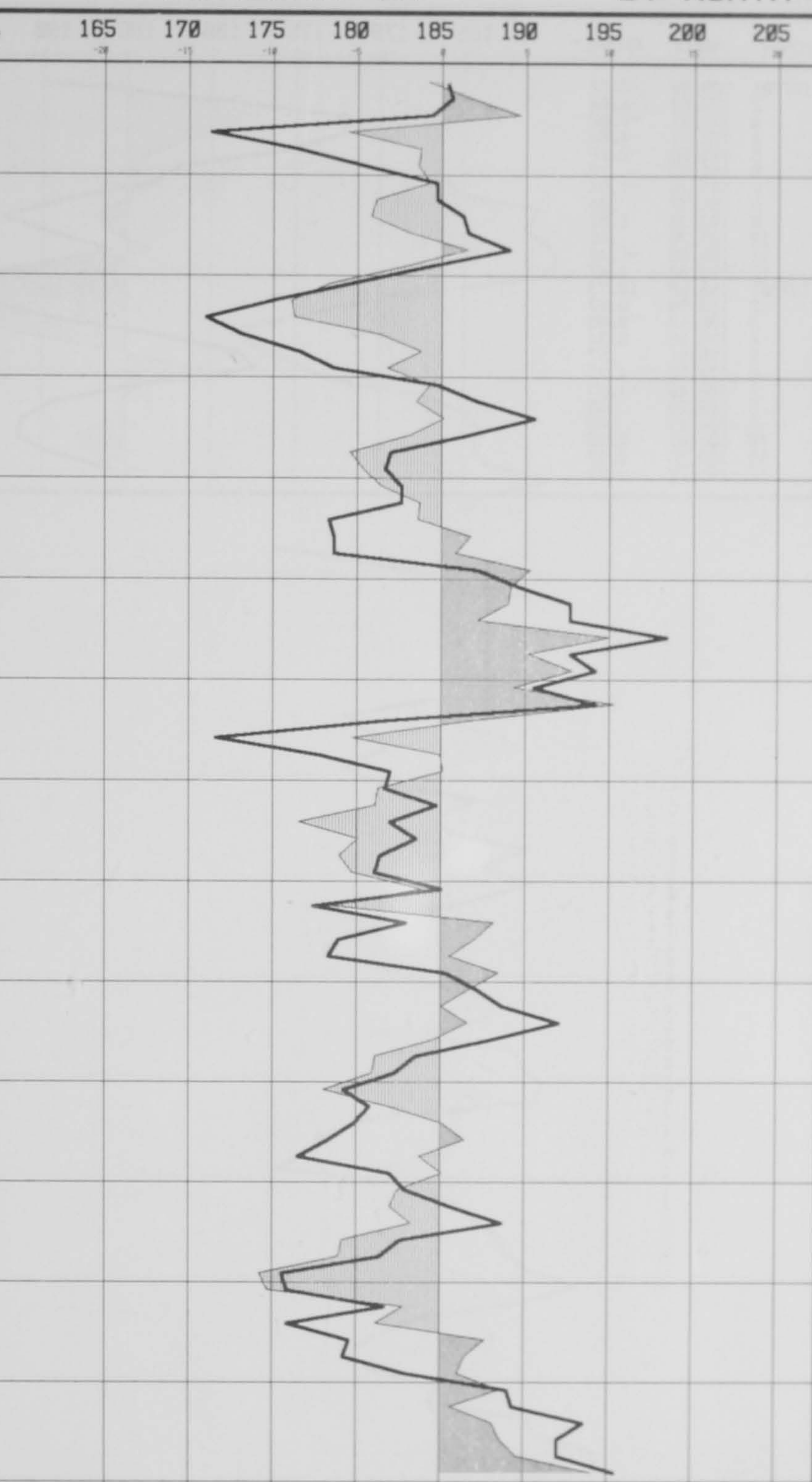
MONTH	VALUE	ANOMALY
196301	NO DATA	
2	NO DATA	
3	NO DATA	
4	NO DATA	
5	NO DATA	
6	NO DATA	
7	187.76	2.32
8	188.37	-.27
9	194.16	3.74
10	189.59	1.16
11	190.20	2.78
12	187.15	.81
196401	185.62	-.54
2	177.09	-6.79
3	175.87	-3.86
4	171.91	-4.94
5	172.21	-5.53
6	178.00	-3.84
7	180.75	-4.69
8	187.15	-1.49
9	189.28	-1.14
10	188.37	-.06
11	184.71	-2.70
12	185.01	-1.32
196501	187.76	1.59
2	184.71	.83
3	186.84	7.11
4	NO DATA	
5	176.17	-1.56
6	183.49	1.65
7	187.45	2.02
8	193.24	4.61
9	NO DATA	
10	NO DATA	
11	NO DATA	
12	NO DATA	
196601	NO DATA	
2	181.97	-1.91
3	177.09	-2.64
4	182.27	5.42
5	184.10	6.36
6	181.66	-.18
7	183.49	-1.94
8	190.50	1.87
9	187.76	-2.66
10	185.93	-2.50
11	189.89	2.48
12	185.62	-.71
196701	186.54	.37
2	182.58	-1.30
3	181.97	2.24
4	179.22	2.37
5	177.09	-.65
6	185.01	3.17
7	186.54	1.10
8	191.11	2.48
9	192.02	1.61
10	183.49	-4.94
11	190.50	3.09
12	188.06	1.73
196801	187.45	1.28
2	188.67	4.80
3	178.61	-1.12
4	175.87	-.98
5	177.39	-.35
6	177.39	-4.45
7	185.01	-.42
8	186.54	-2.10
9	189.28	-1.14
10	188.67	.24
11	185.62	-1.79
12	186.84	.51
196901	194.16	7.99
2	192.63	8.76
3	180.44	.71
4	179.83	2.98
5	181.97	4.23
6	184.40	2.56
7	188.37	2.93
8	190.50	1.87
9	194.77	4.35
10	192.02	3.60
11	192.94	5.53
12	191.72	5.38



NOAA-NMFS. PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

SEA LEVEL MONTEREY, CA BY MONTH

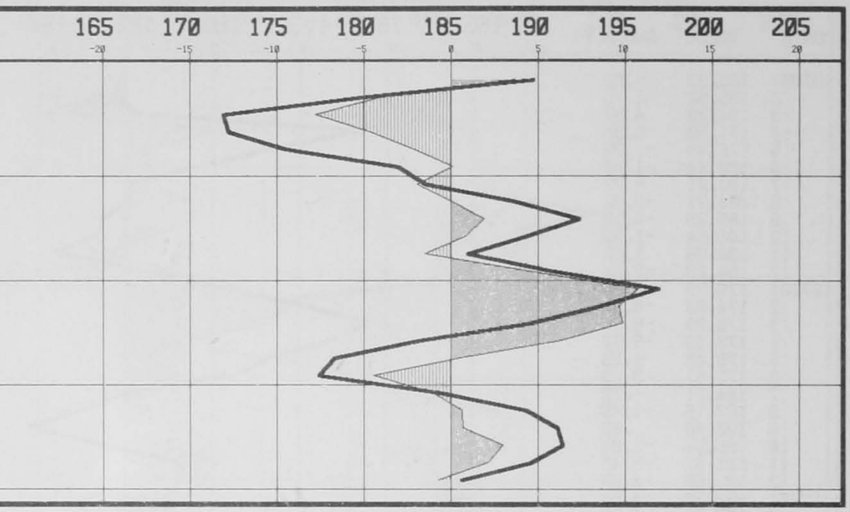
MONTH	VALUE	ANOMALY
197001	185.32	-.85
2	185.62	1.75
3	184.40	4.67
4	171.30	-5.55
5	176.48	-1.26
6	180.44	-1.40
7	184.71	-.72
8	184.71	-3.92
9	186.23	-4.19
10	186.54	-1.89
11	188.98	1.56
12	184.10	-2.24
197101	179.53	-6.64
2	174.96	-8.92
3	170.99	-8.74
4	173.13	-3.72
5	176.48	-1.26
6	178.61	-3.23
7	184.71	-.72
8	187.15	-1.49
9	190.50	.08
10	186.54	-1.89
11	181.97	-5.45
12	181.66	-4.67
197201	182.58	-3.59
2	182.58	-1.30
3	178.31	-1.42
4	178.61	1.76
5	178.61	.87
6	187.15	5.30
7	189.59	4.15
8	192.63	4.00
9	192.63	2.21
10	198.42	10.00
11	192.63	5.22
12	194.16	7.82
197301	190.50	4.33
2	194.16	10.28
3	181.36	1.63
4	171.60	-5.25
5	177.70	-.04
6	181.97	.12
7	181.66	-3.77
8	184.71	-3.92
9	181.97	-8.45
10	183.49	-4.94
11	181.36	-6.06
12	181.05	-5.28
197401	185.01	-1.15
2	177.39	-6.48
3	182.88	3.15
4	178.92	2.07
5	178.31	.57
6	185.32	3.47
7	187.15	1.71
8	188.67	.04
9	192.02	1.61
10	188.06	-.37
11	183.49	-3.92
12	182.27	-4.06
197501	179.22	-6.95
2	180.75	-3.13
3	179.83	.10
4	178.31	1.46
5	176.48	-1.26
6	181.97	.12
7	182.88	-2.55
8	185.62	-3.01
9	188.67	-1.75
10	182.58	-5.85
11	181.36	-6.06
12	175.56	-10.77
197601	175.87	-10.30
2	181.66	-2.21
3	175.87	-3.86
4	179.53	2.68
5	179.22	1.48
6	182.88	1.04
7	188.98	3.54
8	189.28	.65
9	193.55	3.13
10	192.02	3.60
11	192.02	4.61
12	195.38	9.04



NOAA-NMFS, PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

SEA LEVEL MONTEREY, CA BY MONTH

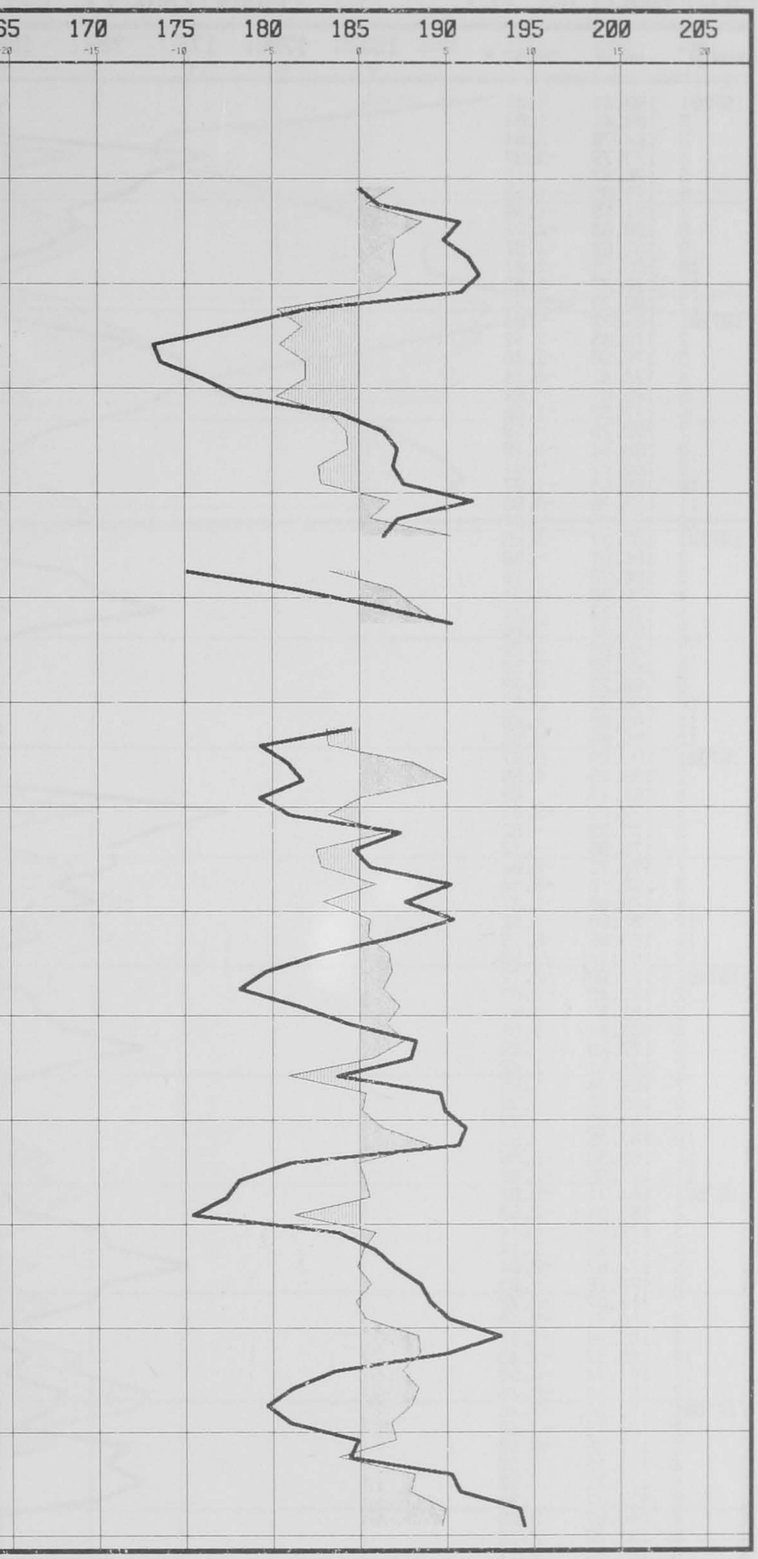
MONTH	VALUE	ANOMALY
197701	189.89	3.72
2	179.83	-4.04
3	171.91	-7.82
4	172.21	-4.64
5	175.56	-2.17
6	181.97	.12
7	183.49	-1.94
8	188.67	.04
9	192.33	1.91
10	189.28	.85
11	185.93	-1.48
12	190.80	4.47
197801	196.90	10.73
2	193.55	9.67
3	189.59	9.86
4	183.18	6.34
5	178.31	.57
6	177.39	-4.45
7	184.40	-1.03
8	189.28	.65
9	191.11	.69
10	191.41	2.99
11	189.59	2.17
12	185.62	-.71



NOAA-NMFS,PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

ADJ. SEA LEVEL MONTEREY, CA BY MONTH

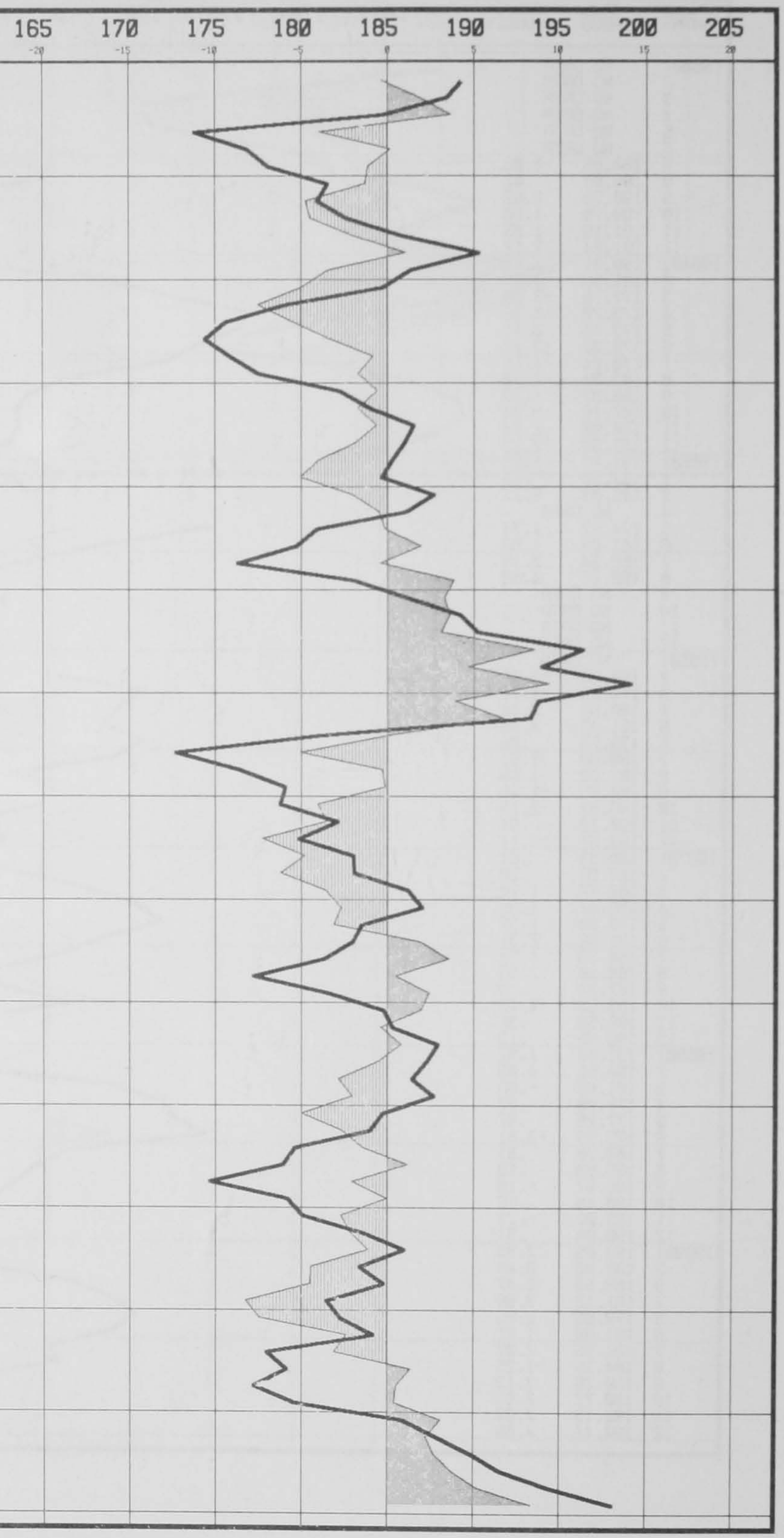
MONTH	VALUE	ANOMALY
196301	NO DATA	
2	NO DATA	
3	NO DATA	
4	NO DATA	
5	NO DATA	
6	NO DATA	
7	184.85	2.06
8	186.06	.42
9	190.75	3.62
10	189.78	1.98
11	191.19	1.95
12	191.84	2.12
196401	190.81	1.09
2	181.88	-4.69
3	177.76	-3.30
4	173.20	-4.56
5	173.60	-3.11
6	176.09	-3.10
7	178.04	-4.75
8	183.94	-1.70
9	186.37	-.76
10	187.16	-.64
11	186.90	-2.34
12	187.50	-2.22
196501	191.45	1.73
2	187.20	.63
3	186.33	5.27
4	NO DATA	
5	174.97	-1.74
6	181.08	1.89
7	185.94	3.15
8	190.23	4.59
9	NO DATA	
10	NO DATA	
11	NO DATA	
12	NO DATA	
196601	NO DATA	
2	184.66	-1.91
3	179.28	-1.78
4	180.86	3.10
5	181.69	4.98
6	179.25	.06
7	180.98	-1.81
8	187.29	1.65
9	184.65	-2.48
10	185.62	-2.18
11	190.18	.94
12	187.61	-2.11
196701	190.33	.61
2	187.07	.50
3	182.76	1.70
4	179.61	1.85
5	178.08	1.37
6	181.50	2.31
7	184.33	1.54
8	188.20	2.56
9	187.92	.79
10	183.68	-4.12
11	189.59	.35
12	189.85	.13
196801	191.04	1.32
2	190.66	4.09
3	181.00	-.06
4	178.06	.30
5	177.28	.57
6	175.38	-3.81
7	183.70	.91
8	185.83	.19
9	186.97	-.16
10	188.46	.66
11	189.01	-.23
12	190.03	.31
196901	193.05	3.33
2	190.02	3.45
3	183.53	2.47
4	181.12	3.36
5	179.66	2.95
6	181.00	1.81
7	184.86	2.07
8	184.39	-1.25
9	190.26	3.13
10	190.72	2.92
11	194.13	4.89
12	194.41	4.69



NOAA-NMFS, PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

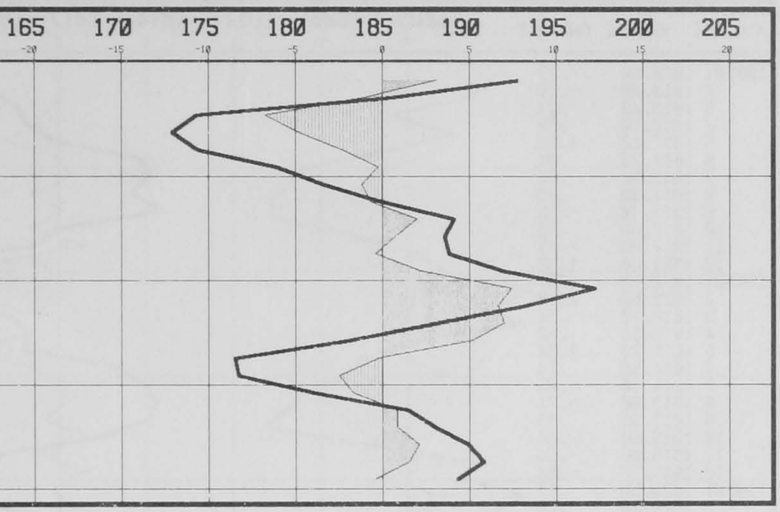
ADJ SEA LEVEL MONTEREY, CA BY MONTH

MONTH	VALUE	ANOMALY
197001	189.31	-.41
2	188.41	1.84
3	184.70	3.64
4	173.79	-3.97
5	176.87	.16
6	178.03	-1.16
7	181.50	-1.29
8	180.90	-4.74
9	182.62	-4.51
10	185.73	-2.07
11	190.27	1.03
12	186.29	-3.43
197101	184.72	-5.00
2	179.05	-7.52
3	175.58	-5.48
4	174.42	-3.34
5	175.87	-.84
6	177.50	-1.69
7	182.20	-.59
8	183.94	-1.70
9	186.49	-.64
10	185.93	-1.87
11	185.26	-3.98
12	184.65	-5.07
197201	187.67	-2.05
2	166.07	-.50
3	180.90	-.16
4	179.70	1.94
5	176.30	-.41
6	183.04	3.85
7	186.08	3.29
8	189.22	3.58
9	190.22	3.09
10	196.32	8.52
11	193.92	4.68
12	199.05	9.33
197301	193.69	3.97
2	193.25	6.68
3	181.15	.09
4	172.69	-5.07
5	176.39	-.32
6	179.06	-.13
7	178.75	-4.04
8	182.10	-3.54
9	179.86	-7.27
10	182.98	-4.82
11	183.05	-6.19
12	186.14	-3.58
197401	187.00	-2.72
2	183.48	-3.09
3	182.97	1.91
4	181.31	3.55
5	177.20	.49
6	181.61	2.42
7	184.74	1.95
8	185.26	-.38
9	187.92	.79
10	187.25	-.55
11	186.38	-2.86
12	187.66	-2.06
197501	184.71	-5.01
2	183.94	-2.63
3	179.62	-1.44
4	178.90	1.14
5	174.67	-2.04
6	179.16	-.03
7	180.07	-2.72
8	183.51	-2.13
9	185.96	-1.17
10	183.37	-4.43
11	184.74	-4.50
12	181.46	-8.26
197601	182.26	-7.46
2	184.15	-2.42
3	177.96	-3.10
4	179.12	1.36
5	177.21	.50
6	179.57	.36
7	185.87	3.08
8	187.87	2.23
9	189.84	2.71
10	191.52	3.72
11	194.42	5.18
12	198.07	8.35



ADJ. SEA LEVEL MONTEREY, CA BY MONTH

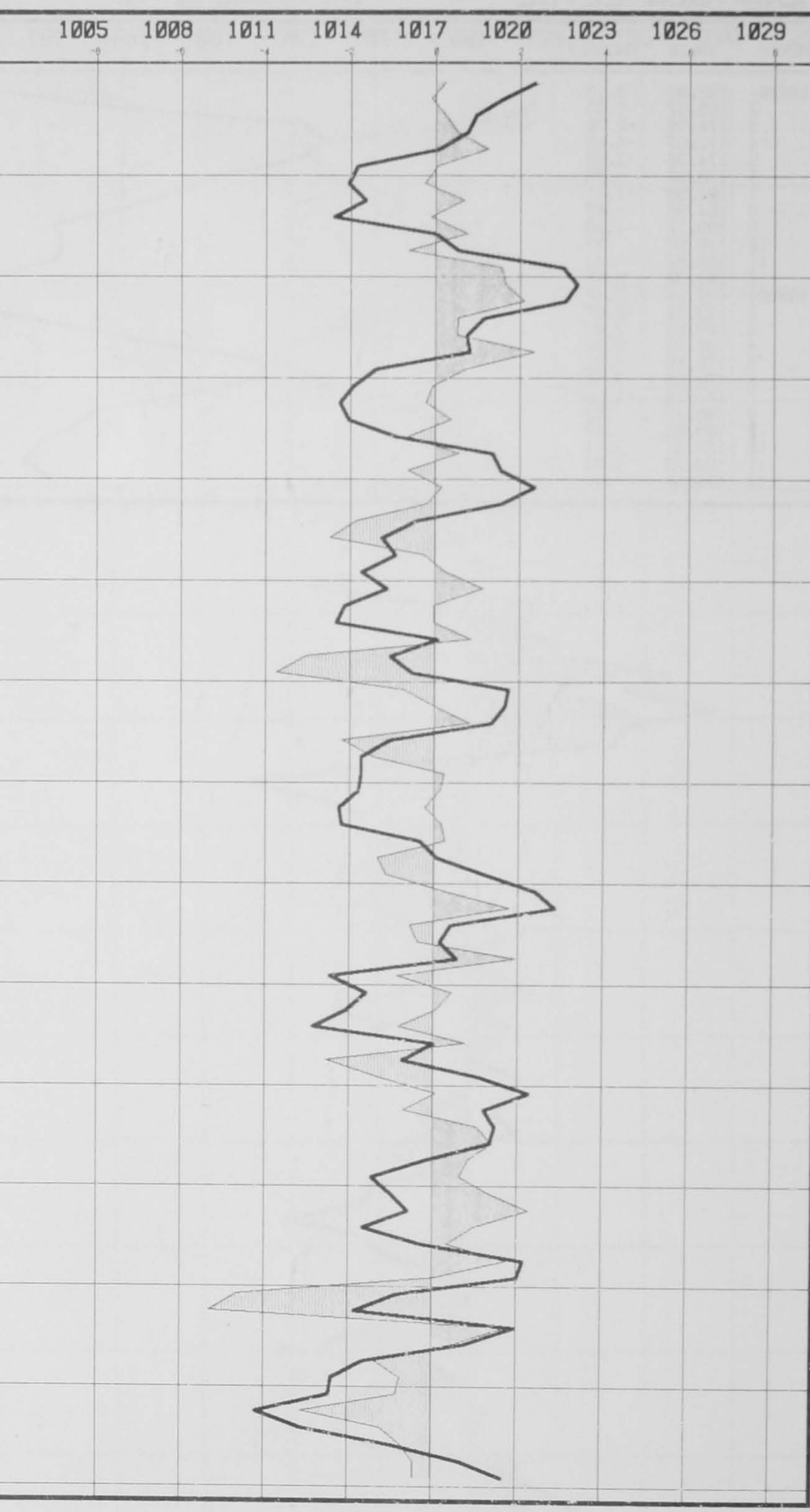
MONTH	VALUE	ANOMALY
197701	192.88	3.16
2	185.52	-1.05
3	174.30	-6.76
4	172.90	-4.86
5	174.36	-2.35
6	178.96	-.23
7	181.58	-1.21
8	184.96	-.68
9	189.12	1.99
10	188.57	.77
11	188.82	-.42
12	191.90	2.18
197801	197.19	7.47
2	193.24	6.67
3	188.08	7.02
4	182.98	5.22
5	176.50	-.21
6	176.68	-2.51
7	181.10	-1.69
8	186.47	.83
9	188.00	.87
10	189.91	2.11
11	190.78	1.54
12	189.31	-.41



NOAA-NMFS, PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

PRESSURE BY MONTH

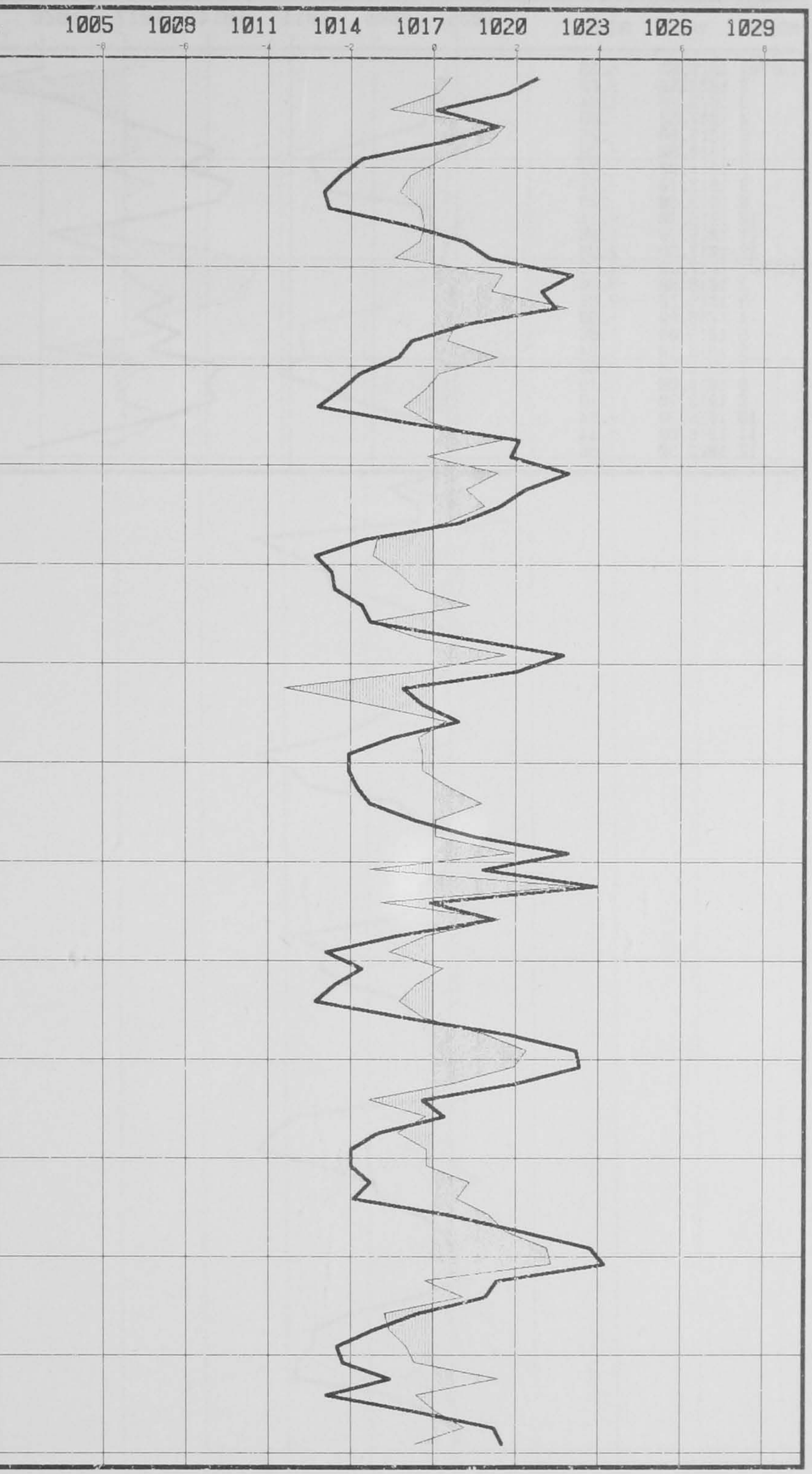
MONTH	VALUE	ANOMALY
196301	1020.60	.27
2	1019.40	-.10
3	1018.40	.24
4	1018.10	.52
5	1017.10	1.24
6	1014.20	.04
7	1013.90	-.26
8	1014.50	.69
9	1013.40	-.12
10	1017.00	.76
11	1017.80	-.64
12	1021.50	1.56
196401	1022.00	1.67
2	1021.60	2.10
3	1018.70	.54
4	1018.10	.52
5	1018.20	2.34
6	1014.90	.74
7	1014.10	-.06
8	1013.60	-.21
9	1013.90	.38
10	1015.60	-.64
11	1019.00	.56
12	1019.30	-.64
196501	1020.50	.17
2	1019.30	-.20
3	1016.30	-1.86
4	1015.10	-2.48
5	1015.60	-.26
6	1014.40	.24
7	1015.30	1.14
8	1013.80	-.01
9	1013.50	-.02
10	1017.10	.86
11	1015.40	-3.04
12	1016.20	-3.74
196601	1019.60	-.73
2	1019.50	.00
3	1019.00	.84
4	1015.40	-2.18
5	1014.40	-1.46
6	1014.40	.24
7	1014.30	.14
8	1013.60	-.21
9	1013.70	.18
10	1016.50	.26
11	1017.10	-1.34
12	1018.80	-1.14
196701	1020.60	.27
2	1021.30	1.80
3	1017.60	-.56
4	1017.20	-.38
5	1017.80	1.94
6	1013.30	-.86
7	1014.60	.44
8	1013.90	.09
9	1012.70	-.82
10	1017.00	.76
11	1015.90	-2.54
12	1018.60	-1.34
196801	1020.40	.07
2	1018.80	-.70
3	1019.20	1.04
4	1019.00	1.42
5	1016.70	.84
6	1014.80	.64
7	1015.50	1.34
8	1016.10	2.29
9	1014.50	.98
10	1016.60	.36
11	1020.20	1.76
12	1020.00	.06
196901	1015.70	-4.63
2	1014.20	-5.30
3	1019.90	1.74
4	1018.10	.52
5	1014.50	-1.36
6	1013.40	-.76
7	1013.30	-.86
8	1010.70	-3.11
9	1012.30	-1.22
10	1015.50	-.74
11	1018.00	-.44
12	1019.50	-.44



NOAA-NMFS, PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

PRESSURE BY MONTH

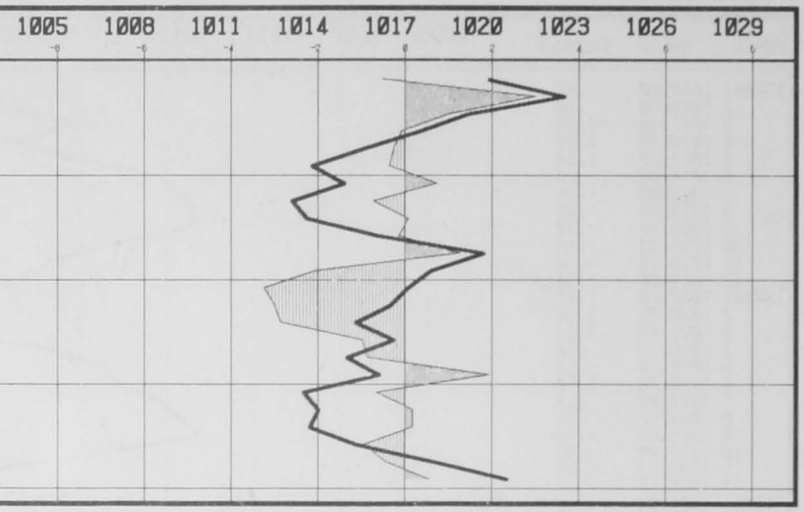
MONTH	VALUE	ANOMALY
197001	1020.80	.47
2	1019.60	.10
3	1017.10	-1.06
4	1019.30	1.72
5	1017.20	1.34
6	1014.40	.24
7	1013.60	-.56
8	1013.00	-.81
9	1013.20	-.32
10	1016.00	-.24
11	1018.10	-.34
12	1019.00	-.94
197101	1022.00	1.67
2	1020.90	1.40
3	1021.40	3.24
4	1018.10	.52
5	1016.20	.34
6	1015.70	1.54
7	1014.30	.14
8	1013.60	-.21
9	1012.80	-.72
10	1016.20	-.04
11	1020.10	1.66
12	1019.80	-.14
197201	1021.90	1.57
2	1020.30	.80
3	1019.40	1.24
4	1017.90	.32
5	1014.50	-1.36
6	1012.70	-1.46
7	1013.30	-.86
8	1013.40	-.41
9	1014.40	.88
10	1014.70	-1.54
11	1018.10	-.34
12	1021.70	1.76
197301	1020.00	-.33
2	1015.90	-3.60
3	1016.60	-1.56
4	1017.90	.32
5	1015.50	-.36
6	1013.90	-.26
7	1013.90	-.26
8	1014.20	.39
9	1014.70	1.18
10	1016.30	.06
11	1018.50	.06
12	1021.90	1.96
197401	1018.80	-1.53
2	1022.90	3.40
3	1016.90	-1.26
4	1019.20	1.62
5	1015.70	-.16
6	1013.10	-1.06
7	1014.40	.24
8	1013.40	-.41
9	1012.70	-.82
10	1016.00	-.24
11	1019.70	1.26
12	1022.20	2.26
197501	1022.30	1.97
2	1020.00	.50
3	1016.60	-1.56
4	1017.40	-.18
5	1015.00	-.86
6	1014.00	-.16
7	1014.00	-.16
8	1014.70	.89
9	1014.10	.58
10	1017.60	1.36
11	1020.20	1.76
12	1022.70	2.76
197601	1023.20	2.87
2	1019.30	-.20
3	1018.90	.74
4	1016.40	-1.18
5	1014.80	-1.06
6	1013.50	-.66
7	1013.70	-.46
8	1015.40	1.59
9	1013.10	-.42
10	1016.30	.06
11	1019.20	.76
12	1019.50	-.44



NOAA-NMFS, PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

PRESSURE BY MONTH

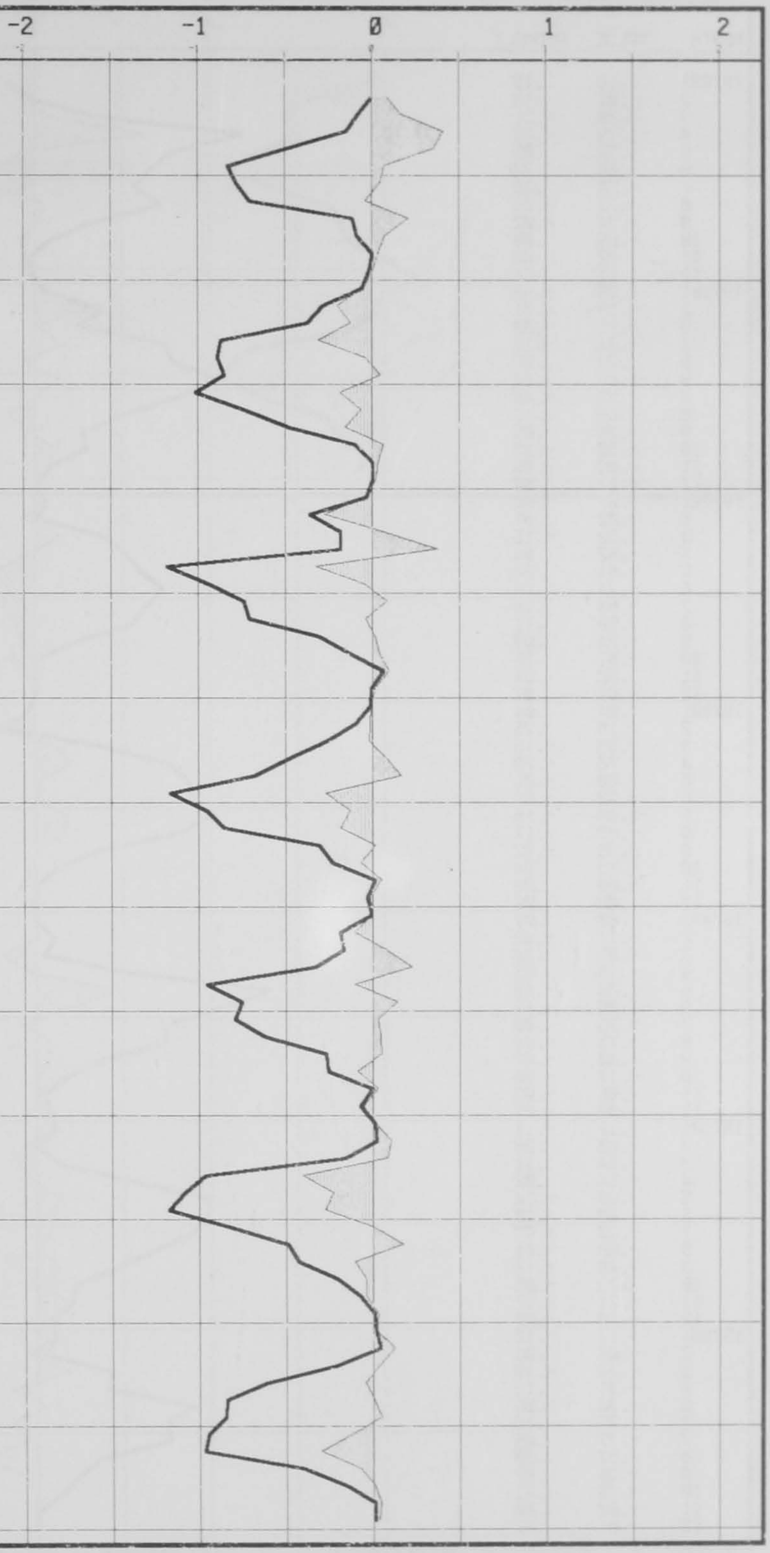
MONTH	VALUE	ANOMALY
197701	1019.80	-.53
2	1022.50	3.00
3	1019.20	1.04
4	1017.50	-.08
5	1015.60	-.26
6	1013.80	-.36
7	1014.90	.74
8	1013.10	-.71
9	1013.60	.08
10	1016.10	-.14
11	1019.70	1.26
12	1017.90	-2.04
197801	1017.10	-3.23
2	1016.50	-3.00
3	1015.30	-2.86
4	1016.60	-.98
5	1015.00	-.86
6	1016.10	1.94
7	1013.50	-.66
8	1014.00	.19
9	1013.70	.18
10	1015.30	-.94
11	1018.00	-.44
12	1020.50	.56



NOAA-NMFS. PACIFIC ENVIRONMENTAL GROUP. MONTEREY. CALIFORNIA

N. COMP. WIND STRESS BY MONTH

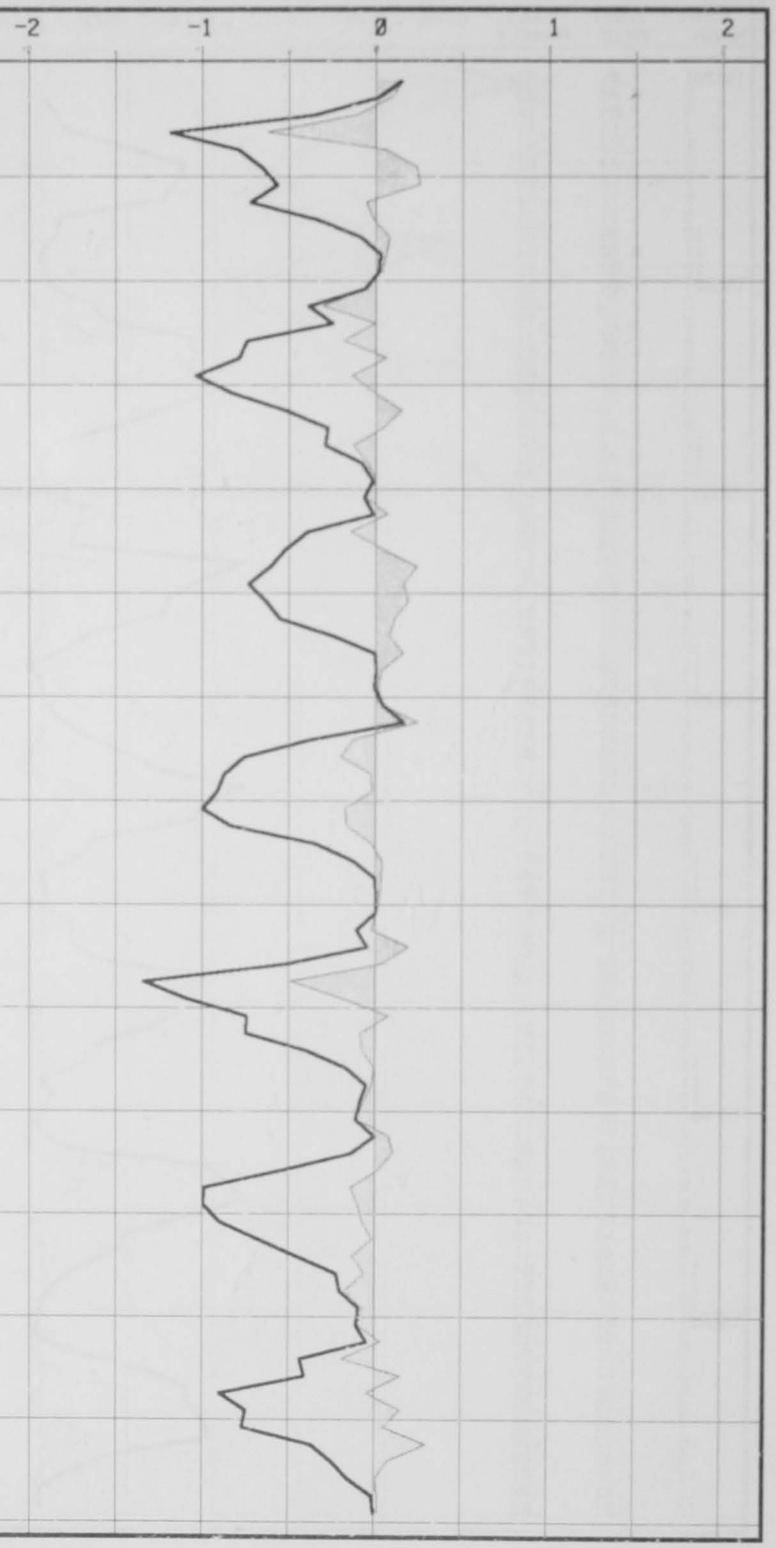
MONTH	VALUE	ANOMALY
196301	-.05	-.05
2	0.00	.08
3	-.08	.17
4	-.15	.41
5	-.50	.36
6	-.83	.07
7	-.78	.05
8	-.71	-.04
9	-.11	.21
10	-.09	.08
11	0.00	.04
12	-.02	.01
196401	-.06	-.05
2	-.29	-.20
3	-.37	-.13
4	-.87	-.31
5	-.89	-.04
6	-.85	.05
7	-1.01	-.19
8	-.73	-.07
9	-.48	-.16
10	-.10	.07
11	0.00	.04
12	-.00	.02
196501	-.04	-.03
2	-.36	-.28
3	-.19	.06
4	-.18	.38
5	-1.18	-.33
6	-.95	-.05
7	-.74	.09
8	-.71	-.04
9	-.31	.02
10	-.13	.04
11	.06	.10
12	-.01	.02
196601	-.02	-.01
2	-.10	-.02
3	-.27	-.02
4	-.48	.08
5	-.69	.17
6	-1.17	-.27
7	-.96	-.13
8	-.85	-.19
9	-.31	.01
10	-.24	-.07
11	.01	.05
12	-.04	-.01
196701	-.01	-.01
2	-.19	-.11
3	-.17	.08
4	-.34	.22
5	-.95	-.10
6	-.76	.14
7	-.80	.03
8	-.62	.04
9	-.27	.05
10	-.26	-.09
11	-.01	.03
12	-.08	-.05
196801	.01	.02
2	.02	.11
3	-.16	.09
4	-.96	-.40
5	-1.08	-.23
6	-1.17	-.28
7	-.82	.00
8	-.49	.18
9	-.43	-.11
10	-.21	-.04
11	-.08	-.04
12	.01	.03
196901	.02	.02
2	.04	.13
3	-.21	.04
4	-.61	-.05
5	-.84	.01
6	-.85	.05
7	-.95	-.12
8	-.97	-.30
9	-.40	-.08
10	-.16	.01
11	.01	.05
12	.01	.03



NOAA-NMFS.PACIFIC ENVIRONMENTAL GROUP. MONTEREY. CALIFORNIA

N. COMP. WIND STRESS BY MONTH

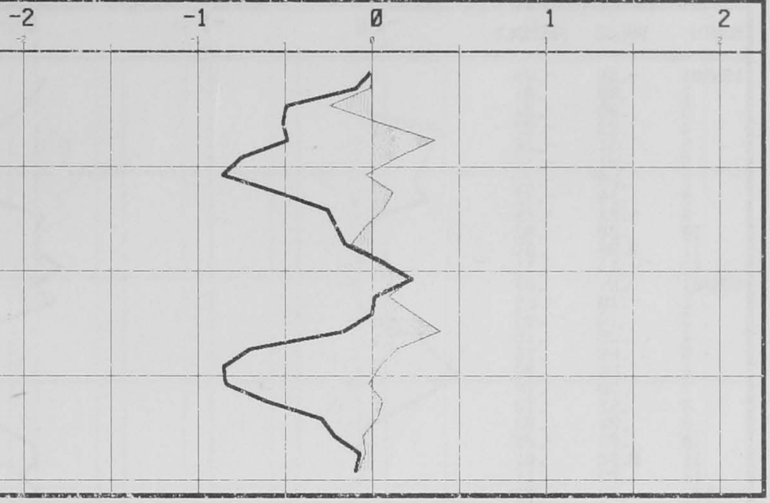
MONTH	VALUE	ANOMALY
197001	.16	.16
2	.01	.10
3	-.36	-.11
4	-1.19	-.63
5	-.79	.06
6	-.66	.24
7	-.57	.26
8	-.72	-.06
9	-.34	-.02
10	-.09	.08
11	.02	.06
12	.01	.04
197101	-.06	-.06
2	-.39	-.31
3	-.25	-.00
4	-.74	-.18
5	-.79	.06
6	-1.04	-.14
7	-.83	-.00
8	-.52	.15
9	-.28	.05
10	-.30	-.13
11	-.09	-.05
12	-.02	.00
197201	-.07	-.06
2	-.02	.07
3	-.39	-.15
4	-.52	.04
5	-.61	.24
6	-.74	.16
7	-.64	.19
8	-.56	.11
9	-.24	.08
10	-.01	.16
11	.00	.04
12	-.01	.02
197301	.04	.04
2	.16	.25
3	-.38	-.13
4	-.76	-.20
5	-.88	-.02
6	-.92	-.02
7	-1.00	-.18
8	-.83	-.17
9	-.35	-.02
10	-.13	.04
11	-.00	.03
12	.00	.03
197401	.00	.01
2	-.11	-.02
3	-.05	.20
4	-.53	.03
5	-1.34	-.49
6	-1.09	-.19
7	-.75	.08
8	-.75	-.08
9	-.40	-.07
10	-.17	-.00
11	-.06	-.02
12	-.09	-.07
197501	-.12	-.11
2	-.00	.08
3	-.14	.11
4	-.54	.02
5	-.99	-.14
6	-1.00	-.10
7	-.90	-.07
8	-.68	-.01
9	-.46	-.13
10	-.23	-.06
11	-.21	-.17
12	-.10	-.07
197601	-.11	-.10
2	-.05	.03
3	-.44	-.19
4	-.41	.15
5	-.90	-.05
6	-.75	.15
7	-.77	.05
8	-.37	.30
9	-.25	.07
10	-.16	.01
11	-.02	.02
12	-.01	.02



NOAA-NMFS, PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

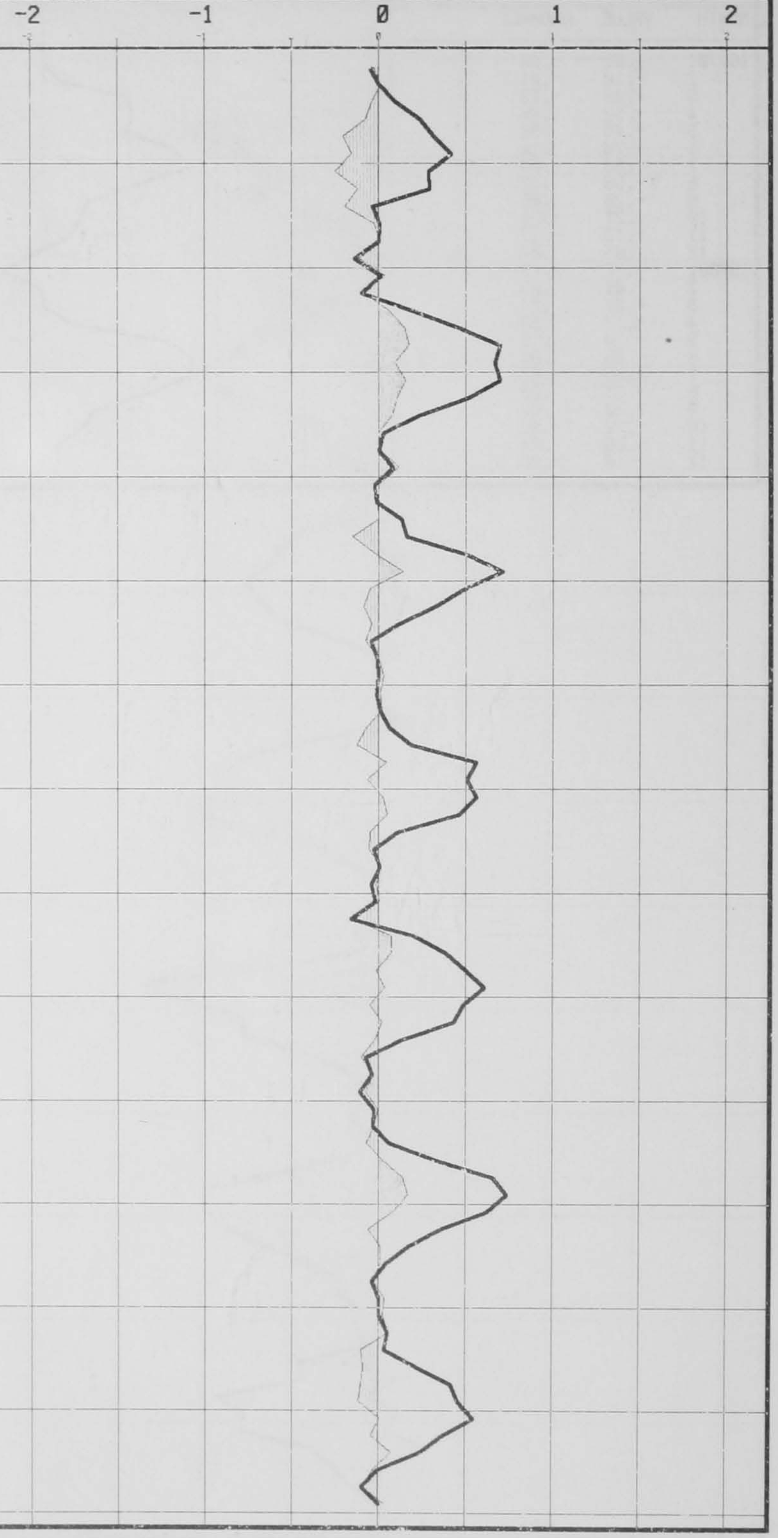
N. COMP. WIND STRESS BY MONTH

MONTH	VALUE	ANOMALY
197701	-.01	.00
2	-.10	-.01
3	-.49	-.25
4	-.52	.05
5	-.49	.36
6	-.76	.14
7	-.86	-.03
8	-.55	.12
9	-.26	.06
10	-.21	-.04
11	-.16	-.12
12	.05	.07
197801	.22	.23
2	.01	.09
3	-.01	.24
4	-.17	.39
5	-.70	.15
6	-.85	.04
7	-.85	-.02
8	-.61	.06
9	-.30	.03
10	-.22	-.05
11	-.08	-.04
12	-.10	-.08



EAST COMP. WIND STRESS BY MONTH

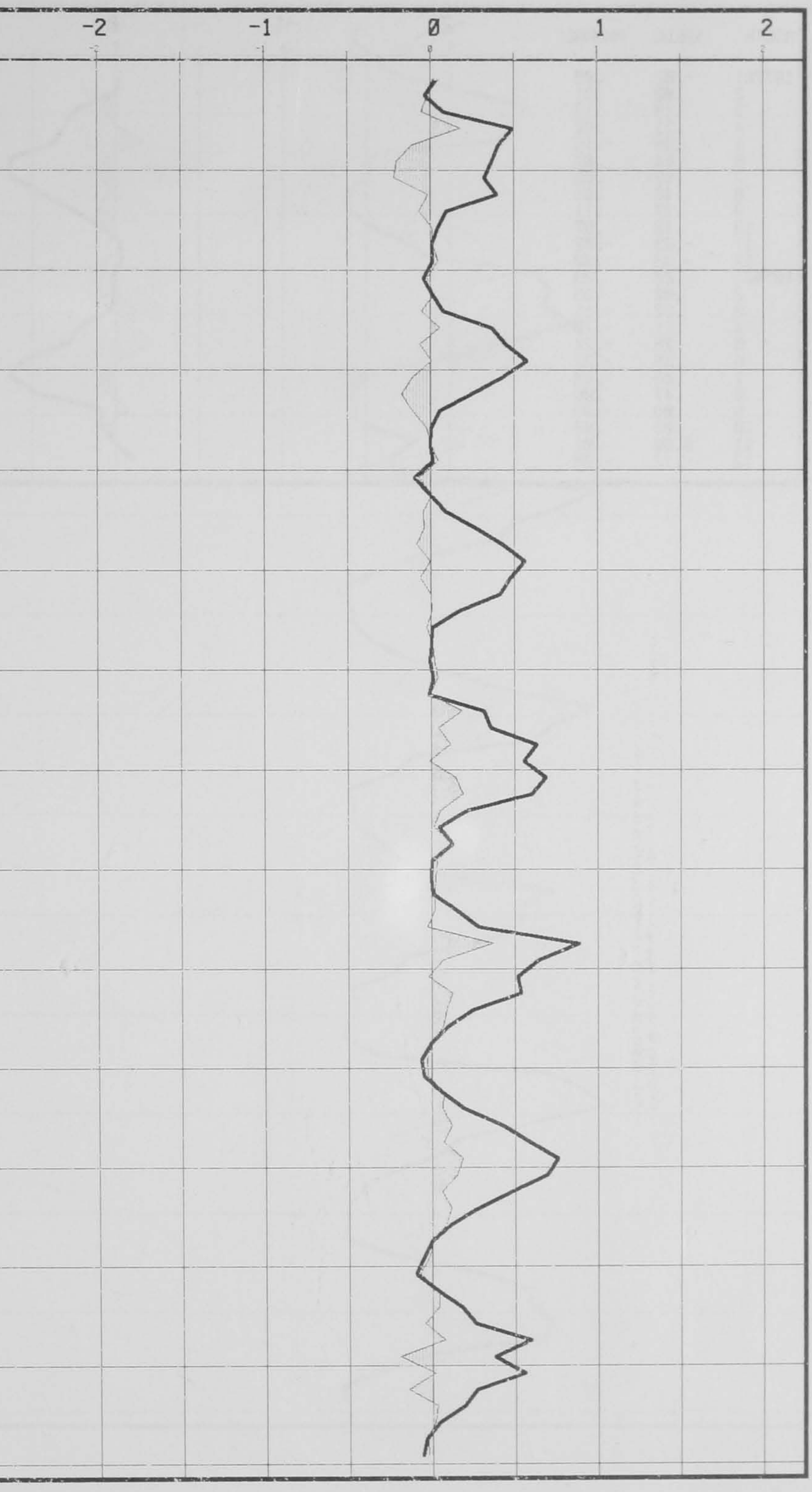
MONTH	VALUE	ANOMALY
196301	-.06	-.03
2	.00	.01
3	.09	-.04
4	.23	-.07
5	.31	-.20
6	.41	-.16
7	.29	-.25
8	.29	-.12
9	-.04	-.19
10	.00	-.02
11	0.00	.01
12	-.14	-.11
196401	.01	.04
2	-.10	-.09
3	.19	.06
4	.45	.15
5	.69	.18
6	.66	.09
7	.70	.16
8	.52	.10
9	.24	.08
10	.03	-.00
11	0.00	.01
12	.08	.11
196501	-.03	-.00
2	-.01	-.00
3	.13	-.00
4	.16	-.15
5	.50	-.02
6	.71	.14
7	.49	-.05
8	.33	-.09
9	.12	-.04
10	-.05	-.07
11	-.01	.00
12	-.00	.03
196601	-.02	.01
2	.01	.02
3	.06	-.07
4	.18	-.12
5	.56	.04
6	.51	-.06
7	.56	.02
8	.46	.05
9	.11	-.05
10	-.03	-.06
11	.01	.02
12	-.05	-.01
196701	-.02	.01
2	-.16	-.15
3	.21	.07
4	.38	.08
5	.50	-.01
6	.61	.04
7	.49	-.05
8	.43	.02
9	.14	-.02
10	-.07	-.10
11	-.04	-.03
12	-.11	-.07
196801	-.03	-.00
2	-.03	-.02
3	.06	-.07
4	.33	.02
5	.65	.14
6	.74	.17
7	.62	.08
8	.35	-.06
9	.17	.01
10	.04	.01
11	-.04	-.03
12	.00	.04
196901	.00	.03
2	.05	.06
3	.03	-.10
4	.22	-.09
5	.41	-.10
6	.45	-.11
7	.55	.01
8	.37	-.04
9	.24	.08
10	-.00	-.03
11	-.10	-.09
12	-.00	.03



NOAA-NMFS.PACIFIC ENVIRONMENTAL GROUP. MONTEREY. CALIFORNIA

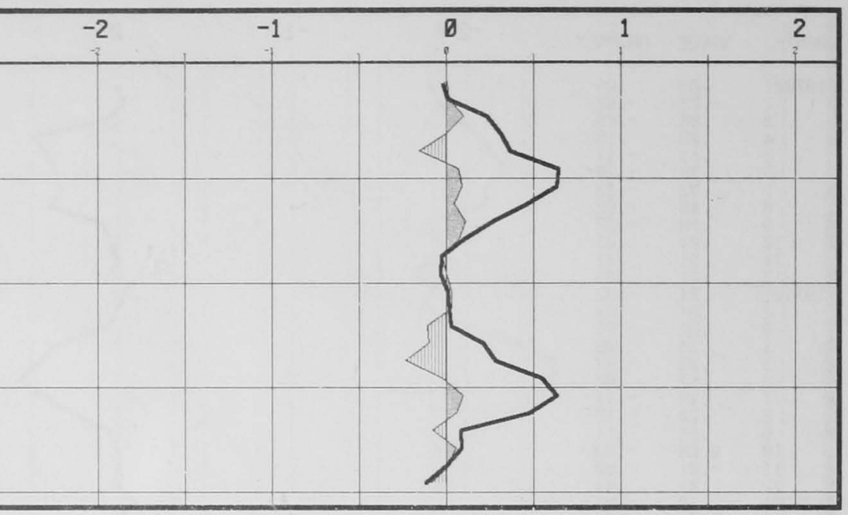
EAST COMP. WIND STRESS BY MONTH

MONTH	VALUE	ANOMALY
197001	.03	.06
2	-.03	-.02
3	.08	-.05
4	.49	.18
5	.41	-.11
6	.36	-.20
7	.32	-.22
8	.40	-.02
9	.09	-.07
10	.04	.01
11	.01	.01
12	.01	.05
197101	-.04	-.02
2	.01	.02
3	.08	-.05
4	.36	.06
5	.45	-.07
6	.57	.00
7	.43	-.11
8	.24	-.17
9	.05	-.11
10	0.00	-.03
11	-.01	.00
12	.01	.04
197201	-.10	-.07
2	-.01	.00
3	.09	-.05
4	.27	-.04
5	.43	-.08
6	.56	-.01
7	.47	-.06
8	.41	-.00
9	.17	.01
10	.00	-.02
11	-.00	.01
12	-.01	.02
197301	.01	.04
2	-.01	-.00
3	.32	.19
4	.36	.05
5	.63	.11
6	.56	-.01
7	.68	.15
8	.60	.19
9	.21	.05
10	.04	.02
11	.13	.13
12	.00	.03
197401	-.00	.02
2	.01	.02
3	.15	.02
4	.28	-.03
5	.89	.37
6	.64	.07
7	.52	-.02
8	.54	.12
9	.25	.09
10	.10	.07
11	-.01	.00
12	-.06	-.03
197501	-.05	-.02
2	.06	.07
3	.20	.06
4	.43	.12
5	.59	.07
6	.75	.19
7	.69	.15
8	.47	.06
9	.28	.12
10	.11	.08
11	-.00	.00
12	-.06	-.02
197601	-.10	-.08
2	.03	.04
3	.17	.04
4	.26	-.05
5	.59	.07
6	.37	-.19
7	.56	.02
8	.27	-.15
9	.19	.03
10	.04	.01
11	-.04	-.03
12	-.06	-.02



EAST COMP. WIND STRESS BY MONTH

MONTH	VALUE	ANOMALY
197701	-.02	.00
2	.00	.01
3	.23	.10
4	.31	.00
5	.36	-.15
6	.64	.07
7	.63	.09
8	.46	.05
9	.27	.11
10	.10	.07
11	-.03	-.02
12	-.03	.00
197801	.00	.03
2	.02	.03
3	.02	-.11
4	.21	-.10
5	.28	-.24
6	.55	-.02
7	.63	.09
8	.47	.06
9	.08	-.08
10	.08	.06
11	0.00	.01
12	-.12	-.08

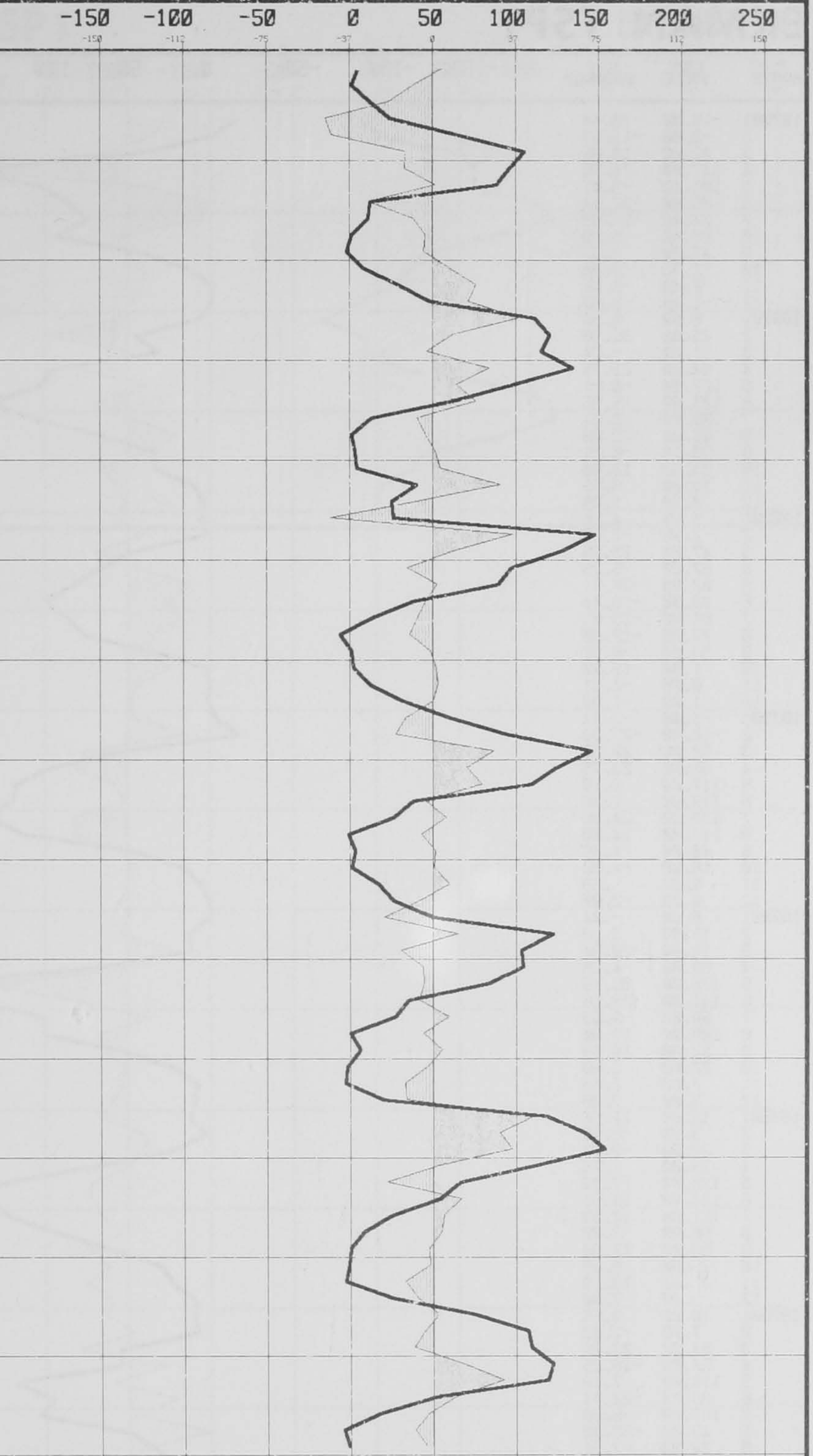


NOAA-NMFS, PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

EKMAN TSPT

BY MONTH

MONTH	VALUE	ANOMALY
196301	5.00	4.56
2	1.00	-8.63
3	12.00	-19.94
4	24.00	-48.25
5	65.00	-45.81
6	105.00	-12.44
7	96.00	-12.63
8	88.00	1.00
9	12.00	-29.31
10	11.00	-9.00
11	1.00	-3.31
12	-2.00	-4.00
196401	8.00	7.56
2	29.00	19.38
3	48.00	16.06
4	111.00	38.75
5	120.00	9.19
6	115.00	-2.44
7	134.00	25.38
8	98.00	11.00
9	61.00	19.69
10	13.00	-7.00
11	1.00	-3.31
12	3.00	1.00
196501	4.00	3.56
2	40.00	30.38
3	25.00	-6.94
4	26.00	-46.25
5	147.00	36.19
6	127.00	9.56
7	97.00	-11.63
8	89.00	2.00
9	38.00	-3.31
10	13.00	-7.00
11	-6.00	-10.31
12	1.00	-1.00
196601	2.00	1.56
2	12.00	2.38
3	32.00	.06
4	60.00	-12.25
5	94.00	-16.81
6	145.00	27.56
7	124.00	15.38
8	109.00	22.00
9	38.00	-3.31
10	26.00	6.00
11	-1.00	-5.31
12	3.00	1.00
196701	1.00	.56
2	17.00	7.38
3	26.00	-5.94
4	50.00	-22.25
5	122.00	11.19
6	103.00	-14.44
7	104.00	-4.63
8	83.00	-4.00
9	35.00	-6.31
10	27.00	7.00
11	0.00	-4.31
12	6.00	4.00
196801	-2.00	-2.44
2	-3.00	-12.63
3	20.00	-11.94
4	118.00	45.75
5	141.00	30.19
6	153.00	35.56
7	111.00	2.38
8	66.00	-21.00
9	54.00	12.69
10	25.00	5.00
11	8.00	3.69
12	0.00	-2.00
196901	-1.00	-1.44
2	-3.00	-12.63
3	25.00	-6.94
4	75.00	2.75
5	107.00	-3.81
6	109.00	-8.44
7	122.00	13.38
8	119.00	32.00
9	52.00	10.69
10	18.00	-2.00
11	-4.00	-8.31
12	-1.00	-3.00

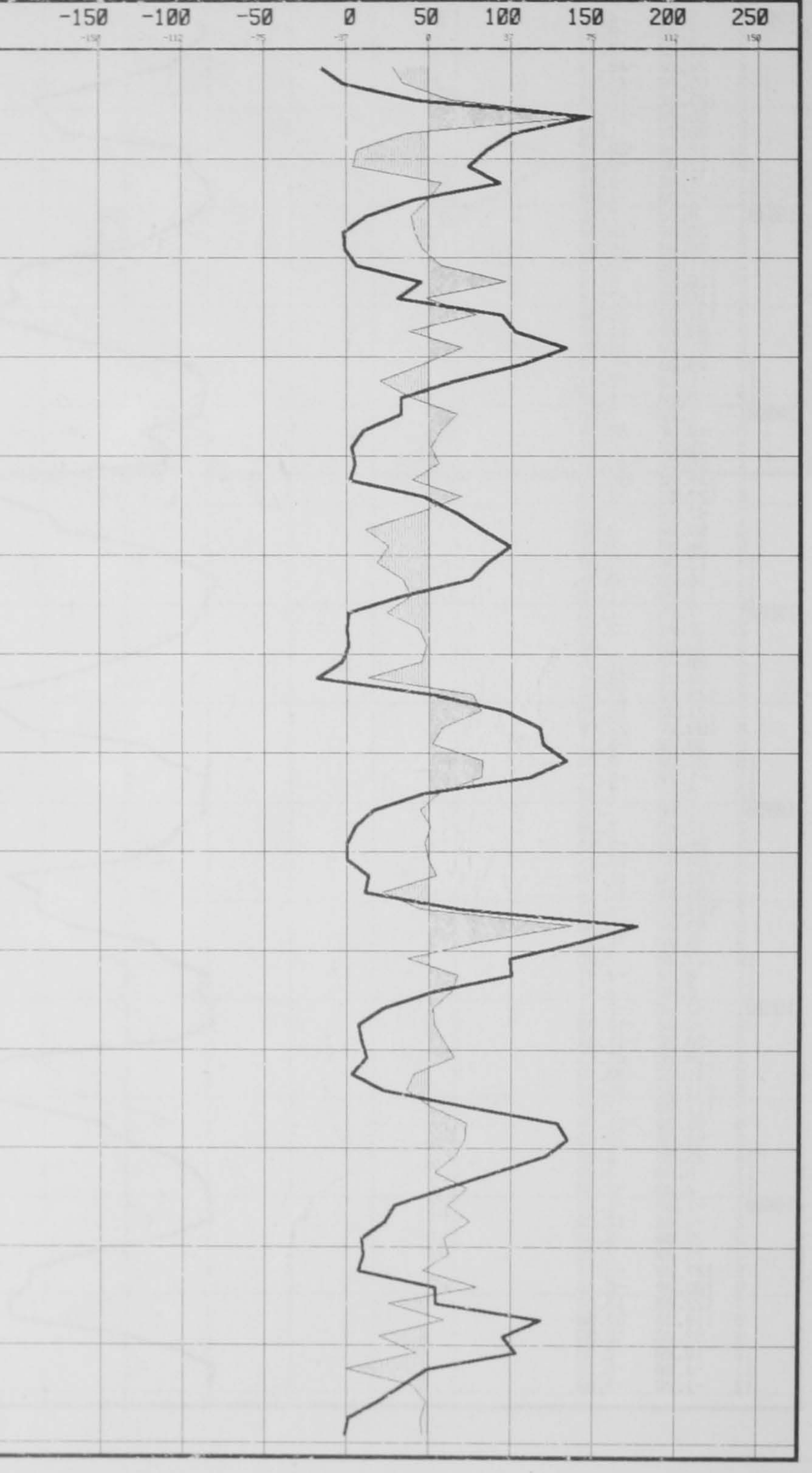


NOAA-NMFS. PACIFIC ENVIRONMENTAL GROUP. MONTEREY. CALIFORNIA

EKMAN TSPT

BY MONTH

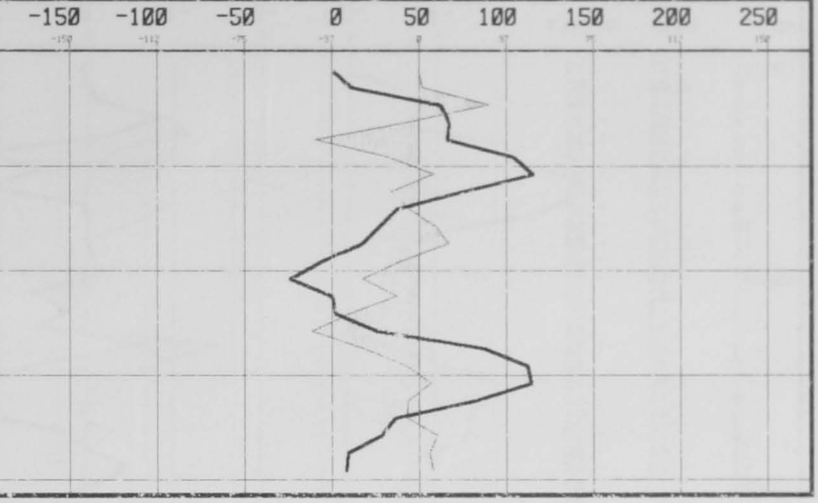
MONTH	VALUE	ANOMALY
197001	-16.00	-16.44
2	-2.00	-11.63
3	42.00	10.06
4	147.00	74.75
5	101.00	-9.81
6	85.00	-32.44
7	74.00	-34.63
8	93.00	6.00
9	41.00	-.31
10	12.00	-8.00
11	-2.00	-6.31
12	-1.00	-3.00
197101	6.00	5.56
2	45.00	35.38
3	31.00	-.94
4	94.00	21.75
5	102.00	-8.81
6	133.00	15.56
7	106.00	-2.63
8	65.00	-22.00
9	33.00	-8.31
10	33.00	13.00
11	10.00	5.69
12	3.00	1.00
197201	5.00	4.56
2	2.00	-7.63
3	47.00	15.06
4	67.00	-5.25
5	82.00	-28.81
6	99.00	-18.44
7	85.00	-23.63
8	75.00	-12.00
9	33.00	-8.31
10	1.00	-19.00
11	0.00	-4.31
12	1.00	-1.00
197301	-3.00	-3.44
2	-18.00	-27.63
3	52.00	20.06
4	96.00	23.75
5	117.00	6.19
6	119.00	1.56
7	133.00	24.38
8	111.00	24.00
9	46.00	4.69
10	16.00	-4.00
11	5.00	.69
12	0.00	-2.00
197401	0.00	-.44
2	13.00	3.38
3	11.00	-20.94
4	68.00	-4.25
5	176.00	65.19
6	141.00	23.56
7	99.00	-9.63
8	100.00	13.00
9	52.00	10.69
10	22.00	2.00
11	7.00	2.69
12	9.00	7.00
197501	12.00	11.56
2	3.00	-6.63
3	22.00	-9.94
4	73.00	.75
5	128.00	17.19
6	134.00	16.56
7	121.00	12.38
8	90.00	3.00
9	59.00	17.69
10	25.00	9.00
11	23.00	18.69
12	9.00	7.00
197601	10.00	9.56
2	7.00	-2.63
3	54.00	22.06
4	54.00	-18.25
5	118.00	7.19
6	95.00	-22.44
7	103.00	-5.63
8	49.00	-38.00
9	34.00	-7.31
10	19.00	-1.00
11	1.00	-3.31
12	-1.00	-3.00



NOAA-NMFS, PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

EKMAN TSPT BY MONTH

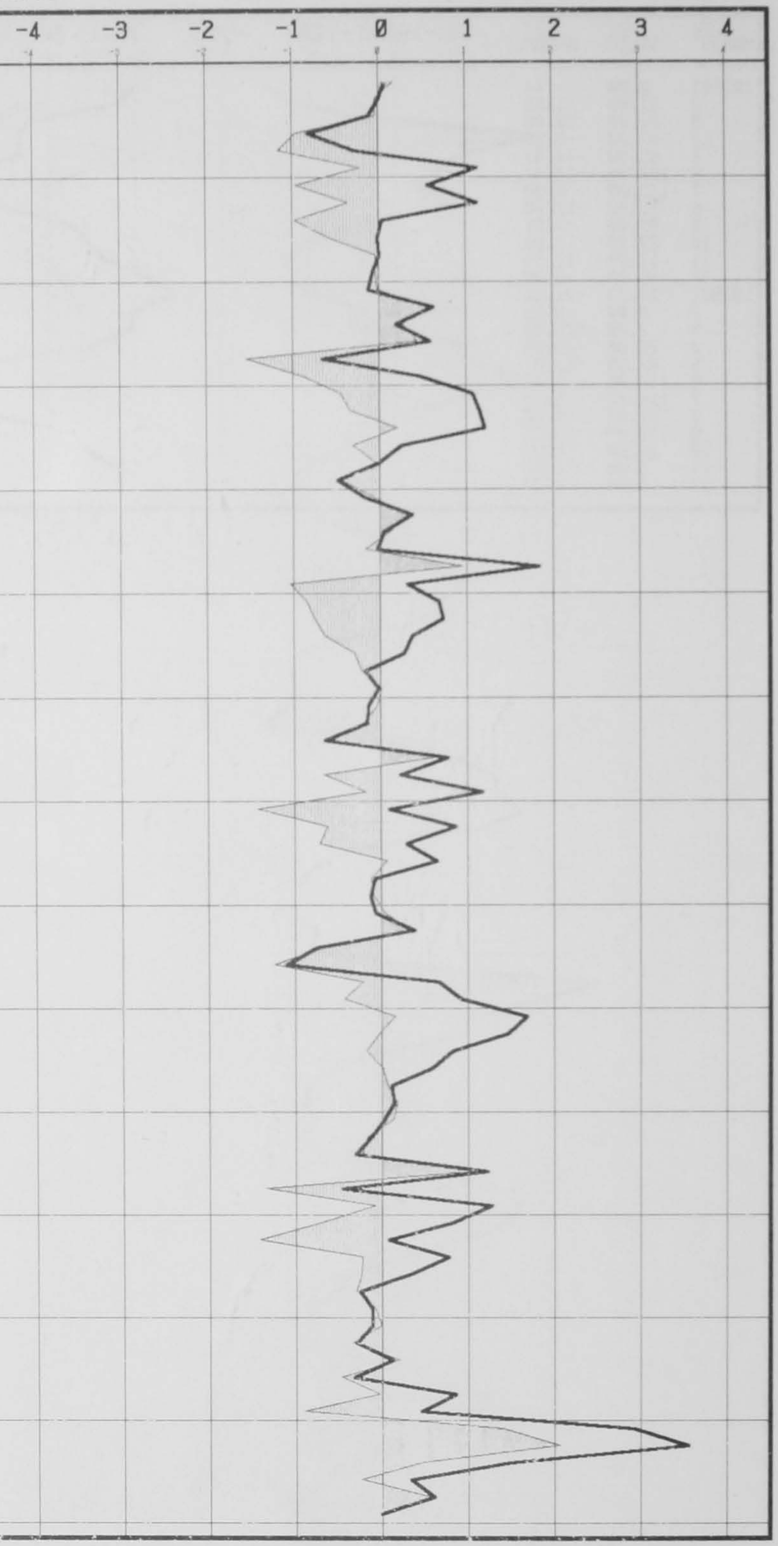
MONTH	VALUE	ANOMALY
197701	0.00	-.44
2	11.00	1.38
3	62.00	30.06
4	67.00	-5.25
5	66.00	-44.81
6	104.00	-13.44
7	115.00	6.38
8	75.00	-12.00
9	37.00	-4.31
10	27.00	7.00
11	17.00	12.69
12	-6.00	-8.00
197801	-24.00	-24.44
2	0.00	-9.63
3	2.00	-29.94
4	26.00	-46.25
5	87.00	-23.81
6	112.00	-5.44
7	114.00	5.38
8	82.00	-5.00
9	36.00	-5.31
10	28.00	8.00
11	9.00	4.69
12	8.00	6.00



NOAA-NMFS.PACIFIC ENVIRONMENTAL GROUP. MONTEREY. CALIFORNIA

SVERDRUP TRANSPORT BY MONTH

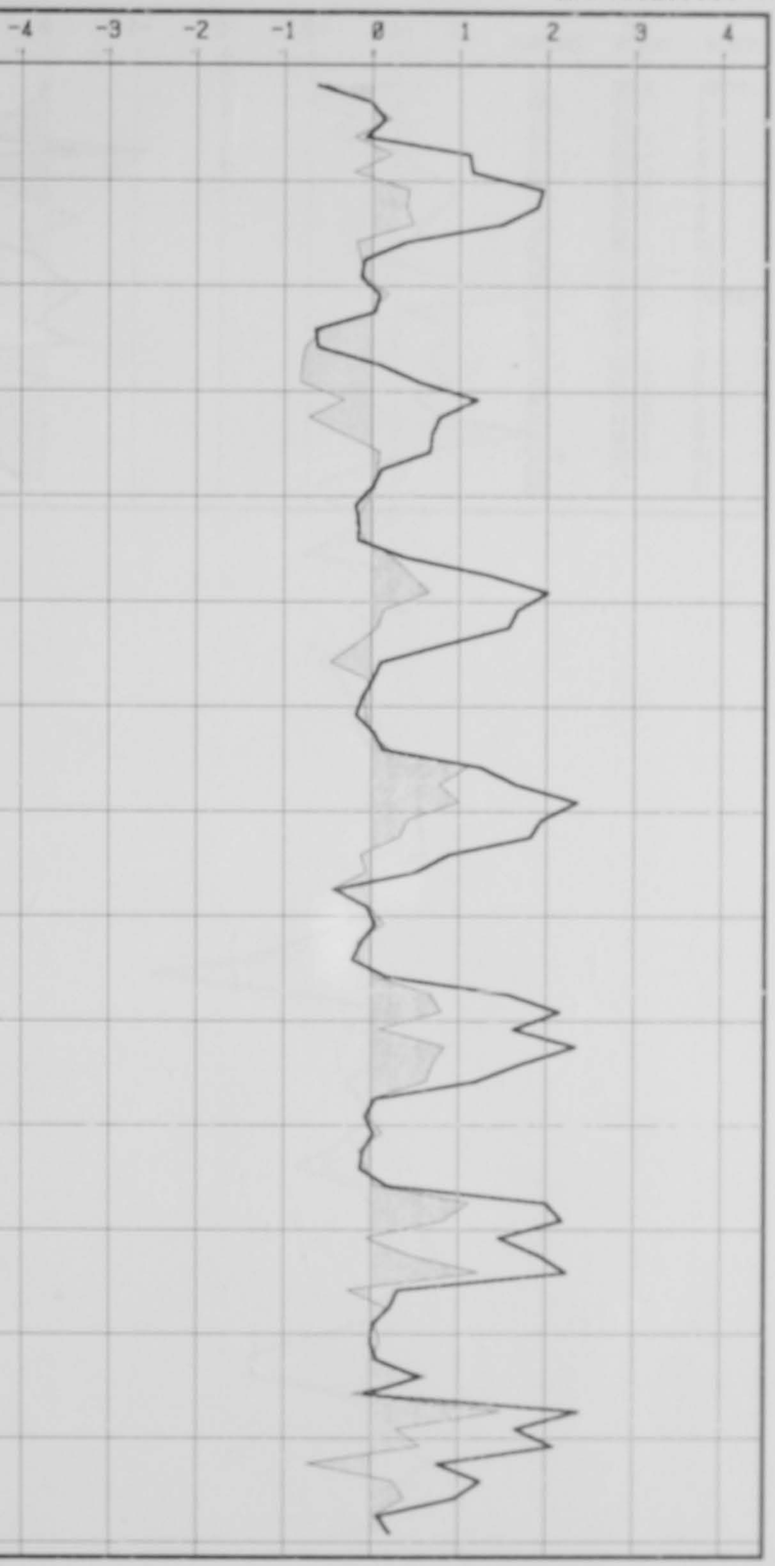
MONTH	VALUE	ANOMALY
196301	.07	.19
2	0.00	-.04
3	-.12	-.04
4	-.82	-.96
5	-.28	-1.16
6	1.13	-.22
7	.56	-.96
8	1.13	-.35
9	.03	-.97
10	-.02	-.59
11	0.00	-.04
12	-.08	-.04
196401	-.13	-.02
2	.62	.58
3	.19	.27
4	.58	.44
5	-.66	-1.54
6	.46	-.89
7	1.07	-.45
8	1.15	-.33
9	1.21	.21
10	.25	-.32
11	-.01	-.05
12	-.49	-.45
196501	-.18	-.07
2	.37	.33
3	.04	.12
4	-.03	-.17
5	1.83	.95
6	.31	-1.04
7	.67	-.85
8	.72	-.76
9	.36	-.64
10	.27	-.30
11	-.18	-.22
12	-.03	.01
196601	-.15	-.04
2	-.16	-.20
3	-.65	-.57
4	.77	.63
5	.22	-.66
6	1.17	-.18
7	.09	-1.43
8	.86	-.62
9	.29	-.71
10	.64	.08
11	-.08	-.12
12	-.13	-.09
196701	-.07	.04
2	.38	.34
3	-.75	-.67
4	-1.10	-1.24
5	.66	-.22
6	.92	-.43
7	1.68	.16
8	1.46	-.02
9	.82	-.18
10	.58	.02
11	.11	.07
12	.14	.18
196801	.02	.14
2	-.13	-.17
3	-.31	-.23
4	1.22	1.08
5	-.46	-1.34
6	1.27	-.08
7	.81	-.71
8	.07	-1.42
9	.77	-.23
10	.33	-.24
11	-.26	-.30
12	-.12	-.08
196901	-.12	-.01
2	-.30	-.34
3	.12	.20
4	-.33	-.47
5	.85	-.03
6	.45	-.90
7	2.92	1.40
8	3.55	2.07
9	1.48	.48
10	.33	-.24
11	.60	.56
12	-.01	.03



NOAA-NMFS.PACIFIC ENVIRONMENTAL GROUP. MONTEREY. CALIFORNIA

SVERDRUP TRANSPORT BY MONTH

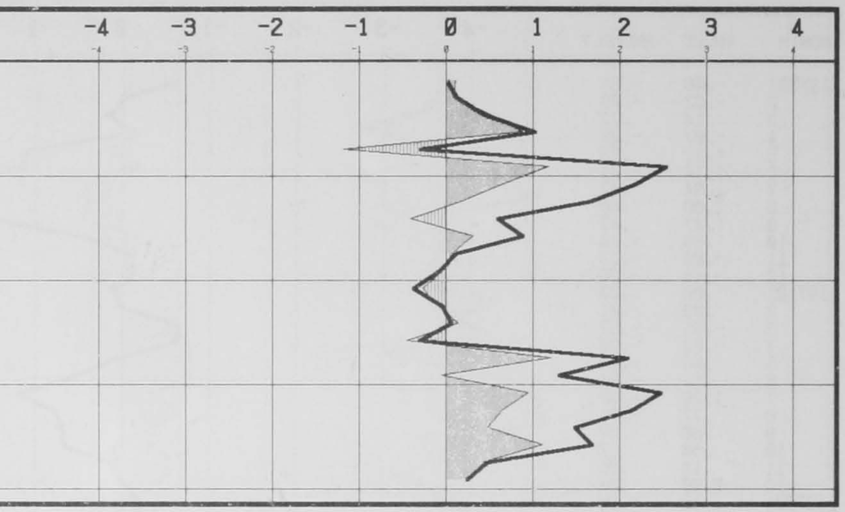
MONTH	VALUE	ANOMALY
197001	-.66	-.55
2	-.02	-.06
3	.14	.22
4	-.07	-.21
5	1.11	.23
6	1.14	-.21
7	1.94	.42
8	1.88	.40
9	1.47	.47
10	.39	-.18
11	-.09	-.13
12	-.13	-.09
197101	.08	.20
2	.03	-.01
3	-.65	-.57
4	-.62	-.76
5	.08	-.80
6	.54	-.81
7	1.20	-.32
8	.77	-.71
9	.68	-.32
10	.66	.10
11	.10	.06
12	0.00	.04
197201	-.19	-.08
2	-.15	-.19
3	-.16	-.08
4	.38	.24
5	1.33	.45
6	2.01	.66
7	1.66	.14
8	1.56	.08
9	.81	-.19
10	.10	-.47
11	.01	-.03
12	-.11	-.07
197301	-.18	-.07
2	.02	-.02
3	.13	.21
4	1.24	1.10
5	1.66	.78
6	2.35	1.00
7	1.94	.42
8	1.81	.33
9	.88	-.12
10	.51	-.05
11	-.42	-.46
12	-.05	-.01
197401	.04	.16
2	-.12	-.16
3	-.22	-.14
4	.18	.04
5	1.56	.68
6	2.15	.80
7	1.62	.10
8	2.33	.85
9	1.70	.70
10	1.19	.63
11	.04	-.00
12	-.07	-.03
197501	.02	.14
2	-.10	-.14
3	-.13	-.05
4	.18	.04
5	2.00	1.12
6	2.18	.83
7	1.46	-.06
8	1.92	.44
9	2.23	1.23
10	.30	-.27
11	.21	.17
12	.01	.05
197601	-.01	.11
2	.06	.02
3	.56	.64
4	-.08	-.22
5	2.37	1.49
6	1.65	.30
7	2.08	.56
8	.75	-.73
9	1.25	.25
10	.95	.39
11	.08	.04
12	.21	.25



NOAA-NMFS.PACIFIC ENVIRONMENTAL GROUP. MONTEREY. CALIFORNIA

SVERDRUP TRANSPORT BY MONTH

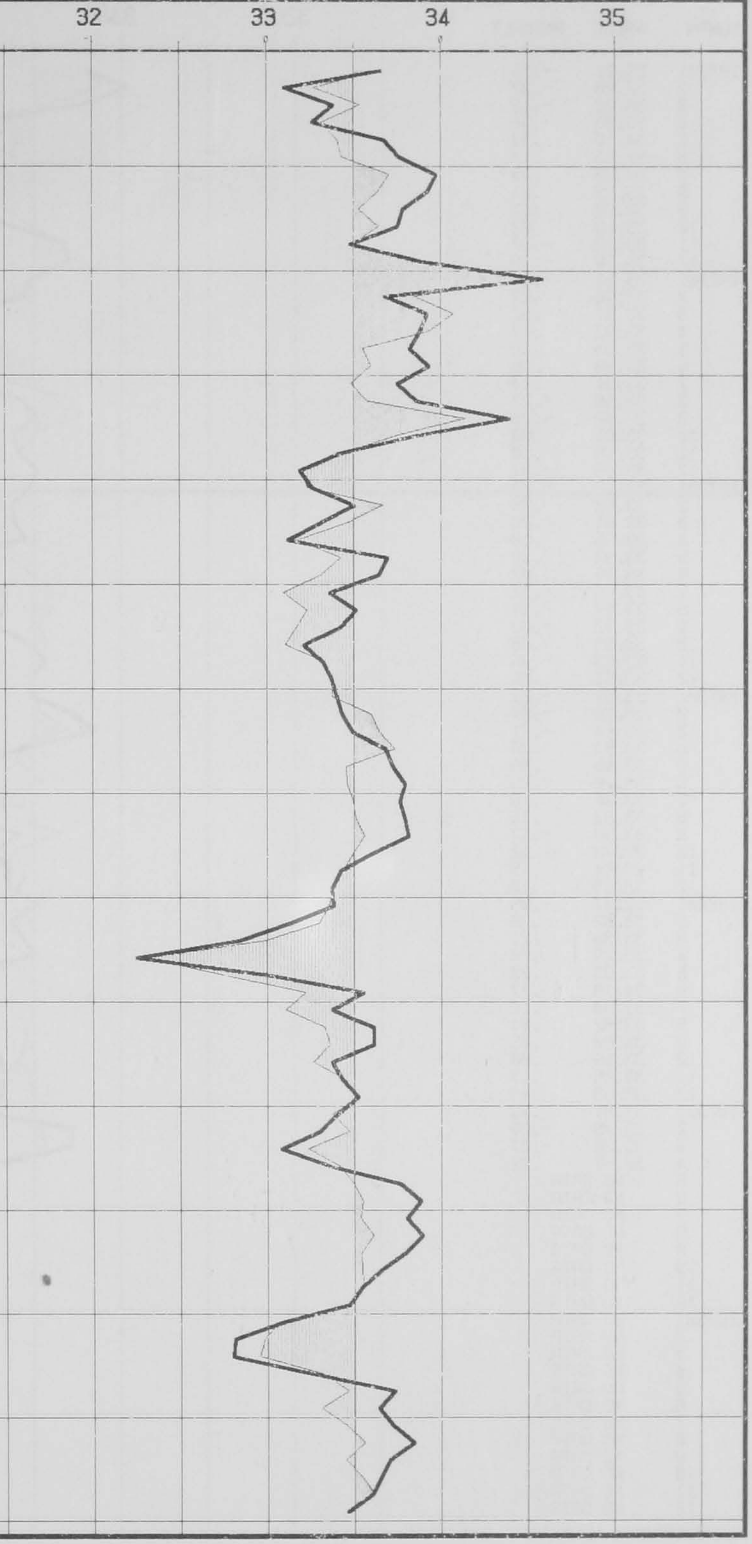
MONTH	VALUE	ANOMALY
197701	0.00	.12
2	.12	.08
3	.43	.51
4	1.02	.88
5	-.30	-1.18
6	2.53	1.18
7	2.18	.66
8	1.66	.18
9	.59	-.41
10	.88	.32
11	.11	.07
12	-.08	-.04
197801	-.38	-.27
2	-.05	-.09
3	.06	.14
4	-.31	-.45
5	2.09	1.21
6	1.30	-.05
7	2.47	.95
8	2.14	.66
9	1.48	.48
10	1.68	1.12
11	.47	.43
12	.24	.28



NOAA-NMFS.PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

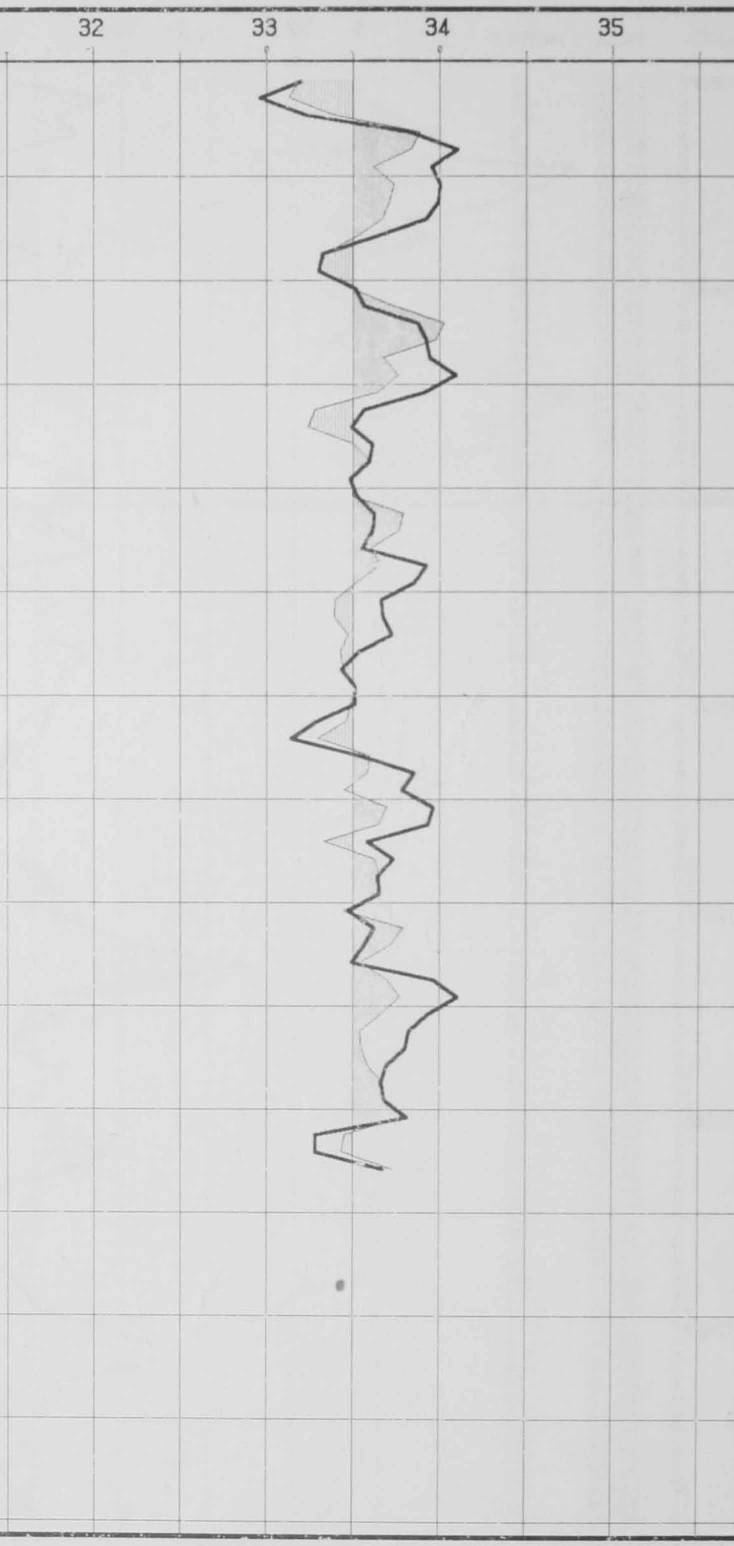
SALINITY PACIFIC GROVE, CA BY MONTH

MONTH	VALUE	ANOMALY
196301	33.67	.15
2	33.10	-.23
3	33.38	.03
4	33.26	-.19
5	33.67	-.09
6	33.76	-.07
7	33.97	.20
8	33.92	.14
9	33.78	.03
10	33.75	.14
11	33.48	-.01
12	33.89	.40
196401	34.58	1.06
2	33.68	.35
3	33.92	.57
4	33.88	.43
5	33.82	.06
6	33.93	.10
7	33.75	-.02
8	33.86	.08
9	34.39	.64
10	33.85	.24
11	33.42	-.07
12	33.19	-.30
196501	33.26	-.26
2	33.50	.17
3	33.31	-.04
4	33.12	-.33
5	33.69	-.07
6	33.64	-.19
7	33.36	-.41
8	33.51	-.27
9	33.42	-.33
10	33.21	-.40
11	33.32	-.17
12	33.37	-.12
196601	33.40	-.12
2	33.43	.10
3	33.49	.14
4	33.68	.23
5	33.72	-.04
6	33.79	-.04
7	33.76	-.01
8	33.79	.01
9	33.81	.06
10	33.60	-.01
11	33.42	-.07
12	33.37	-.12
196701	33.38	-.14
2	33.13	-.20
3	32.84	-.51
4	32.25	-1.20
5	33.01	-.75
6	33.55	-.28
7	33.37	-.40
8	33.61	-.17
9	33.61	-.14
10	33.37	-.24
11	33.43	-.06
12	33.52	.03
196801	33.40	-.12
2	33.30	-.03
3	33.08	-.27
4	33.36	-.09
5	33.76	-.00
6	33.88	.05
7	33.80	.03
8	33.89	.11
9	33.79	.04
10	33.65	.04
11	33.54	.05
12	33.47	-.02
196901	33.09	-.43
2	32.81	-.52
3	32.80	-.55
4	33.26	-.19
5	33.73	-.03
6	33.64	-.19
7	33.72	-.05
8	33.84	.06
9	33.70	-.05
10	33.65	.04
11	33.60	.11
12	33.46	-.03



SALINITY PACIFIC GROVE, CA BY MONTH

MONTH	VALUE	ANOMALY
197001	33.21	-.31
2	32.96	-.37
3	33.23	-.12
4	33.83	.38
5	34.10	.34
6	33.95	.12
7	34.00	.23
8	33.99	.21
9	33.92	.17
10	33.63	.02
11	33.32	-.17
12	33.30	-.19
197101	33.51	-.01
2	33.56	.23
3	33.87	.52
4	33.92	.47
5	33.94	.18
6	34.09	.26
7	33.91	.14
8	33.56	-.22
9	33.49	-.26
10	33.61	.00
11	33.59	.10
12	33.48	-.01
197201	33.52	-.00
2	33.62	.29
3	33.61	.26
4	33.55	.10
5	33.92	.16
6	33.85	.02
7	33.66	-.11
8	33.67	-.11
9	33.72	-.03
10	33.53	-.08
11	33.43	-.06
12	33.51	.02
197301	33.51	-.01
2	33.29	-.04
3	33.14	-.21
4	33.54	.09
5	33.85	.09
6	33.78	-.05
7	33.96	.19
8	33.93	.15
9	33.58	-.17
10	33.73	.12
11	33.64	.15
12	33.65	.16
197401	33.47	-.05
2	33.62	.29
3	33.56	.21
4	33.49	.04
5	33.96	.20
6	34.10	.27
7	33.93	.16
8	33.82	.04
9	33.80	.05
10	33.69	.08
11	33.66	.17
12	33.68	.19
197501	33.81	.29
2	33.78	-.05
3	33.28	-.07
4	33.67	.22
5	NO DATA	
6	NO DATA	
7	NO DATA	
8	NO DATA	
9	NO DATA	
10	NO DATA	
11	NO DATA	
12	NO DATA	
197601	NO DATA	
2	NO DATA	
3	NO DATA	
4	NO DATA	
5	NO DATA	
6	NO DATA	
7	NO DATA	
8	NO DATA	
9	NO DATA	
10	NO DATA	
11	NO DATA	
12	NO DATA	



NOAA-NMFS. PACIFIC ENVIRONMENTAL GROUP. MONTEREY. CALIFORNIA

SALINITY PACIFIC GROVE, CA BY MONTH

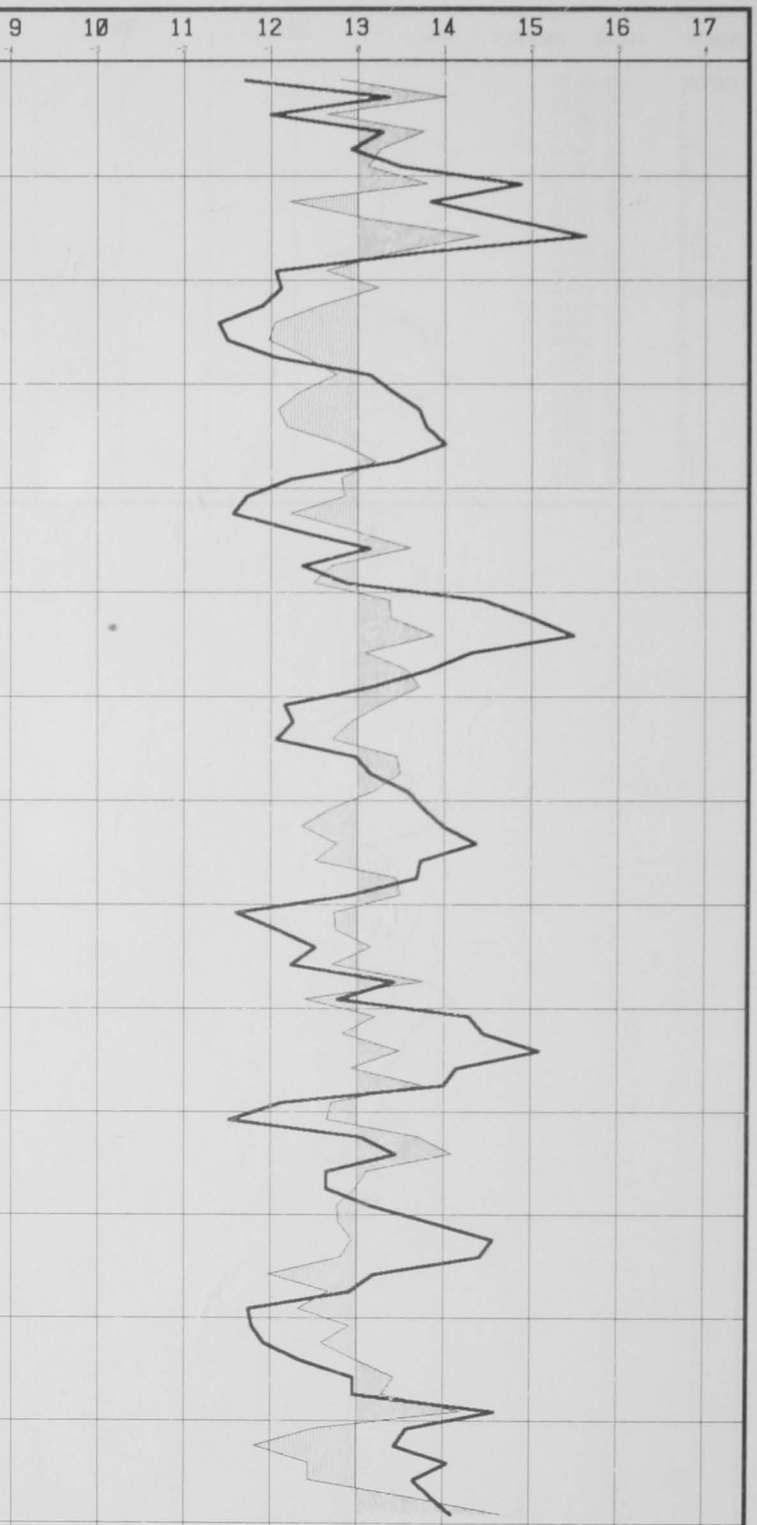
MONTH	VALUE	ANOMALY
197701	NO DATA	
2	NO DATA	
3	NO DATA	
4	NO DATA	
5	NO DATA	
6	NO DATA	
7	NO DATA	
8	NO DATA	
9	NO DATA	
10	NO DATA	
11	NO DATA	
12	NO DATA	
197801	NO DATA	
2	NO DATA	
3	NO DATA	
4	NO DATA	
5	NO DATA	
6	NO DATA	
7	NO DATA	
8	NO DATA	
9	NO DATA	
10	NO DATA	
11	NO DATA	
12	NO DATA	

32 33 34 35

NOAA-NMFS.PACIFIC ENVIRONMENTAL GROUP. MONTEREY. CALIFORNIA

SST PACIFIC GROVE, CA BY MONTH

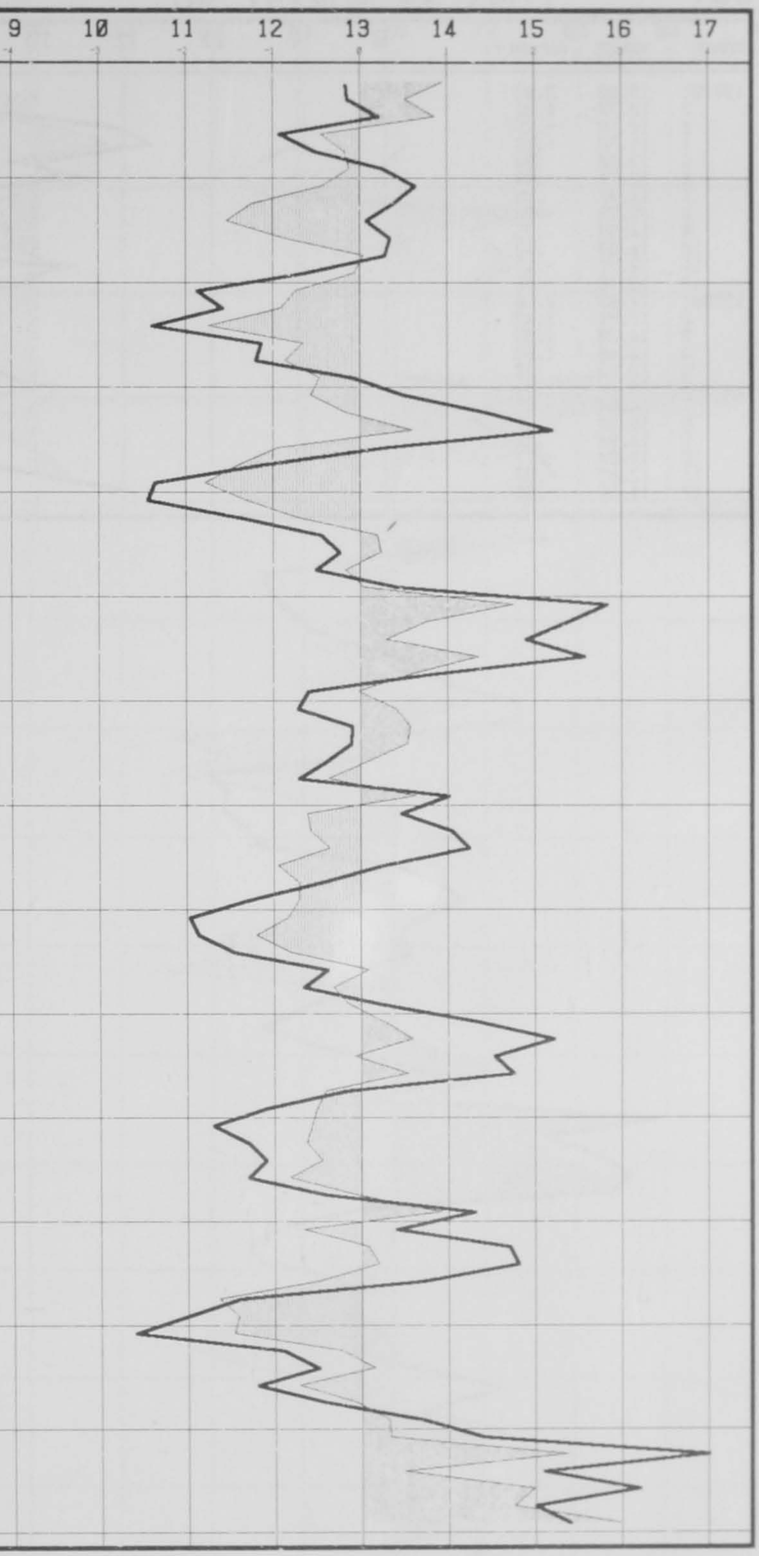
MONTH	VALUE	ANOMALY
196301	11.66	-.21
2	13.35	1.02
3	11.99	-.36
4	13.28	.76
5	12.92	.26
6	13.50	.12
7	14.87	.80
8	13.83	-.79
9	14.70	.10
10	15.61	1.40
11	13.61	.37
12	12.05	-.37
196401	12.11	.24
2	11.90	-.43
3	11.39	-.96
4	11.49	-1.03
5	12.06	-.60
6	13.13	-.25
7	13.40	-.67
8	13.70	-.92
9	13.78	-.82
10	14.00	-.21
11	13.44	.20
12	12.23	-.19
196501	11.72	-.15
2	11.56	-.77
3	12.30	-.05
4	13.13	.61
5	12.36	-.30
6	12.87	-.51
7	14.44	.37
8	15.00	.38
9	15.48	.88
10	14.30	.09
11	13.81	.57
12	13.13	.71
196601	12.15	.28
2	12.25	-.08
3	12.06	-.29
4	12.97	.45
5	13.15	.49
6	13.57	.19
7	13.76	-.31
8	13.98	-.64
9	14.36	-.24
10	13.72	-.49
11	13.68	.44
12	12.91	.49
196701	11.60	-.27
2	12.08	-.25
3	12.51	.16
4	12.23	-.29
5	13.42	.76
6	12.77	-.61
7	14.28	.21
8	14.45	-.17
9	15.09	.49
10	14.14	-.07
11	13.99	.75
12	12.12	-.30
196801	11.52	-.35
2	13.03	.70
3	13.44	1.09
4	12.64	.12
5	12.64	-.02
6	13.15	-.23
7	13.86	-.21
8	14.56	-.06
9	14.41	-.19
10	13.19	-1.02
11	12.91	-.33
12	11.74	-.68
196901	11.78	-.09
2	11.92	-.41
3	12.34	-.01
4	12.95	.43
5	12.95	.29
6	14.58	1.20
7	13.57	-.50
8	13.43	-1.19
9	14.04	-.56
10	13.65	-.56
11	13.86	.62
12	14.09	1.67



NOAA-NMFS.PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

SST PACIFIC GROVE, CA BY MONTH

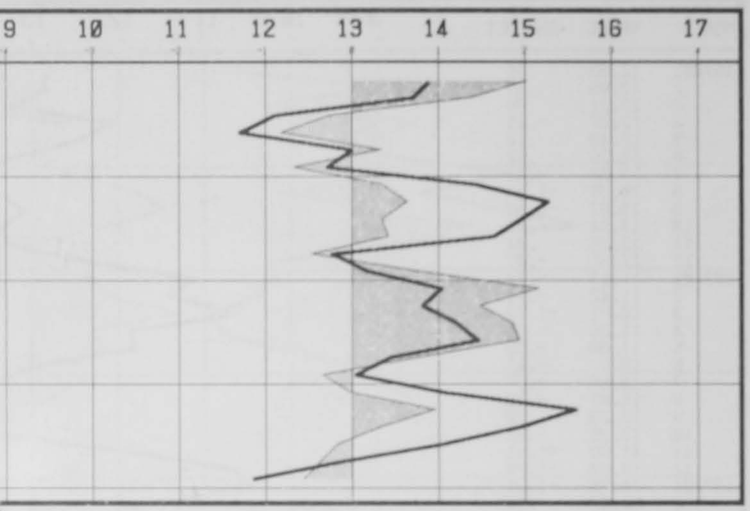
MONTH	VALUE	ANOMALY
197001	12.83	.96
2	12.85	.52
3	13.21	.86
4	12.07	-.45
5	12.48	-.18
6	13.26	-.12
7	13.63	-.44
8	13.38	-1.24
9	13.07	-1.53
10	13.34	-.87
11	13.28	.04
12	12.35	-.07
197101	11.13	-.74
2	11.42	-.91
3	10.61	-1.74
4	11.86	-.66
5	11.80	-.86
6	12.91	-.47
7	13.50	-.57
8	14.46	-.16
9	15.20	.60
10	13.26	-.95
11	11.83	-1.41
12	10.64	-1.78
197201	10.56	-1.31
2	11.61	-.72
3	12.55	.20
4	12.76	.24
5	12.49	-.17
6	13.42	.04
7	15.83	1.76
8	15.38	.76
9	14.90	.30
10	15.57	1.36
11	13.83	.59
12	12.40	-.02
197301	12.28	.41
2	12.90	.57
3	12.89	.54
4	12.61	.09
5	12.29	-.37
6	14.01	.63
7	13.46	-.61
8	14.04	-.58
9	14.24	-.36
10	13.26	-.95
11	12.53	-.71
12	11.71	-.71
197401	11.03	-.84
2	11.13	-1.20
3	11.55	-.80
4	12.61	.09
5	12.34	-.32
6	13.24	-.14
7	14.34	.27
8	15.21	.59
9	14.53	-.07
10	14.75	.54
11	12.83	-.41
12	11.91	-.51
197501	11.30	-.57
2	11.70	-.63
3	11.90	-.45
4	11.70	-.82
5	12.60	-.06
6	14.30	.92
7	13.40	-.67
8	14.70	.08
9	14.80	.20
10	13.70	-.51
11	11.60	-1.64
12	11.00	-1.42
197601	10.40	-1.47
2	12.10	-.23
3	12.50	.15
4	11.80	-.72
5	12.60	-.06
6	13.70	.32
7	14.40	.33
8	17.00	2.38
9	15.10	.50
10	16.20	1.99
11	15.00	1.76
12	15.40	2.98



NOAA-NMFS, PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

SST PACIFIC GROVE, CA BY MONTH

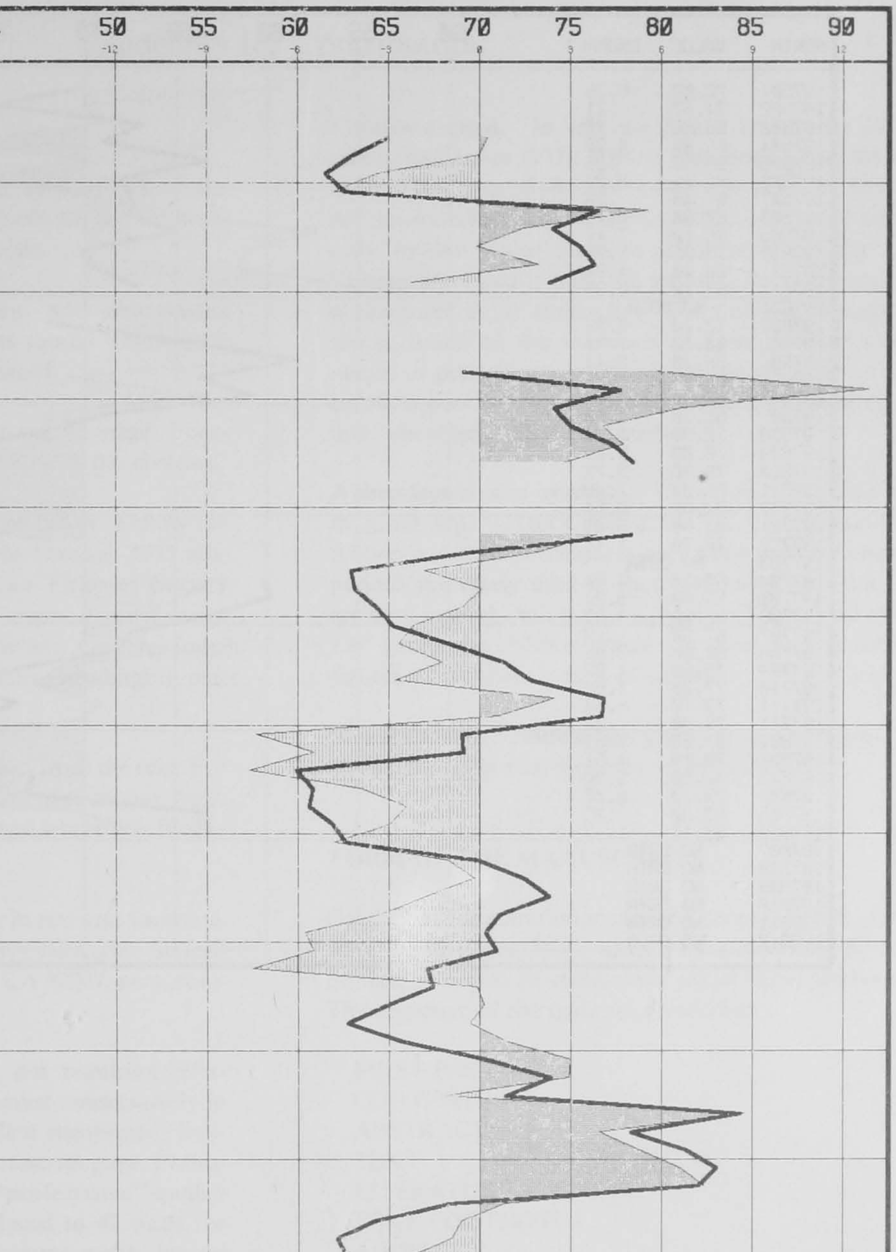
MONTH	VALUE	ANOMALY
197701	13.90	2.03
2	13.70	1.37
3	12.10	-.25
4	11.70	-.82
5	13.00	.34
6	12.71	-.67
7	14.42	.35
8	15.26	.64
9	14.95	.35
10	14.63	.42
11	12.77	-.47
12	13.18	.76
197801	14.03	2.16
2	13.81	1.48
3	14.20	1.85
4	14.45	1.93
5	13.43	.77
6	13.04	-.34
7	14.04	-.03
8	15.58	.96
9	14.94	.34
10	14.04	-.17
11	12.87	-.37
12	11.86	-.56



NOAA-NMFS, PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

CM DYNAMIC HEIGHT BY MONTH

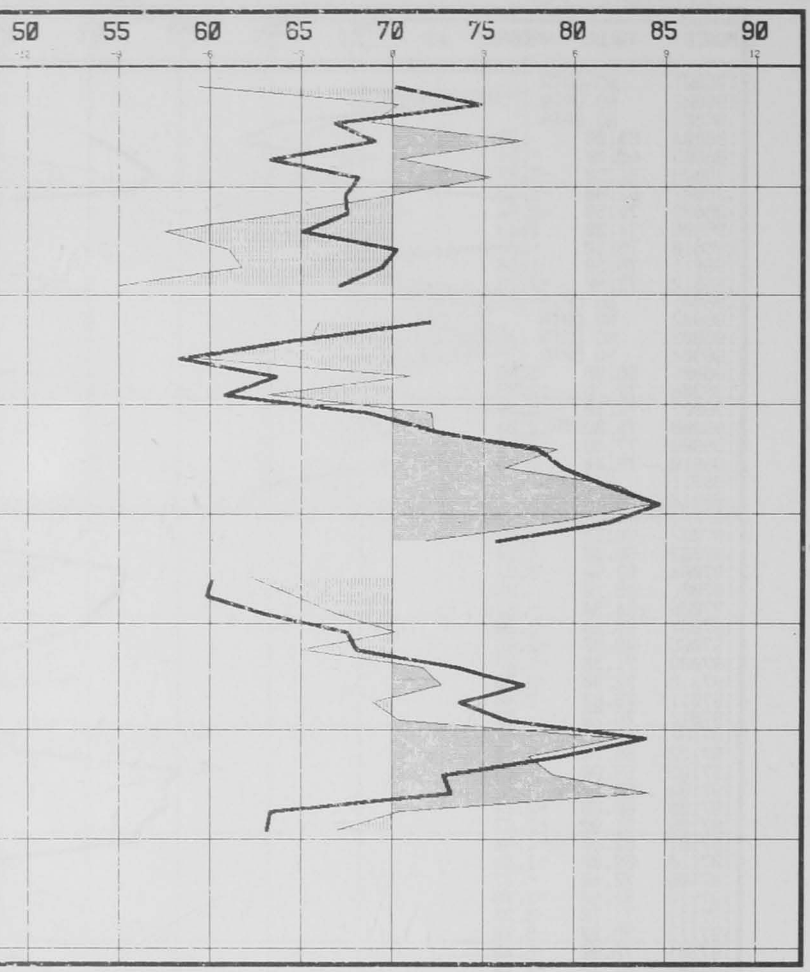
MONTH	VALUE	ANOMALY
196801	NO DATA	
196802	NO DATA	
196803	NO DATA	
196804	65.00	.26
196805	63.00	-.04
196806	61.50	-3.37
196807	62.60	-4.80
196808	76.50	5.54
196809	74.00	1.43
196810	75.50	-.08
196811	76.30	1.96
196812	73.80	-2.26
196901	NO DATA	
196902	NO DATA	
196903	NO DATA	
196904	NO DATA	
196905	68.90	5.86
196906	77.70	12.83
196907	74.10	6.70
196908	75.00	4.04
196909	77.30	4.73
196910	78.40	2.82
196911	NO DATA	
196912	86.60	10.54
197001	NO DATA	
197002	78.50	3.91
197003	69.40	1.90
197004	62.90	-1.84
197005	63.10	.06
197006	64.30	-.57
197007	65.20	-2.20
197008	68.30	-2.66
197009	71.30	-1.27
197010	72.80	-2.78
197011	76.60	2.46
197012	76.70	.64
197101	69.00	-7.39
197102	69.10	-5.49
197103	59.90	-7.60
197104	60.80	-3.94
197105	60.60	-2.44
197106	61.90	-2.97
197107	62.60	-4.80
197108	69.90	-1.05
197109	72.40	-.17
197110	73.60	-1.78
197111	71.10	-3.24
197112	70.30	-5.76
197201	70.90	-5.49
197202	67.10	-7.49
197203	67.40	-.10
197204	64.90	.16
197205	62.70	-.34
197206	65.70	.83
197207	70.40	3.00
197208	73.90	2.94
197209	71.40	-1.17
197210	84.30	8.72
197211	78.30	3.96
197212	81.30	5.24
197301	83.00	6.61
197302	82.00	7.41
197303	68.30	.80
197304	64.10	-.64
197305	62.10	-.94
197306	62.60	-2.27
197307	66.80	-.62
197308	68.20	-2.76
197309	67.70	-4.87
197310	69.50	-6.08
197311	67.70	-6.64
197312	71.50	-4.55
197401	76.10	-.29
197402	72.80	-1.79
197403	70.60	3.10
197404	69.10	4.36
197405	NO DATA	
197406	NO DATA	
197407	68.70	1.30
197408	70.00	-.96
197409	74.90	2.33
197410	74.80	-.78
197411	74.00	-.34
197412	72.40	-3.66



NOAA-NMFS. PACIFIC ENVIRONMENTAL GROUP, MONTEREY, CALIFORNIA

CM DYNAMIC HEIGHT BY MONTH

MONTH	VALUE	ANOMALY
197501	70.00	-6.39
197502	74.80	.21
197503	66.80	-.70
197504	60.00	4.26
197505	63.30	.26
197506	60.10	3.23
197507	67.40	.00
197508	67.50	-3.46
197509	65.10	-7.47
197510	70.20	-5.38
197511	69.40	-4.94
197512	67.10	-8.96
197601	NO DATA	
197602	72.20	-2.39
197603	64.80	-2.70
197604	58.30	-6.44
197605	63.60	.56
197606	60.80	-4.07
197607	66.70	1.30
197608	72.30	1.34
197609	78.00	5.43
197610	79.30	3.72
197611	81.80	7.46
197612	84.60	8.54
197701	81.80	5.41
197702	75.70	1.11
197703	NO DATA	
197704	60.10	-4.64
197705	59.80	-3.24
197706	63.00	-1.87
197707	67.50	.10
197708	68.00	-2.96
197709	73.60	1.03
197710	77.20	1.62
197711	73.70	-.64
197712	76.30	.24
197801	83.90	7.51
197802	79.10	4.51
197803	72.80	5.30
197804	73.20	8.46
197805	63.30	.20
197806	63.10	-1.77
197807	NO DATA	
197808	NO DATA	
197809	NO DATA	
197810	NO DATA	
197811	NO DATA	
197812	NO DATA	



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