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HAWAII DEEP WATER CABLE PROGRAM

PHASE II-C

TASK 8.4

ENVIRONMENTAL DESIGN CRITERIA FOR CABLE DEPLOYMENT OPERATIONS IN THE ALENUIHAHA CHANNEL

Department of Planning and Economic Development

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ENVIRONMENTAL DESIGN CRITERIA FOR CABLE DEPLOYMENT OPERATIONS IN THE ALENUIHAHA CHANNEL

Prepared by

Edward K. Noda and Associates
(Report No. EKN-1095-R-1-1)

for

Hawaiian Dredging and Construction Company

Parsons Hawaii

Hawaiian Electric Company, Inc.

and the

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Department of Planning and Economic Development

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1.0 INTRODUCTION

In September 1983, Edward K. Noda and Associates prepared a report entitled "Evaluation of Expected Operational Wind, Wave and Current Conditions in the Alenuihaha Channel Related to the Design Criteria for the Cable Laying Vessel for the Hawaii Deep Water Cable Program". This study established preliminary deployment criteria based primarily on theoretical/empirical models, since at that time there were no long-term direct field measurements of winds, waves and currents in the Alenuihaha Channel.

As part of the Hawaii Deep Water Cable Program (HDWCP), field programs were initiated to acquire data within the channel to enable more realistic assessments of the expected environmental conditions for design and deployment of the deep water cable. This report provides a re-assessment of the operational wind, wave and current criteria for deployment based on the data acquired to date. Field programs are still on-going, and thus, further refinement of the deployment criteria may be required in the future with the acquisition of additional data.

2.0 WINDS

2.1 SUMMARY OF MEASURED WINDS

Two years of wind measurements have been acquired at Upolu Point and correlated with other wind data by Paul Haraguchi, Pacific Weather Inc. Thus, this section summarizes the results of Haraguchi (1986).

Wind data from the National Weather Service (NWS) stations at Lihue and Kahului Airports, as well as at Upolu Point, were obtained for the period March 1984 through March 1986. A special wind measuring station was established for about one year at Upolu Point (Upolu 38) during late 1984 to obtain more representative data for the Alenuihaha Channel.

Lihue Airport is considered a representative wind station for the Hawaiian Islands since it is the only long-term wind station that has good exposure to tradewinds. The broad scale tradewinds are the dominant winds comprising at least 73% of the winds at Lihue Airport and about 84% of the winds in the Alenuihaha Channel. Based on a comparison of the 1984-1985 tradewind data with the long term average speeds and frequency of occurrence, it was determined that the tradewinds were more frequent and with higher than normal speeds during the last two years than the long term average.

Tradewinds are persistent during the summer months but are reduced to near 50% during the winter months. The average monthly wind speeds are strongest for the summer months and weakest for winter and fall months. However, the strongest daily tradewinds occur during winter and spring months when very strong high pressure cells pass from the west to east north of the islands. Figures 2.1-1 and 2.1-2 show the seasonal variations of the winds from the NWS Upolu Station based on the two years of data.

2.2 OPERATIONAL WIND CRITERIA

The NWS Upolu Station is automatically queried every hour and the 1-minute sustained wind speed and peak gust data are available for operational use at the Honolulu office of the NWS. Unfortunately, the wind speed from this station has significant error in characterizing the channel winds because of the sensor location and land effects. Thus, another Upolu Point wind station (Upolu 38) was established for about one year in a more exposed location. Average monthly wind speeds from Upolu 38 are significantly higher than the NWS Upolu winds. Figure 2.2-1 compares the monthly % frequency of time in which the sustained winds are $\leq$20 knots for the NWS Upolu and Upolu 38 stations. In general, it was found that there was better correlation of peak gust speeds than 1-minute sustained speeds from the NWS

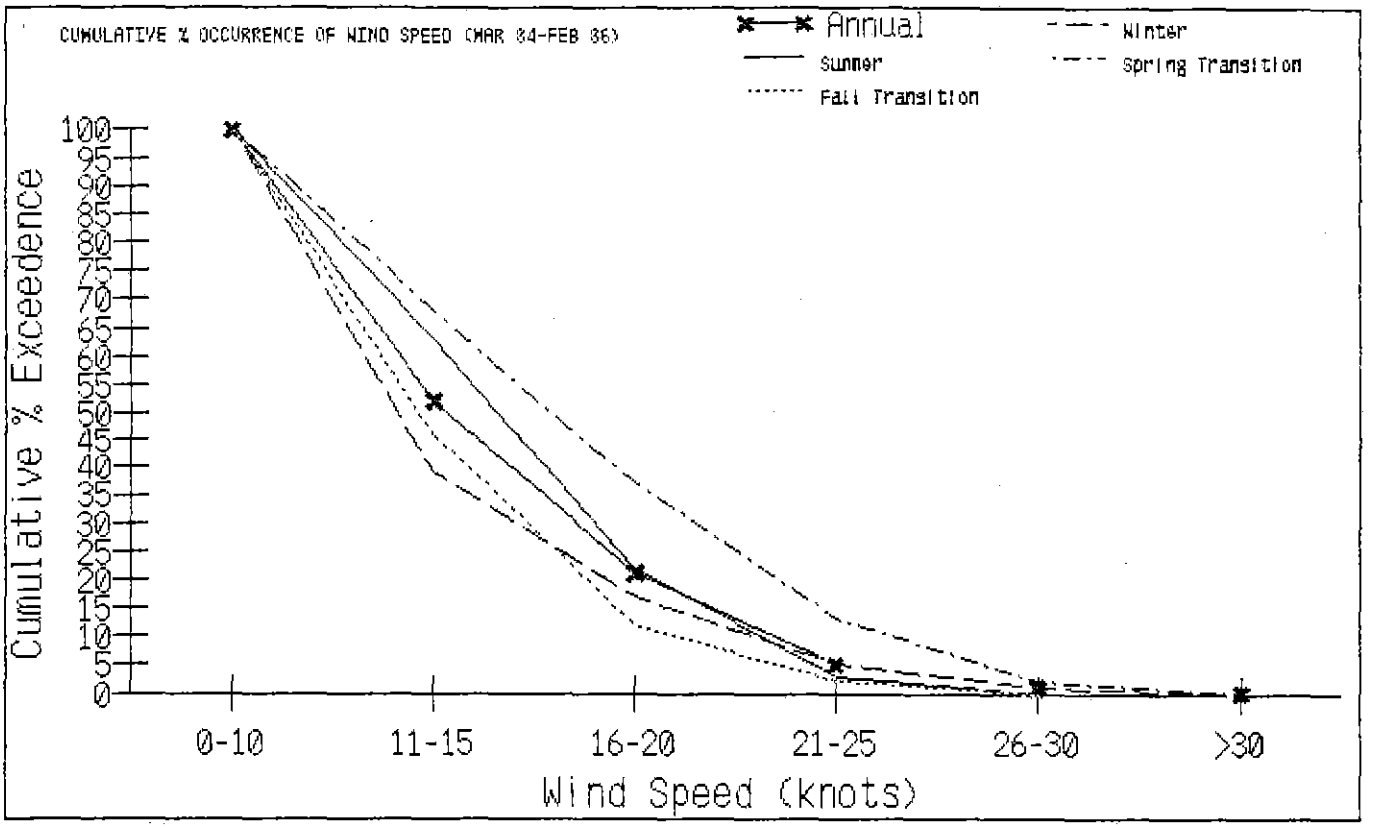


Figure 2.1-1 Cumulative percent frequency of exceedence of wind speed from NWS Upolu Station (March 1984-February 1986)

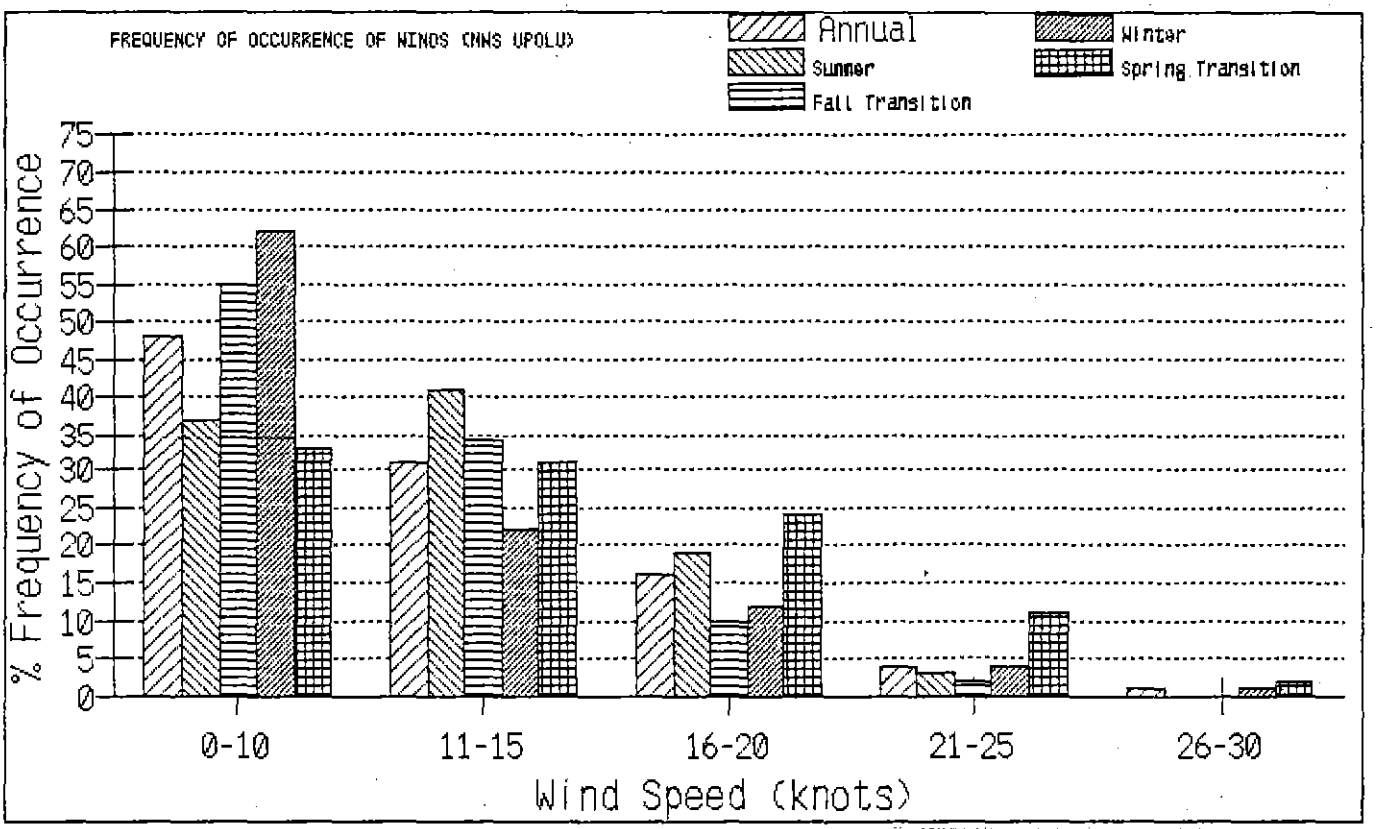


Figure 2.1-2 Annual and seasonal percent frequency of occurrence distributions of wind speed from the NWS Upolu Station

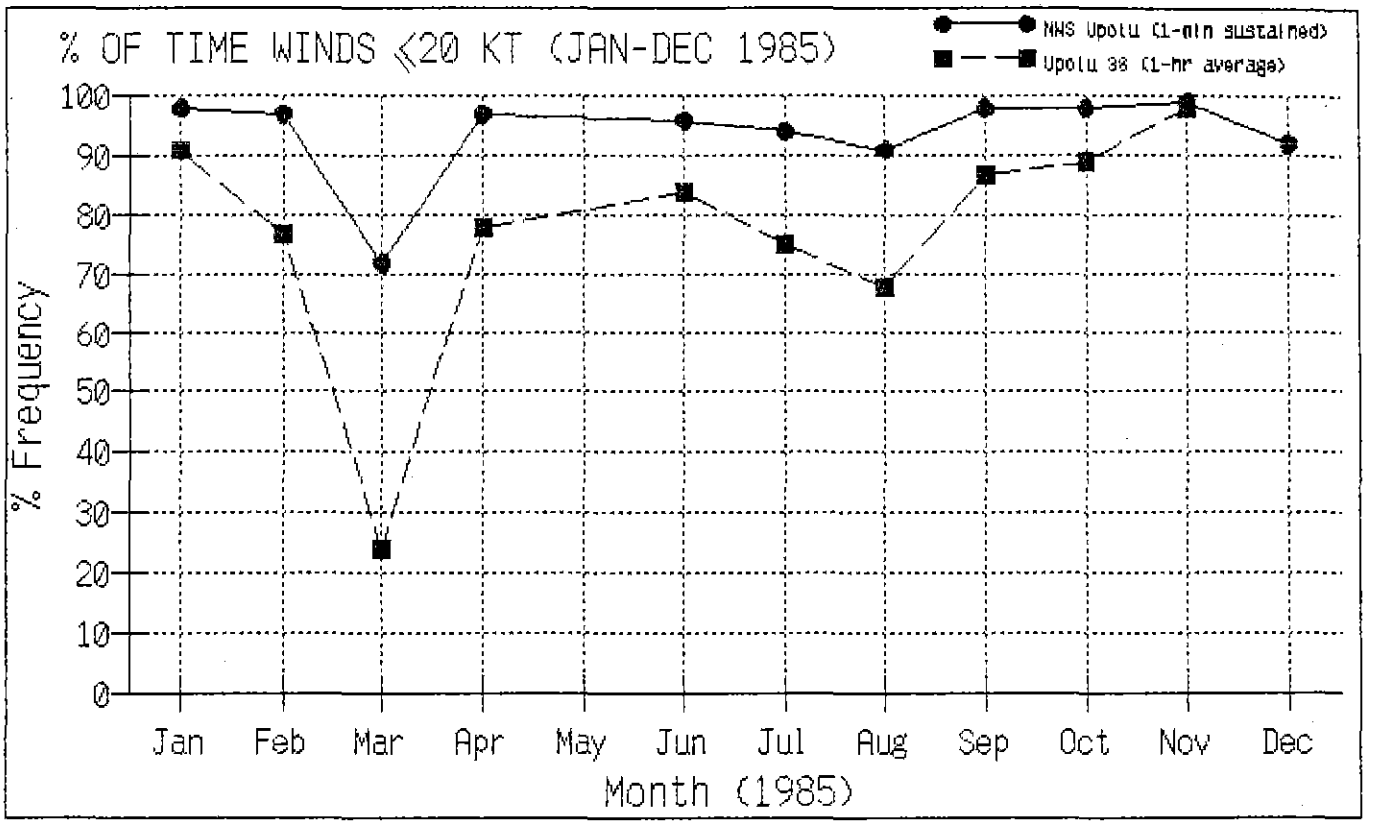


Figure 2.2-1 Comparison of monthly % frequency of time sustained winds ≤ 20 knots from NWS Upolu and Upolu 38 Stations

Upolu station with the average hourly speeds at Upolu 38.

Wind data for March 1986 from the recently installed NOAA experimental buoy in the Alenuihaha Channel was correlated with the NWS Upolu data. The results were similar to the correlations between the NWS Upolu and Upolu 38 stations. The NOAA buoy data showed higher speeds than the NWS Upolu data, and the NWS Upolu peak gust speeds correlated better than 1-minute sustained speeds with the NOAA buoy 2-minute sustained speeds. Based on this correlation, the following regression equations are recommended for determining Alenuihaha Channel winds based on NWS Upolu winds:

Alenuihaha Channel winds =
6.886 + 0.7637(NWS Upolu 1-min sustained)

Alenuihaha Channel winds =
4.239 + 0.9232(NWS Upolu peak gust)

From Haraguchi's data, an operational design tradewind speed of 30 knots is established. A sustained tradewind speed of 30 knots is expected to be exceeded less than 5% of the time during a typical year. An operational design Kona wind speed of 25 knots is established. Southerly to westerly winds occurred only about 16% of the time during the 2-year data period. Of the times when Kona winds occurred, a sustained speed of >25 knots occurred less than 5% of the time.

3.0 WAVES

3.1 SUMMARY OF WAVE DATA

The wave climate in Hawaiian waters is characterized by two primary seasons: summer and winter. The summer wave climate is dominated by the strong northeasterly tradewind-generated waves as well as southern swell generated by distant winter storms in the southern hemisphere. In the Alenuihaha Channel, the high-energy tradewind waves predominate over the low energy southern swell. However, these two wave types can occur simultaneously. The winter wave climate is characterized by a weakening of the tradewinds and the occurrence of infrequent southwesterly "Kona" storm waves as well as frequent northwesterly swell generated by winter storms in the North Pacific or by mid-latitude low pressure systems. The Alenuihaha Channel is somewhat sheltered from the northwesterly swell by the island of Maui, but is directly exposed to southwesterly waves.

This evaluation of operational wave criteria is based on data obtained to date as part of the HDWCP, as well as other data sources as described below:

(a) Edward K. Noda and Associates (HDWCP):

Two years of measured wave data (May 1984 - May 1986) are available from the Sea Data Wave and Current Meter Model 635-12 which was moored off Upolu Point. The instrument was moored in water depth of 170 meters with the sensor located at a minimum depth of 10 meters. Since this is a subsurface pressure-sensing instrument, high wave frequencies shorter than about 4-second period cannot be measured. Also, since the instrument can be depressed to deeper depths with strong currents acting on the mooring, wave periods up to about 6 seconds can sometimes be filtered out. A separate study was undertaken to identify and quantify the high frequency end of the wave spectrum. Based on the results of this study (Edward K. Noda and Associates, 1986b), the data obtained from the Sea Data meter were corrected by estimating the high frequency wave energy portion of the spectrum. The tabulation and summaries of all wave data acquired during the two-year program are provided in a data report by Edward K. Noda and Associates (1986a). This data set provides the most quantitative and long-term measurement of waves in the Alenuihaha Channel to date.

(b) Coastal Data Information Program:

This on-going program is jointly sponsored by the U.S. Army Corps of Engineers and the California Department of Boating and Waterways. A system of wave measuring instruments, primarily located along the California coast, is maintained by the Scripps Institution of Oceanography. The data are transmitted via telecommunications to computers

at Scripps, where the data are processed in near real-time and can be accessed via telecommunications. Monthly and yearly data summary reports are also published by Scripps. Two Waverider Buoys located in Hawaii are part of this system. The first buoy was installed in August 1981, located five miles offshore Makapuu Point, Oahu, in about 200 meters of water. This buoy has approximately the same wave exposure as the Alenuihaha Channel, except that more northwesterly wave energy can reach the Makapuu Waverider buoy. A second buoy, operated by the U.S. Navy Pacific Missile Range Facility at Barking Sands, Kauai, was incorporated into this system in October 1982. This buoy is exposed to different wave conditions than expected in the Alenuihaha Channel.

(c) NOAA, National Weather Service Buoy:

As part of the National Weather Service, the National Data Buoy Center (NDBC) develops and operates automated data-acquisition systems to provide real-time environmental observations. As part of their moored-buoy network, there are four permanent offshore buoys located in deep water northwest through south of the Hawaiian Islands, and one experimental buoy located in the Alenuihaha Channel. The Alenuihaha buoy was deployed in November 1985 and became fully operational in about January 1986. As an experimental buoy, it is unknown for how long this buoy will remain as part of the network. Meteorological as well as wave data are accessible in near real-time. Data summary reports are not available, however, the archived data can be obtained on magnetic tape from the National Ocean Data Center.

(d) Spectral Ocean Wave Model (SOWM):

Developed by the National Climatic Center, the SOWM is a sophisticated hindcast model which utilizes the atmospheric pressure fields to determine the large-scale wind fields and subsequent wind-generated wave fields. Deepwater wave statistics for a typical year were developed from data generated over a 13-year period from 1964-1977. The statistics appear to under-represent the North Pacific swell from the northwesterly direction and the model does not include wave generation in the southern hemisphere. However, since these two wave types are not dominant in the Alenuihaha Channel, this data set has general applicability for characterizing the long-term typical wave climate in the channel.

Figure 3.1-1 depicts the locations of the Sea Data meter and the NOAA Buoy within the Alenuihaha Channel.

3.2 OPERATIONAL WAVE CRITERIA

The NOAA buoy in the Alenuihaha Channel probably provides a more accurate representation of waves than the Sea Data meter since the latter is a subsurface pressure

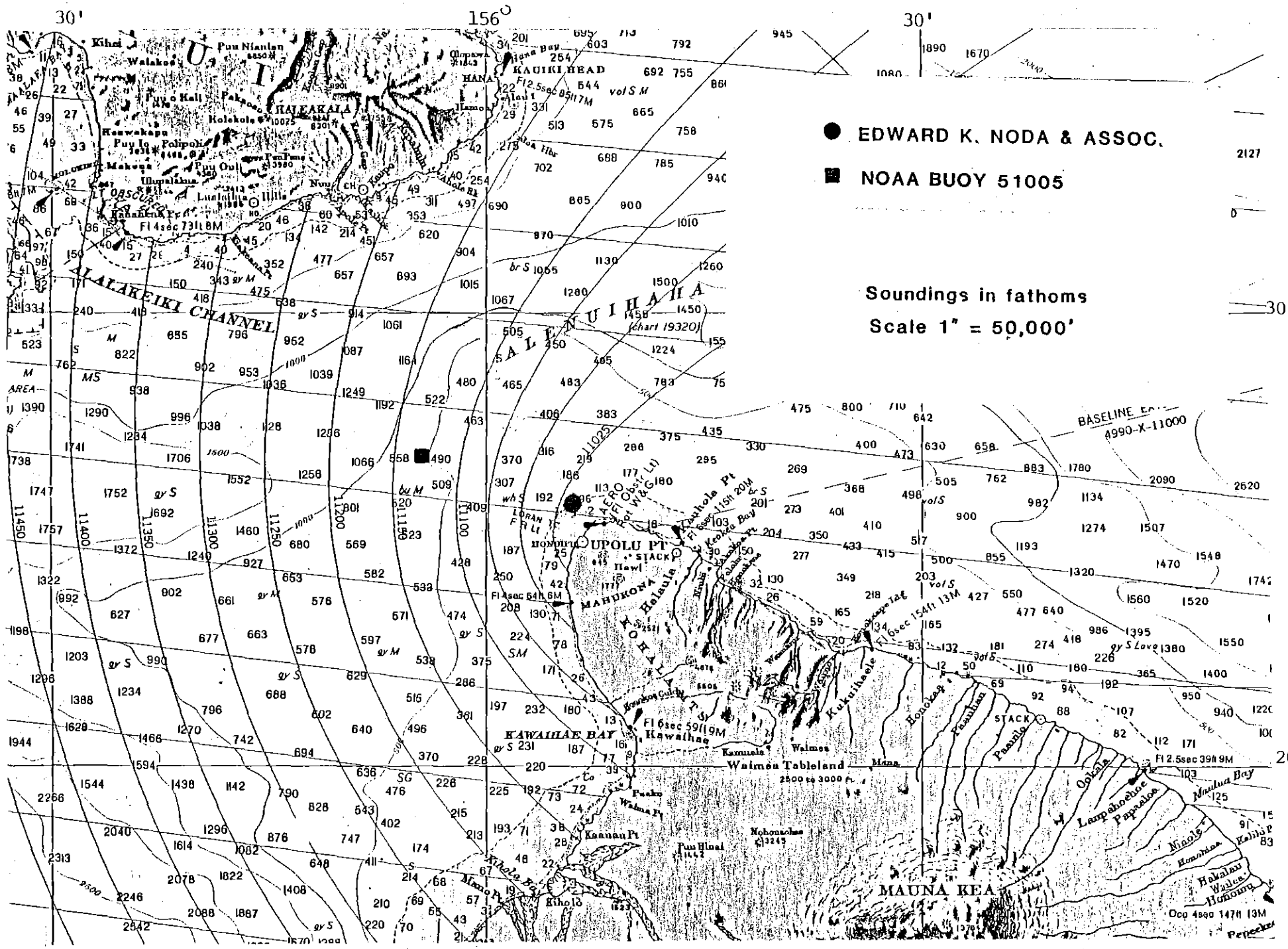
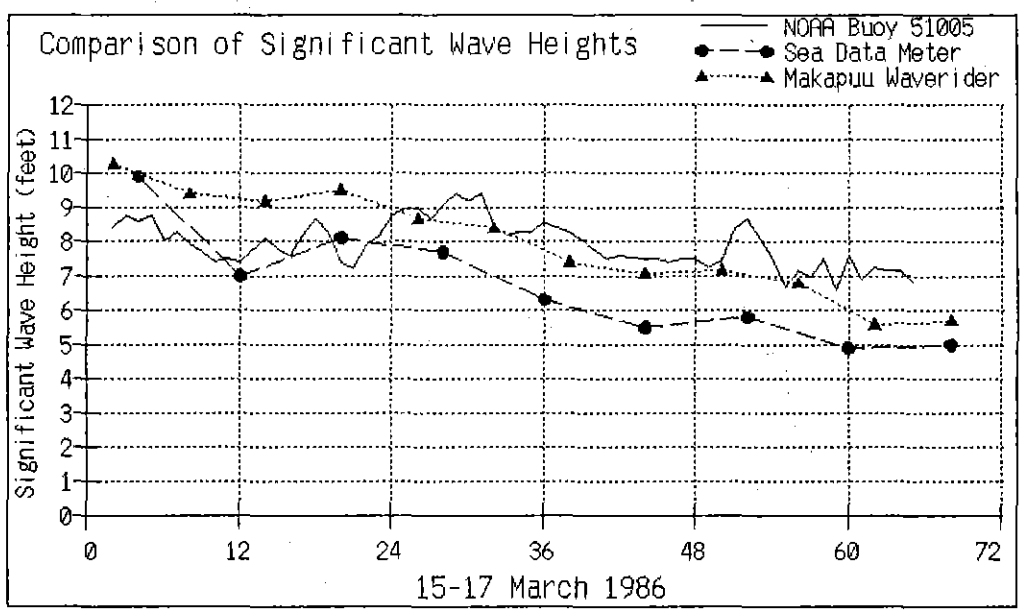


Figure 3.1-1 Location of wave data stations in the Alenuihaha Channel

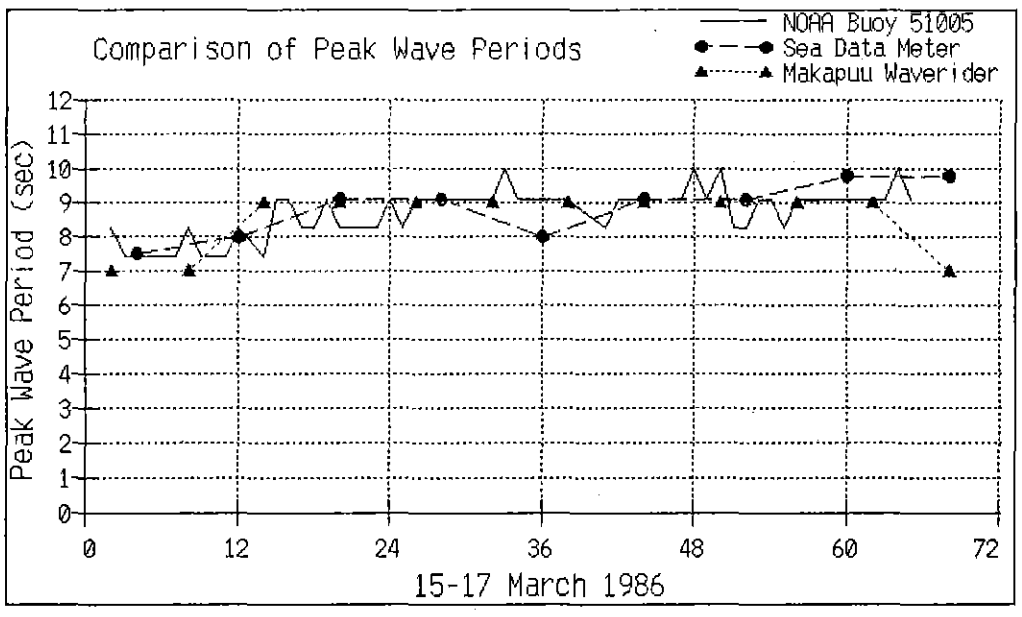
sensing instrument and hence has limitations in measuring the short period end of the wave spectrum. Figure 3.2-1 compares the significant wave heights and peak periods from the NOAA Buoy, Sea Data meter, and Makapuu Waverider buoy during a period of moderately strong tradewinds and moderately high seas. (The significant wave heights from the Sea Data meter were adjusted by inclusion of the estimated high frequency portion of the wave spectrum.) The peak periods from all three instruments show the predominance of the relatively short-period wind waves of 8-9 seconds. Mean wind speeds and direction are shown from the NOAA buoy and the NWS Upolu station. Note that the NWS Upolu winds are consistently lower and about 40 degrees more easterly than the NOAA buoy winds. The NOAA buoy is more exposed to the open channel winds and less influenced by land effects than the NWS Upolu station. The significant wave heights from the Sea Data meter (based on inclusion of the estimated high frequency energy) are about 2 feet lower than the NOAA buoy heights for 16-17 March, when winds were easterly. This would be expected since the Sea Data meter is located just offshore Upolu Point where the winds are probably reduced due to land effects. Note that there is better correlation of waves when the winds are northeasterly (15 March). There is relatively good correlation between the Makapuu Waverider and NOAA buoy waves for easterly winds.

Due to the short duration of record, the NOAA buoy data cannot be used to provide a statistical representation of typical waves on an annual basis. The Makapuu Waverider buoy provides almost five years of data. While this buoy provides a good representation of tradewind waves in the channel, it is exposed to more northwesterly wave energy than can reach the Alenuihaha Channel. Hence, wave energy during the winter months experienced at the Makapuu Waverider buoy would be considerably higher than expected in the Alenuihaha Channel. The Sea Data meter provided two years of nearly continuous data at 8-hour intervals, and is the best data source of measured waves in the Alenuihaha Channel. Appendix A provides % frequency of occurrence distributions of significant wave height versus average wave period on a monthly and annual basis.

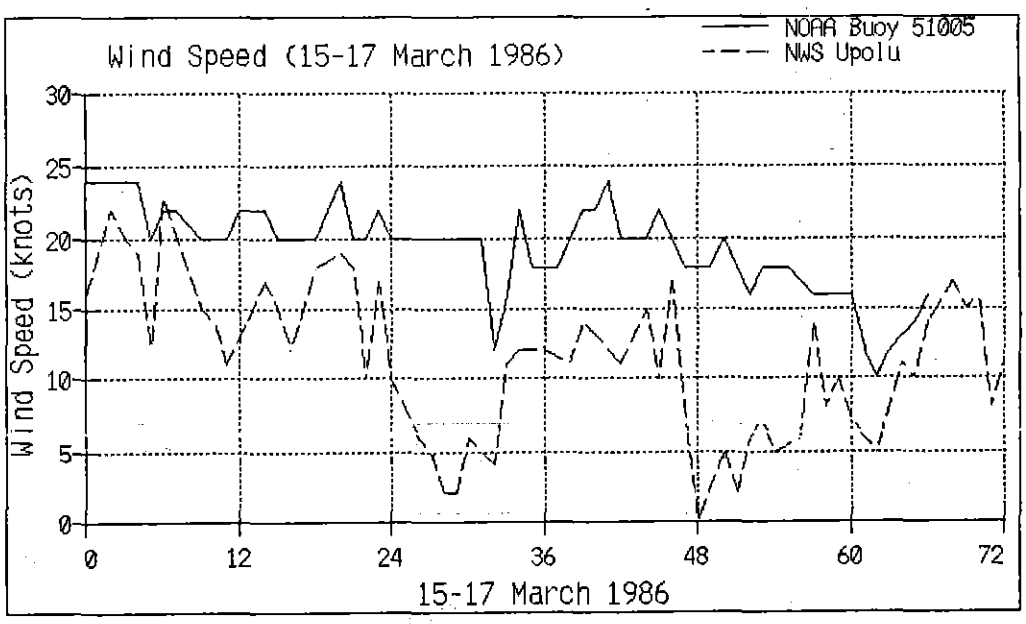
A two-year data record is not a statistically valid representation of typical annual waves since long-period climatic cycles such as "El Nino" events can cause yearly variations in the wave conditions. If the data period is very long, then these climatic cycles are averaged out. However, if the data period is short, then there is a greater probability that the data are not representative of the long-term average. For example, Figure 3.2-2 shows the % frequency of occurrence distribution of significant wave heights and periods for March 1985 and 1986. According to P. Haraguchi, March 1985 was an unusually windy month with the occurrence of tradewinds 39% more frequent than normal



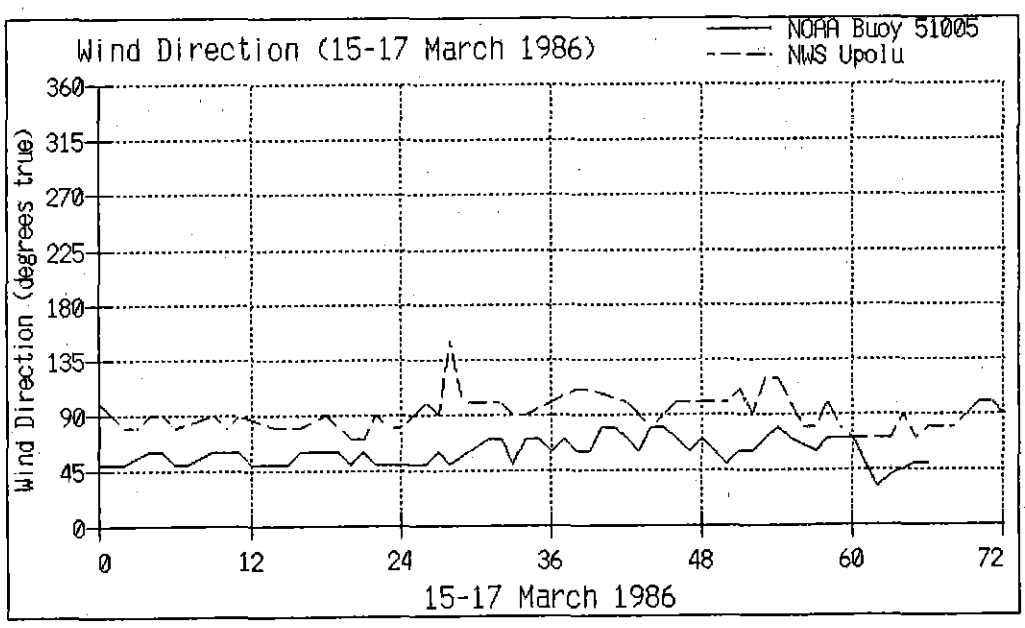
WAVE HEIGHTS



WAVE PERIODS

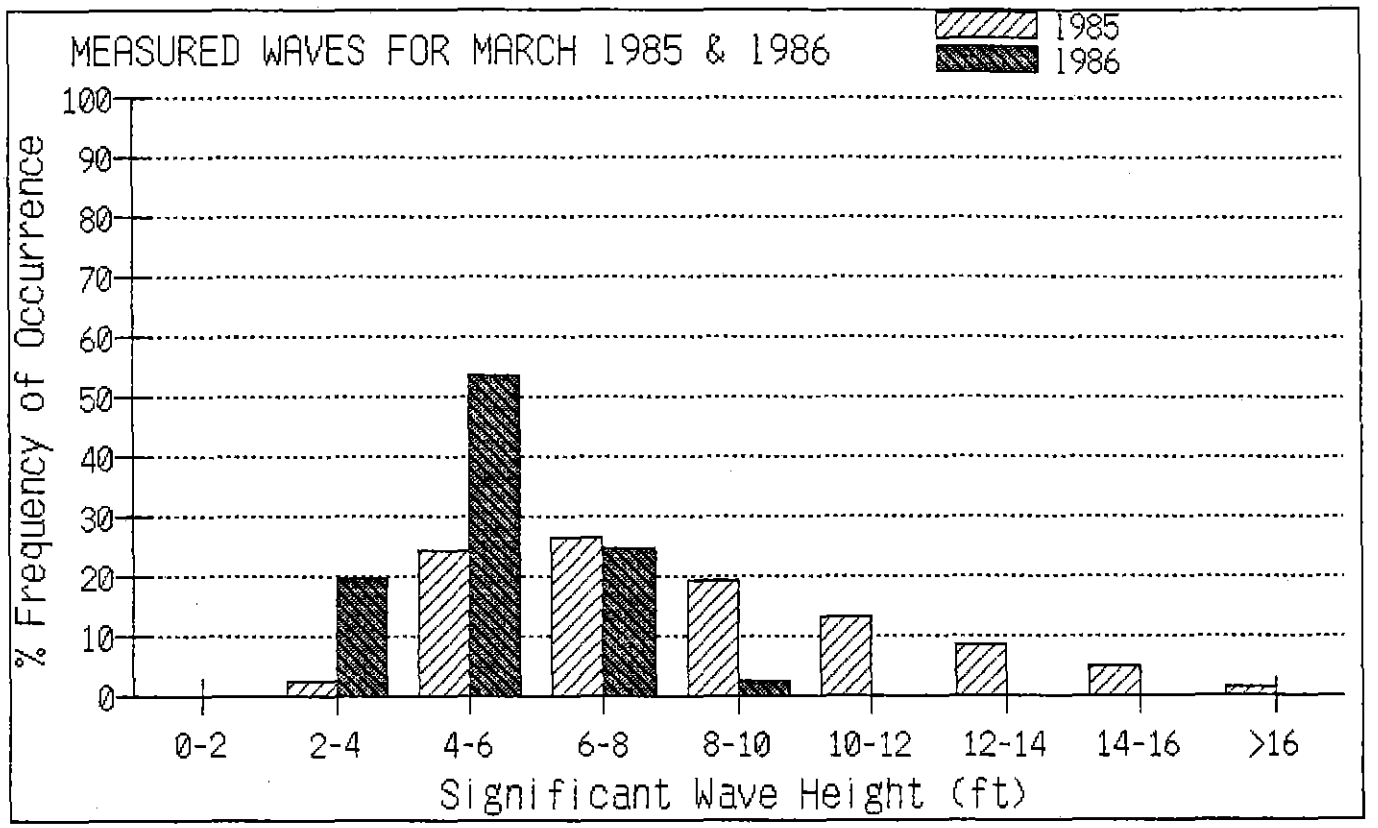


WIND SPEED



WIND DIRECTION

Figure 3.2-1 Comparisons of significant wave height and period from the NOAA Buoy, Sea Data meter, and Makapuu Waverider buoy, 15-17 March 1986



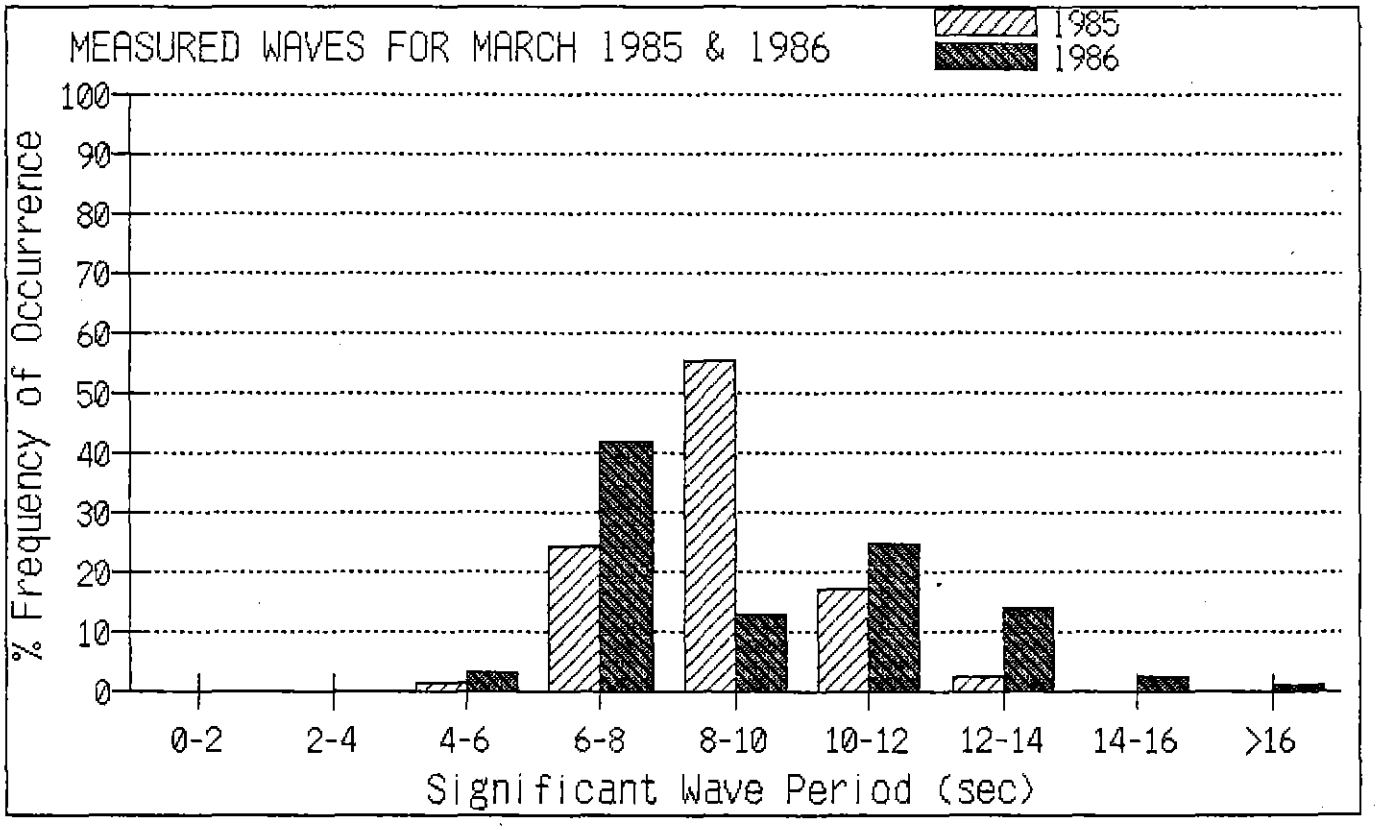


Figure 3.2-2 Percent frequency of occurrence distributions of wave height and period for March 1985 and 1986

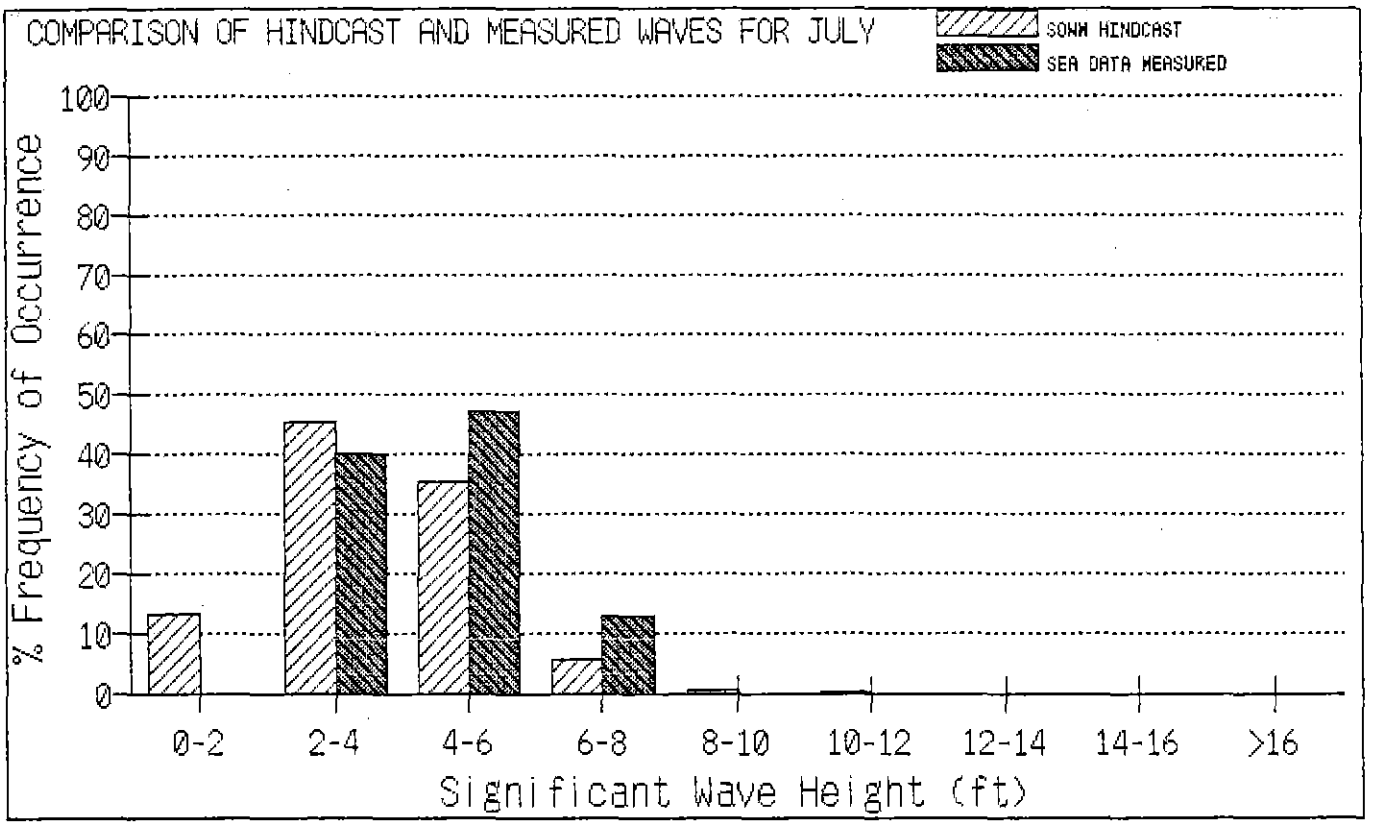
and the average speed 8 mph higher than normal. The distribution of waves show large heights with relatively short periods attributable to these strong winds. Thus, depending on the winds, the wave climate can vary significantly from year to year.

The SOWM hindcast data for the 13-year period from 1964-1977 probably provides a fairly good representation of wave statistics for a typical year. Figure 3.2-3 graphically compares the % frequency of occurrence of significant wave heights and average wave periods from the SOWM hindcast data and the Sea Data meter for the month of July, which is a typical summer month. The Sea Data statistics represent the combined data for July 1984 and 1985. Wind data as evaluated by P. Haraguchi indicates that the occurrence and strength of tradewinds for July 1984 and 1985 deviated little from the typical long-term values, and the wave height and period comparisons of the long-term hindcast and short-term measured data confirm this typical tradewind-generated wave climate. Significant wave heights are typically 2-6 feet, with predominant period of 4-6 seconds. Figure 3.2-4 graphically compares the % frequency of occurrence of significant wave heights and average wave periods from the SOWM hindcast and the Sea Data meter for the month of January, which is a typical winter month. Significant wave heights are typically 2-8 feet, with predominant period of 6-8 seconds. Note that the SOWM hindcast data reflects the occurrence of the long-period northerly swell which does not significantly affect the Alenuihaha Channel.

Thus, while there are minor discrepencies with respect to characterization of the swell waves within the channel, the SOWM hindcast statistics appear to provide a fairly good representation of the predominant tradewind wave climate. Likewise, the statistics generated from the combined 2 years of Sea Data record appears to provide a reasonably good representation of typical expected waves, even though there can be significant variations from year to year. Figure 3.2-5 shows a comparison of the annual frequency of occurrence distribution of wave heights and periods from the SOWM hindcast data and the Sea Data meter.

In order to determine which month(s) are most favorable for deployment operations, Figure 3.2-6 shows the cumulative percentage of time that significant wave heights are <6 feet on a monthly basis. In general, there is good agreement between the SOWM hindcast and Sea Data measured wave heights. From this figure, it appears that the summer months of June through September are the most favorable in terms of significant wave heights being less than 6 feet about 80% or more of the time.

Since the wave climate varies seasonally, the operational design wave will be expected to vary depending on the time



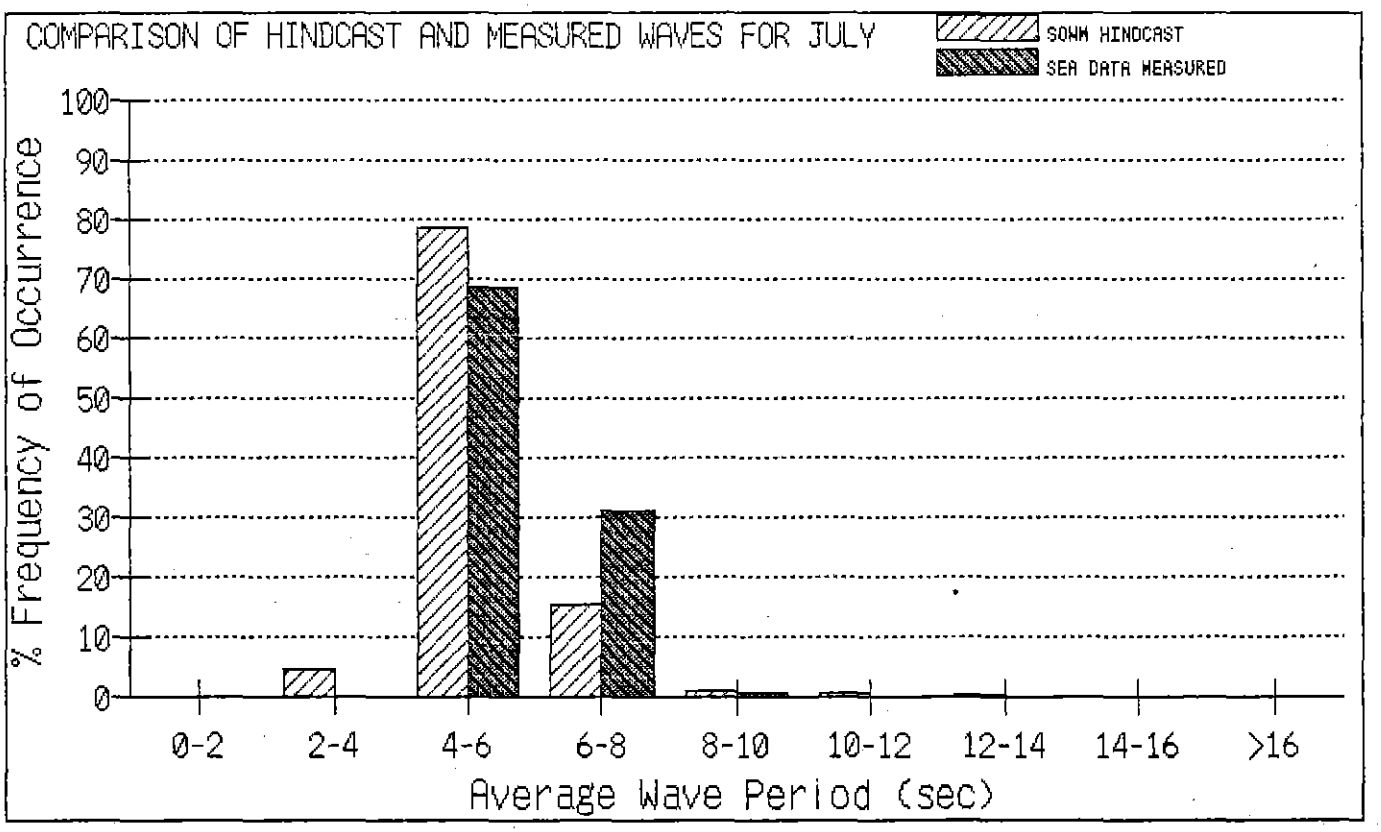
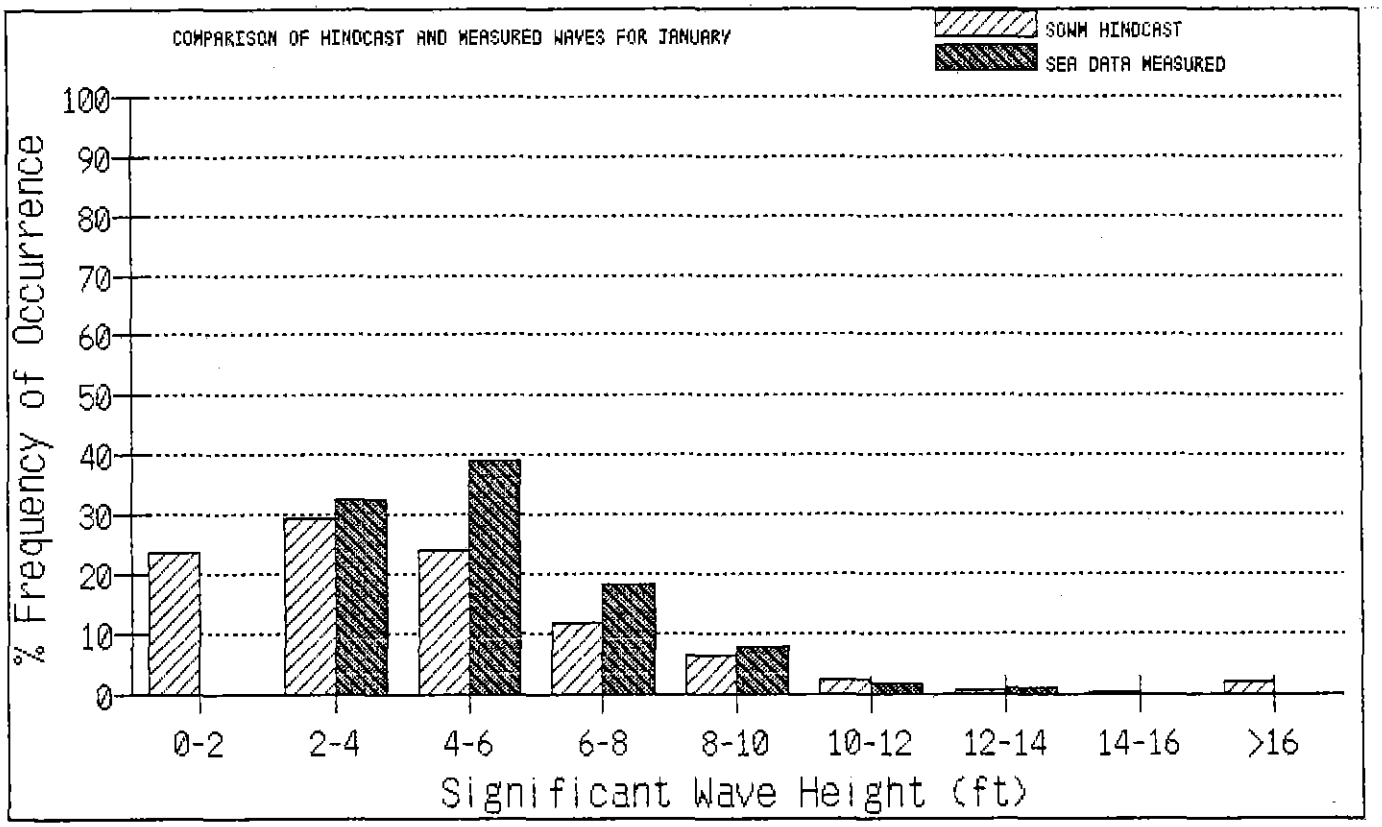


Figure 3.2-3 Comparisons of % frequency of occurrence distributions from the SOWM hindcast and the Sea Data measured waves for the month of July



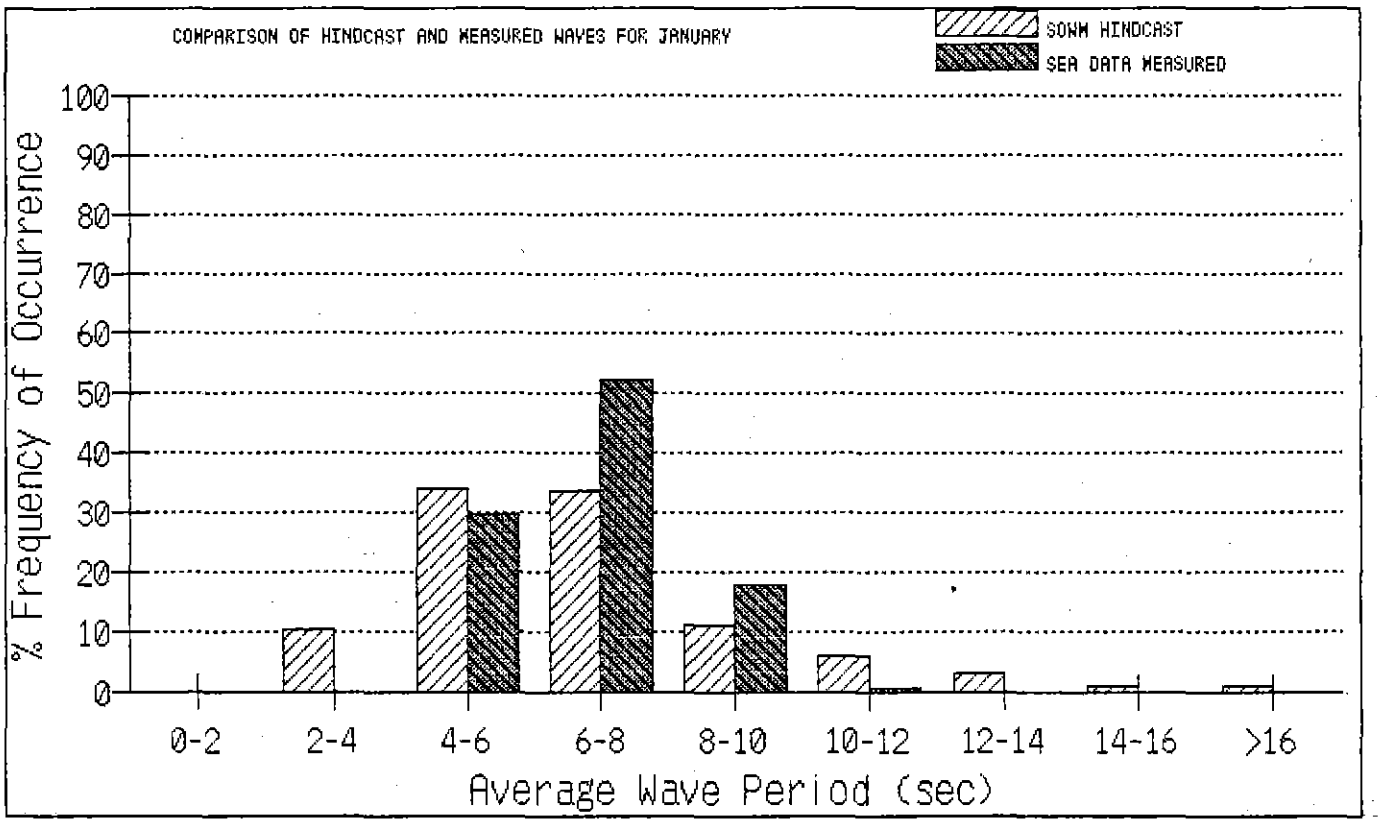
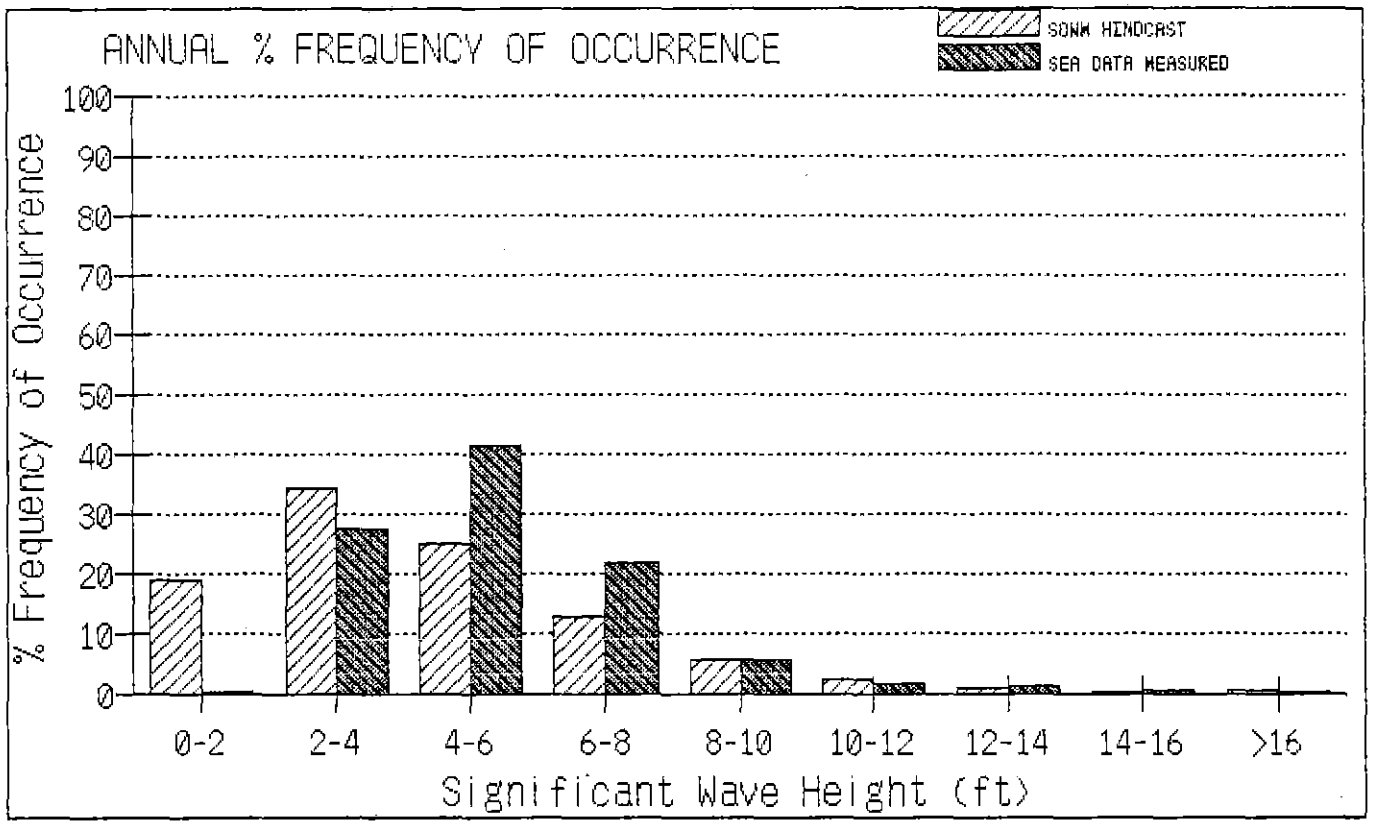


Figure 3.2-4 Comparisons of % frequency of occurrence distributions from the SOWM hindcast and Sea Data measured waves for the month of January



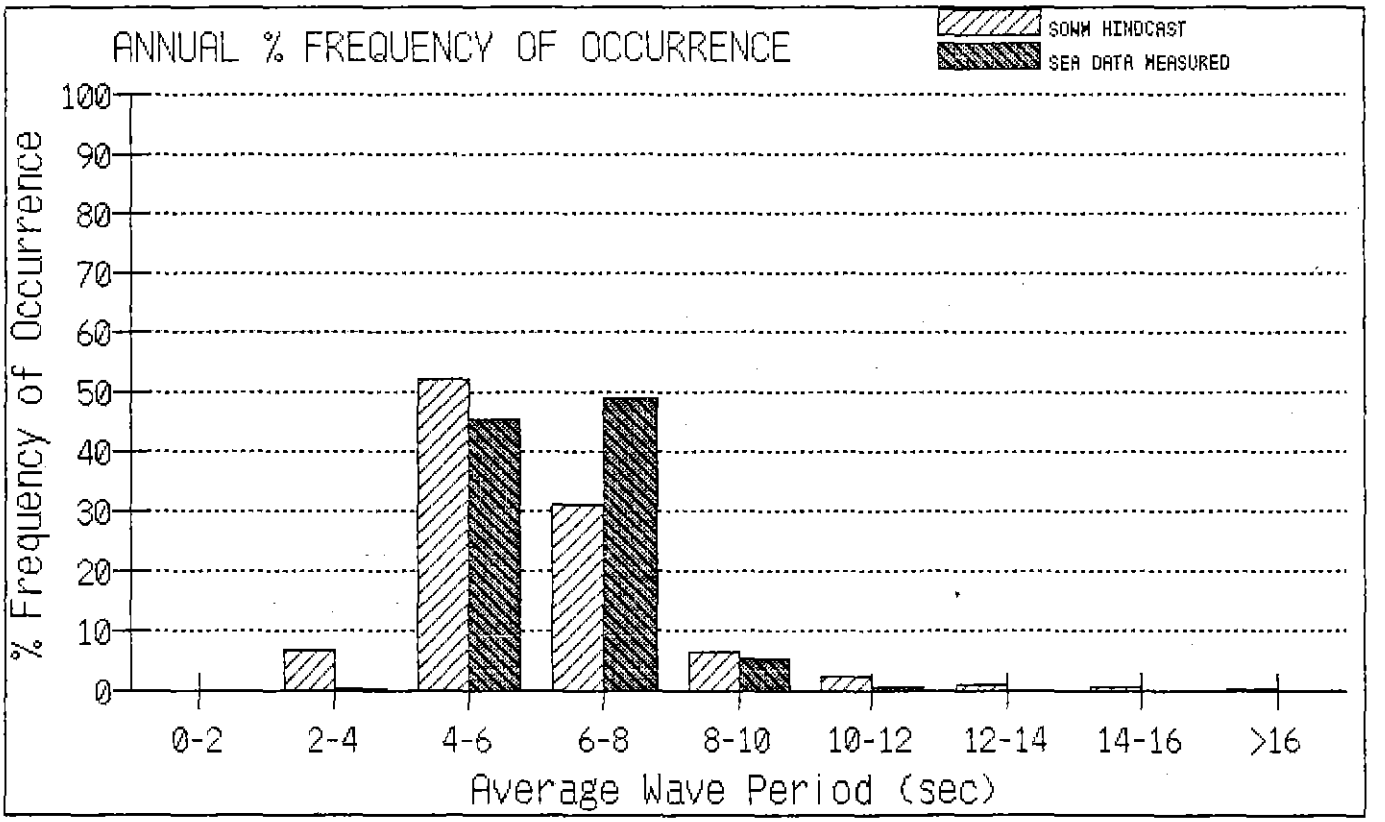


Figure 3.2-5 Annual % frequency of occurrence distributions from the SOWM hindcast and the Sea Data measured waves

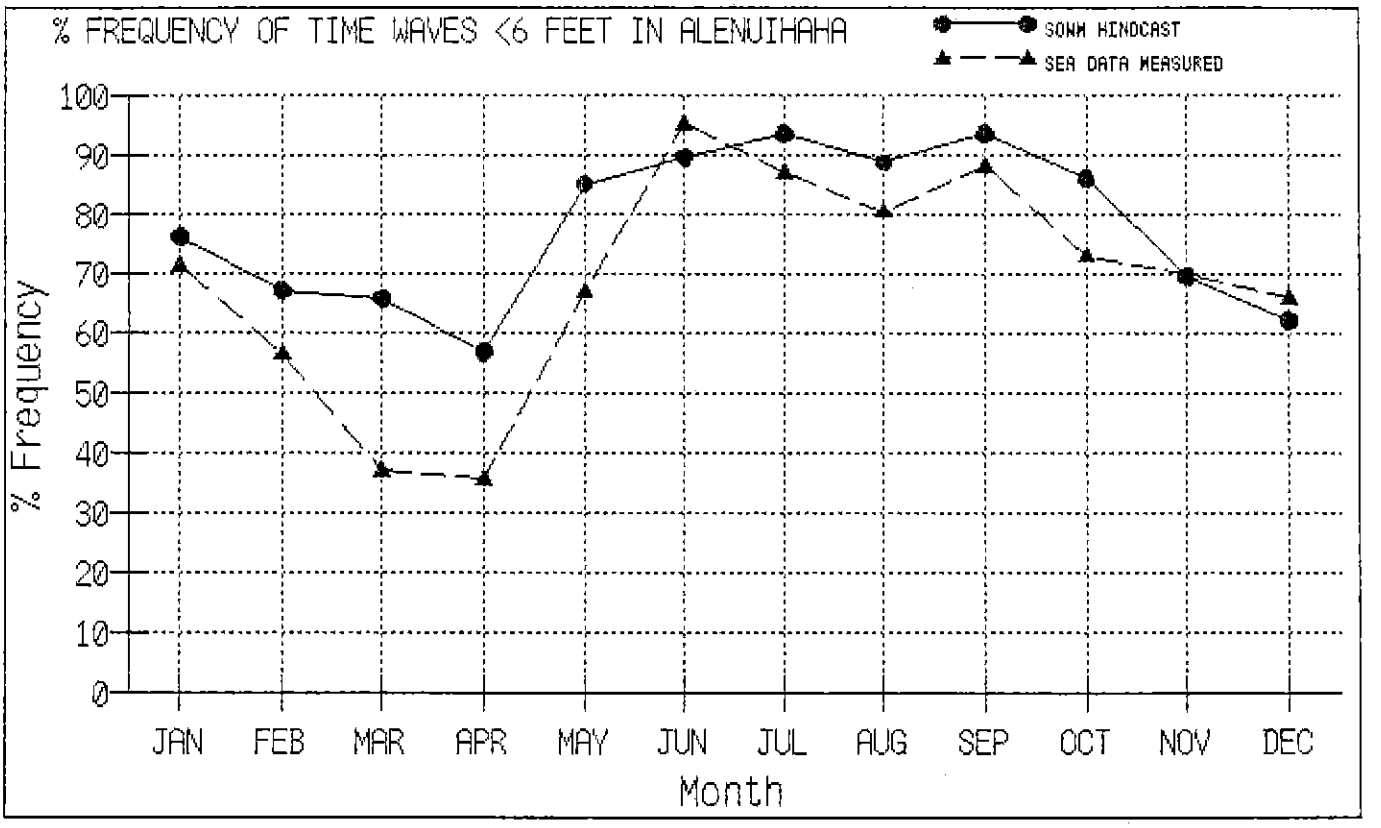


Figure 3.2-6 Monthly % frequency of time waves <6 feet in the Alenuihaha

of year. The operational design wave is defined here as the significant wave height that is expected to be exceeded about 10% of the time during any given month. The design period is given as the range of average wave periods associated with the given design wave height. Table 3.2-1 lists the monthly operational design wave conditions, based on evaluation of both the Sea Data measured waves and the SOWM hindcast statistics.

Table 3.2-1 Alenuihaha Operational Design Waves (Exceeded 10% of the time)

	Sea Data Measured		SOWM Hindcast		Design	
Month	H_s(ft)	T(sec)	H_s(ft)	T(sec)	H_s(ft)	T(sec)
Jan	8.5	4-10	8.8	6-8	8.6	4-10
Feb	8.9	6-10	9.8	6-8	9.4	6-10
Mar	12.2	6-10	9.9	6-8	11.1	6-10
Apr	9.7	4-8	10.3	6-8	10.0	4-8
May	8.0	4-8	7.6	4-8	7.8	4-8
Jun	6.1	4-6	6.0	4-6	6.1	4-6
Jul	6.7	4-6	6.4	4-6	6.6	4-6
Aug	7.2	4-6	6.4	4-6	6.8	4-6
Sep	6.7	4-8	5.8	4-6	6.2	4-8
Oct	7.9	4-8	7.3	4-10	7.6	4-10
Nov	8.0	4-8	9.7	6-8	8.8	4-8
Dec	10.4	4-8	9.2	6-8	9.8	4-8

The significant wave heights used to develop the percent frequency of occurrence distributions in Appendix A (and thus the operational design waves in Table 3.2-1) were determined from the individual Sea Data wave records based on the total energy contained in the frequency spectrum. The significant wave height is defined as the average of the highest 1/3 of all wave heights. Thus, wave heights higher than the significant wave height occur simultaneously within the wave spectrum. Assuming a Rayleigh distribution of heights, the highest one percent of all waves is $H_1=1.67H_s$. This would mean, for example, that for a given sea state described by a significant wave height of 6 feet, the range of wave heights between H_s and H_1 is 6-10 feet.

These characteristic wave heights are calculated assuming that the wave spectrum is unimodal, having a single peak in the energy spectrum. If long-period swell occur simultaneously with locally-generated wind waves, then the energy spectrum will be bimodal or double-peaked. Thus, the significant height calculated assuming a unimodal spectrum represents a type of overall combined height from the simultaneous occurrence of wind and swell waves. In order to characterize the bimodal sea state, which is prevalent in

Hawaiian waters, the wave records were analyzed using a technique similar to that of Soares (1984).

The methodology and results of this analysis, which include percent frequency of occurrence distributions of the bimodal spectra significant heights and periods on a monthly and seasonal basis, are too voluminous to include herein and can be reviewed in the data report for the 2-year wave and near-surface current measurement program (Edward K. Noda and Associates, 1986a). In general, the results indicated that the Sea Data wave records exhibited bimodal characteristics nearly 100% of the time. About 50% of the time during the year, the two spectral peaks had peak energy periods less than 10 seconds, while 50% of the time the bimodal spectra had peak energy periods representing both short-period (<10 second) wind waves as well as long-period (≥10 second) swell. Figure 3.2-7 depicts the annual cumulative occurrence (percent frequency of exceedence) of significant wave heights for the overall (assuming unimodal spectra), ≥10 second period and <10 second period spectra (from bimodal analysis). The modal or peak energy period for each spectrum is used to classify the individual spectra into either the ≥10 sec or <10 sec category. Thus, while the percent frequency of occurrence distributions in Appendix A (which are based on the overall H_s and average wave period) show the predominance of short period wind waves, the bimodal analysis indicates that long period swell waves are also a significant component of the total wave energy in the channel.

Figure 3.2-8 shows the total percent of time during which <10 second and ≥10 second period spectra occur on a monthly basis. Spectra having modal periods <10 seconds occur more than 90% of the time during any month, and close to 100% of the time during the summer months. Spectra having modal periods ≥10 seconds occur more frequently during the winter months than summer months, indicating the greater frequency of North Pacific swell than south swell.

Figure 3.2-9 shows the cumulative percent of time that <10 second and ≥10 second period spectral significant wave heights are <4 feet on a monthly basis, normalized to the total percent occurrence reflected in Figure 3.2-8. For <10 second spectra, significant heights are <4 feet less than 30% of the time during the months of March-April when winds are strong and gusty. For ≥10 second spectra, significant heights are <4 feet 100% of the time when they occur during the months of June-July, characteristic of the low, long-period south swell. In contrast, significant heights are <4 feet between 30% and 70% of the time when they occur during the winter and spring months, characteristic of the higher energy North Pacific swell.

Thus, bimodal analysis of wave spectra can provide a more valid representation of the sea state from the point of view

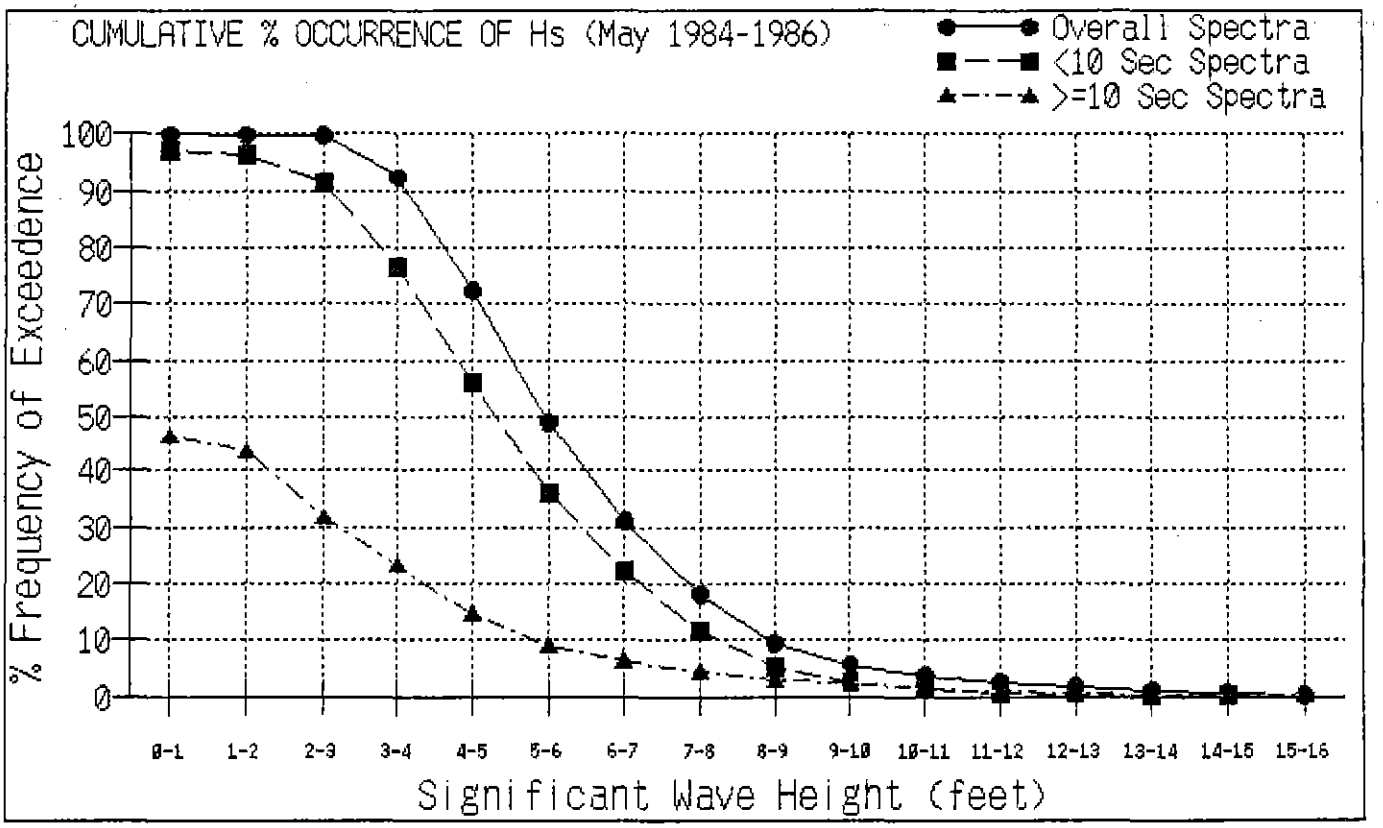


Figure 3.2-7 Cumulative % exceedence of significant wave heights for entire 2-year record, Sea Data meter offshore Upolu Point, Hawaii

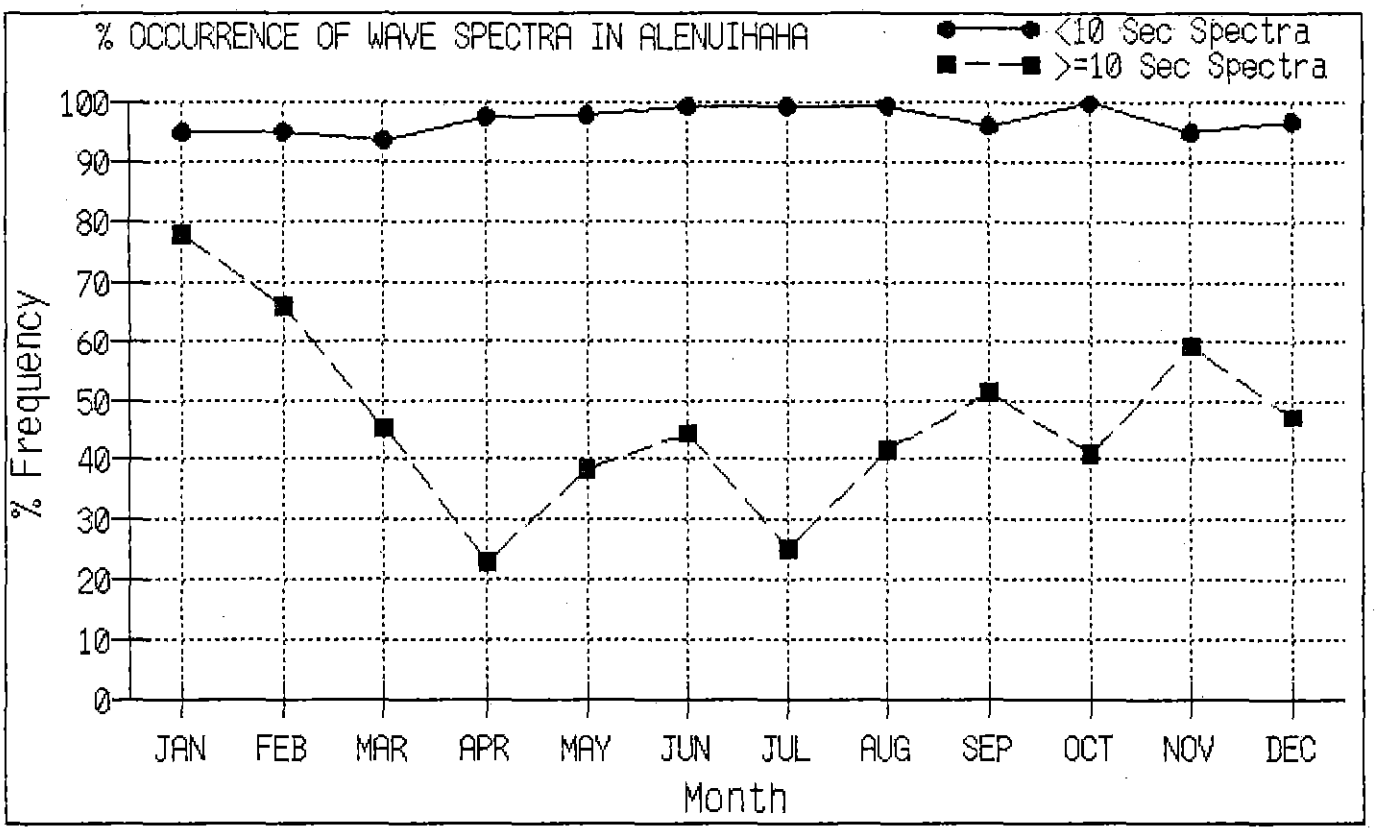


Figure 3.2-8 Monthly total % of time during which <10 sec and ≥10 sec period spectra occur

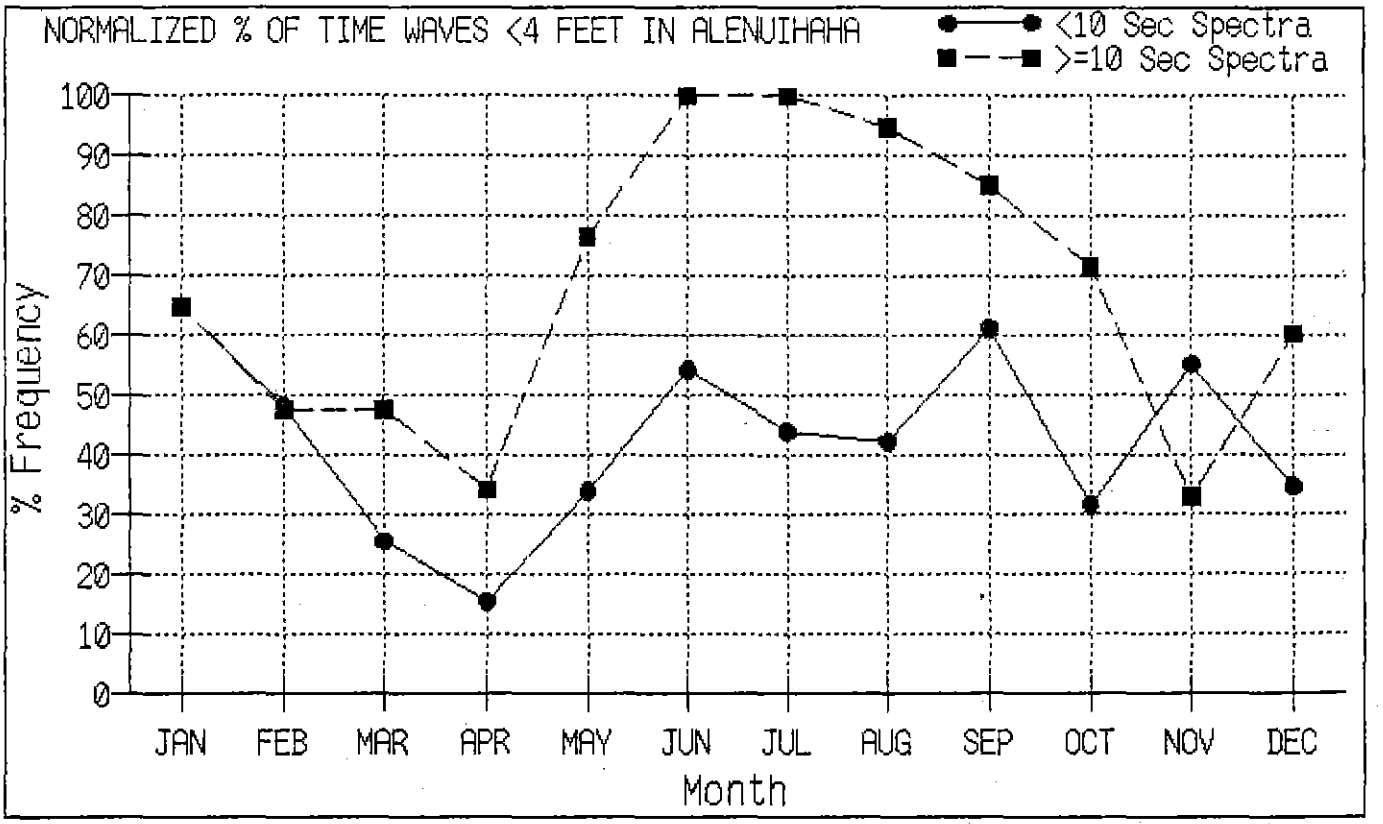


Figure 3.2-9 Monthly % frequency of time significant heights <4 feet for <10 sec and ≥10 sec period spectra, normalized to total % occurrence

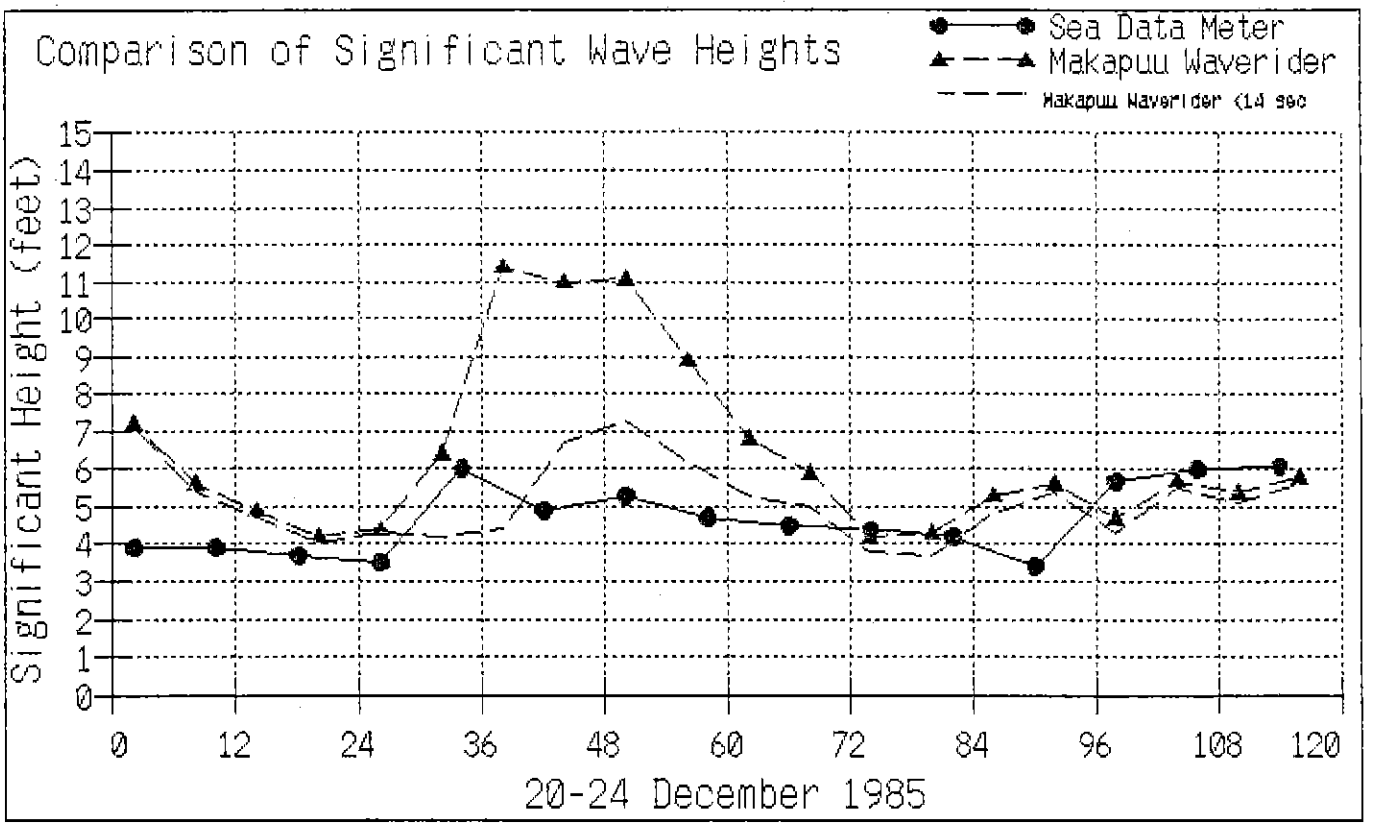
of evaluating wave forces and the dynamic response of offshore structures or systems. What would be considered as the design wave characteristics or design spectra for a given situation can be expected to be dependent on the system being analyzed. For example, the cable-vessel system is apparently very sensitive to wave forcing at the high frequency range of wave periods. Since it is unknown at this time what the full range of design wave considerations may be, no attempt was made to develop operational design criteria for separate "sea" and "swell" conditions based on the bimodal analysis of data. The reader is referred to the data report (Edward K. Noda and Associates, 1986a) for detailed data summaries.

Although wave direction data are not provided, the directionality of long-period swell waves can be assumed depending on the time of year when they occur. Short-period wind waves are almost always due to tradewinds from the ENE. Thus, a design bimodal sea state may, for example, consist of northerly swell with spectral period 12-14 seconds in combination with 4-6 second tradewind waves, which would occur during the winter months. From the data report, spectral heights and frequency of occurrence distributions can be determined.

3.3 PREDICTION OF WAVES DURING DEPLOYMENT

If the NOAA buoy 51005 is still operational, then the wave data (as well as winds) measured hourly at this buoy will provide a good report of expected waves in the Alenuihaha Channel. If this buoy is not operational, then the Makapuu Waverider buoy can be used to predict the wave conditions in the channel. However, during the winter months when northwesterly swell energy is high, the Makapuu Waverider buoy will experience larger long-period waves than would be expected in the Alenuihaha Channel.

Figure 3.3-1 compares the significant wave heights and peak periods from the Sea Data meter and the Makapuu Waverider buoy for 20-24 December 1985, during a period of high northwesterly swell. Surf at Sunset Beach on Oahu peaked at 12-15 feet on 21 and 22 December. Maximum significant wave height at the Makapuu Waverider was 11.4 feet on 21 December (1400 hrs) with peak period of 20-22 seconds. Significant wave heights at the Sea Data meter did not exceed 6 feet. If wave energy greater than 14 second period is removed from the Makapuu Waverider spectra, the significant heights calculated from the remaining energy compare reasonably well with the Sea Data significant heights. Hence, this technique can be used to estimate the wave energy expected in the Alenuihaha Channel during periods of northwesterly swell, based on wave spectral data from the Makapuu Waverider buoy. Directionality associated with the Makapuu Waverider swell energy can be estimated based on observed



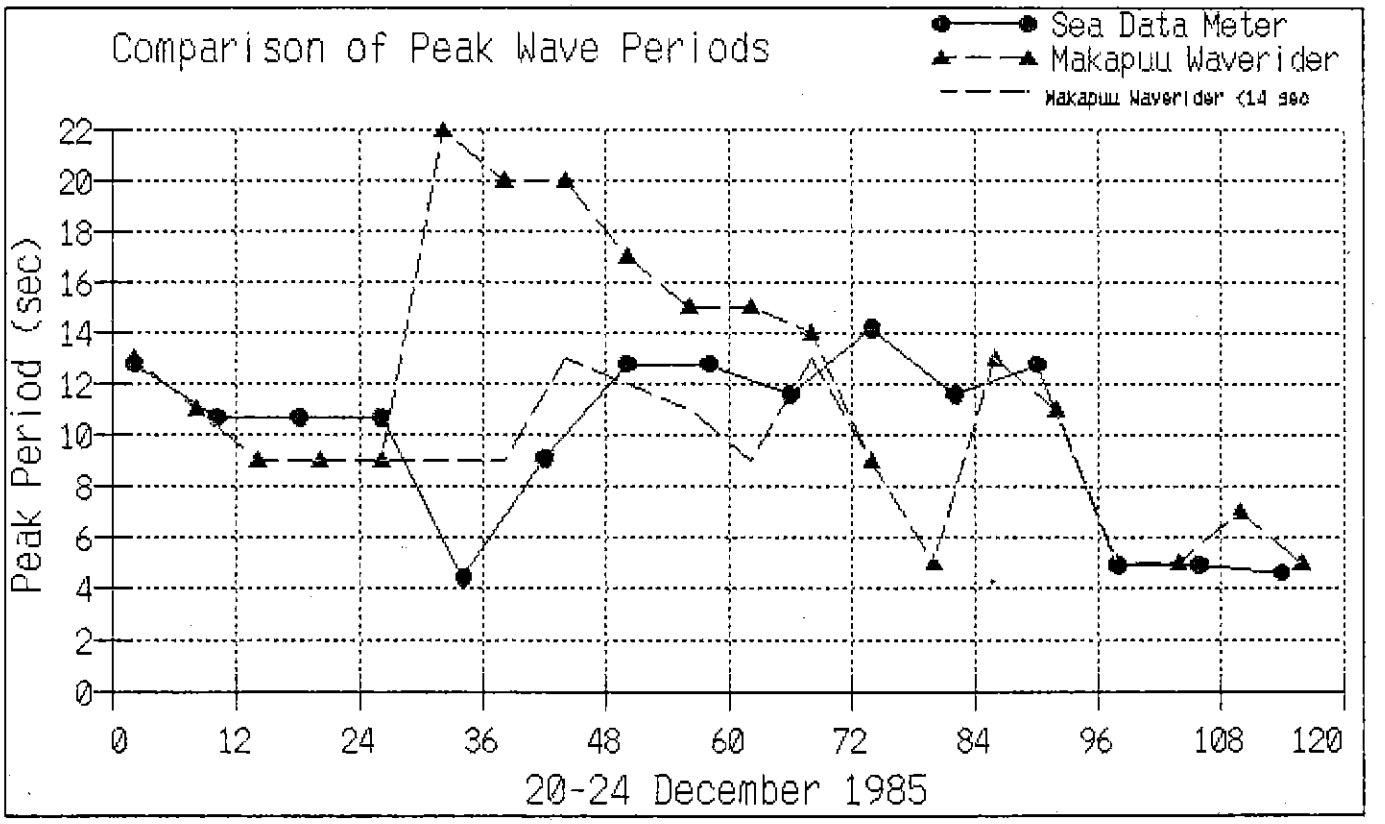


Figure 3.3-1 Comparisons of significant wave height and period from the Sea Data meter and Makapuu Waverider buoy, 20-24 December 1985 (period of NW swell)

surf heights at Oahu beaches, i.e. high surf at Sunset Beach indicates northwesterly swell, high surf at Makaha indicates southwest to westerly swell, surf at Ala Moana/Diamond Head indicates south swell. The northwesterly swell is the only type that cannot directly enter the Alenuihaha Channel.

4.0 CURRENTS

4.1 GENERAL

Coastal currents in the vicinity are typically comprised of the following components:

Tidal currents
Wind-driven currents
Eddy currents
Background oceanic currents

The relative magnitudes of these components vary depending on the particular location, distance from shore, and also vertically with depth.

Available current data in the Alenuihaha Channel indicate that the currents are primarily driven by the tides and winds, and are influenced by eddy currents. Eddy currents, while being a predominant component in waters west of Hawaii, are not as dominant a feature within the channel itself. It is postulated that strong winds blowing through the channel may be the mechanism for eddy formation. However, fully developed eddies do not "live" within the confines of the channel, although they may influence the near-surface currents within the channel. A discussion on eddies is presented here to provide an understanding of their influence in the general vicinity of Maui and Hawaii. This discussion is drawn primarily from the work of Patzert (1969).

Figure 4.1-1 locates the centers of observed eddies from 20 cruises that documented the hydrographic conditions of the eddies. Eddies were observed as close as 40 km from shore (Figure 4.1-2) and as far away as 350 km from the islands. The eddy radius varies from 28 km for a weak eddy near Hawaii to 80 km for a well-developed eddy farther offshore. As the eddies age and move away from Hawaii, they increase in area as indicated in Figure 4.1-3.

The small eddy observed during Cruise UH-12 (Figure 4.1-2) was in its early developing stage. During the last days of the cruise, six parachute drogues were released in the Alenuihaha Channel (Figure 4.1-4). These drogues showed an oscillating drift pattern, indicating the influence of tidal currents. Although the hydrographic data showed a weak eddy in its early stages of formation, there were no strong flows through the channel. Figure 4.1-5 shows the cyclonic pattern of the winds in the area of the weak eddy. These winds were strong (15-20 knots) and steady. Therefore, wind shear was the apparent driving force for the eddy, and not any strong flow around Hawaii as being the cause of eddy formation.

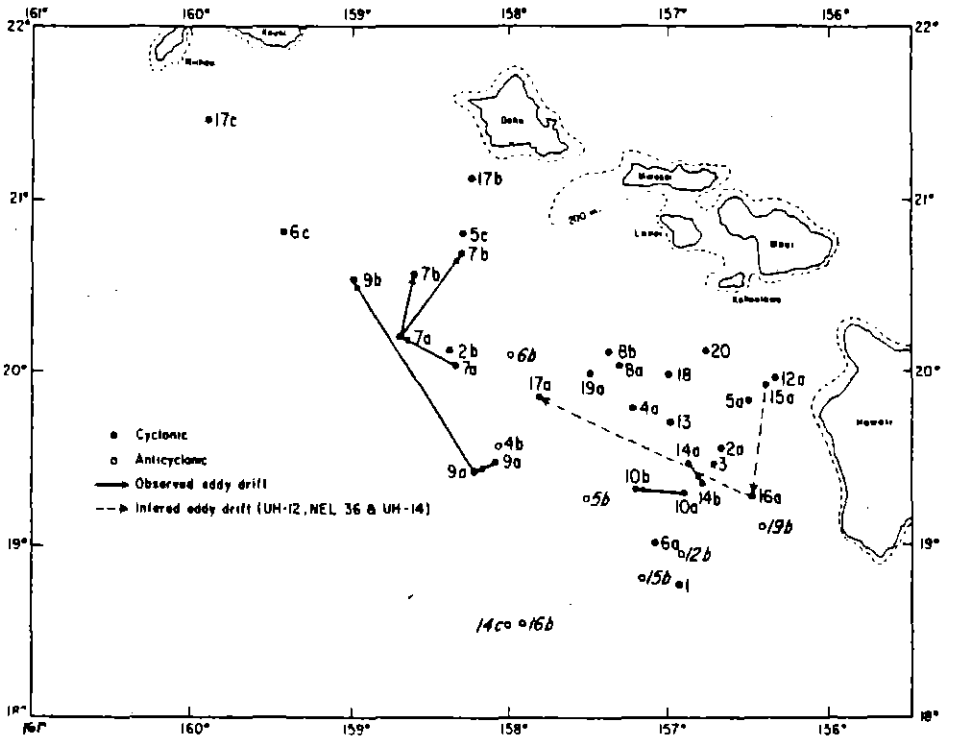


Figure 4.1-1 Location and drift of eddies in the lee of the Hawaiian Islands. The positions represent the centers of the eddies. (Patzert, 1969)

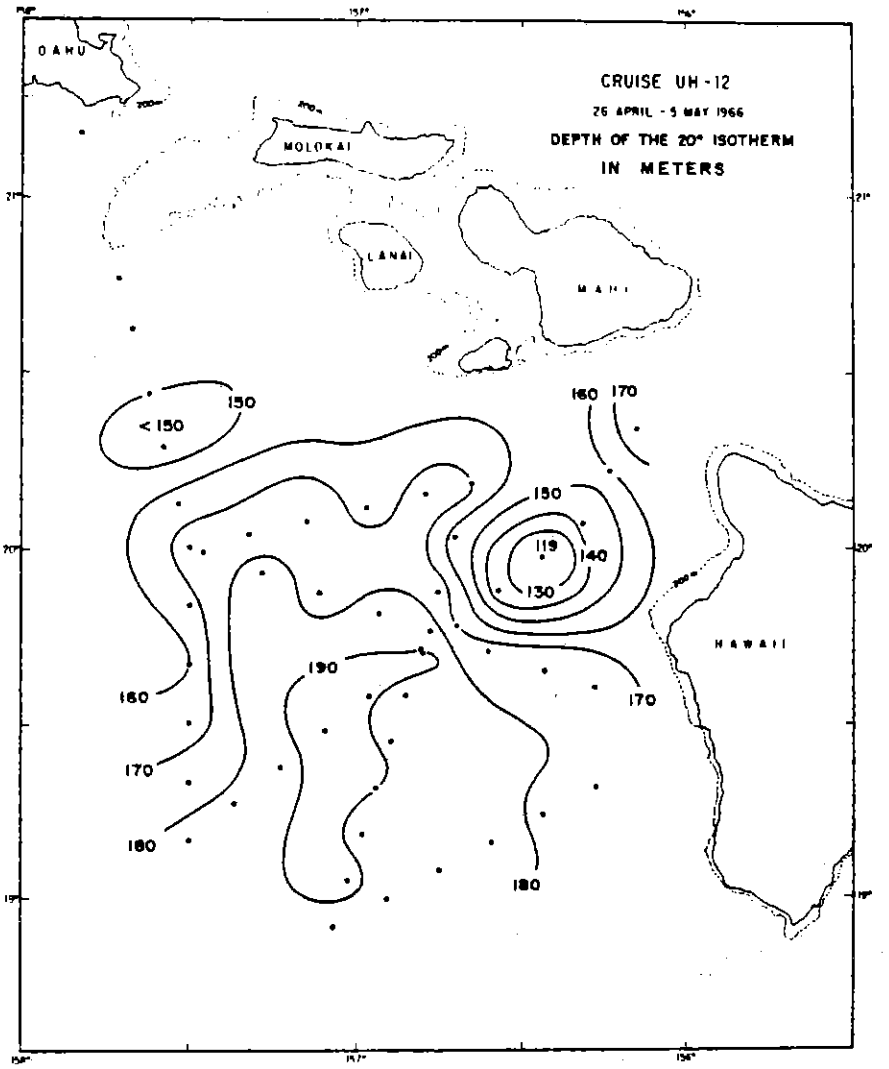


Figure 4.1-2 Depth of the 20°C isotherm from Cruise UH-12, April 26 - May 5, 1966. (Patzert, 1969)

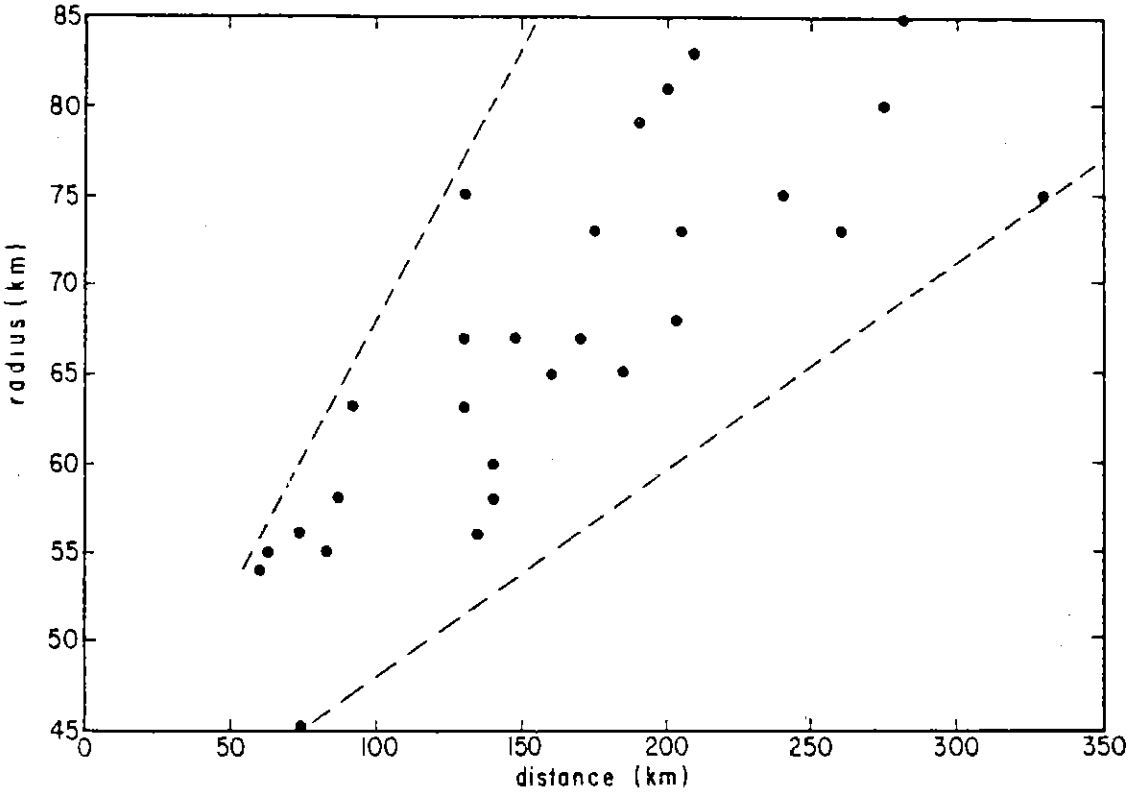


Figure 4.1-3 Observed eddy radius versus the distance of the center of the eddy from Island of Hawaii. (Patzert, 1969)

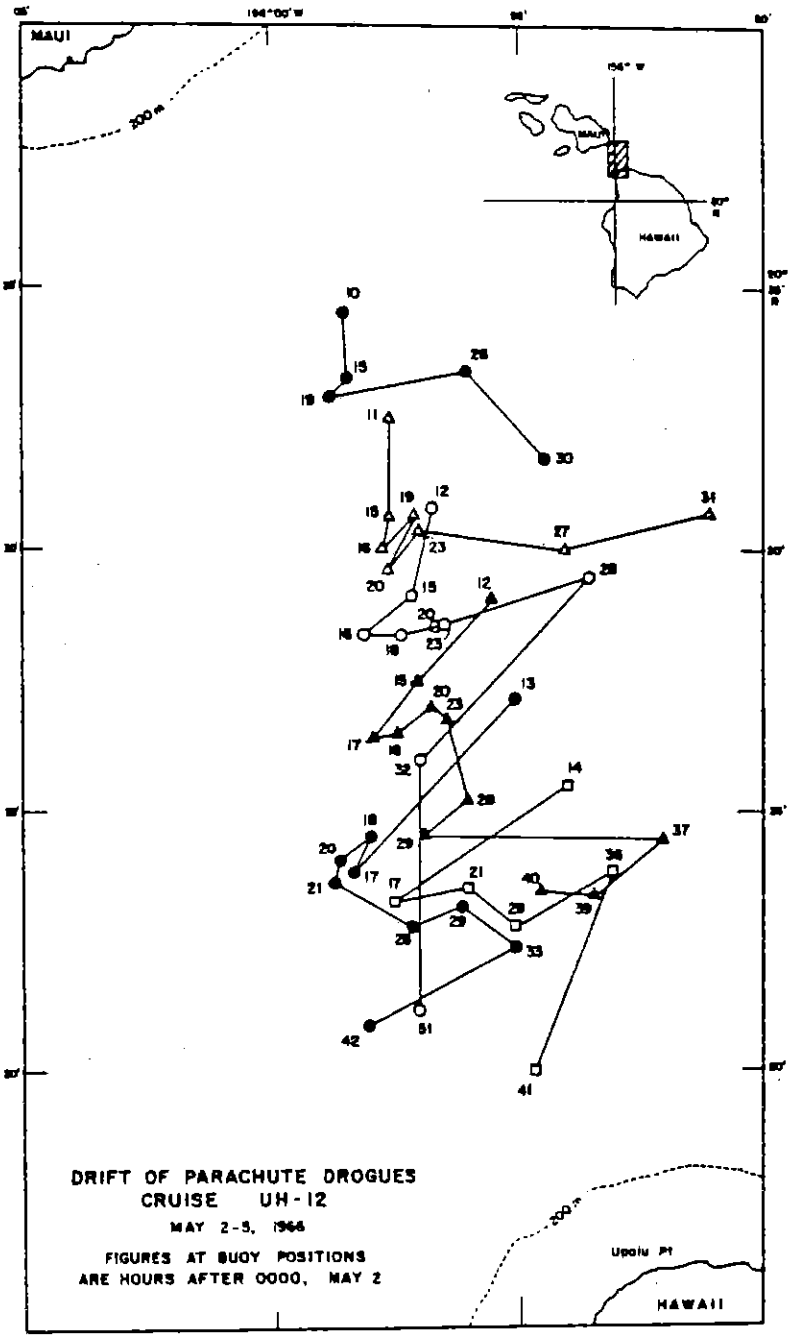


Figure 4.1-4 Drift of parachute drogues from Cruise UH-12, May 2 - 5, 1966. Figures at buoy positions are hours after 0000, May 2. (Patzert, 1969)

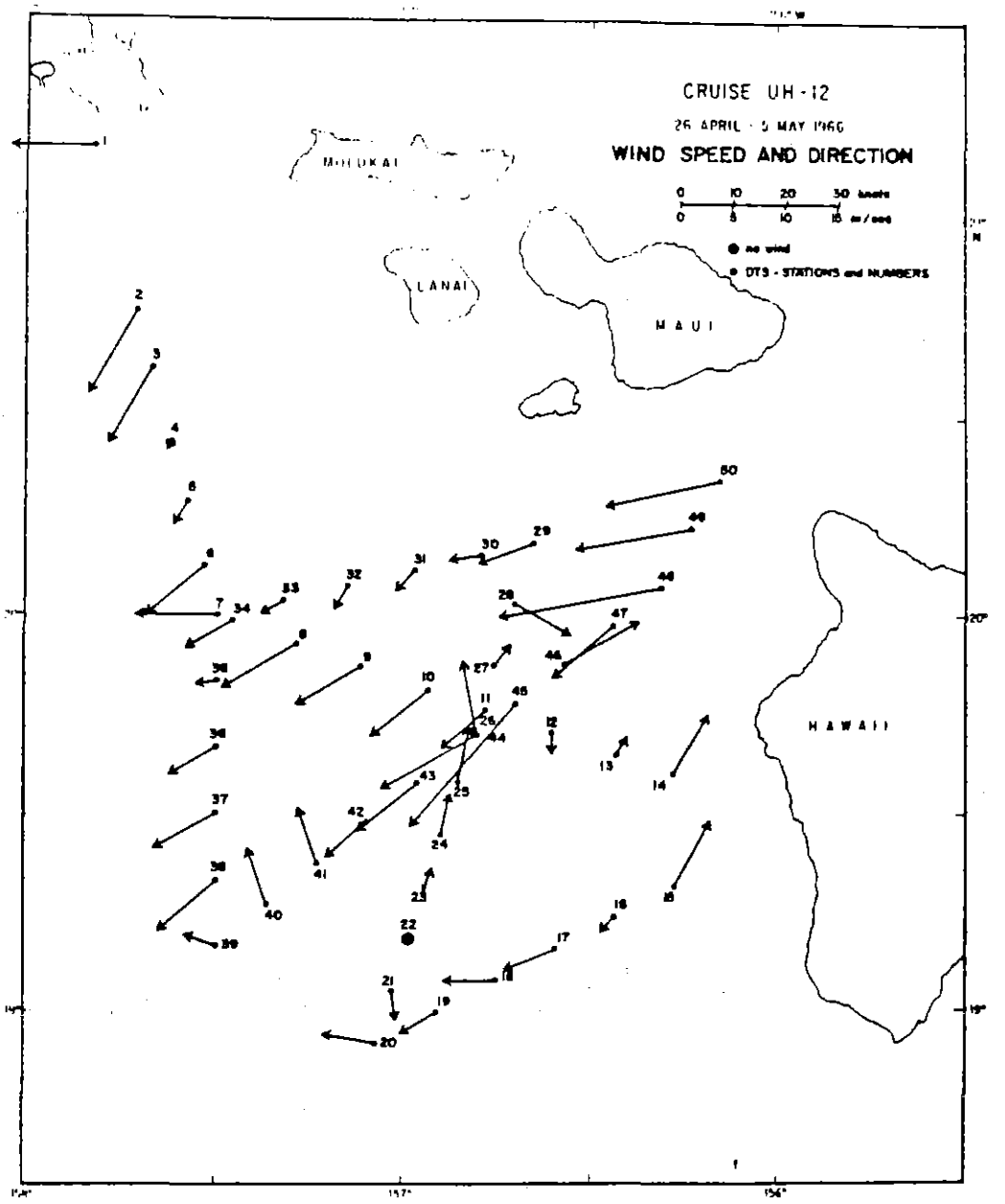


Figure 4.1-5 Wind speed and direction from Cruise UH-12, April 26 - May 5, 1966. (Patzert, 1969)

A fully developed eddy can influence flows within the channel as illustrated by Figure 4.1-6. Near-surface current measurements by Wyrtki et al (1969) confirmed strong northeasterly flows off Upolu Point and strong westerly flows off Kiakaena Point, south Maui, during a large cyclonic eddy occurring west of Hawaii in the summer of 1967. Near-surface current measurements taken during the Deep Water Cable Program also indicate moderate to strong northeasterly flows offshore Upolu Point, with some periods of weak northerly flows. The influence of strong offshore eddies on the near-surface circulation within the channel will vary at different locations across the channel depending on the size and movement of the offshore eddy.

Eddy flows are shallow and generally confined to the upper 300 to 400 meters in offshore waters. Approximately 75% of the observed dynamic height difference is concentrated in the upper 200 meters. Hence, any eddy influence on currents in the channel would be confined within this upper 300 to 400 meters. Below this depth, the currents are driven primarily by the tides.

4.2 SUMMARY OF MEASURED CURRENTS

This evaluation of operational current criteria is based on data obtained to date as part of the HDWCP, as well as previous studies conducted by Wyrtki et al (1969) and Patzert (1969). Following is a summary of the data sources:

(a) Edward K. Noda and Associates (HDWCP)
Sea Data Wave and Current Meter Model 635-12
Location: Upolu Point, HI
Position: 20°17.34'N, 155°54.00'W
Water depth: 170 m
Sensor depth: 10 m
Data period: 5 May 1984 - 26 May 1986
Total duration: 704 days (7 deployments)

(b) Edward K. Noda and Associates (HDWCP)
Aanderaa RCM-5 Current Meters
Location: Alenuihaha Channel,
top of Kohala slope (Station 2)
Position: (approx) 20°27.7'N, 156°0.5'W
Water depth: 930 m (Deployment 1)
920 m (Deployment 2)
Sensor depth: 913 m and 919 m (Deployment 1)
903 m and 909 m (Deployment 2)
Data period: 22 Aug 1985 - 26 Feb 1986
Total duration: 186 days (2 deployments)

(c) Edward K. Noda and Associates (HDWCP)
Aanderaa RCM-5 Current Meters
Location: Alenuihaha Channel,
bottom of Kohala slope (Station 1)

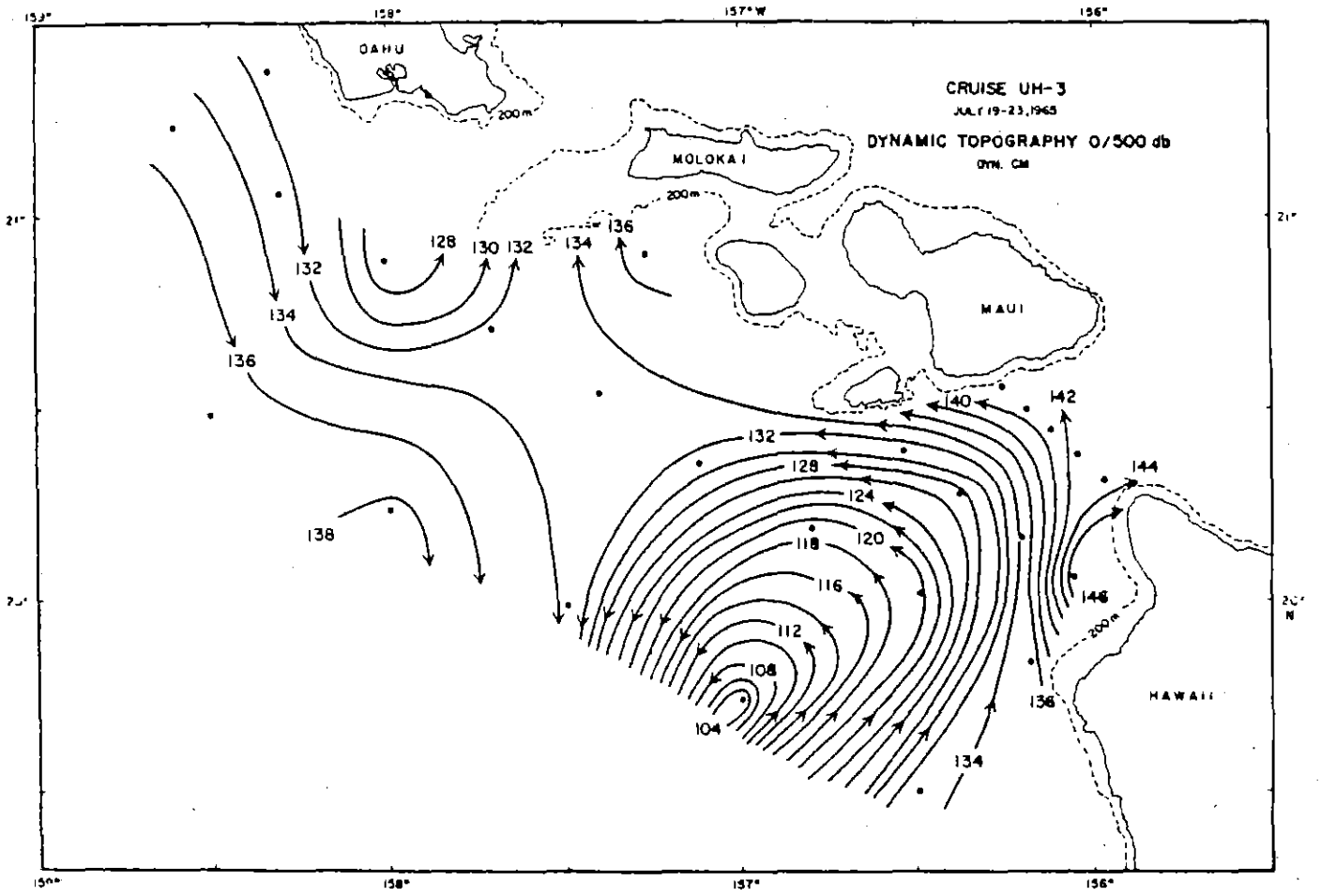


Figure 4.1-6 Dynamic topography 0/500 db from Cruise UH-3, July 19 - 23, 1965. (Patzert, 1969)

Position: (approx) 20°29.9'N, 156°1.7'W
Water depth: 1970 m (Deployment 1)
1910 m (Deployment 2)
Sensor depth: 1953 m and 1959 m (Deployment 1)
1893 m and 1899 m (Deployment 2)
Data period: 22 Aug 1985 - 26 Feb 1986
Total duration: 186 days (2 deployments)

(d) Horizon Marine, Inc. (HDWCP)
Expendable Current Profilers (XCP)
Location: Alenuihaha Channel
Position: 10 stations across channel
Water depth: 175 - 1950 m
Sensor depth: continuous vertical profiles
Data period: 28 May 1985, 1 Jul 1985, 28 Aug 1985
Total duration: instantaneous profiles,
non-synoptic

(e) Wyrtki et al (1969)
Paddle-wheel current meter
Location: Upolu Point, HI
Position: 20°15.8'N, 155°54.4'W
Water depth: 60 m
Sensor depth: 10 m
Data period: 22 Jul 1967 - 12 Aug 1967
Total duration: 21 days

(f) Wyrtki et al (1969)
Geodyne Film-recording current meter
Location: Upolu Point, HI
Position: 20°16.0'N, 155°54.0'W
Water depth: 70 m
Sensor depth: 15 m
Data period: 2 Aug 1968 - 8 Sep 1968
Total duration: 37 days

(g) Wyrtki et al (1969)
Paddle-wheel current meter
Location: Kiakaena Point, south Maui
Position: 20°34.3'N, 156°22.4'W
Water depth: 80 m
Sensor depth: 10 m
Data period: 12 Aug 1967 - 22 Aug 1967
Total duration: 10 days

(h) Wyrtki et al (1969)
Geodyne Magnetic-tape current meter
Location: Kauiki Head, east Maui
Position: 20°43.0'N, 155°58.2'W
Water depth: 60 m
Sensor depth: 18 m
Data period: 3 Aug 1968 - 8 Sep 1968
Total duration: 36 days

(i) Patzert (1969)
Hydrographic data from 20 cruises of observed eddies west of Hawaii.

Figure 4.2-1 depicts the locations of these current data stations. The data are too voluminous to include herein. The reader is referred to the respective reports for specific data.

4.3 TIDAL CURRENTS

Currents below approximately 300-400 meters are not directly influenced by wind stress and eddy effects. These deep currents are driven primarily by the tides, and hence are expected to be quite predictable, given a sufficiently long record to enable resolution of the tidal constituents for any particular location. Since the tidal currents are influenced by bathymetry and island effects, the magnitudes and phases are expected to be different for various locations within the Alenuihaha Channel. Figure 4.3-1 is a co-tidal chart showing the movement of the tide wave through the islands, propagating from the NNE toward the SSW. In the open ocean, peak tidal currents are towards the SSW under the wave crest (high tide) and towards the NNE under the wave trough (low tide). Around the islands, however, the tide wave interacts with the island masses, creating diverging currents on upstream sides and converging currents on downstream sides, eddies around points and headlands, and flow intensification through channels. Tidal currents are also influenced by bathymetry, and tend to follow the depth contours with intensification along steep slopes.

Tidal currents along the proposed cable path are expected to be nearly in phase. However, the amplitudes would vary due to the steep slopes and deep water depths. Peak tidal currents from the Sea Data current meter directly off Upolu Point in water depth of about 170 meters are higher than those at the deepwater Aanderaa Stations 1 and 2. Thus, tidal current components extracted from the Sea Data and Aanderaa data records are used in conjunction with the XCP vertical profile data to estimate tidal currents along the proposed cable path.

4.3.1 Evaluation of Aanderaa Near-Bottom Currents

Appendix B gives semi-diurnal and diurnal tidal ellipses from the near-bottom current data obtained during Deployments 1 and 2 spanning the period 22 August 1985 through 26 February 1986. Table 4.3-1 summarizes the amplitudes and directions along the principal axis (peak tidal currents) for each ellipse and the combined peak tidal current vector. Note that the semi-diurnal and diurnal tidal components for Station 1 (bottom of Kohala slope) are

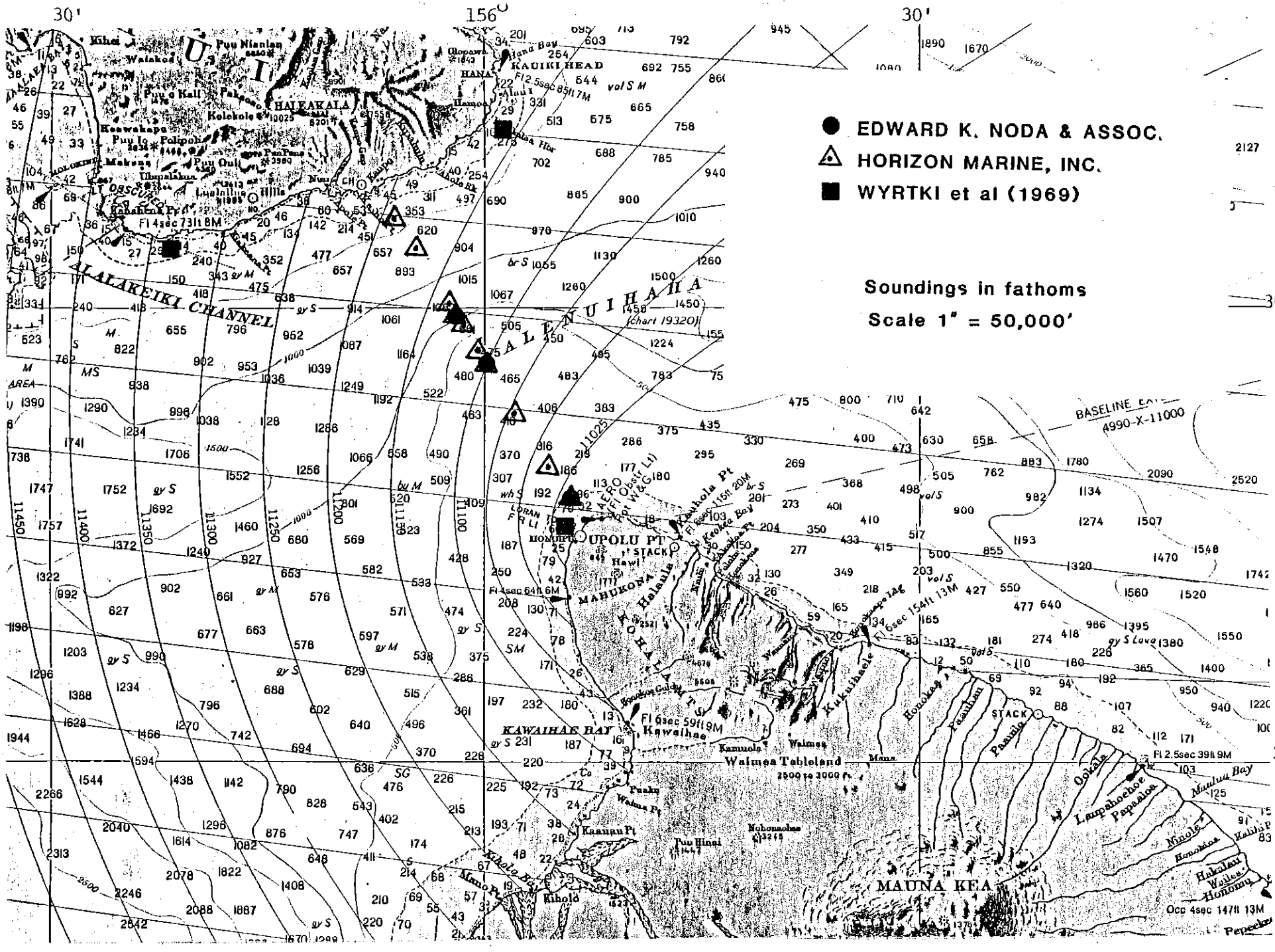


Figure 4.2-1 Location of Current Data Stations

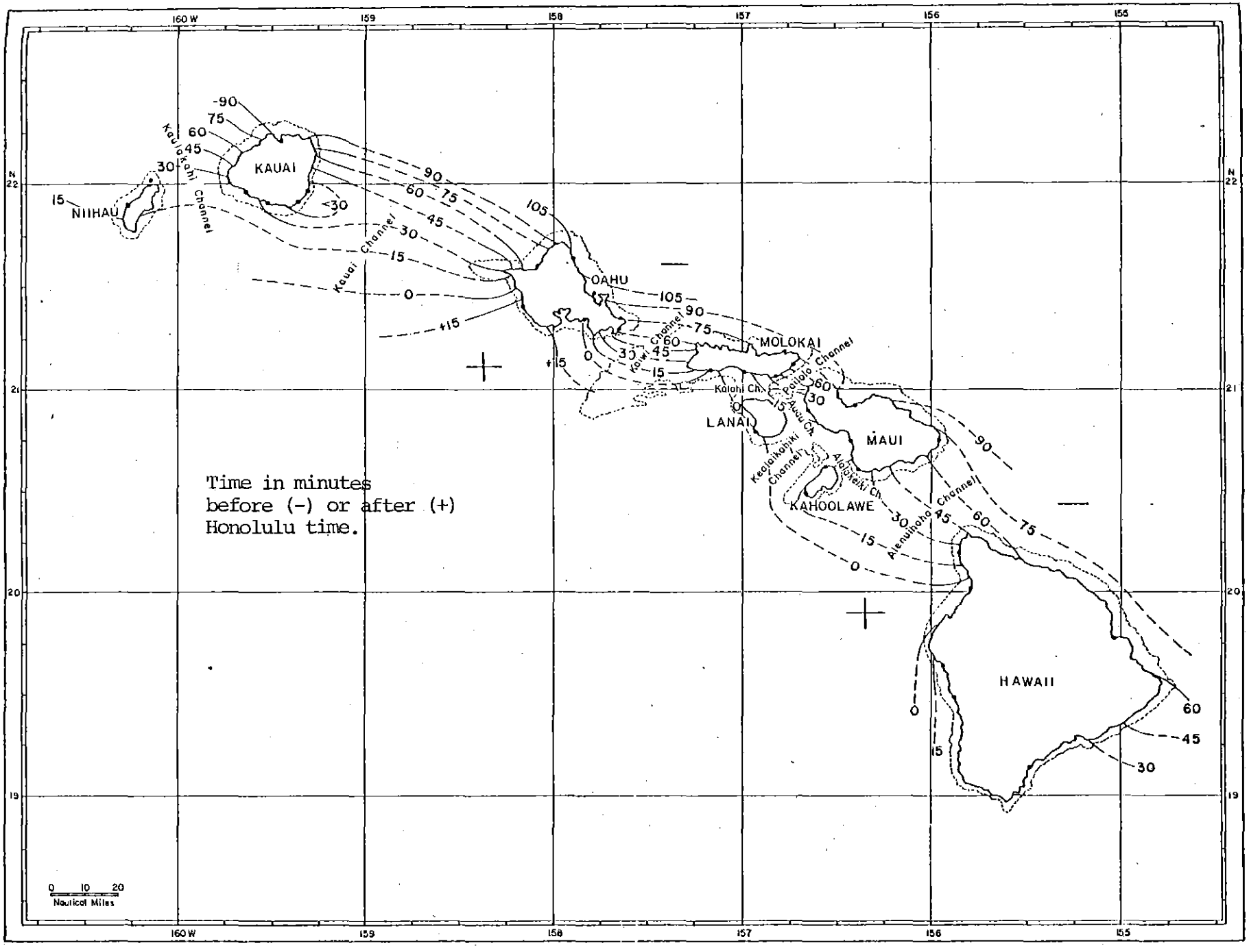


Figure 4.3-1 Co-tidal chart for the Hawaiian Islands. (Laevastu et al, 1964)

Table 4.3-1 Alenuihaha Tidal Currents, Top and Bottom of Kohala Slope

	Diurnal		Semi-diurnal		Combined	
	Amplitude (cm/sec)	Dir. °T	Amplitude (cm/sec)	Dir. °T	Amplitude (cm/sec)	Dir. °T
NEAR-BOTTOM STATION 1 (1910-1970 m depth) Bottom of Kohala Slope						
Deployment 1 (22 Aug-2 Nov 85):						
Maximum (2 S.D.)						
Top meter	14.2	72	19.2	79	33.3	76
Bottom meter	16.3	65	19.6	70	35.9	68
Typical (1 S.D.)						
Top meter	7.1	72	9.6	79	16.7	76
Bottom meter	8.2	65	9.8	70	18.0	68
Deployment 2 (4 Nov 85-26 Feb 86):						
Maximum (2 S.D.)						
Top meter	20.1	70	21.2	79	41.2	75
Bottom meter	19.1	60	20.2	70	39.1	65
Typical (1 S.D.)						
Top meter	10.1	70	10.6	79	20.6	75
Bottom meter	9.6	60	10.1	70	19.6	65
NEAR-BOTTOM STATION 2 (920-930 m depth) Top of Kohala Slope						
Deployment 1 (22 Aug-2 Nov 85):						
Maximum (2 S.D.)						
Top meter	9.8	87	29.3	68	38.7	73
Bottom meter	10.1	91	29.5	69	39.1	74
Typical (1 S.D.)						
Top meter	4.9	87	14.6	68	19.4	73
Bottom meter	5.1	91	14.7	69	19.6	74
Deployment 2 (4 Nov 85-26 Feb 86):						
Maximum (2 S.D.)						
Top meter	12.1	79	25.0	59	36.6	65
Bottom meter	11.7	74	24.8	56	36.1	62
Typical (1 S.D.)						
Top meter	6.0	79	12.5	59	18.3	65
Bottom meter	5.8	74	12.4	56	18.1	62

(Note that principal axis direction as given is the angle from true north. Add 180 degrees to this direction to determine principal axis alignment.)

of the same order of magnitude and direction, while for Station 2 (top of Kohala slope) the semi-diurnal component is 2-3 times larger than the diurnal component and with a 20° shift in principal axis direction. For Station 1, the maximum combined peak tidal current is 41 cm/sec and the typical combined peak current is 21 cm/sec. The current direction is 65-76°T/245-256°T. The Deployment 2 location is closer to the bottom of the steep Kohala slope than Deployment 1, and hence the tidal currents are higher. For Station 2, the maximum combined peak tidal current is 39 cm/sec and the typical combined peak current is 20 cm/sec. The current direction is 62-74°T/242-254°T. The Deployment 1 location is a little closer to the edge of the steep drop-off than Deployment 2. While the individual tidal components are quite different between Station 1 and Station 2, the maximum combined peak currents are within 5% of each other.

The time series of current speed and direction show the very strong tidal dependence. Current speeds are oscillatory with peak speeds occurring at periods between about 6 and 12 hours corresponding to the high and low tide cycles of the semi-diurnal and diurnal tidal constituents. Tides in Hawaii are predominantly semi-diurnal with diurnal inequality. Figure 4.3-2 shows a time series of current speed for predominantly semi-diurnal tides (13-19 September 1985). Peak current direction is towards the WSW during Honolulu high tide and towards the ENE during Honolulu low tide. Figure 4.3-3 shows a time series of current speed for predominantly diurnal tides (17-24 December 1985). For Station 1, the peak current direction is typically towards the WSW and can occur during high and/or low tide, depending on the semi-diurnal tidal phase constituent. For Station 2, peak current direction is typically towards the ENE.

Table 4.3-2 lists all occurrences of current speeds exceeding 40 cm/sec during the 22 August 1985 - 26 February 1986 data period. Figures 4.3-4 thru 4.3-9 depict the current speed/direction, tidal height, and wind speed/direction for the long-duration events. (Only even hourly data points are plotted.) Note that these extreme currents generally occur during mixed tides with strong diurnal component and tidal heights exceeding 2 feet. Note also that these extreme currents have occurred during both light and strong wind conditions. Maximum measured current speed was 55 cm/sec for Station 1 at the top meter (6 February 1986, 2140 hrs). Maximum measured current speed at Station 2 was 52.2 cm/sec at the bottom meter (31 December 1985, 0040 hrs). The maximum duration in which currents persisted above 40 cm/sec was about 4 hours for Station 1 (11 January 1986, top meter). The maximum duration in which currents persisted above 40 cm/sec for Station 2 was about 2 hours (31 December 1985, bottom meter).

Figures 4.3-10 and 4.3-11 depict the cumulative percent

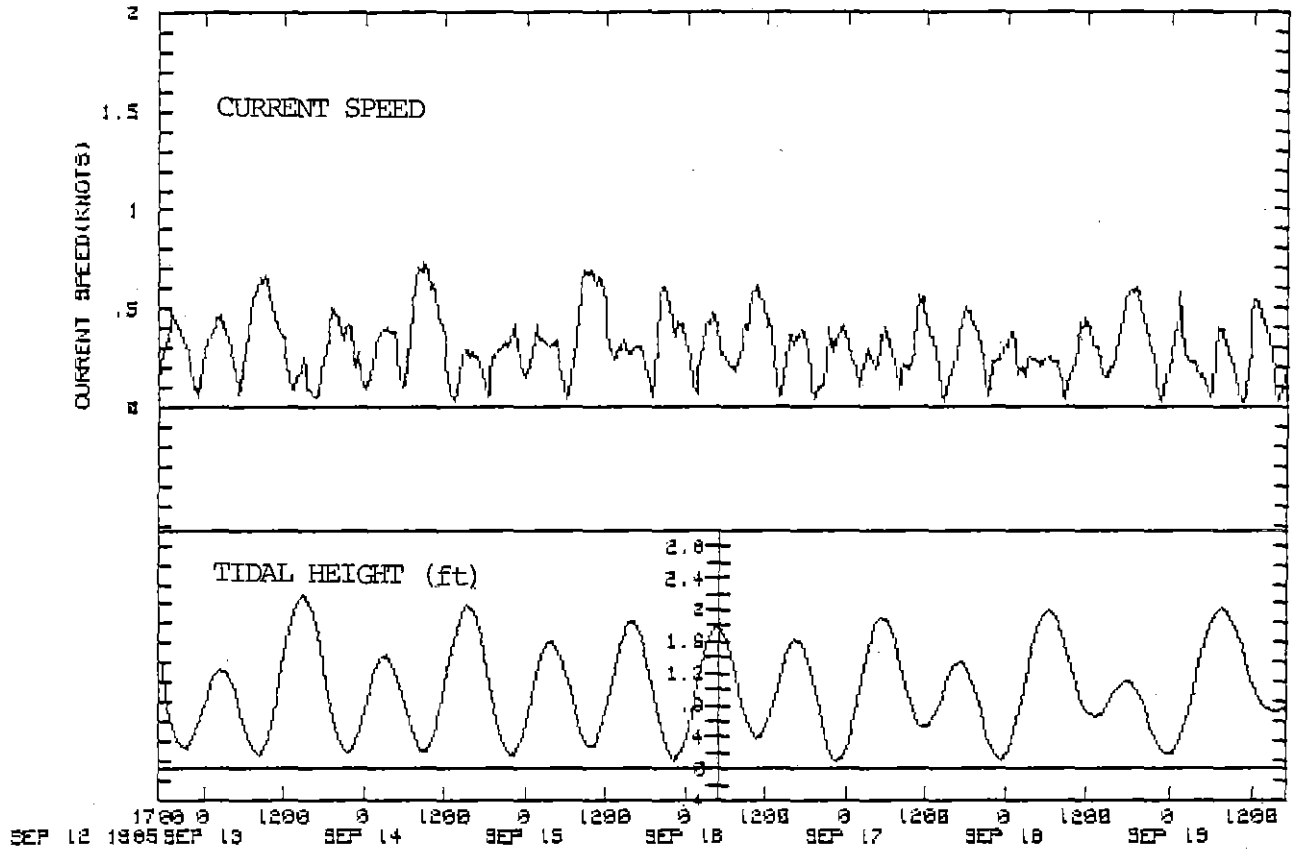


Figure 4.3-2 Time series of current speed and Honolulu tidal height for predominantly semi-diurnal tides, Aanderaa near-bottom current meter, Station 1, top meter.

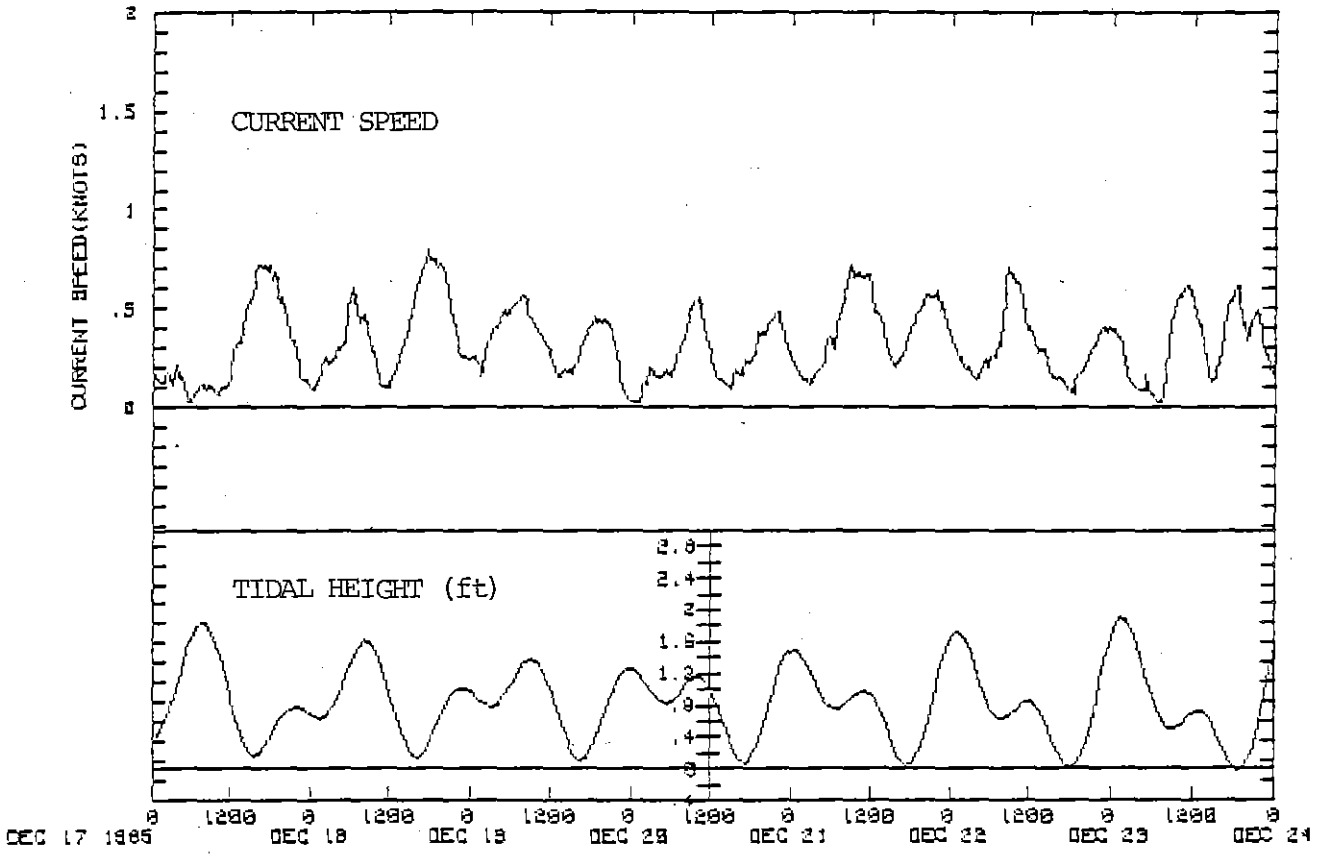
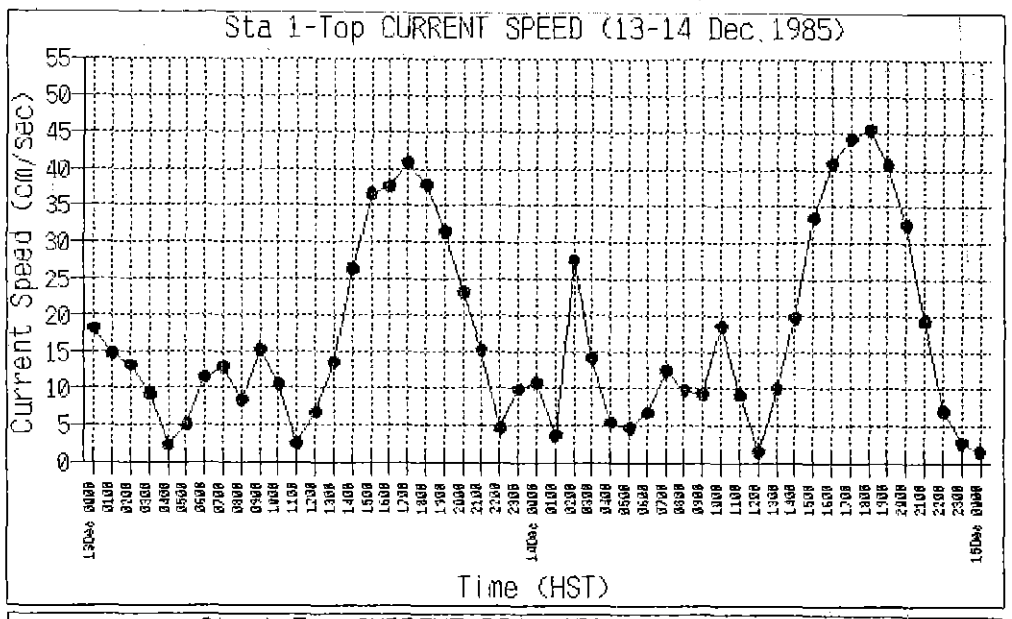


Figure 4.3-3 Time series of current speed and Honolulu tidal height for predominantly diurnal tides, Aanderaa near-bottom current meter, Station 1, top meter.

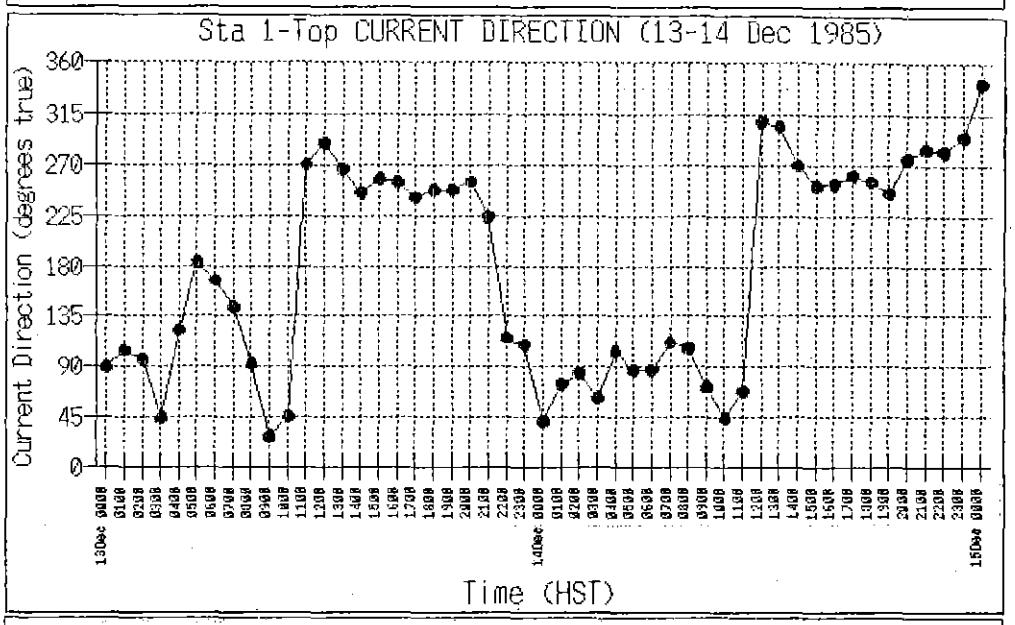
Table 4.3-2 Alenuihaha Near-Bottom Measured Currents >40 cm/sec
(22 August 1985 - 26 February 1986)

Date	Time (HST)	Sta 1-top Speed	Sta 1-top Dir°T	Sta 1-bottom Speed	Sta 1-bottom Dir°T	Sta 2-top Speed	Sta 2-top Dir°T	Sta 2-bottom Speed	Sta 2-bottom Dir°T
11Sep85	1000	42.9	75						
13Nov85	2320					42.0	58		
	2340					41.0	35		
13Dec85	1620	40.4	234						
	1640	41.3	255						
	1700	40.8	241						
14Dec85	1540	40.4	243						
	1600	40.8	253						
	1620	43.8	246						
	1640	44.4	256						
	1700	44.2	260						
	1720	40.1	255	41.6	248				
	1740	44.0	247	40.8	240				
	1800	45.5	255						
	1820	44.0	259						
	1840	41.1	253	42.1	233				
	1900	40.7	245	41.3	234				
14Dec85	2140							42.5	102
15Dec85	0140							40.3	54
15Dec85	1700	40.8	266						
16Dec85	0020							40.8	63
18Dec85	1940	40.6	250						
30Dec85	2300							40.7	51
	2320							47.4	47
	2340							47.2	56
31Dec85	0000							51.6	75
	0020							51.9	63
	0040							52.2	43
	0100							51.2	37
	0120							41.5	63
9Jan86	1320							43.4	227
	1340							41.9	237
	1400							43.3	239
10Jan86	1520							42.6	262
11Jan86	0020	41.1	68						
11Jan86	1420	41.5	258						
	1440	40.6	249						
	1500	45.8	258						
	1520	45.7	261						
	1540	48.9	249						
	1600	50.2	268	42.9	233				
	1620	47.9	250	41.5	236				
	1640	47.4	253	44.2	244				
	1700	49.8	244	43.9	243				
	1720	46.8	252	44.1	236				
	1740	44.8	253	43.2	249				
	1800	42.7	265	45.2	233				
	1820	40.4	268	43.0	242				
	1840	40.9	271	42.0	246				

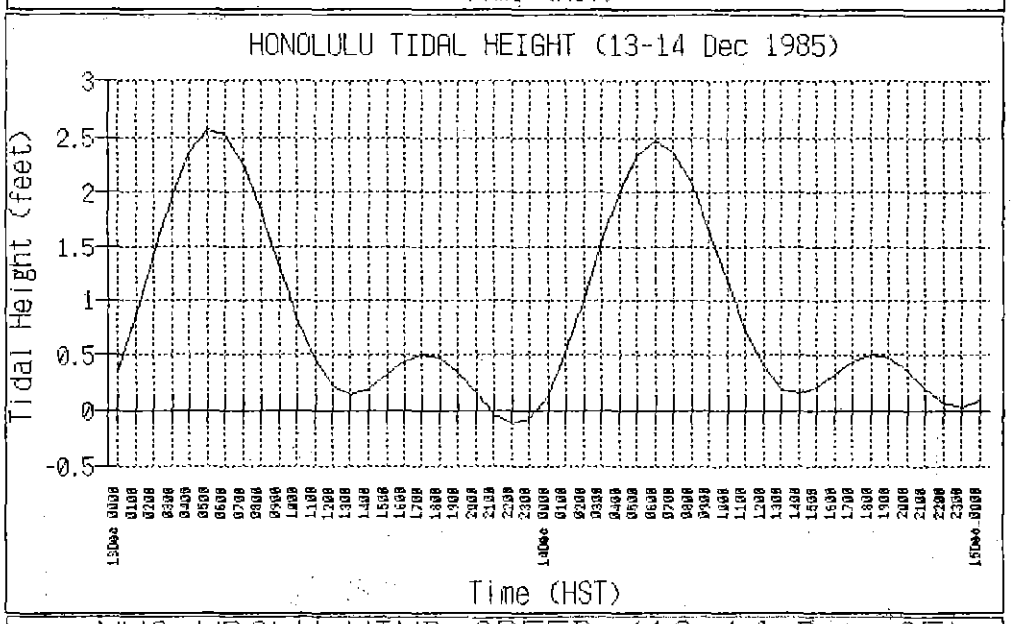
Date	Time (HST)	Sta 1-top Speed	Sta 1-top Dir°T	Sta 1-bottom Speed	Sta 1-bottom Dir°T	Sta 2-top Speed	Sta 2-top Dir°T	Sta 2-bottom Speed	Sta 2-bottom Dir°T
11Jan86	2340	45.0	70						
12Jan86	0000	42.5	63						
12Jan86	0040			43.4	70				
	0100			40.2	75				
15Jan86	0240	40.1	94						
15Jan86	0820							40.6	278
20Jan86	1120	40.6	278						
	1140	42.0	284						
	1200	41.7	276						
	1220	42.8	277	40.1	263				
	1240	42.3	276						
	1300	40.0	295						
	1320			41.7	261				
21Jan86	1500	40.6	253						
28Jan86	1640	40.0	243						
6Feb86	2040	41.3	60						
	2100	48.4	62						
	2120	51.4	75						
	2140	55.0	82						
	2200	52.3	81	45.5	64				
	2220	51.8	87	49.3	74				
	2240	49.4	80	51.3	74				
	2300	41.5	87	44.5	71				
	2320			50.7	81				
	2340			42.6	76				
9Feb86	2120	44.1	58						
	2140	48.4	71						
	2200	46.2	75						
	2220	43.4	88	41.2	58				
	2240	45.2	99	42.5	66				
	2300	43.2	84	41.1	79				
9Feb86	2340			40.4	94				
10Feb86	2120	40.8	69						
10Feb86	2240	40.7	99						
17Feb86	0900	40.4	229						
18Feb86	0820	40.1	275						
	0840	40.9	276						
21Feb86	1240	40.0	249						
21Feb86	1320	40.0	239						
24Feb86	1400	41.2	255						
	1420	40.4	270						
25Feb86	1440	41.9	277						
	1500	41.5	271						
	1520	42.0	264						
	1540			40.5	247				



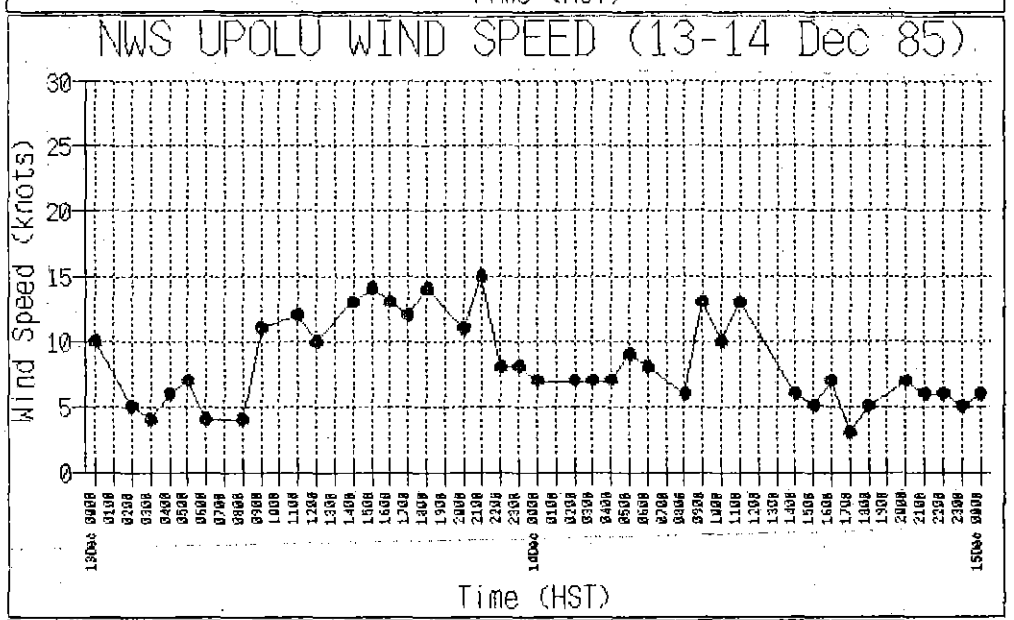
CURRENT SPEED



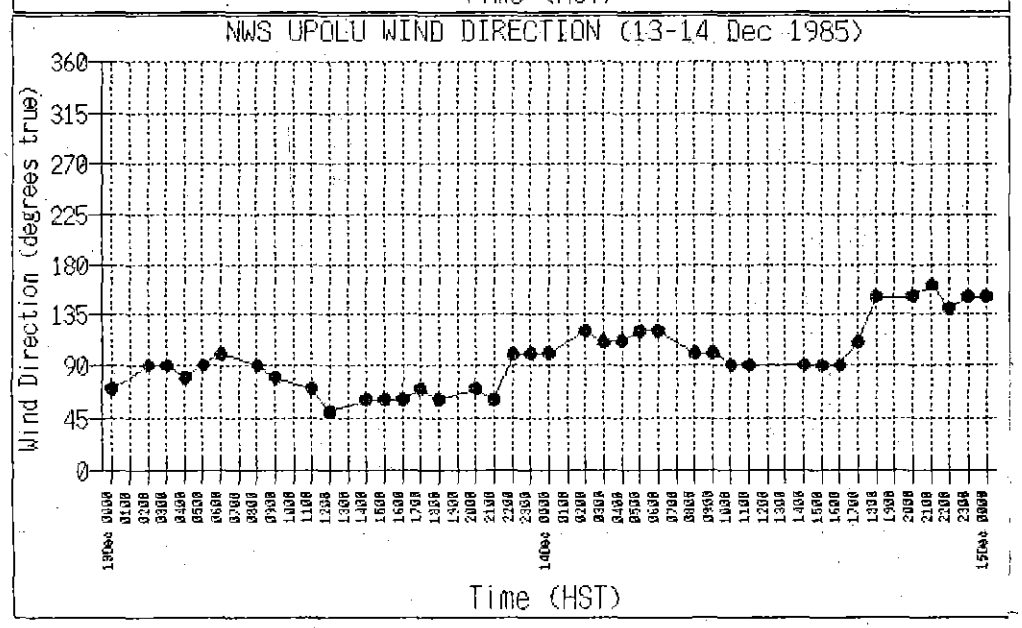
CURRENT DIRECTION



TIDAL HEIGHT

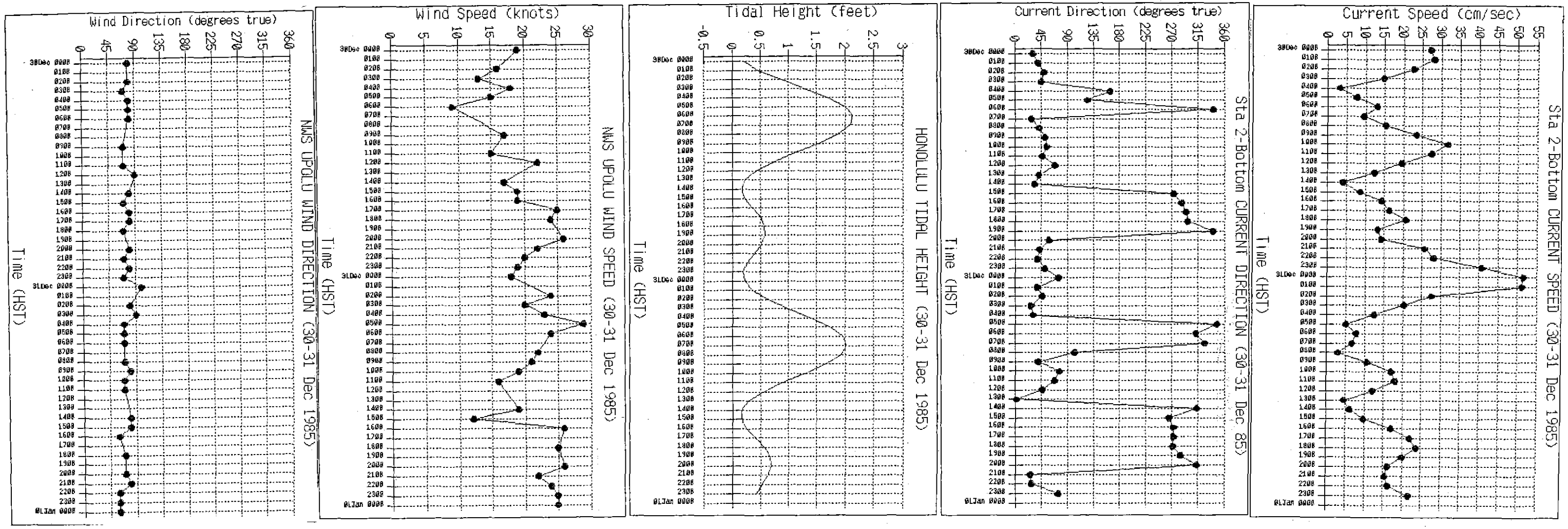


WIND SPEED



WIND DIRECTION

Figure 4.3-4 Comparison of currents, tide and winds, 13-14 Dec 1985, Aanderaa Station 1, top meter



CURRENT SPEED

CURRENT DIRECTION

TIDAL HEIGHT

WIND SPEED

WIND DIRECTION

Figure 4.3-5 Comparison of currents, tide and winds, 30-31 Dec 1985, Aanderaa Station 2, bottom meter

CURRENT SPEED

CURRENT DIRECTION

TIDAL HEIGHT

WIND SPEED

WIND DIRECTION

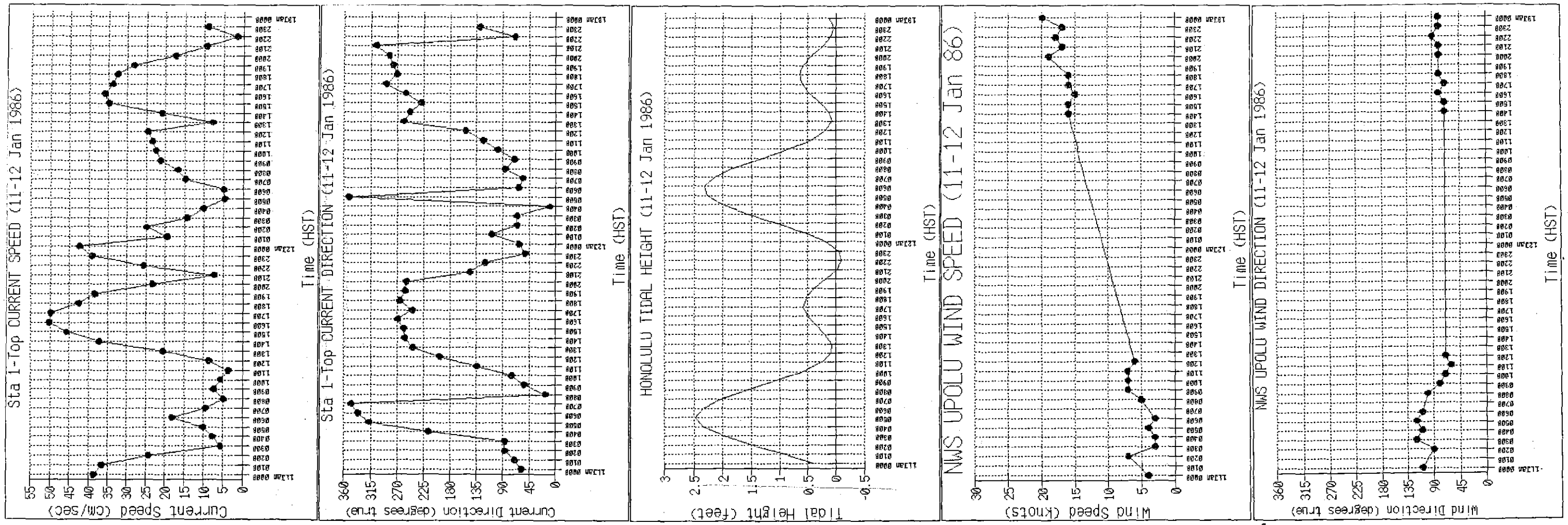


Figure 4.3-6 Comparison of currents, tide and winds, 11-12 Jan 1986, Aanderaa Station 1, top meter

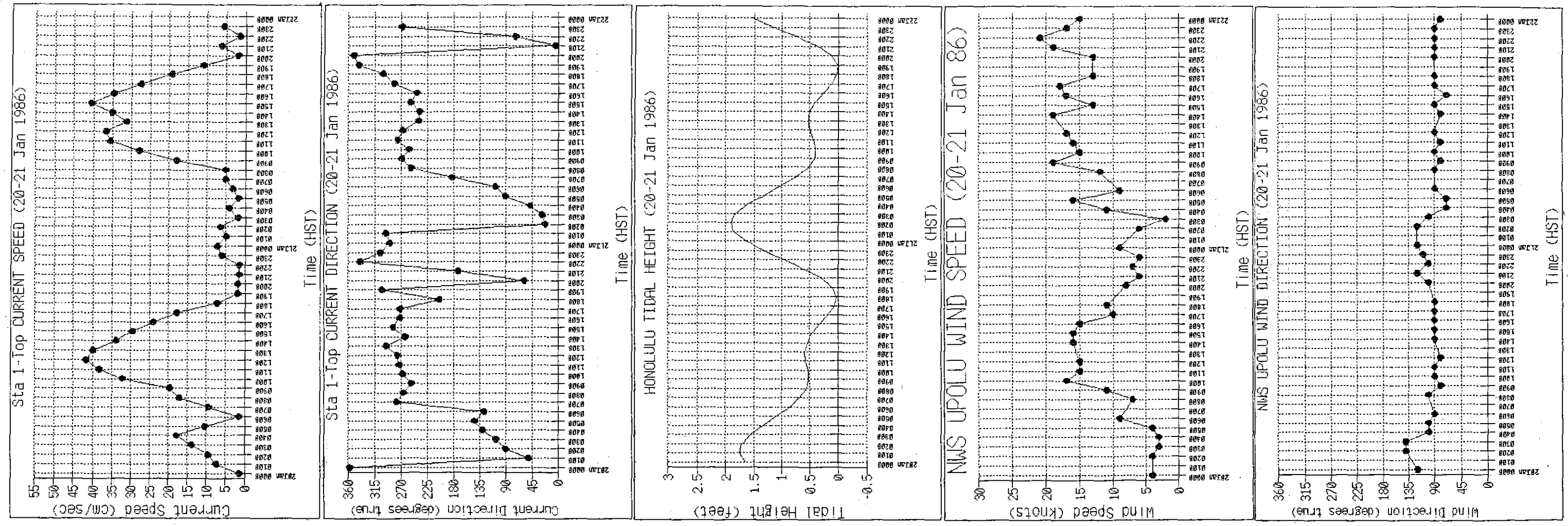
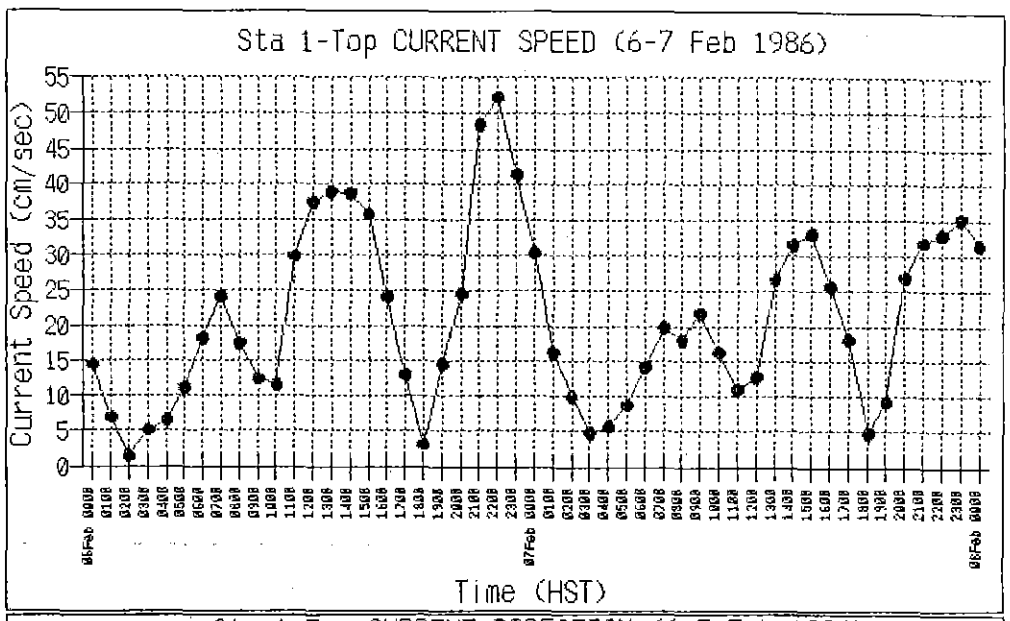
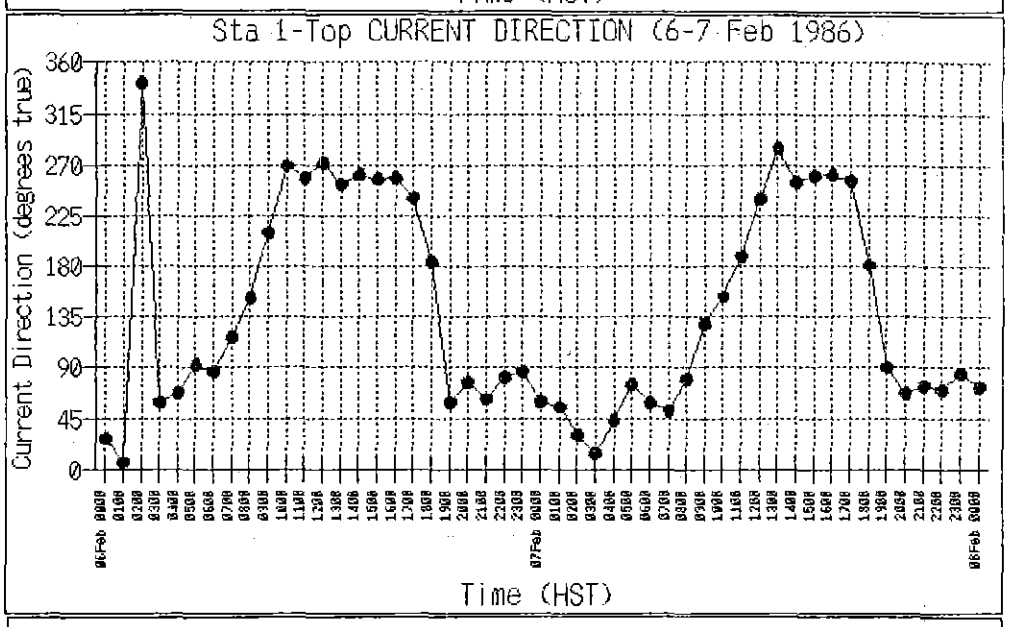


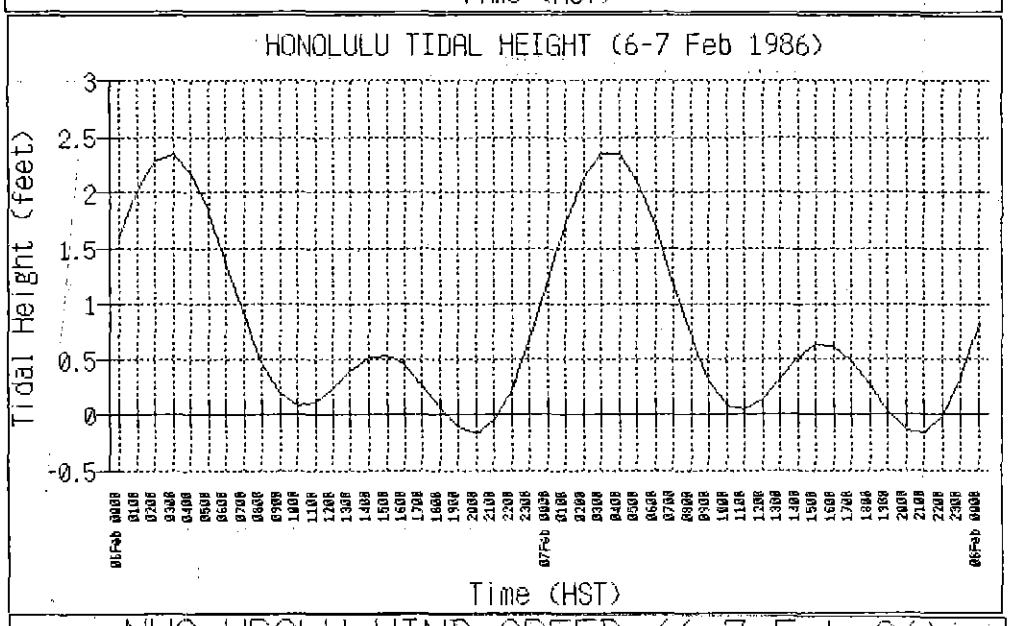
Figure 4.3-7 Comparison of currents, tide and winds, 20-21 Jan 1986, Aanderaa Station 1, top meter



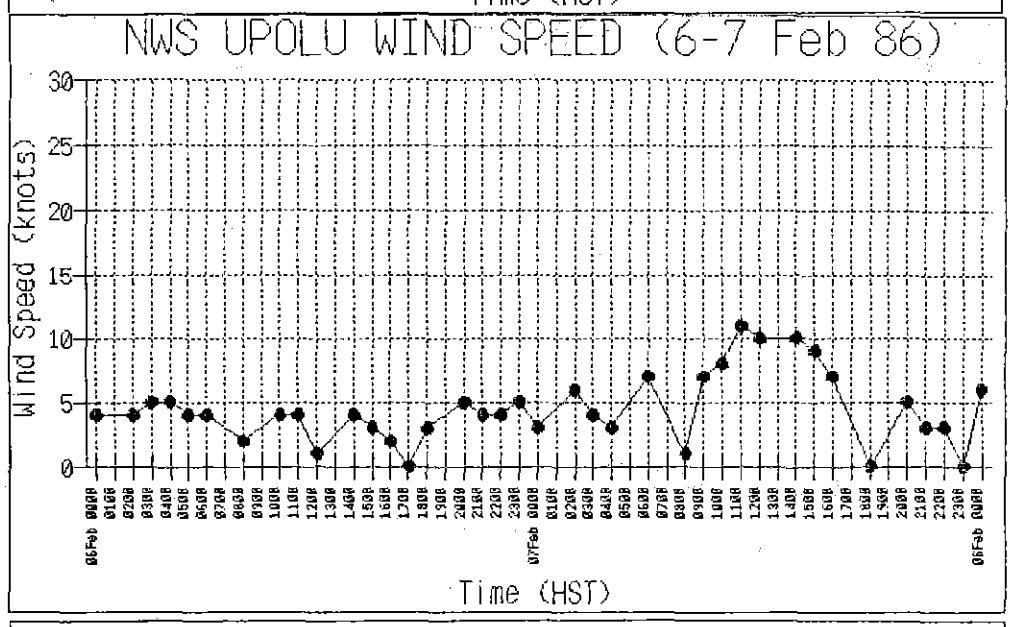
CURRENT SPEED



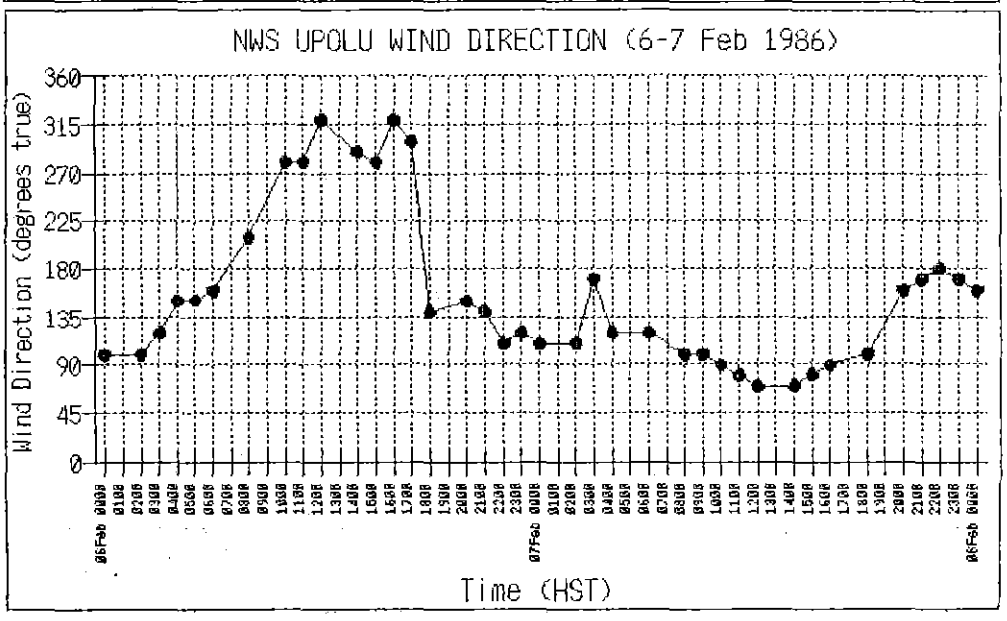
CURRENT DIRECTION



TIDAL HEIGHT

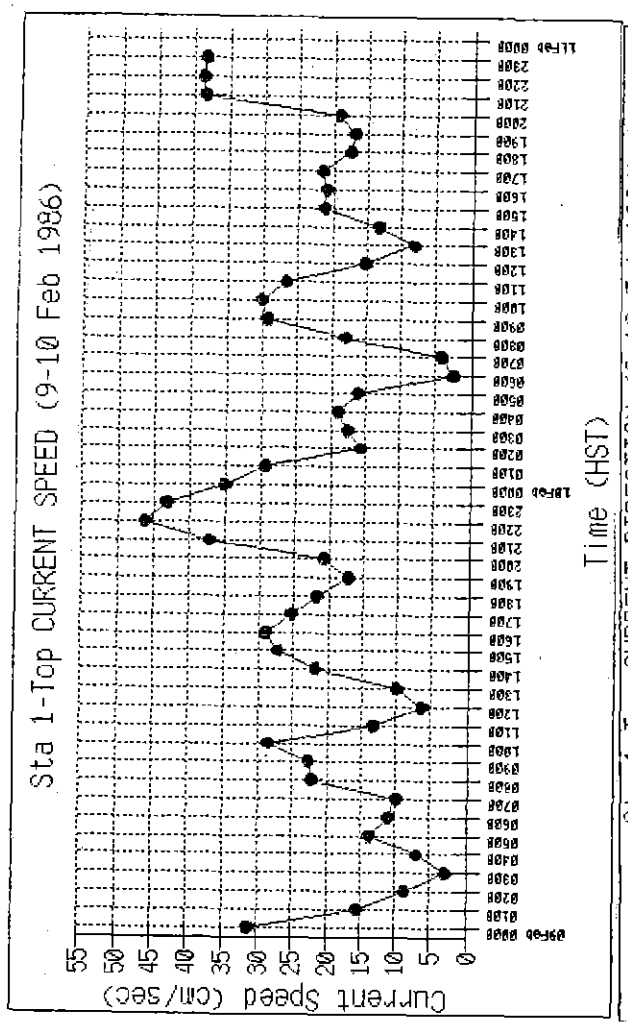


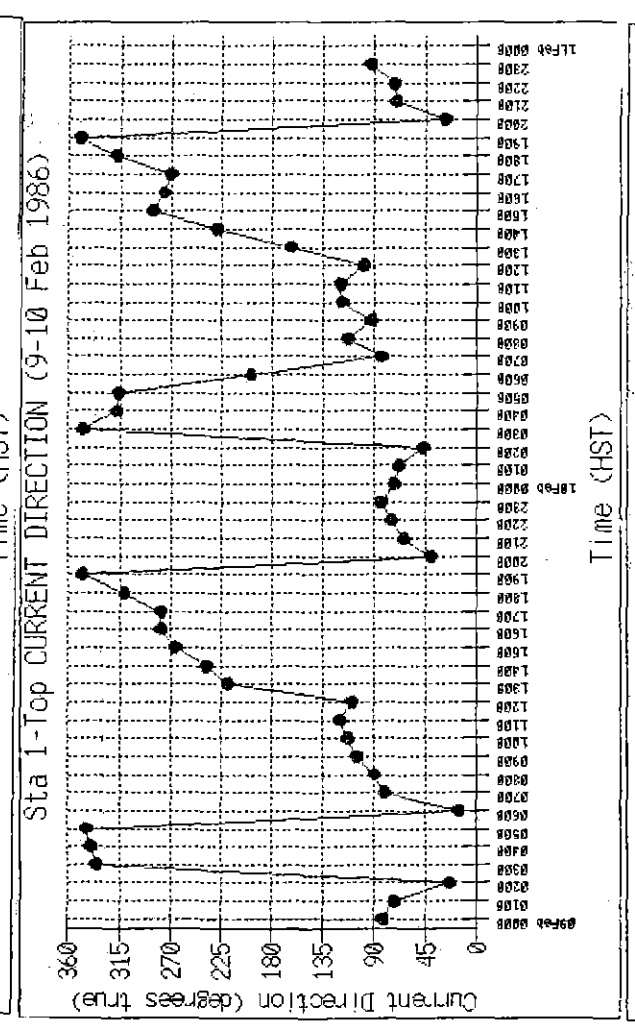
WIND SPEED

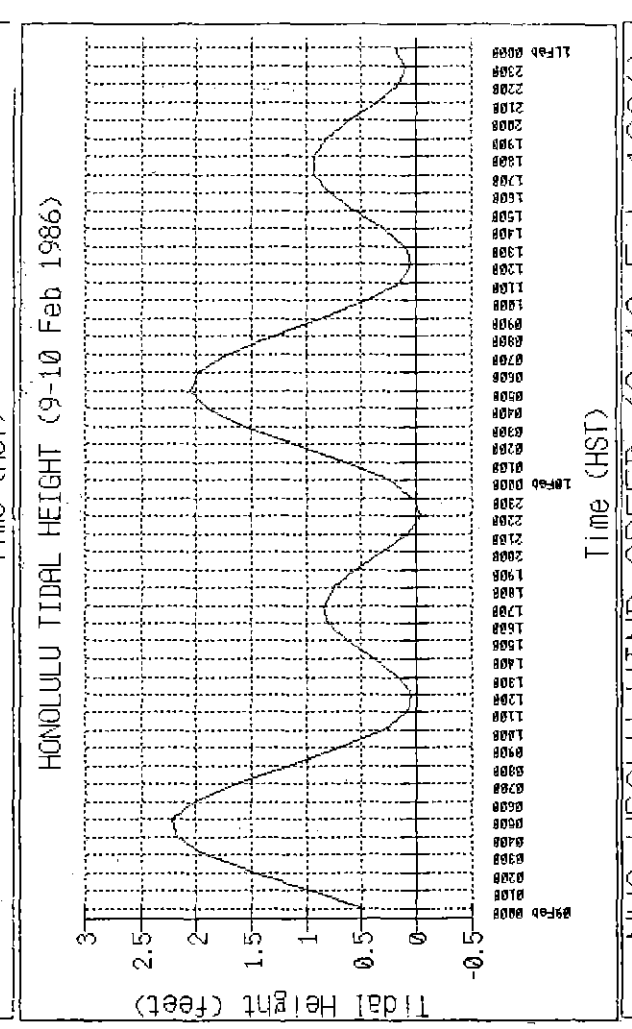


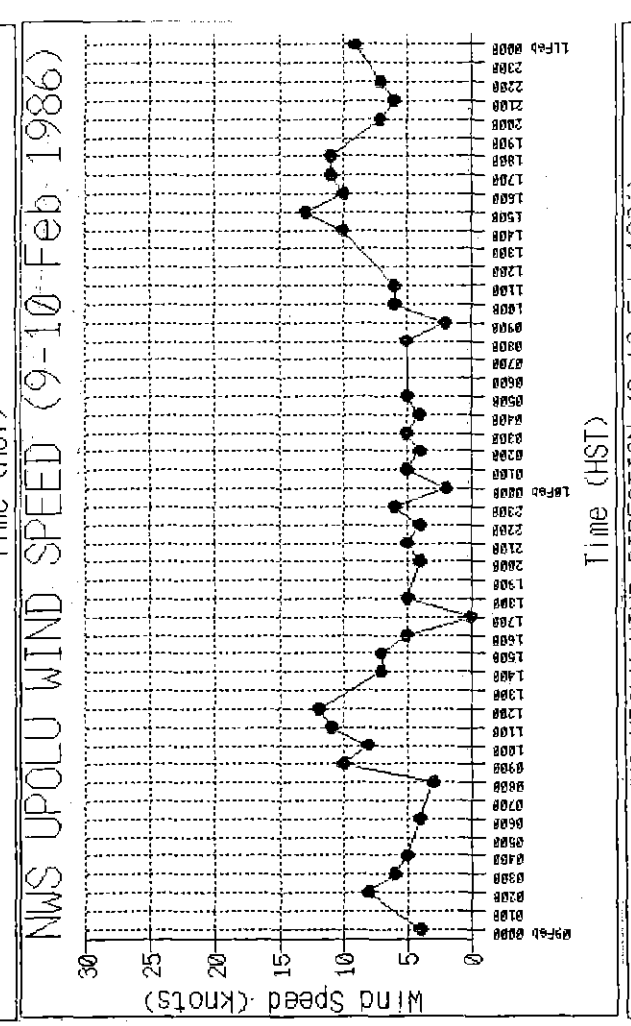
WIND DIRECTION

Figure 4.3-8 Comparison of currents, tide and winds, 6-7 Feb 1986, Aanderaa Station 1, top meter









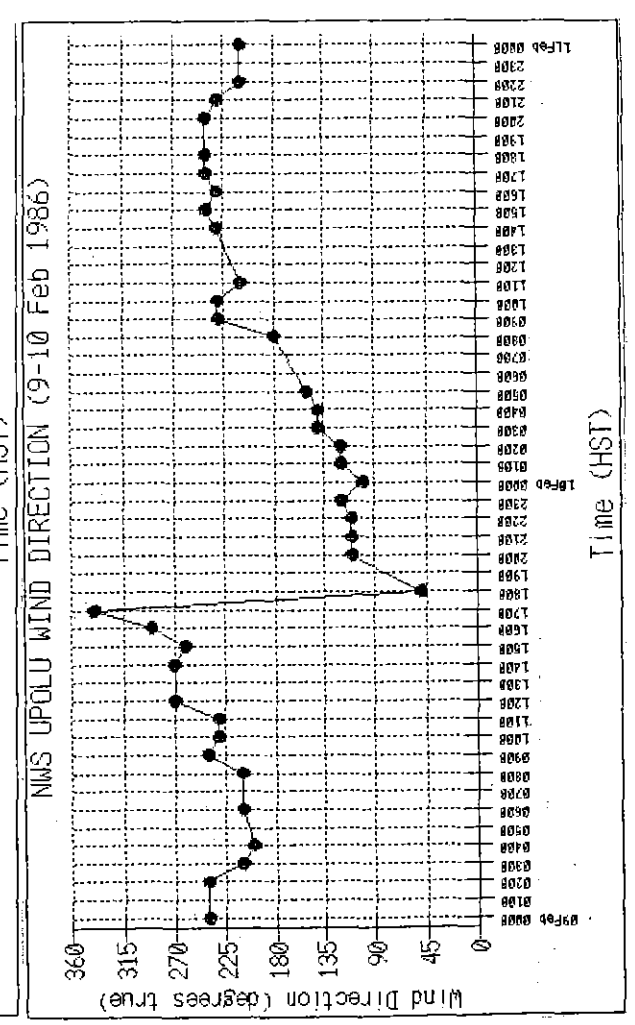


Figure 4.3-9 Comparison of currents, tide and winds, 9-10 Feb 1986, Aanderaa Station 1, top meter

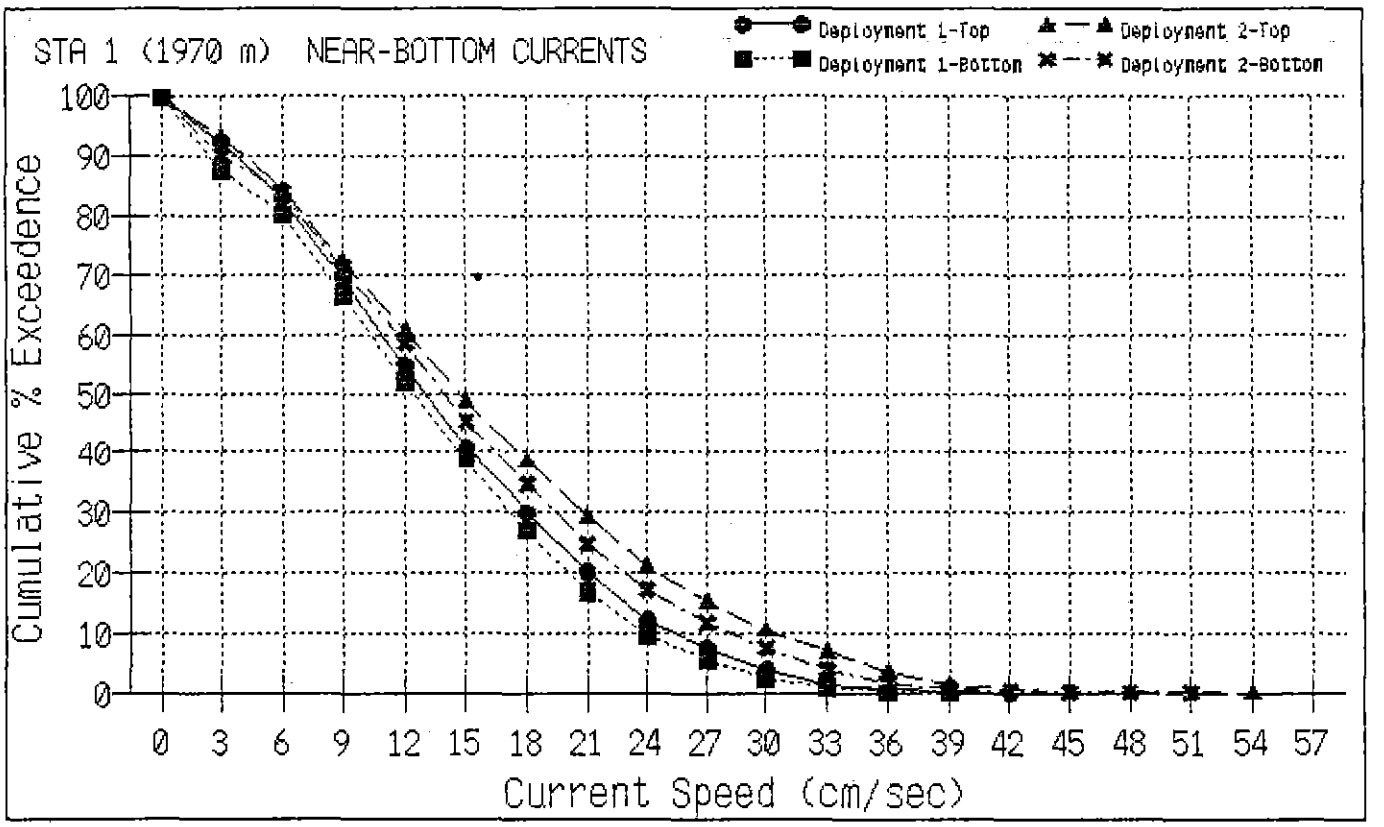


Figure 4.3-10 Cumulative percent exceedence for currents at Station 1 (bottom of Kohala slope)

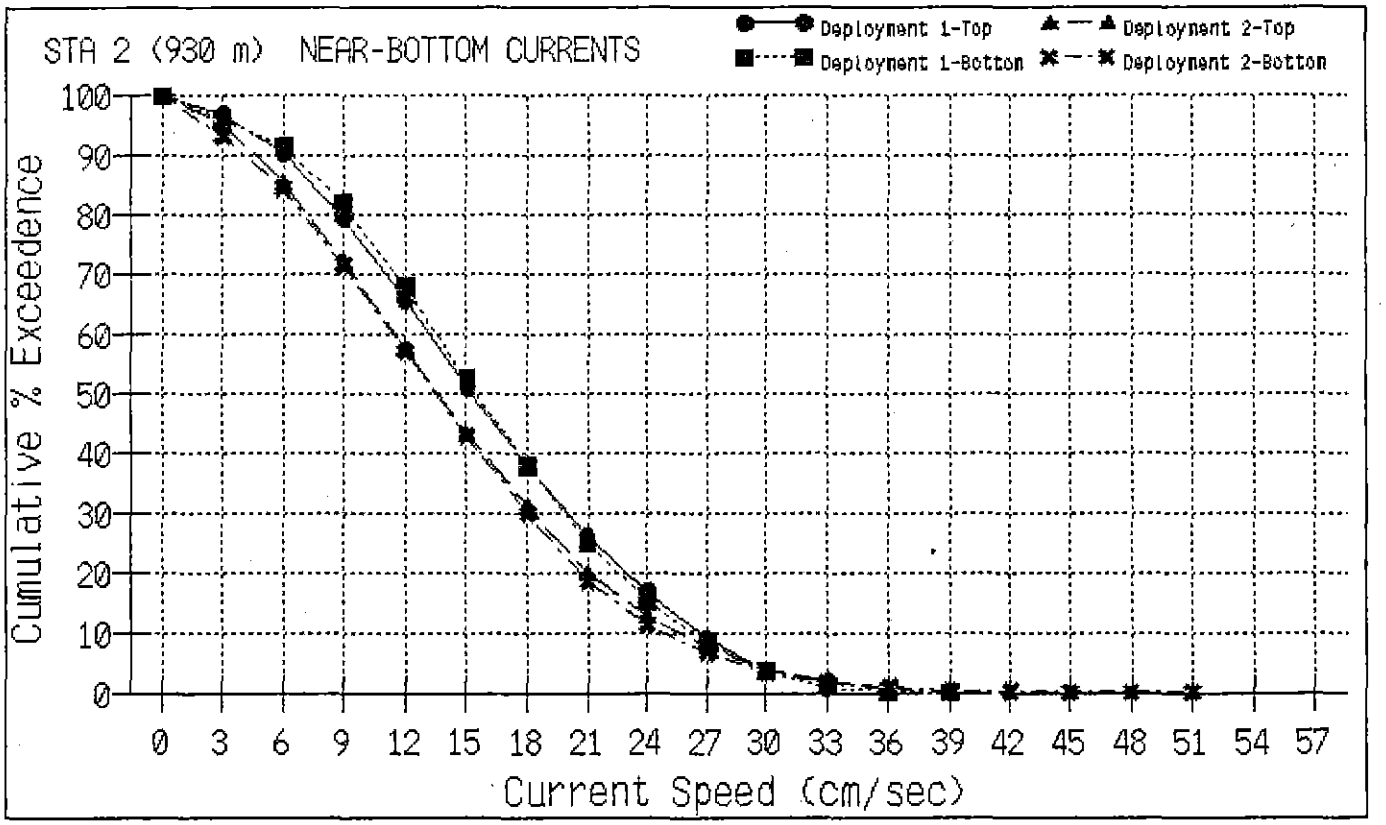


Figure 4.3-11 Cumulative percent exceedence for currents at Station 2 (top of Kohala slope)

exceedence for the measured near-bottom currents at Station 1 and Station 2, respectively. Based on combined statistics for Deployments 1 and 2, currents exceeded 40 cm/sec about 0.5% and 0.2% of the time for Station 1 top and bottom meters, respectively. For Station 2, the currents exceeded 40 cm/sec about 0.01% and 0.1% of the time for the top and bottom meters, respectively. Based on combined statistics for Deployments 1 and 2, currents exceeded 20 cm/sec about 25-29% of the time for both Stations, top and bottom meters. The maximum duration in which currents persisted above 20 cm/sec was 19 and 11 hours for Station 1 and Station 2, respectively.

Principal tidal current constituents were calculated for Deployment 2, as given in Tables 4.3-3 and 4.3-4 for Station 1-top and 2-bottom, respectively. Each constituent is separated into a north-south and east-west component. Deployment 2 is a longer data record than Deployment 1, and is expected to yield more accurate resolution of the tidal constituents. For a given station location, comparison between the top and bottom meters was quite good.

The tidal current constituents were used to predict the tidal currents for comparison with the measured currents. Figures 4.3-12 through 4.3-15 show the comparisons for four of the high current occurrences. In Figure 4.3-12 (30-31 December 1985), there appears to be a northeasterly current which amplifies the ebb tide currents and suppresses the westerly flood tide currents. In Figure 4.3-13 (20-21 January 1986), the mean current switches directions, amplifying the westerly tidal currents. This mean westerly current almost nearly prevents tidal current reversal towards the northeast. In Figure 4.3-14 (6-7 February 1986), the mean current apparently starts to shift back towards the northeasterly direction. In Figure 4.3-15 (9-10 February 1986), we can clearly see the influence of a mean easterly current.

Figure 4.3-16 shows progressive vector plots of daily resultant currents for the predicted tidal currents and measured currents for Deployment 2, Station 1, top meter. It is apparent that there is a mean flow superposed on the reversing tidal currents which can result in net drift of about 5-10 nautical miles per day (10-20 cm/sec). As indicated by the previous Figures 4.3-12 through 4.3-15, this mean current flows in either an east-northeasterly or westerly direction. The apparent period of oscillation is on the order of 20-25 days. Figure 4.3-17 shows histograms of current speed and direction for the measured currents and predicted tidal currents.

Figure 4.3-18 compares the cumulative percent exceedence for the measured currents and predicted tidal currents for Deployment 2, Station 1, top meter. The maximum predicted tidal current during this period was 38.3 cm/sec as compared

Table 4.3-3 Principal Tidal Current Constituents, Bottom of the Kohala Slope, Station 1-top, Deployment 2 (4 Nov 85 - 26 Feb 86)

DEPLOYMENT NUMBER: 2 STATION NUMBER: 1T

MEAN OF NORTH-SOUTH COMPONENTS = .70 CM/SEC
MEAN OF EAST-WEST COMPONENTS = -2.03 CM/SEC

SEMI-DIURNAL TIDES

COMPONENT	PERIOD (Hour)	NORTH - SOUTH AMPLITUDE (cm/sec)	NORTH - SOUTH PHASE (Deg)	EAST - WEST AMPLITUDE (cm/sec)	EAST - WEST PHASE (Deg)
K2	11.90	.89	65.19	.25	317.67
S2	12.00	1.93	76.38	3.12	171.90
T2	12.02	1.59	323.10	2.91	284.71
L2	12.19	.53	327.81	.92	130.91
M2	12.42	2.46	38.00	12.65	57.00
N2	12.66	1.67	120.39	2.28	171.62
ν2	12.60	.88	95.30	1.02	327.38
2N2	12.91	.58	261.21	.74	252.92

DIURNAL TIDES

COMPONENT	PERIOD (Hour)	NORTH - SOUTH AMPLITUDE (cm/sec)	NORTH - SOUTH PHASE (Deg)	EAST - WEST AMPLITUDE (cm/sec)	EAST - WEST PHASE (Deg)
(OO)1	22.31	.35	90.68	.32	343.38
J1	23.10	.89	40.70	.57	329.72
K1	23.94	3.83	160.58	9.72	148.08
P1	24.07	.53	286.57	1.62	294.33
M1	24.83	.31	135.49	.55	234.87
O1	25.82	2.29	123.25	6.43	111.71
RHO1	26.72	.89	22.50	.42	269.13
Q1	26.87	.28	201.85	1.48	227.56

Figure 4.3-4 Principal Tidal Current Constituents, Top of the Kohala Slope, Station 2-bottom, Deployment 2 (4 Nov 85 - 26 Feb 86)

DEPLOYMENT NUMBER: 2 STATION NUMBER: 2B

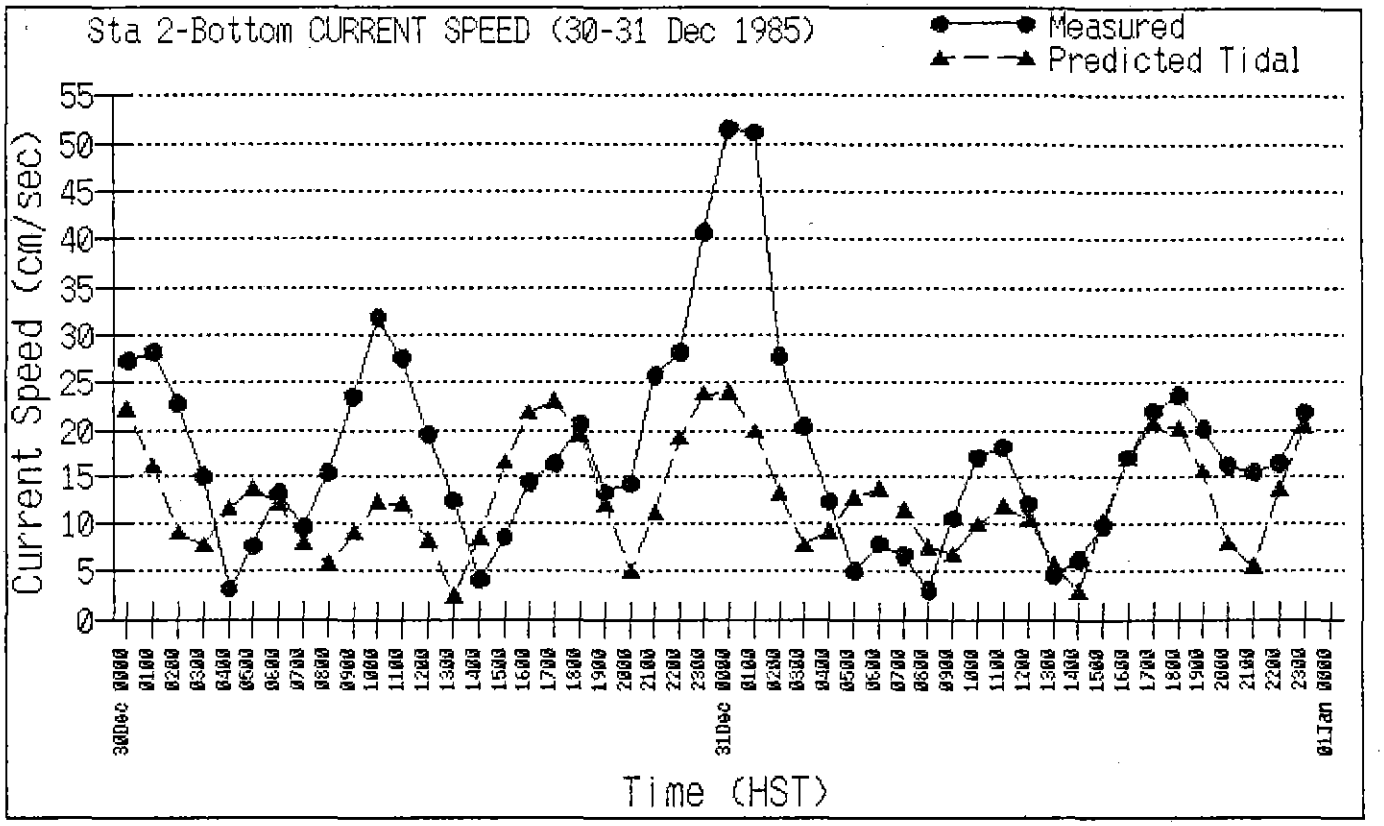
MEAN OF NORTH-SOUTH COMPONENTS = 3.86 CM/SEC
MEAN OF EAST-WEST COMPONENTS = .02 CM/SEC

SEMI-DIURNAL TIDES

COMPONENT	PERIOD (Hour)	NORTH - SOUTH AMPLITUDE (cm/sec)	NORTH - SOUTH PHASE (Deg)	EAST - WEST AMPLITUDE (cm/sec)	EAST - WEST PHASE (Deg)
K2	11.90	.38	26.92	.62	324.78
S2	12.00	1.69	295.55	2.83	258.38
T2	12.02	1.90	4.31	2.47	331.22
L2	12.19	.97	148.60	.24	6.52
M2	12.42	7.75	155.27	12.55	125.95
N2	12.66	2.22	254.19	2.42	228.72
v2	12.60	.61	227.41	.29	131.66
2N2	12.91	.35	331.47	.14	18.22

DIURNAL TIDES

COMPONENT	PERIOD (Hour)	NORTH - SOUTH AMPLITUDE (cm/sec)	NORTH - SOUTH PHASE (Deg)	EAST - WEST AMPLITUDE (cm/sec)	EAST - WEST PHASE (Deg)
(OO)1	22.31	.63	22.80	.34	118.33
J1	23.10	.43	215.94	.49	101.35
K1	23.94	1.51	232.92	5.41	229.22
P1	24.07	.73	13.90	2.00	301.60
M1	24.83	.06	21.95	.40	323.84
O1	25.82	1.51	141.82	1.19	175.38
RHO1	26.72	.42	352.62	.36	237.15
Q1	26.87	1.07	273.33	.63	210.52



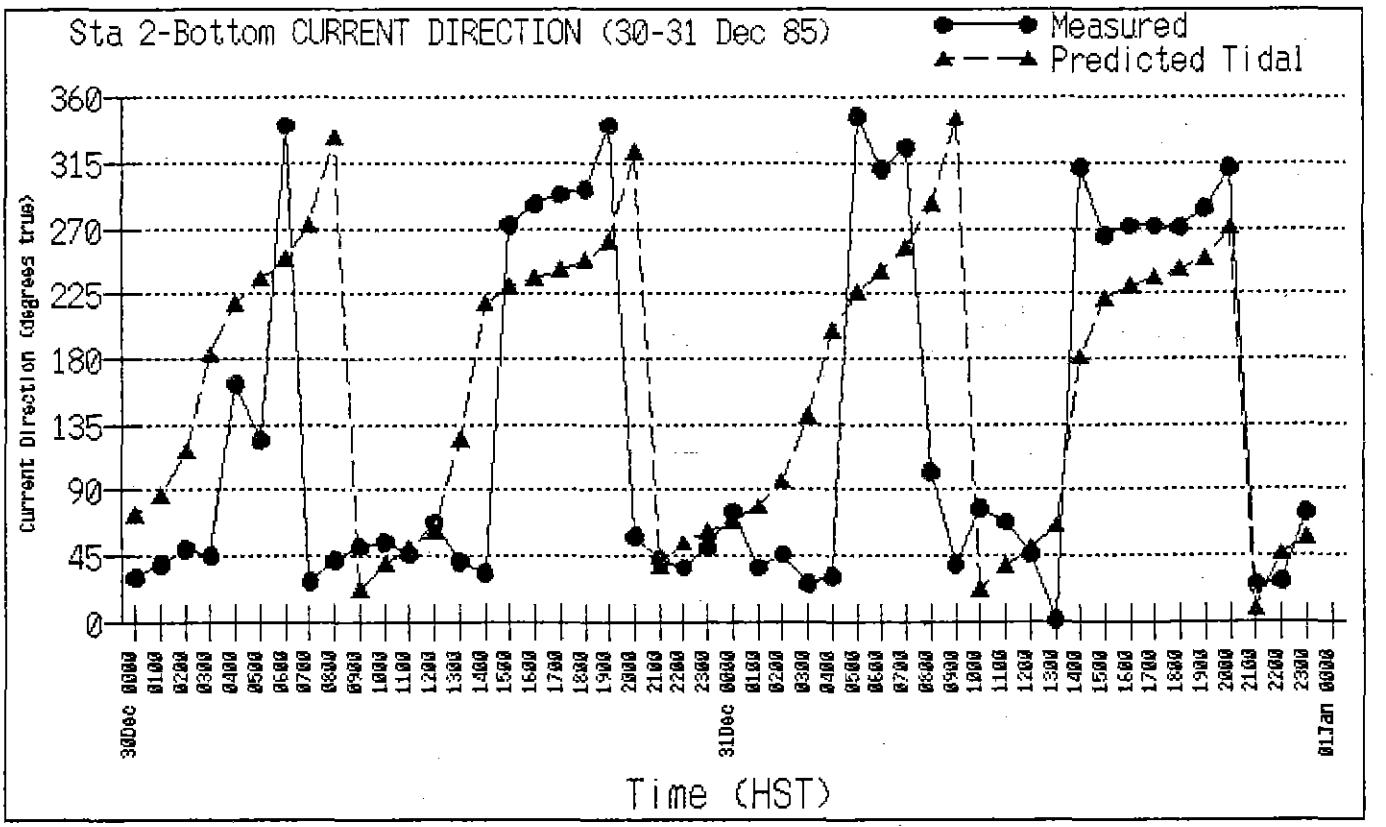
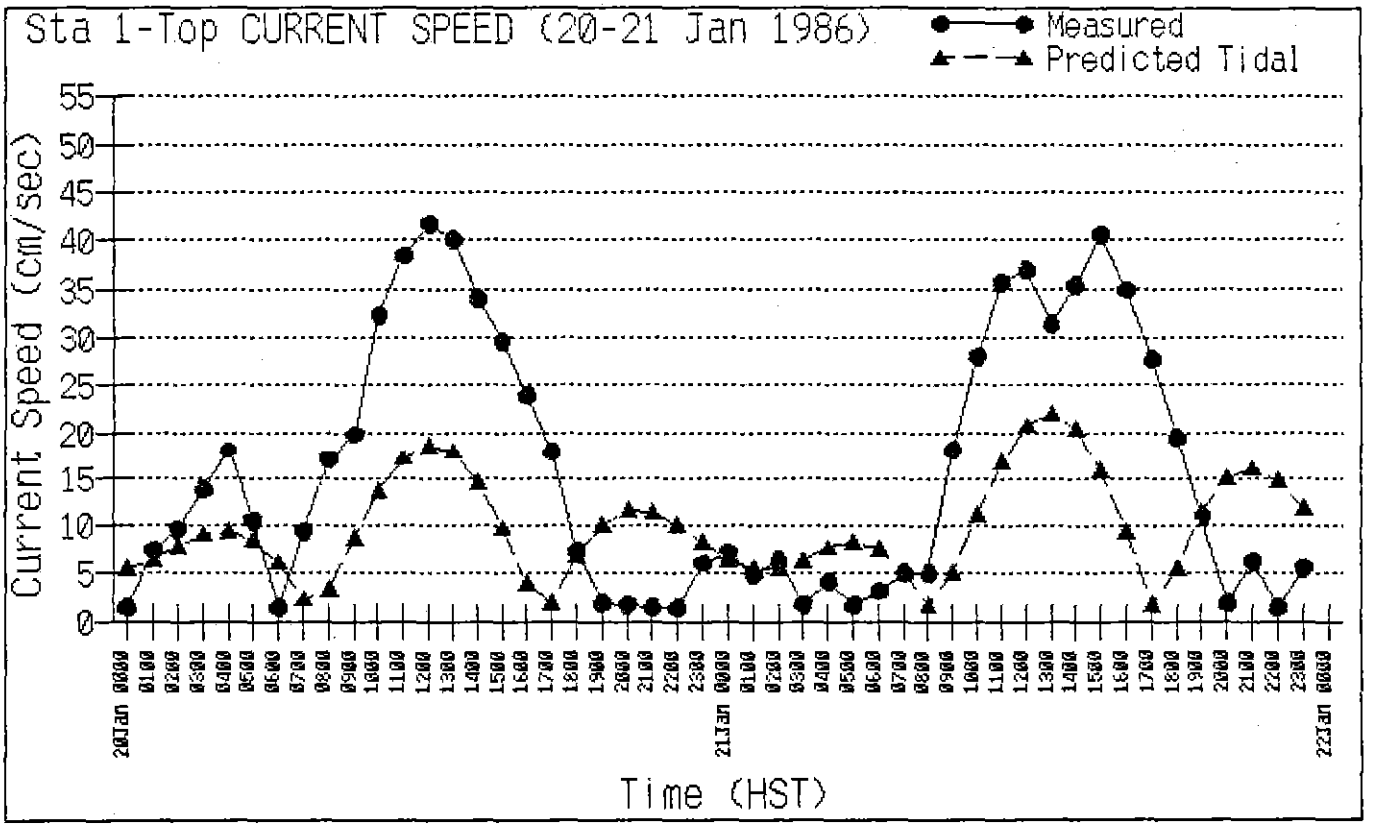


Figure 4.3-12 Comparison of predicted tidal currents and measured currents, 30-31 December 1985, Aanderaa Station 2, bottom meter



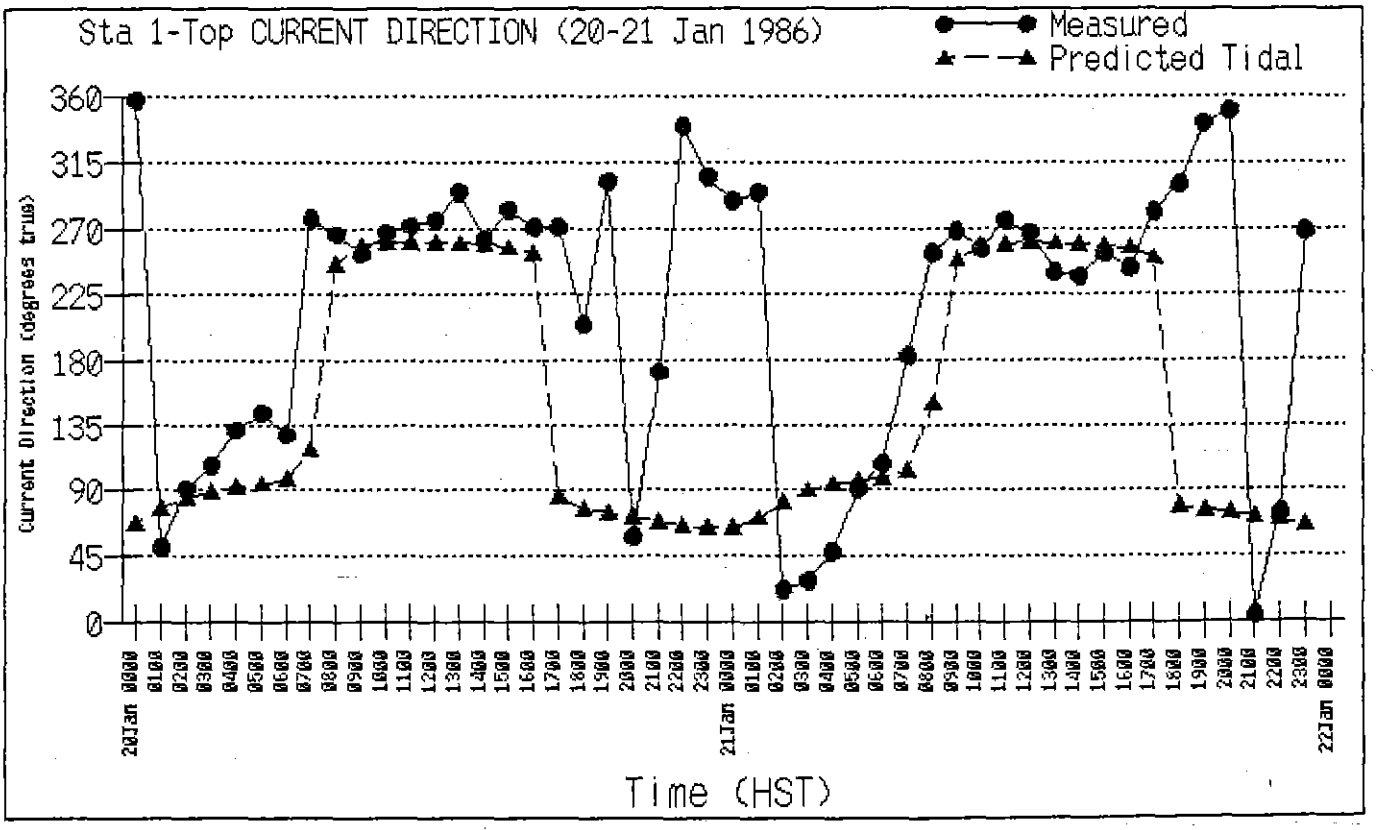
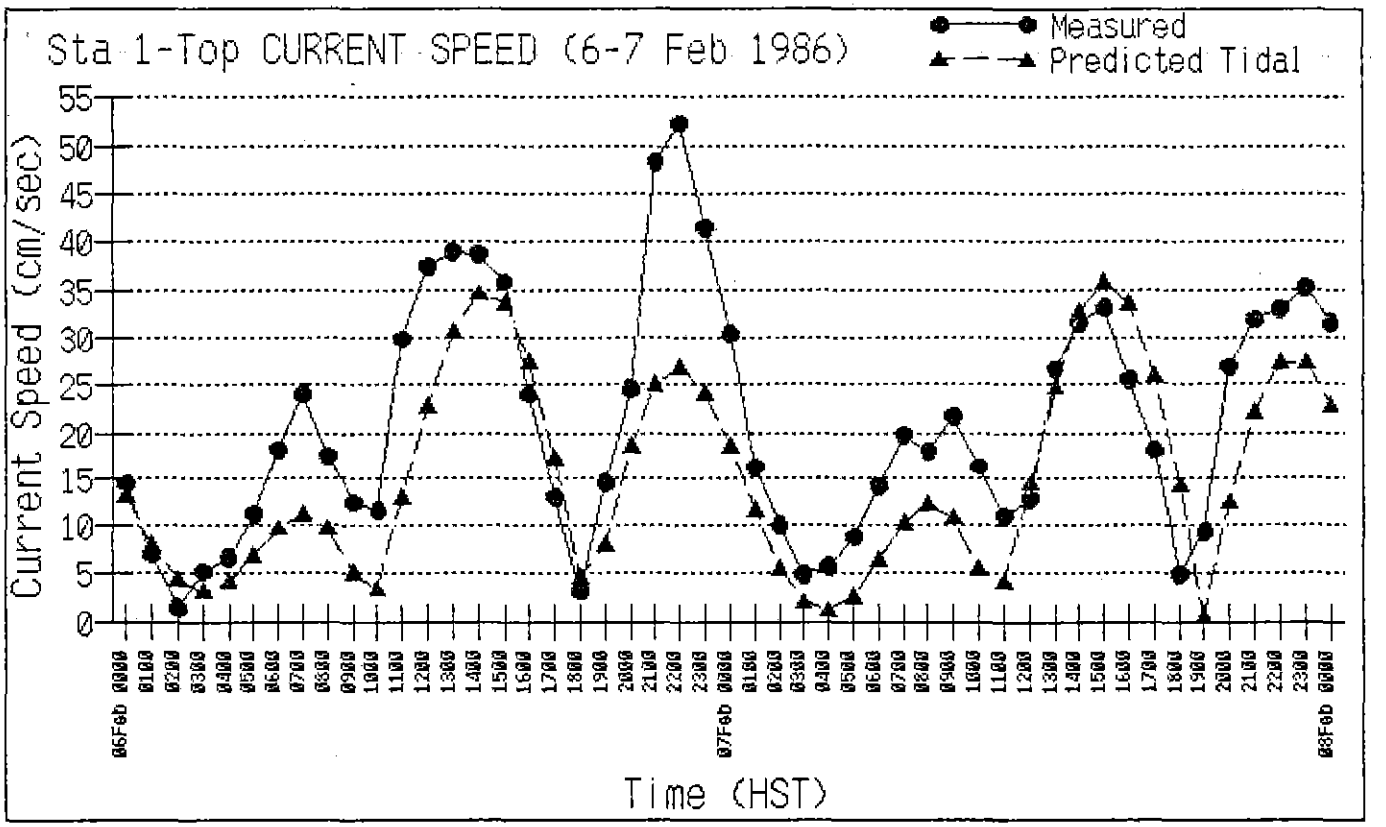


Figure 4.3-13 Comparison of predicted tidal currents and measured currents, 20-21 January 1986, Aanderaa Station 1, top meter



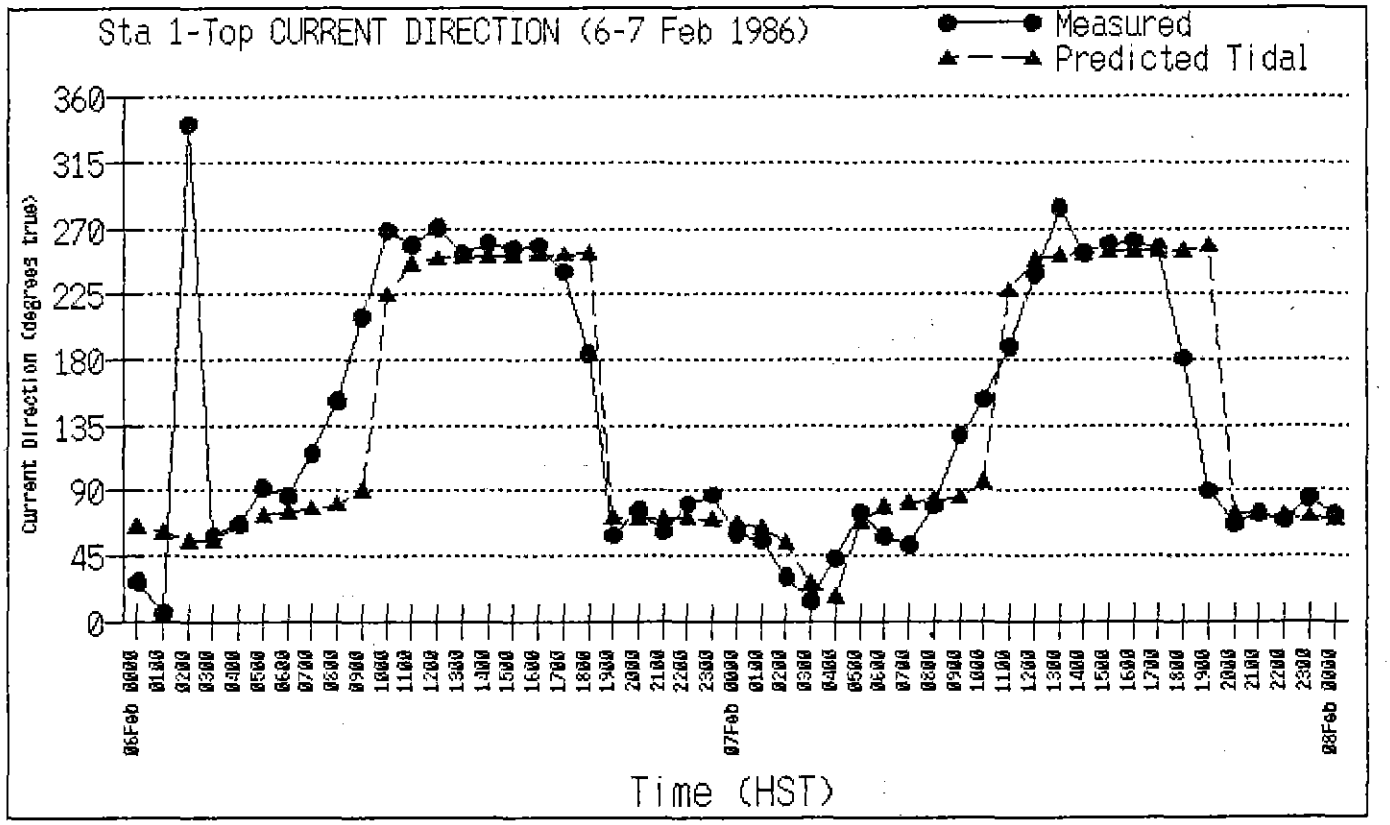
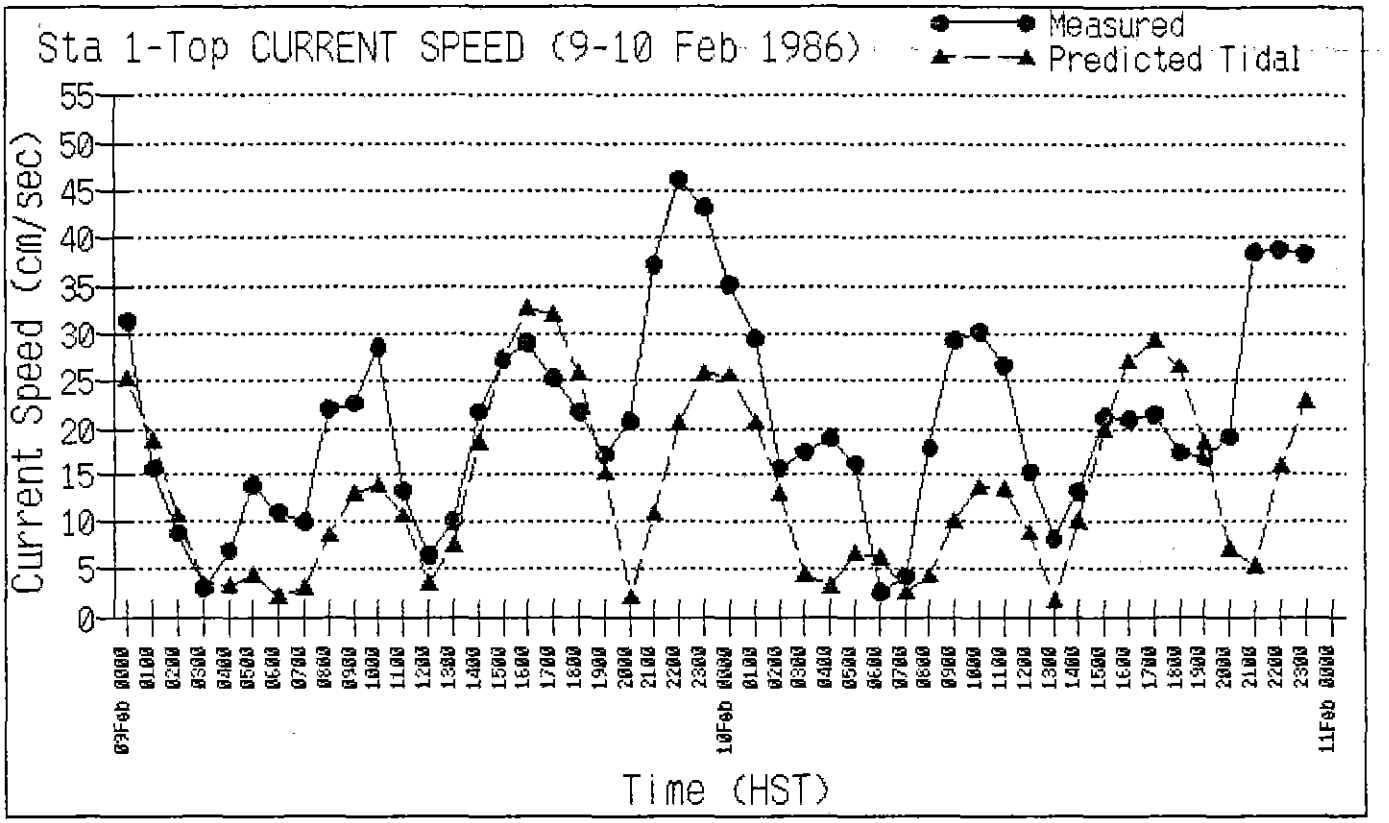


Figure 4.3-14 Comparison of predicted tidal currents and measured currents, 6-7 February 1986, Aanderaa Station 1, top meter



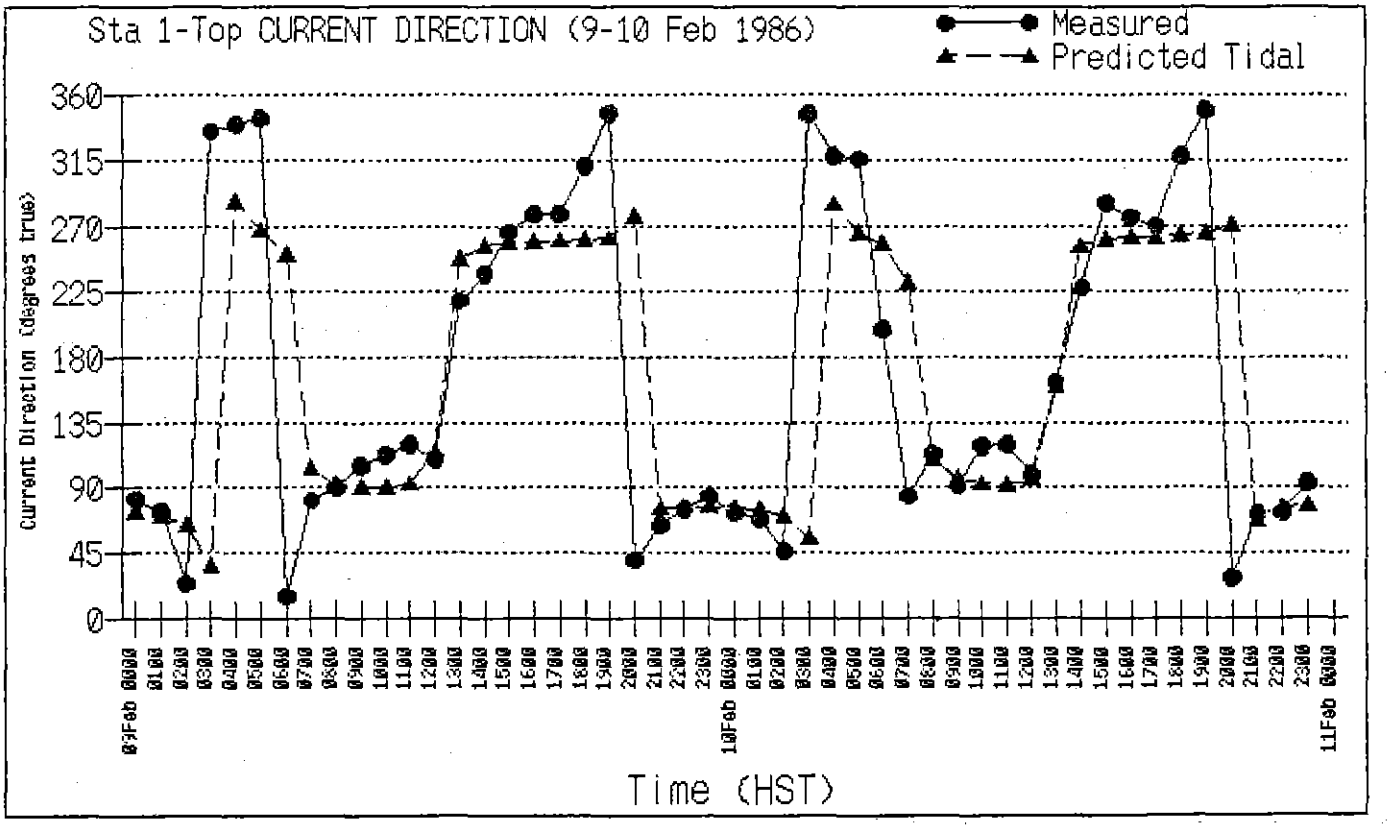


Figure 4.3-15 Comparison of predicted tidal currents and measured currents, 9-10 February 1986, Aanderaa Station 1, top meter

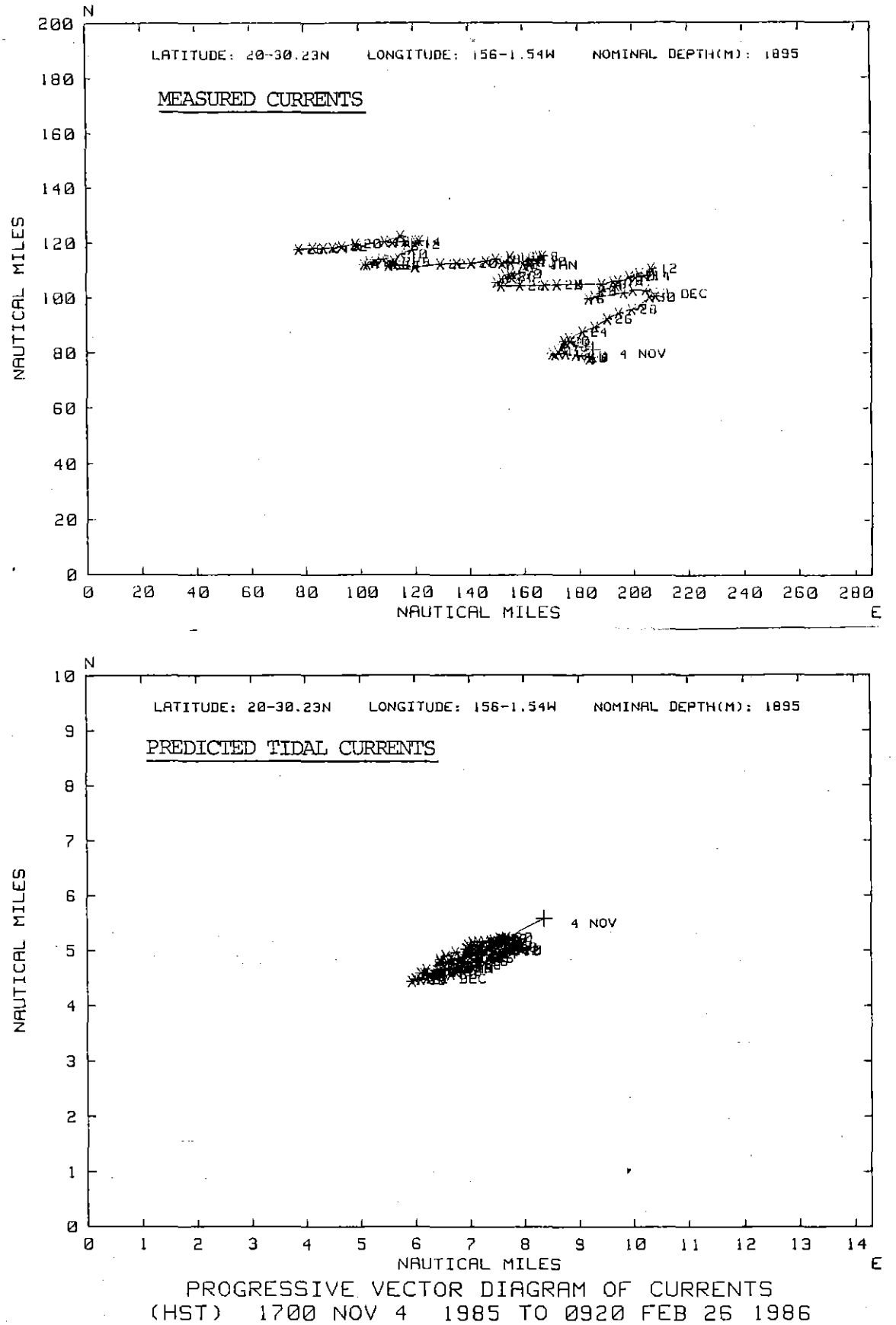


Figure 4.3-16 Progressive vector plots for Deployment 2, Aanderaa Station 1, top meter, Measured currents and Predicted tidal currents

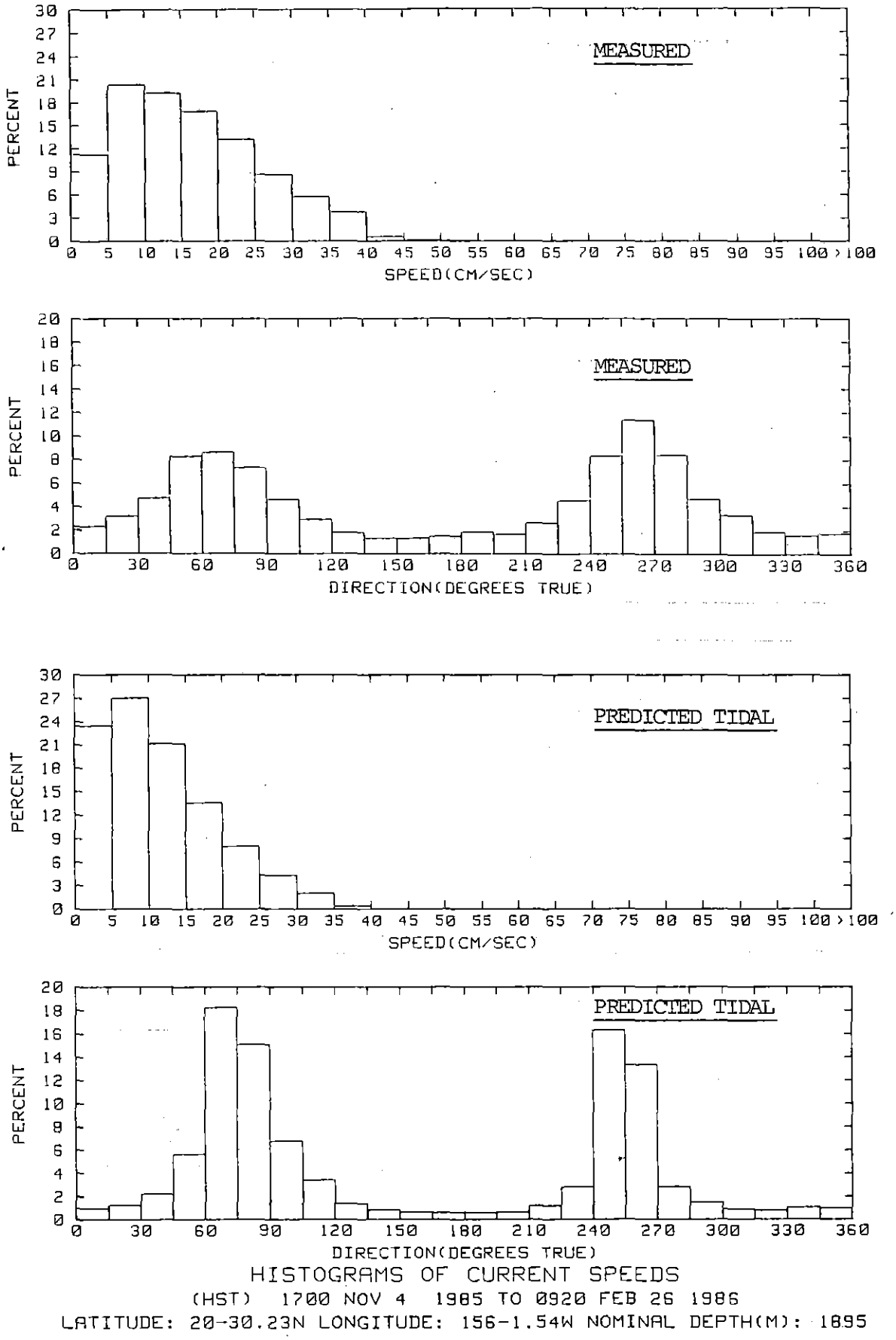


Figure 4.3-17 Percent frequency of occurrence distributions of current speed and direction for measured currents and predicted tidal currents, Aanderaa Deployment 2, Station 1, top meter

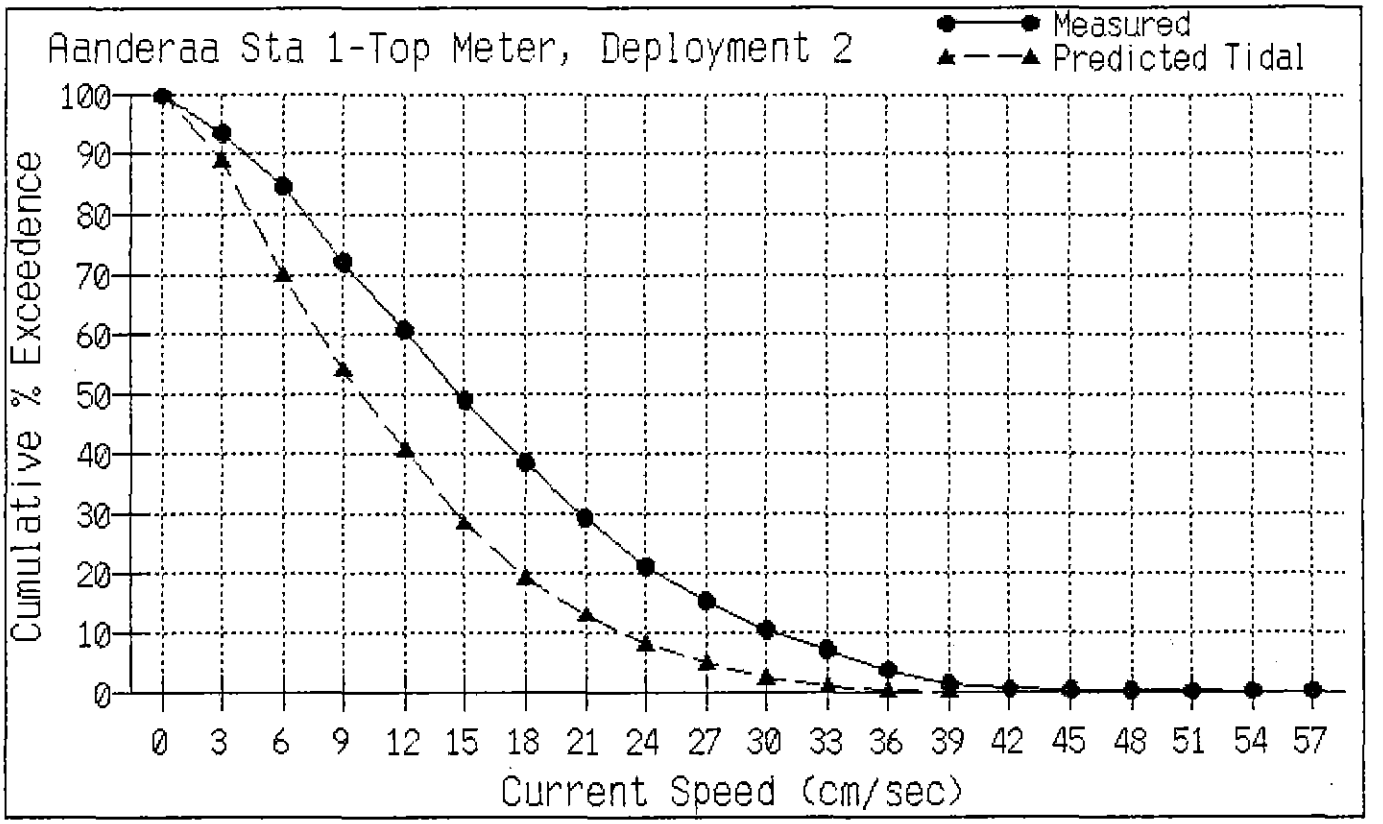


Figure 4.3-18 Cumulative percent exceedence for measured currents and predicted tidal currents, Aanderaa Deployment 2, Station 1, top meter

to a maximum measured speed of 55 cm/sec. A background oceanic current of 10 cm/sec is assumed for the operational current criteria. This background current is assumed to occur in either an east-northeasterly or westerly direction. Thus, for a typical peak tidal current of 20 cm/sec (which is expected to be exceeded about 15% of the time), a combined current of 30 cm/sec is expected to be exceeded about 10% of the time overall. For a maximum peak tidal current of 40 cm/sec, a combined current of 50 cm/sec is expected to be exceeded less than 0.1% of the time.

4.3.2 Evaluation of Near-surface Sea Data Currents

Semi-diurnal and diurnal tidal ellipses from the near-surface data are given in Appendix B. Data from the last 5 of 7 deployments were combined since the Sea Data current meter was deployed on a permanent mooring and the tidal data would be representative of a single location. (The first two deployments were not included due to the short duration of records.) Table 4.3-5 summarizes the amplitudes and directions along the principal axis and the combined peak tidal current vector. The maximum combined peak tidal current is 46 cm/sec and the typical current direction is 70°T/250°T. This peak speed is about 15% higher than the combined peak tidal currents at the deepwater Aanderaa stations.

Table 4.3-5 Alenuihaha Tidal Currents off Upolu Point 170 m water depth, 5 May 1984-26 May 1986

	Diurnal		Semi-diurnal		Combined	
	Amplitude (cm/sec)	Dir. °T	Amplitude (cm/sec)	Dir. °T	Amplitude (cm/sec)	Dir. °T
Maximum (2 S.D.)	6.9	66	39.4	71	46.2	70
Typical (1 S.D.)	3.4	66	19.7	71	23.1	70

(Note that principal axis direction as given is the angle from true north. Add 180° to this direction to determine principal axis alignment.)

While the time series of current speed and direction show the strong tidal signal, persistent mean flows due to wind and eddy currents are also evident. Figure 4.3-19 shows a time series of current speed during a period of strong persistent tradewinds. For this month of August 1984, the resultant drift was 32 cm/sec towards 36°T. Thus, the influence of eddy currents can be significant in near-surface waters, as will be evaluated in Section 4.4.

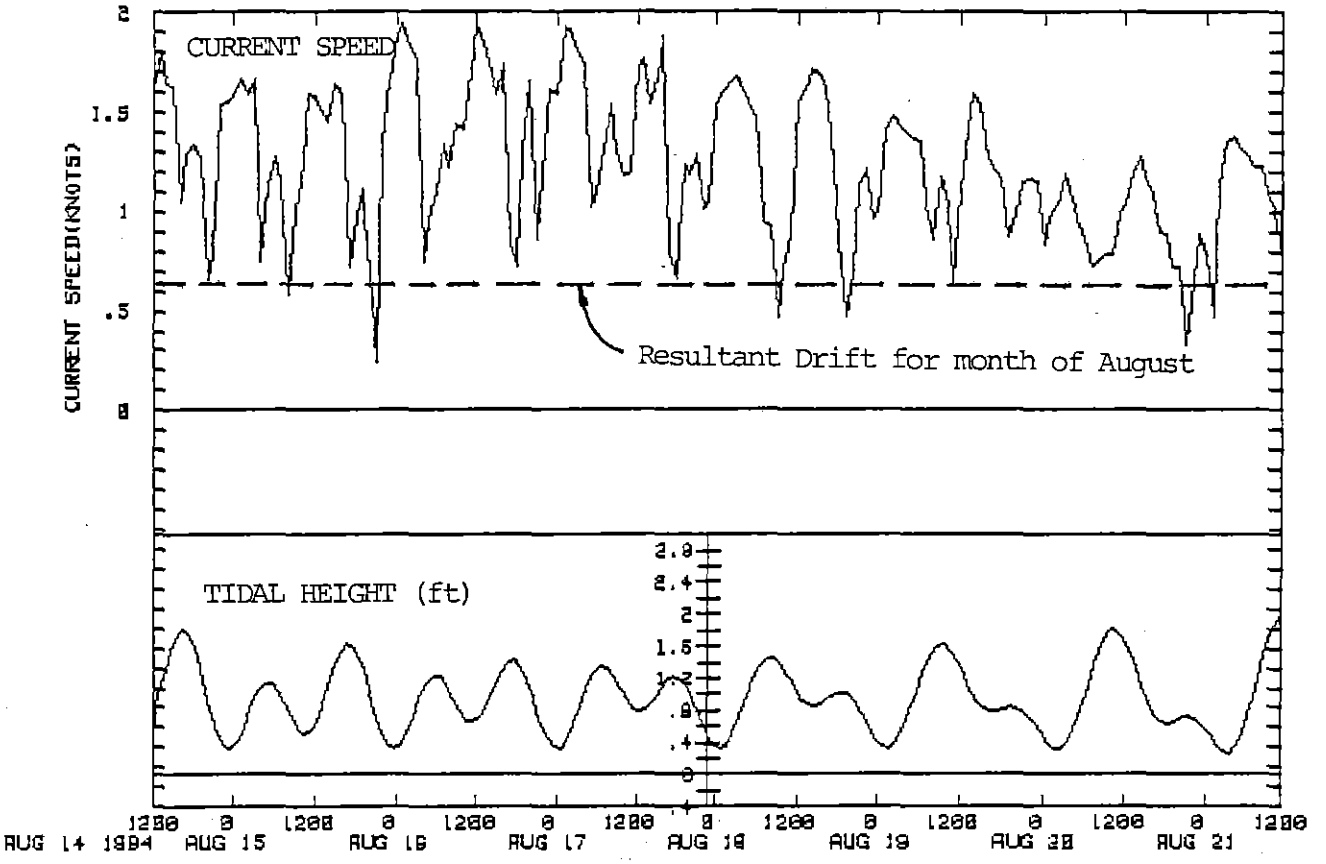


Figure 4.3-19 Time series of current speed and Honolulu tidal height during a period of strong persistent trade winds, Sea Data near-surface current meter off Upolu Point.

Principal tidal current constituents were calculated from Deployment 3 (26 November 1984 - 28 March 1985), as given in Table 4.3-6. Predicted tidal currents are compared with measured currents in Figure 4.3-20. This record is from a persistent period of light and variable winds with only a small eddy influence.

4.3.3 Evaluation of XCP Vertical Profiles

The 28 August 1985 Survey 3 is the only XCP deployment during which concurrent near-bottom Aanderaa current meter data are available. Direct comparison of XCP data and Aanderaa data is not entirely satisfactory due to the significant variability of XCP current speed and direction with depth (possibly due to internal waves) and the method of positioning which places the XCPs in only general proximity to the Aanderaa current meter stations. In order to "smooth" the XCP data, a mean current vector was determined from the data below 500 meter depth which represents the predominant tidal currents. The mean current speeds for the 28 August 1985 profiles are generally within the ballpark with the Aanderaa currents. The mean directions show the same general trend as the Aanderaa currents although the phase relationships between XCP drop locations are not consistent.

Since the XCP profiles are not synoptic, the tidal phase relationships between drop locations cannot be easily determined with the limited number of profiles. Therefore, predicted tidal currents from the Aanderaa station locations were correlated with the XCP mean currents below 500 meter depth from all three surveys in order to be able to estimate the peak tidal currents at other locations along the proposed cable route where no long-term current measurements are available.

Table 4.3-7 lists the mean XCP currents below 500 meters and the predicted Aanderaa tidal currents corresponding to the time of the XCP drops. Note that mean currents for XCP drop locations 1 and 1A are not given since these profiles are in water depths less than 500 meters and therefore influenced by wind and eddy currents. Aanderaa Station 1 is closest to XCP drop location 5A. Aanderaa Station 2 is closest to XCP drop location 3A. XCP drop locations 4, 5, and 6 are closer to Aanderaa Station 1 than 2. XCP drop locations 2 and 3 are closer to Aanderaa Station 2 than 1. XCP drop location 7 is at approximately the same depth as Aanderaa Station 2 on the opposite channel slope. Appendix C provides the XCP profiles with overplots of the measured currents at the depths of the current meter stations.

Table 4.3-8 gives the correlation coefficients and linear coefficients of best fit for each XCP drop location and

Table 4.3-6 Principal Tidal Current Constituents, 170 Meter Water Depth off Upolu Point, Deployment 3 (26 Nov 84 - 28 Mar 85)

DEPLOYMENT NUMBER: 3 STATION NUMBER: 1

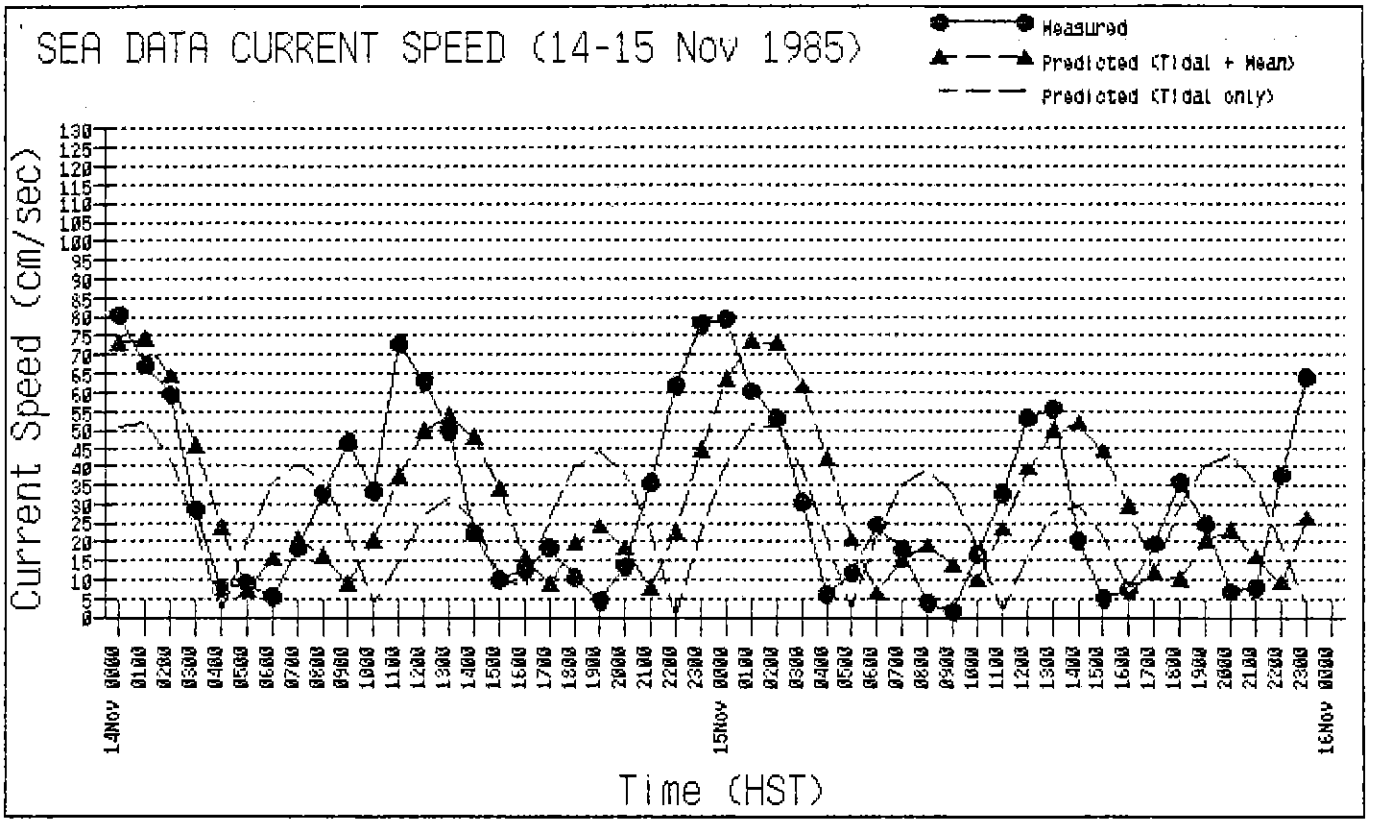
MEAN OF NORTH-SOUTH COMPONENTS = 16.68 CM/SEC
MEAN OF EAST-WEST COMPONENTS = 11.22 CM/SEC

SEMI-DIURNAL TIDES

COMPONENT	PERIOD (Hour)	NORTH - SOUTH AMPLITUDE (cm/sec)	NORTH - SOUTH PHASE (Deg)	EAST - WEST AMPLITUDE (cm/sec)	EAST - WEST PHASE (Deg)
K2	11.90	.26	139.48	.93	151.73
S2	12.00	7.69	21.24	11.50	20.48
T2	12.02	4.59	178.54	7.78	178.82
L2	12.19	2.50	252.72	1.65	289.94
M2	12.42	19.18	.19	27.61	357.75
N2	12.66	3.71	265.10	5.26	281.89
ν2	12.60	1.18	328.98	.79	150.69
2N2	12.91	.96	247.33	1.26	78.68

DIURNAL TIDES

COMPONENT	PERIOD (Hour)	NORTH - SOUTH AMPLITUDE (cm/sec)	NORTH - SOUTH PHASE (Deg)	EAST - WEST AMPLITUDE (cm/sec)	EAST - WEST PHASE (Deg)
(OO)1	22.31	.35	323.12	.59	88.34
J1	23.10	.88	314.24	.89	277.48
K1	23.94	1.55	144.01	1.97	161.70
P1	24.07	1.26	189.90	1.73	194.22
M1	24.83	.51	34.85	1.35	51.71
O1	25.82	3.82	140.21	4.37	141.36
RHO1	26.72	.19	154.32	.46	219.65
Q1	26.87	.85	115.13	1.01	175.85



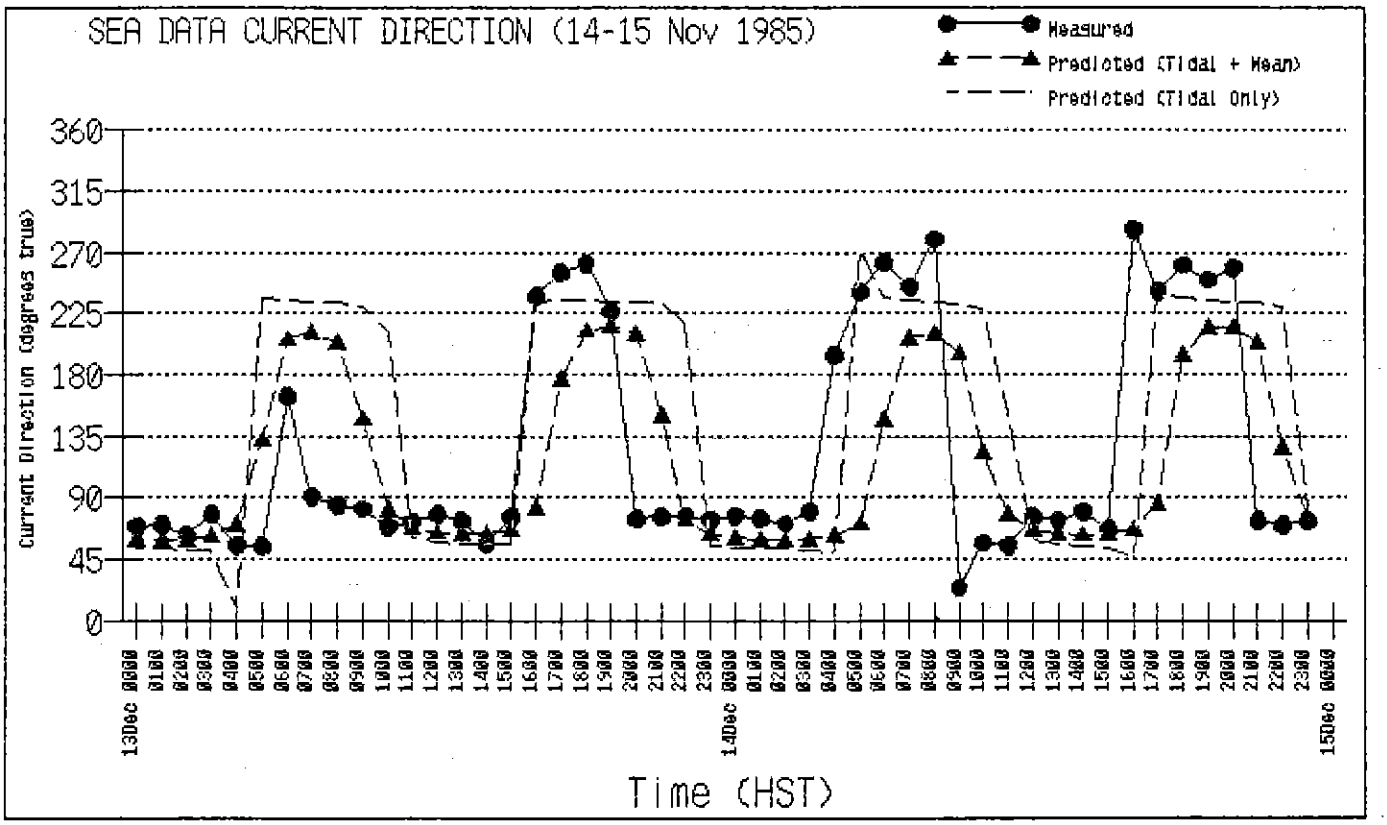


Figure 4.3-20 Comparison of predicted currents with measured currents, 14-15 November 1985, Sea Data near-surface current meter

Table 4.3-7 Comparison of Predicted Tidal Currents at Current Meter Stations with XCP Vertical Profile Data

		XCP Mean Current Below 500 m					Aanderaa Sta 1/Sta 2	
Date	Time	Survey	Leg	Drop	Speed (cm/sec)	Dir. (°T)	Speed (cm/sec)	Dir. (°T)
5/28/85	1108	1	1	1	-	-	-	-
5/28/85	1158	1	1	3	-	-	-	-
5/28/85	1211	1	1	4	7.6	20	10/4	270/300
5/28/85	1244	1	1	6	19.2	37	6/6	285/140
5/28/85	1726	1	2	2	34.3	74	16/16	70/85
5/28/85	1704	1	2	4	31.1	97	17/19	65/75
5/28/85	1650	1	2	5	21.1	171	18/19	65/70
5/28/85	1637	1	2	6	25.9	74	17/20	65/70
5/28/85	1608	1	2	7	-	-	-	-
7/1/85	1218	2	1	1A	-	-	-	-
7/1/85	1242	2	1	1	-	-	-	-
7/1/85	1313	2	1	2	11.6	296	15/5	310/210
7/1/85	1409	2	1	3	10.8	6	11/7	50/240
7/1/85	1422	2	1	4	5.5	353	10/8	50/240
7/1/85	1439	2	1	5	3.5	212	9/8	50/240
7/1/85	1507	2	1	6	6.0	248	8/8	60/250
7/1/85	1539	2	1	7	6.9	57	6/6	60/260
7/1/85	2157	2	2	1A	-	-	-	-
7/1/85	2128	2	2	1	-	-	-	-
7/1/85	2016	2	2	2	25.5	75	10/11	140/65
7/1/85	1938	2	2	3A	10.6	80	9/11	105/60
7/1/85	1925	2	2	3	11.5	64	9/10	100/60
7/1/85	1905	2	2	4	3.8	232	8/10	80/55
7/1/85	1846	2	2	5A	12.9	208	8/9	80/50
7/1/85	1828	2	2	5	9.0	16	7/8	75/45
7/1/85	1745	2	2	6	10.5	151	6/5	70/110
7/1/85	1712	2	2	7	8.8	109	5/4	65/340
8/28/85	0806	3	1	1A	-	-	-	-
8/28/85	0835	3	1	1	-	-	-	-
8/28/85	0900	3	1	2	11.9	91	19/15	80/80
8/28/85	0930	3	1	3A	15.0	84	19/12	80/80
8/28/85	0950	3	1	3	16.1	46	19/11	80/90
8/28/85	1016	3	1	4	8.0	7	18/8	80/110
8/28/85	1058	3	1	5A	5.1	32	15/4	70/150
8/28/85	1149	3	1	5	13.7	96	12/6	65/210
8/28/85	1250	3	1	6	12.4	160	9/11	45/240
8/28/85	1339	3	1	7	15.8	348	7/13	25/250
8/28/85	2023	3	2	1A	-	-	-	-
8/28/85	1917	3	2	2	7.6	88	13/13	100/50
8/28/85	1840	3	2	3A	17.1	295	12/12	90/40
8/28/85	1821	3	2	3	5.8	341	11/11	90/35
8/28/85	1809	3	2	4	6.6	175	10/10	80/30
8/28/85	1728	3	2	5	11.4	19	9/8	70/200
8/28/85	1748	3	2	5A	5.1	223	10/9	80/90
8/28/85	1655	3	2	6	5.1	280	7/6	60/350
8/28/85	1635	3	2	7	8.8	315	7/7	50/320

corresponding current meter station. With the few data points for each XCP location, there is much scatter and rather poor correlation with the Aanderaa data except for a few locations. XCP location 3A correlates well with Aanderaa Station 2, however, the coefficients are unreasonably high. XCP locations 5A and 7 show good correlation with the Aanderaa data. Based on maximum tidal currents of 41.2 cm/sec (75°T) and 39.1 cm/sec (74°T) for Aanderaa stations 1-top and 2-bottom, respectively, estimated peak tidal currents of 46 cm/sec and 53 cm/sec were determined for XCP locations 5A and 7, respectively. These estimated tidal currents together with the peak tidal currents from Tables 4.3-1 and 4.3-5 were used to interpolate peak tidal currents along the proposed cable route as depicted in Figure 4.3-21.

Table 4.3-8 Tidal Current Correlations Between XCP Locations and Current Meter Stations

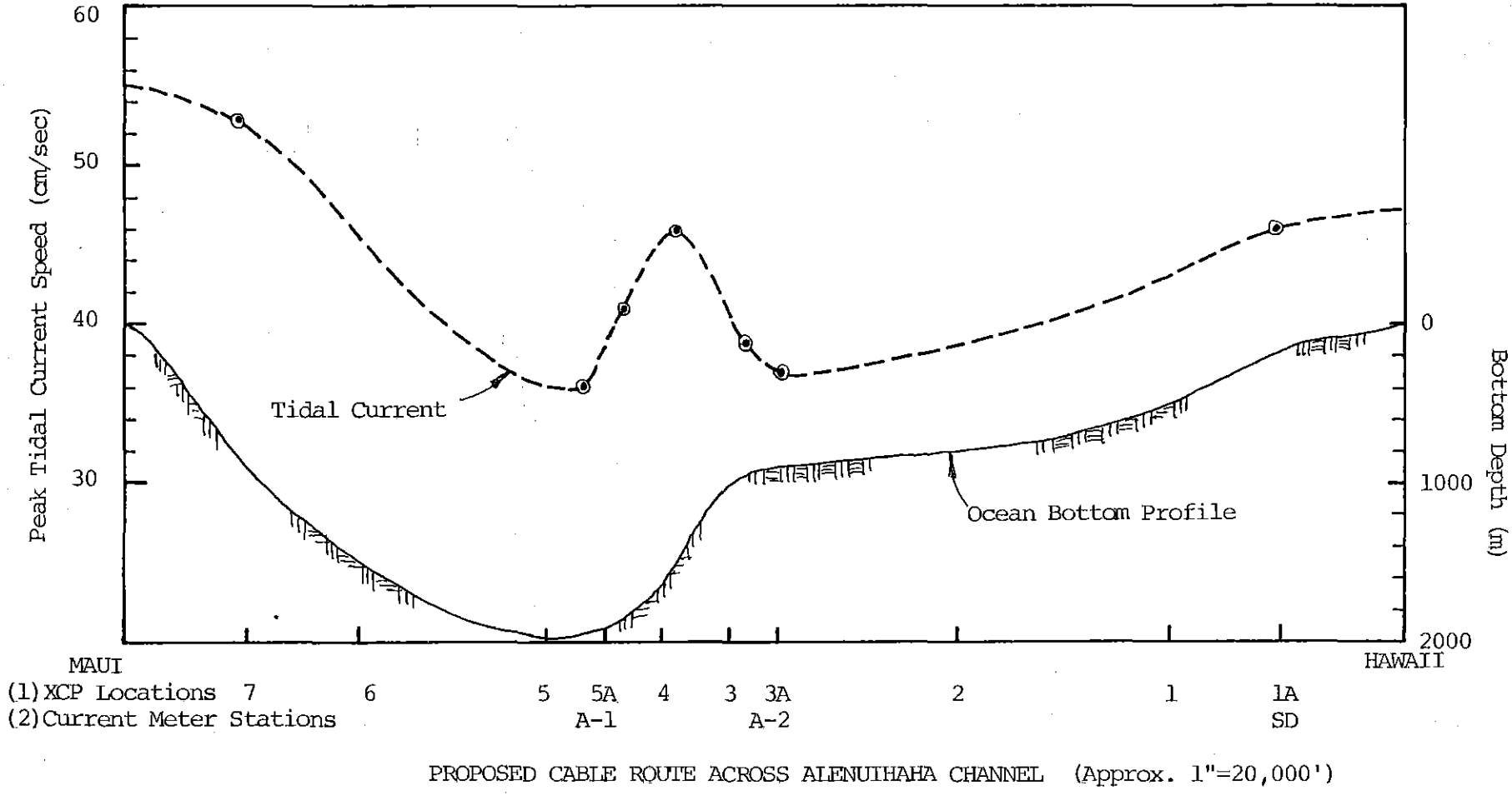
XCP	Current	# data	E-W Component			N-S Component		
			A	B	r	A	B	r
Location	Meter Station	points	<1>	<1>	<2>	<1>	<1>	<2>
2	Aanderaa 2-bottom	5	-4.99	1.90	.83	5.12	-0.35	-.39
3A	Aanderaa 2-bottom	3	-66.17	7.17	.90	-0.95	0.80	.90
3	Aanderaa 2-bottom	4	2.63	0.54	.61	9.51	-0.53	-.89
4	Aanderaa 1-top	6	2.00	0.40	.31	1.94	-0.19	-.09
5A	Aanderaa 1-top	3	-17.30	1.42	.99	-13.14	3.46	.91
5	Aanderaa 1-top	5	-0.10	0.44	.31	22.93	-5.16	-.94
6	Aanderaa 1-top	6	3.33	0.44	.26	4.03	-0.97	-.22
7	Aanderaa 2-bottom	4	10.88	1.10	.98	6.70	-1.17	-.69

<1> XCP = A + B(Aanderaa)
<2> r = correlation coefficient

4.3.4 Operational Tidal Current Criteria

Currents in the Alenuihaha Channel below about 300-400 meter depth are primarily driven by the tides. These tidal currents rotate in direction, with peak currents occurring towards the ENE and WSW. The period between peak currents is between 6 and 12 hours corresponding to the high and low tide cycles of the semi-diurnal and diurnal tidal constituents. Currents in the upper 300-400 meter depth are influenced by wind-driven and eddy currents. These currents, which are superposed on the tidal currents, will be evaluated in the following Section 4.4.

The tidal currents within the channel are influenced by bathymetry, and hence vary depending on location. For the



(1) XCP locations are approximate and vary somewhat with each drop due to method of positioning.
(2) A-1, A-2 = Aanderaa near-bottom stations, SD = Sea Data near-surface station

Figure 4.3-21 Estimated peak tidal currents along the proposed cable route, Alenuihaha Channel

proposed cable route, which crosses the channel nearly perpendicular to the bottom contours, the peak tidal currents are expected to flow nearly perpendicular to the cable axis. Based on correlations between the current meter data and the XCP vertical profiles, Table 4.3-9 gives the estimated peak tidal currents along the proposed cable route. These currents are provided as a function of nominal bottom depth along the cable route. Largest tidal currents occur in shallower water depths at the edges of the channel and on the steep Kohala slope in mid-channel. (The estimated tidal currents on the steep Kohala slope can be verified following retrieval of an Aanderaa current meter presently deployed in this location.) While there may be localized variability due to bathymetric irregularities in the bottom contours, these would generally be confined to the near-bottom corresponding to the bottom roughness features.

Table 4.3-9 Estimated Peak Tidal Currents Along the Proposed Cable Route, Alenuihaha Channel

Location	Bottom Depth (m)	Speed (cm/sec)	Source
Offshore Upolu Pt	170	46	Sea Data meter
	500	43	Interpolated
	800	39	Interpolated
Top of Kohala Slope	900	37	Aanderaa Sta 2
	1000	39	Aanderaa Sta 2
	1600	46	XCP-Aanderaa Correlation
Bottom of Kohala Slope	1900	41	Aanderaa Sta 1
	2000	36	Aanderaa Sta 1
	1500	45	Interpolated
Maui Slope	900	53	XCP-Aanderaa Correlation
	200	55	Extrapolated

Note: Peak tidal currents can flow towards ENE or WSW, generally perpendicular to contours. Typical direction is 70°T/250°T along cable path.

Mean background oceanic currents are also evident in the channel. These currents are superposed on the tidal currents and can occur in either an east-northeasterly or westerly direction, with an apparent period of oscillation of about 20-25 days. A background oceanic current of 10 cm/sec is assumed for the operational current criteria.

4.4 WIND-DRIVEN AND EDDY CURRENTS

Within the top 300-400 meters, wind-induced and eddy currents can be dominant components superposed on the tidal currents. Wind-induced currents caused by direct wind stress on the water surface are confined to the upper 200 meters for winds less than 30 knots. Wind-induced currents can be estimated using Ekman's empirical relation:

$$V_0 = \frac{0.0127\ W}{(\sin \phi)^{1/2}}$$

where: V_0 = surface current speed (knots)
W = wind speed (knots)
ϕ = latitude = 20.3°

The direction of this surface current is 45° cum sole from the direction of the wind. The current speed decays exponentially with depth and the direction is deflected clockwise so that at a depth z = D, the current is directed opposite to the surface current. At this depth D, the current speed is $e^{-\pi}$ times the surface current, or 1/23 of the surface current speed. This depth of frictional resistence is given by:

$$D = \frac{3.91\ W}{(\sin \phi)^{1/2}}$$

where W is in knots and D is in meters. The wind-induced current velocity as a function of depth is given by:

$$V_x = V_0\ e^{-\pi z/D} \cos\ (\pi/4 - \pi z/D)$$
$$V_y = V_0\ e^{-\pi z/D} \sin\ (\pi/4 - \pi z/D)$$

where: V_x = current component 90° from the wind
V_y = current component in the direction of the wind

This model assumes that the eddy viscosity decreases to zero at a lower limit of the wind-stirred layer. However, in the presence of other currents, such as tidal or eddy currents, the eddy viscosity probably depends more on the stability of the stratification than on the geometric distance from the free surface. Since there is no theory which accounts for this, Ekman's model will be used in-as-much as it provides a satisfactory approximation.

The eddy current component is difficult to evaluate since it is dependent on the size of the offshore eddies and distance from the channel. An eddy's influence at different locations within the channel also varies due to the configuration of the channel. For example, eddy-induced flows due to the large eddy depicted in Figure 4.1-6 are east-northeasterly off Upolu Point, northerly in the middle of the channel, and westerly at the southwest tip of Maui.

Eddy flows in deepwater are typically confined to the upper 300-400 meters, with the strongest flows concentrated in the upper 200 meters. Formation time of the eddies is about 1-2 weeks for a weak eddy to a month for an intense eddy. The eddies have been observed to move westerly at an average speed of 6.0 cm/sec, with life times of two months or more before they decay.

The eddy current components extracted from the near-surface Sea Data records were correlated with the XCP vertical profile data to estimate the eddy-induced currents along the proposed cable path.

4.4.1 Evaluation of Near-Surface Sea Data Currents

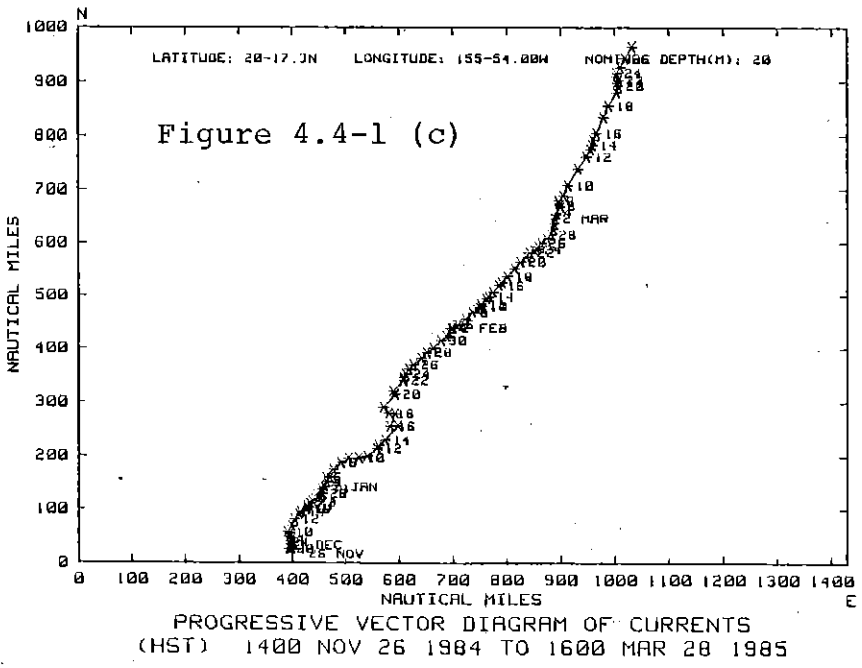
Table 4.4-1 lists the monthly resultant current vector as well as maximum measured currents from the Sea Data wave and current meter located off Upolu Point. Since the tidal currents are rotational, the resultant vector indicates the presence of a mean net drift due to eddy and/or wind influence. Note that the resultant drift is consistently towards the northeasterly direction for relatively high drift speeds. This reflects the influence of eddy currents. At lower net drift speeds, the direction is northerly to northwesterly, consistent with Ekman wind-induced near-surface currents for easterly tradewinds. Figure 4.4-1 provides progressive vector plots of daily resultant currents for each of the seven deployments which clearly show the net drift trends.

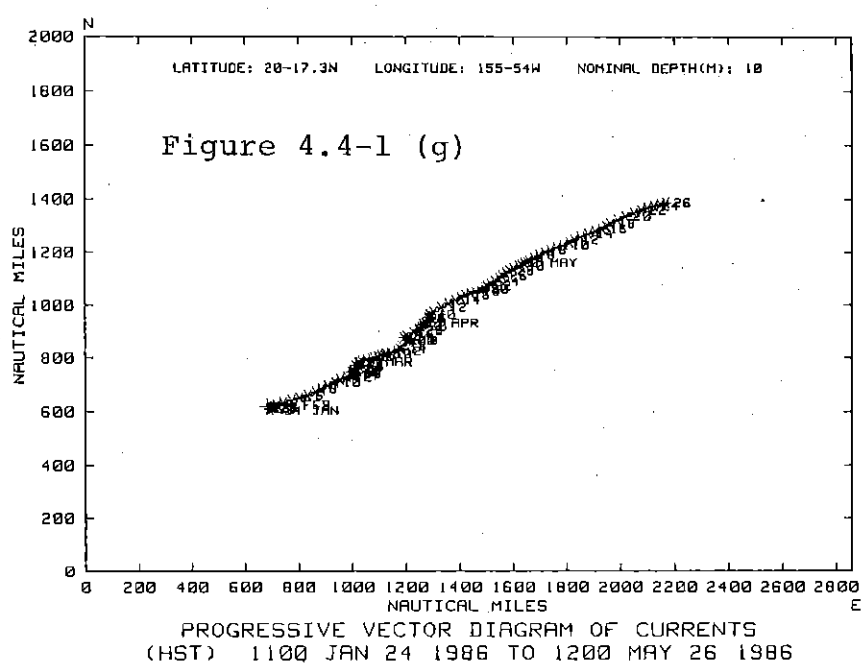
Figure 4.4-2 depicts the current speed/direction, tidal height and wind speed/direction for a period when winds were strong but the resultant drift was small. Tidal currents were predicted (Figure 4.4-3) and then extracted from this record in order to compare the residual currents with the theoretical Ekman currents. While there is some cyclical variation to the residual current due to inexact phase relationship between the actual and predicted tidal currents, Figure 4.4-4 indicates that the Ekman predicted wind-induced currents are close to the average of the residual currents. (The "mean" represented by the dashed line is the mean of the actual record.)

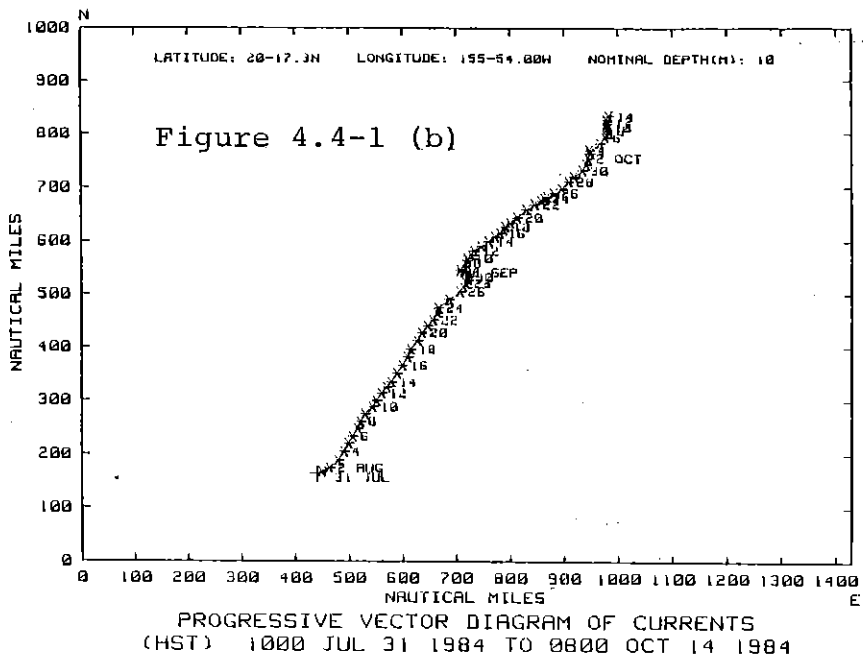
In order to be able to separate the eddy-induced flows from the measured data, the tidal current oscillations were completely removed from the record by filtering out the primary tidal constituent periods. The theoretical Ekman wind-induced currents were then extracted from this mean flow, leaving the residual currents comprised of the eddy currents and any background oceanic current. This was accomplished for four periods (Figures 4.4-5 through 4.4-8) during which eddy flows were strong. The theoretical Ekman and residual (eddy) currents are given in Figures 4.4-9 through 4.4-12 for each of the strong flow occurrences.

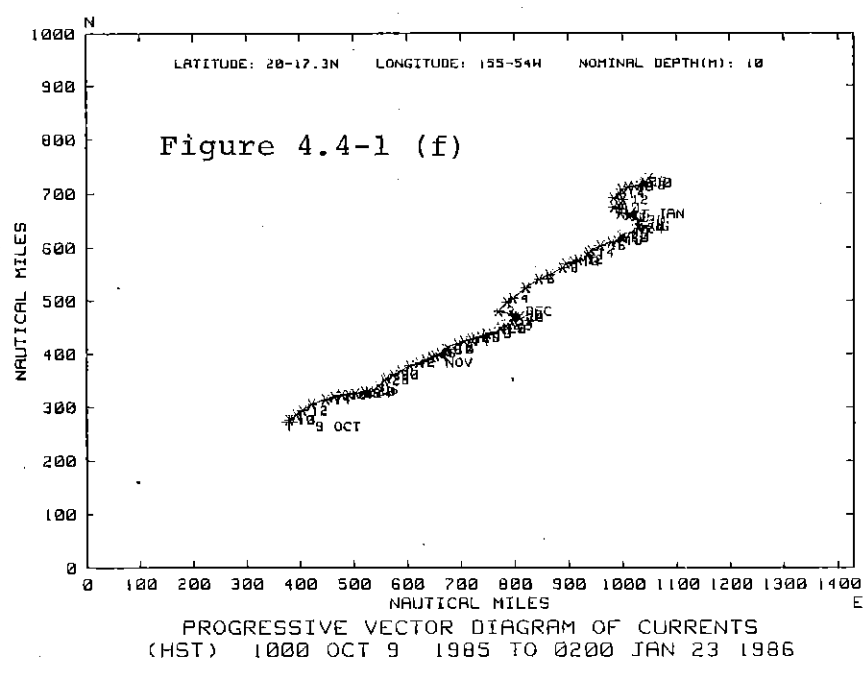
Table 4.4-1 Monthly Maximum Measured Currents and Resultant Drift Vectors from the Sea Data Meter off Upolu Point, May 1984-1986
(Water Depth 170 m, Sensor Depth min. 10 m)

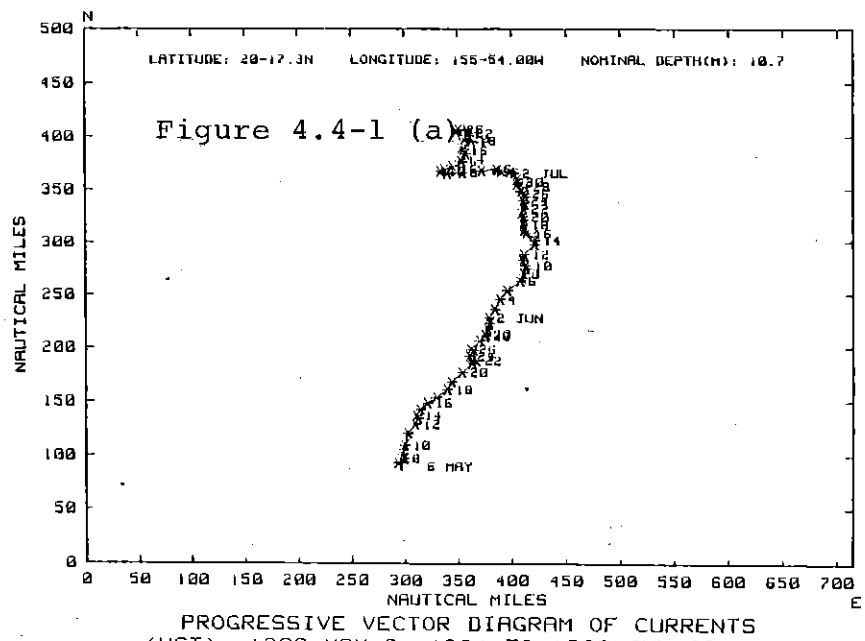
	Month	Max Current Speed (cm/sec)	Resultant Drift Speed(cm/sec)	Resultant Drift Dir(°T)
	May 1984	94.5	12.9	33
	Jun 1984	88.0	10.0	11
	Jul 1984	93.5	6.2	309
	Aug 1984	113.6	32.0	36
	Sep 1984	101.6	21.3	47
(14d)	Oct 1984	81.8	16.9	26
(5d)	Nov 1984	52.4	3.3	297
	Dec 1984	91.4	9.1	30
	Jan 1985	134.9	25.6	39
	Feb 1985	104.4	21.1	44
	Mar 1985	124.3	29.5	24
	Apr 1985	87.8	8.1	307
	May 1985	92.8	16.1	44
	Jun 1985	73.6	7.1	9
	Jul 1985	97.1	15.4	34
	Aug 1985	112.0	28.6	30
	Sep 1985	107.5	24.6	28
	Oct 1985	108.2	19.1	61
	Nov 1985	96.8	15.4	63
	Dec 1985	106.8	19.4	49
	Jan 1986	94.1	7.0	43
	Feb 1986	105.3	26.9	63
	Mar 1986	96.8	19.6	59
	Apr 1986	101.8	30.5	58
	May 1986	97.3	50.0	66











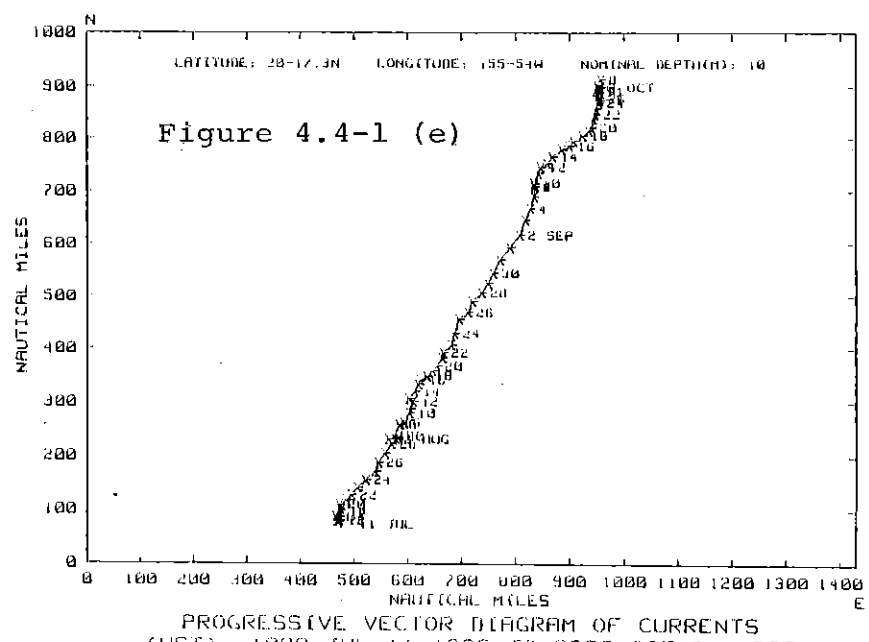
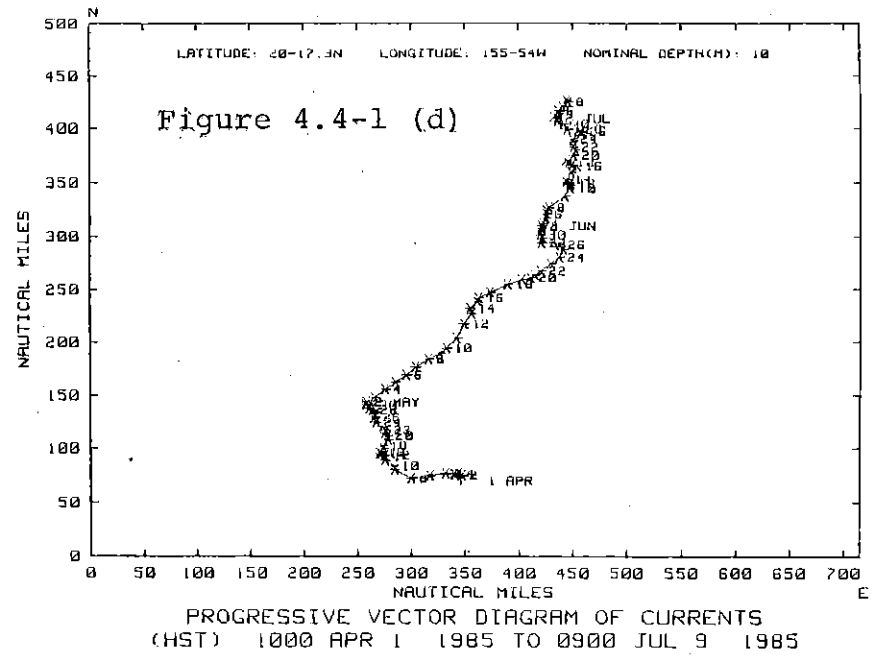


Figure 4.4-1 Progressive vector plots of daily resultant currents for Sea Data meter off Upolu Point, 6 May 1984 - 26 May 1986



CURRENT SPEED

CURRENT DIRECTION

TIDAL HEIGHT

WIND SPEED

WIND DIRECTION

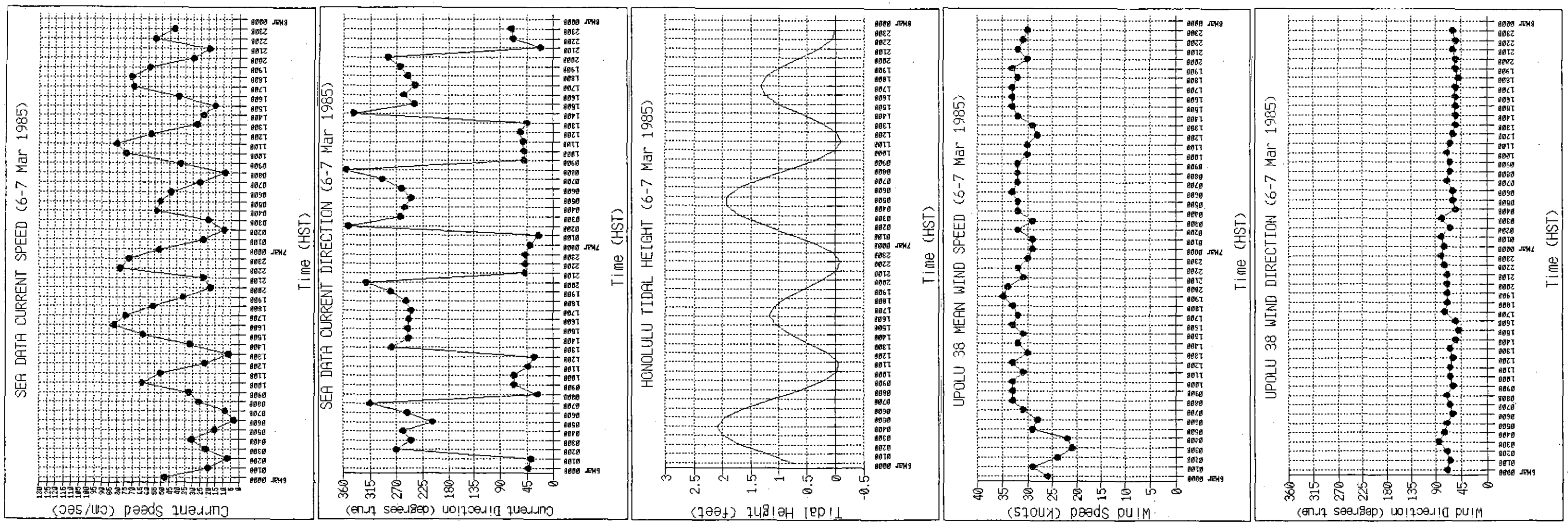
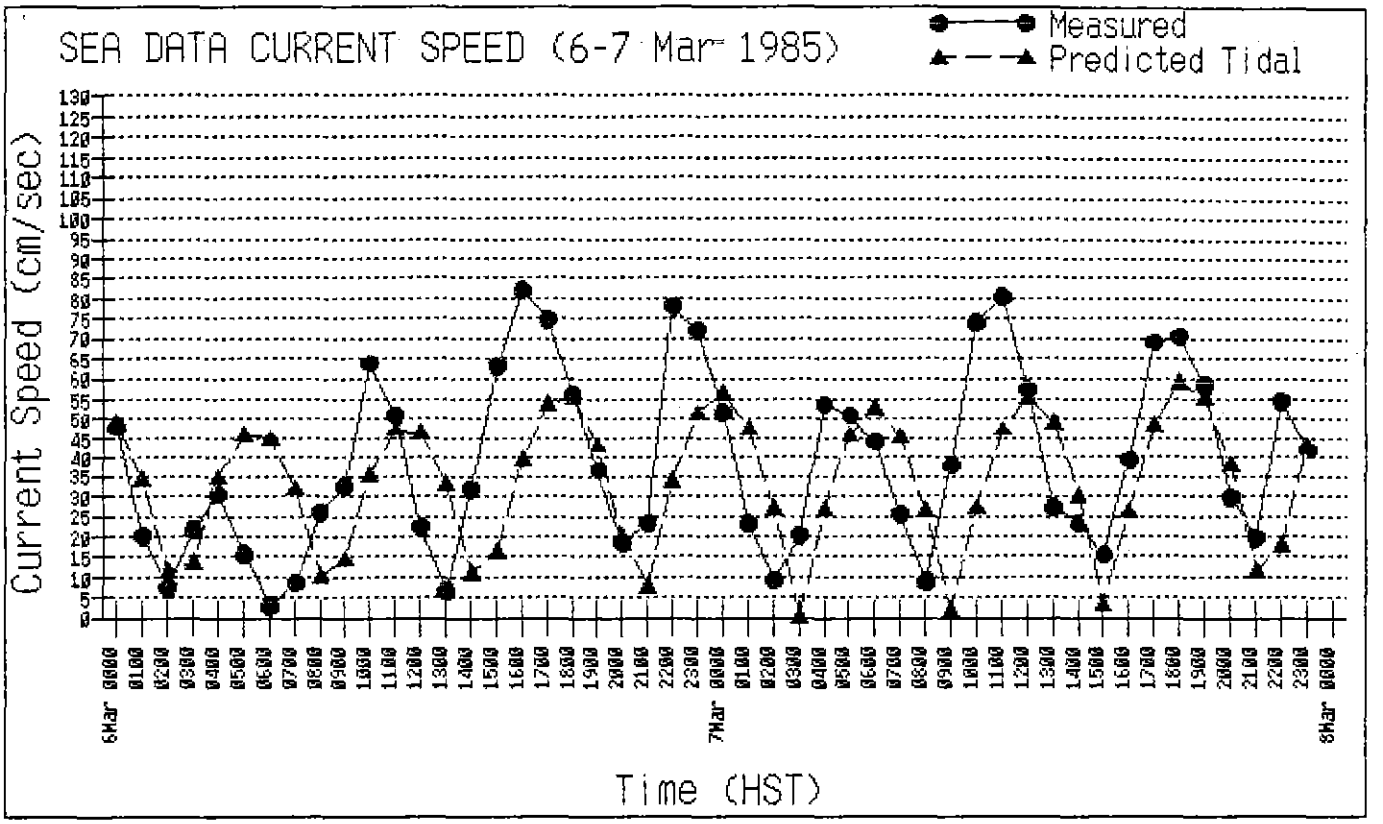


Figure 4.4-2 Comparison of currents, tide and winds, 6-7 March 1985, Sea Data meter off Upolu Point



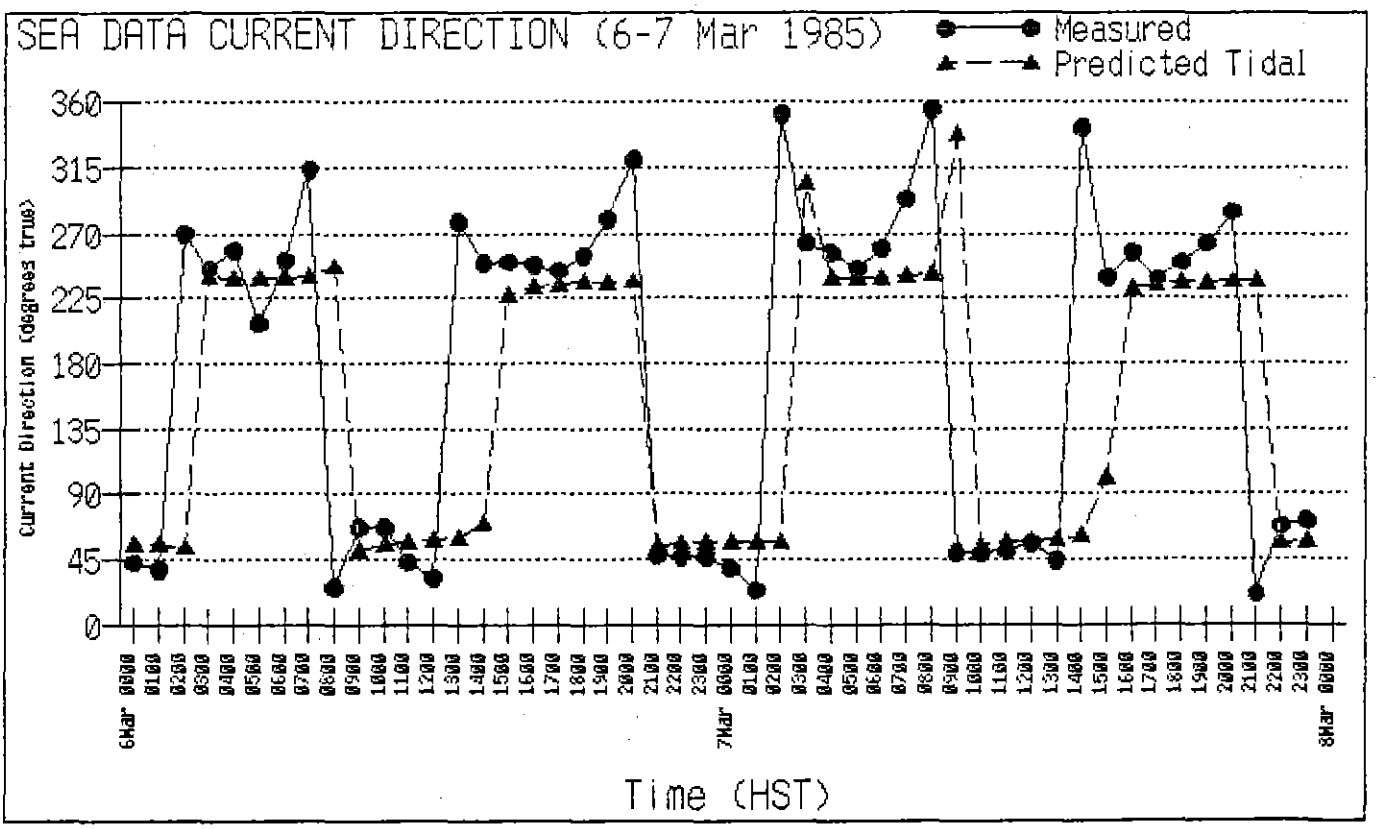
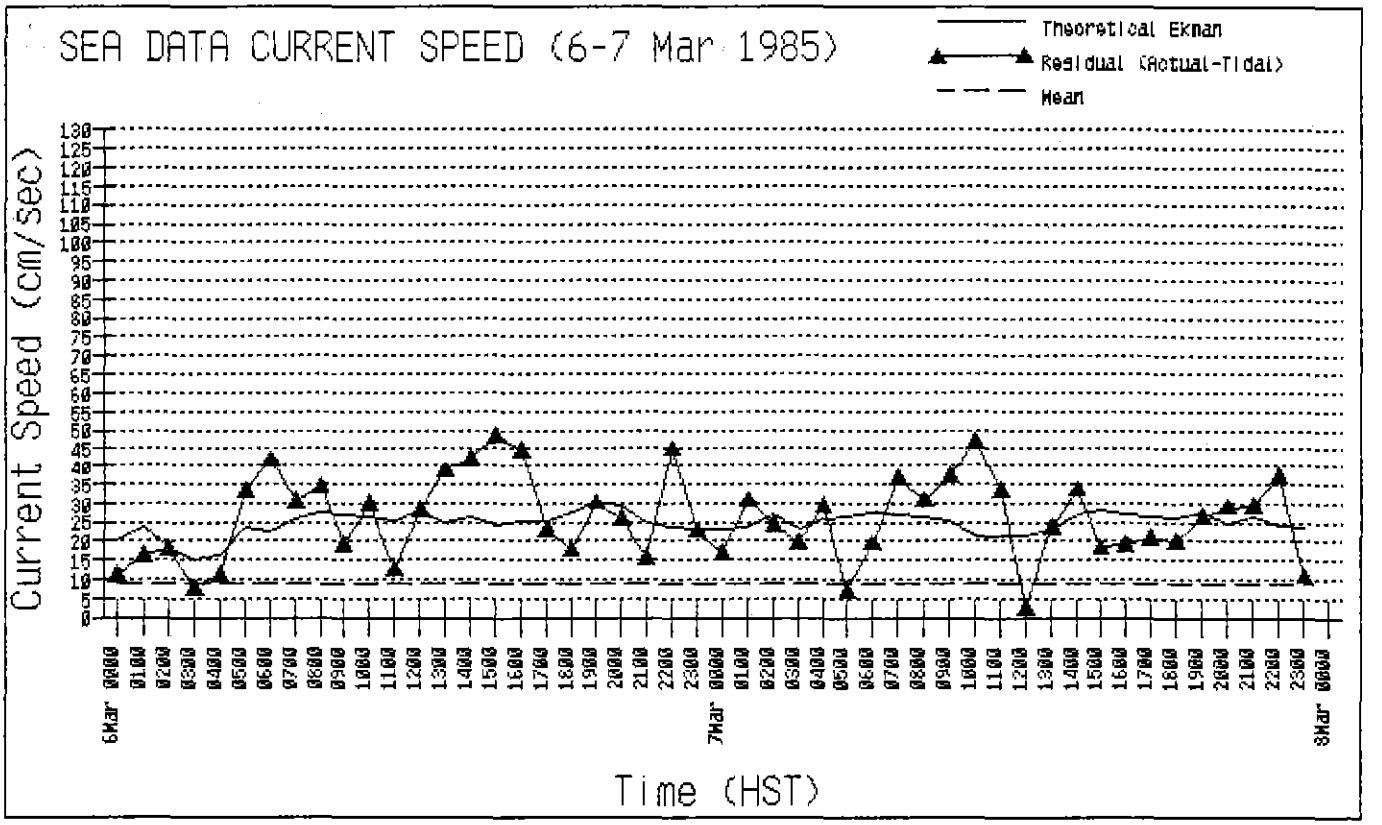


Figure 4.4-3 Comparison of predicted tidal currents and measured currents, 6-7 March 1985, Sea Data Meter



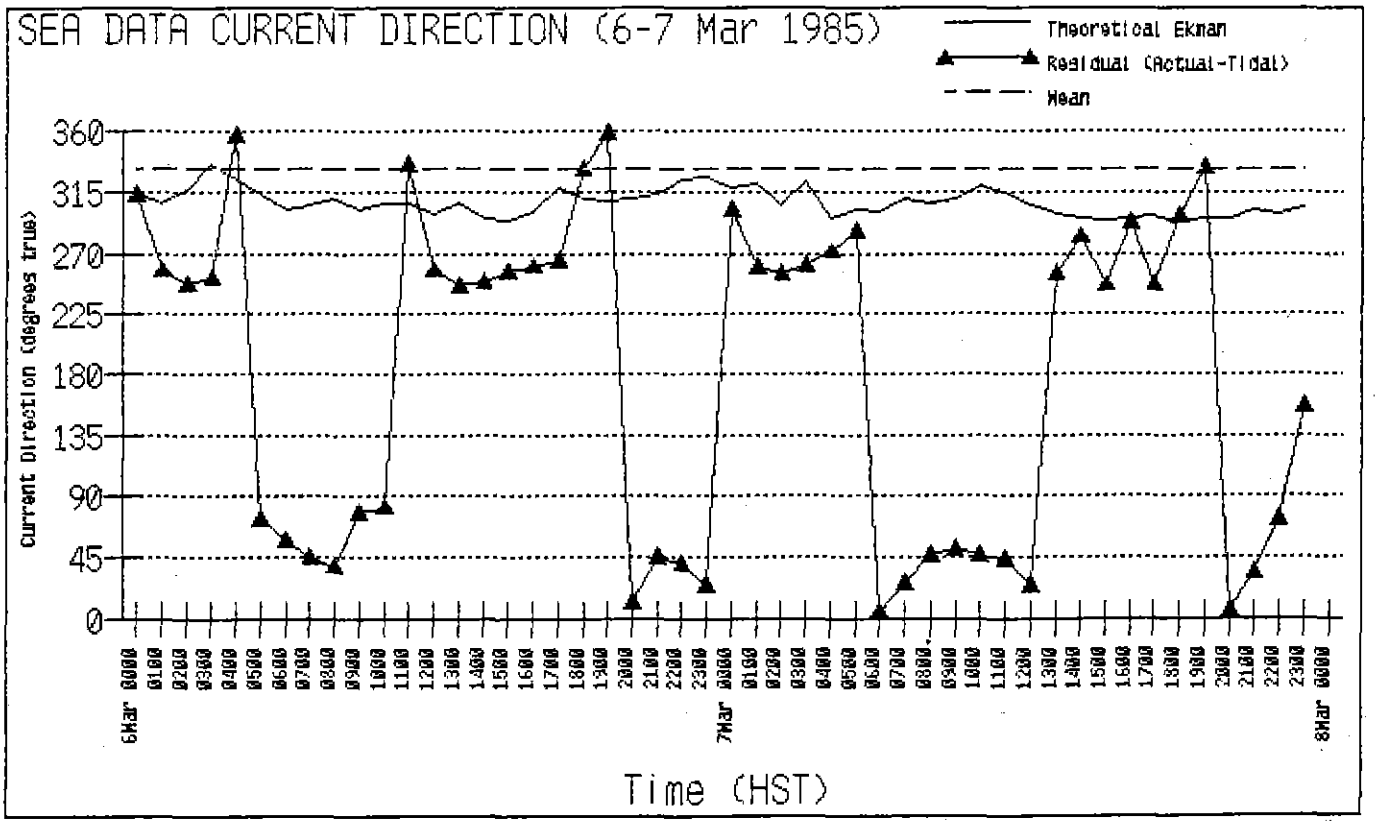
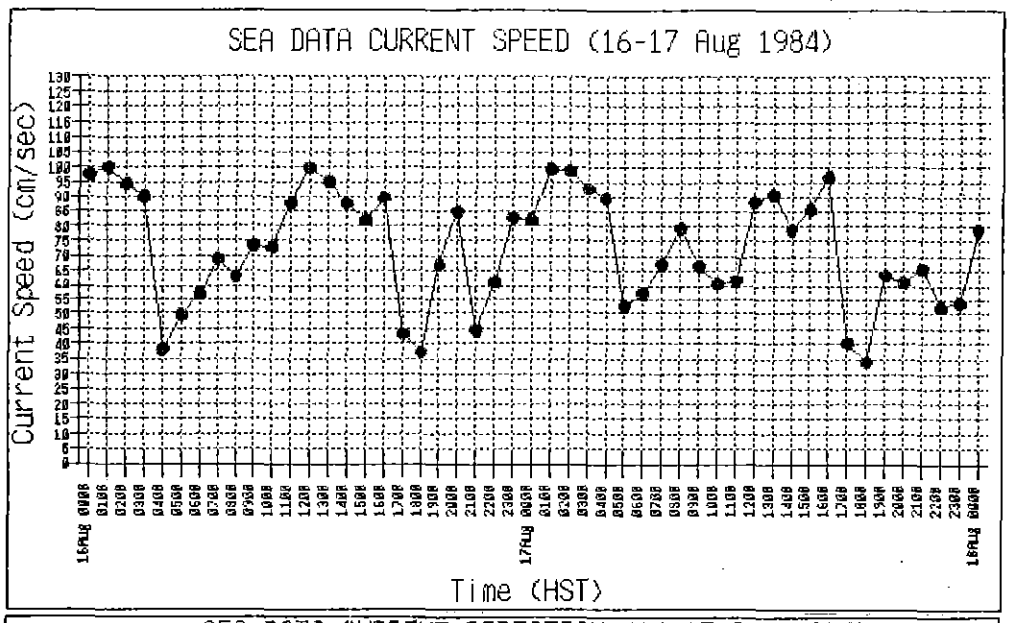
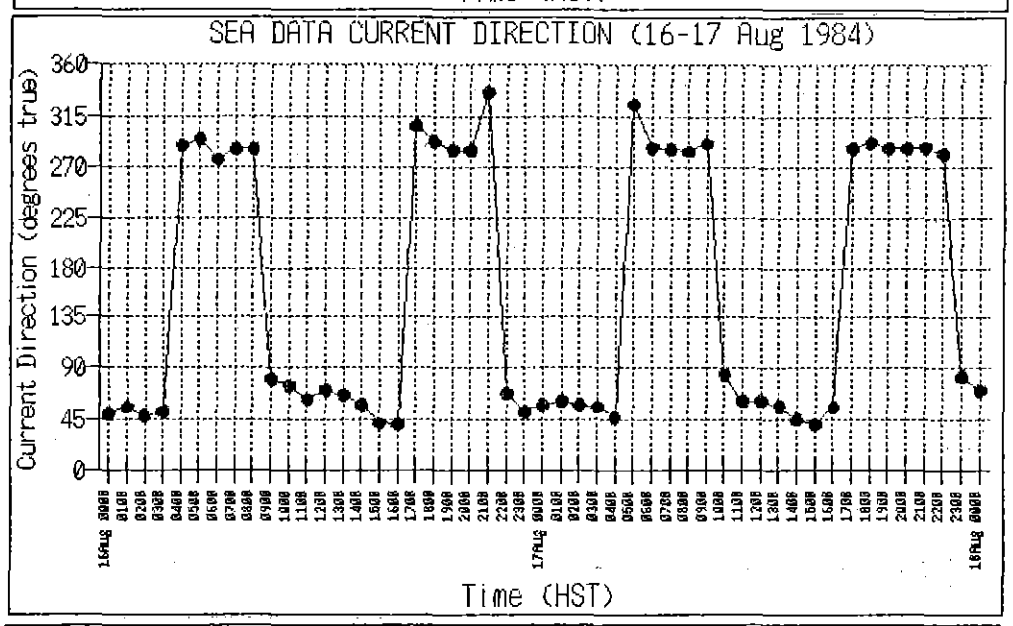


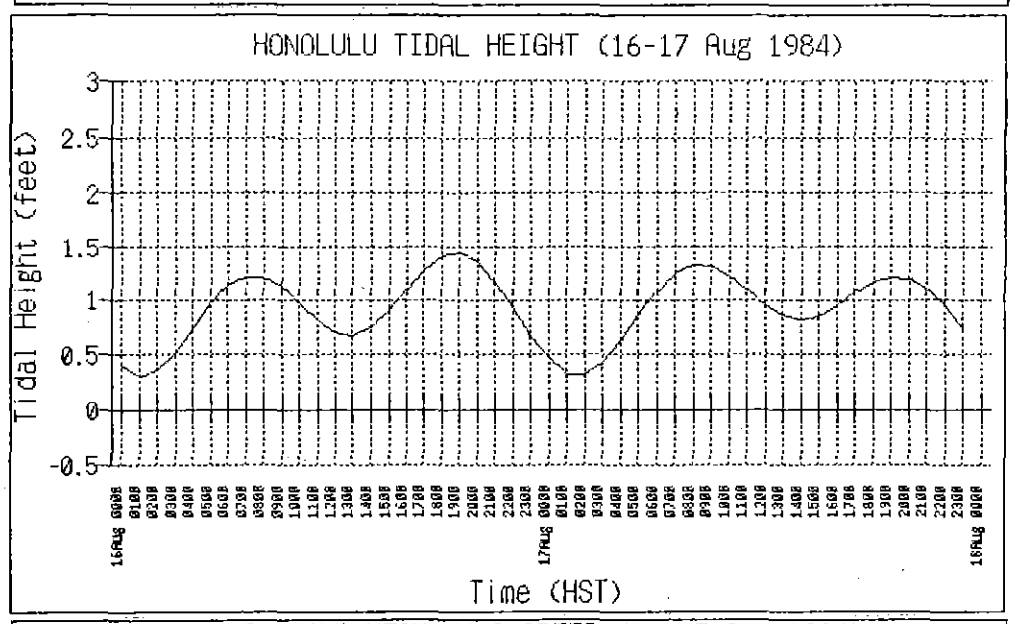
Figure 4.4-4 Comparison of theoretical Ekman currents with residual (measured minus predicted tidal) currents, 6-7 March 1985, Sea Data meter



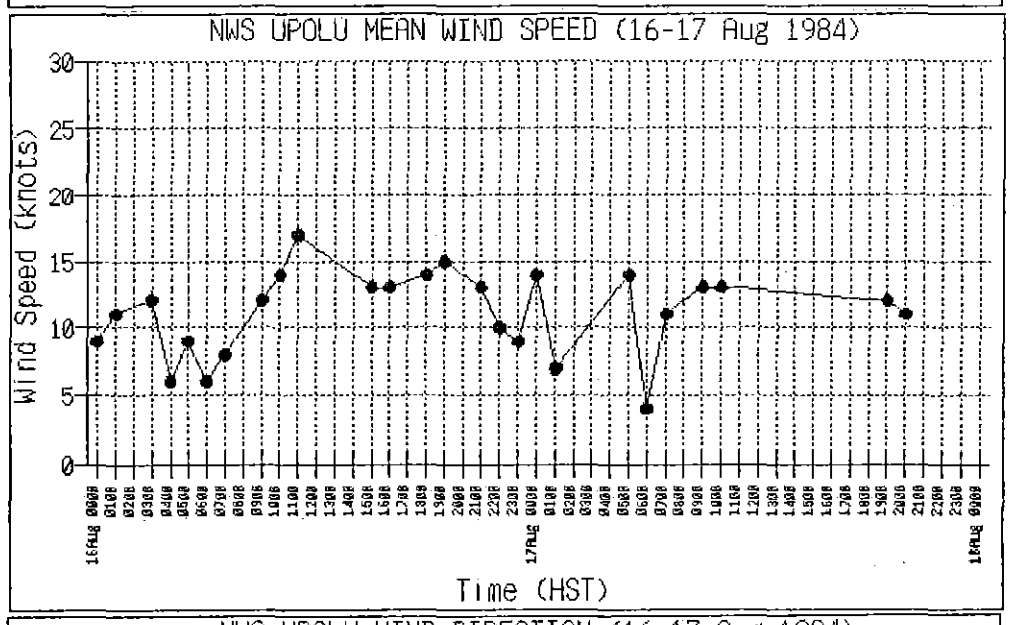
CURRENT SPEED



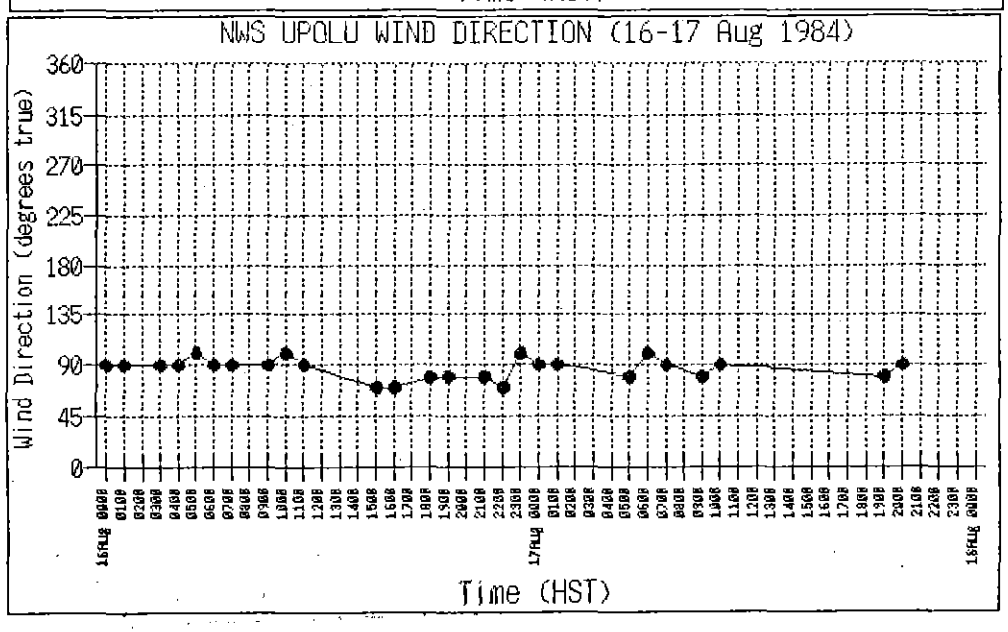
CURRENT DIRECTION



TIDAL HEIGHT

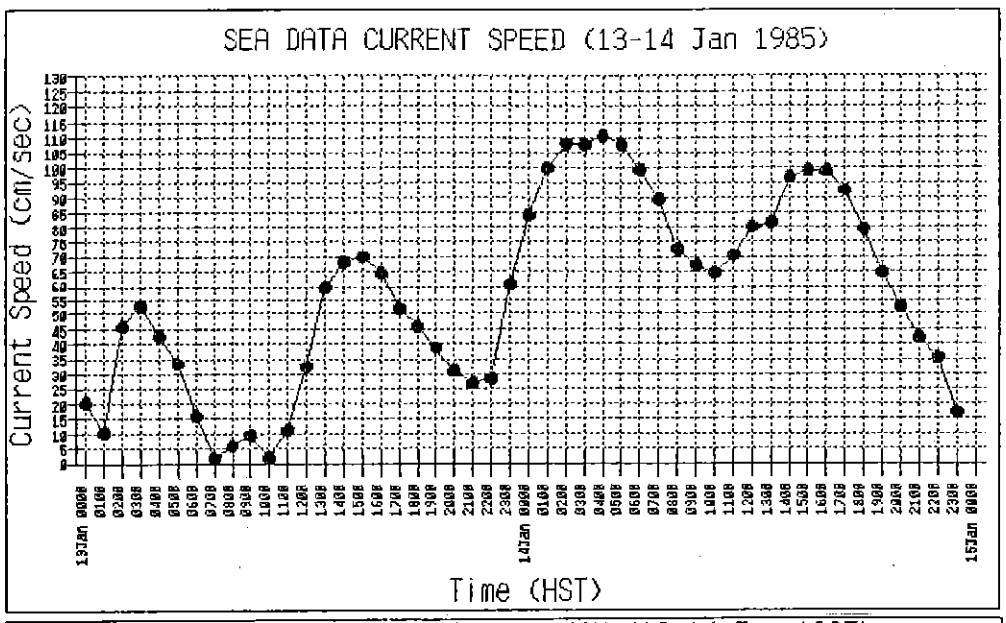


WIND SPEED

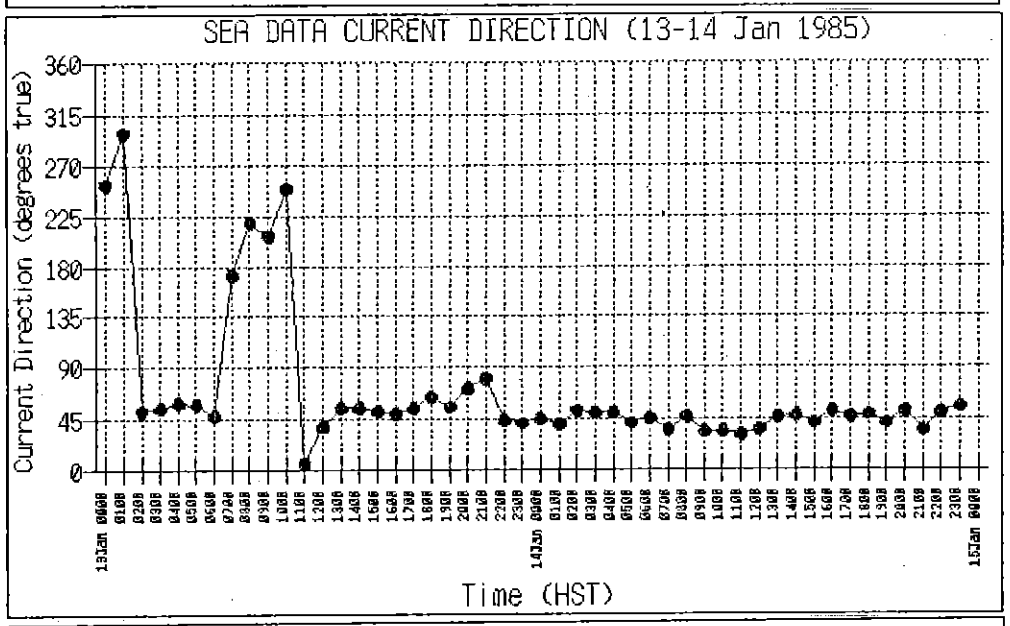


WIND DIRECTION

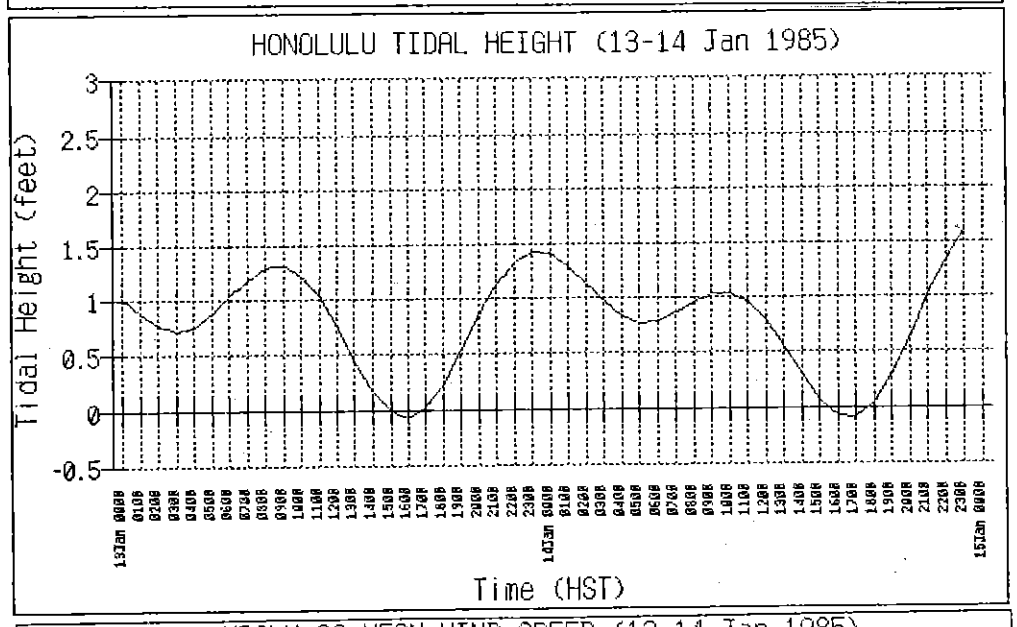
Figure 4.4-5 Comparison of currents, tide and winds, 16-17 August 1984, Sea Data meter off Upolu Point



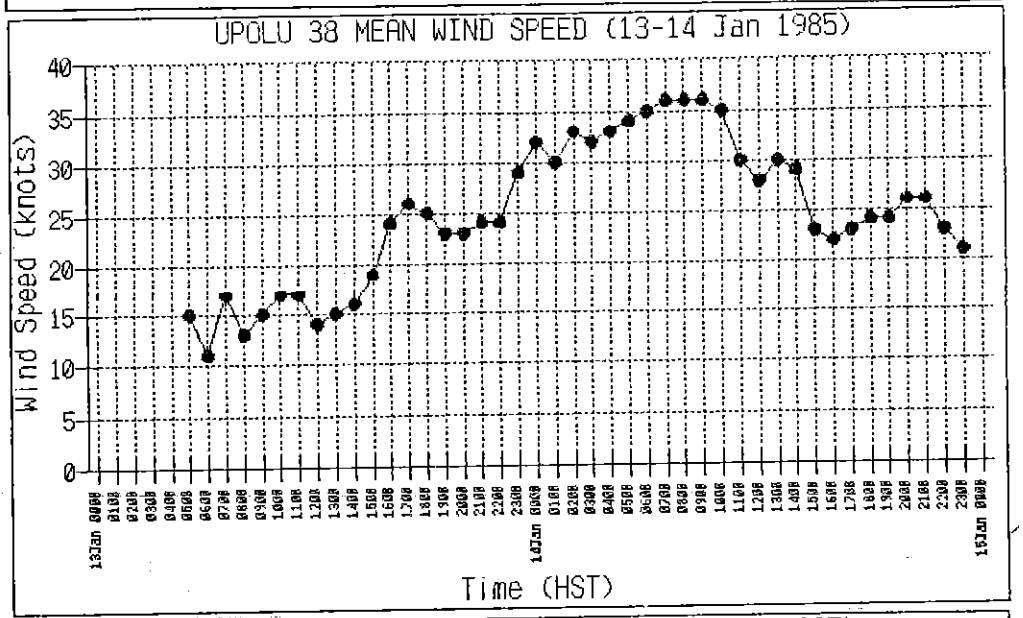
CURRENT SPEED



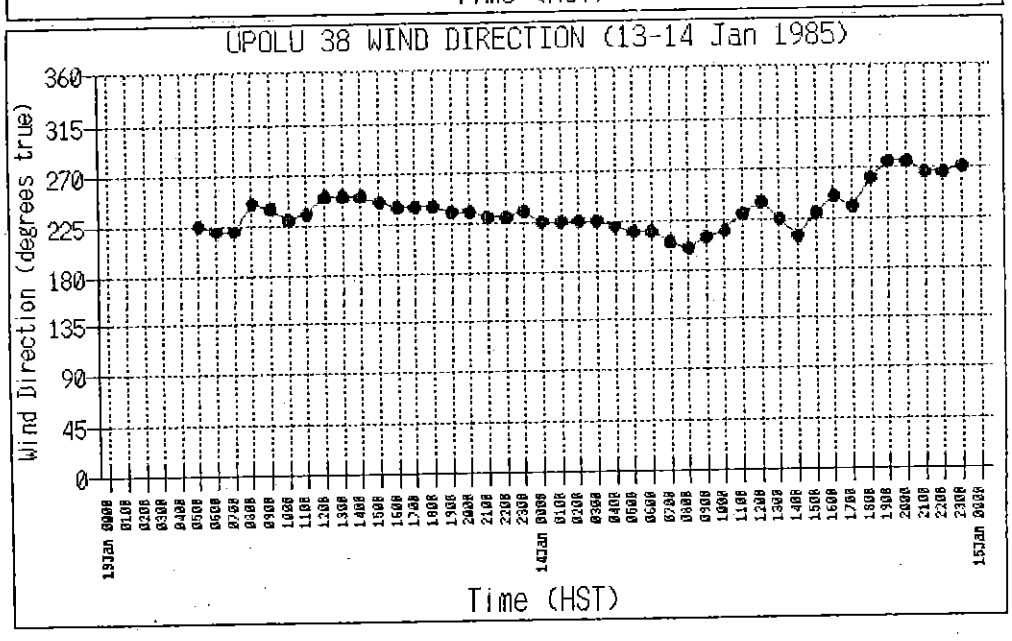
CURRENT DIRECTION



TIDAL HEIGHT

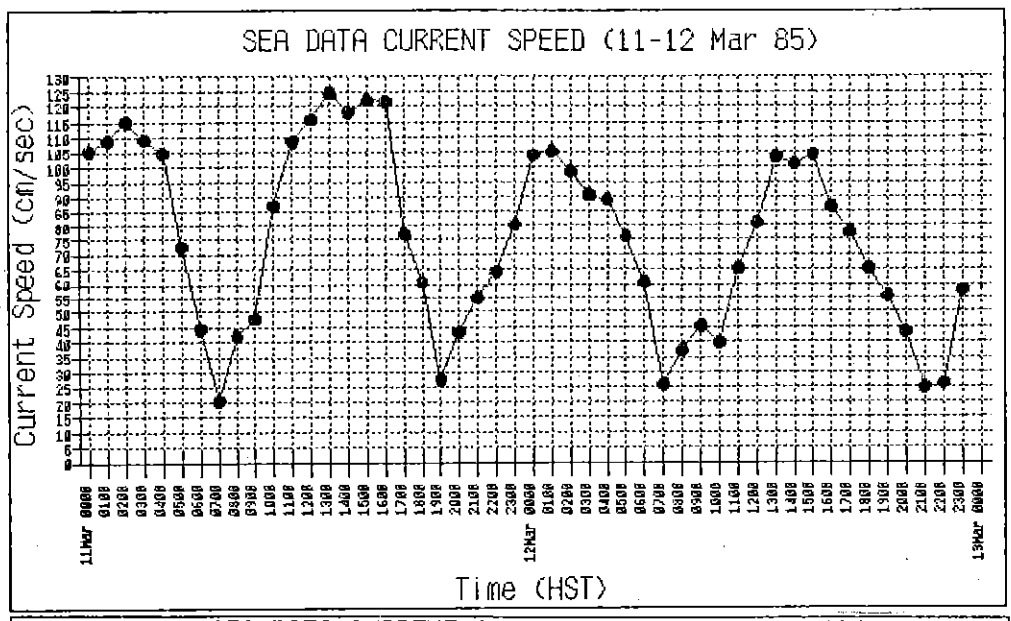


WIND SPEED

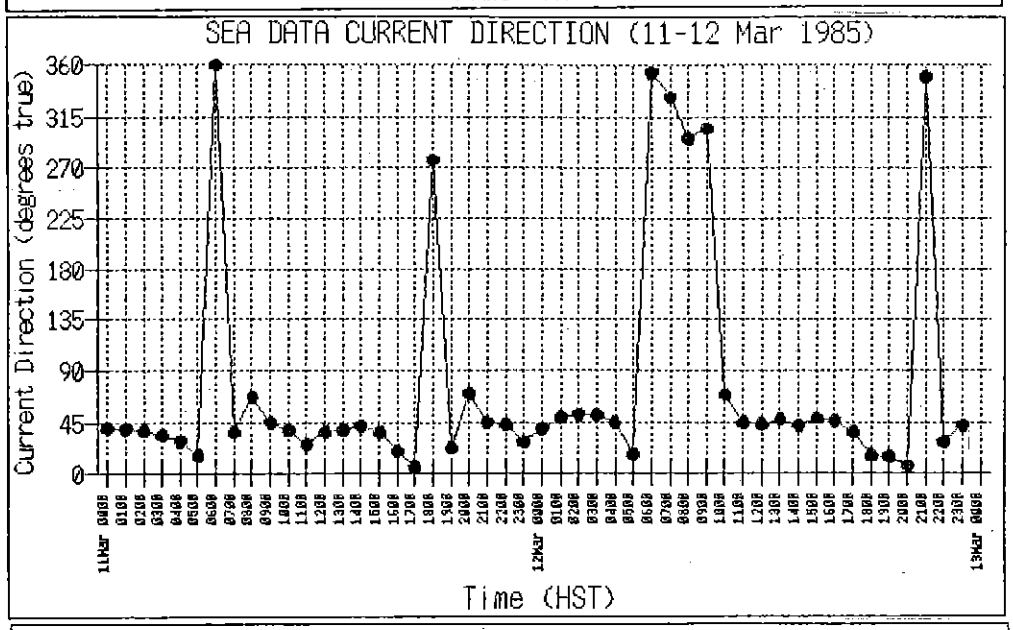


WIND DIRECTION

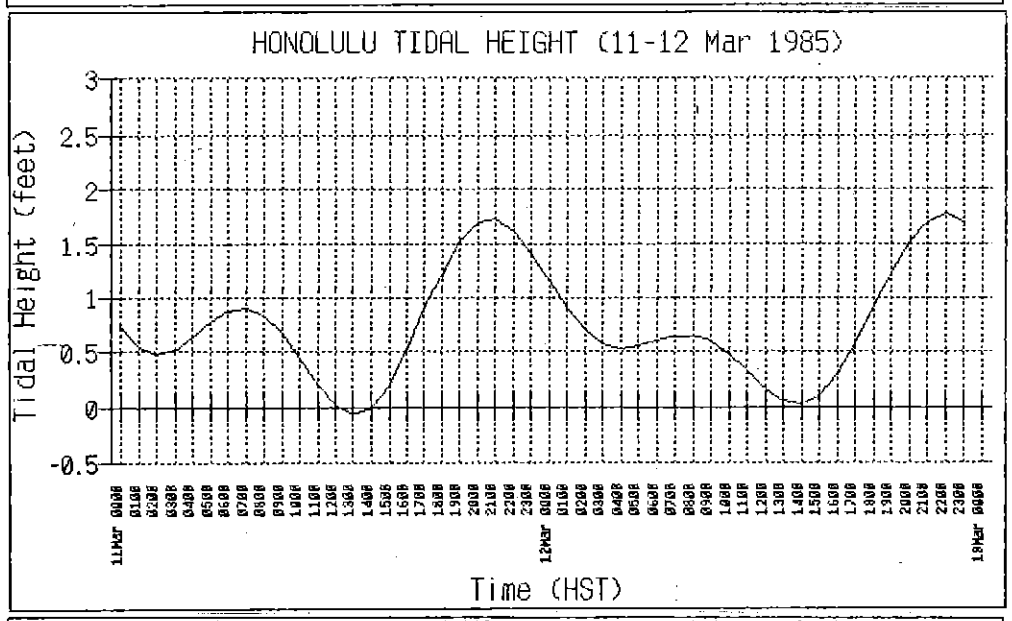
Figure 4.4-6 Comparison of currents, tide and winds, 13-14 January 1985, Sea Data meter off Upolu Point



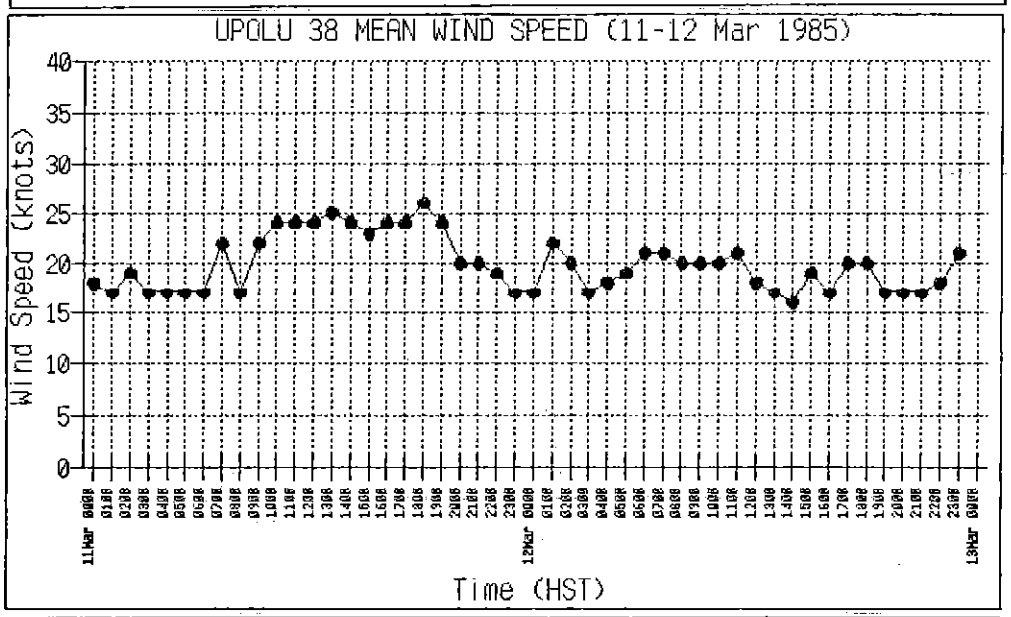
CURRENT SPEED



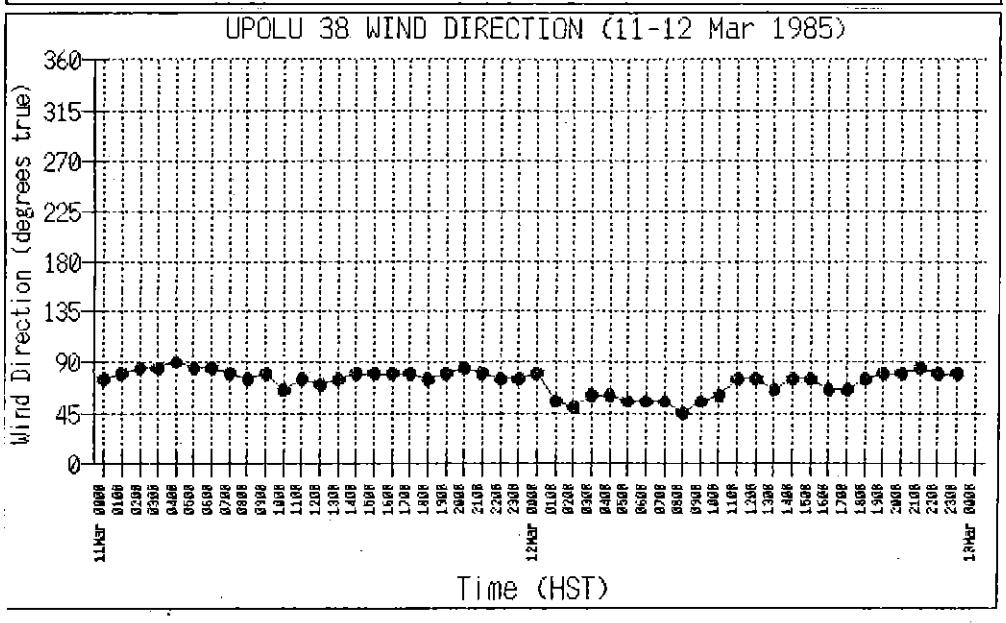
CURRENT DIRECTION



TIDAL HEIGHT

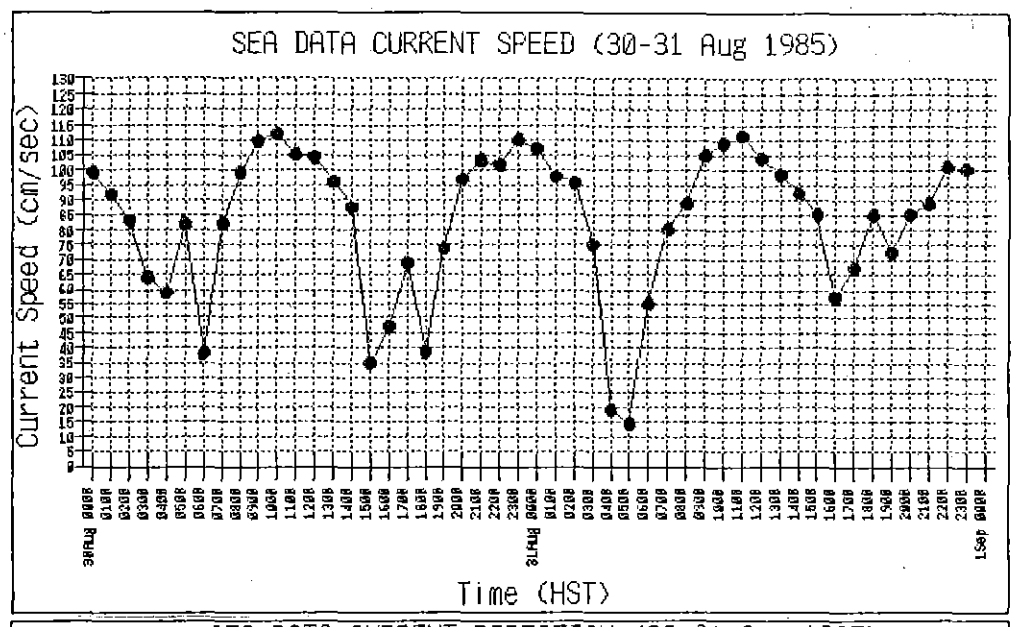


WIND SPEED

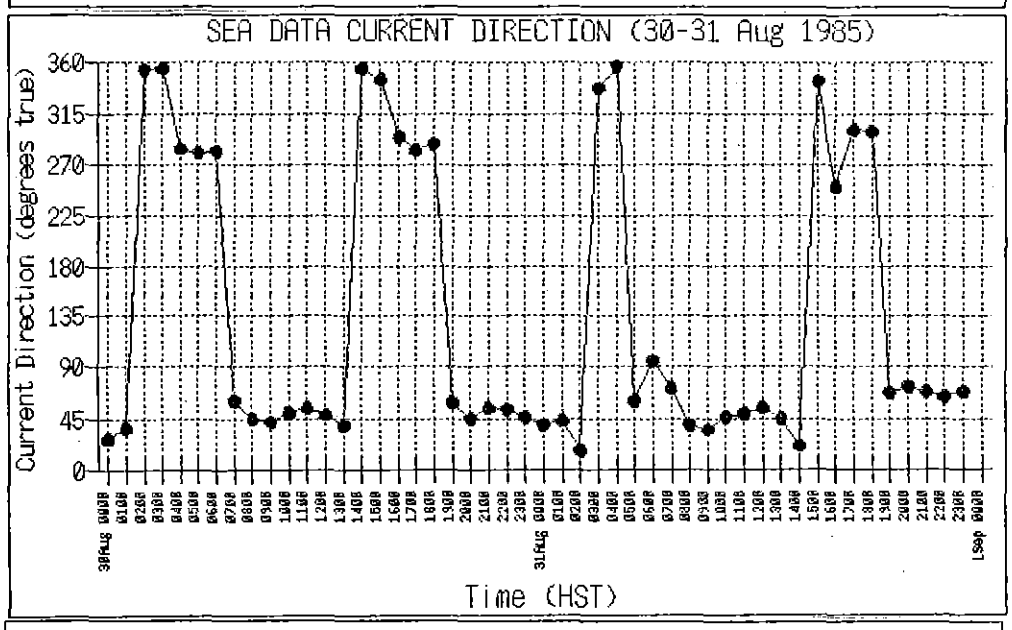


WIND DIRECTION

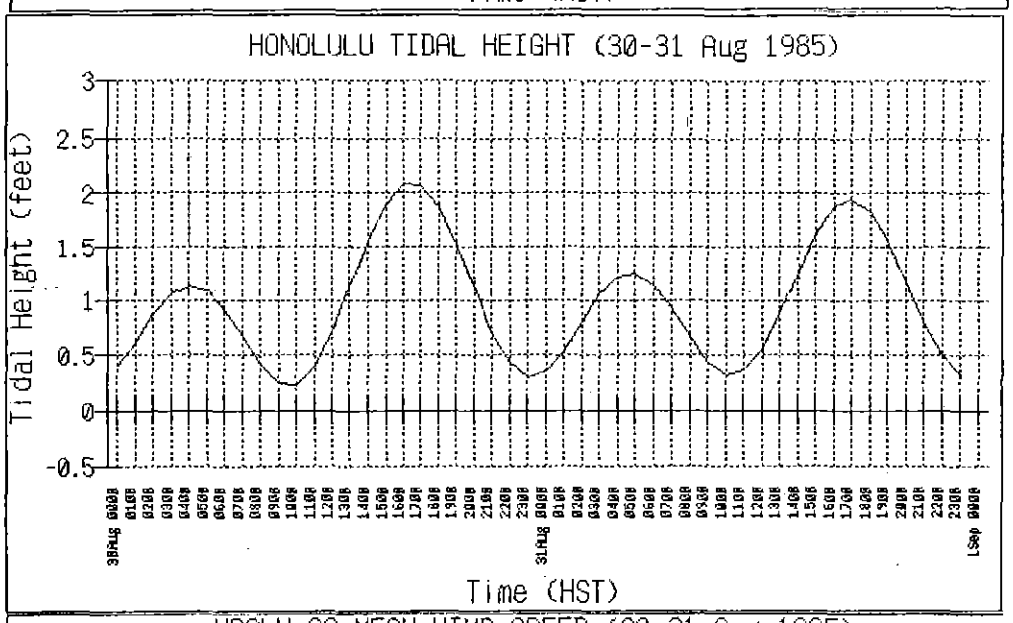
Figure 4.4-7 Comparison of currents, tide and winds, 11-12 March 1985, Sea Data meter off Upolu Point



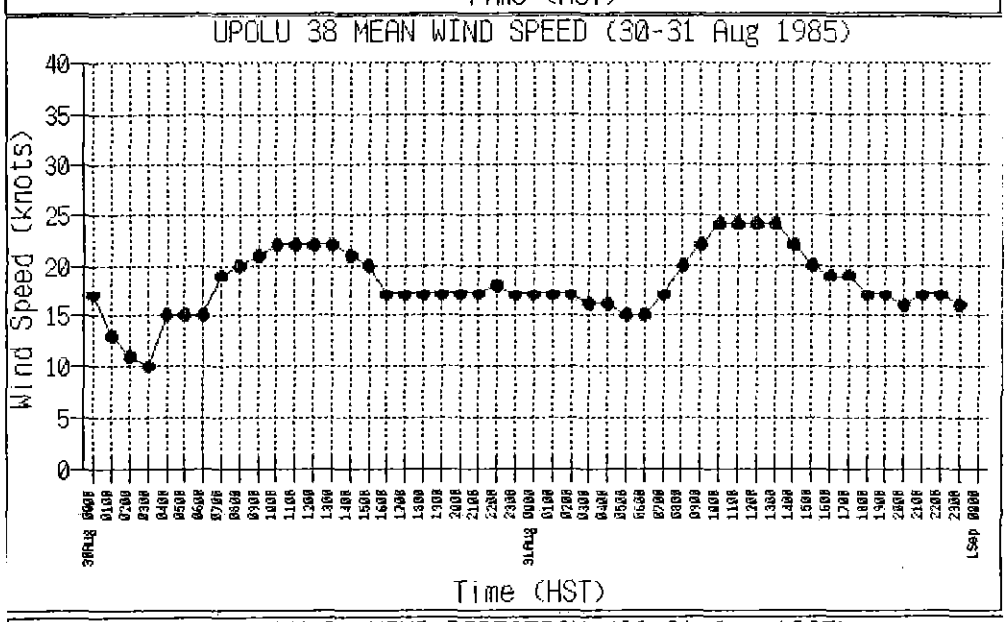
CURRENT SPEED



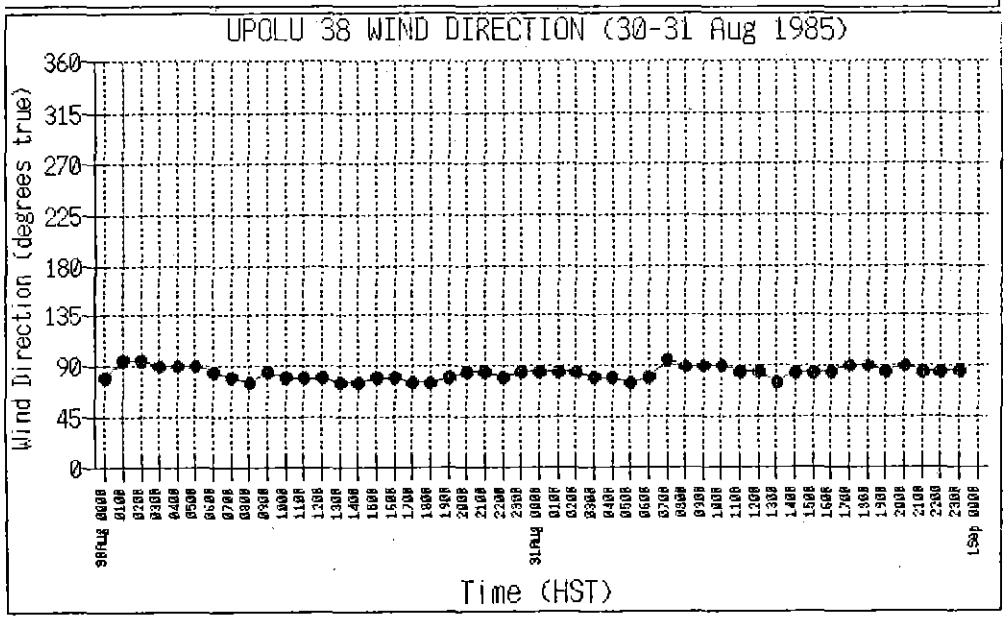
CURRENT DIRECTION



TIDAL HEIGHT



WIND SPEED



WIND DIRECTION

Figure 4.4-8 Comparison of currents, tide and winds, 30-31 August 1985, Sea Data meter off Upolu Point

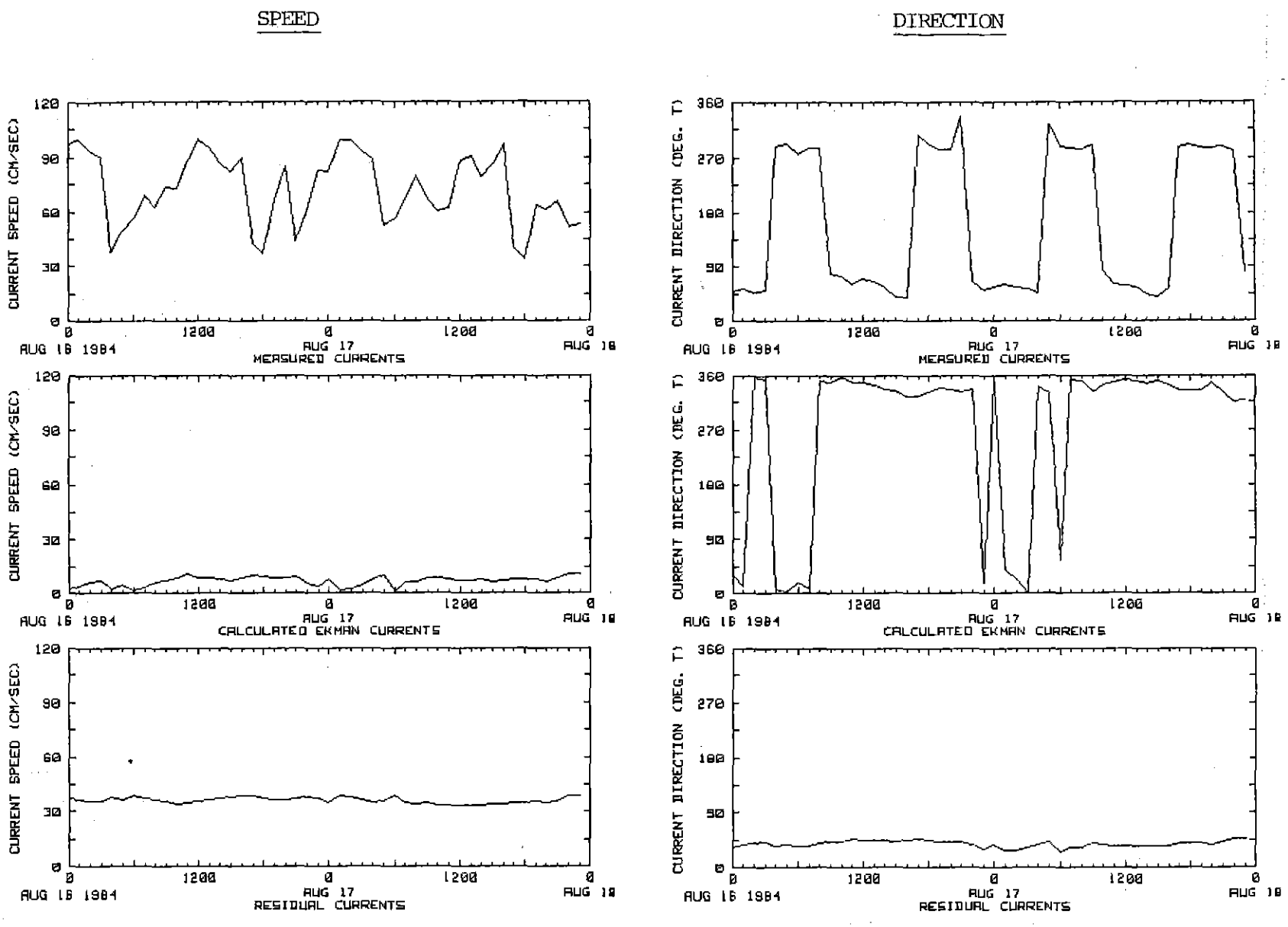


Figure 4.4-9 Residual eddy-induced current, 16-17 August 1984, Sea Data meter off Upolu Point

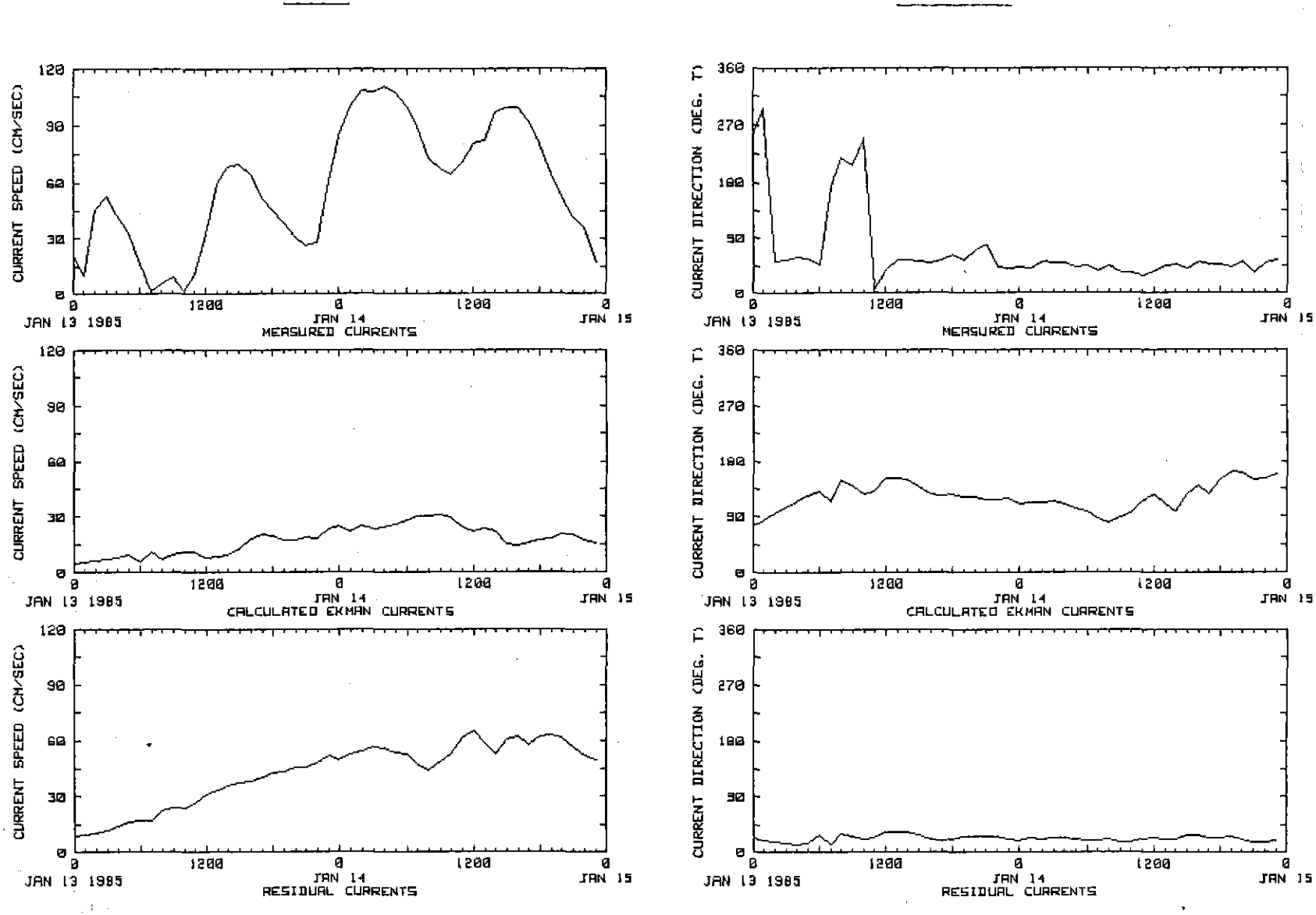


Figure 4.4-10 Residual eddy-induced current, 13-14 January 1985, Sea Data meter off Upolu Point

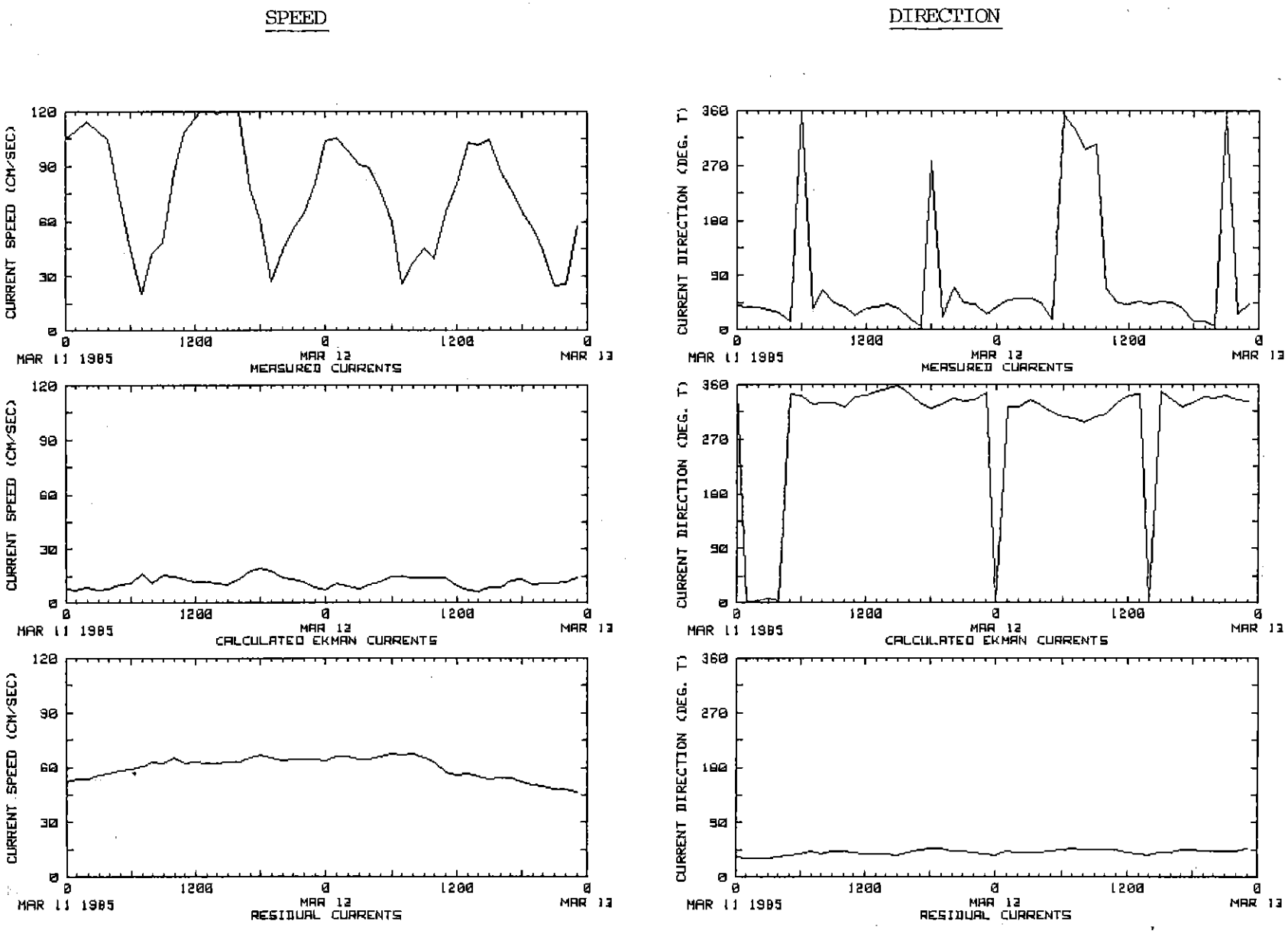


Figure 4.4-11 Residual eddy-induced current, 11-12 March 1985, Sea Data meter off Upolu Point

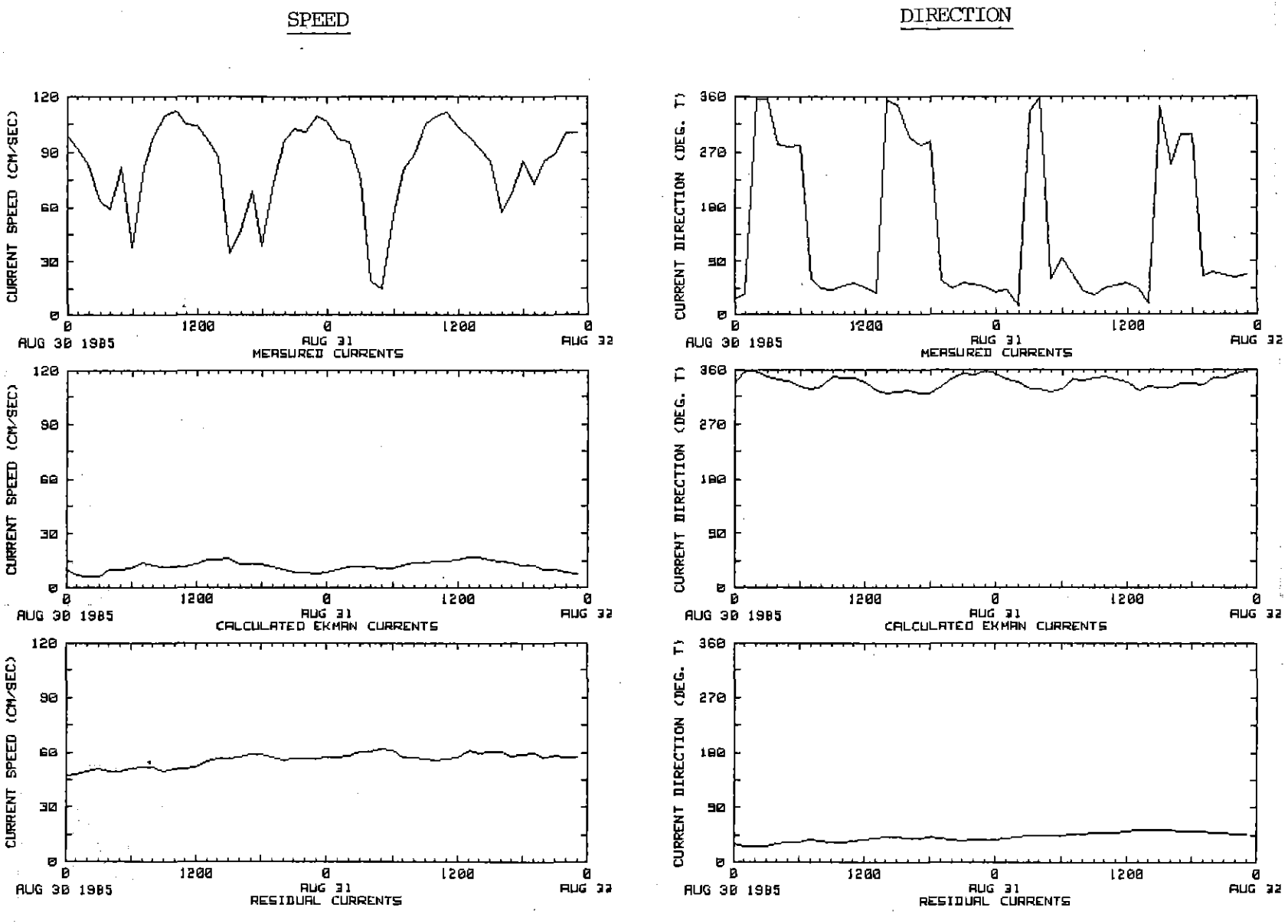


Figure 4.4-12 Residual eddy-induced current, 30-31 August 1985, Sea Data meter off Upolu Point

Table 4.4-2 lists the peak residual (eddy) currents from these four periods. Residual currents approaching 70 cm/sec were determined. Background oceanic currents, if present, would be relatively small on the order of 10-20 cm/sec, as determined previously from evaluation of the near-bottom Aanderaa current data. For the 30-31 August 1985 period, the Aanderaa data indicates a net drift towards the west. Since it would be difficult to separate any background oceanic current from the eddy current component, we shall assume that the residual current speeds represent typical maximum combined eddy plus background oceanic currents at the Sea Data meter location.

Based on this evaluation, an operational design mean current of 70 cm/sec flowing towards the northeast is assumed for the Sea Data location off Upolu Point. This mean current includes both near-surface eddy currents as well as background oceanic currents.

Table 4.4-2 Strong Eddy Currents from the Sea Data Meter off Upolu Point

		Peak Residual (Eddy) Current		
		Speed	Direction	Depth
Date	Winds	(cm/sec)	(°T)	(m)
16-17 Aug 1984	moderate E	39	29	22
13-14 Jan 1985	strong SW	65	24	21
11-12 Mar 1985	mod. strong ENE	68	45	20
30-31 Aug 1985	mod. strong E	62	45	22

4.4.2 Evaluation of XCP Vertical Profiles

In order to determine the eddy influence across the channel, the XCP profiles were evaluated in conjunction with the Sea Data currents. From the progressive vector plots of the Sea Data currents, Survey 3 (28 August 1985) is the only XCP deployment time during which any strong eddy flow is evident. Figure 4.4-13 shows the Sea Data residual current speed in which the tidal currents and theoretical Ekman currents have been removed from the measured currents for the three days during which the XCPs were deployed. The maximum eddy current was about 50 cm/sec on 28 August 1985.

Mean currents below 500 meters, which are assumed to be predominantly tidal currents, and theoretical Ekman currents were removed from the August XCP profiles and the resultant profiles are provided in Appendix D for the upper 500

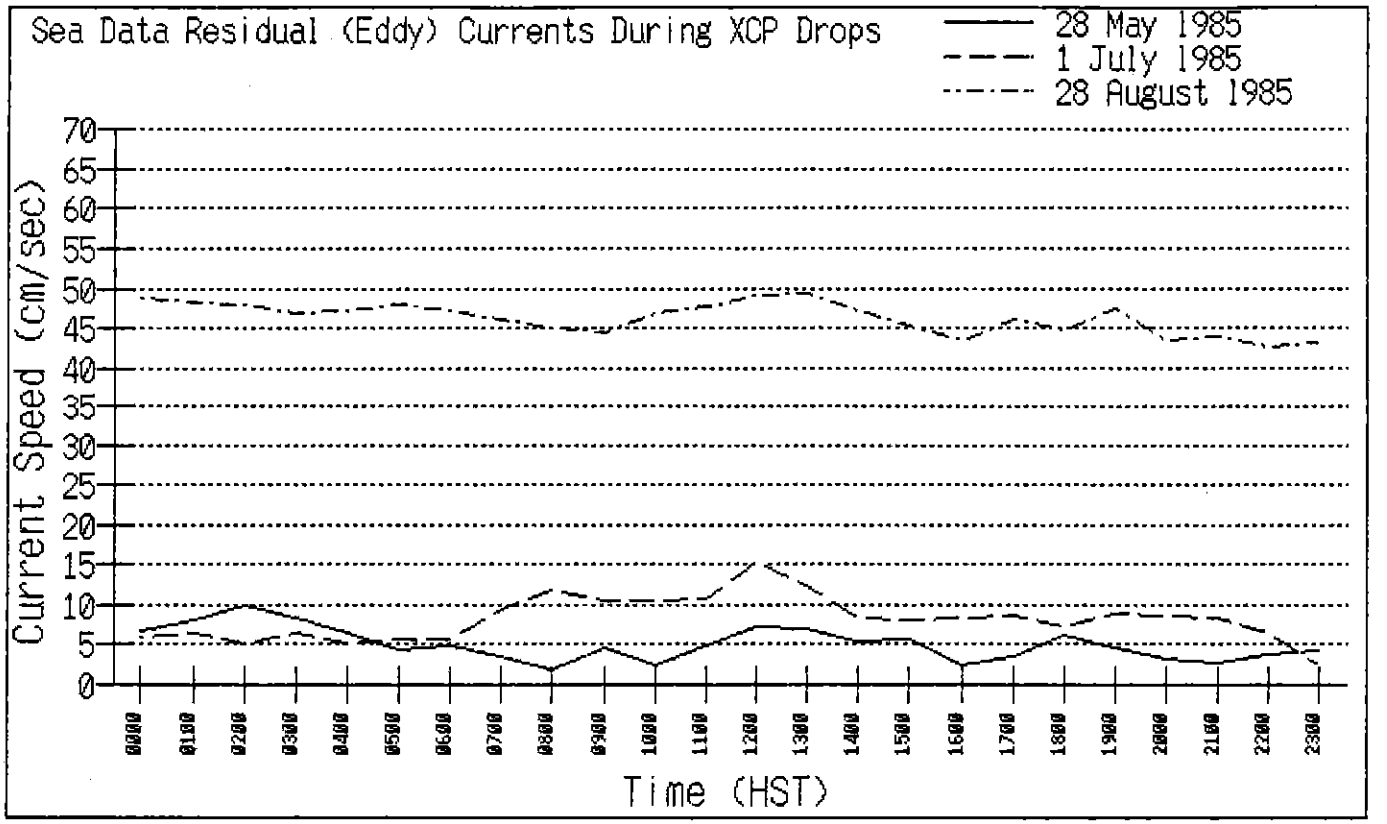


Figure 4.4-13 Residual eddy-induced currents from the Sea Data meter for three days concurrent with XCP vertical profiles

meters. Table 4.4-3 lists the mean speed and direction in the upper 50 meters for each of these XCP resultant profiles and the corresponding Sea Data residual current speed and direction.

Table 4.4-3 Comparison of Eddy Currents from the 28 August 1985 XCP Vertical Profiles with the Sea Data Residual (Eddy) Currents

	Survey 3				<1>	
	XCP Mean Eddy Current Above 50m				Sea Data Residual Current	
			Speed	Dir.	Speed	Dir
Time	Leg	Drop	(cm/sec)	(°T)	(cm/sec)	(°T)
0806	1	1A	51	40	45	64
0835	1	1	38	57	45	64
0900	1	2	42	49	44	64
0930	1	3A	36	50	46	64
0950	1	3	29	45	47	64
1016	1	4	22	69	47	65
1058	1	5A	36	50	48	66
1149	1	5	26	83	49	66
1250	1	6	16	101	50	61
1339	1	7	19	137	48	59
2023	2	1A	70	50	44	52
1917	2	2	49	48	46	53
1840	2	3A	36	54	47	53
1821	2	3	27	52	45	52
1809	2	4	22	26	45	51
1728	2	5	14	81	45	53
1748	2	5A	25	69	45	51
1655	2	6	21	132	45	55
1635	2	7	14	113	45	55

<1> Depth of current meter was between 15 and 30 meters.

The Sea Data residual eddy current is rather consistent at about 45-50 cm/sec on this day. Thus, one would expect to see a well-defined eddy current system showing counter-clockwise rotation similar to Figure 4.1-6. The XCP eddy currents, however, do not reflect a rotational sense across the channel. The currents within the upper 50 meters are northeasterly for all locations except stations 6 and 7 on the Maui side of the channel. The near-surface speed decreases from a maximum on the Hawaii side to a minimum on the Maui side.

Figure 4.4-14 shows vector plots of the eddy currents averaged every 50 meters along the vertical profiles. These profiles are from the first leg of Survey 3. The strongest eddy currents are typically in the upper 50 meters. XCP location 1A shows consistently northeasterly currents

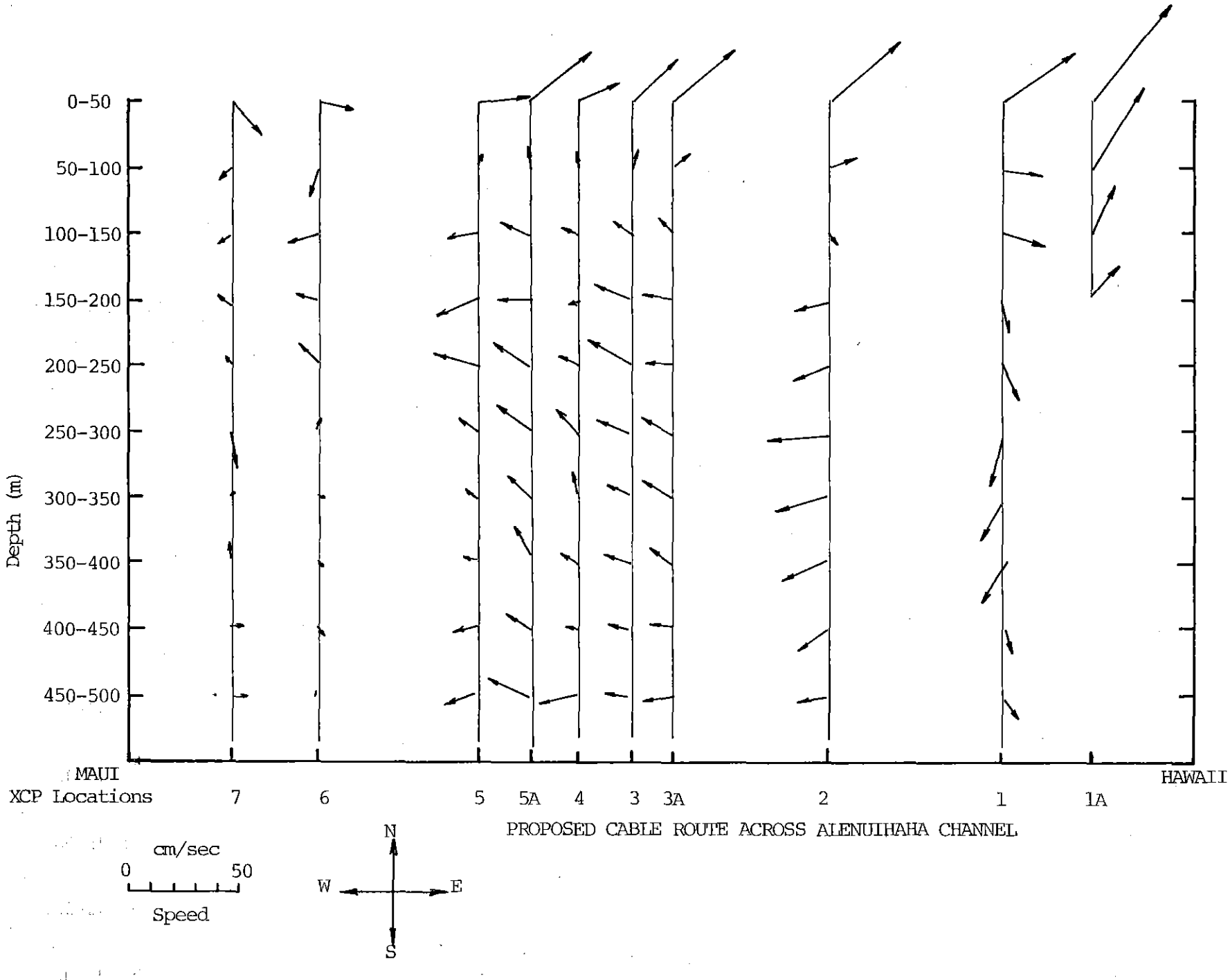


Figure 4.4-14 Residual eddy-induced currents from XCP vertical profiles, Survey 3, Leg 1

throughout the profile depth. In mid-channel (XCP locations 2 through 5), currents below 100 meters are westerly. XCP locations 6 and 7 are probably too far north within the channel to be influenced directly by the eddy. Apparently, the stratification of currents is strongly related to the density stratification, where the strongest flows are contained within the mixed layer, and weaker flows within the thermocline. From this data, it is apparent that the eddy influence within the Alenuihaha Channel is not easily definable due to the bathymetric and topographic constraints of the channel on the offshore eddies.

4.4-3 Operational Wind-Driven and Eddy Current Criteria

Currents in the Alenuihaha Channel in the upper 200-300 meters are influenced by wind-driven and eddy currents. Wind-driven currents are on the order of 2% of the wind speed near the surface, decreasing exponentially with depth. The direction of the surface current is 45° cum sole from the direction of the wind, with the direction deflected clockwise with depth so that at a depth z = D, the direction is opposite to the surface current. At this depth D, which is about 200 meters for a wind speed of 30 knots, the current speed is only about 4% of the surface current speed. The wind-induced operational currents are given in Table 4.4-4 for strong tradewind and Kona wind conditions.

For the purpose of defining a design operational eddy profile, we shall assume a mean eddy current uniform in speed and direction within the upper 50 meters, decreasing linearly to zero at 200 meter depth. The speed of the near-surface eddy current decreases from a maximum of 70 cm/sec on the Hawaii side of the channel (XCP location 1A) to 20 cm/sec on the Maui side (XCP location 7). Table 4.4-5 lists the estimated peak operational eddy currents along the proposed cable route.

Table 4.4-4 Operational Wind-Induced Design Currents for Tradewind and Kona Wind Conditions

TRADEWIND CONDITIONS
Sustained wind speed 30 knots
Wind direction from 70 °T

Depth (m)	Speed (cm/sec)	Direction (°T)
0	33.3	295
25	22.4	318
50	15.1	340
75	10.2	3
100	6.9	25
125	4.6	48
150	3.1	71
175	2.1	93
200	1.4	116

KONA WIND CONDITIONS
Sustained wind speed 25 knots
Wind direction from 225 °T

Depth (m)	Speed (cm/sec)	Direction (°T)
0	27.7	90
25	17.3	117
50	10.8	144
75	6.7	171
100	4.2	198
125	2.6	226
150	1.6	253
175	1.0	280
200	0.6	307

Table 4.4-5 Estimated Peak Operational Eddy Currents Along the Proposed Cable Route, Alenuihaha Channel

Location	Bottom Depth (m)	Speed (cm/sec)	Direction (°T)
Offshore Upolu Pt	170	70	45
	500	65	50
	800	54	50
Top of Kohala Slope	900	45	50
	1000	44	50
	1600	40	50
Bottom of Kohala Slope	1900	38	60
	2000	34	80
	1500	25	115
Maui Slope	900	20	125
	200	16	130

Note: Eddy current given is the mean current within upper 50 meters. The eddy current is assumed to decrease linearly to zero at 200 meter depth.

4.5 SUMMARY OF OPERATIONAL CURRENT CRITERIA

Currents within the Alenuihaha Channel are comprised of tidal currents, wind-driven currents, eddy currents, and background oceanic currents. As evaluated in the previous sections, the relative magnitudes of these components vary depending on the particular location, distance from shore, and also vertically with depth. Tables 4.5-1 through 4.5-4 provide the operational design currents in the Alenuihaha Channel as a function of location along the proposed cable route for combinations of peak tidal currents and wind-driven currents with the design eddy currents. Vertical current profiles are given in Appendix E for each location.

From the data obtained to date, it is not apparent that there is a particular time of year which is most favorable with respect to operational currents. The tradewinds are stronger and more persistent during the spring and summer months (March through August), and thus one would expect the wind-driven and eddy currents to be similarly stronger during this time. However, the Sea Data near-surface current measurements do not reflect a significant seasonal difference, as can be seen in Figures 4.5-1 and 4.5-2. This may be due to the hydrography of the eddies, whereby the formation time, movement, lifetime and decay are not instantaneous functions of the wind but have a great deal of inertia. Formation time is estimated at one week to over a month for an intense eddy with lifetimes of two months or more before they decay (Patzert, 1969).

Table 4.5-1 Operational Design Currents in the Alenuihaha Channel - Peak Northeasterly Tidal Current, Tradewind Conditions

	Nominal Bottom Depth Across Alenuihaha Channel (Maui to Hawaii)																					
Vertical	200 m		900 m		1500 m		2000 m		1900 m		1600 m		1000 m		900 m		800 m		500 m		170 m	
Depth(m)	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir
0	41	56	42	60	40	61	49	49	63	41	71	38	69	36	68	35	78	38	93	40	101	38
25	55	63	56	66	54	67	63	56	75	49	83	45	80	44	79	43	90	44	105	46	113	43
50	63	69	64	71	63	72	70	62	81	55	88	51	86	49	85	49	96	49	111	50	118	48
75	66	72	67	74	64	75	68	66	78	59	84	56	81	54	79	54	89	54	102	54	108	52
100	65	74	66	75	62	76	63	69	71	63	77	60	73	58	72	58	80	58	91	57	96	55
125	64	75	63	76	59	77	57	71	64	66	70	63	65	62	63	61	70	61	79	61	84	59
150	61	74	60	75	54	76	50	72	57	68	62	66	56	65	54	65	59	64	67	64	71	62
175	58	73	57	74	50	74	44	72	49	70	54	68	48	68	46	68	49	67	55	67	61	65
200	56	71	54	71	46	71	37	72	42	71	47	71	40	71	38	72	40	71	44	71		
>200			63	70	55	70	46	70	51	70	56	70	49	70	47	70	49	70	53	70		

Note: Current speed cm/sec, Direction °T

For upper 200 meters depth, operational design currents comprised of peak tidal currents (Table 4.3-9), wind-induced currents (Table 4.4-4), and eddy currents (Table 4.4-5).

For >200 meter depth, operational design currents comprised of peak tidal currents (Table 4.3-9) and background oceanic current of 10 cm/sec, unidirectional with tidal current.

Table 4.5-2 Operational Design Currents in the Alenuihaha Channel - Peak Southwesterly Tidal Current, Tradewind Conditions

	Nominal Bottom Depth Across Alenuihaha Channel (Maui to Hawaii)																					
Vertical	200 m		900 m		1500 m		2000 m		1900 m		1600 m		1000 m		900 m		800 m		500 m		170 m	
Depth(m)	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir
0	71	258	66	256	51	257	32	284	41	298	49	299	44	311	43	315	44	324	46	333	54	333
25	56	257	50	255	36	255	19	303	30	316	38	314	36	330	36	335	39	345	44	353	51	350
50	47	252	42	248	27	245	10	325	22	331	30	324	30	345	31	350	36	359	42	6	48	1
75	44	247	40	244	27	239	6	297	16	319	23	313	22	338	22	346	26	356	30	3	36	358
100	45	244	41	241	29	236	9	256	14	290	21	291	16	316	16	325	17	339	20	348	25	343
125	47	244	44	241	33	237	15	245	19	266	24	271	17	283	15	289	14	300	15	308	19	309
150	49	245	46	243	36	241	22	245	26	255	31	258	23	263	20	264	20	268	21	271	24	274
175	52	247	49	246	40	245	28	246	33	250	38	252	30	253	28	254	29	254	31	255	32	259
200	54	249	52	249	44	249	35	248	40	249	45	249	38	248	36	248	38	248	42	249		
>200			63	250	55	250	46	250	51	250	56	250	49	250	47	250	49	250	53	250		

Note: Current speed cm/sec, Direction °T

For upper 200 meters depth, operational design currents comprised of peak tidal currents (Table 4.3-9), wind-induced currents (Table 4.4-4), and eddy currents (Table 4.4-5).

For >200 meter depth, operational design currents comprised of peak tidal currents (Table 4.3-9) and background oceanic current of 10 cm/sec, unidirectional with tidal current.

Table 4.5-3 Operational Design Currents in the Alenuihaha Channel - Peak Northeasterly Tidal Current, Kona Wind Conditions

	Nominal Bottom Depth Across Alenuihaha Channel (Maui to Hawaii)																					
Vertical	200 m		900 m		1500 m		2000 m		1900 m		1600 m		1000 m		900 m		800 m		500 m		170 m	
Depth(m)	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir
0	92	85	94	86	93	87	97	79	104	72	110	68	107	67	106	67	116	66	131	64	137	62
25	79	90	82	91	80	92	83	83	90	74	95	69	92	69	91	68	102	67	116	65	122	62
50	70	90	72	92	71	93	74	83	81	73	87	68	83	67	82	66	93	65	108	64	114	60
75	63	87	64	88	62	90	64	80	71	71	76	66	72	65	71	65	81	64	93	63	99	60
100	59	82	60	84	56	86	56	77	63	69	69	65	64	64	63	64	71	63	82	62	87	59
125	57	78	57	79	52	81	51	75	57	68	63	65	58	64	56	63	62	63	72	62	77	60
150	56	75	56	76	50	77	46	72	52	67	57	65	51	64	50	64	55	63	62	63	66	61
175	56	72	54	72	47	73	41	71	46	68	52	67	45	66	43	66	47	66	52	65	58	64
200	55	69	53	69	45	69	36	69	41	69	46	69	39	69	37	69	39	69	43	69		
>200			63	70	55	70	46	70	51	70	56	70	49	70	47	70	49	70	53	70		

Note: Current speed cm/sec, Direction °T

For upper 200 meters depth, operational design currents comprised of peak tidal currents (Table 4.3-9), wind-induced currents (Table 4.4-4), and eddy currents (Table 4.4-5).

For >200 meter depth, operational design currents comprised of peak tidal currents (Table 4.3-9) and background oceanic current of 10 cm/sec, unidirectional with tidal current.

Table 4.5-4 Operational Design Currents in the Alenuihaha Channel - Peak Southwesterly Tidal Current, Kona Wind Conditions

	Nominal Bottom Depth Across Alenuihaha Channel (Maui to Hawaii)																					
Vertical	200 m		900 m		1500 m		2000 m		1900 m		1600 m		1000 m		900 m		800 m		500 m		170 m	
Depth(m)	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir	Speed	Dir
0	31	202	30	191	27	163	28	103	23	77	18	57	29	59	32	59	39	57	46	54	48	45
25	44	213	42	206	34	187	21	134	10	107	4	53	14	60	17	61	24	56	31	52	34	40
50	50	221	47	215	37	201	16	159	4	170	6	281	7	28	10	38	17	41	24	41	28	27
75	53	230	49	226	38	216	15	199	11	244	17	267	8	296	7	314	9	353	14	9	19	357
100	54	237	50	234	39	227	18	226	19	253	24	264	16	276	13	282	12	299	12	317	18	319
125	54	241	51	238	40	236	22	239	25	255	30	261	22	267	19	270	18	277	18	284	22	289
150	54	245	51	244	41	242	27	246	30	254	35	258	27	261	25	262	24	265	25	267	28	271
175	55	248	52	248	43	247	31	249	36	253	41	254	33	255	31	256	32	257	34	257	35	261
200	55	251	53	251	45	251	36	251	41	251	46	251	39	251	37	251	39	251	43	251		
>200			63	250	55	250	46	250	51	250	56	250	49	250	47	250	49	250	53	250		

Note: Current speed cm/sec, Direction °T

For upper 200 meters depth, operational design currents comprised of peak tidal currents (Table 4.3-9), wind-induced currents (Table 4.4-4), and eddy currents (Table 4.4-5).

For >200 meter depth, operational design currents comprised of peak tidal currents (Table 4.3-9) and background oceanic current of 10 cm/sec, unidirectional with tidal current.

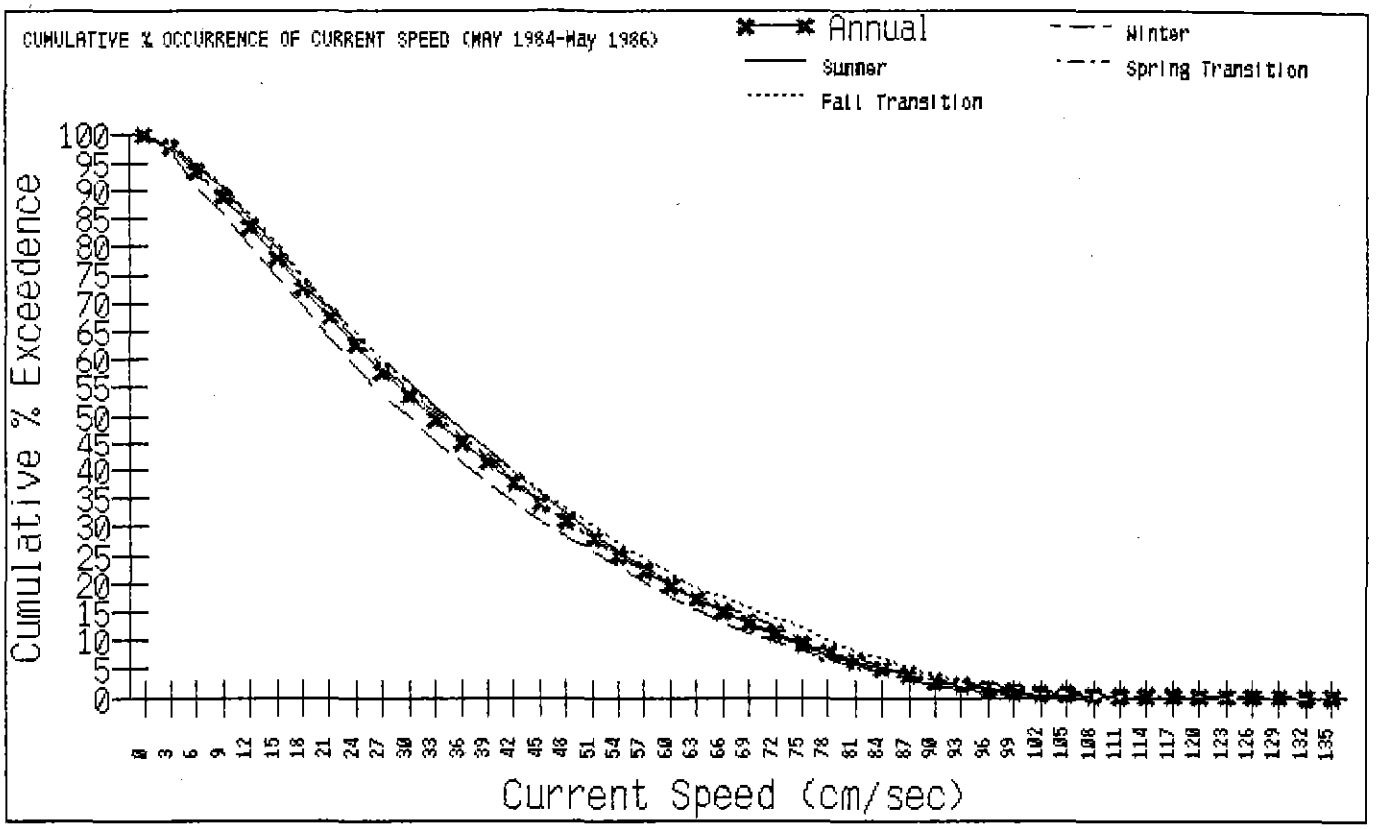


Figure 4.5-1 Cumulative percent frequency of exceedence of Sea Data current speeds, May 1984 - May 1986

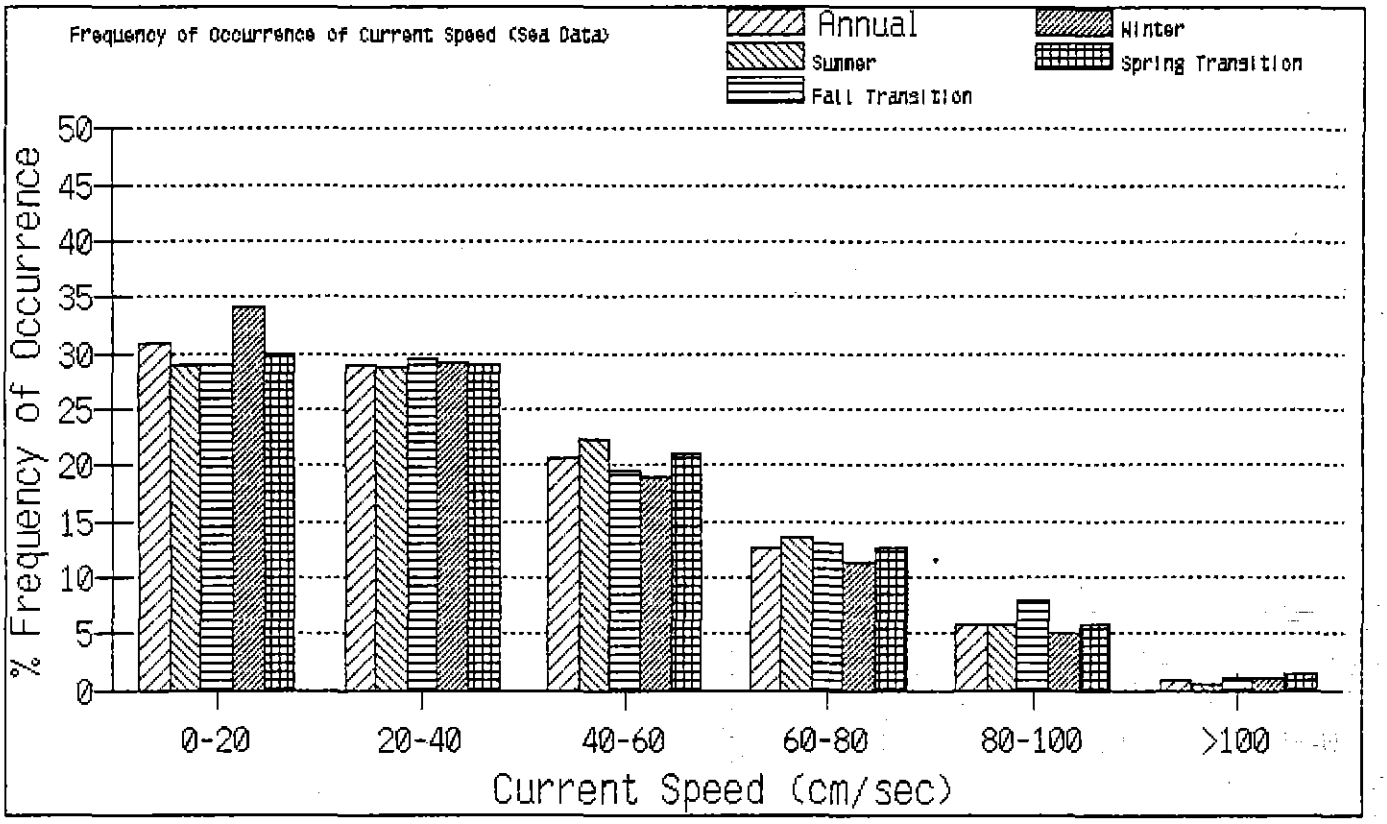


Figure 4.5-2 Annual and seasonal percent frequency of occurrence distributions of the Sea Data currents offshore Upolu Point

Hence, there is about the same probability of encountering the design operational currents at all times of the year. The near-surface eddy currents near the Hawaii coast would enhance the peak tidal currents perpendicular to the cable route. For deep currents beyond the influence of wind and eddy effects, the deterministic tidal currents are strongest near the time of the new moon phase when tidal height changes are large.

4.6 PREDICTION OF CURRENTS DURING DEPLOYMENT

Since tidal currents are deterministic, they can be predicted using the tidal current constituents developed from the current meter data. Estimates for locations where current meter data are not available can be made based on the correlations developed between the XCP drop locations and the current meter stations (Table 4.3-8).

Wind-driven currents can be estimated using Ekman's empirical relation based on reported winds from the NOAA buoy or shipboard measured winds (corrected for ship's speed).

Eddy currents cannot be predicted with any certainty at this time. While the formation of eddies is apparently linked to the winds blowing through the Alenuihaha Channel, there is presently no model for real-time prediction of these eddies. If the near-surface currents must be known with some degree of accuracy, then it is recommended that vertical current profiles be measured periodically along the cable route.

5.0 SUMMARY OF OPERATIONAL CONDITIONS

5.1 GENERAL

The expected operational wind, wave and current conditions in the Alenuihaha Channel were evaluated from measured data acquired to date as part of the Hawaii Deep Water Cable Program. The design operational criteria represent extreme conditions which can occur during a typical year. Infrequent extreme events such as hurricanes are not considered.

Winds and waves vary seasonally while currents do not show a significant seasonal trend, as generally depicted in Figure 5.0-1. In this figure, significant wave heights <6 feet (measured by the Sea Data meter offshore Upolu Point) are expected to occur 81% of the time during the summer months, decreasing to 66% of the time during the winter months and 36% of the time during the spring months. Wind speeds <20 knots (measured at the NWS Upolu Station) are expected to occur about 97-99% of the time during the summer and fall months, decreasing to less than 90% of the time during the spring. Near-surface current speeds <50 cm/sec (measured by the Sea Data meter offshore Upolu Point) are expected to occur about 70% of the time throughout the year. From this data, the least favorable time of year for deployment operations is in the spring (March-April). Tradewinds are gusty and high wave conditions result from the combination of tradewind generated seas and late winter as well as early summer swell. The most favorable time of year is during the summer months when typical tradewind waves predominate.

5.2 RECOMMENDED OPERATIONAL CRITERIA

The following summarizes the design operational wind, wave and current conditions in the Alenuihaha Channel along the proposed cable route.

WINDS: (sustained, exceeded <5% of the time)

Tradewind condition	30 knots from ENE
Kona wind condition	25 knots from WSW

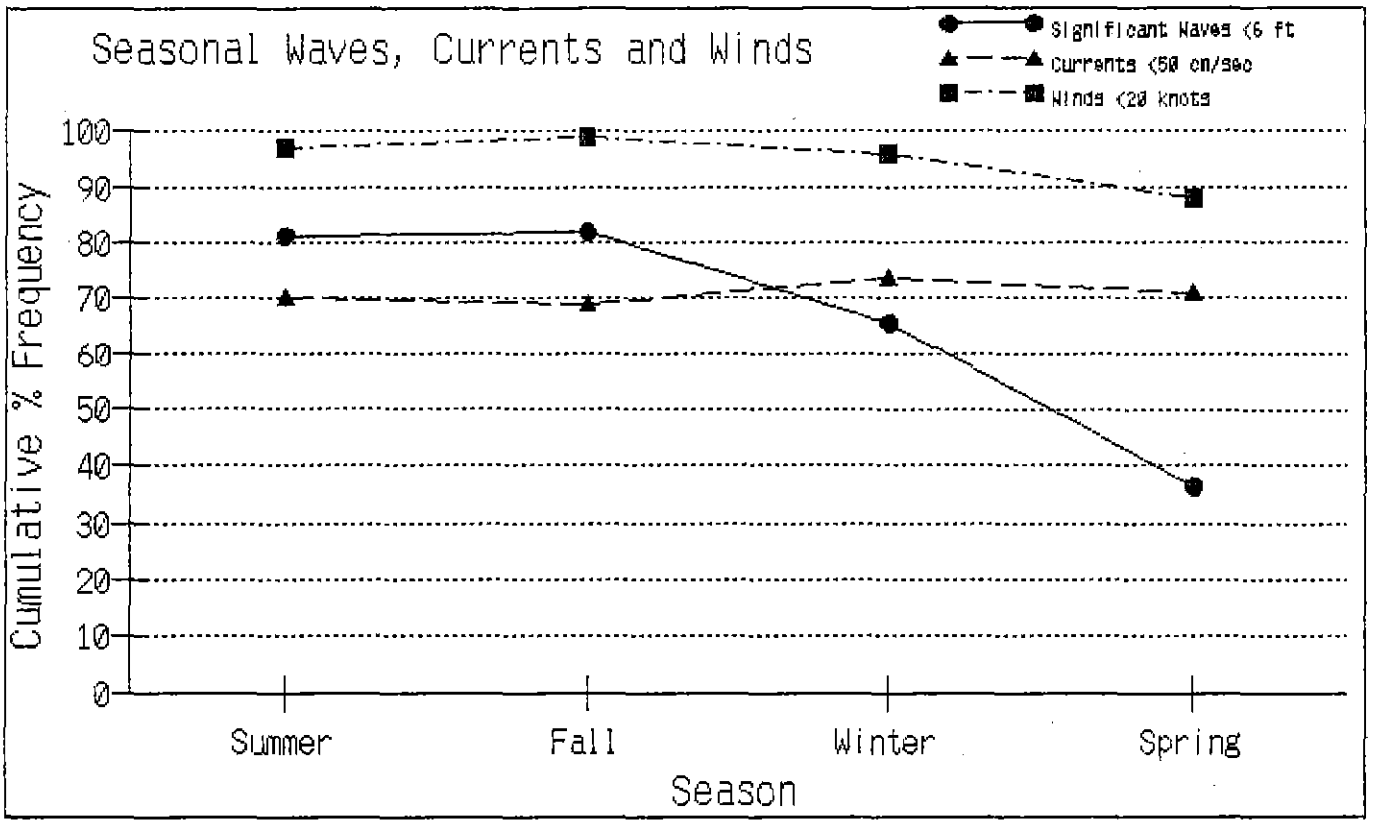


Figure 5.0-1 Seasonal variation of winds, waves and currents in the Alenuihaha Channel offshore Upolu Point

WAVES: (overall significant height, average wave period, exceeded 10% of the time)

Month	H_s (ft)	T (sec)
Jan	8.6	4-10
Feb	9.4	6-10
Mar	11.1	6-10
Apr	10.0	4-8
May	7.8	4-8
Jun	6.1	4-6
Jul	6.6	4-6
Aug	6.8	4-6
Sep	6.2	4-8
Oct	7.6	4-10
Nov	8.8	4-8
Dec	9.8	4-8

CURRENTS: (typical maximum individual current components; combined profiles are provided in Section 4.5 and Appendix E)

Location	Bottom Depth(m)	<1> Tidal Speed (cm/sec)	<2> Tradewind Driven (cm/sec)	<3> Eddy Speed (cm/sec)	Dir (°T)
Offshore Upolu Pt	170	46	33	70	45
	500	43	33	65	50
	800	39	33	54	50
Top of Kohala Slope	900	37	33	45	50
	1000	39	33	44	50
	1600	46	33	40	50
Bottom of Kohala Slope	1900	41	33	38	60
	2000	36	33	34	80
	1500	45	33	25	115
Maui Slope	900	53	33	20	125
	200	55	33	16	130

<1> Peak tidal currents can flow towards ENE or WSW, generally perpendicular to contours. Typical direction is 70°T/250°T along cable path. Uniform over entire depth.

<2> Surface current direction is towards WNW, deflected clockwise with depth. Speed decreases exponentially with depth; negligible at 200 meter depth for 30 knot wind.

<3> Eddy current speed constant 0-50 meters, decreasing linearly to 0 at 200 meter depth.

5.3 COMPARISON OF RECOMMENDED CRITERIA WITH PREVIOUSLY ESTABLISHED CRITERIA

The preliminary criteria previously established by Edward K. Noda and Associates (1983) was developed primarily from theoretical/empirical models without benefit of long-term direct measured data in the Alenuihaha Channel. It was pointed out that the established criteria should be viewed as a guide to understanding the environmental phenomena rather than as a "set-in-concrete" list of design criteria. It was assumed, for the purposes of developing the criteria, that the deployment would be performed within a 24-48 hour period during the month of March. For the above reasons, it is expected that the present recommended criteria would be more encompassing and realistic, based on the quantity of data which have been acquired to date in the Alenuihaha Channel.

The following summarizes the major differences between the preliminary criteria previously established and the present recommended criteria.

WINDS:

PREVIOUS	PRESENT
35 knots (ENE)	30 knots ENE 25 knots WSW
Probability of nonexceedence >76% during March	Probability of nonexceedence >95% during typical year

WAVES:

PREVIOUS	PRESENT
Sea: H_s = 8 feet T_s = 6.1 sec	Varies seasonally:
Probability of nonexceedence 71% during March	min: H_s = 6.1 feet (June) T_{avg} = 4-6 sec
Swell: H_s = 4 feet T_s = 13 sec Direction 147-235°T	max: H_s = 11.1 feet (March) T_{avg} = 6-10 sec
Probability of nonexceedence 92% during summer	Probability of nonexceedence 90% on monthly basis

Energy spectrum: Bretschneider (1959,1963) based on unimodal sea spectrum	Energy spectrum: Edward K.Noda & Assoc.(1986b) based on ISSC spectra bimodal sea state

CURRENTS:

PREVIOUS	PRESENT
Only 1 vertical profile	Vertical profiles specified at 11 locations along cable route, 2 tide and 2 wind conditions each
Surface current speed 2.94 knots (151 cm/sec)	Max near-surface speed 137 cm/sec (2.66 knots) offshore Upolu Pt. towards 62°T
Near-bottom current speed 1.2 knots (62 cm/sec)	Max near-bottom speed 63 cm/sec (1.22 knots) Maui side of channel towards 70°T and 250°T

REFERENCES

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APPENDIX A

SEA DATA METER
MONTHLY AND ANNUAL DISTRIBUTIONS
OF SIGNIFICANT WAVE HEIGHT VS. PERIOD

OVERALL SPECTRUM

JANUARY 1985 AND JANUARY 1986 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 182
BIMODAL OBS. 164 (90.1%)
UNIMODAL OBS. 18 (9.9%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

TZ / HS	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0-3.0	0.0	0.0	1.1	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9
3.0-4.0	0.0	0.0	5.5	17.6	3.8	.5	0.0	0.0	0.0	0.0	0.0	27.5
4.0-5.0	0.0	0.0	4.9	17.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	25.8
5.0-6.0	0.0	0.0	6.6	4.4	2.2	0.0	0.0	0.0	0.0	0.0	0.0	13.2
6.0-7.0	0.0	0.0	3.3	2.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	7.7
7.0-8.0	0.0	0.0	4.4	3.3	2.7	0.0	0.0	0.0	0.0	0.0	0.0	10.4
8.0-9.0	0.0	0.0	1.6	1.1	1.6	0.0	0.0	0.0	0.0	0.0	0.0	4.4
9.0-10.	0.0	0.0	.5	1.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	3.3
10.-11.	0.0	0.0	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.5
11.-12.	0.0	0.0	.5	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
12.-13.	0.0	0.0	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.5
13.-14.	0.0	0.0	0.0	0.0	.5	0.0	0.0	0.0	0.0	0.0	0.0	.5
14.-15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.-16.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	0.0	29.7	52.2	17.6	.5	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

FEBRUARY 1985 AND FEBRUARY 1986 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 168
BIMODAL OBS. 153 (91.1%)
UNIMODAL OBS. 15 (8.9%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

HS \ TZ	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0-3.0	0.0	0.0	.6	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
3.0-4.0	0.0	0.0	.6	7.7	1.8	0.0	0.0	0.0	0.0	0.0	0.0	10.1
4.0-5.0	0.0	0.0	4.2	21.4	1.8	0.0	0.0	0.0	0.0	0.0	0.0	27.4
5.0-6.0	0.0	0.0	3.6	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.9
6.0-7.0	0.0	.6	7.1	13.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	22.6
7.0-8.0	0.0	0.0	3.0	4.2	1.8	0.0	0.0	0.0	0.0	0.0	0.0	8.9
8.0-9.0	0.0	0.0	.6	2.4	1.2	.6	0.0	0.0	0.0	0.0	0.0	4.8
9.0-10.	0.0	0.0	1.8	.6	.6	0.0	0.0	0.0	0.0	0.0	0.0	3.0
10.-11.	0.0	0.0	0.0	.6	0.0	.6	0.0	0.0	0.0	0.0	0.0	1.2
11.-12.	0.0	0.0	0.0	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.6
12.-13.	0.0	0.0	.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8
13.-14.	0.0	0.0	0.0	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.6
14.-15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.-16.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	.6	22.0	67.3	8.9	1.2	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

MARCH 1985 AND MARCH 1986 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 176
BIMODAL OBS. 142 (80.7%)
UNIMODAL OBS. 34 (19.3%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

HS \ TZ	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0-3.0	0.0	0.0	0.0	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.6
3.0-4.0	0.0	0.0	1.7	5.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	8.0
4.0-5.0	0.0	0.0	2.8	8.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	13.6
5.0-6.0	0.0	0.0	6.3	7.4	1.1	0.0	0.0	0.0	0.0	0.0	0.0	14.8
6.0-7.0	0.0	0.0	9.7	5.7	0.0	.6	0.0	0.0	0.0	0.0	0.0	15.9
7.0-8.0	0.0	0.0	9.7	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.8
8.0-9.0	0.0	0.0	3.4	5.1	.6	0.0	0.0	0.0	0.0	0.0	0.0	9.1
9.0-10.	0.0	0.0	1.7	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3
10.-11.	0.0	0.0	1.1	3.4	.6	0.0	0.0	0.0	0.0	0.0	0.0	5.1
11.-12.	0.0	0.0	.6	1.7	.6	0.0	0.0	0.0	0.0	0.0	0.0	2.8
12.-13.	0.0	0.0	0.0	1.7	.6	0.0	0.0	0.0	0.0	0.0	0.0	2.3
13.-14.	0.0	0.0	.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7
14.-15.	0.0	0.0	.6	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3
15.-16.	0.0	0.0	0.0	.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	1.7
16.-17.	0.0	0.0	0.0	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.6
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.6
TOT. %	0.0	0.0	38.1	52.8	8.5	.6	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

APRIL 1985 AND APRIL 1986 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 179
BIMODAL OBS. 160 (89.4%)
UNIMODAL OBS. 19 (10.6%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

TZ / HS	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0-4.0	0.0	0.0	4.5	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6
4.0-5.0	0.0	0.0	10.6	6.1	.6	0.0	0.0	0.0	0.0	0.0	0.0	17.3
5.0-6.0	0.0	0.0	5.6	6.7	.6	0.0	0.0	0.0	0.0	0.0	0.0	12.8
6.0-7.0	0.0	0.0	11.7	9.5	.6	0.0	0.0	0.0	0.0	0.0	0.0	21.8
7.0-8.0	0.0	0.0	8.9	8.9	1.7	0.0	0.0	0.0	0.0	0.0	0.0	19.6
8.0-9.0	0.0	0.0	5.6	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.3
9.0-10.	0.0	0.0	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
10.-11.	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
11.-12.	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7
12.-13.	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8
13.-14.	0.0	0.0	0.0	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.6
14.-15.	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
15.-16.	0.0	0.0	0.0	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.6
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.6
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	0.0	48.6	48.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

MAY 1984, 1985 AND 1986 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 247
BIMODAL OBS. 224 (90.7%)
UNIMODAL OBS. 23 (9.3%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

HS \ TZ	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0-3.0	0.0	0.0	2.8	4.9	.4	0.0	0.0	0.0	0.0	0.0	0.0	8.1
3.0-4.0	0.0	0.0	8.5	9.3	.8	.4	0.0	0.0	0.0	0.0	0.0	19.0
4.0-5.0	0.0	0.0	10.5	9.3	.8	0.0	0.0	0.0	0.0	0.0	0.0	20.6
5.0-6.0	0.0	.4	9.7	8.9	.4	0.0	0.0	0.0	0.0	0.0	0.0	19.4
6.0-7.0	0.0	0.0	10.1	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0
7.0-8.0	0.0	0.0	6.1	4.9	.4	0.0	0.0	0.0	0.0	0.0	0.0	11.3
8.0-9.0	0.0	0.0	.8	2.0	.4	0.0	0.0	0.0	0.0	0.0	0.0	3.2
9.0-10.	0.0	0.0	.4	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
10.-11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.-12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.-13.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.-14.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.-15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.-16.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	.4	49.0	47.0	3.2	.4	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

JUNE 1984 AND JUNE 1985 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 180
BIMODAL OBS. 172 (95.6%)
UNIMODAL OBS. 8 (4.4%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

TZ / HS	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0-3.0	0.0	0.0	10.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.4
3.0-4.0	0.0	0.0	22.8	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.4
4.0-5.0	0.0	.6	22.2	11.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.9
5.0-6.0	0.0	.6	8.3	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.8
6.0-7.0	0.0	0.0	2.8	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3
7.0-8.0	0.0	0.0	.6	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
8.0-9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.0-10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.-11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.-12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.-13.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.-14.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.-15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.-16.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	1.1	66.7	32.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

JULY 1984 AND JULY 1985 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 165
BIMODAL OBS. 151 (91.5%)
UNIMODAL OBS. 14 (8.5%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

HS \ TZ	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0-3.0	0.0	0.0	1.8	5.5	.6	0.0	0.0	0.0	0.0	0.0	0.0	7.9
3.0-4.0	0.0	0.0	15.2	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.1
4.0-5.0	0.0	0.0	22.4	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.9
5.0-6.0	0.0	0.0	18.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.4
6.0-7.0	0.0	0.0	7.9	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5
7.0-8.0	0.0	0.0	3.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2
8.0-9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.0-10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.-11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.-12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.-13.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.-14.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.-15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.-16.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	0.0	68.5	30.9	.6	0.0	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

AUGUST 1984 AND AUGUST 1985 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 186
BIMODAL OBS. 172 (92.5%)
UNIMODAL OBS. 14 (7.5%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

HS \ TZ	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	.5	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
2.0-3.0	0.0	0.0	7.5	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5
3.0-4.0	0.0	0.0	14.5	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.1
4.0-5.0	0.0	0.0	11.8	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.4
5.0-6.0	0.0	0.0	15.1	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.5
6.0-7.0	0.0	0.0	11.8	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0
7.0-8.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8
8.0-9.0	0.0	.5	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6
9.0-10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.-11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.-12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.-13.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.-14.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.-15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.-16.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	.5	66.1	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

SEPTEMBER 1984 AND SEPTEMBER 1985 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 180
BIMODAL OBS. 165 (91.7%)
UNIMODAL OBS. 15 (8.3%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

TZ / HS	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
2.0-3.0	0.0	0.0	5.0	12.8	2.8	0.0	0.0	0.0	0.0	0.0	0.0	20.6
3.0-4.0	0.0	0.0	8.9	20.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	30.6
4.0-5.0	0.0	0.0	8.9	10.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.4
5.0-6.0	0.0	0.0	8.9	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7
6.0-7.0	0.0	0.0	2.8	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4
7.0-8.0	0.0	0.0	1.7	2.2	.6	0.0	0.0	0.0	0.0	0.0	0.0	4.4
8.0-9.0	0.0	0.0	.6	.6	.6	0.0	0.0	0.0	0.0	0.0	0.0	1.7
9.0-10.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.-11.	0.0	0.0	0.0	.6	.6	0.0	0.0	0.0	0.0	0.0	0.0	1.1
11.-12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.-13.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.-14.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.-15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.-16.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	0.0	36.7	57.2	6.1	0.0	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

OCTOBER 1984 AND OCTOBER 1985 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 130
BIMODAL OBS. 115 (88.5%)
UNIMODAL OBS. 15 (11.5%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

TZ / HS	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0-3.0	0.0	0.0	.8	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5
3.0-4.0	0.0	0.0	2.3	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8
4.0-5.0	0.0	0.0	15.4	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.4
5.0-6.0	0.0	0.0	18.5	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.4
6.0-7.0	0.0	0.0	9.2	3.8	.8	0.0	0.0	0.0	0.0	0.0	0.0	13.8
7.0-8.0	0.0	0.0	3.1	3.8	0.0	.8	0.0	0.0	0.0	0.0	0.0	7.7
8.0-9.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
9.0-10.	0.0	0.0	.8	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3
10.-11.	0.0	0.0	0.0	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.8
11.-12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.-13.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.-14.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.-15.	0.0	0.0	0.0	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.8
15.-16.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	0.0	51.5	46.9	.8	.8	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

NOVEMBER 1984 AND NOVEMBER 1985 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 103
BIMODAL OBS. 92 (89.3%)
UNIMODAL OBS. 11 (10.7%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

HS \ TZ	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0-3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0-4.0	0.0	0.0	3.9	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5
4.0-5.0	0.0	0.0	5.8	23.3	1.9	0.0	0.0	0.0	0.0	0.0	0.0	31.1
5.0-6.0	0.0	0.0	5.8	15.5	1.0	1.0	0.0	0.0	0.0	0.0	0.0	23.3
6.0-7.0	0.0	0.0	1.9	9.7	2.9	0.0	0.0	0.0	0.0	0.0	0.0	14.6
7.0-8.0	0.0	0.0	1.0	8.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0	10.7
8.0-9.0	0.0	0.0	1.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
9.0-10.	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
10.-11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.-12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.-13.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.-14.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.-15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.-16.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	0.0	19.4	71.8	7.8	1.0	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

DECEMBER 1984 AND DECEMBER 1985 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 186
BIMODAL OBS. 161 (86.6%)
UNIMODAL OBS. 25 (13.4%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

HS \ TZ	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0-3.0	0.0	0.0	0.0	.5	.5	0.0	0.0	0.0	0.0	0.0	0.0	1.1
3.0-4.0	0.0	0.0	5.9	12.4	1.1	0.0	0.0	0.0	0.0	0.0	0.0	19.4
4.0-5.0	0.0	0.0	5.9	16.7	1.6	0.0	0.0	0.0	0.0	0.0	0.0	24.2
5.0-6.0	0.0	.5	8.1	11.3	1.6	0.0	0.0	0.0	0.0	0.0	0.0	21.5
6.0-7.0	0.0	0.0	6.5	3.8	.5	0.0	0.0	0.0	0.0	0.0	0.0	10.8
7.0-8.0	0.0	0.0	3.8	2.7	.5	0.0	0.0	0.0	0.0	0.0	0.0	7.0
8.0-9.0	0.0	0.0	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
9.0-10.	0.0	0.0	1.1	2.2	1.1	0.0	0.0	0.0	0.0	0.0	0.0	4.3
10.-11.	0.0	0.0	1.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7
11.-12.	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
12.-13.	0.0	0.0	1.1	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6
13.-14.	0.0	0.0	0.0	0.0	.5	.5	0.0	0.0	0.0	0.0	0.0	1.1
14.-15.	0.0	0.0	.5	.5	.5	0.0	0.0	0.0	0.0	0.0	0.0	1.6
15.-16.	0.0	0.0	0.0	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.5
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	.5	35.5	55.4	8.1	.5	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

MAY 1984 TO MAY 1986 WAVE SUMMARY
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 2082
BIMODAL OBS. 1871 (89.9%)
UNIMODAL OBS. 211 (10.1%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

TZ / HS	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	.0	.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.2
2.0-3.0	0.0	0.0	2.6	4.3	.4	0.0	0.0	0.0	0.0	0.0	0.0	7.3
3.0-4.0	0.0	0.0	8.2	10.9	.9	.1	0.0	0.0	0.0	0.0	0.0	20.0
4.0-5.0	0.0	.0	10.5	11.9	1.1	0.0	0.0	0.0	0.0	0.0	0.0	23.5
5.0-6.0	0.0	.1	9.5	7.7	.6	.0	0.0	0.0	0.0	0.0	0.0	17.9
6.0-7.0	0.0	.0	7.3	4.9	.6	.0	0.0	0.0	0.0	0.0	0.0	12.9
7.0-8.0	0.0	0.0	4.3	3.7	.7	.0	0.0	0.0	0.0	0.0	0.0	8.7
8.0-9.0	0.0	.0	1.4	1.8	.4	.0	0.0	0.0	0.0	0.0	0.0	3.7
9.0-10.	0.0	0.0	.6	1.1	.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0
10.-11.	0.0	0.0	.3	.6	.1	.0	0.0	0.0	0.0	0.0	0.0	1.1
11.-12.	0.0	0.0	.1	.6	.0	0.0	0.0	0.0	0.0	0.0	0.0	.7
12.-13.	0.0	0.0	.2	.5	.0	0.0	0.0	0.0	0.0	0.0	0.0	.8
13.-14.	0.0	0.0	.0	.2	.1	.0	0.0	0.0	0.0	0.0	0.0	.4
14.-15.	0.0	0.0	.1	.3	.0	0.0	0.0	0.0	0.0	0.0	0.0	.5
15.-16.	0.0	0.0	0.0	.1	.1	0.0	0.0	0.0	0.0	0.0	0.0	.2
16.-17.	0.0	0.0	0.0	.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0
>=20.	0.0	0.0	0.0	.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0
TOT. %	0.0	.3	45.2	48.8	5.4	.4	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

SPRING TRANSITION (MARCH & APRIL) WAVE SUMMARY
YEARS - 1985 & 1986
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 355
BIMODAL OBS. 302 (85.1%)
UNIMODAL OBS. 53 (14.9%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

TZ / HS	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0-3.0	0.0	0.0	0.0	.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.3
3.0-4.0	0.0	0.0	3.1	3.1	.6	0.0	0.0	0.0	0.0	0.0	0.0	6.8
4.0-5.0	0.0	0.0	6.8	7.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	15.5
5.0-6.0	0.0	0.0	5.9	7.0	.8	0.0	0.0	0.0	0.0	0.0	0.0	13.8
6.0-7.0	0.0	0.0	10.7	7.6	.3	.3	0.0	0.0	0.0	0.0	0.0	18.9
7.0-8.0	0.0	0.0	9.3	7.0	.8	0.0	0.0	0.0	0.0	0.0	0.0	17.2
8.0-9.0	0.0	0.0	4.5	5.9	.3	0.0	0.0	0.0	0.0	0.0	0.0	10.7
9.0-10.	0.0	0.0	1.4	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2
10.-11.	0.0	0.0	.6	2.3	.3	0.0	0.0	0.0	0.0	0.0	0.0	3.1
11.-12.	0.0	0.0	.3	1.7	.3	0.0	0.0	0.0	0.0	0.0	0.0	2.3
12.-13.	0.0	0.0	0.0	2.3	.3	0.0	0.0	0.0	0.0	0.0	0.0	2.5
13.-14.	0.0	0.0	.3	.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
14.-15.	0.0	0.0	.3	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7
15.-16.	0.0	0.0	0.0	.6	.6	0.0	0.0	0.0	0.0	0.0	0.0	1.1
16.-17.	0.0	0.0	0.0	.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.3
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.3
>=20.	0.0	0.0	0.0	.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.3
TOT. %	0.0	0.0	43.4	50.4	5.9	.3	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

SUMMER (MAY, JUNE, JULY & AUG.) WAVE SUMMARY
YEARS - 1984, 1985 & 1986
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 778
BIMODAL OBS. 719 (92.4%)
UNIMODAL OBS. 59 (7.6%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

HS \ TZ	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	.1	.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.3
2.0-3.0	0.0	0.0	5.4	5.4	.3	0.0	0.0	0.0	0.0	0.0	0.0	11.1
3.0-4.0	0.0	0.0	14.7	11.3	.3	.1	0.0	0.0	0.0	0.0	0.0	26.3
4.0-5.0	0.0	.1	16.1	8.7	.3	0.0	0.0	0.0	0.0	0.0	0.0	25.2
5.0-6.0	0.0	.3	12.5	5.5	.1	0.0	0.0	0.0	0.0	0.0	0.0	18.4
6.0-7.0	0.0	0.0	8.4	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3
7.0-8.0	0.0	0.0	3.6	1.9	.1	0.0	0.0	0.0	0.0	0.0	0.0	5.7
8.0-9.0	0.0	.1	.5	.6	.1	0.0	0.0	0.0	0.0	0.0	0.0	1.4
9.0-10.	0.0	0.0	.1	.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.4
10.-11.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.-12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.-13.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.-14.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.-15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.-16.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	.5	61.3	36.9	1.2	.1	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

FALL TRANSITION (SEPT. & OCT.) WAVE SUMMARY
YEARS - 1984 & 1985
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 310
BIMODAL OBS. 280 (90.3%)
UNIMODAL OBS. 30 (9.7%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

HS \ TZ	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.6
2.0-3.0	0.0	0.0	3.2	11.9	1.6	0.0	0.0	0.0	0.0	0.0	0.0	16.8
3.0-4.0	0.0	0.0	6.1	15.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	22.3
4.0-5.0	0.0	0.0	11.6	10.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.9
5.0-6.0	0.0	0.0	12.9	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.3
6.0-7.0	0.0	0.0	5.5	2.6	.3	0.0	0.0	0.0	0.0	0.0	0.0	8.4
7.0-8.0	0.0	0.0	2.3	2.9	.3	.3	0.0	0.0	0.0	0.0	0.0	5.8
8.0-9.0	0.0	0.0	1.0	.3	.3	0.0	0.0	0.0	0.0	0.0	0.0	1.6
9.0-10.	0.0	0.0	.3	.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
10.-11.	0.0	0.0	0.0	.6	.3	0.0	0.0	0.0	0.0	0.0	0.0	1.0
11.-12.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.-13.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.-14.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.-15.	0.0	0.0	0.0	.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.3
15.-16.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	0.0	42.9	52.9	3.9	.3	0.0	0.0	0.0	0.0	0.0	100.0

OVERALL SPECTRUM

WINTER (NOV., DEC., JAN. & OCT.) WAVE SUMMARY
YEARS - 1984, 1985 & 1986
ALENUIHAHA CHANNEL, HAWAII

TOTAL OBS. 639
BIMODAL OBS. 570 (89.2%)
UNIMODAL OBS. 69 (10.8%)

PCT. OCCURRENCE - AVG. APPARENT WAVE PERIOD(SEC) VS OVERALL SIG. WAVE HEIGHT(FT)

HS \ TZ	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	>=20	TOT %
<1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0-3.0	0.0	0.0	.5	1.4	.2	0.0	0.0	0.0	0.0	0.0	0.0	2.0
3.0-4.0	0.0	0.0	4.1	12.5	1.9	.2	0.0	0.0	0.0	0.0	0.0	18.6
4.0-5.0	0.0	0.0	5.2	19.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	26.6
5.0-6.0	0.0	.2	6.1	10.8	1.3	.2	0.0	0.0	0.0	0.0	0.0	18.5
6.0-7.0	0.0	.2	5.0	6.7	1.7	0.0	0.0	0.0	0.0	0.0	0.0	13.6
7.0-8.0	0.0	0.0	3.3	4.2	1.6	0.0	0.0	0.0	0.0	0.0	0.0	9.1
8.0-9.0	0.0	0.0	1.1	1.7	.8	.2	0.0	0.0	0.0	0.0	0.0	3.8
9.0-10.	0.0	0.0	.9	1.3	.9	0.0	0.0	0.0	0.0	0.0	0.0	3.1
10.-11.	0.0	0.0	.6	.5	0.0	.2	0.0	0.0	0.0	0.0	0.0	1.3
11.-12.	0.0	0.0	.2	.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
12.-13.	0.0	0.0	.6	.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
13.-14.	0.0	0.0	0.0	.2	.3	.2	0.0	0.0	0.0	0.0	0.0	.6
14.-15.	0.0	0.0	.2	.2	.2	0.0	0.0	0.0	0.0	0.0	0.0	.5
15.-16.	0.0	0.0	0.0	.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.2
16.-17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.-18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.-19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.-20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOT. %	0.0	.3	27.7	60.3	11.0	.8	0.0	0.0	0.0	0.0	0.0	100.0

APPENDIX B

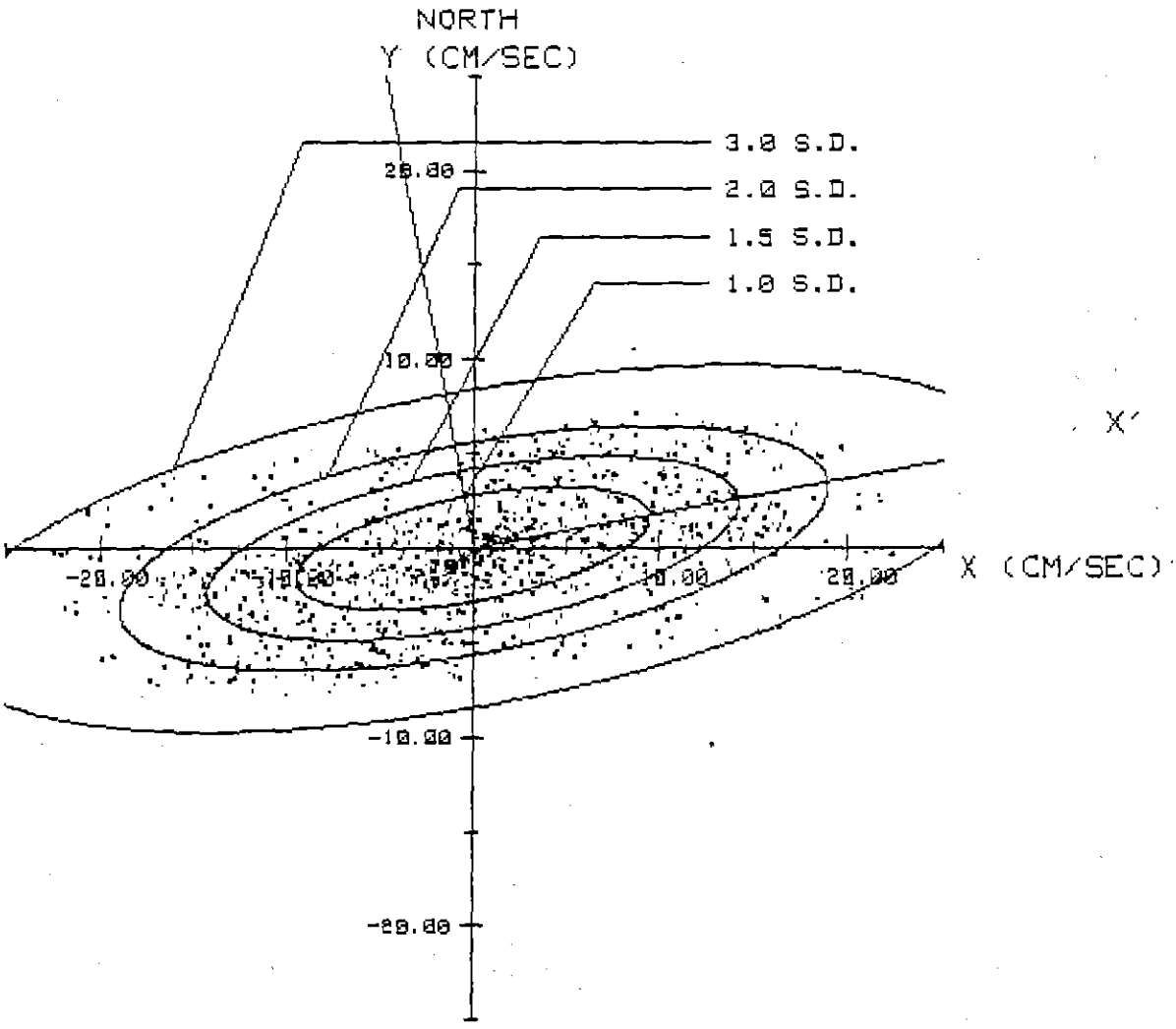
TIDAL ELLIPSES

ALENUIHAHA NEAR BOTTOM CURRENTS

SEMI-DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 1 AUGUST 20 1985 TO NOVEMBER 2 1985
STATION NO. 1T

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	-2.05 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	.51 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	-.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	8.96 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	3.19 CM/SEC
COVARIANCE OF X,Y	=	13.58 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	9.62 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	2.77 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	79.40 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	19.23 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	5.54 CM/SEC

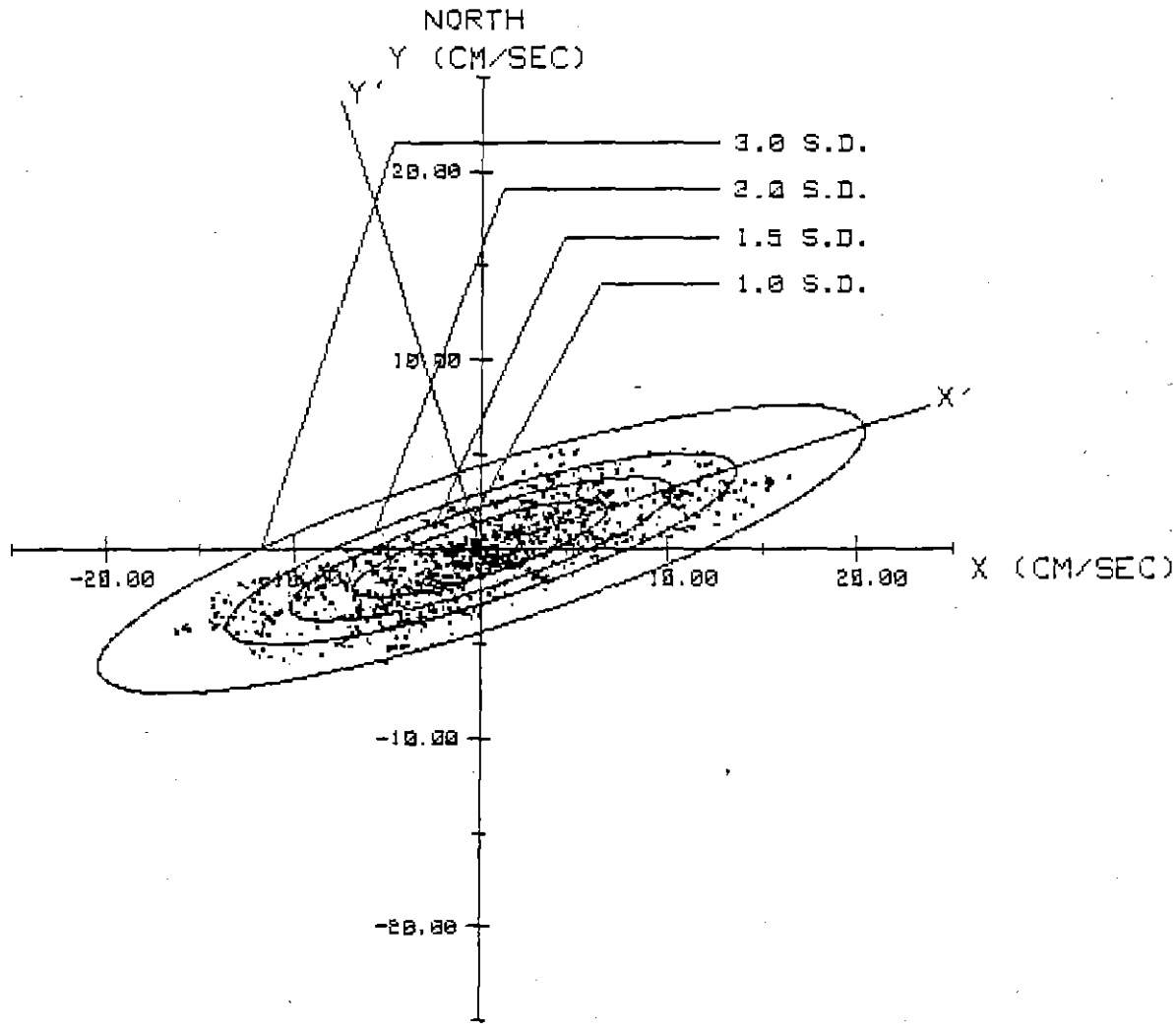


ALENUIHAHA NEAR BOTTOM CURRENTS

DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 1 AUGUST 20 1985 TO NOVEMBER 2 1985
STATION NO. 1T

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	-2.05 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	.51 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	6.43 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	2.44 CM/SEC
COVARIANCE OF X,Y	=	12.51 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	7.10 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	1.41 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	72.35 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	14.19 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	2.82 CM/SEC

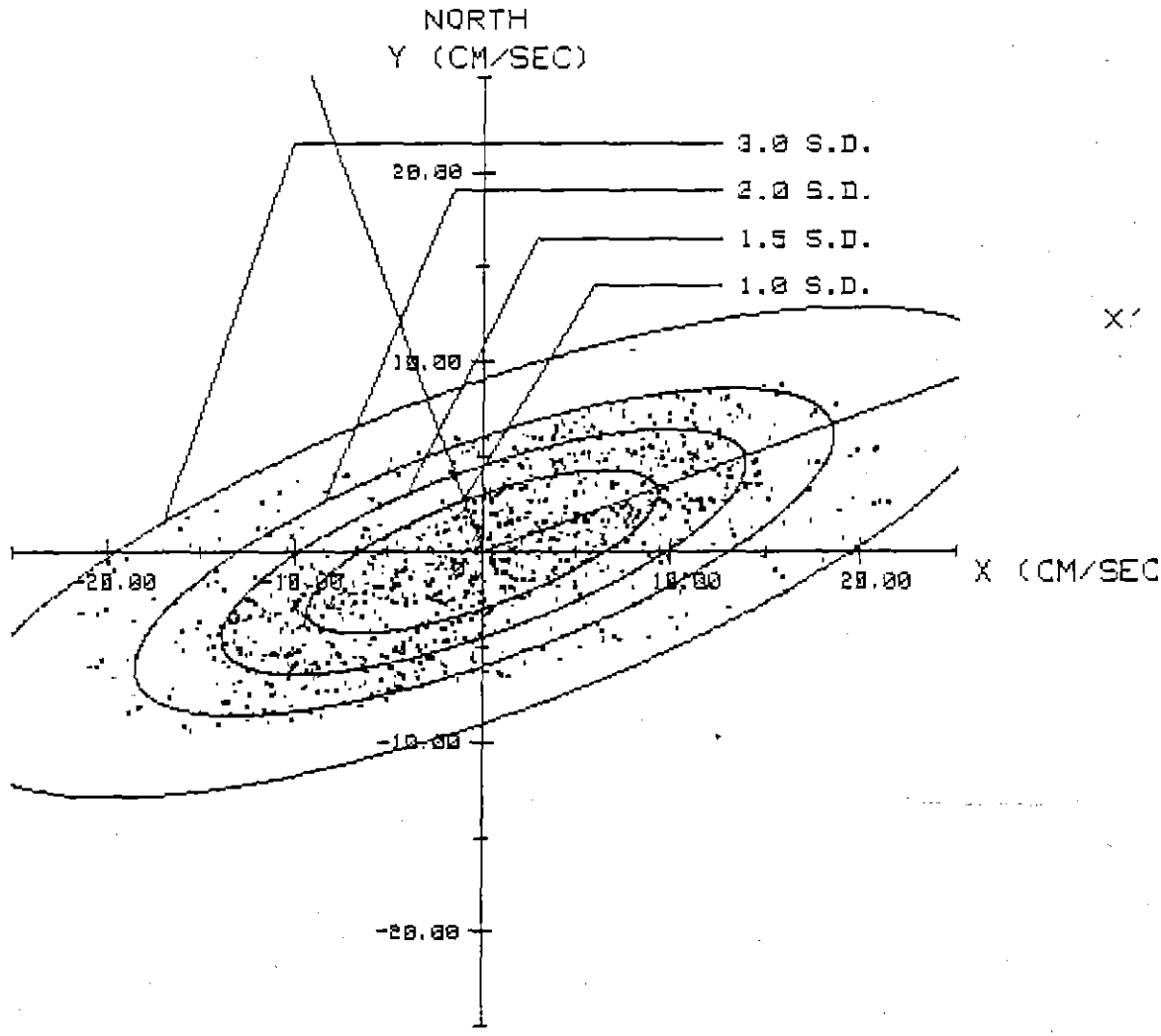


ALENUIHAHA NEAR BOTTOM CURRENTS

SEMI-DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 1 AUGUST 20 1985 TO NOVEMBER 2 1985
STATION NO. 1B

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	-1.90 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	-.56 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	-.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	8.56 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	4.11 CM/SEC
COVARIANCE OF X,Y	=	23.83 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	9.80 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	2.86 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	69.91 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	19.60 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	5.71 CM/SEC

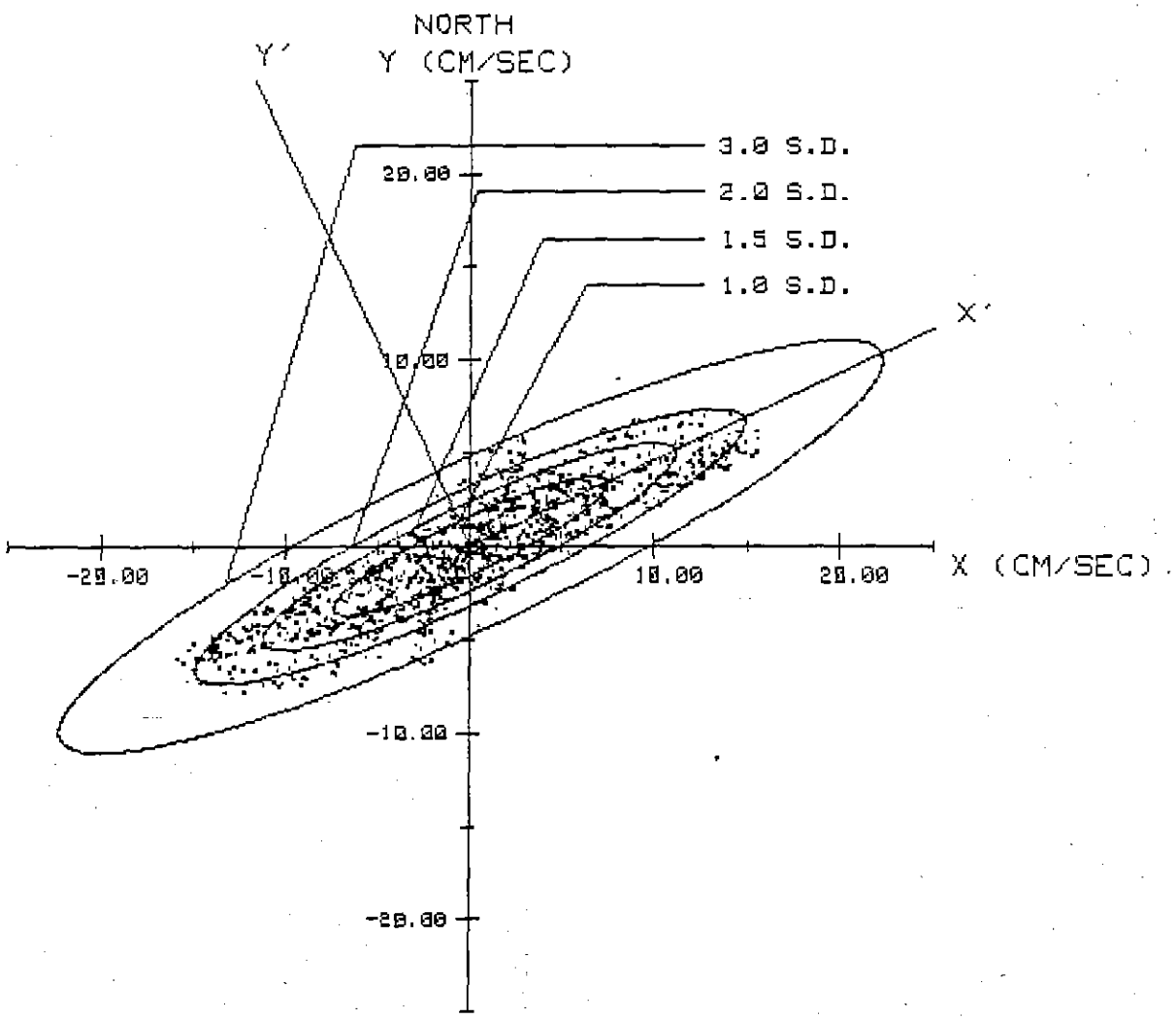


ALENUIHAHA NEAR BOTTOM CURRENTS

DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 1 AUGUST 20 1985 TO NOVEMBER 2 1985
STATION NO. 1B

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	-1.90 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	-.56 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	-.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	6.90 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	3.47 CM/SEC
COVARIANCE OF X,Y	=	21.21 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	8.15 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	1.46 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	64.98 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	16.30 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	2.93 CM/SEC

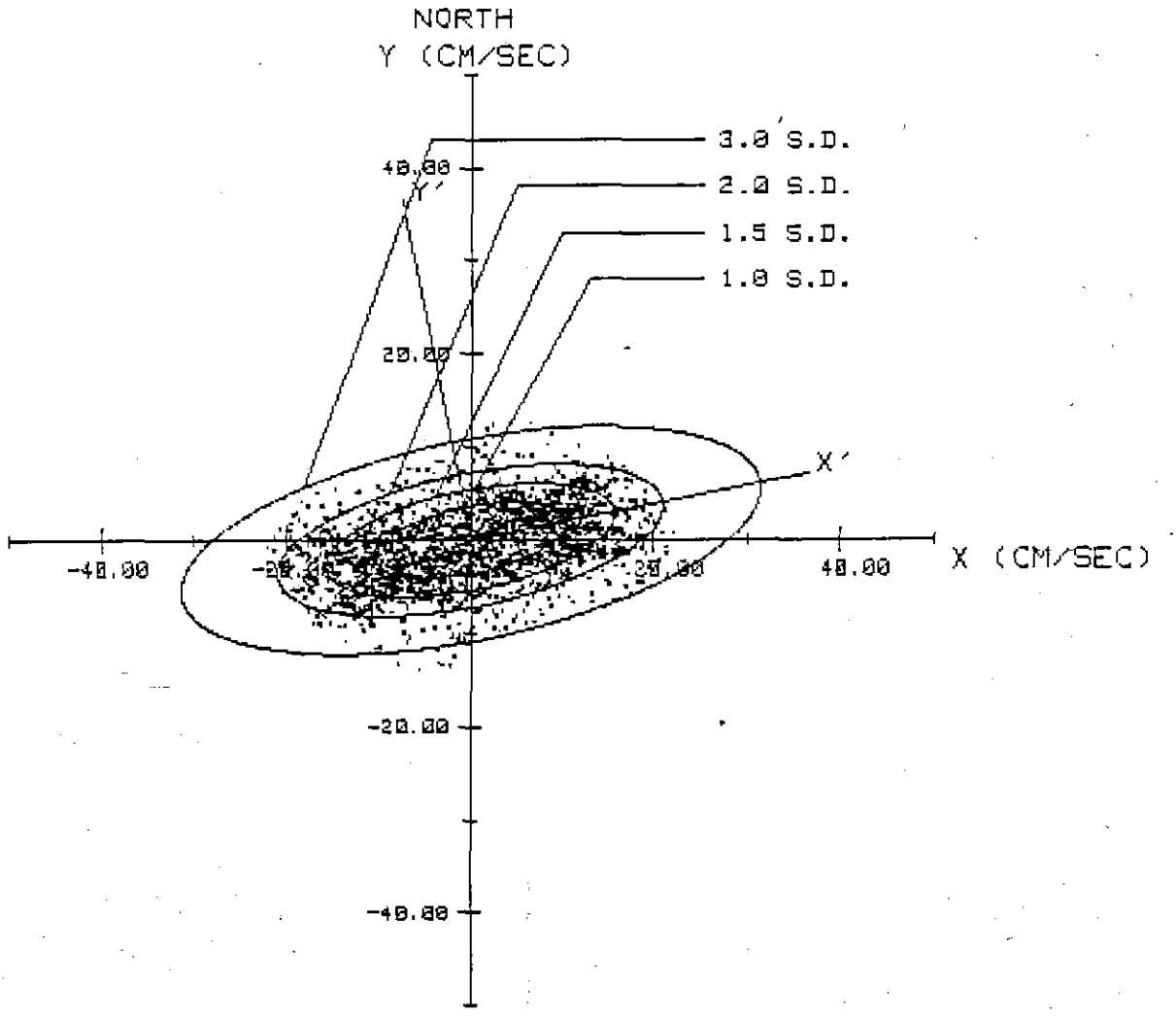


ALENUIHAHA NEAR BOTTOM CURRENTS

SEMI-DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 2 NOVEMBER 3 1985 TO FEBRUARY 27 1986
STATION NO. 1T

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	-1.83 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	.80 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	-.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	9.71 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	4.01 CM/SEC
COVARIANCE OF X,Y	=	16.39 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	10.62 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	3.58 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	78.64 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	21.24 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	7.15 CM/SEC

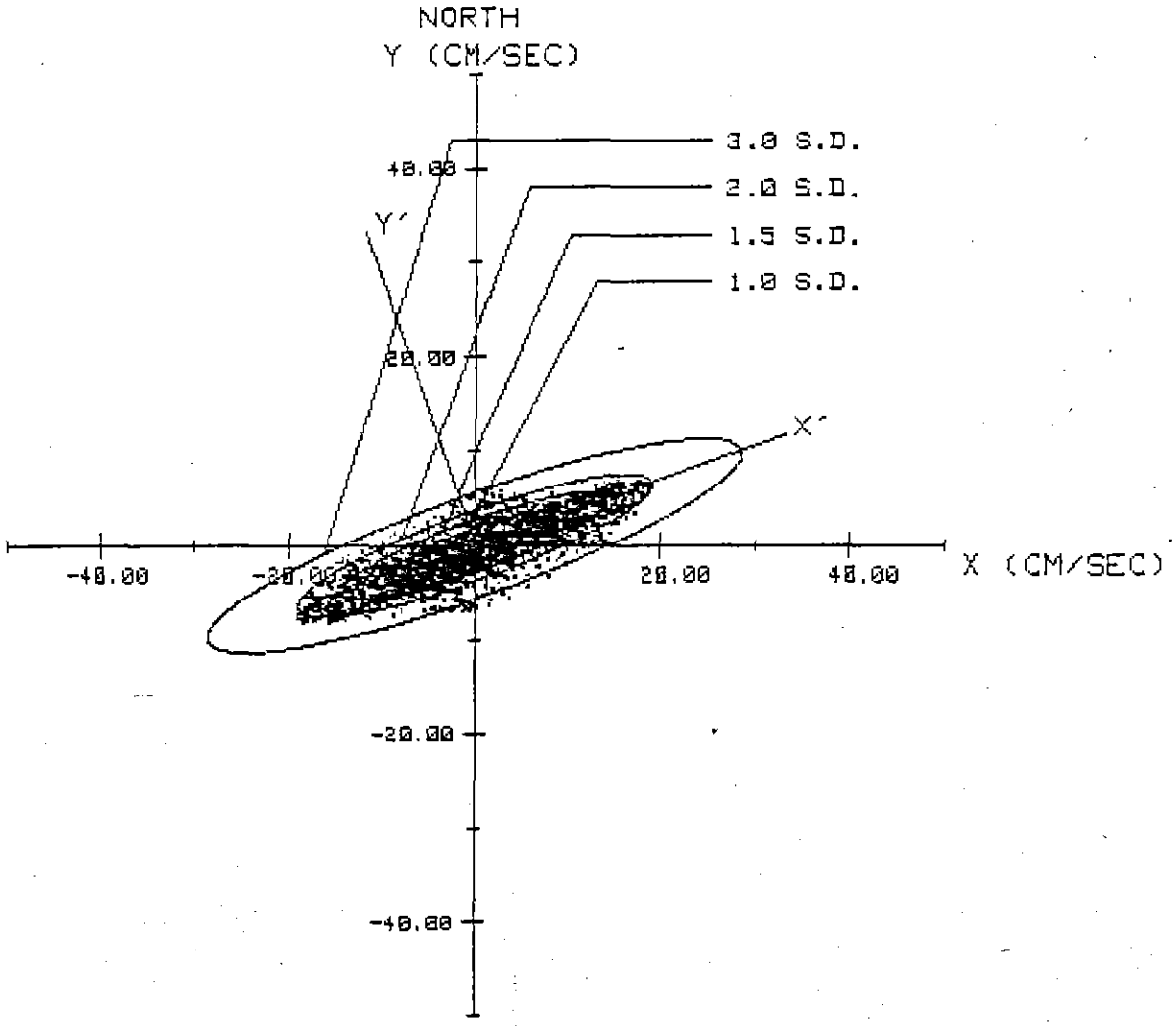


ALENUIHAHA NEAR BOTTOM CURRENTS

DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 2 NOVEMBER 3 1985 TO FEBRUARY 27 1986
STATION NO. 1T

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	-1.83 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	.80 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	-.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	8.99 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	3.61 CM/SEC
COVARIANCE OF X,Y	=	27.59 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	10.06 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	1.79 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	70.43 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	20.13 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	3.58 CM/SEC

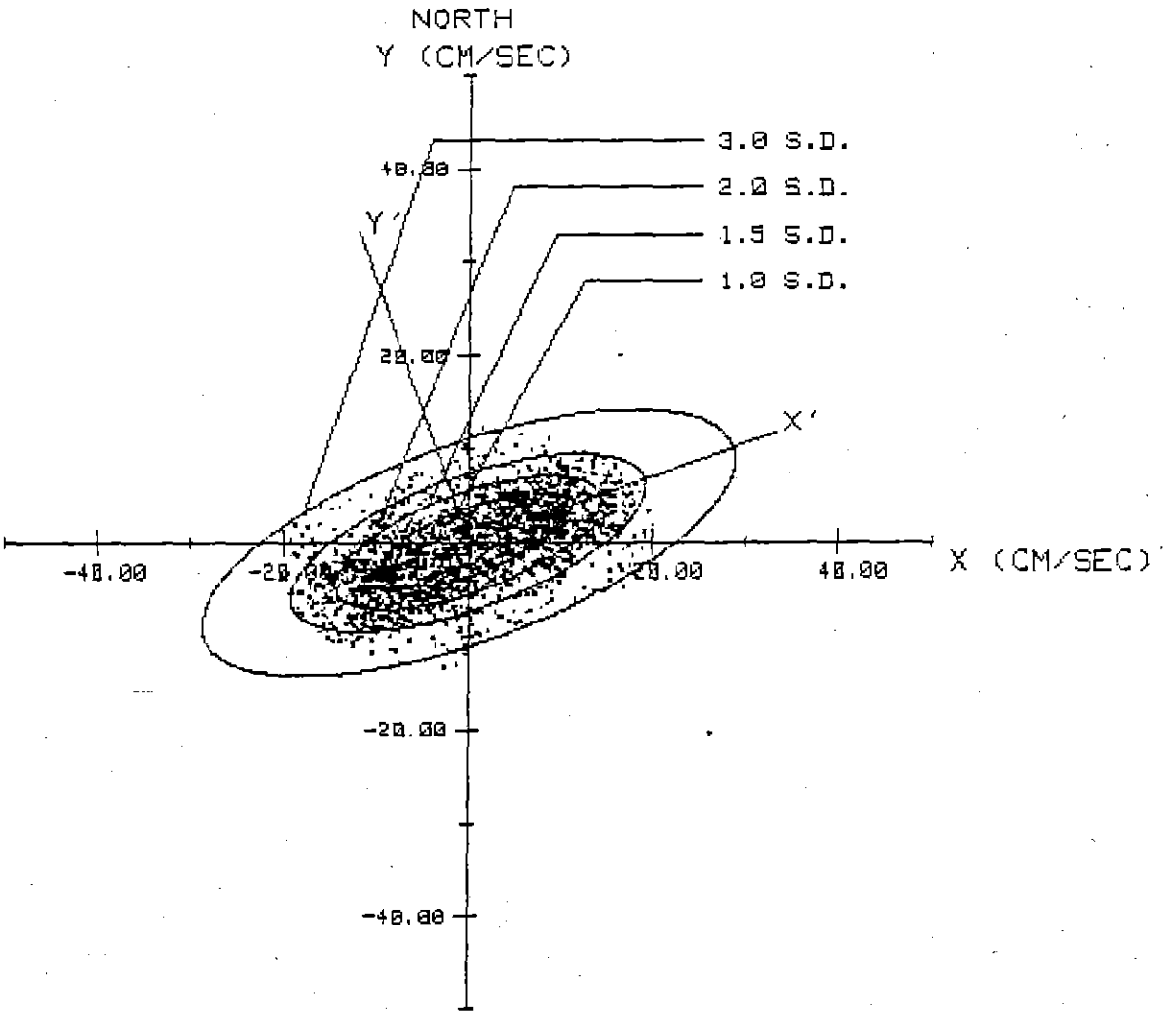


ALENUIHAHA NEAR BOTTOM CURRENTS

SEMI-DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 2 NOVEMBER 3 1985 TO FEBRUARY 27 1986
STATION NO. 1B

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	-1.42 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	-.70 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	8.72 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	4.54 CM/SEC
COVARIANCE OF X,Y	=	22.90 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	10.09 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	3.51 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	70.24 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	20.18 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	7.03 CM/SEC

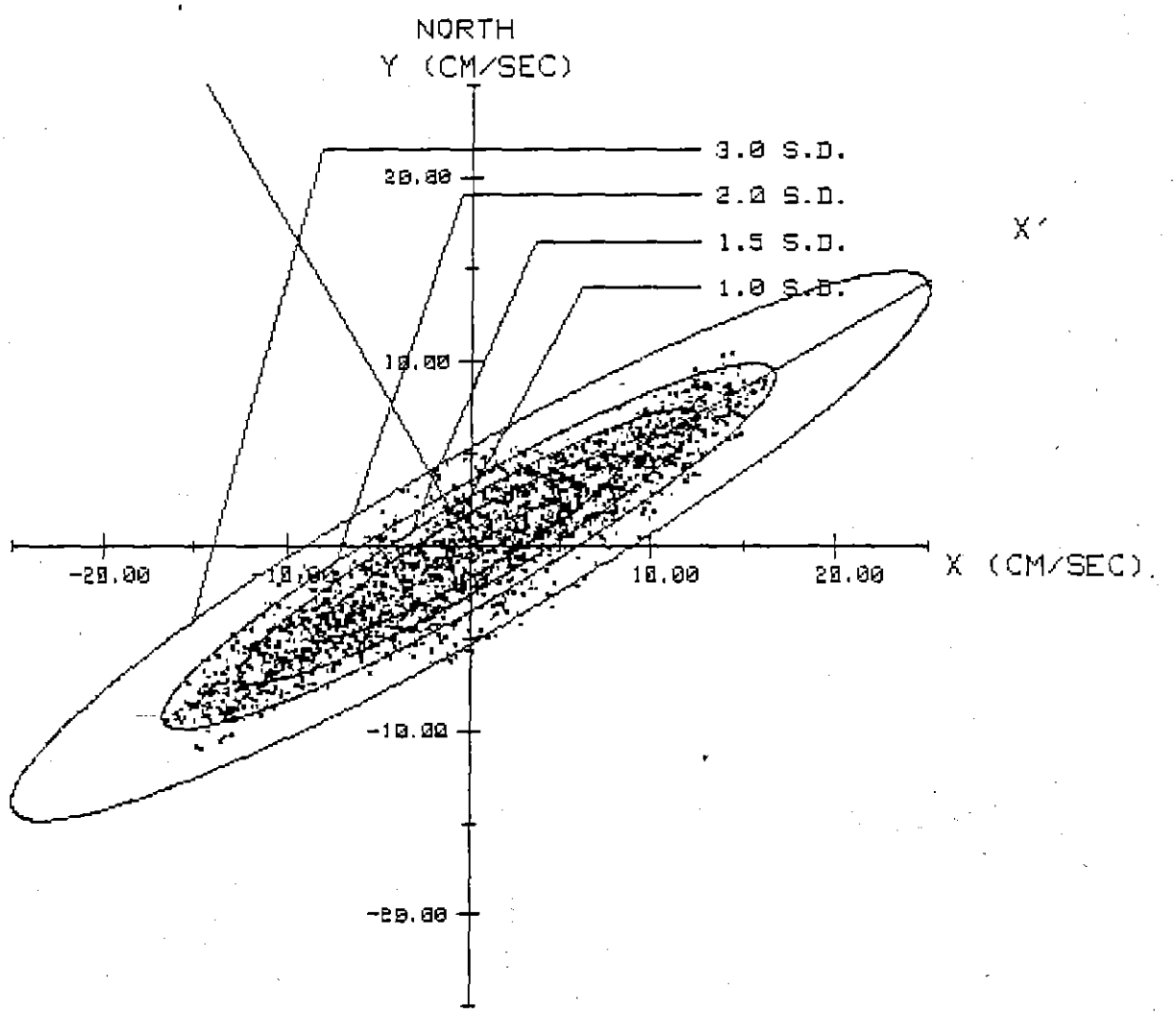


ALENUIHAHA NEAR BOTTOM CURRENTS

DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 2 NOVEMBER 3 1985 TO FEBRUARY 27 1986
STATION NO. 13

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	-1.42 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	-.70 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	-.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	7.67 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	4.60 CM/SEC
COVARIANCE OF X,Y	=	32.51 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	9.57 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	1.55 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	60.06 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	19.13 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	3.10 CM/SEC

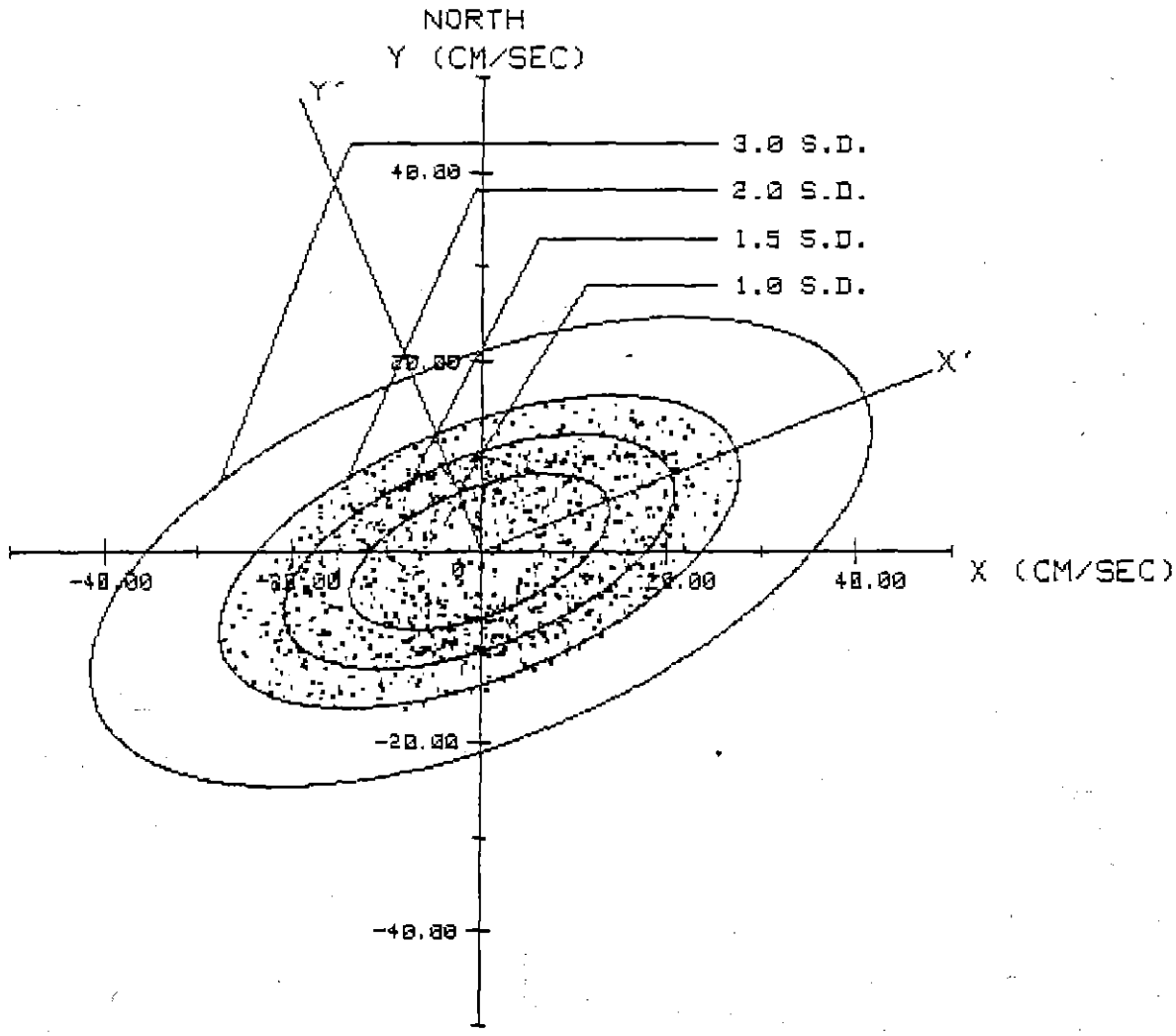


ALENUIHAHA NEAR BOTTOM CURRENTS

SEMI-DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 1 AUGUST 20 1985 TO NOVEMBER 2 1985
STATION NO. 2T

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	-.03 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	3.66 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	12.08 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	7.78 CM/SEC
COVARIANCE OF X,Y	=	40.69 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	14.63 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	6.65 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	68.19 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	29.26 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	13.29 CM/SEC

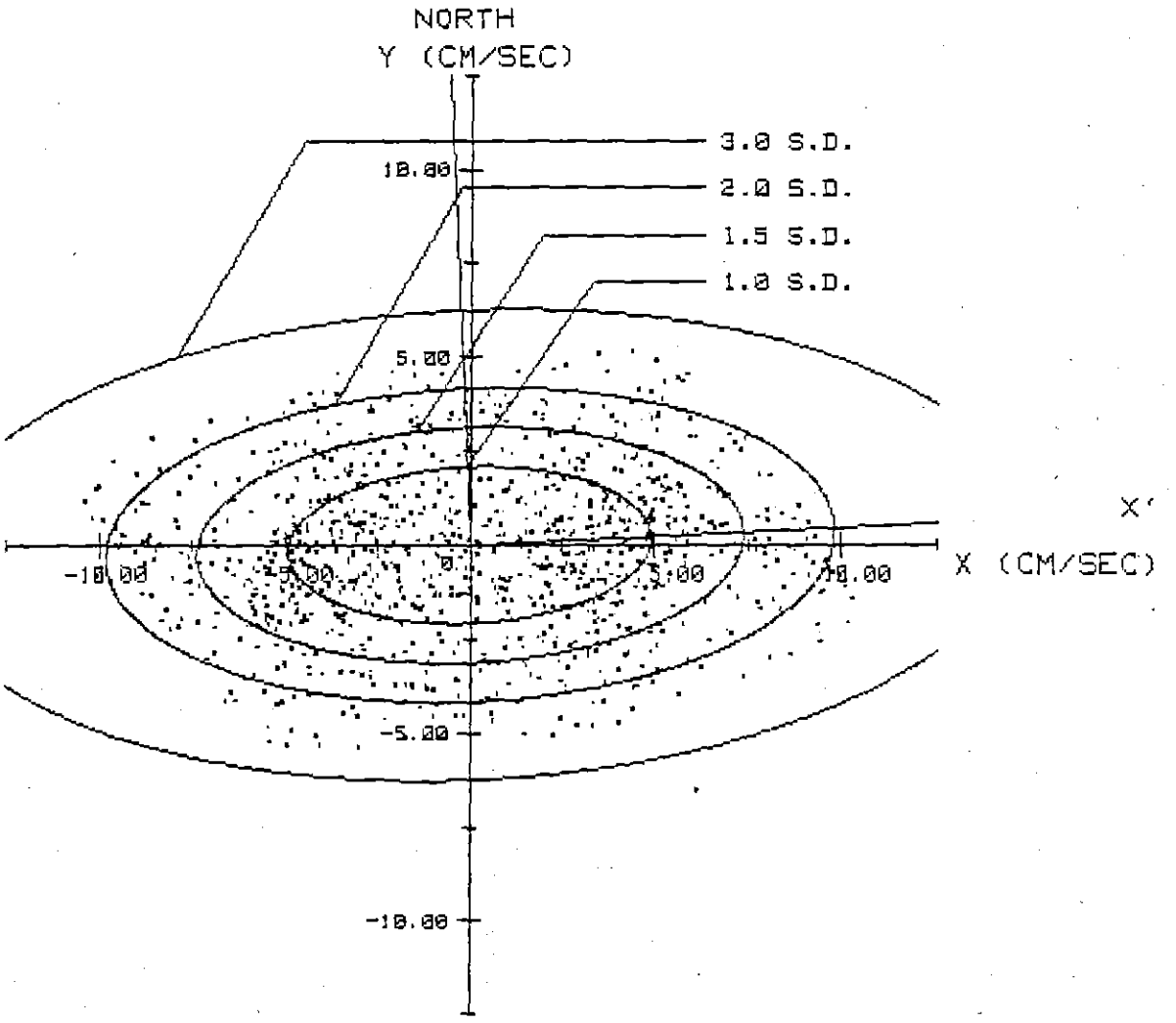


ALENUIHAHA NEAR BOTTOM CURRENTS

DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 1 AUGUST 20 1985 TO NOVEMBER 2 1985
STATION NO. 2T

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	-.03 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	3.66 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	-.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	4.43 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	2.09 CM/SEC
COVARIANCE OF X,Y	=	.67 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	4.90 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	2.08 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	87.49 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	9.81 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	4.17 CM/SEC

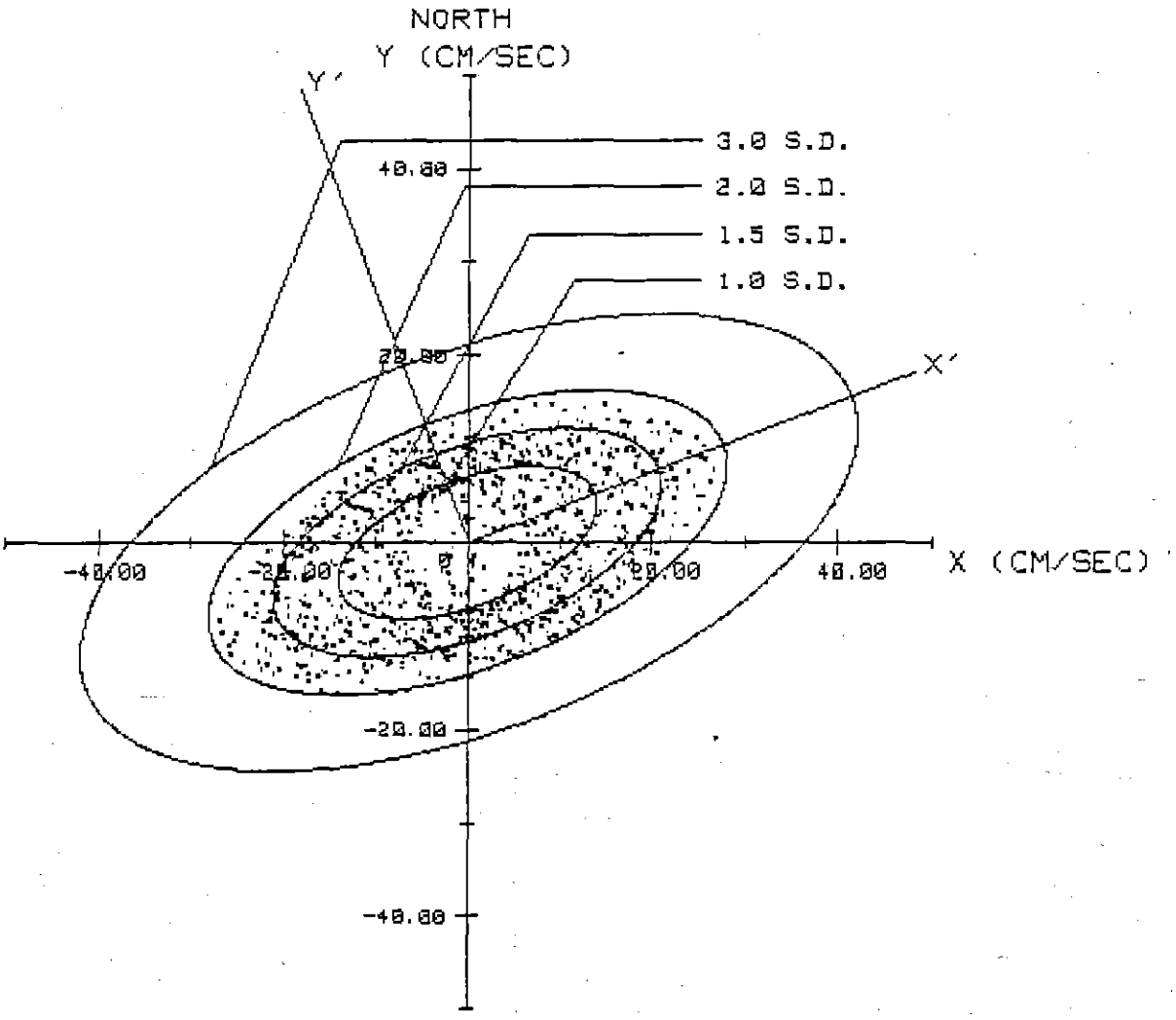


ALENUIHAHA NEAR BOTTOM CURRENTS

SEMI-DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 1 AUGUST 20 1985 TO NOVEMBER 2 1985
STATION NO. 2B

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	-.09 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	2.03 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	-.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	12.24 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	7.75 CM/SEC
COVARIANCE OF X,Y	=	39.42 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	14.73 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	6.72 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	69.36 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	29.47 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	13.44 CM/SEC

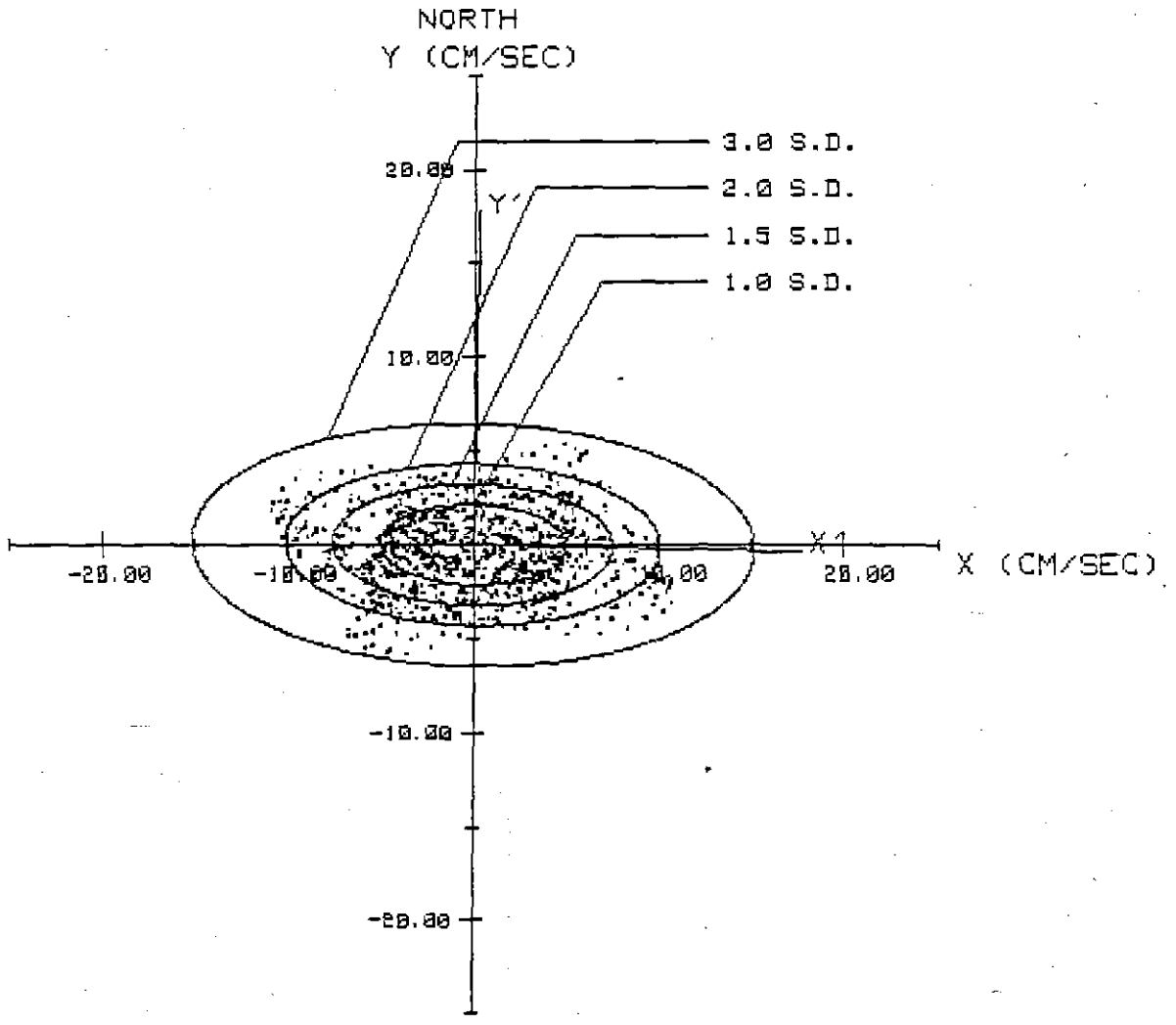


ALENUIHAHA NEAR BOTTOM CURRENTS

DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 1 AUGUST 20 1985 TO NOVEMBER 2 1985
STATION NO. 2B

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	-.09 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	2.03 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	-.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	4.58 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	2.16 CM/SEC
COVARIANCE OF X,Y	=	-.32 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	5.06 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	2.16 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	91.13 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	10.13 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	4.32 CM/SEC

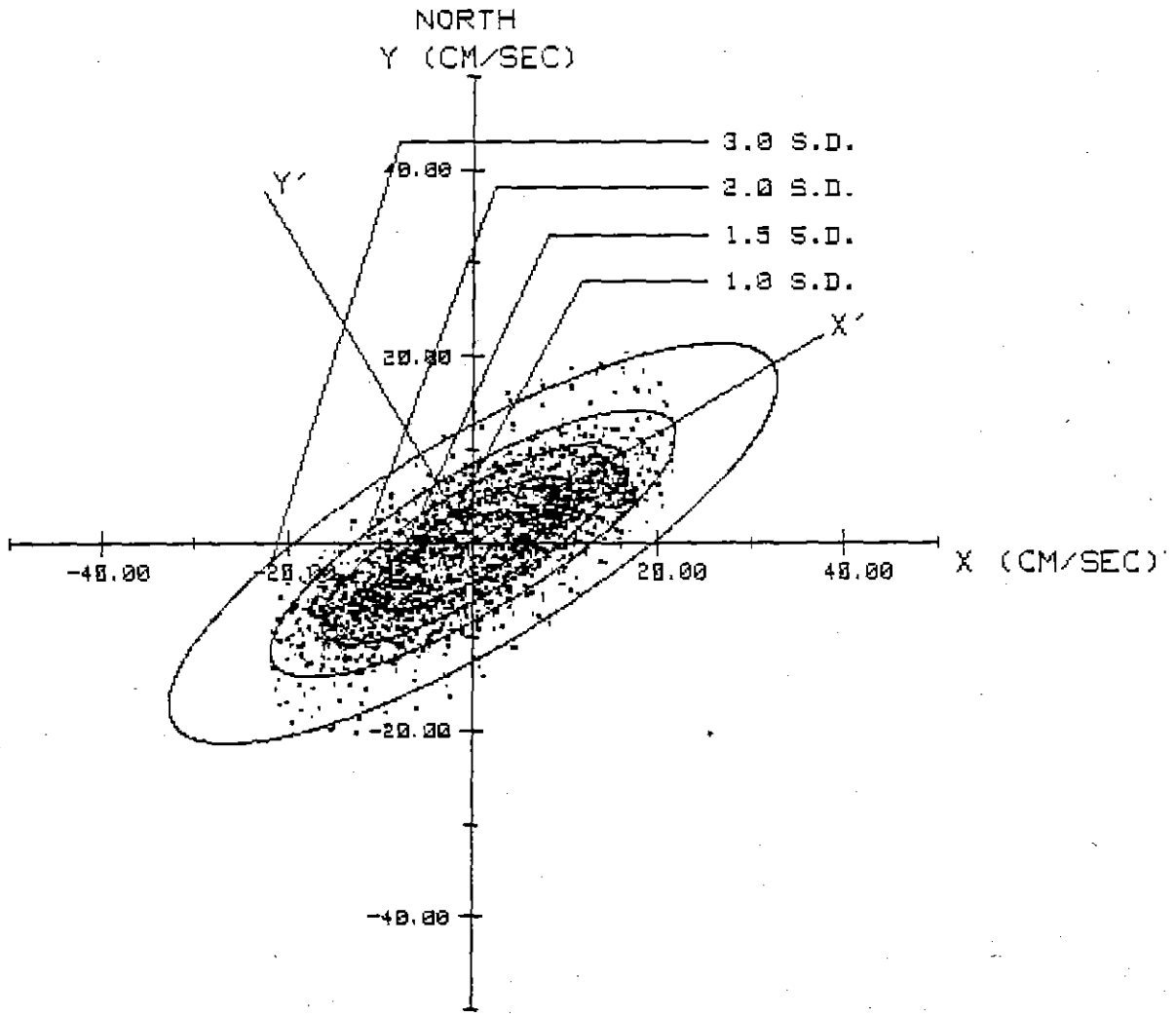


ALENUIHAHA NEAR BOTTOM CURRENTS

SEMI-DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 2 NOVEMBER 3 1985 TO FEBRUARY 27 1986
STATION NO. 2T

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	1.69 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	4.13 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	-.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	9.84 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	6.57 CM/SEC
COVARIANCE OF X,Y	=	49.60 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	12.49 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	3.69 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	59.21 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	24.97 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	7.39 CM/SEC

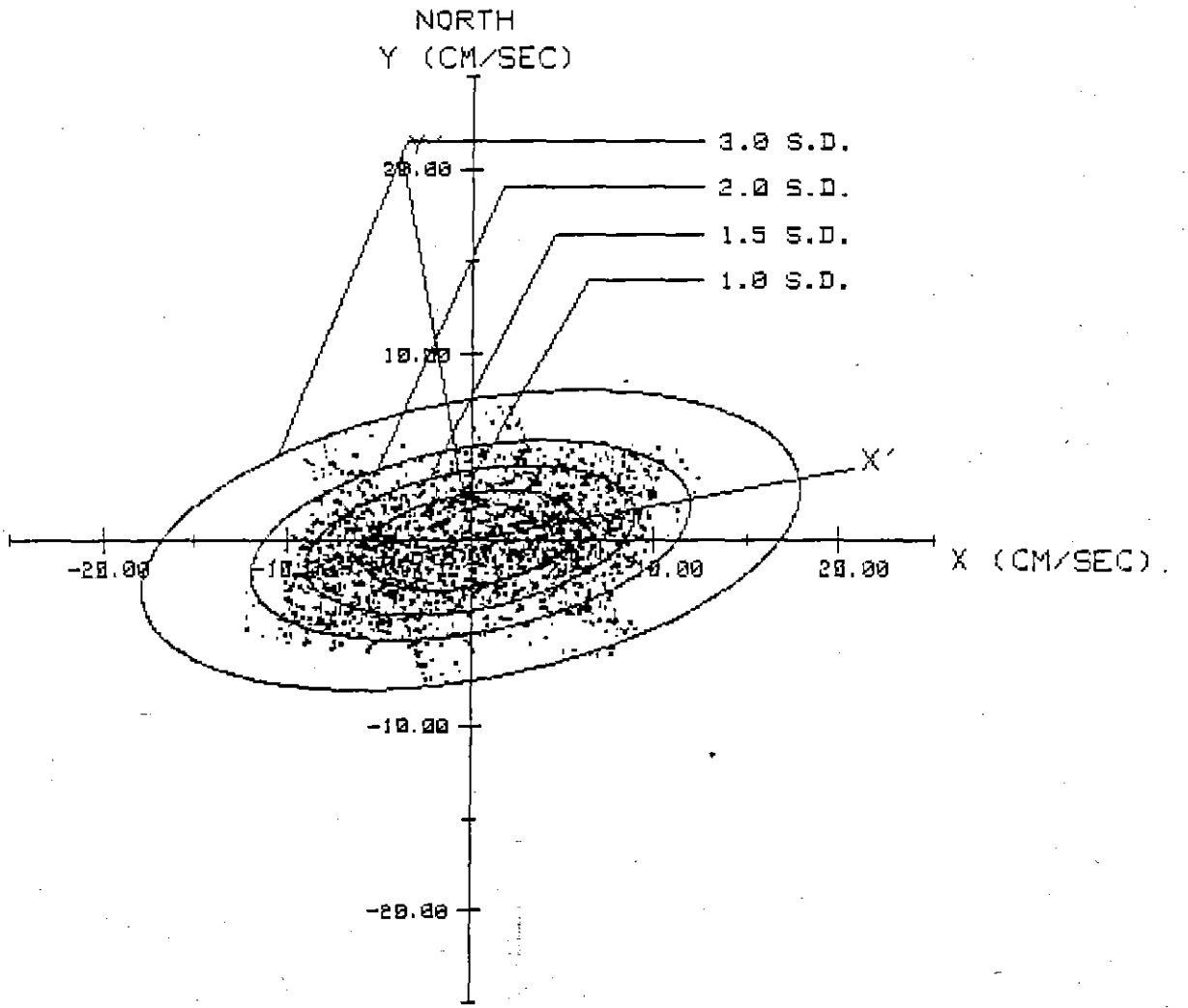


ALENUIHAHA NEAR BOTTOM CURRENTS

DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 2 NOVEMBER 3 1985 TO FEBRUARY 27 1986
STATION NO. 2T

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	1.69 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	4.13 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	-.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	-.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	5.38 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	2.65 CM/SEC
COVARIANCE OF X,Y	=	4.24 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	6.04 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	2.49 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	79.41 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	12.07 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	4.99 CM/SEC

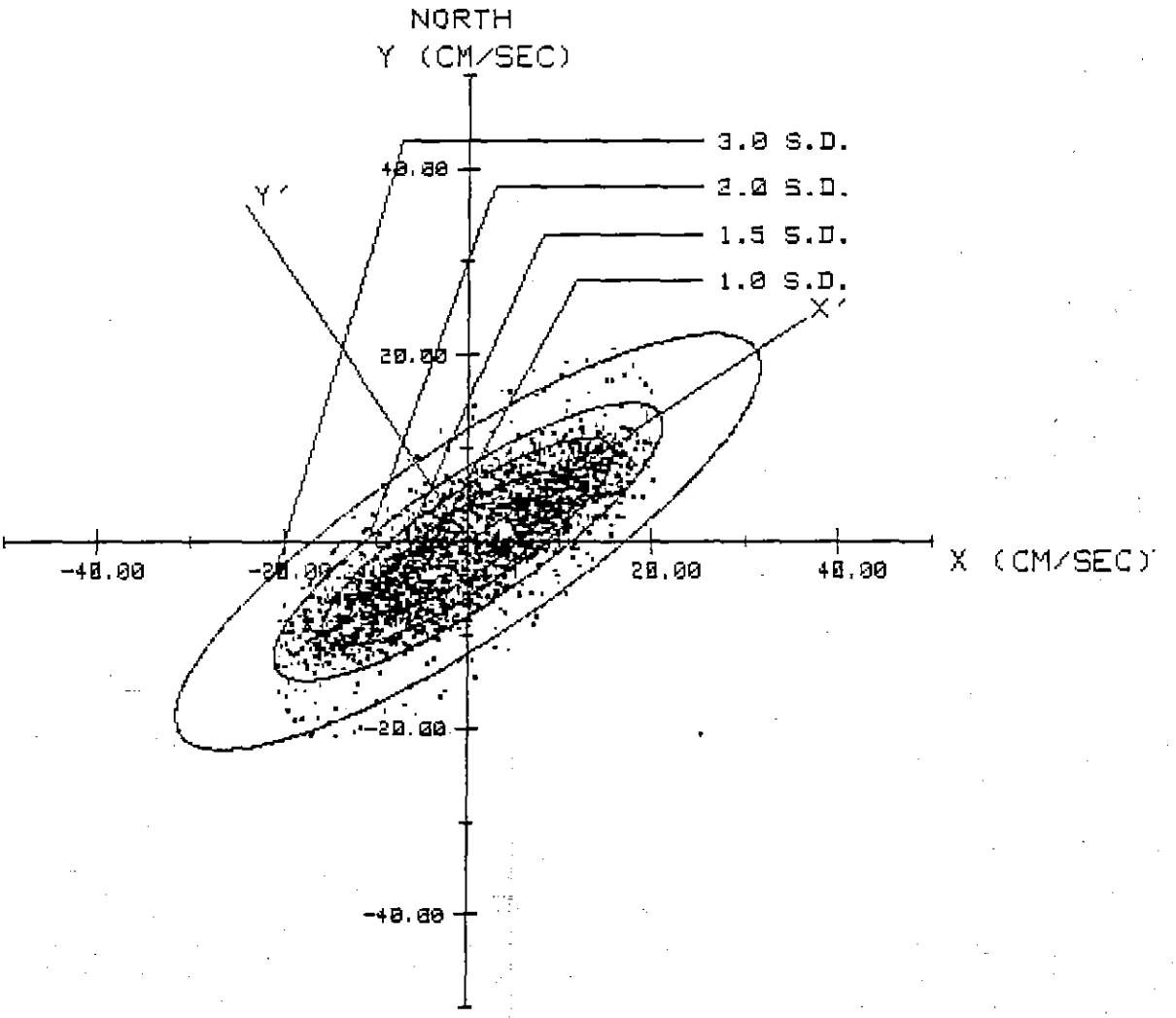


ALENUIHAHA NEAR BOTTOM CURRENTS

SEMI-DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 2 NOVEMBER 3 1985 TO FEBRUARY 27 1986
STATION NO. 2B

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	1.03 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	4.20 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	-.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	9.48 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	6.80 CM/SEC
COVARIANCE OF X,Y	=	52.12 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	12.40 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	3.40 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	56.35 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	24.81 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	6.81 CM/SEC

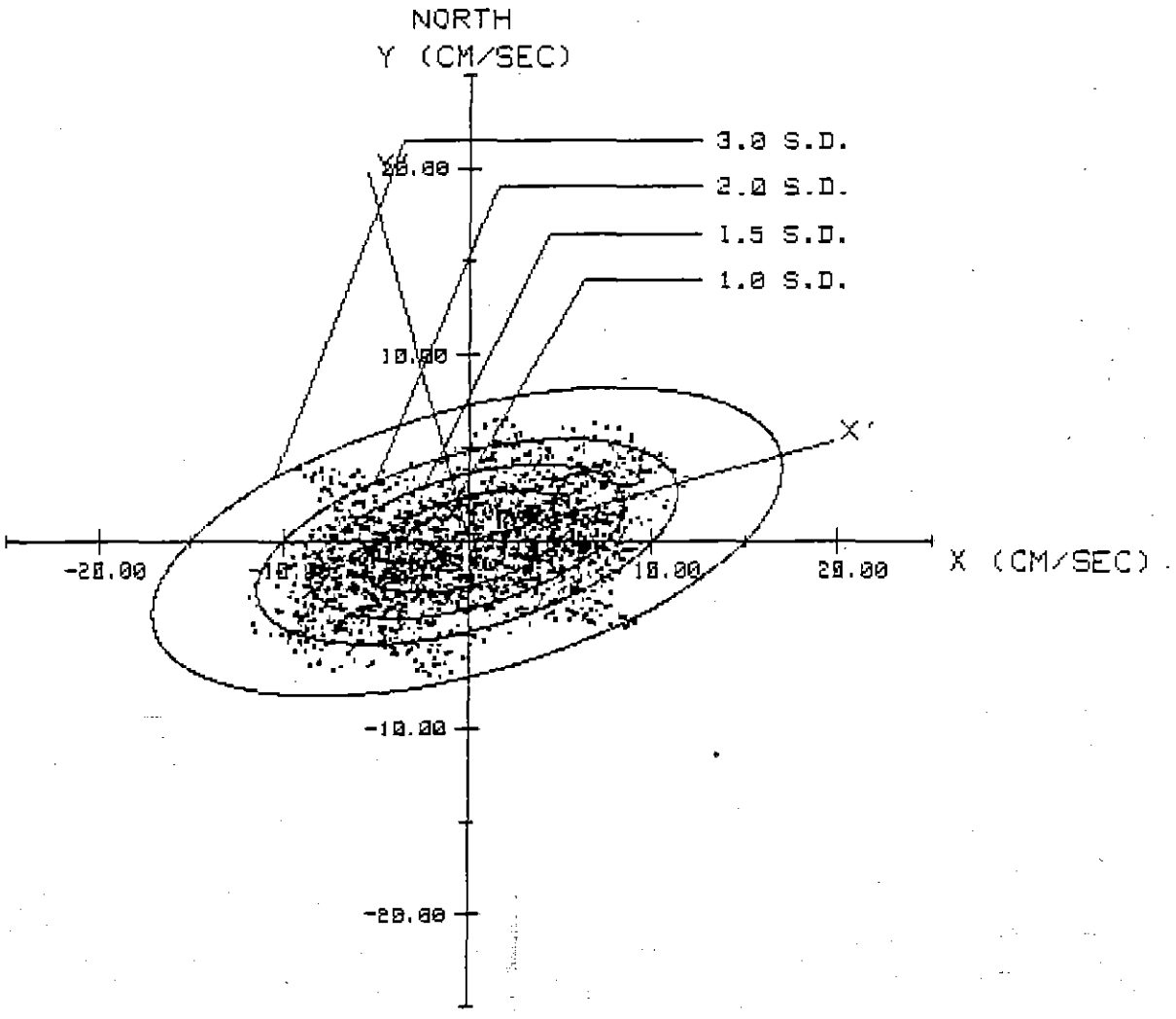


ALENUIHAHA NEAR BOTTOM CURRENTS

DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENT NO. 2 NOVEMBER 3 1985 TO FEBRUARY 27 1986
STATION NO. 2B

MEAN VALUE OF RAW DATA IN X-DIRECTION	=	1.03 CM/SEC
MEAN VALUE OF RAW DATA IN Y-DIRECTION	=	4.20 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	5.11 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	2.67 CM/SEC
COVARIANCE OF X,Y	=	5.70 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	5.85 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	2.36 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	74.54 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	11.70 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	4.71 CM/SEC

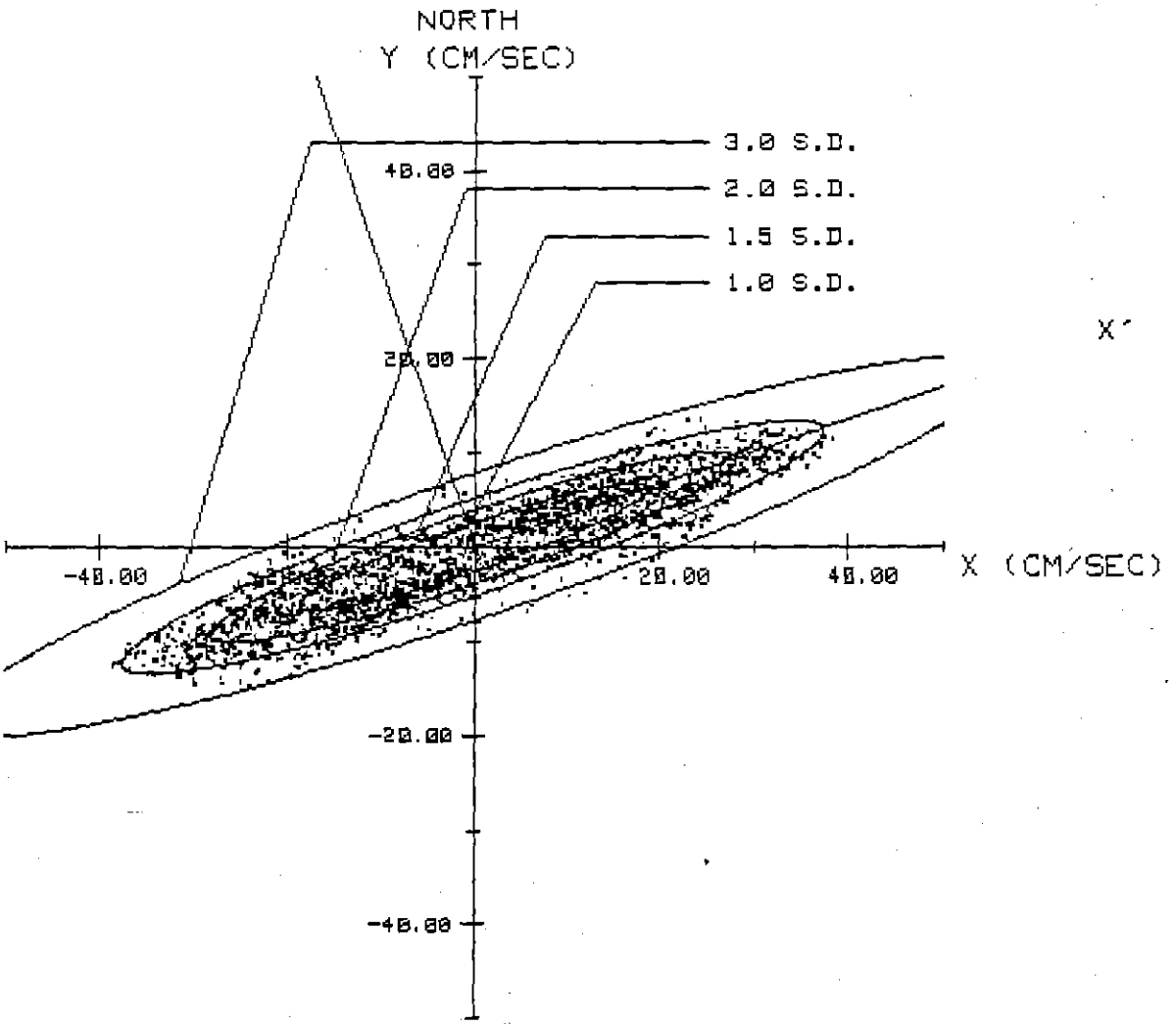


ALENUNIHAHA NEAR-SURFACE CURRENTS

SEMI-DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENTS 3-7 NOVEMBER 26 1985 TO MAY 26 1986
SEA DATA STATION

MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	-.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	17.83 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	6.46 CM/SEC
COVARIANCE OF X,Y	=	105.32 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	19.70 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	2.48 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	71.33 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	39.40 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	4.96 CM/SEC

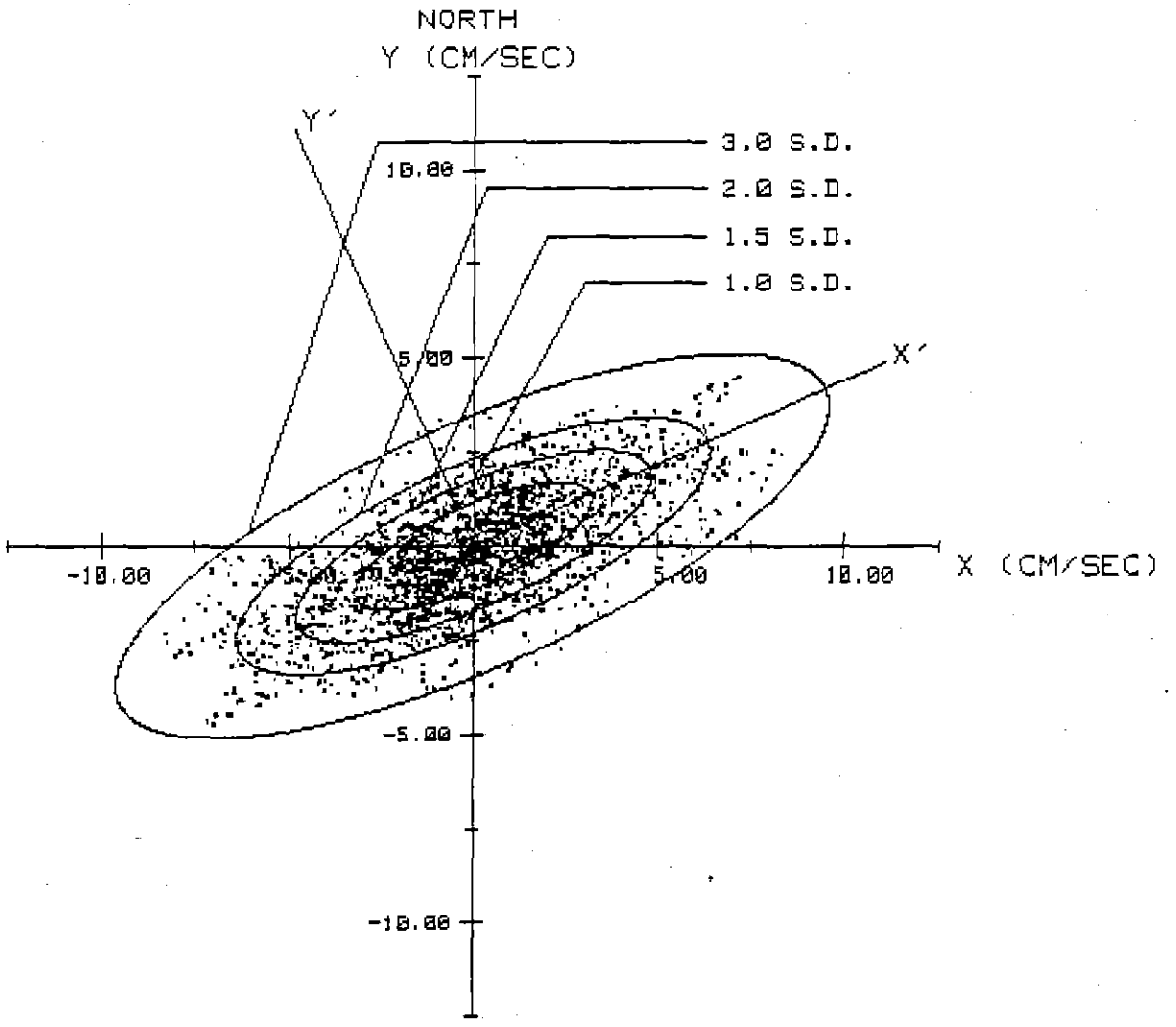


ALENUNIHAHA NEAR-SURFACE CURRENTS

DIURNAL TIDAL CURRENT ELLIPSE CHARACTERISTICS

DEPLOYMENTS 3-7 NOVEMBER 26 1985 TO MAY 26 1986
SEA DATA STATION

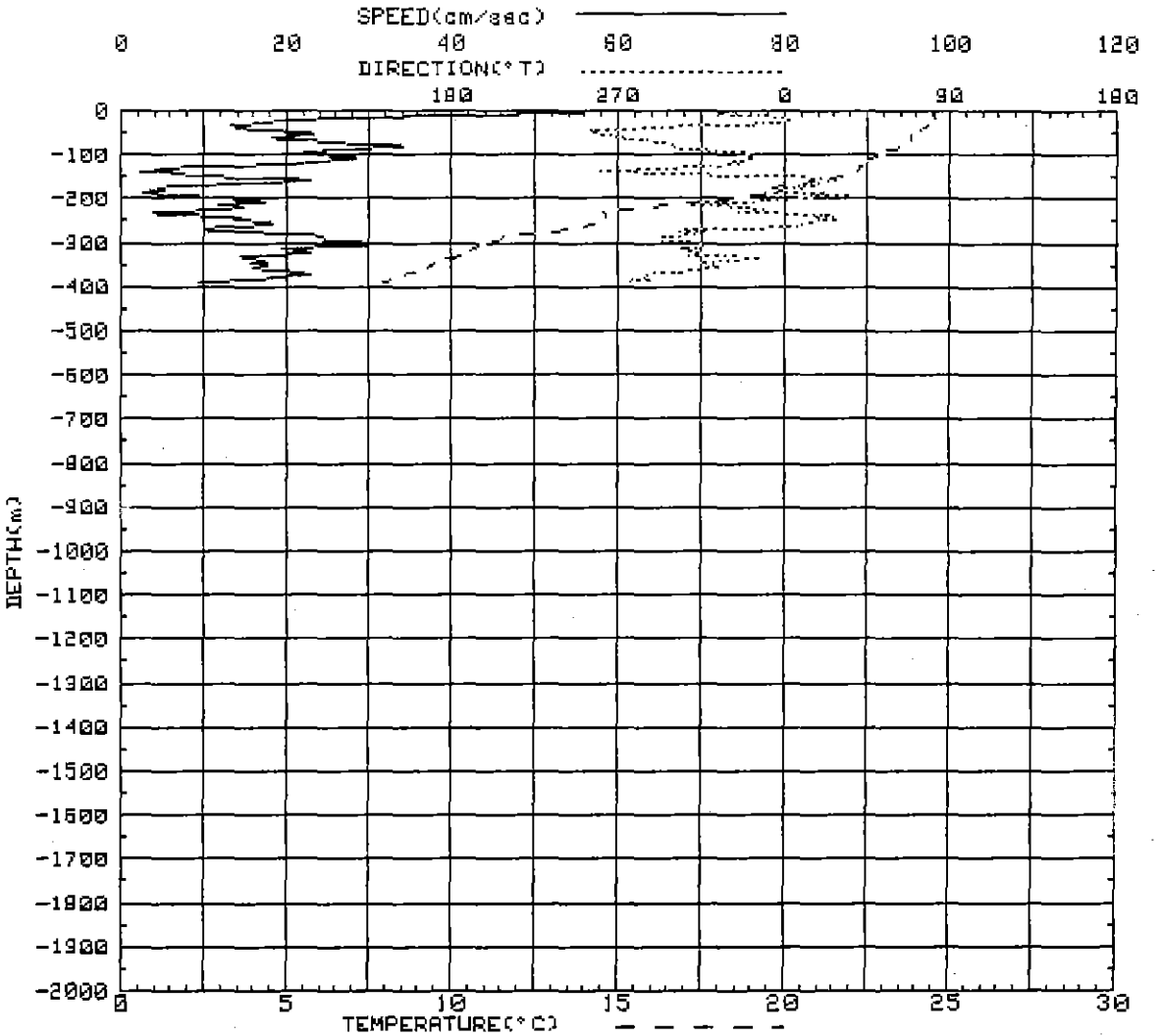
MEAN VALUE OF FILTERED TIME SERIES IN X-DIRECTION	=	-.00 CM/SEC
MEAN VALUE OF FILTERED TIME SERIES IN Y-DIRECTION	=	.00 CM/SEC
STANDARD DEVIATION ALONG X-AXIS	=	2.91 CM/SEC
STANDARD DEVIATION ALONG Y-AXIS	=	1.60 CM/SEC
COVARIANCE OF X,Y	=	3.22 (CM/SEC)**2
STANDARD DEVIATION ALONG PRINCIPAL AXIS X' (SD X')	=	3.45 CM/SEC
STANDARD DEVIATION ALONG PRINCIPAL AXIS Y' (SD Y')	=	1.08 CM/SEC
ANGLE OF THE X' AXIS FROM NORTH (+ CLOCKWISE)	=	66.27 DEGREES
AMPLITUDE OF ELLIPSE ON X' AXIS (2*SD X')	=	6.90 CM/SEC
AMPLITUDE OF ELLIPSE ON Y' AXIS (2*SD Y')	=	2.15 CM/SEC



APPENDIX C

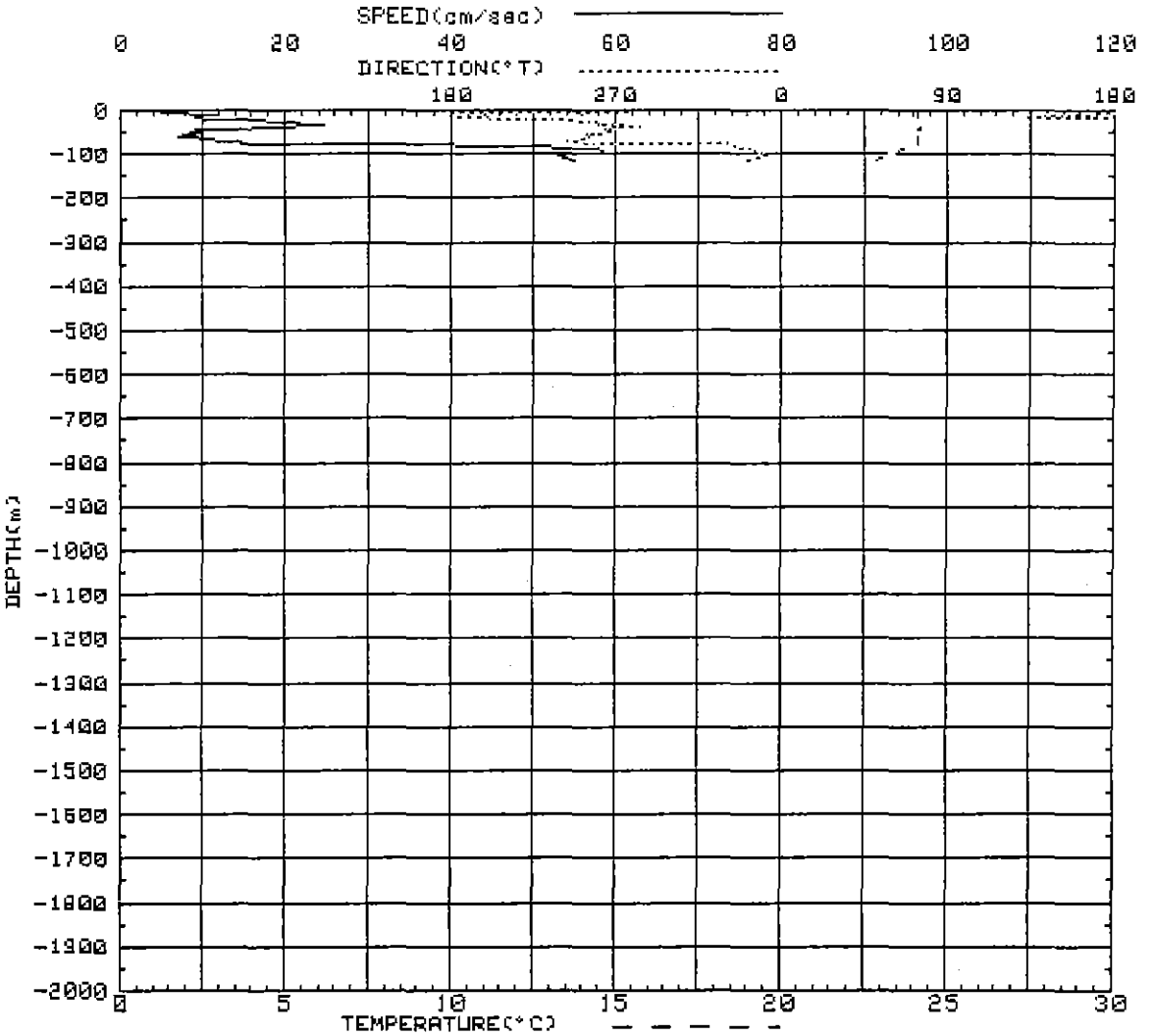
XCP VERTICAL CURRENT PROFILES
WITH OVERPLOTS OF MEASURED CURRENTS
AT CURRENT METER STATIONS
(* speed, + direction)

SURVEY DATE: MAY 28, 1985 DROP TIME: 1108



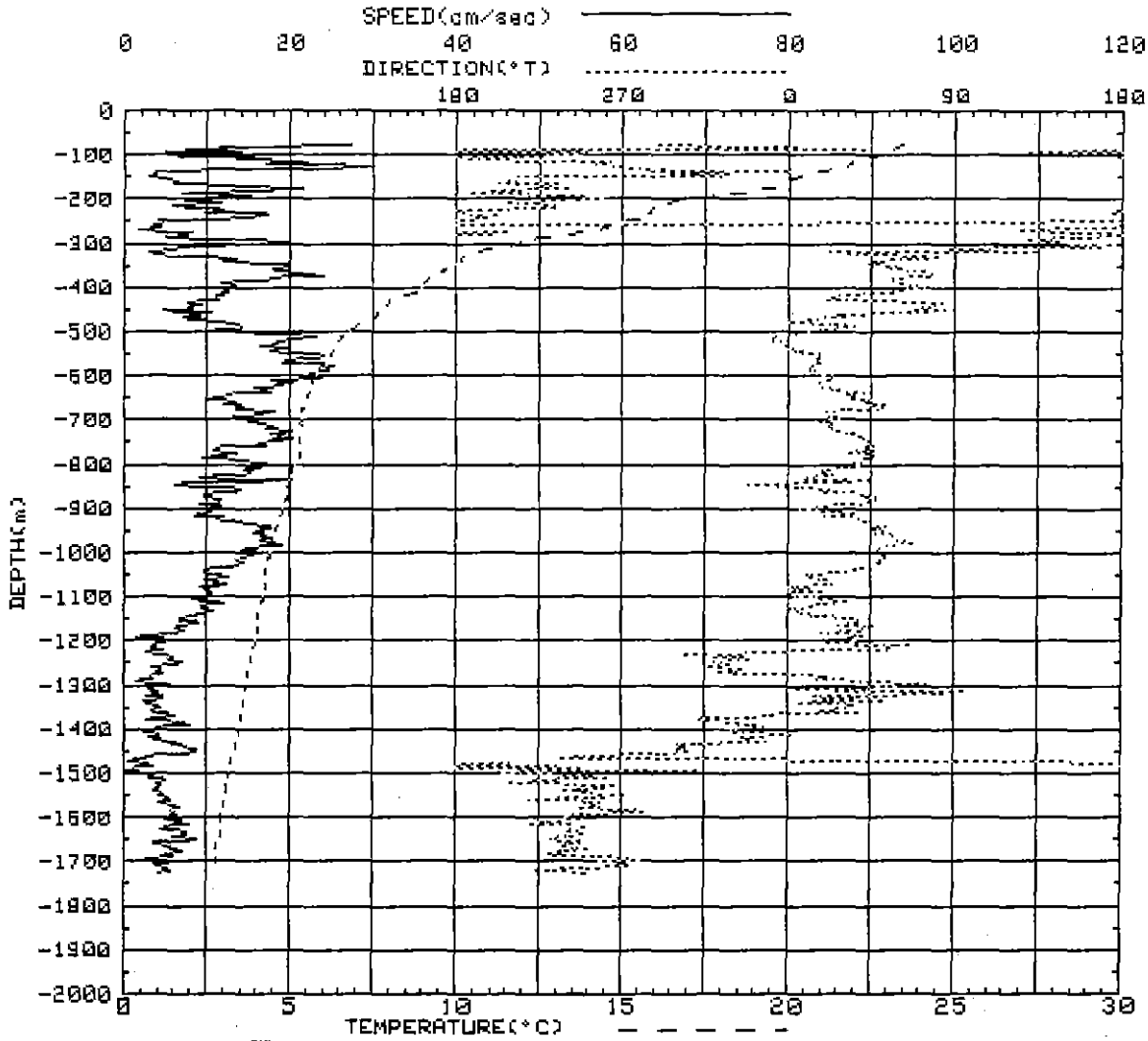
LATITUDE: 20°19'25"N LONGITUDE: 155°55'20"W
SURVEY 1 LEG 1 DROP 1

SURVEY DATE: MAY 28, 1985 DROP TIME: 1158



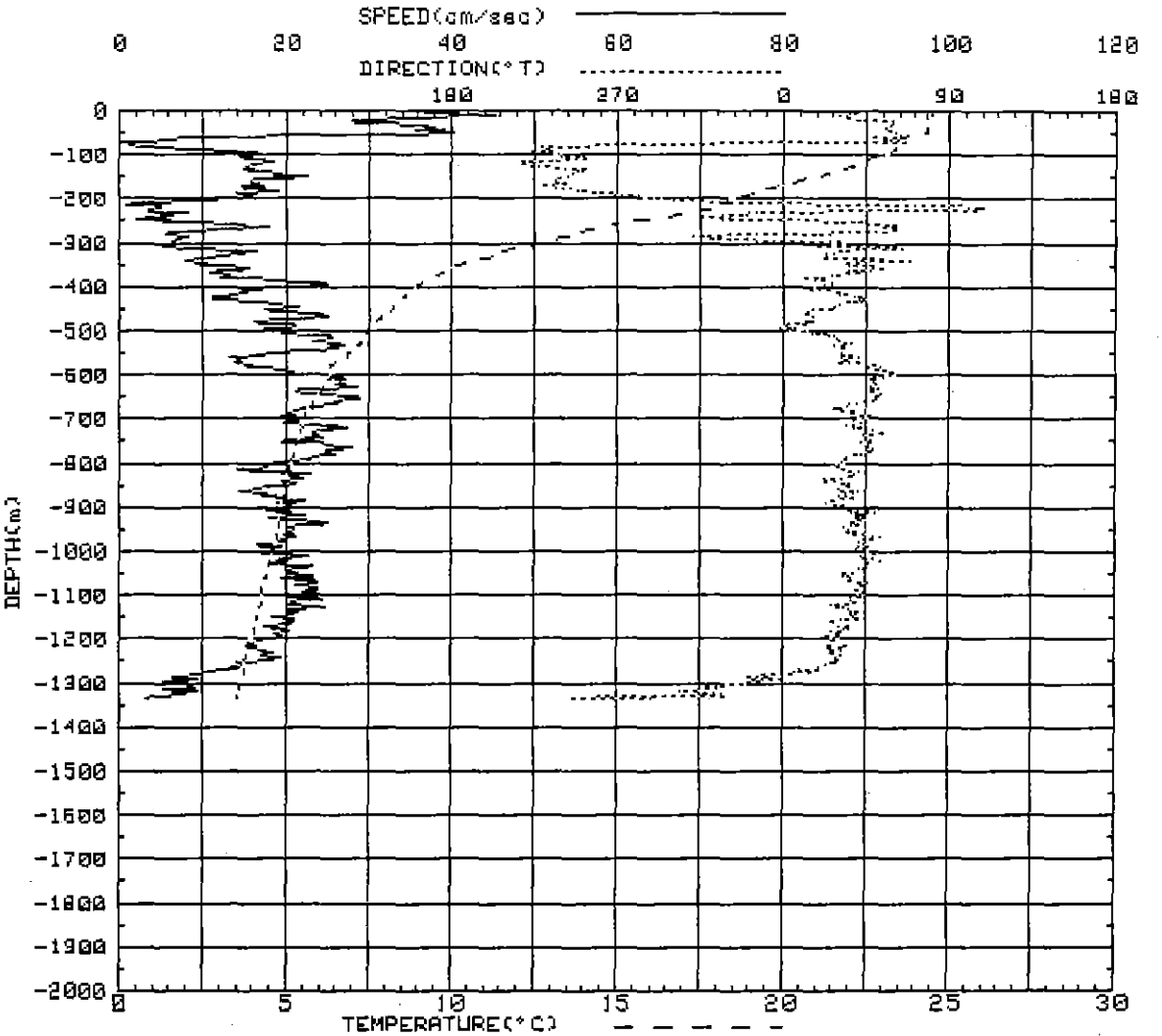
LATITUDE: 20°27'00"N LONGITUDE: 156°00'30"W
SURVEY 1 LEG 1 DROP 3

SURVEY DATE: MAY 28, 1985 DROP TIME: 1211



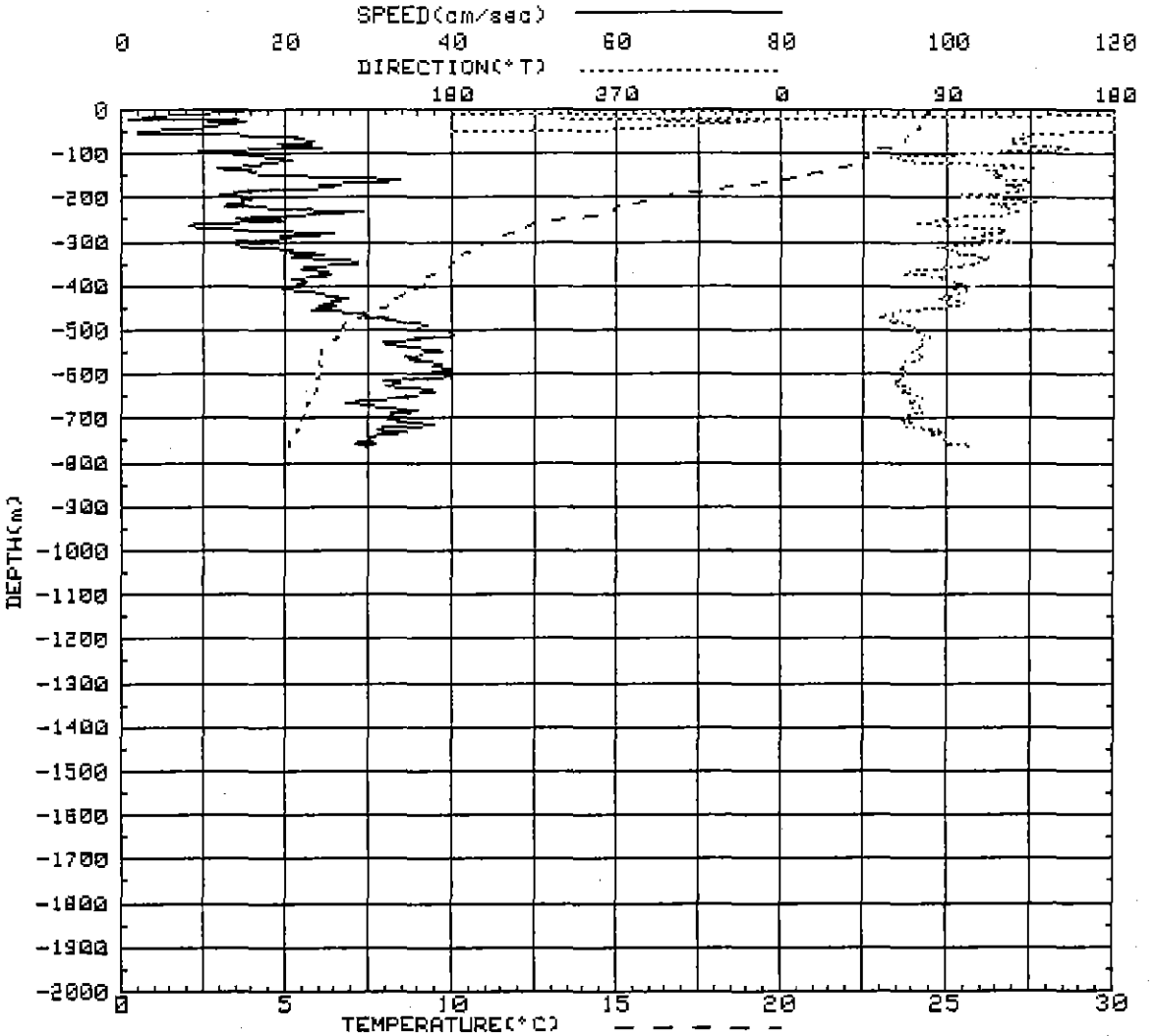
LATITUDE: 20°28'45"N LONGITUDE: 156°01'35"W
SURVEY 1 LEG 1 DROP 4

SURVEY DATE: MAY 28, 1985 DROP TIME: 1244



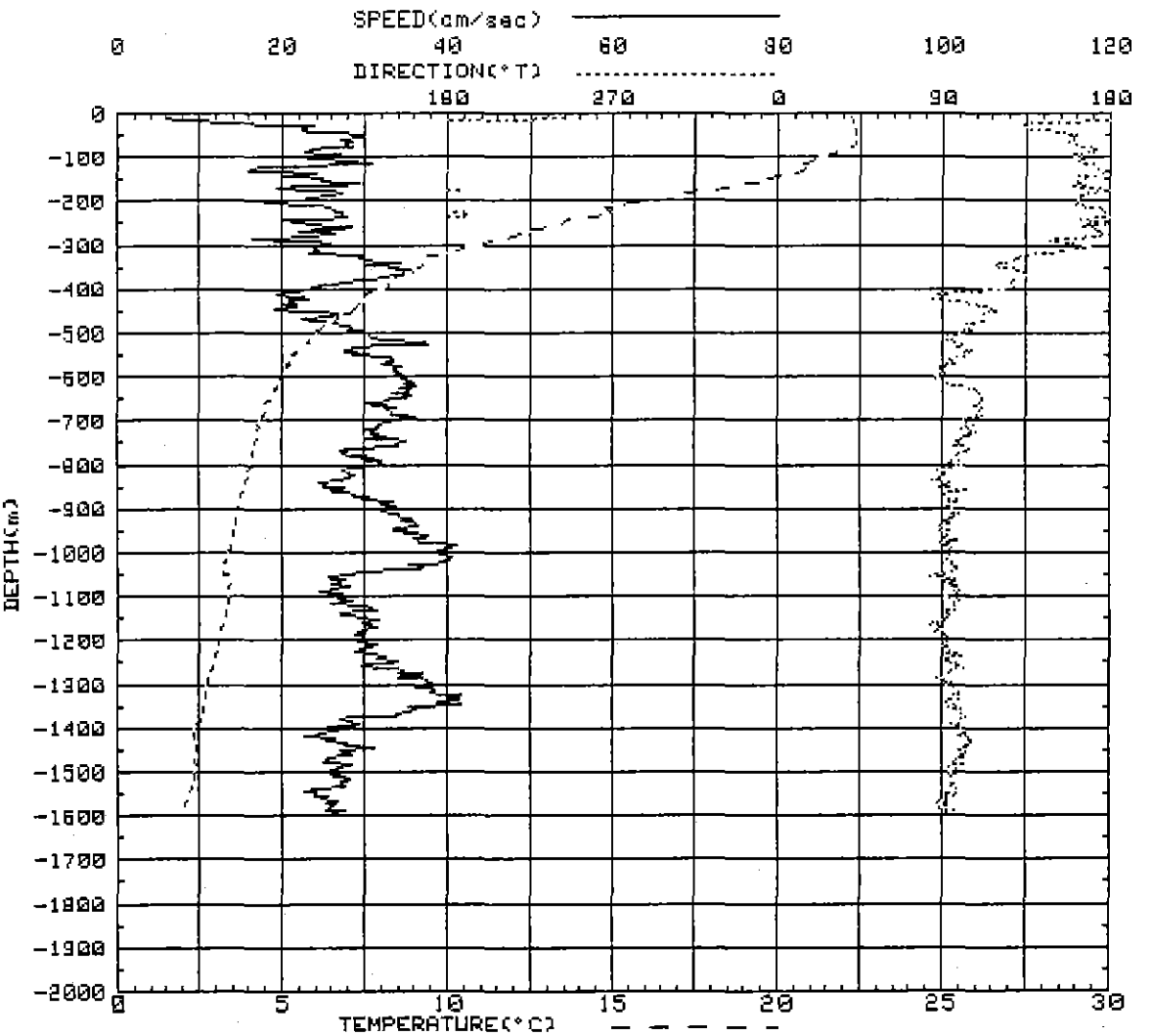
LATITUDE: 20°33'40"N LONGITUDE: 156°04'55"W
SURVEY 1 LEG 1 DROP 6

SURVEY DATE: MAY 28, 1985 DROP TIME: 1726



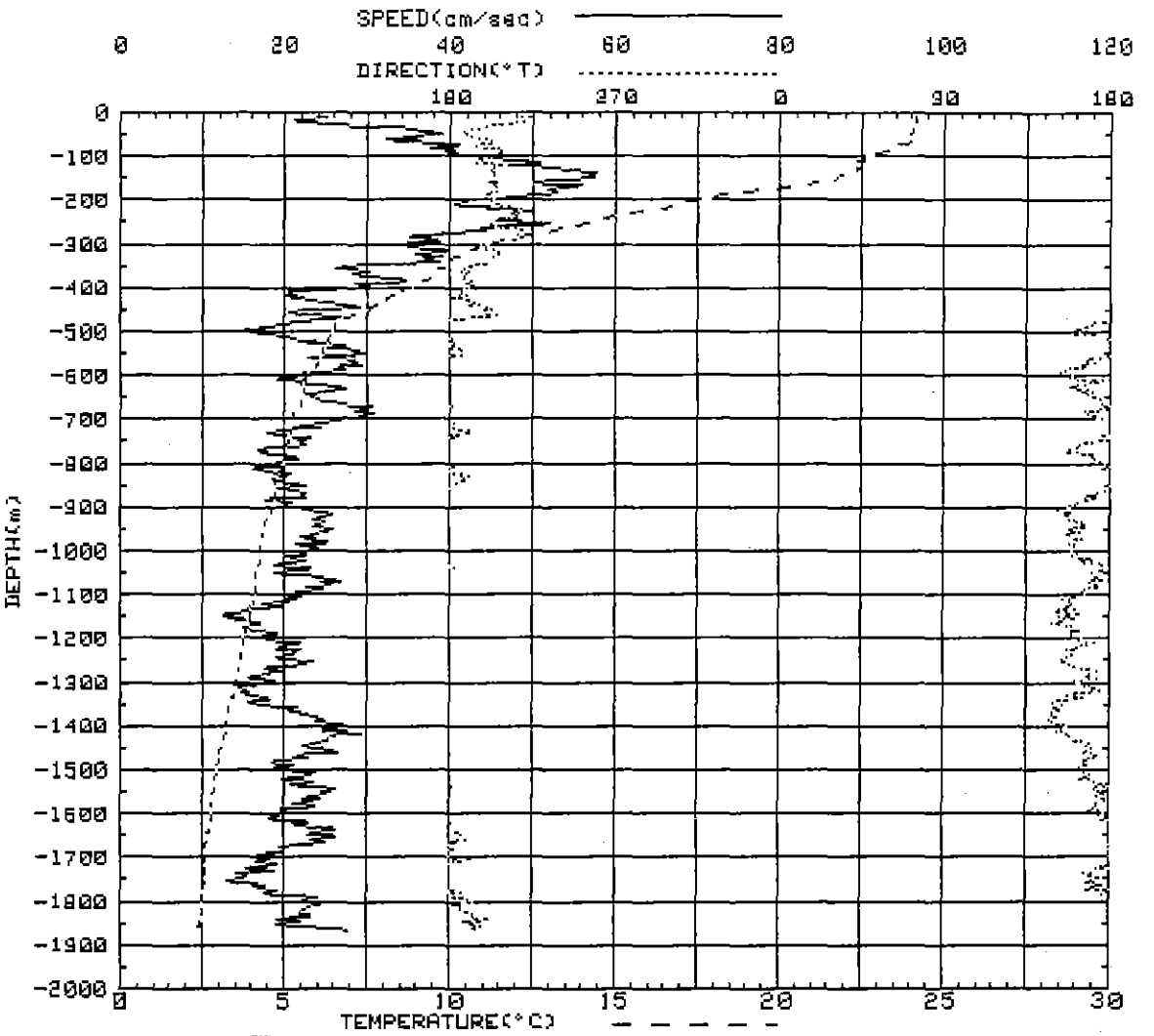
LATITUDE: 20°23'10"N LONGITUDE: 155°57'50"W
SURVEY 1 LEG 2 DROP 2.

SURVEY DATE: MAY 28, 1985 DROP TIME: 1704



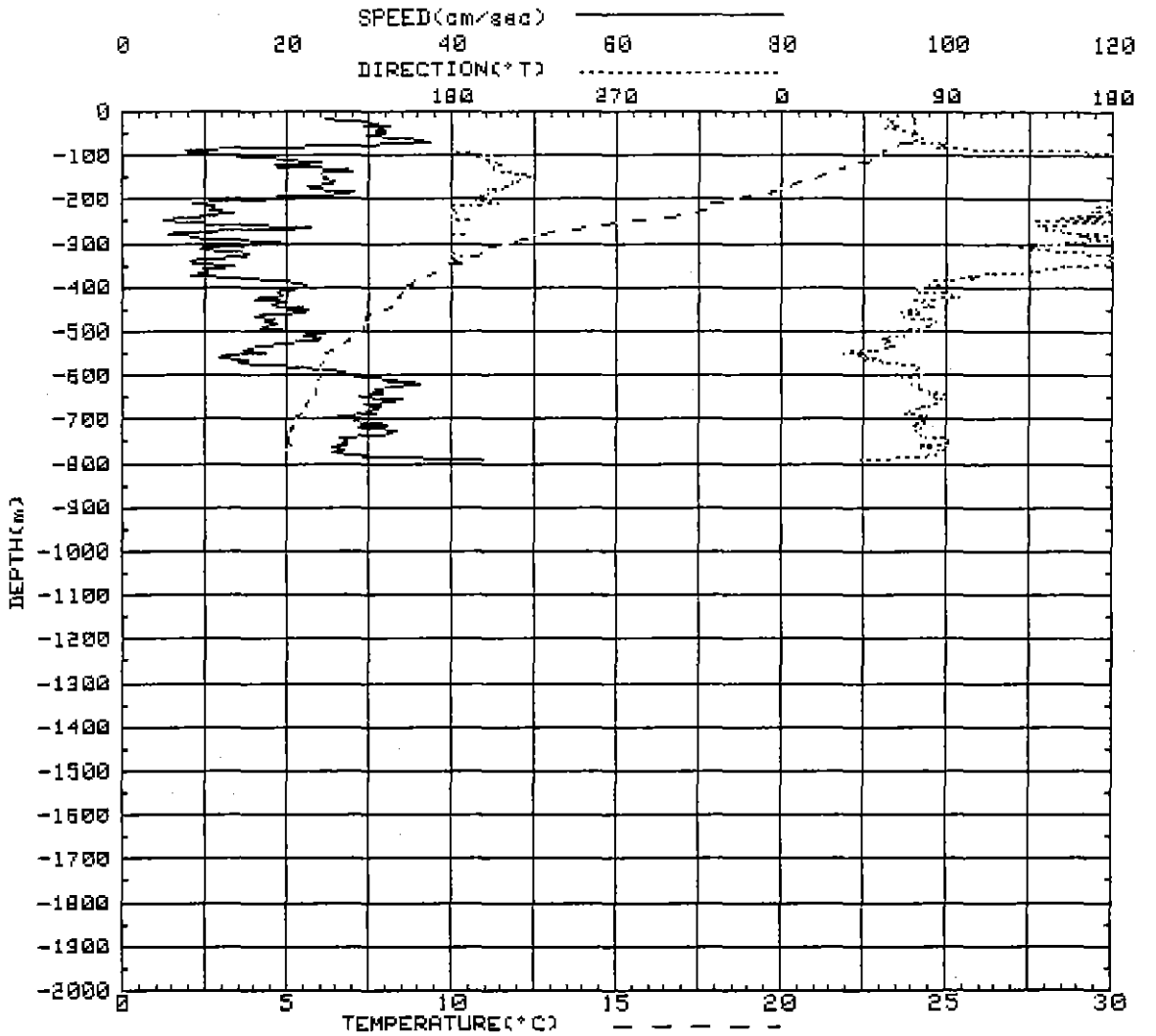
LATITUDE: 20°38'45"N LONGITUDE: 156°01'35"W
SURVEY 1 LEG 2 DROP 4'

SURVEY DATE: MAY 28, 1985 DROP TIME: 1650



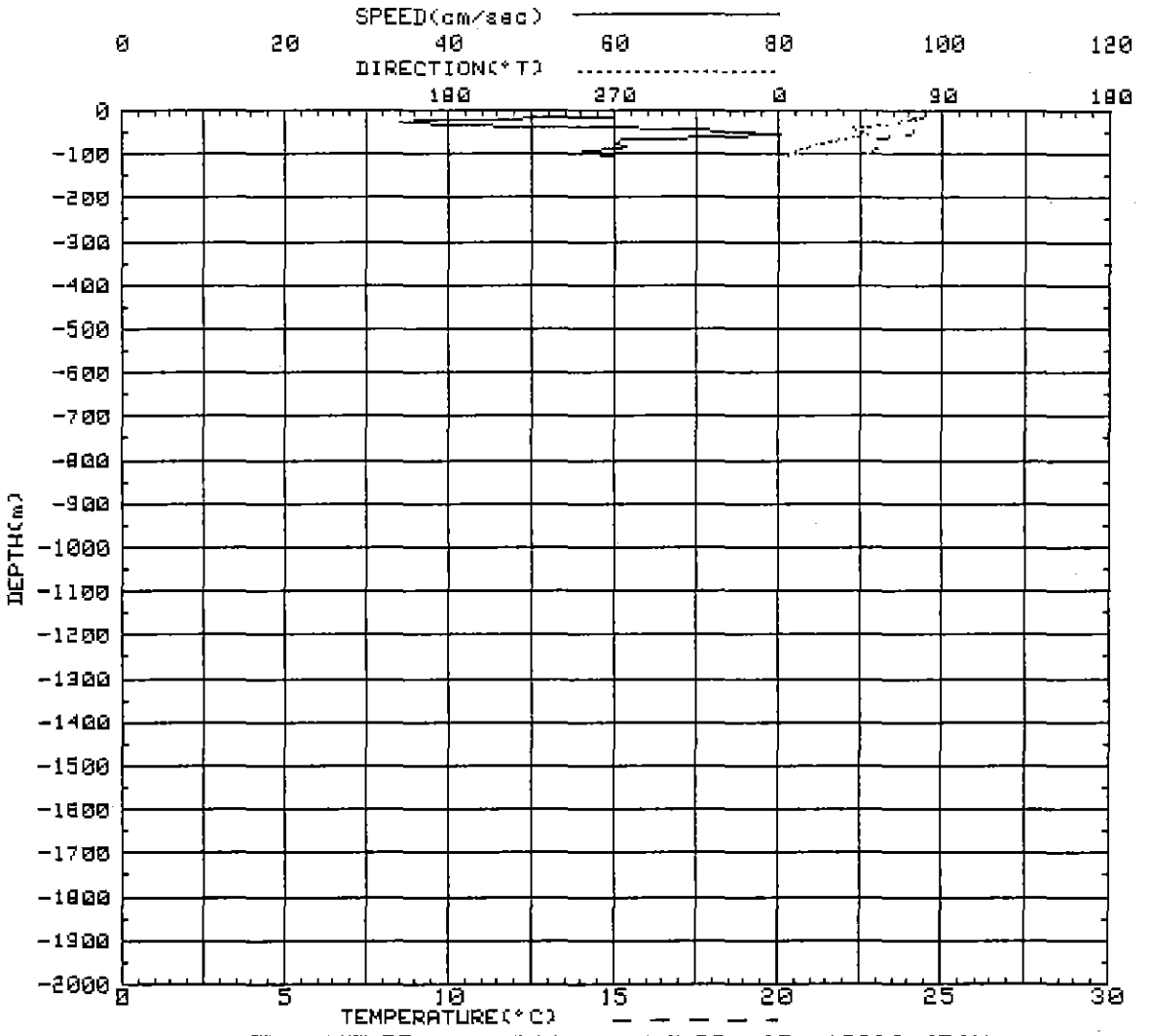
LATITUDE: 20°30'15"N LONGITUDE: 156°02'40"W
SURVEY 1 LEG 2 DROP 5

SURVEY DATE: MAY 28, 1985 DROP TIME: 1637



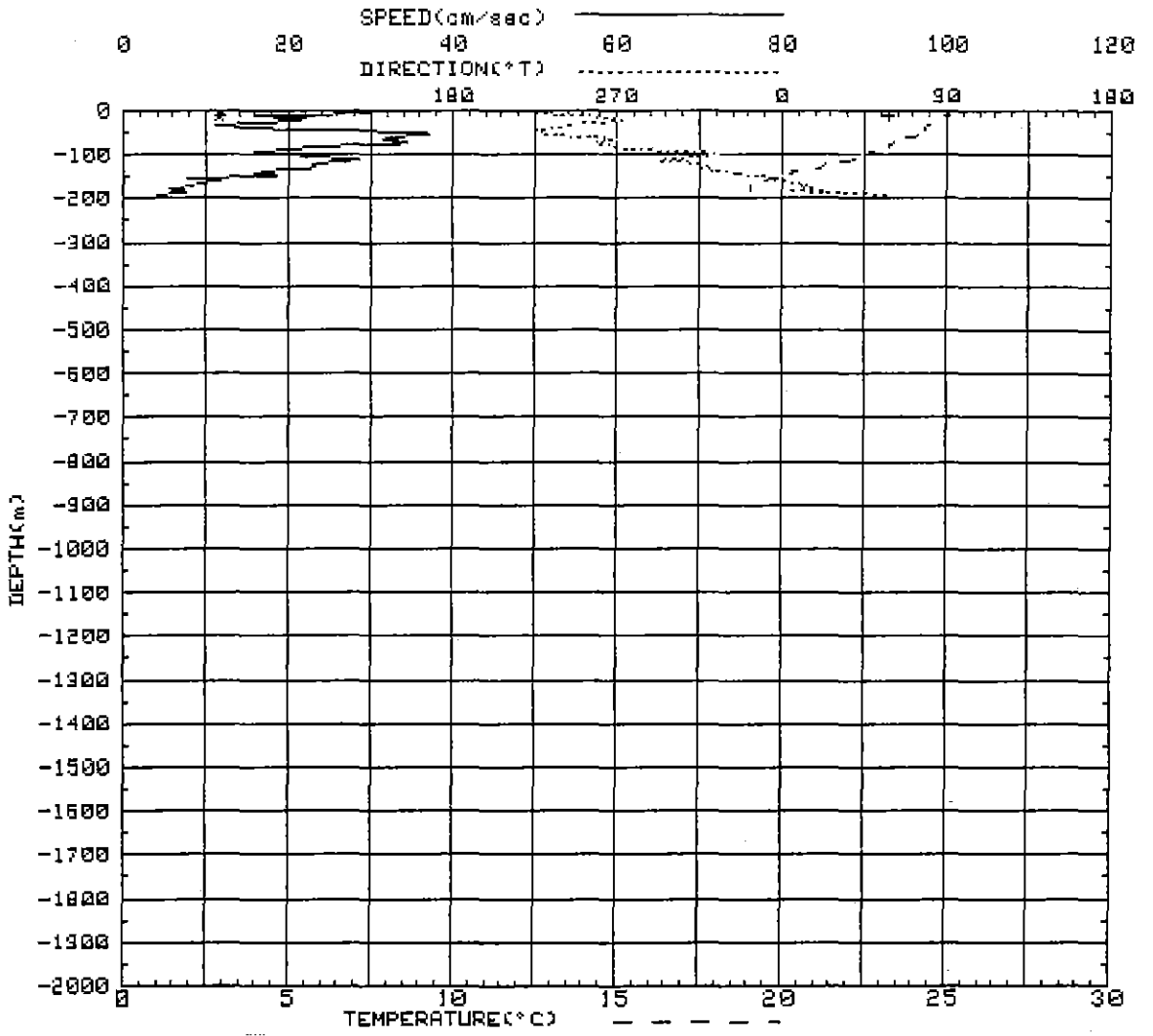
LATITUDE: 20°33'40"N LONGITUDE: 156°04'55"W
SURVEY 1 LEG 2 DROP 6.

SURVEY DATE: MAY 28, 1985 DROP TIME: 1608



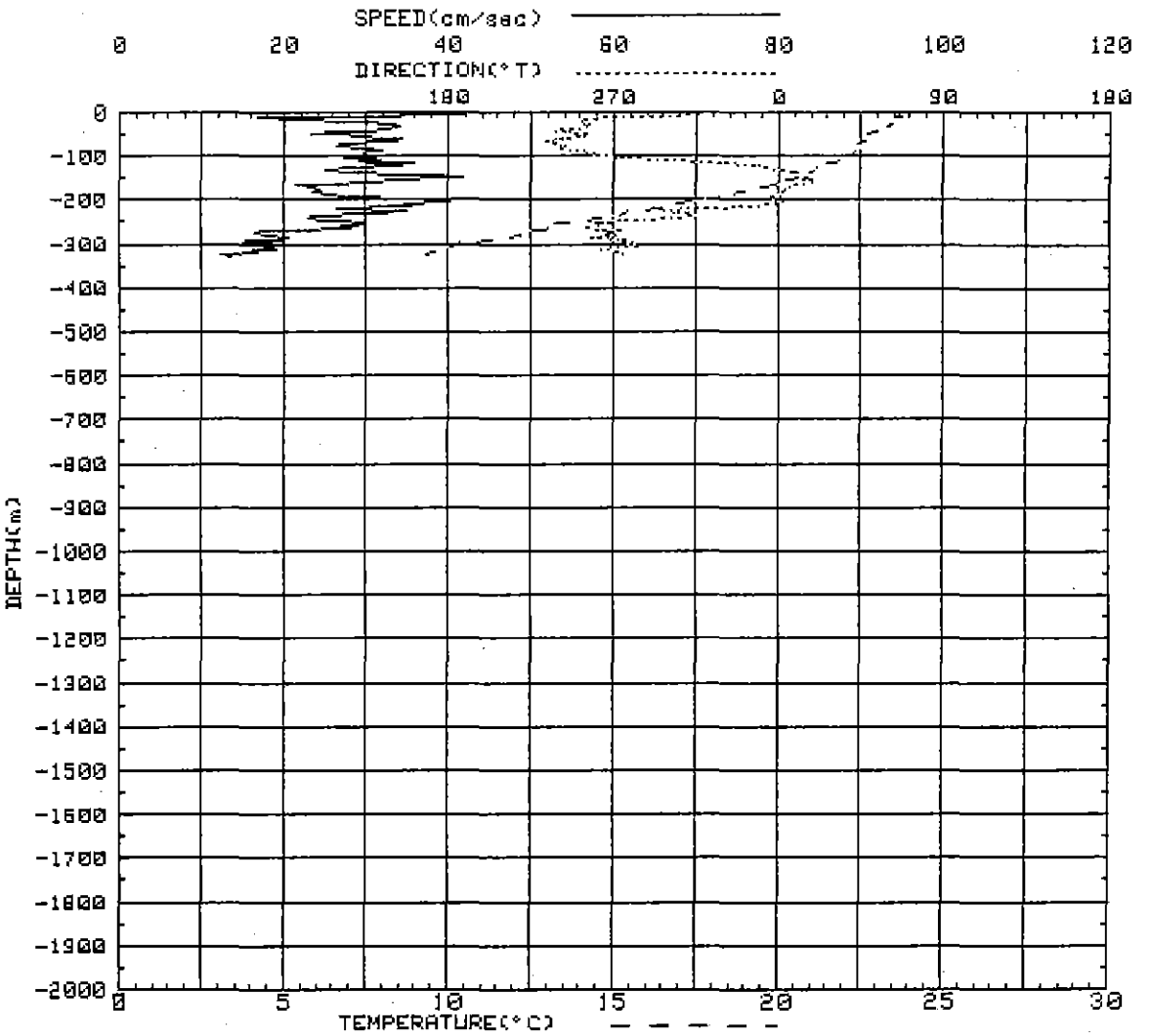
LATITUDE: 20°33'40"N LONGITUDE: 156°6'5"W
SURVEY 1 LEG 2 DROP 7

SURVEY DATE: JULY 1, 1985 DROP TIME: 1218



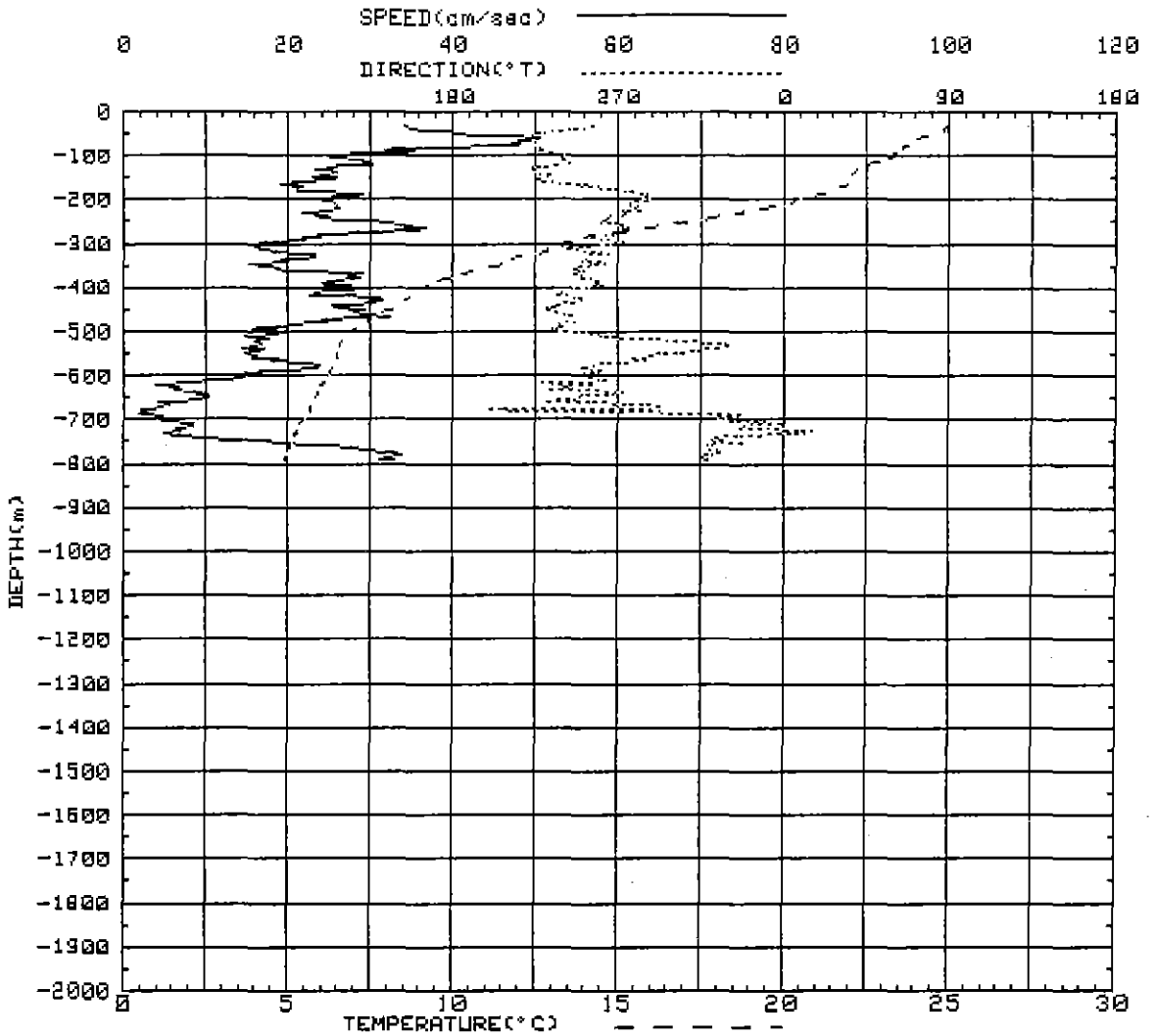
LATITUDE: 20°17'34"N LONGITUDE: 155°54'00"W
SURVEY 2 LEG 1 DROP 4A

SURVEY DATE: JULY 1, 1985 DROP TIME: 1242



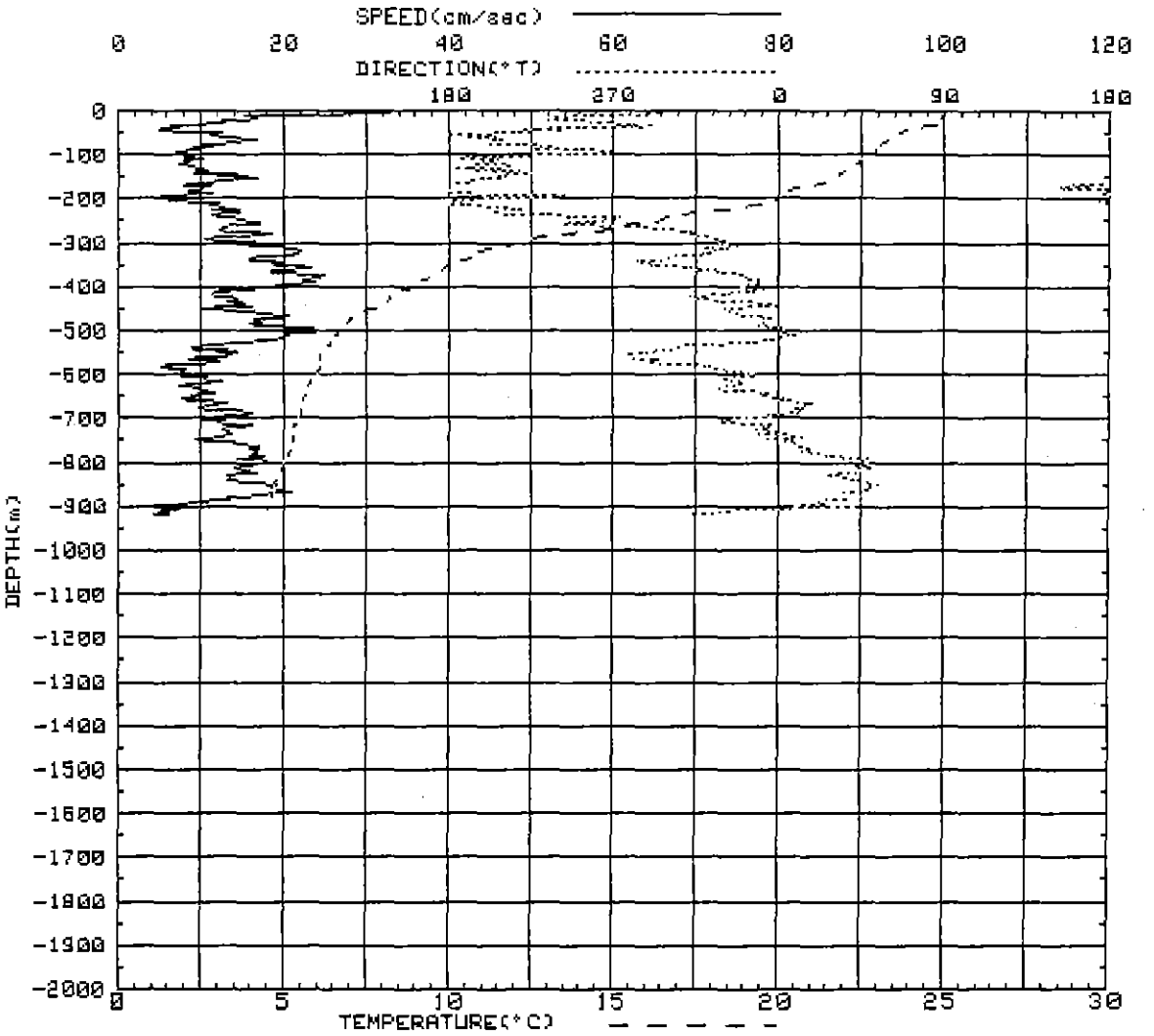
LATITUDE: 20°19'25"N LONGITUDE: 155°55'20"W
SURVEY 2 LEG 1 DROP 1

SURVEY DATE: JULY 1, 1985 DROP TIME: 1313



LATITUDE: 20°23'10"N LONGITUDE: 155°57'50"W
SURVEY 2 LEG 1 DROP 2

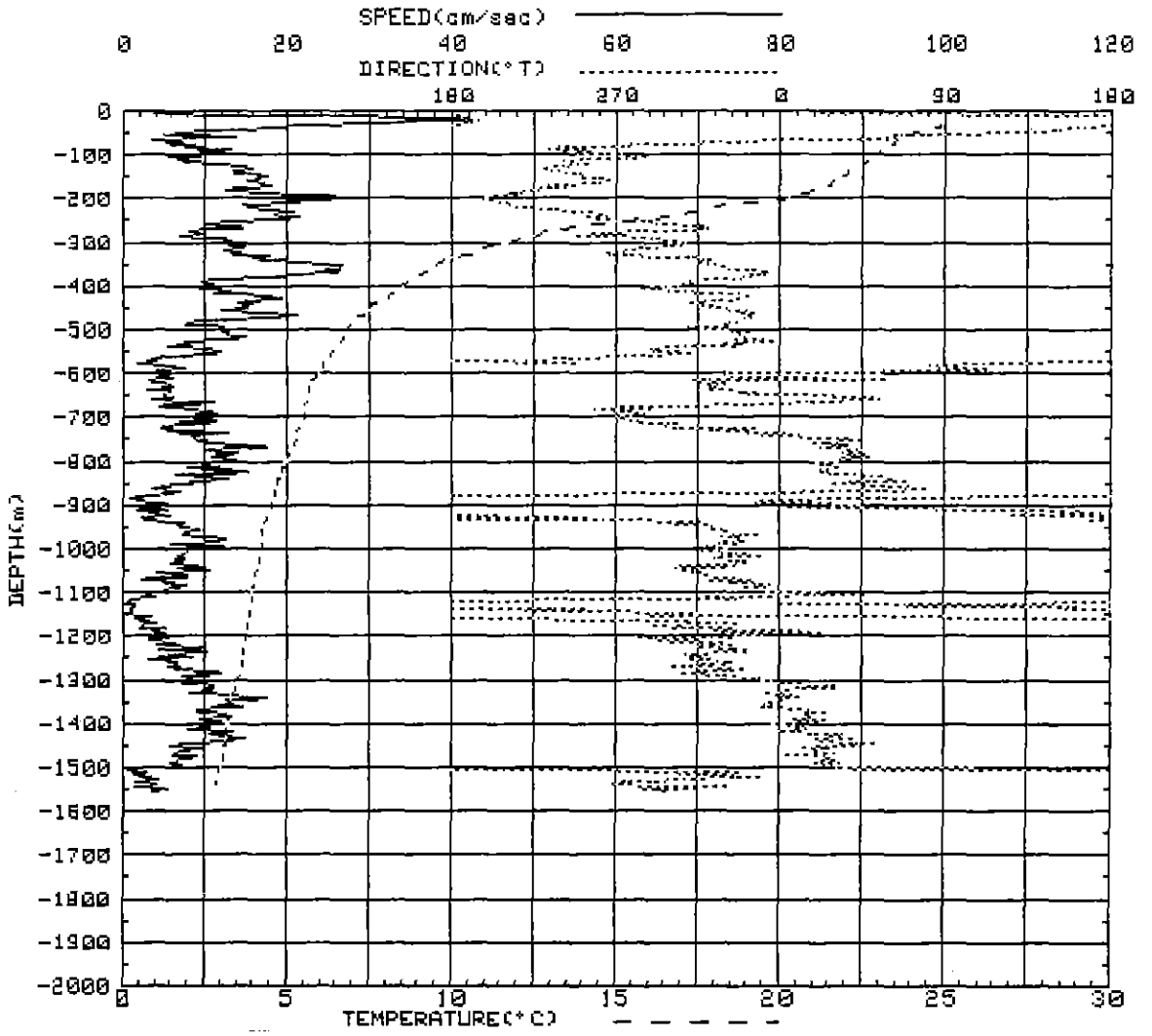
SURVEY DATE: JULY 1, 1985 DROP TIME: 1409



LATITUDE: 20°27'00"N LONGITUDE: 156°00'30"W

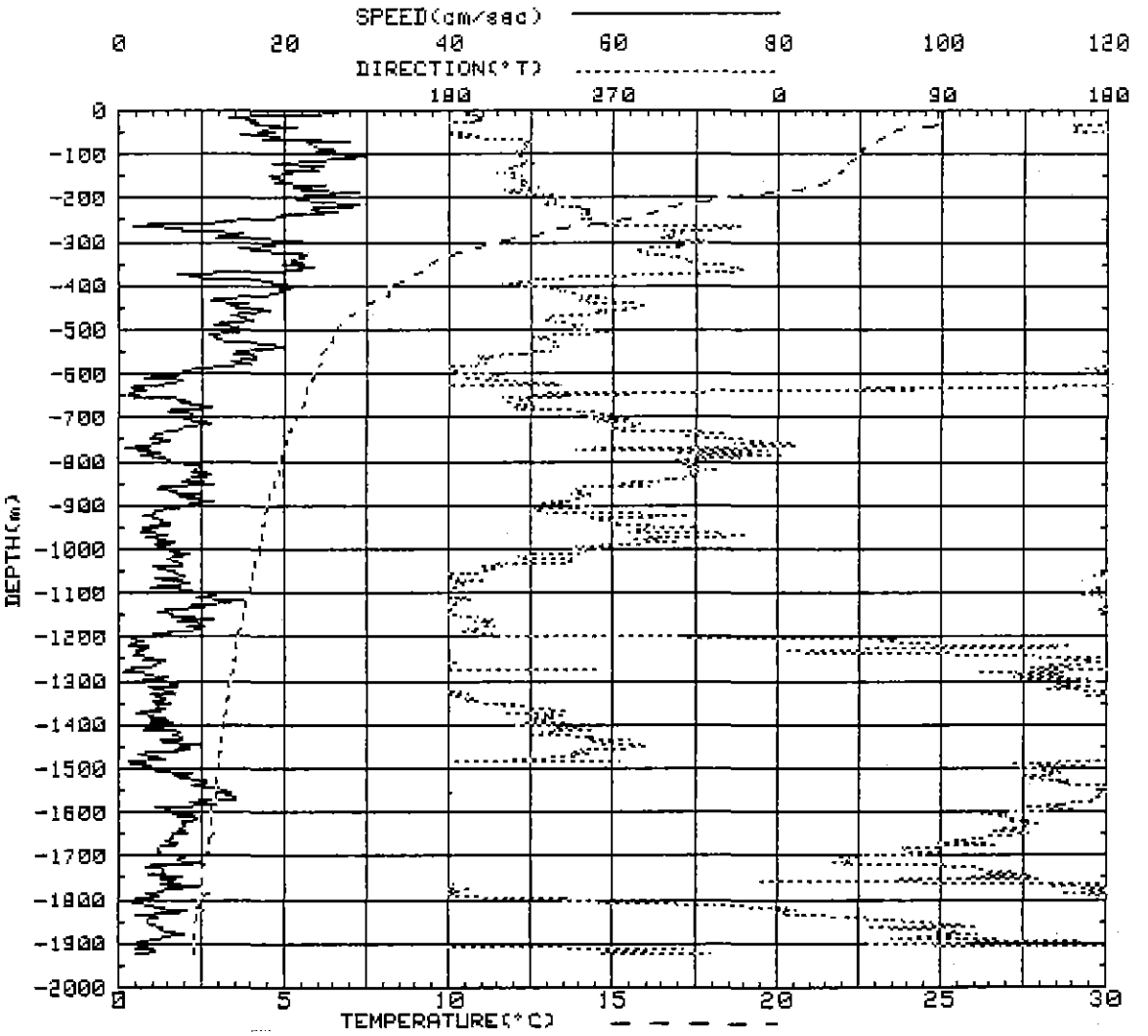
SURVEY 2 LEG 1 DROP 3

SURVEY DATE: JULY 1, 1985 DROP TIME: 1422



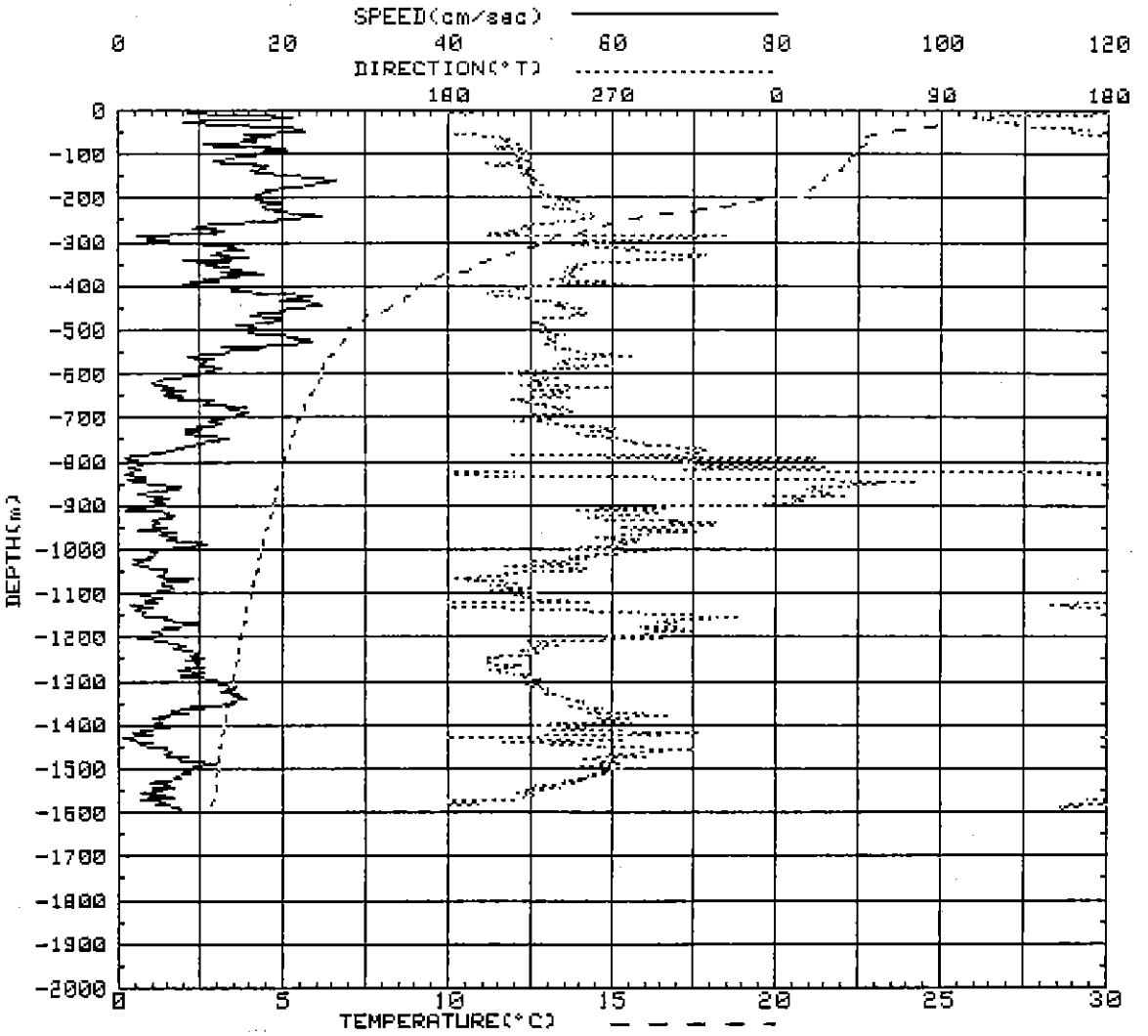
LATITUDE: 20°28'45"N LONGITUDE: 156°01'45"W
SURVEY 2 LEG 1 DROP 4

SURVEY DATE: JULY 1, 1985 DROP TIME: 1439



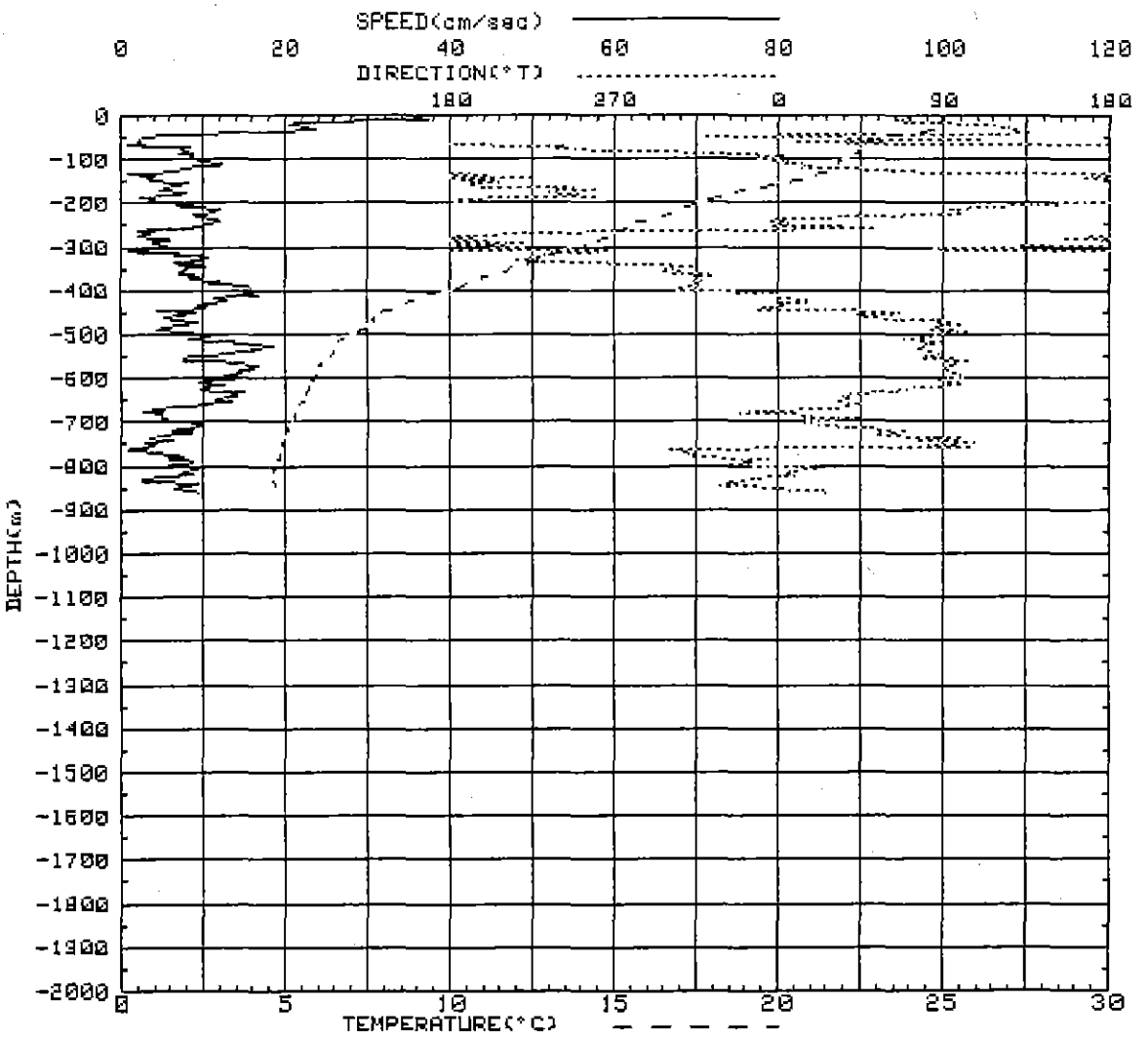
LATITUDE: 20°30'15"N LONGITUDE: 156°02'40"W
SURVEY 2 LEG 1 DROP 5'

SURVEY DATE: JULY 1, 1985 DROP TIME: 1507



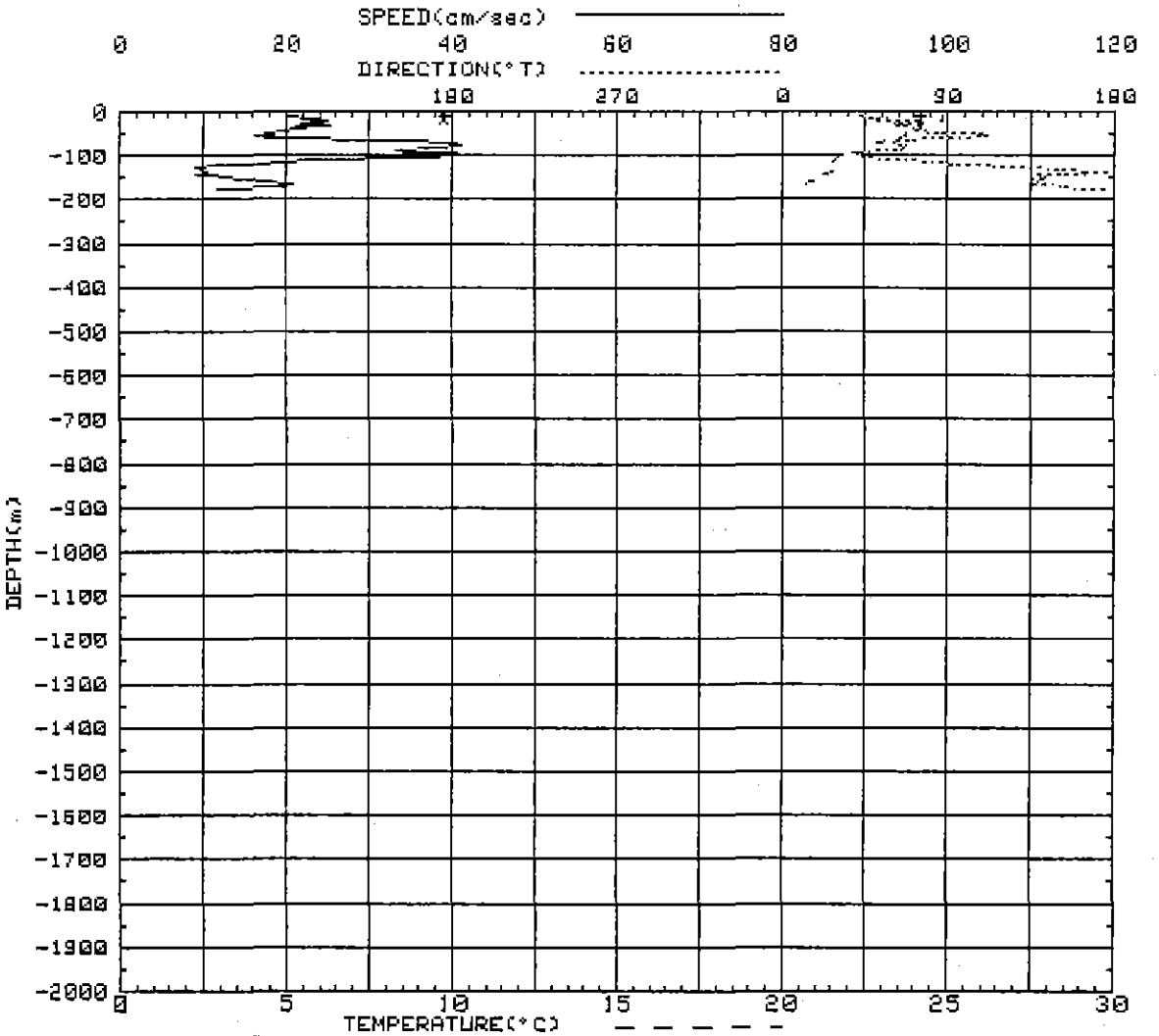
LATITUDE: 20°33'40"N LONGITUDE: 156°04'55"W
SURVEY 2 LEG 1 DROP 6

SURVEY DATE: JULY 1, 1985 DROP TIME: 1539



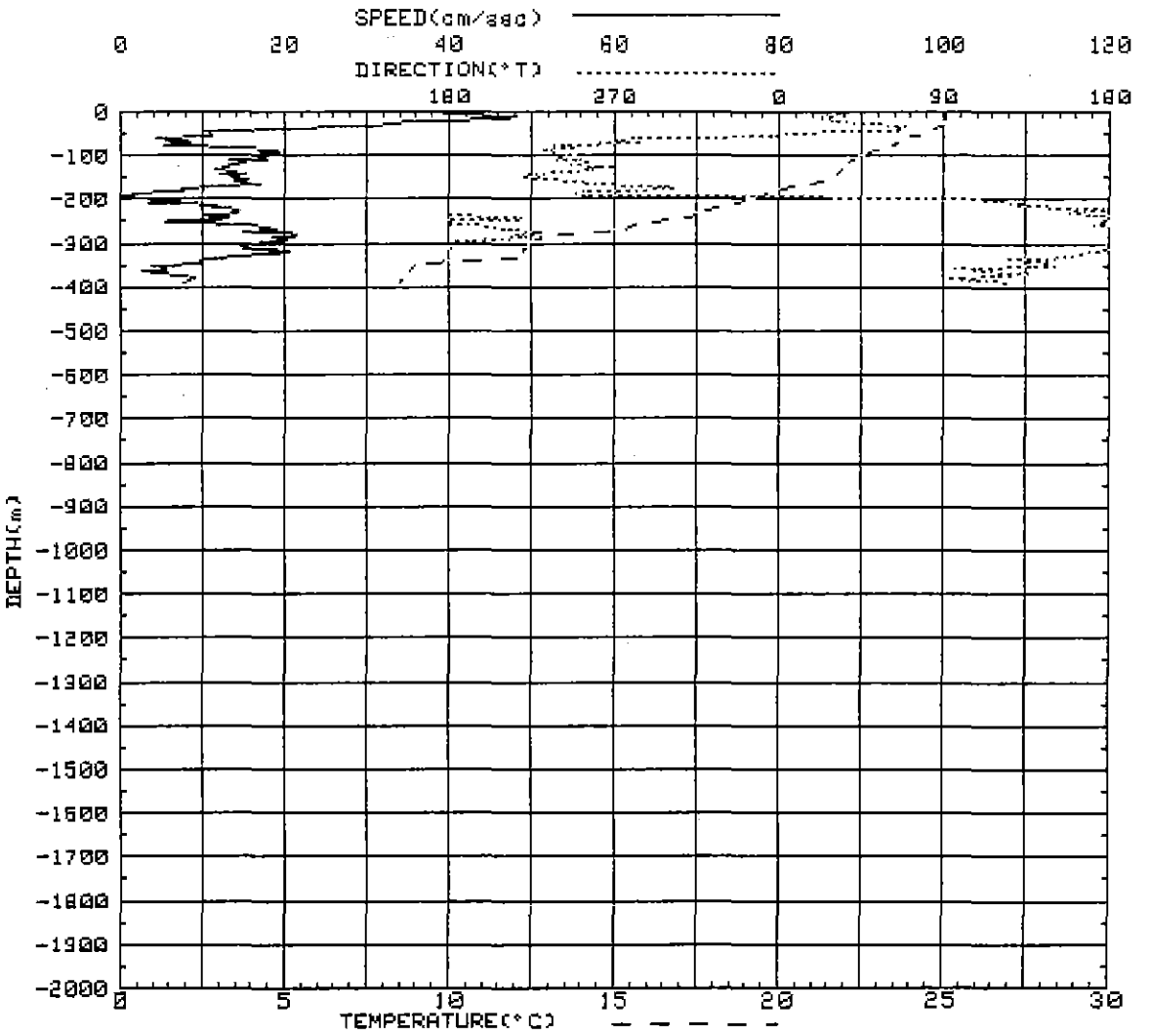
LATITUDE: 20°35'40"N LONGITUDE: 156°6 '5"N
SURVEY 2 LEG 1 DROP 7

SURVEY DATE: JULY 1, 1985 DROP TIME: 2157



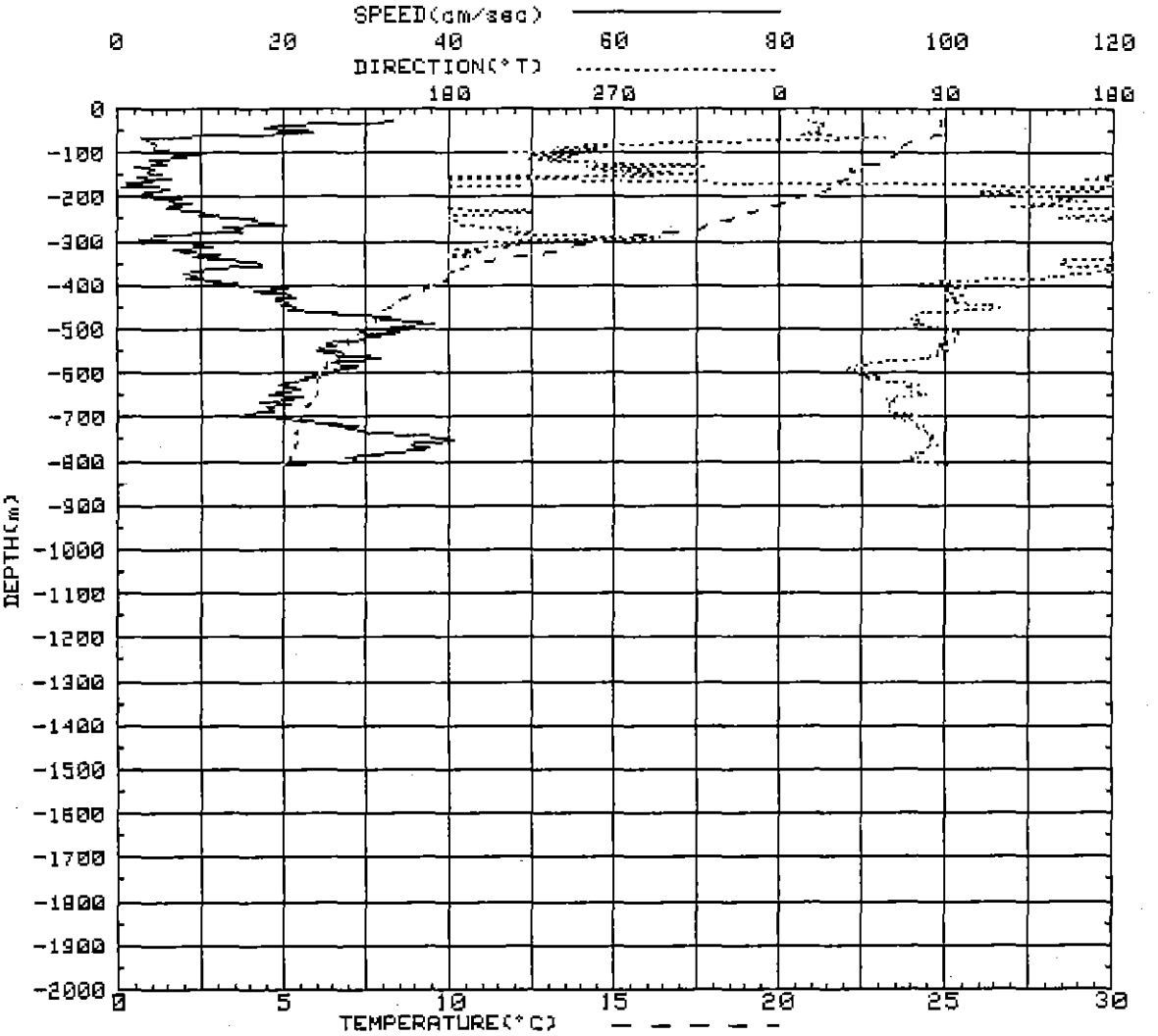
LATITUDE: 20°17'34"N LONGITUDE: 155°54'00"W
SURVEY 2 LEG 2 DROP 1A

SURVEY DATE: JULY 1, 1985 DROP TIME: 2128



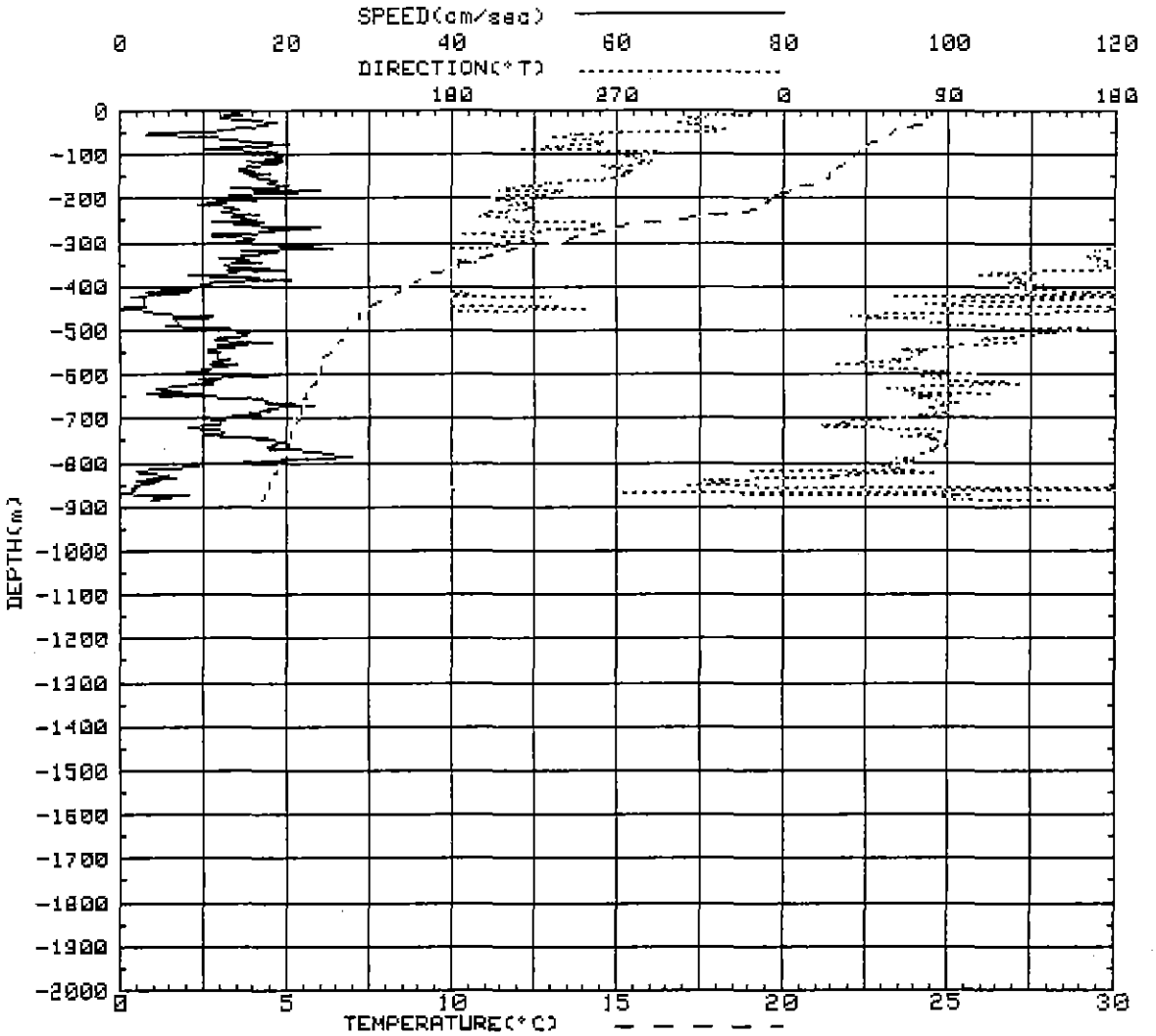
LATITUDE: 20°19'25"N LONGITUDE: 155°55'20"W
SURVEY 2 LEG 2 DROP 1.

SURVEY DATE: JULY 1, 1985 DROP TIME: 2016



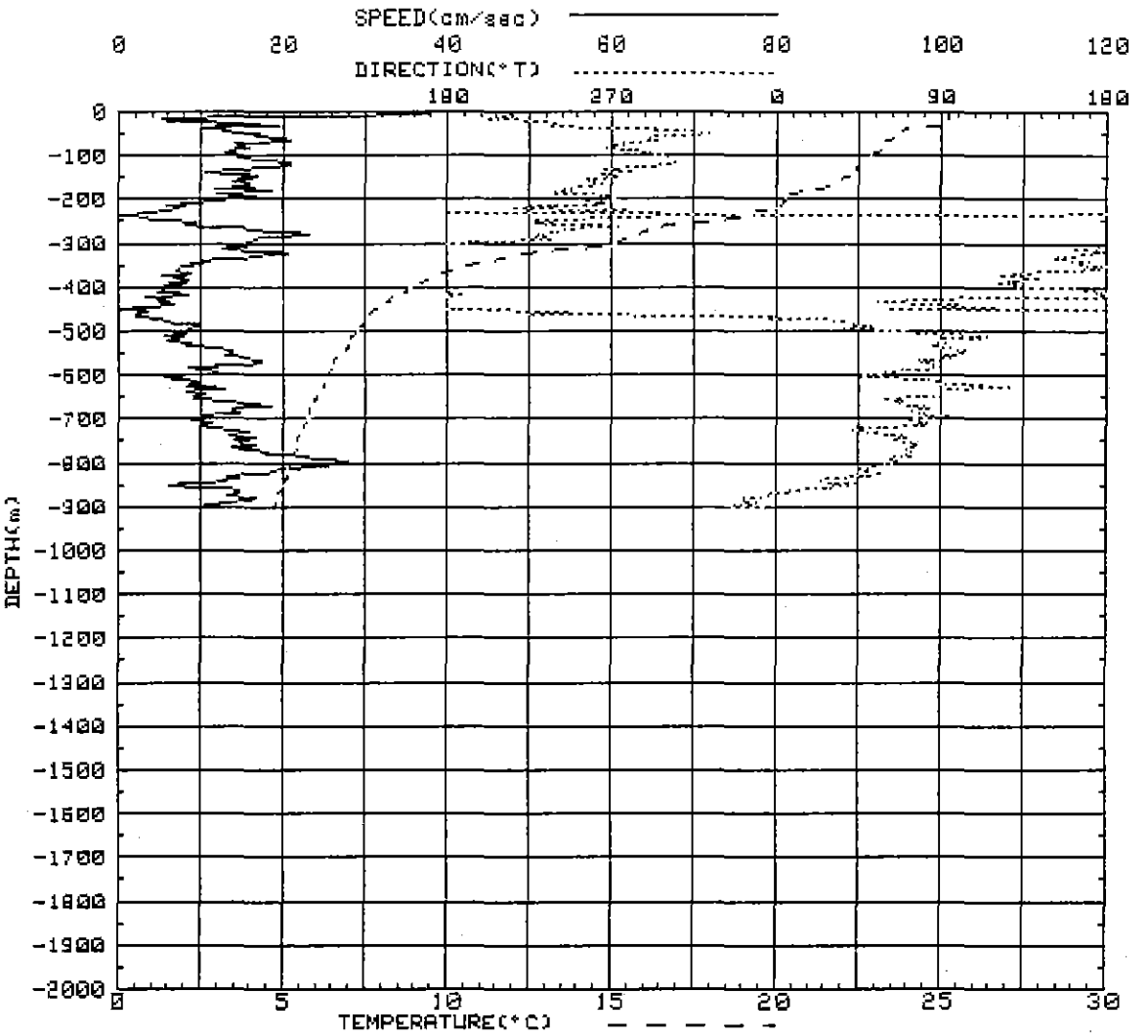
LATITUDE: 20°23'10"N LONGITUDE: 155°57'50"W
SURVEY 2 LEG 2 DROP 8

SURVEY DATE: JULY 1, 1985 DROP TIME: 1938



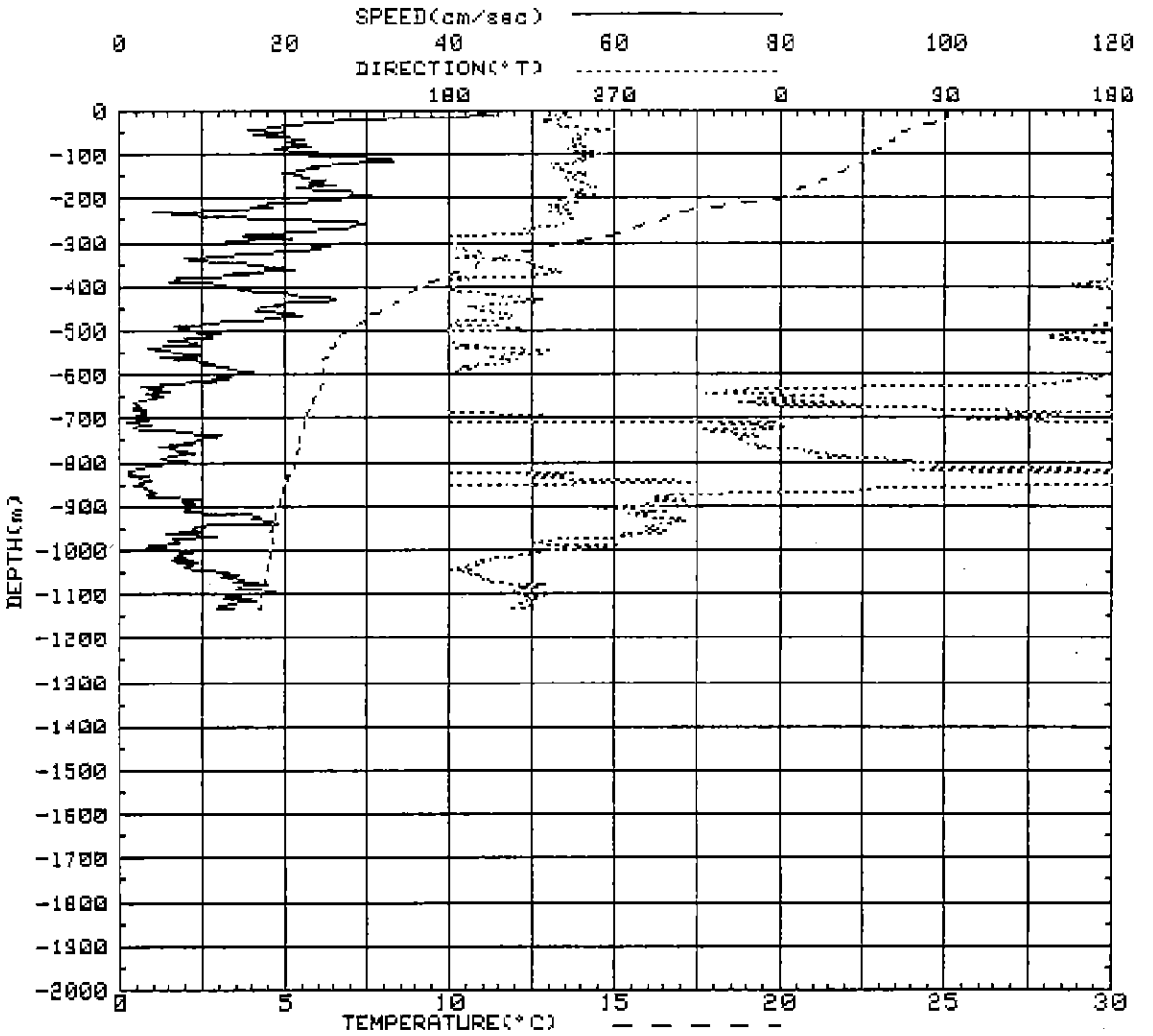
LATITUDE: 20°26'05"N LONGITUDE: 156°00'00"W
SURVEY 2 LEG 2 DROP 3A

SURVEY DATE: JULY 1, 1985 DROP TIME: 1925



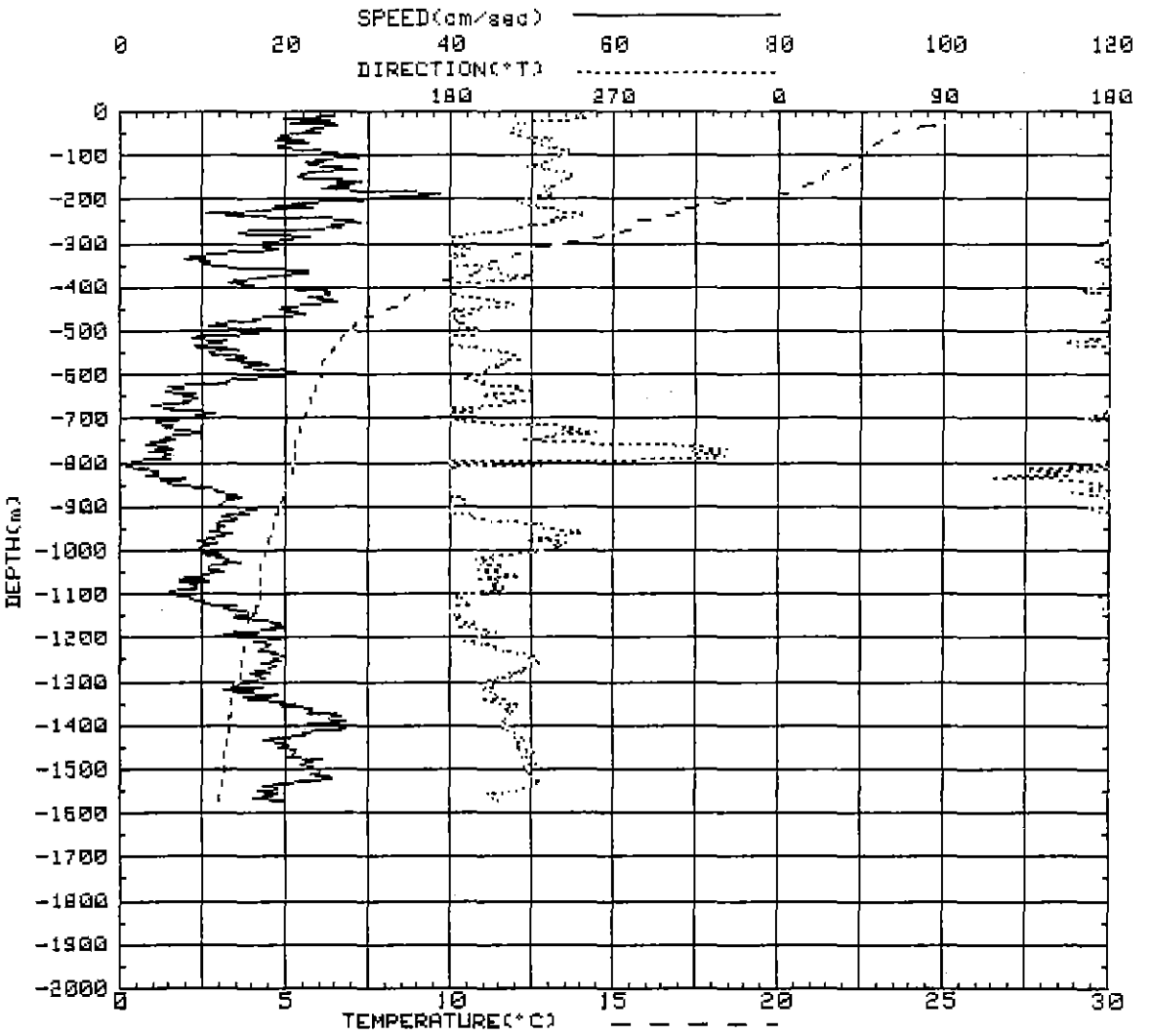
LATITUDE: 20°27'00"N LONGITUDE: 156°00'30"W
SURVEY 2 LEG 2 DROP 3

SURVEY DATE: JULY 1, 1985 DROP TIME: 1905



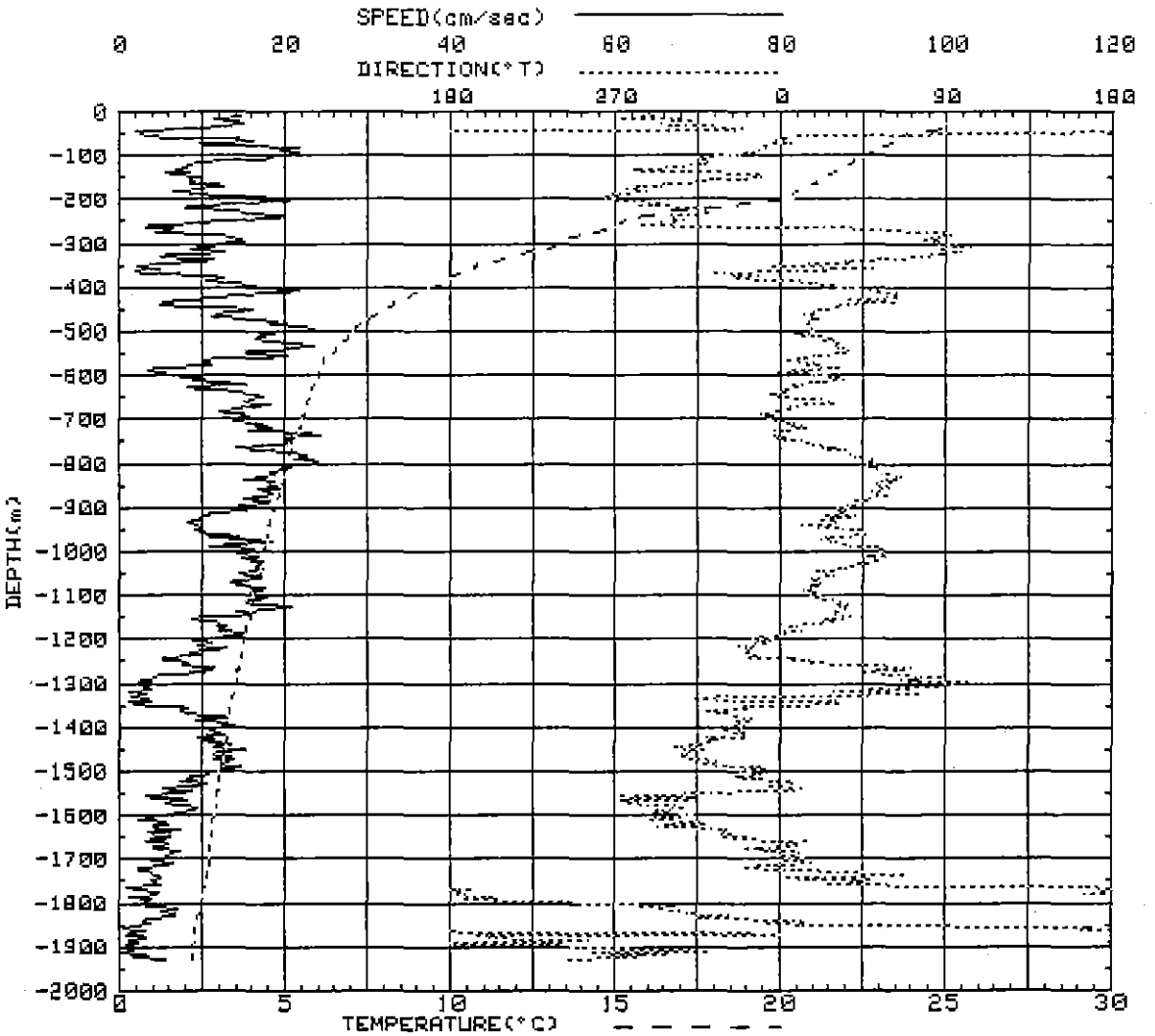
LATITUDE: 20°28'45"N LONGITUDE: 156°01'35"W
SURVEY 2 LEG 2 DROP 4

SURVEY DATE: JULY 1, 1985 DROP TIME: 1846



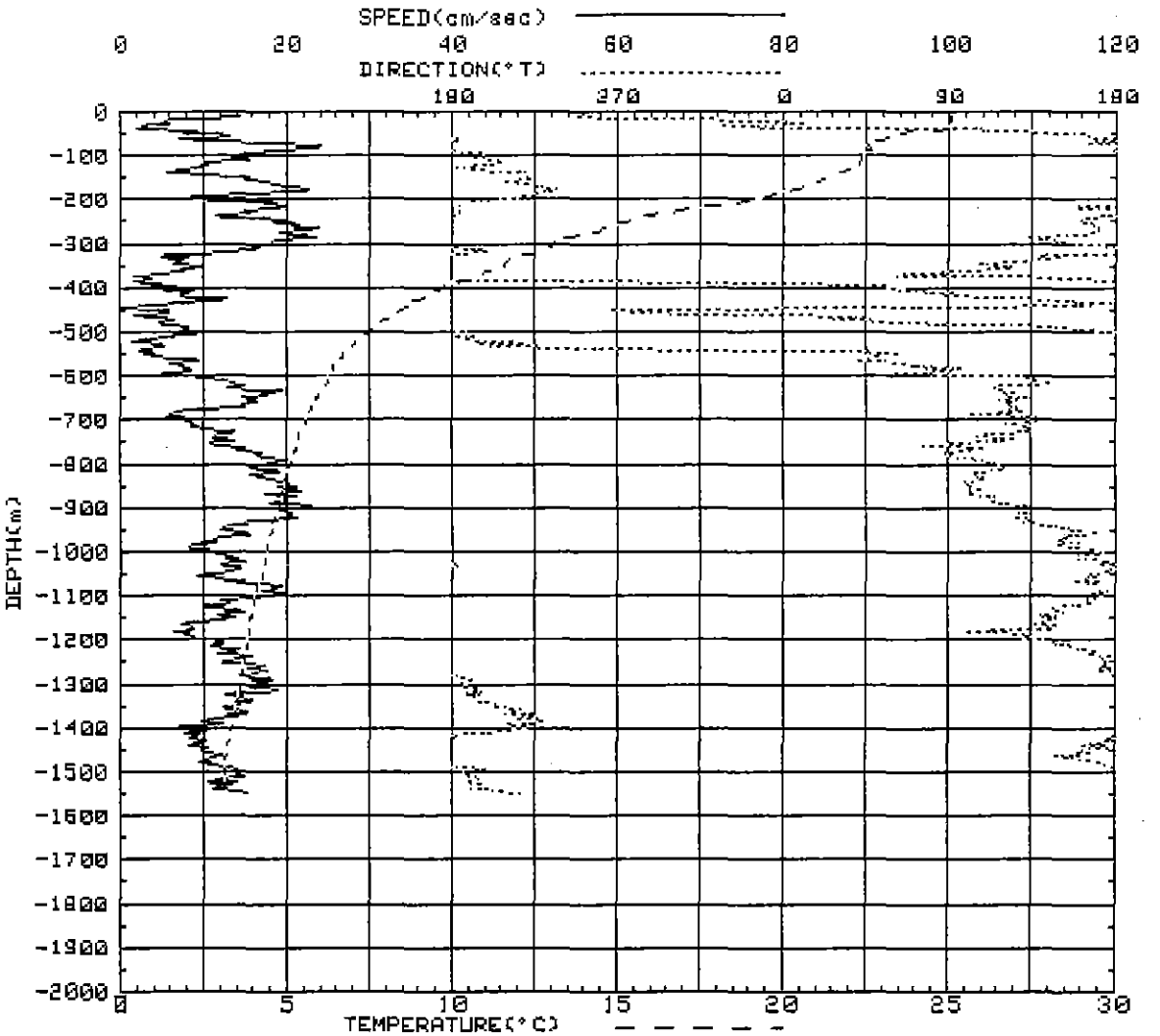
LATITUDE: 20°29'15"N LONGITUDE: 156°02'00"W
SURVEY 2 LEG 2 DROP 5A

SURVEY DATE: JULY 1, 1985 DROP TIME: 1828



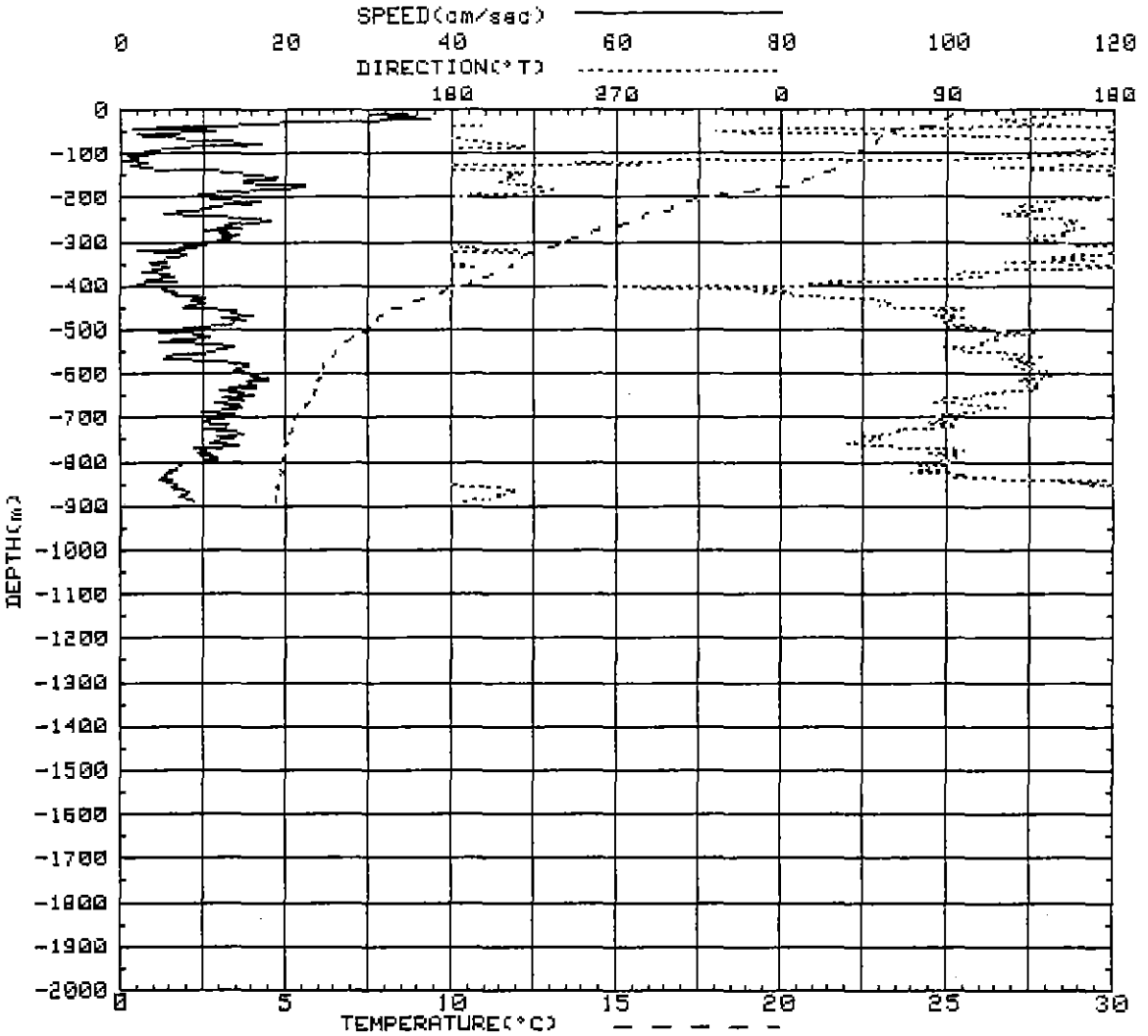
LATITUDE: 20°30'15"N LONGITUDE: 156°02'40"W
SURVEY 2 LEG 2 DROP 5

SURVEY DATE: JULY 1, 1985 DROP TIME: 1745



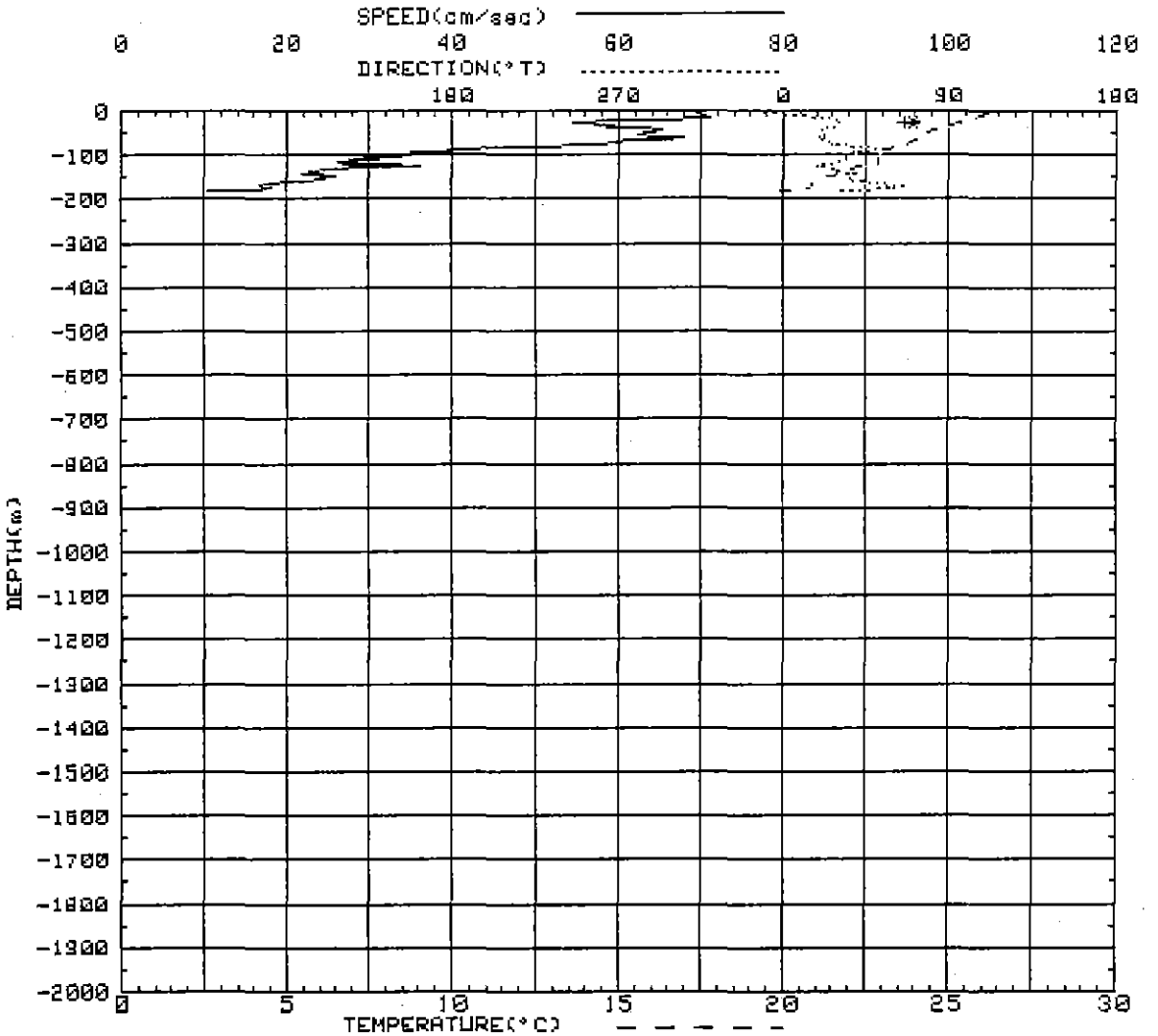
LATITUDE: 20°33'40"N LONGITUDE: 156°04'55"W
SURVEY 2 LEG 2 DROP 6

SURVEY DATE: JULY 1, 1985 DROP TIME: 1712



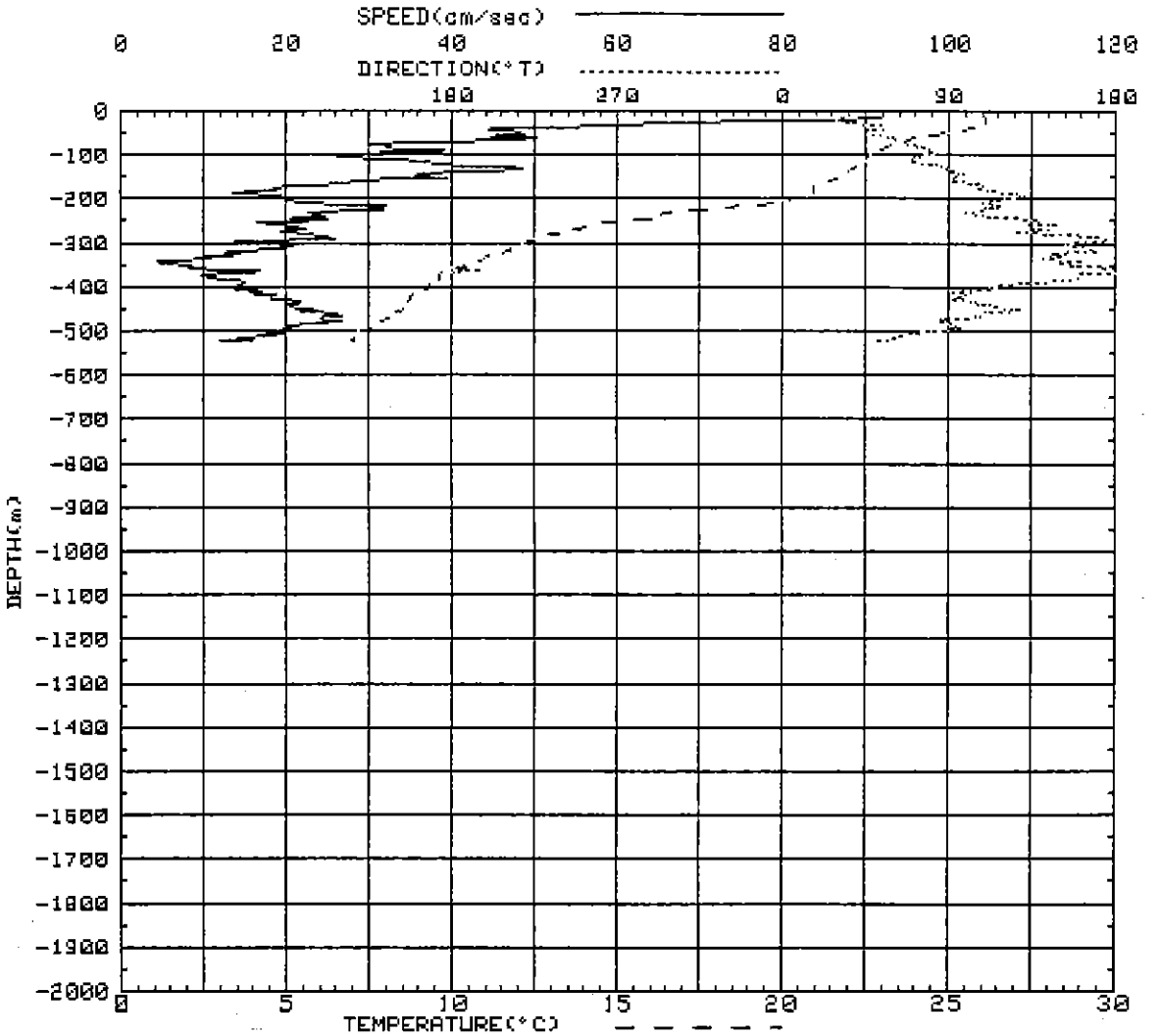
LATITUDE: 20°35'40"N LONGITUDE: 156°06'15"W
SURVEY 2 LEG 2 DROP 7.

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 0806



LATITUDE: 20°17'34"N LONGITUDE: 155°54'00"W
SURVEY 3 LEG 1 DROP 1-A

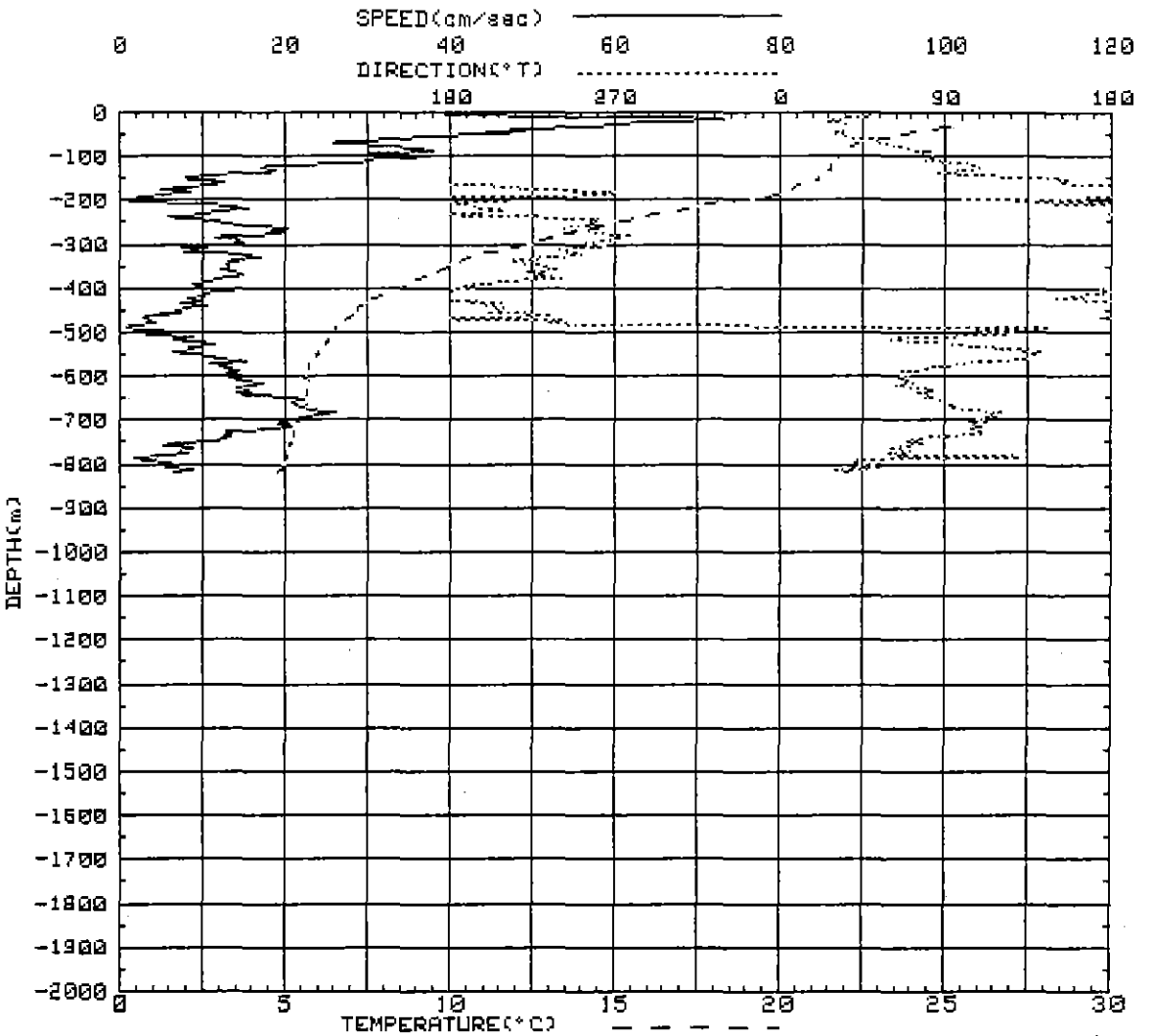
SURVEY DATE: AUGUST 28, 1985 DROP TIME: 0835



LATITUDE: 20°19'25"N LONGITUDE: 155°55'20"W

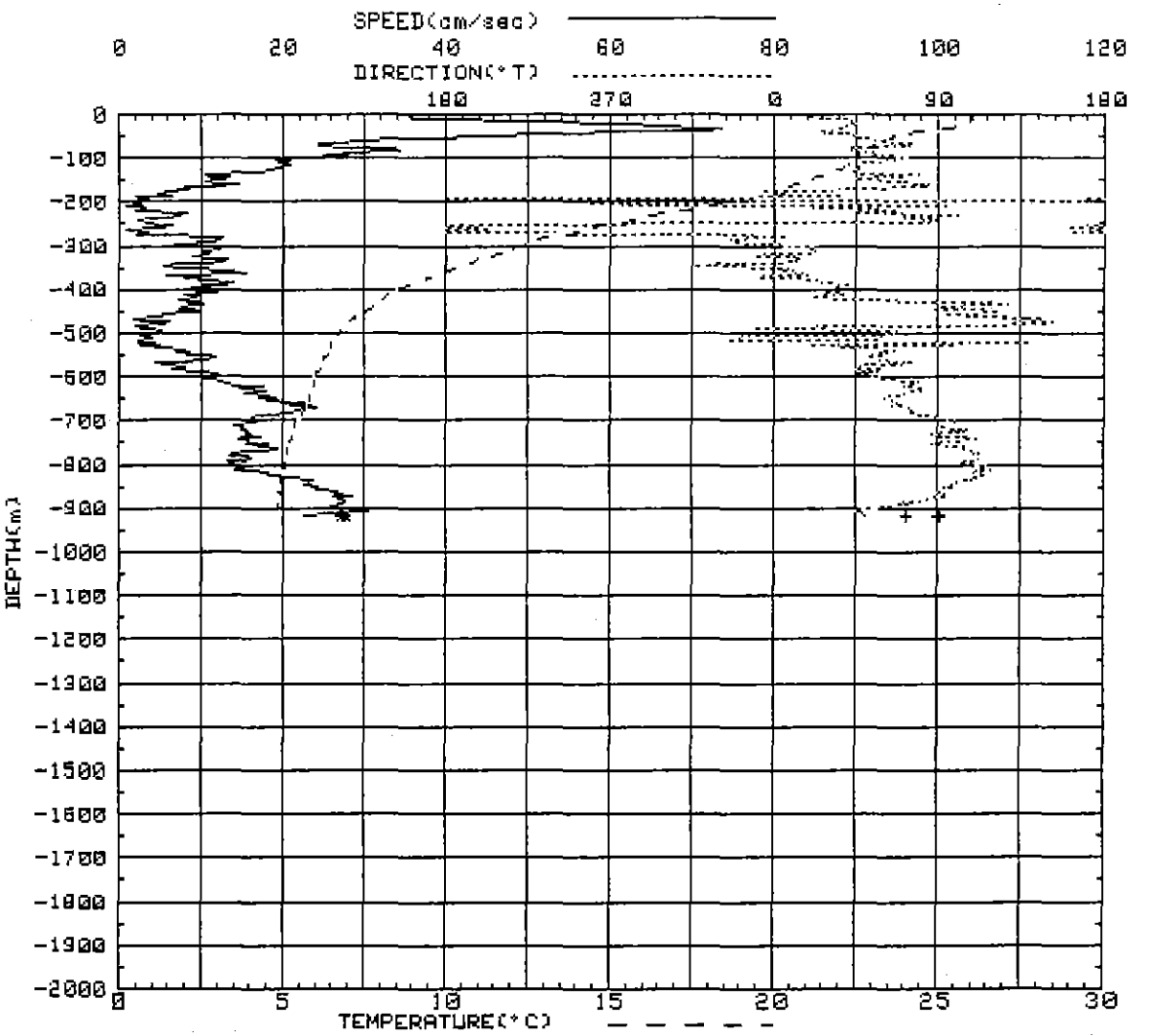
SURVEY 3 LEG 1 DROP 1

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 0900



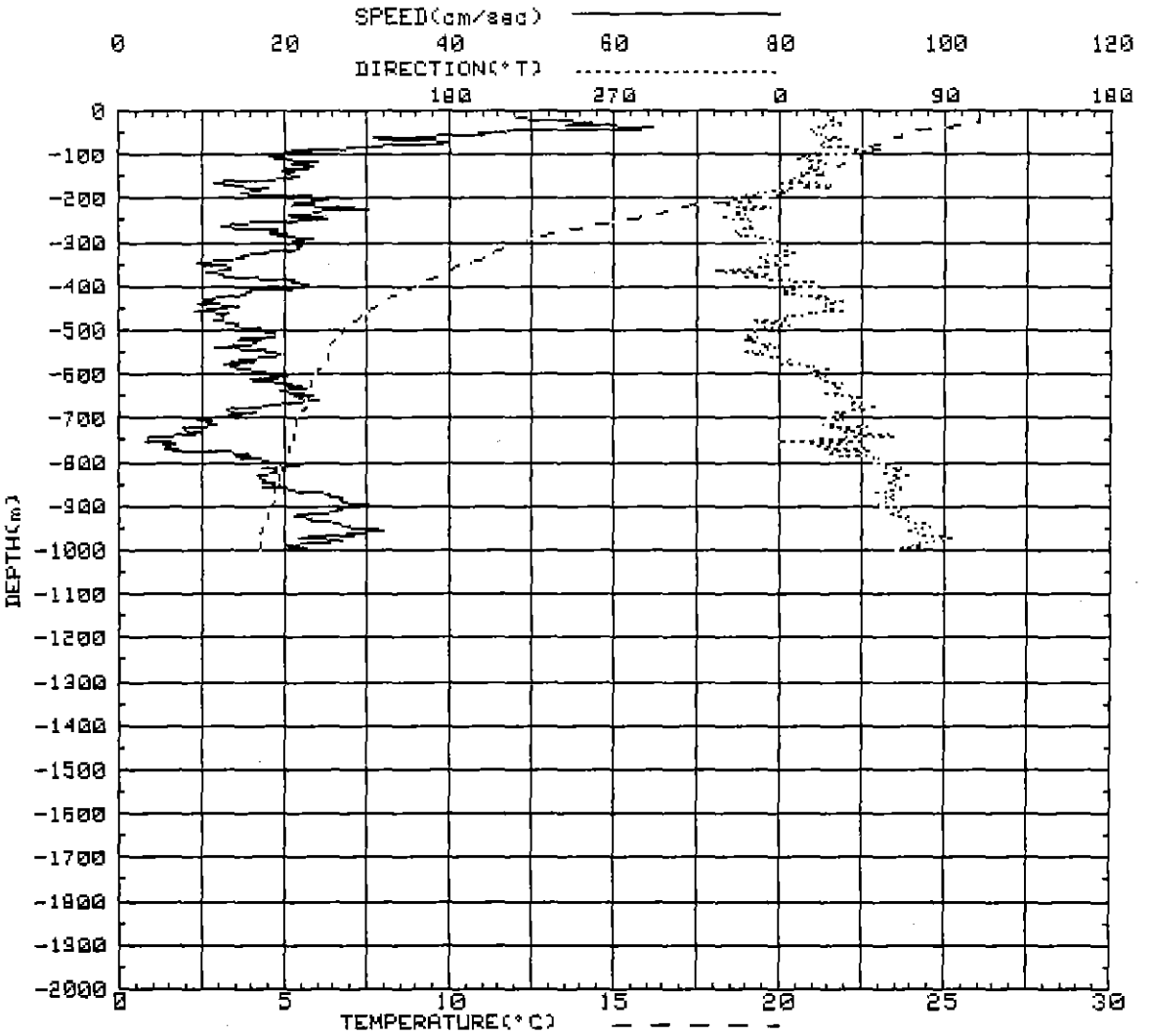
LATITUDE: 20°23'10"N LONGITUDE: 155°57'50"W
SURVEY 3 LEG 1 DROP 2

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 0930



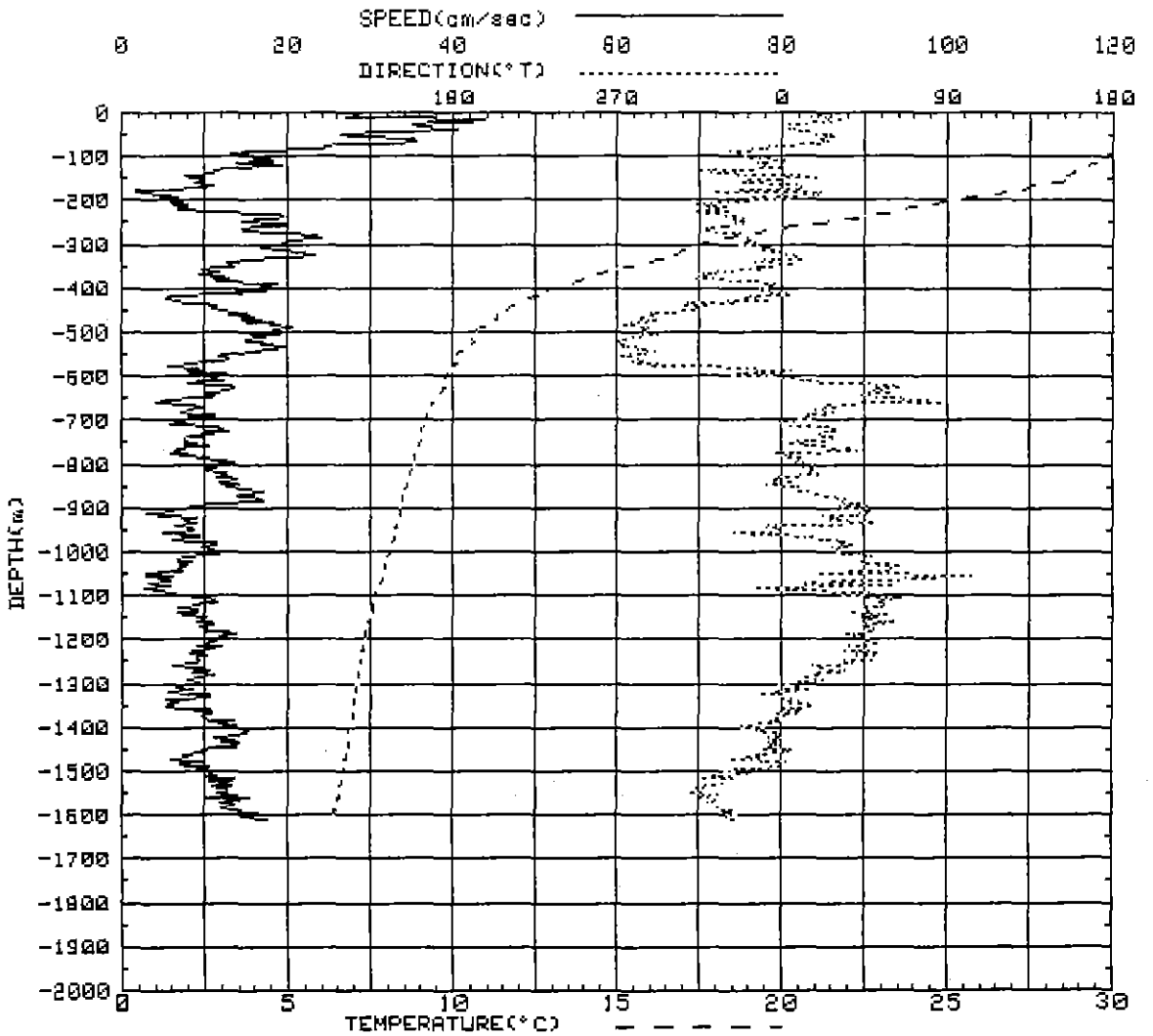
LATITUDE: 20°26'05"N LONGITUDE: 156°00'00"W
SURVEY 3 LEG 1 DROP 3A

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 0950



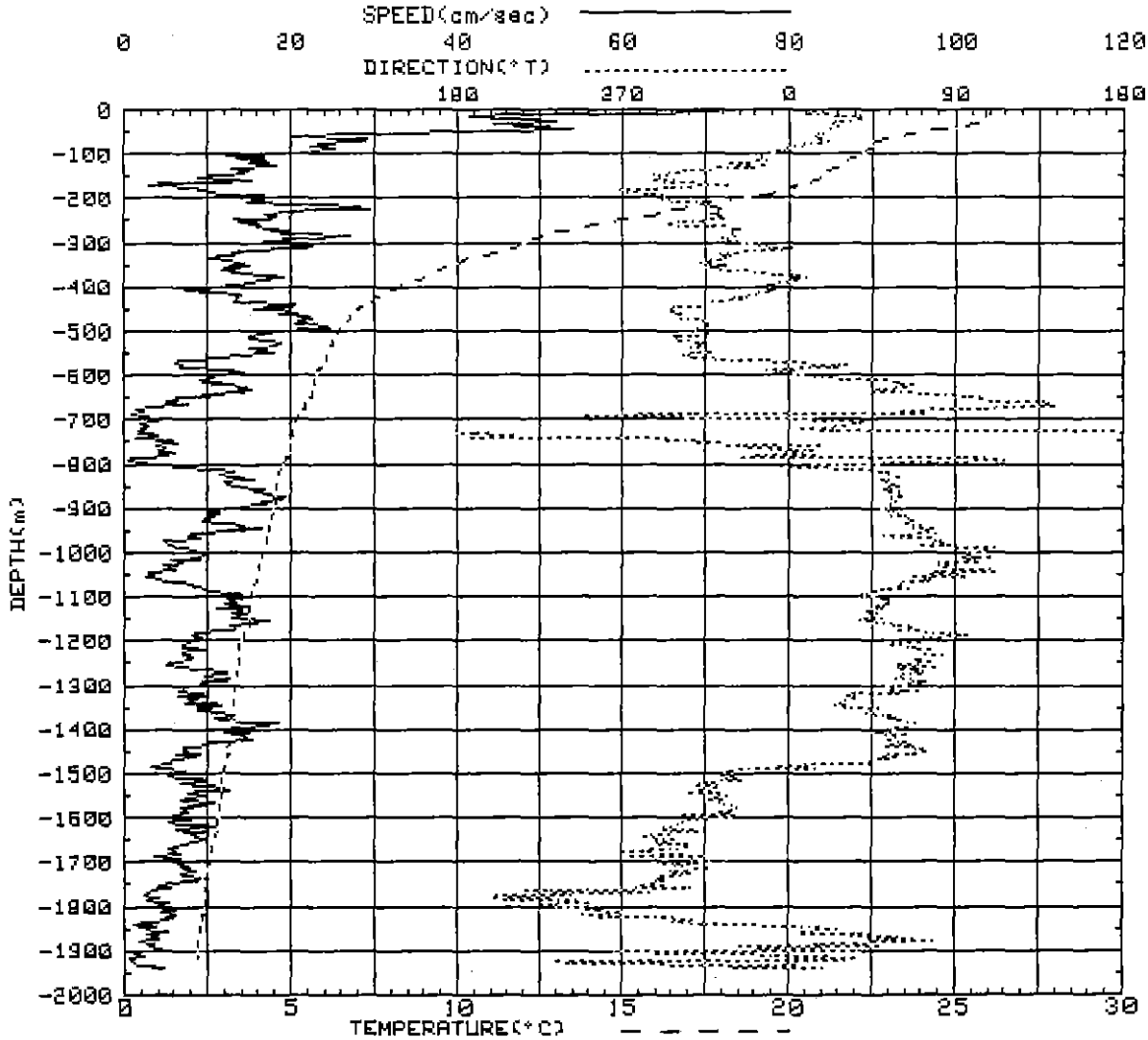
LATITUDE: 20°27'00"N LONGITUDE: 156°00'30"W
SURVEY 3 LEG 1 DROP 3

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1016



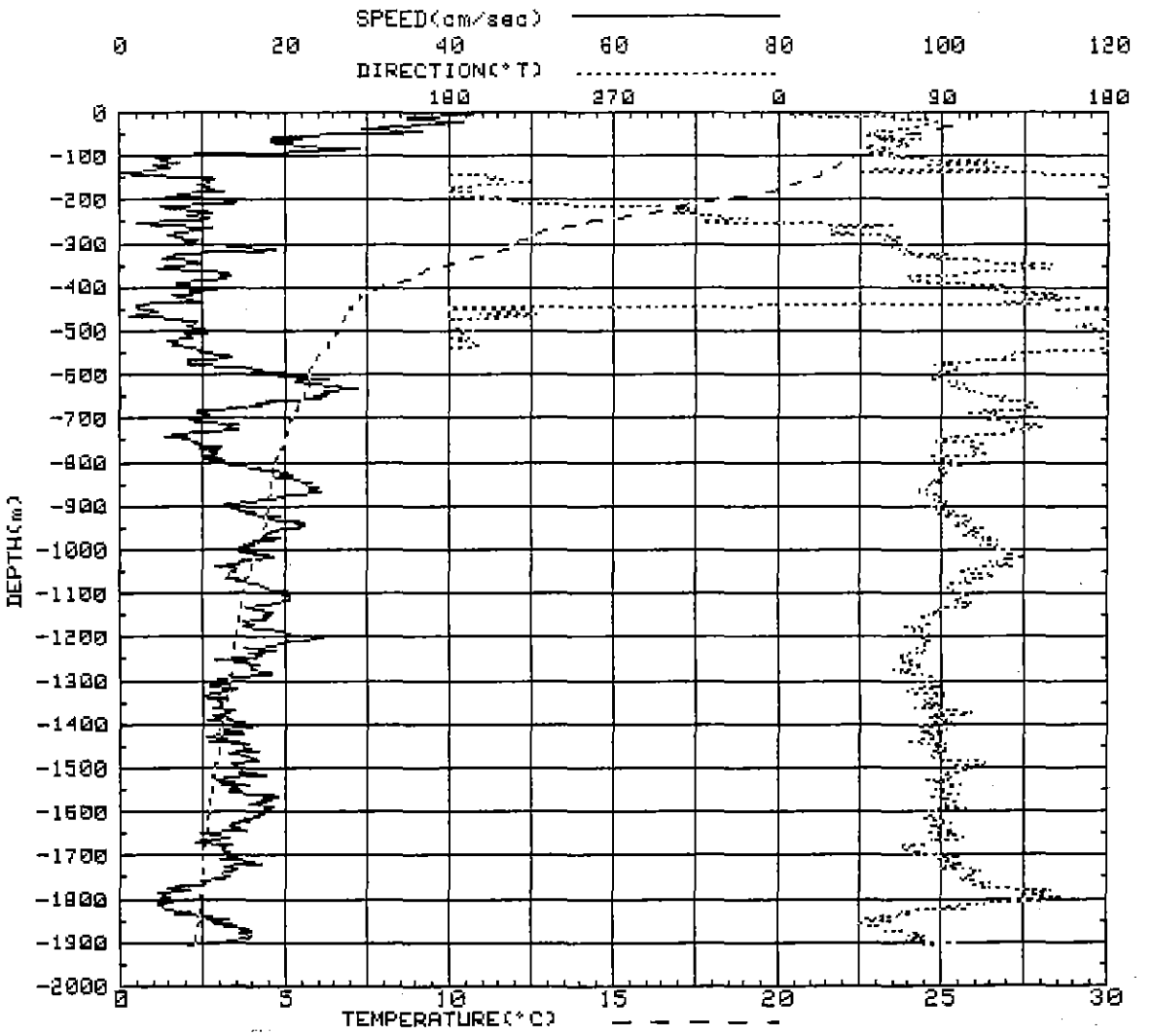
LATITUDE: 20°28'45"N LONGITUDE: 156°01'45"W
SURVEY 3 LEG 1 DROP 4

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1058



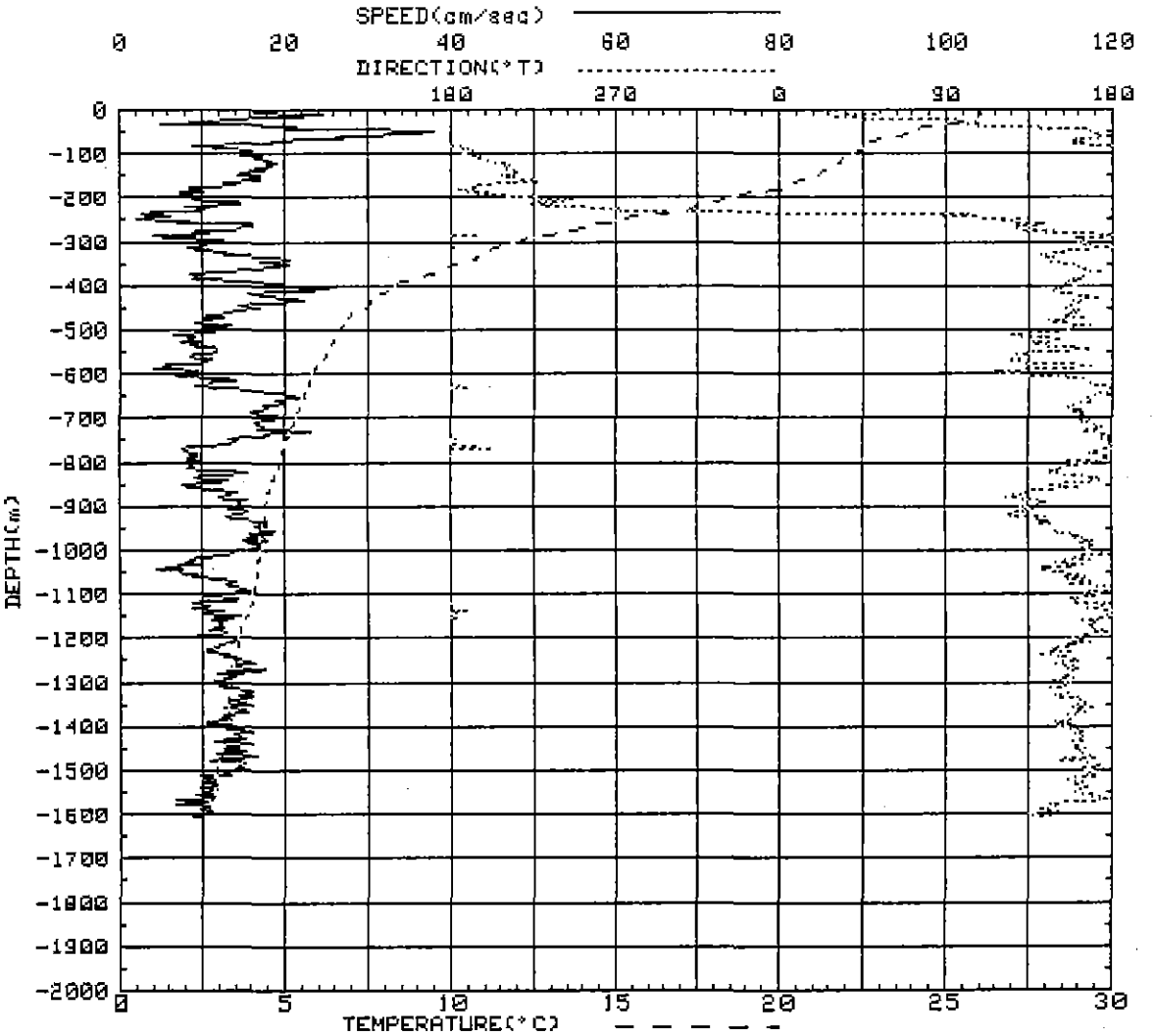
LATITUDE: 20°29'25"N LONGITUDE: 156°02'07"W
SURVEY 3 LEG 1 DROP 5A

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1149



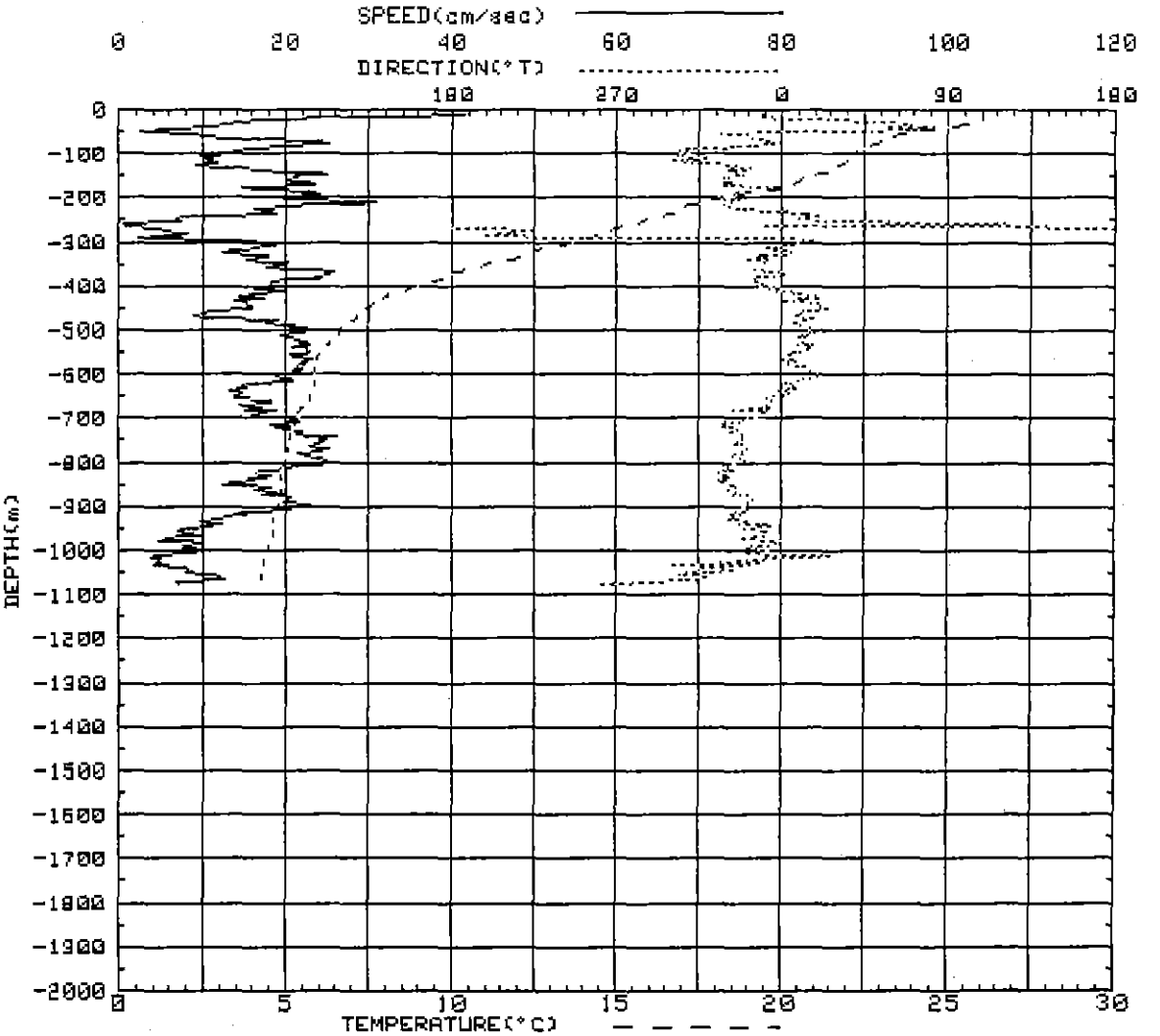
LATITUDE: 20°30'15"N LONGITUDE: 156°02'40"W
SURVEY 3 LEG 1 DROP 5

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1250



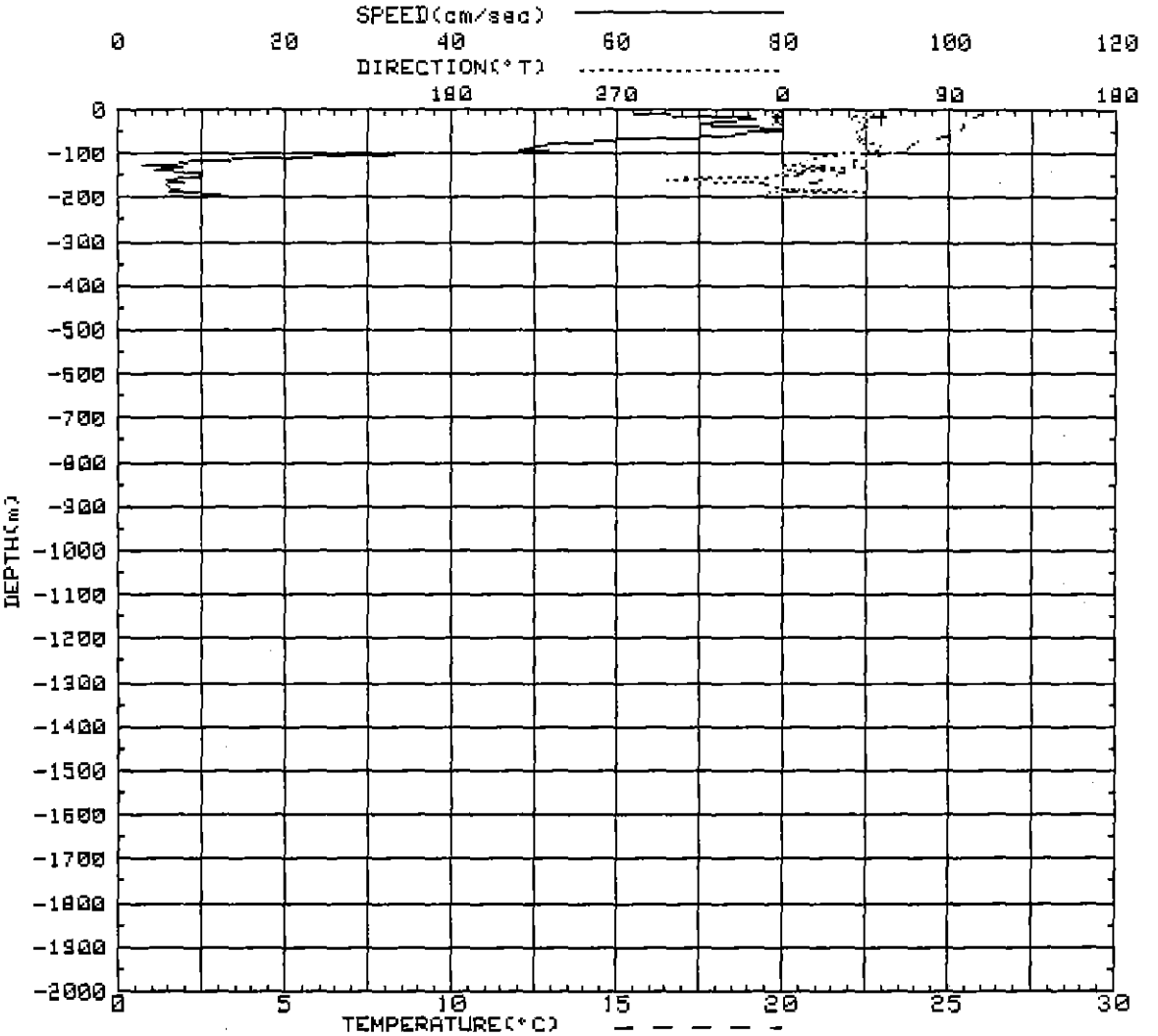
LATITUDE: 20°33'40"N LONGITUDE: 156°04'55"W
SURVEY 3 LEG 1 DROP 6'

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1339



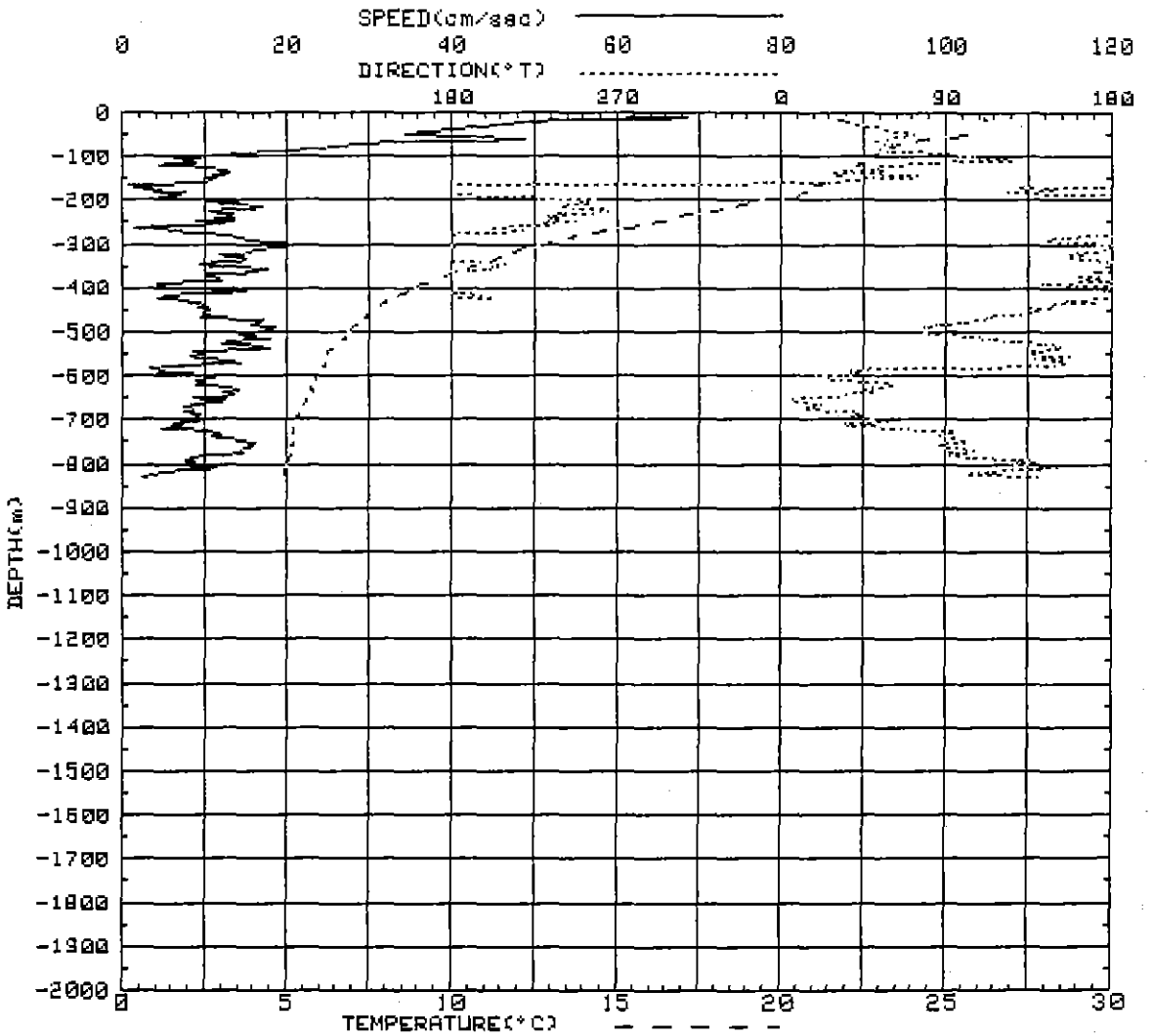
LATITUDE: 20°35'40"N LONGITUDE: 156°06'15"W
SURVEY 3 LEG 1 DROP 7

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 2023



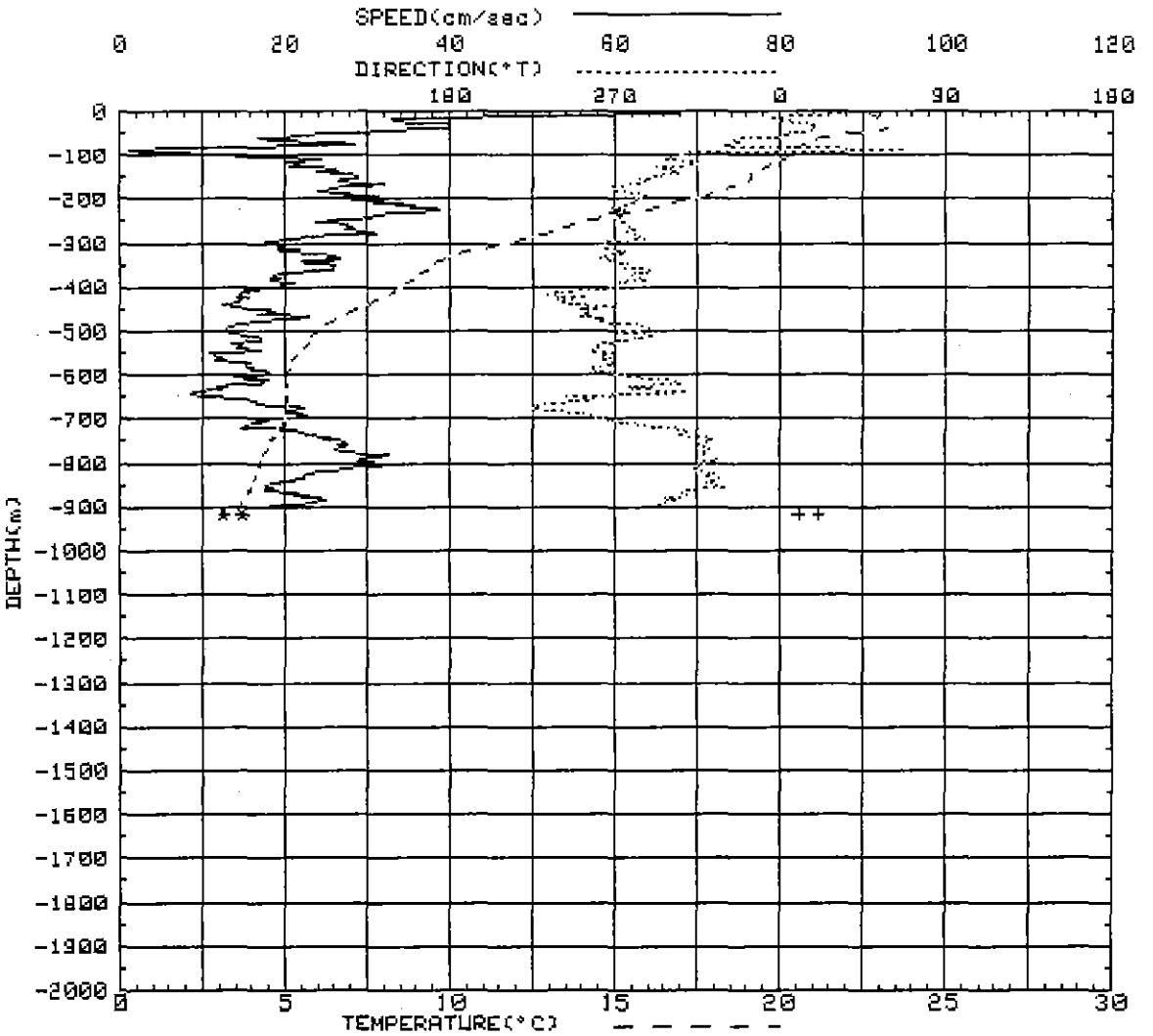
LATITUDE: 20°17'34"N LONGITUDE: 155°54'00"W
SURVEY 3 LEG 2 DROP 1A

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1917



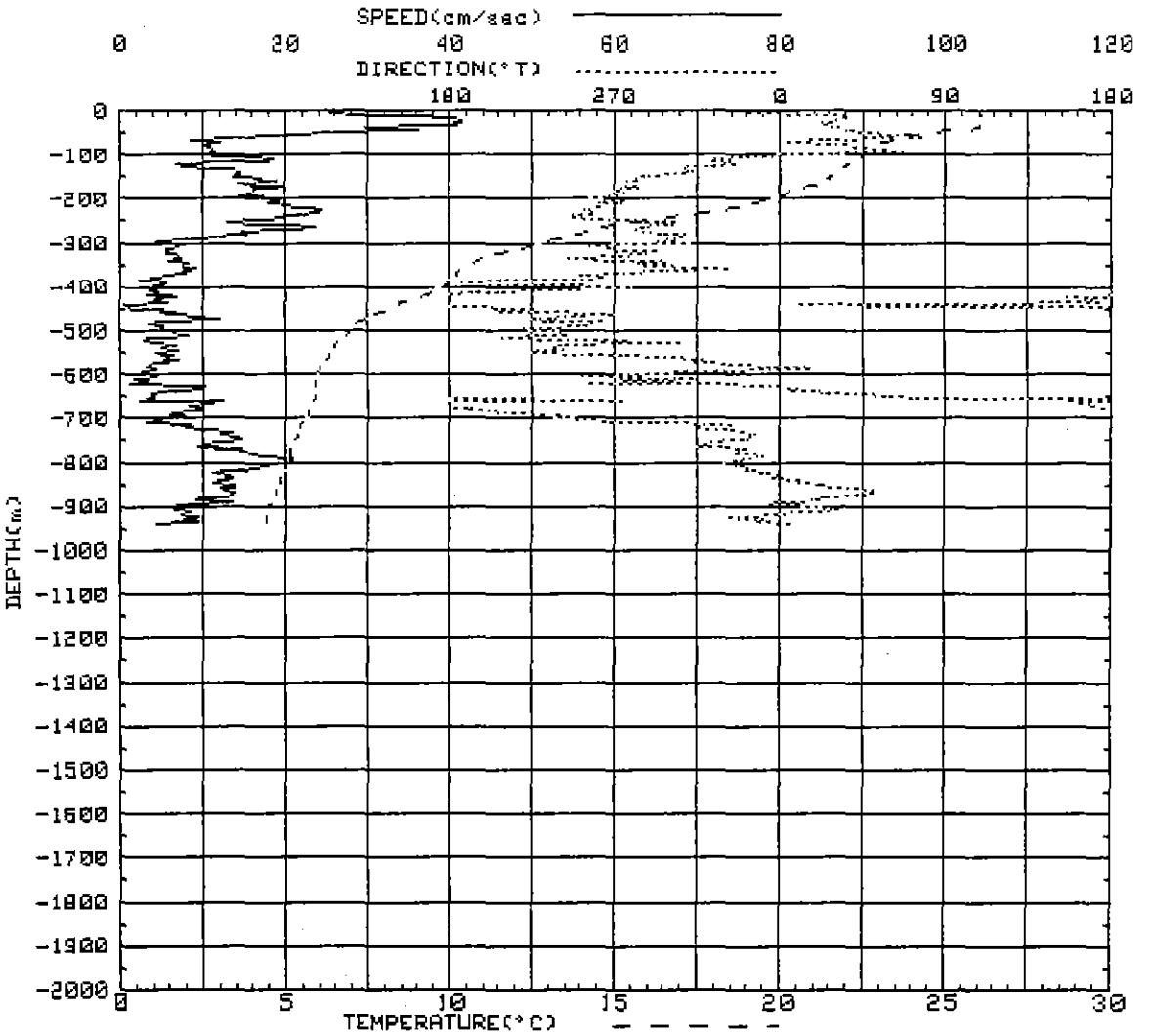
LATITUDE: 20°23'10"N LONGITUDE: 155°57'50"W
SURVEY 3 LEG 2 DROP 2

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1840



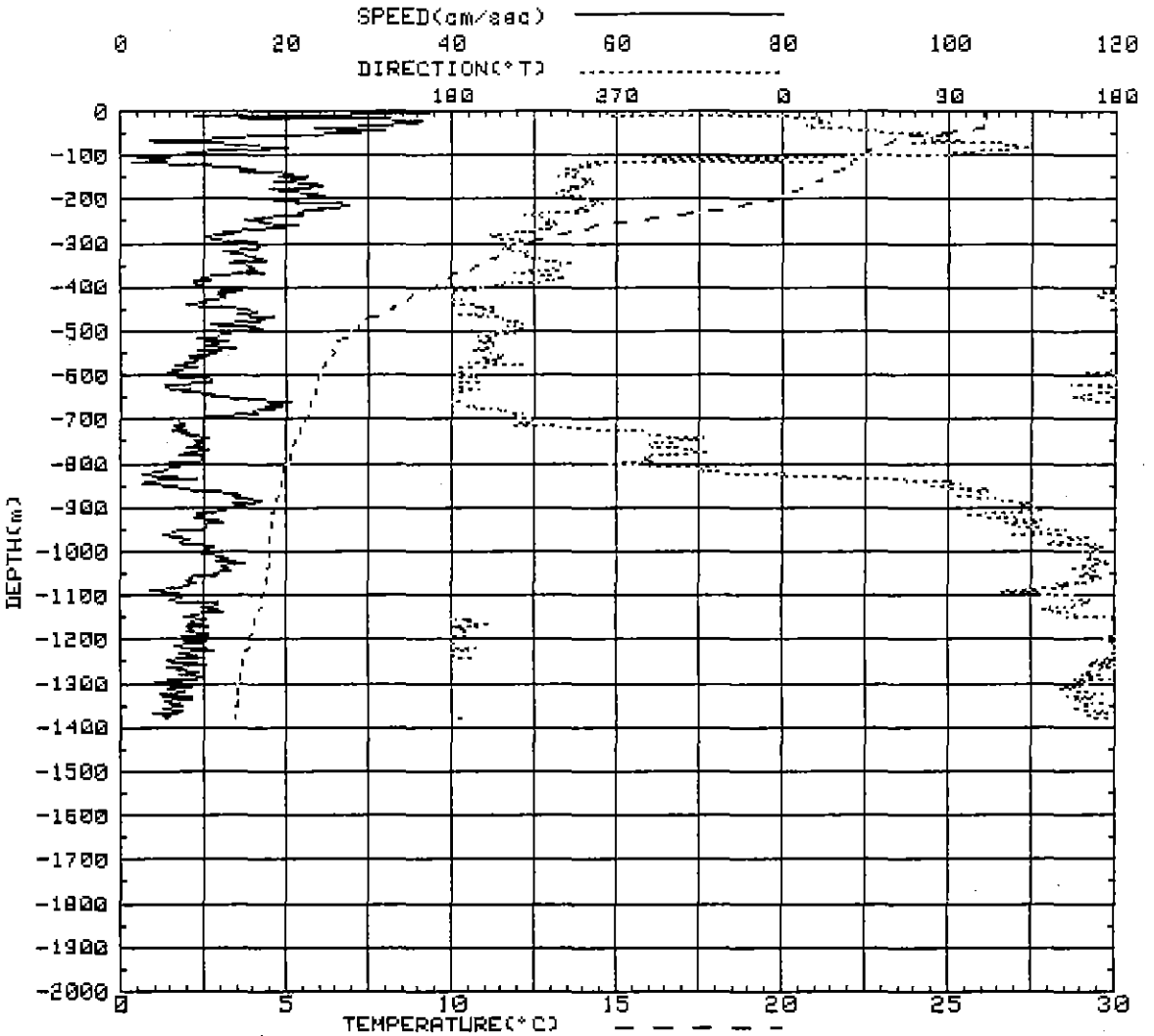
LATITUDE: 20°26'05"N LONGITUDE: 156°00'00"W
SURVEY 3 LEG 2 DROP 3A

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1821



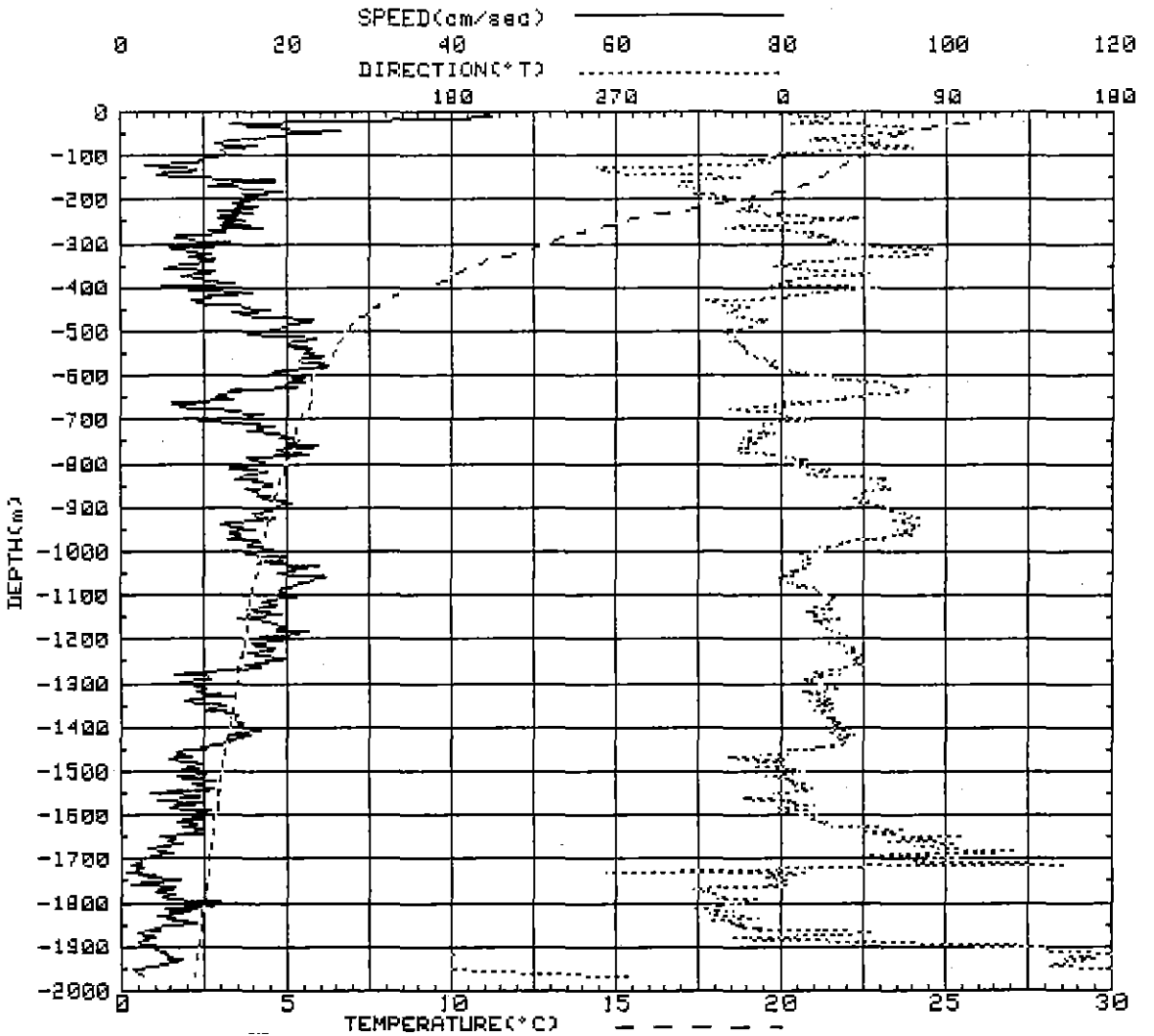
LATITUDE: 20°27'00"N LONGITUDE: 156°00'30"W
SURVEY 3 LEG 2 DROP 3.

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1809



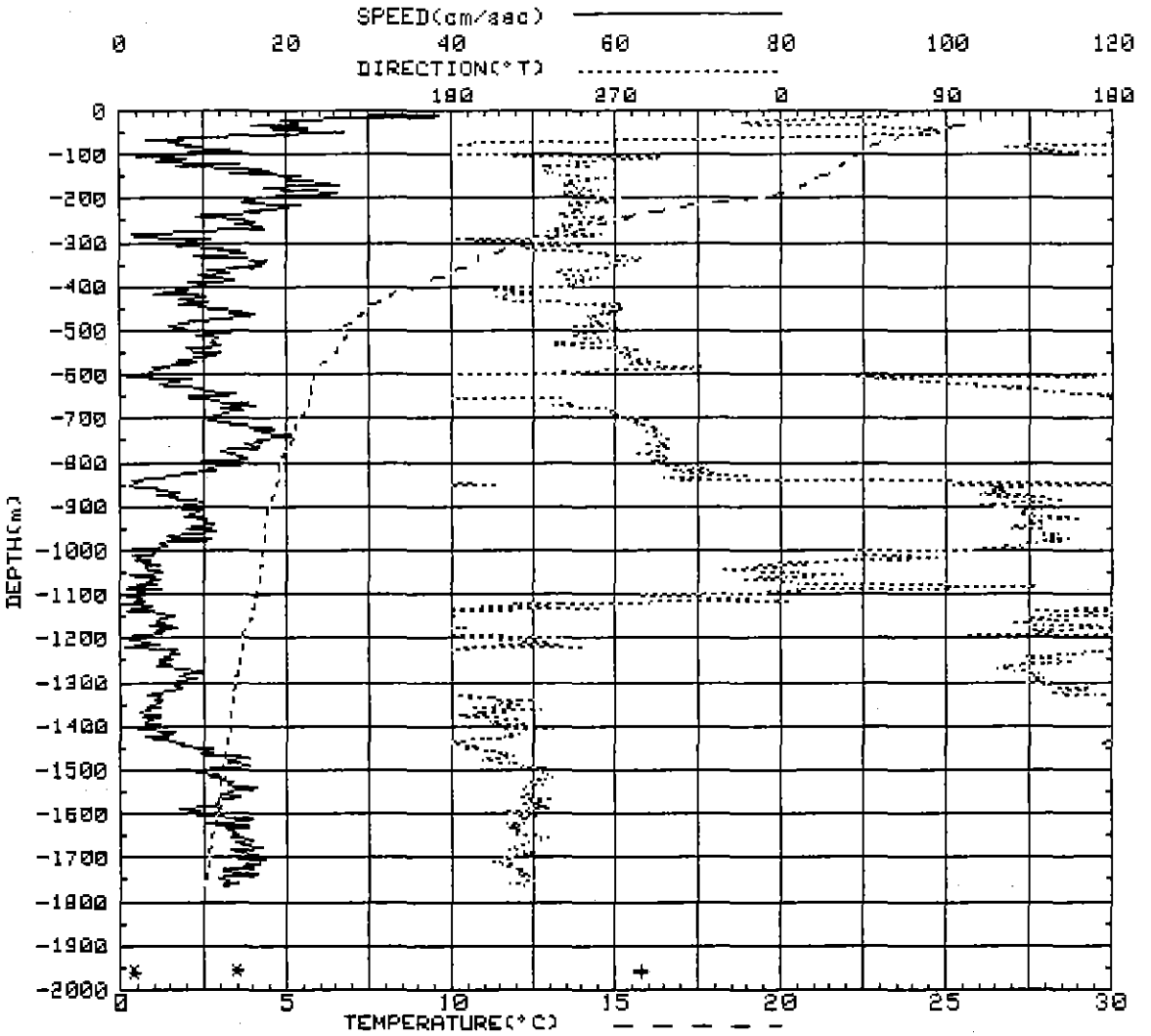
LATITUDE: 20°28'45"N LONGITUDE: 156°01'45"W
SURVEY 3 LEG 2 DROP 4

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1728



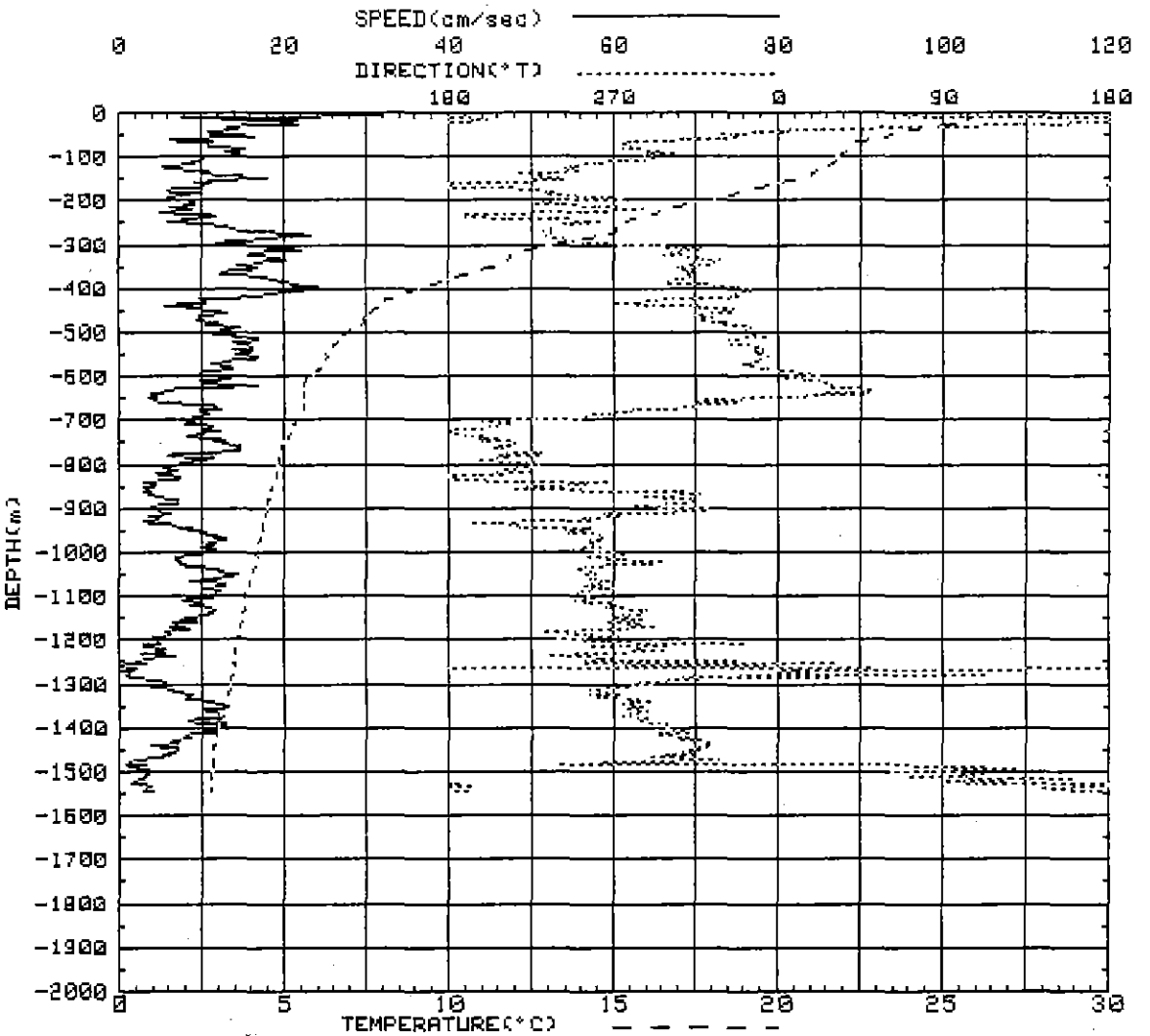
LATITUDE: 20°30'15"N LONGITUDE: 156°02'40"W
SURVEY 3 LEG 2 DROP 5

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1748



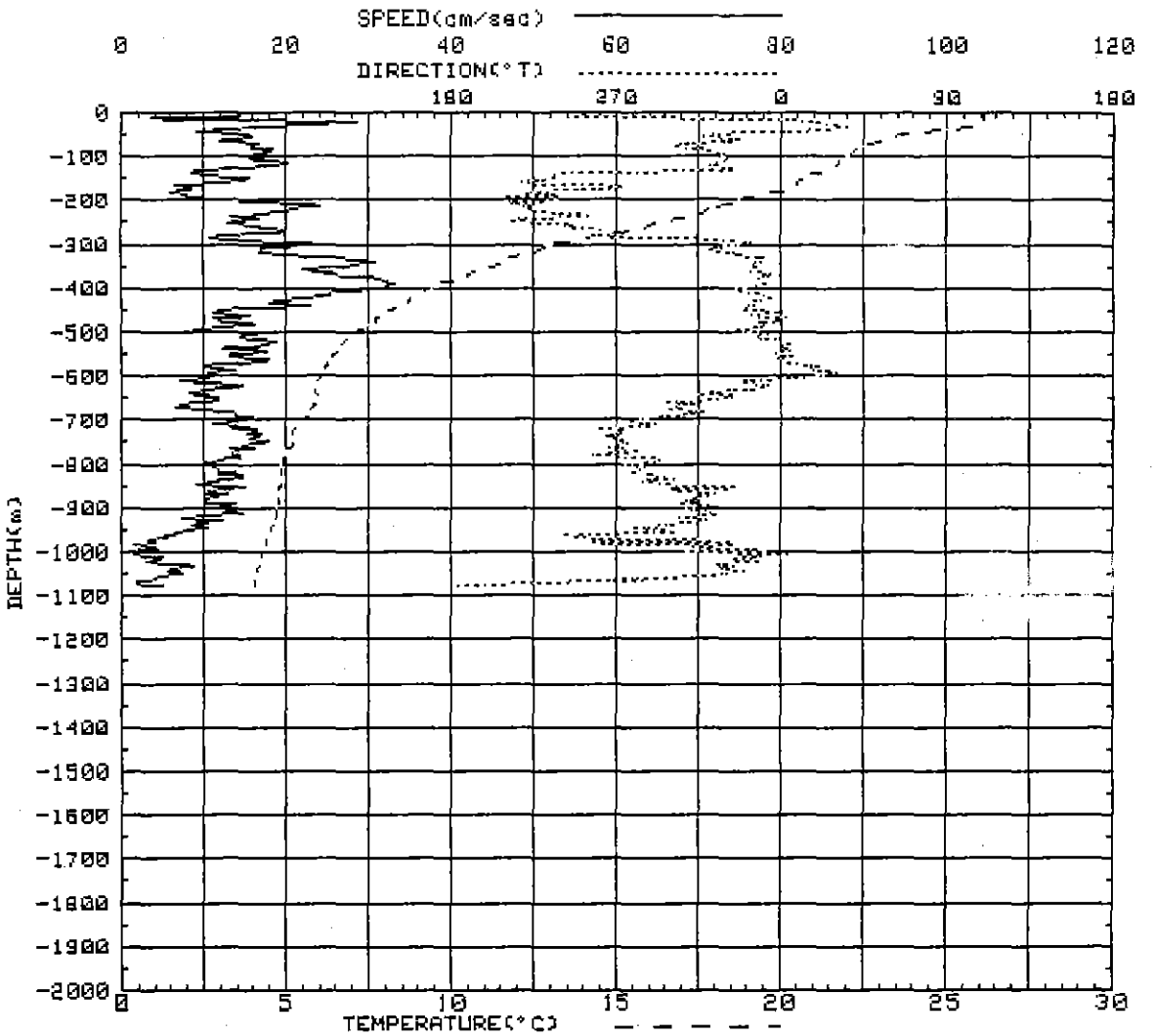
LATITUDE: 20°29'25"N LONGITUDE: 156°02'07"W
SURVEY 3 LEG 2 DROP 5A

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1655



LATITUDE: 20°33'40"N LONGITUDE: 156°04'55"W
SURVEY 3 LEG 2 DROP 6

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1635



LATITUDE: 20°35'40"N LONGITUDE: 156°06'15"W
SURVEY 3 LEG 2 DROP 7

APPENDIX D

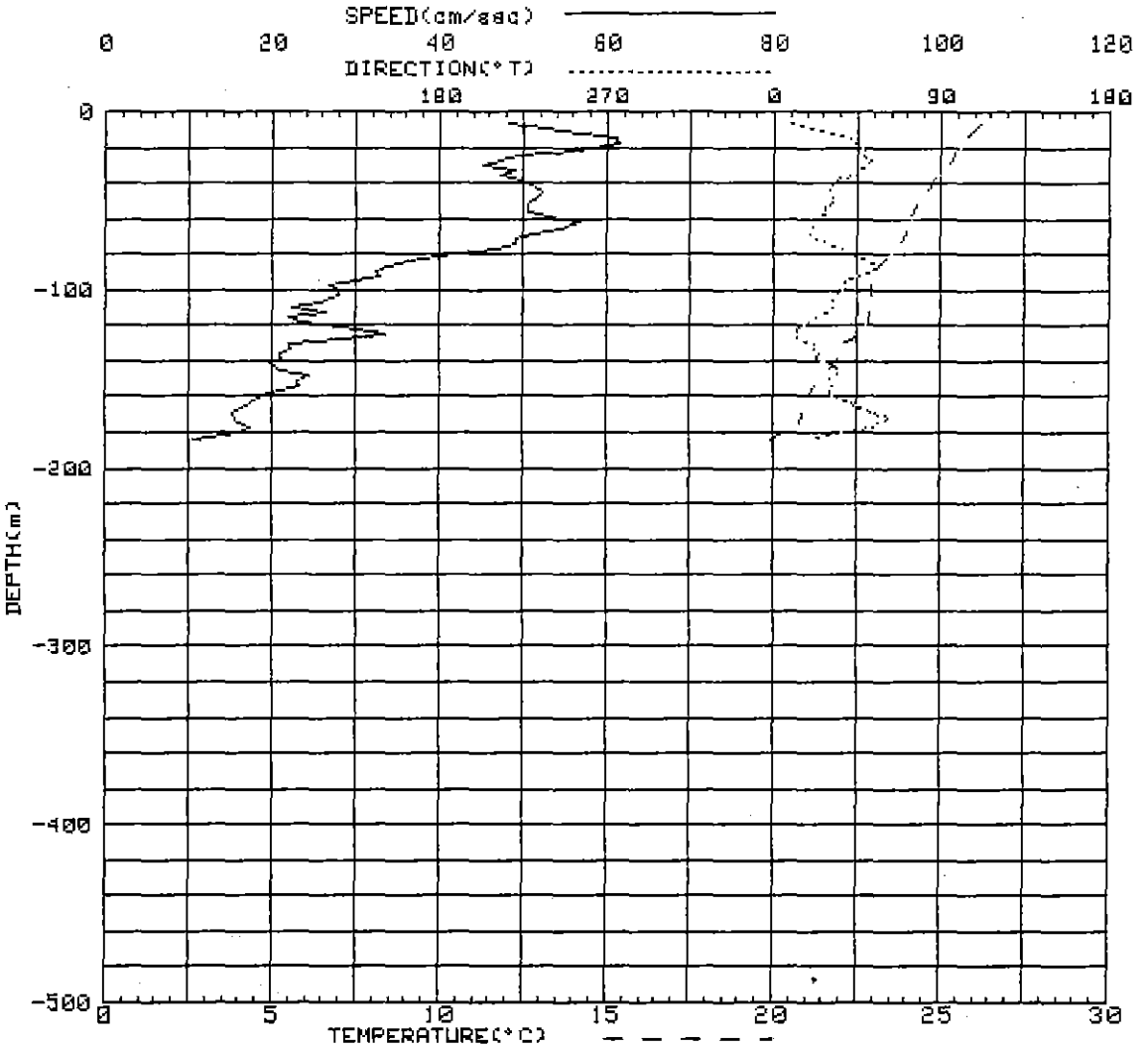
XCP VERTICAL CURRENT PROFILES IN UPPER 500 M, WITH MEAN (TIDAL) CURRENTS AND THEORETICAL EKMAN CURRENTS REMOVED

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 0806

MEAN SPEED BELOW 500m (cm/sec) 0.0 DIRECTION(°T) 0.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	50.7	40
50-100	42.8	33
100-150	24.1	25
150-200	16.7	42
200-250	0.0	0
250-300	0.0	0
300-350	0.0	0
350-400	0.0	0
400-450	0.0	0
450-500	0.0	0



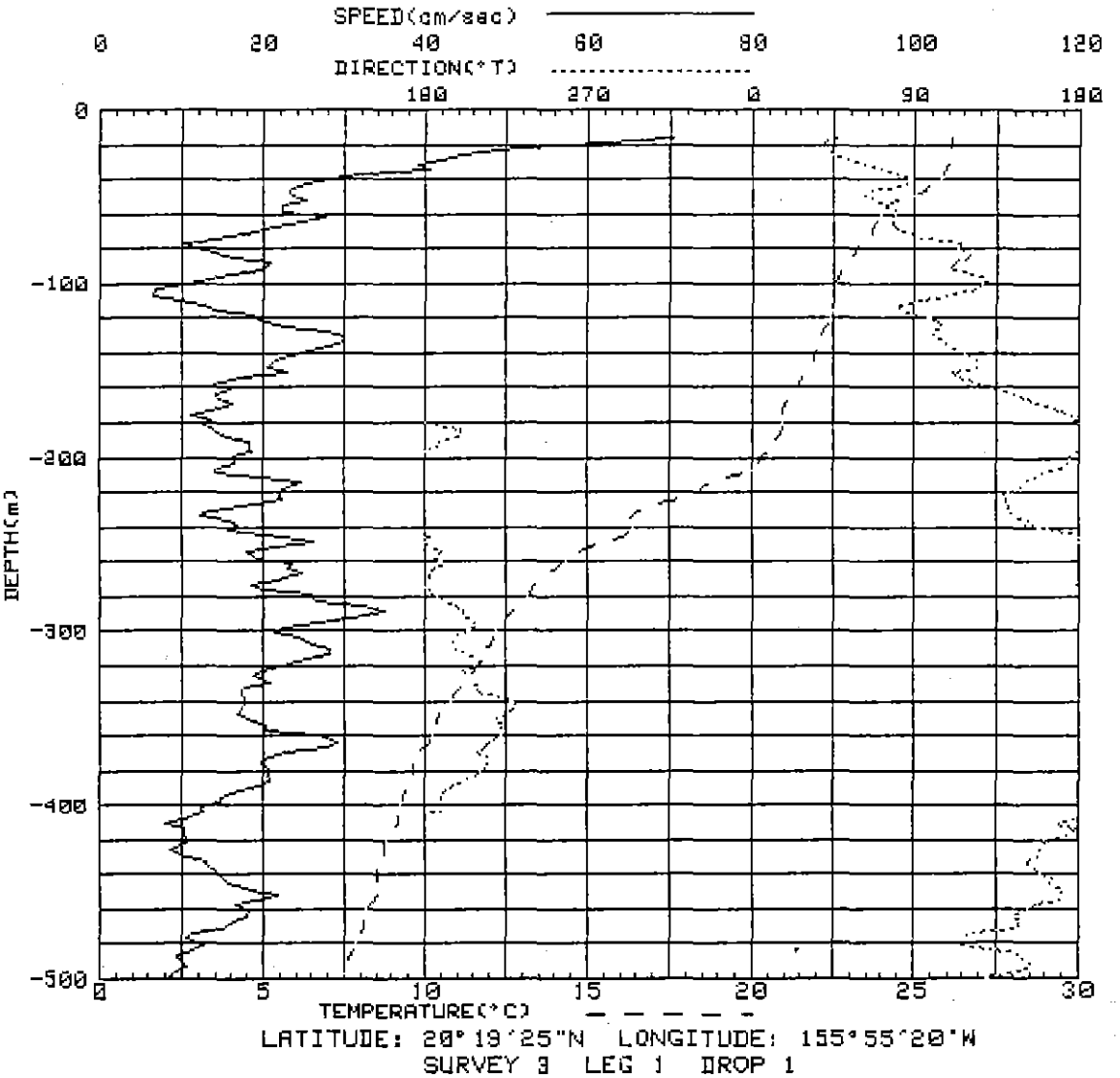
LATITUDE: 20°17'34"N LONGITUDE: 155°54'00"W
SURVEY 3 LEG 1 DROP 1A

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 0835

MEAN SPEED BELOW 500m (cm/sec) 16.6 DIRECTION(°T) 65.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	42.5	55
50-100	18.7	89
100-150	19.5	102
150-200	13.2	163
200-250	18.1	155
250-300	24.4	193
300-350	20.7	208
350-400	20.7	210
400-450	11.9	166
450-500	12.7	144



LATITUDE: 20°19'25"N LONGITUDE: 155°55'20"W

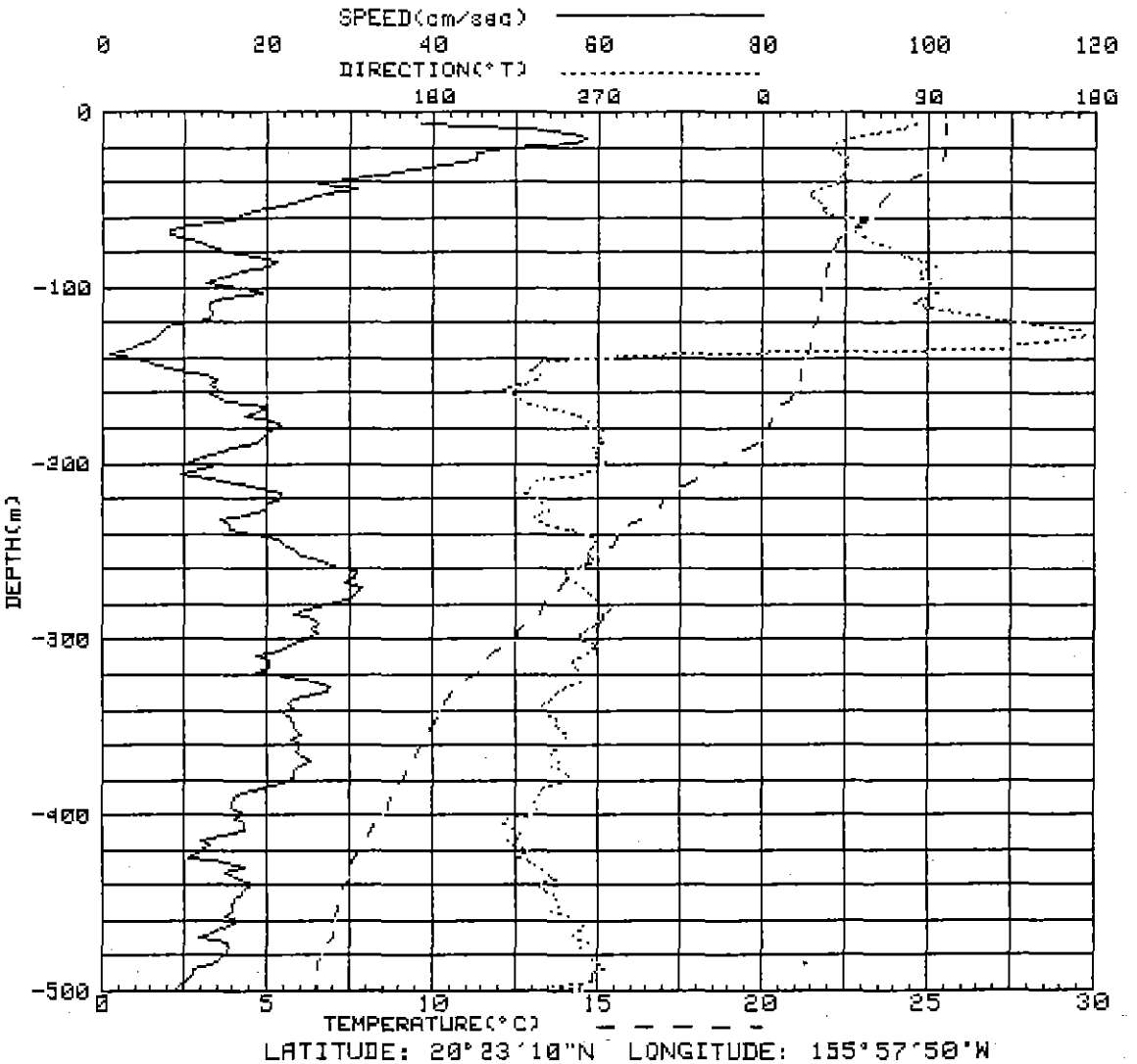
SURVEY 3 LEG 1 DROP 1

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 0900

MEAN SPEED BELOW 500m (cm/sec) 11.9 DIRECTION(°T) 91.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	46.3	50
50-100	15.3	69
100-150	5.9	134
150-200	15.8	253
200-250	17.7	244
250-300	28.1	262
300-350	23.4	251
350-400	22.1	244
400-450	15.5	232
450-500	13.1	258



LATITUDE: 20°23'10"N LONGITUDE: 155°57'50"W

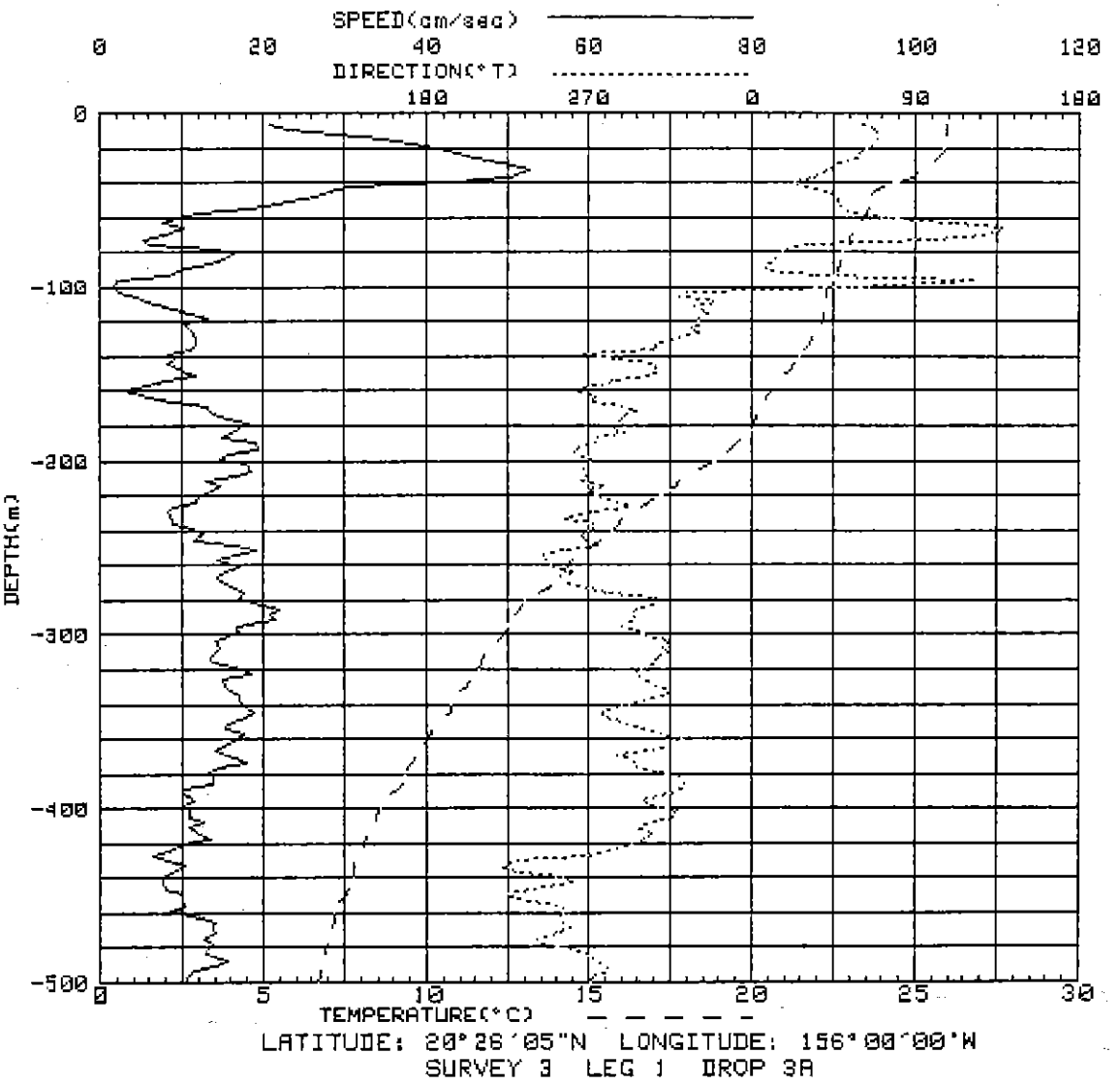
SURVEY 3 LEG 1 DROP 2

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 0930

MEAN SPEED BELOW 500m (cm/sec) 15.0 DIRECTION(°T) 84.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	39.5	50
50-100	8.3	49
100-150	8.8	317
150-200	13.7	277
200-250	13.4	270
250-300	18.0	277
300-350	16.8	297
350-400	14.5	302
400-450	8.9	269
450-500	13.2	260



LATITUDE: 20°26'05"N LONGITUDE: 156°00'00"W

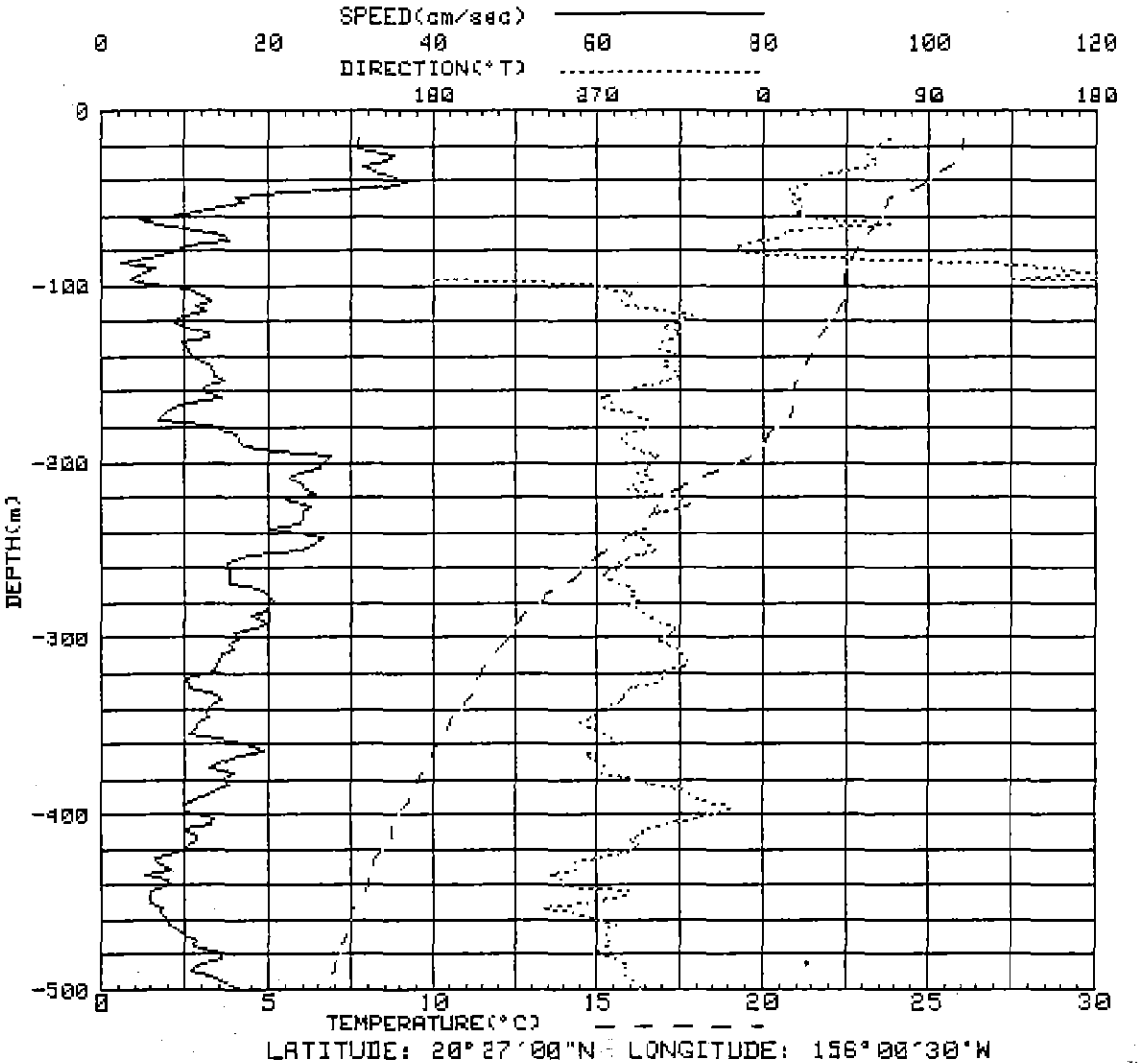
SURVEY 3 LEG 1 DROP 3A

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 0950

MEAN SPEED BELOW 500m (cm/sec) 16.1 DIRECTION(°T) 46.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	32.5	46
50-100	5.9	19
100-150	11.8	306
150-200	14.8	290
200-250	24.5	299
250-300	18.6	291
300-350	13.6	296
350-400	13.6	290
400-450	8.7	279
450-500	11.8	277



LATITUDE: 20°27'00"N LONGITUDE: 156°00'30"W

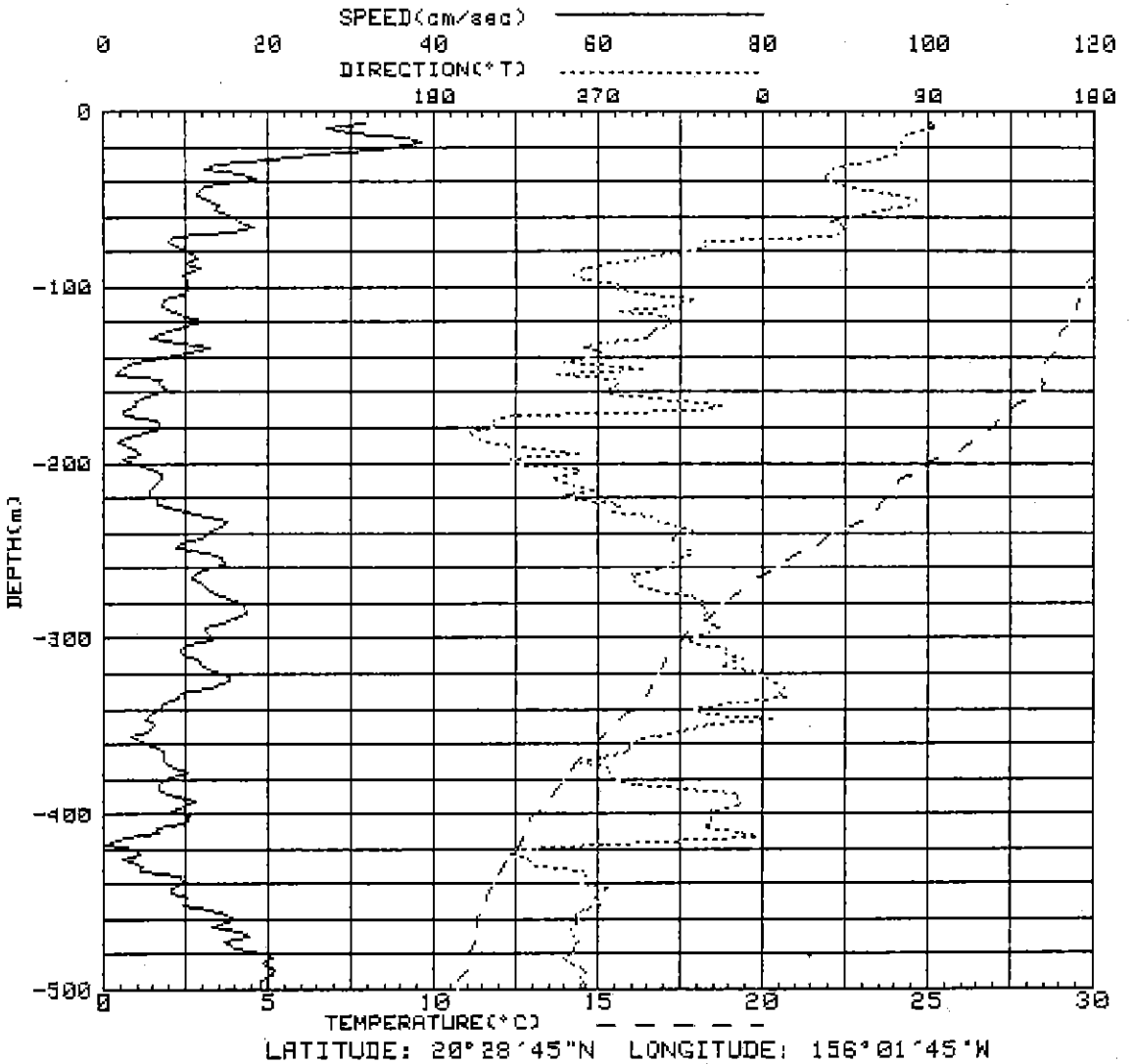
SURVEY 3 LEG 1 DROP 3

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1016

MEAN SPEED BELOW 500m (cm/sec) 8.0 DIRECTION(°T) 7.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	23.5	67
50-100	5.9	0
100-150	8.0	292
150-200	4.1	259
200-250	9.7	292
250-300	14.5	315
300-350	10.1	347
350-400	7.3	301
400-450	5.4	279
450-500	18.1	259



LATITUDE: 20°28'45"N LONGITUDE: 156°01'45"W

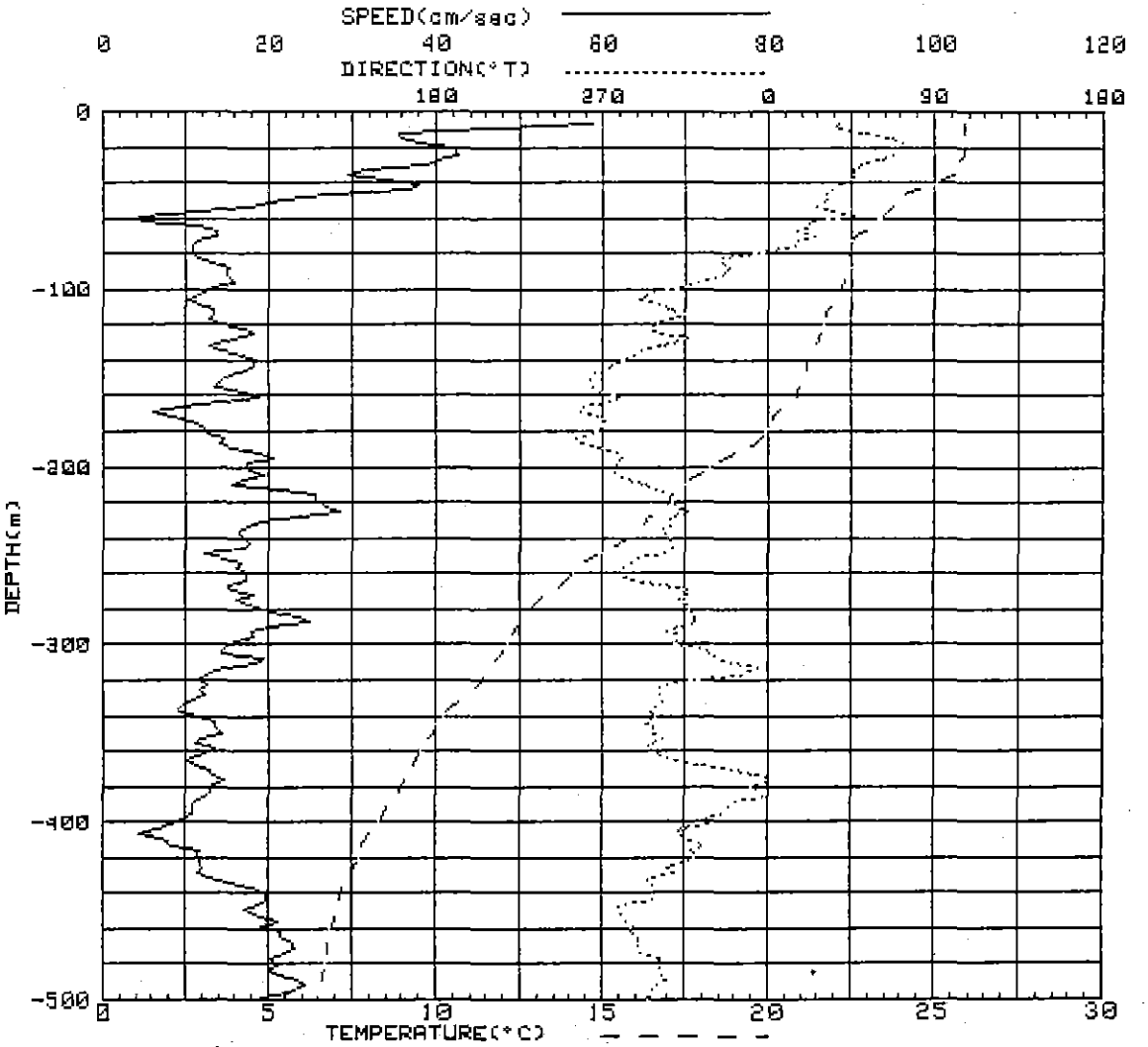
SURVEY 3 LEG 1 DROP 4

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1058

MEAN SPEED BELOW 500m (cm/sec) 5.1 DIRECTION(°T) 32.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	37.6	51
50-100	11.1	354
100-150	15.0	293
150-200	14.1	270
200-250	20.3	303
250-300	18.5	308
300-350	12.8	317
350-400	11.5	332
400-450	12.9	302
450-500	22.4	293



LATITUDE: 20°29'25"N LONGITUDE: 156°02'07"W

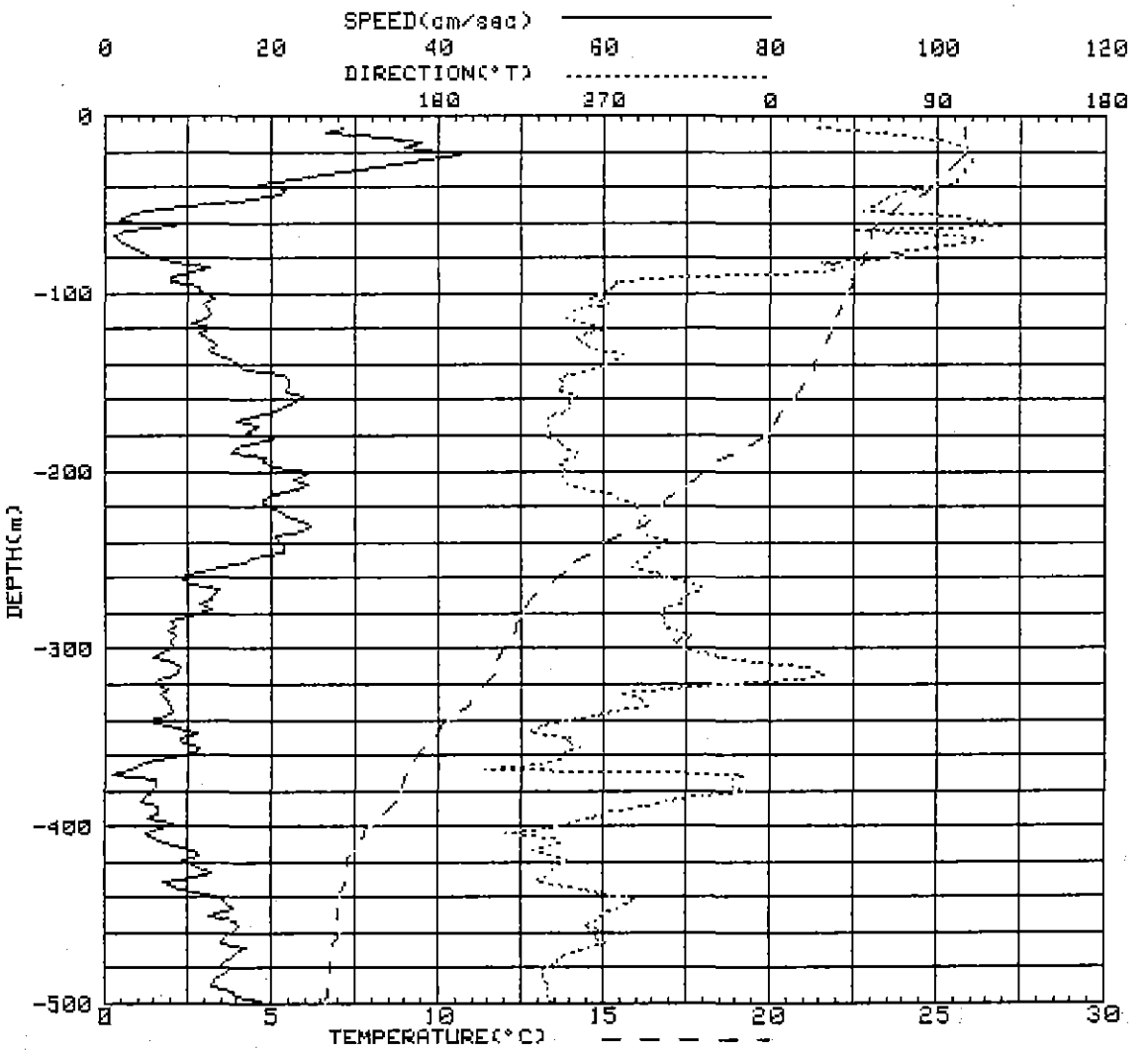
SURVEY 3 LEG 1 DROP 5A

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1149

MEAN SPEED BELOW 500m (cm/sec) 13.7 DIRECTION(°T) 96.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	28.8	79
50-100	2.8	13
100-150	14.9	264
150-200	20.0	248
200-250	21.8	285
250-300	11.5	308
300-350	5.6	301
350-400	5.2	284
400-450	10.6	258
450-500	16.0	254



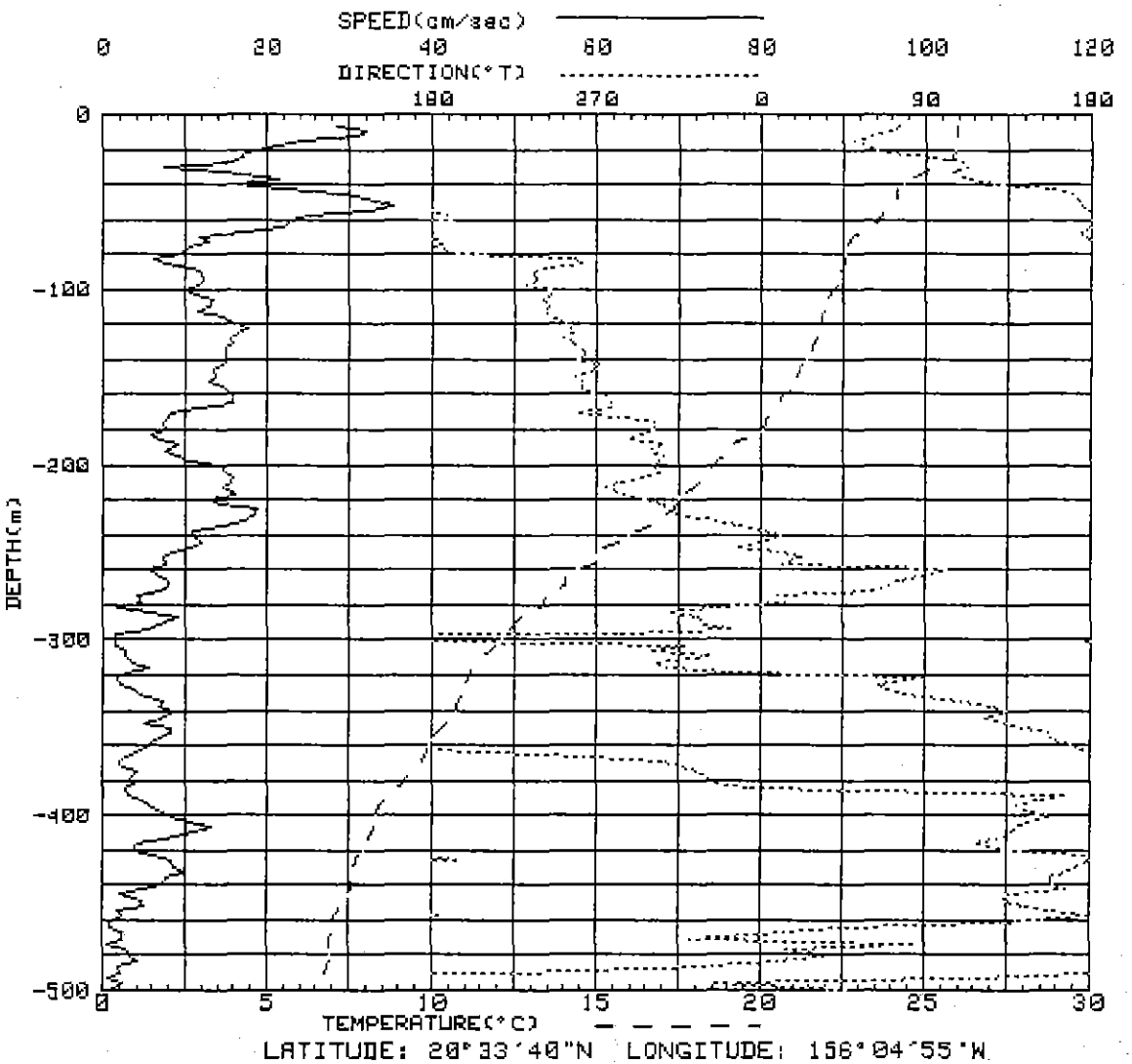
LATITUDE: 20°30'15"N LONGITUDE: 156°02'40"W
SURVEY 3 LEG 1 DROP 5

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1250

MEAN SPEED BELOW 500m (cm/sec) 12.4 DIRECTION(°T) 160.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	18.2	98
50-100	13.2	198
100-150	15.2	255
150-200	11.0	280
200-250	14.0	312
250-300	4.1	13
300-350	1.5	94
350-400	1.7	180
400-450	6.6	158
450-500	1.0	301



LATITUDE: 20°33'40"N LONGITUDE: 156°04'55"W

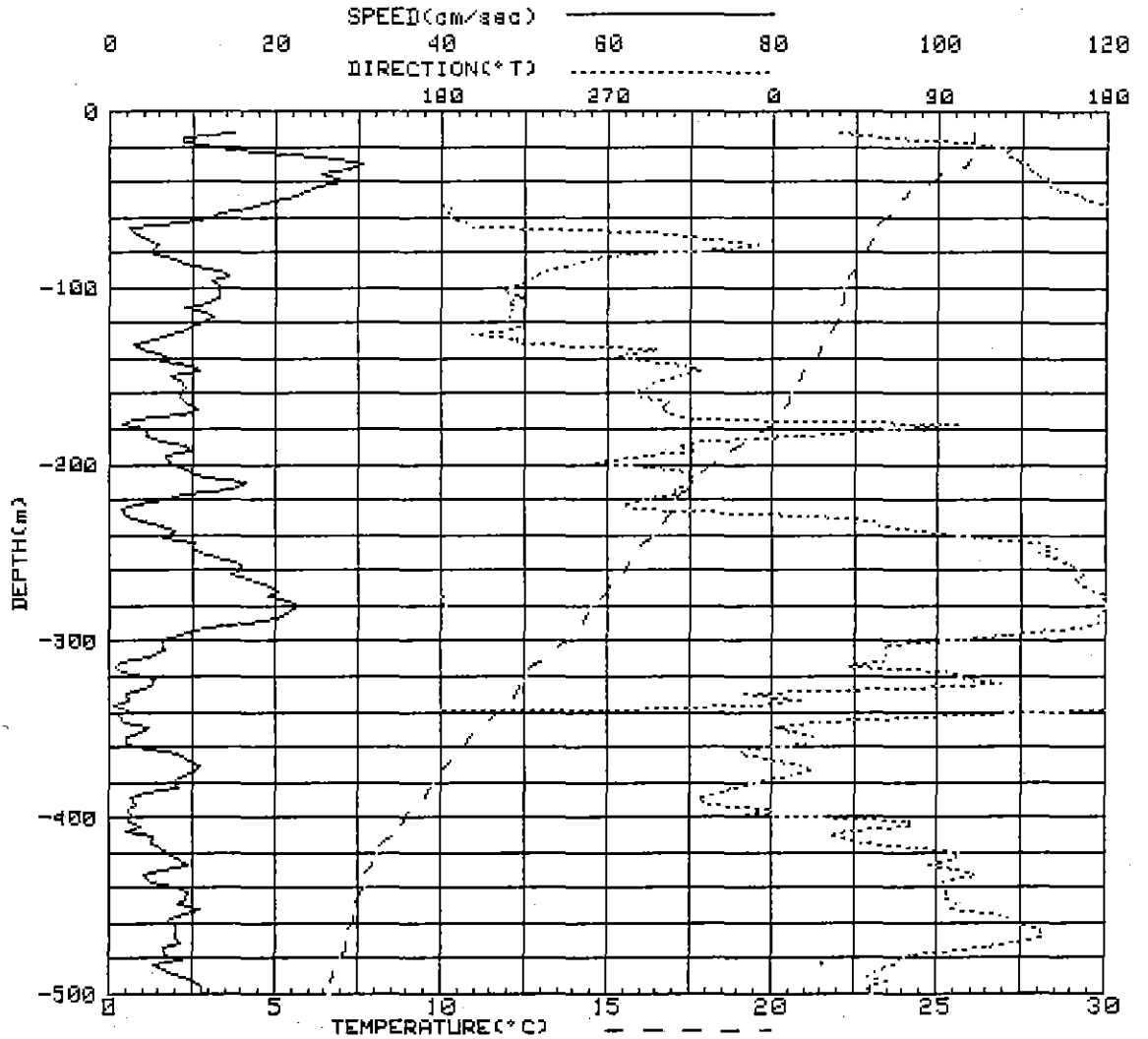
SURVEY 3 LEG 1 DROP 6

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1339

MEAN SPEED BELOW 500m (cm/sec) 15.8 DIRECTION(°T) 348.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	20.3	134
50-100	7.4	222
100-150	7.9	241
150-200	6.8	301
200-250	3.6	323
250-300	15.8	169
300-350	2.1	64
350-400	5.4	357
400-450	6.3	92
450-500	6.6	92



LATITUDE: 20°35'40"N LONGITUDE: 156°06'15"W

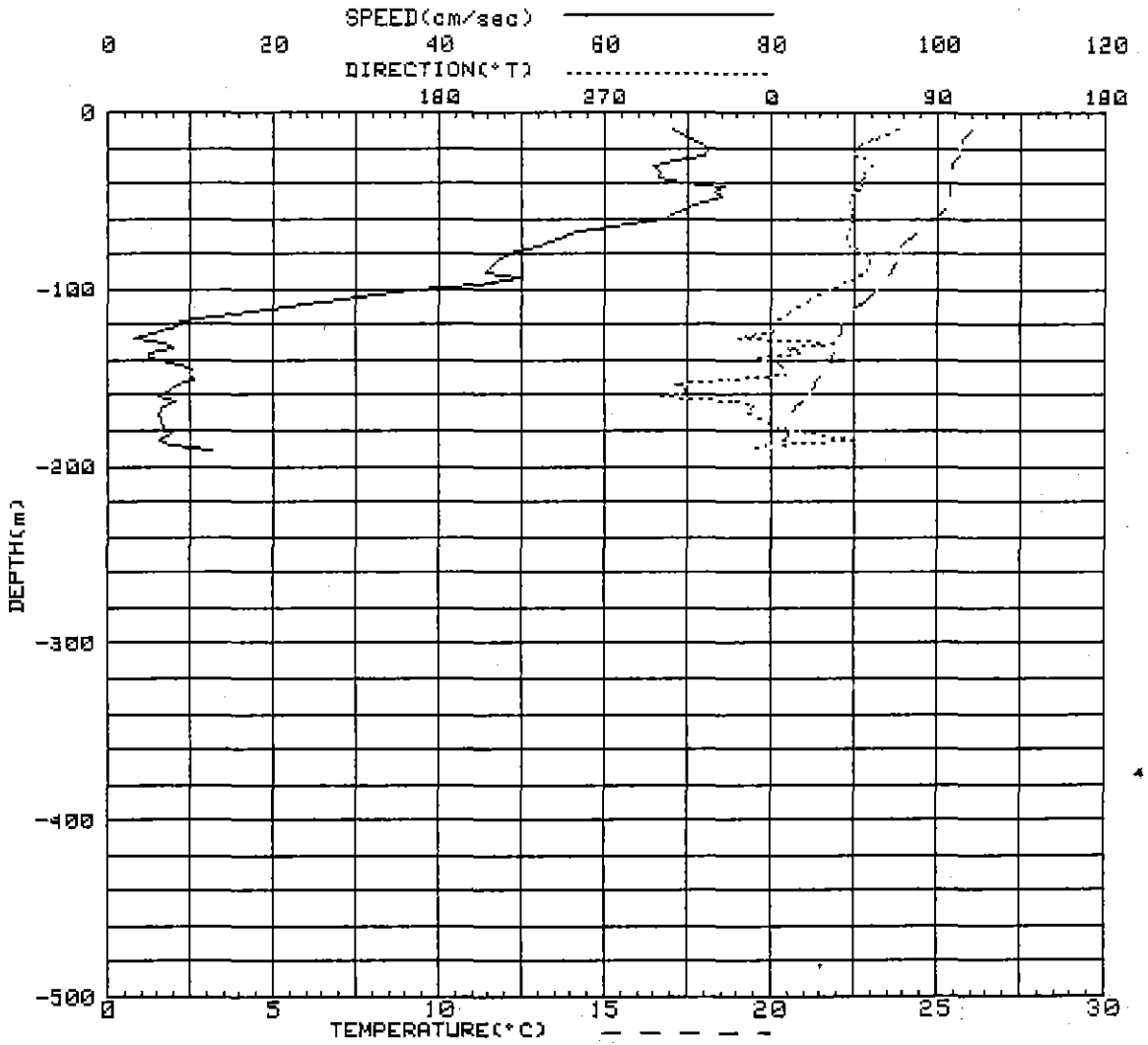
SURVEY 3 LEG 1 DROP 7

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 2023

MEAN SPEED BELOW 500m (cm/sec) 0.0 DIRECTION(°T) 0.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	70.0	51
50-100	53.4	44
100-150	6.6	2
150-200	7.2	343
200-250	3.6	323
250-300	15.8	169
300-350	2.1	64
350-400	5.4	357
400-450	6.3	92
450-500	6.6	92



LATITUDE: 20°17'34"N LONGITUDE: 155°54'00"W

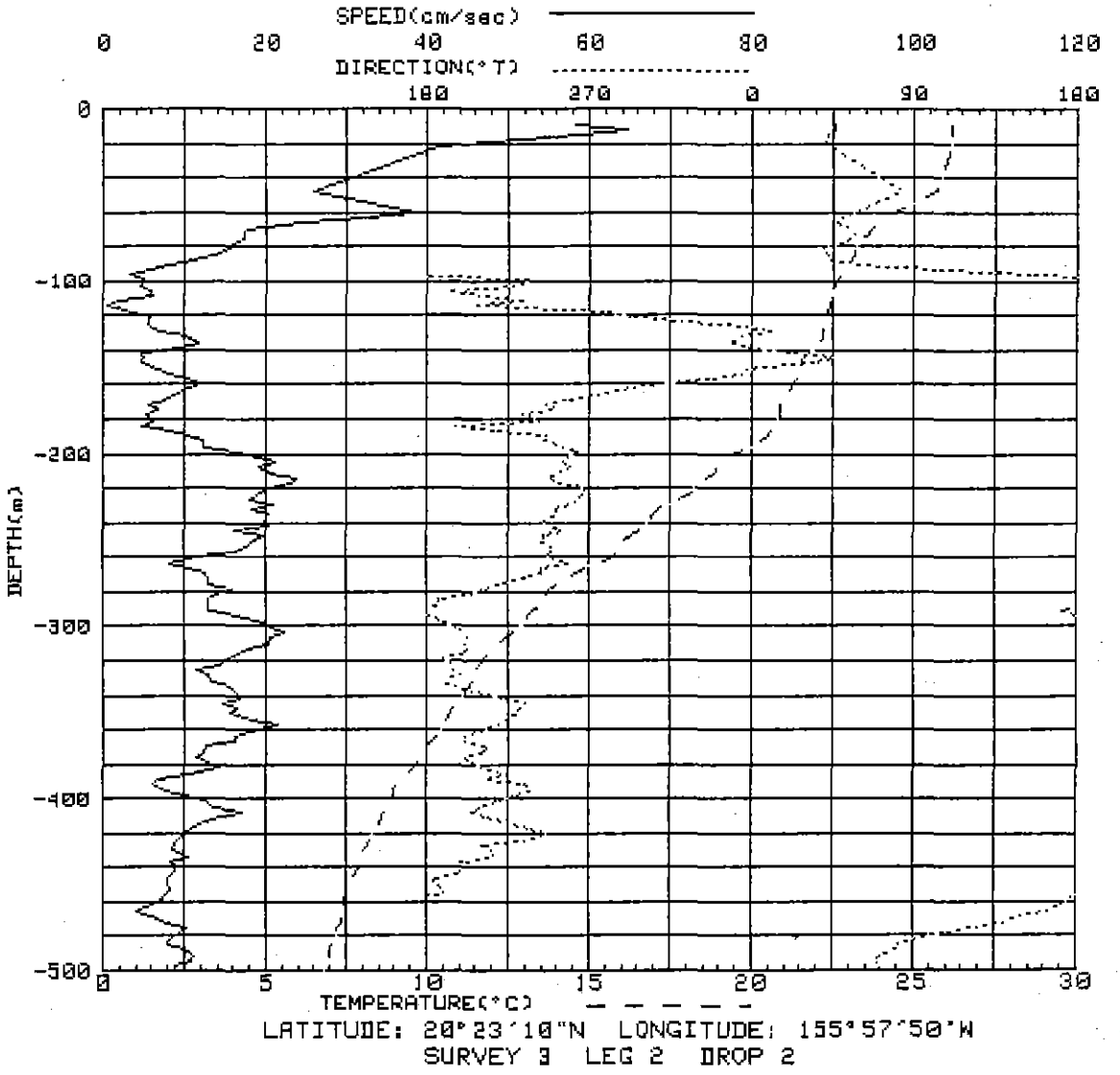
SURVEY 3 LEG 2 DROP 1A

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1917

MEAN SPEED BELOW 500m (cm/sec) 7.6 DIRECTION(°T) 88.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	60.3	48
50-100	17.3	50
100-150	3.9	347
150-200	7.3	270
200-250	20.0	255
250-300	12.9	213
300-350	15.8	204
350-400	12.5	215
400-450	9.8	211
450-500	6.7	110

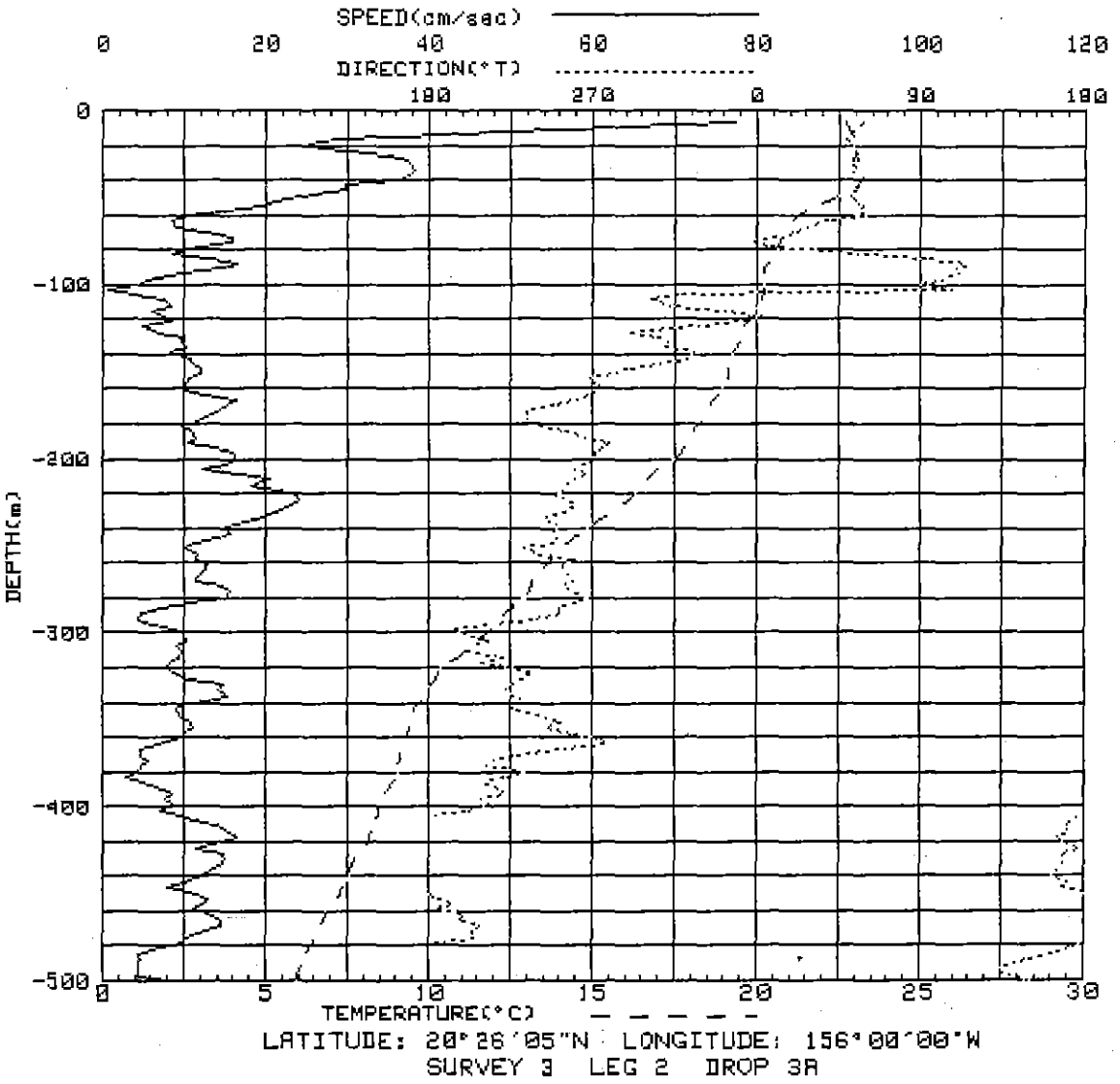


RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1840

MEAN SPEED BELOW 500m (cm/sec) 17.1 DIRECTION(°T) 295.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	40.2	53
50-100	10.3	56
100-150	8.1	318
150-200	12.7	260
200-250	19.6	254
250-300	10.8	249
300-350	11.4	221
350-400	6.9	233
400-450	13.2	172
450-500	8.6	185



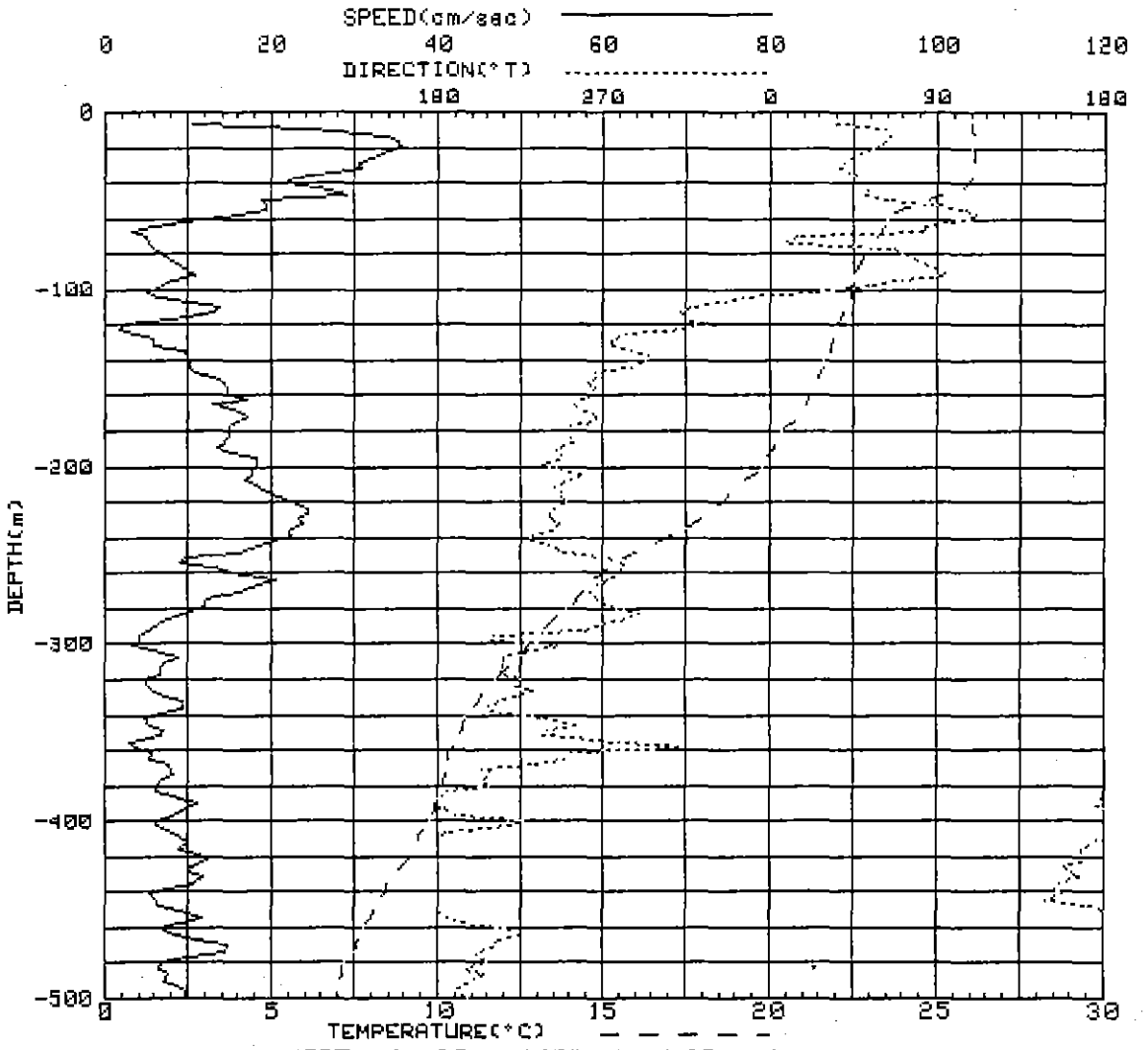
LATITUDE: 20°26'05"N LONGITUDE: 156°00'00"W
SURVEY 3 LEG 2 DROP 3A

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1821

MEAN SPEED BELOW 500m (cm/sec) 5.8 DIRECTION(°T) 341.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	30.0	52
50-100	8.4	82
100-150	8.2	299
150-200	16.2	255
200-250	21.9	245
250-300	11.5	270
300-350	7.4	222
350-400	6.4	209
400-450	9.9	167
450-500	9.9	200



LATITUDE: 20°27'00"N LONGITUDE: 156°00'30"W

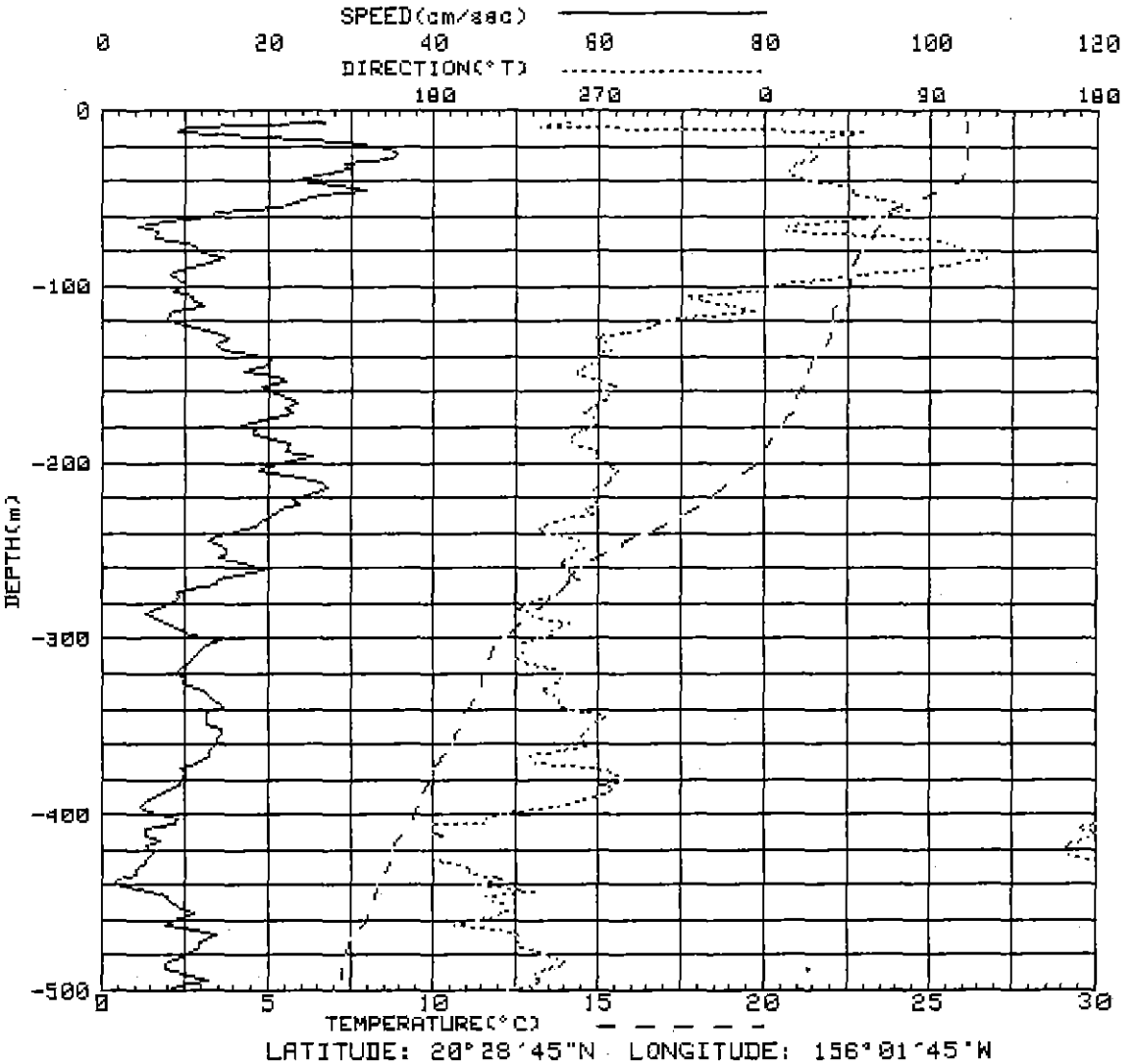
SURVEY 3 LEG 2 DROP 3

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1809

MEAN SPEED BELOW 500m (cm/sec) 6.6 DIRECTION(°T) 175.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	23.4	28
50-100	9.4	76
100-150	12.5	288
150-200	22.0	266
200-250	21.4	262
250-300	11.8	250
300-350	11.8	245
350-400	9.7	258
400-450	5.7	190
450-500	10.6	227



LATITUDE: 20°28'45"N LONGITUDE: 156°01'45"W

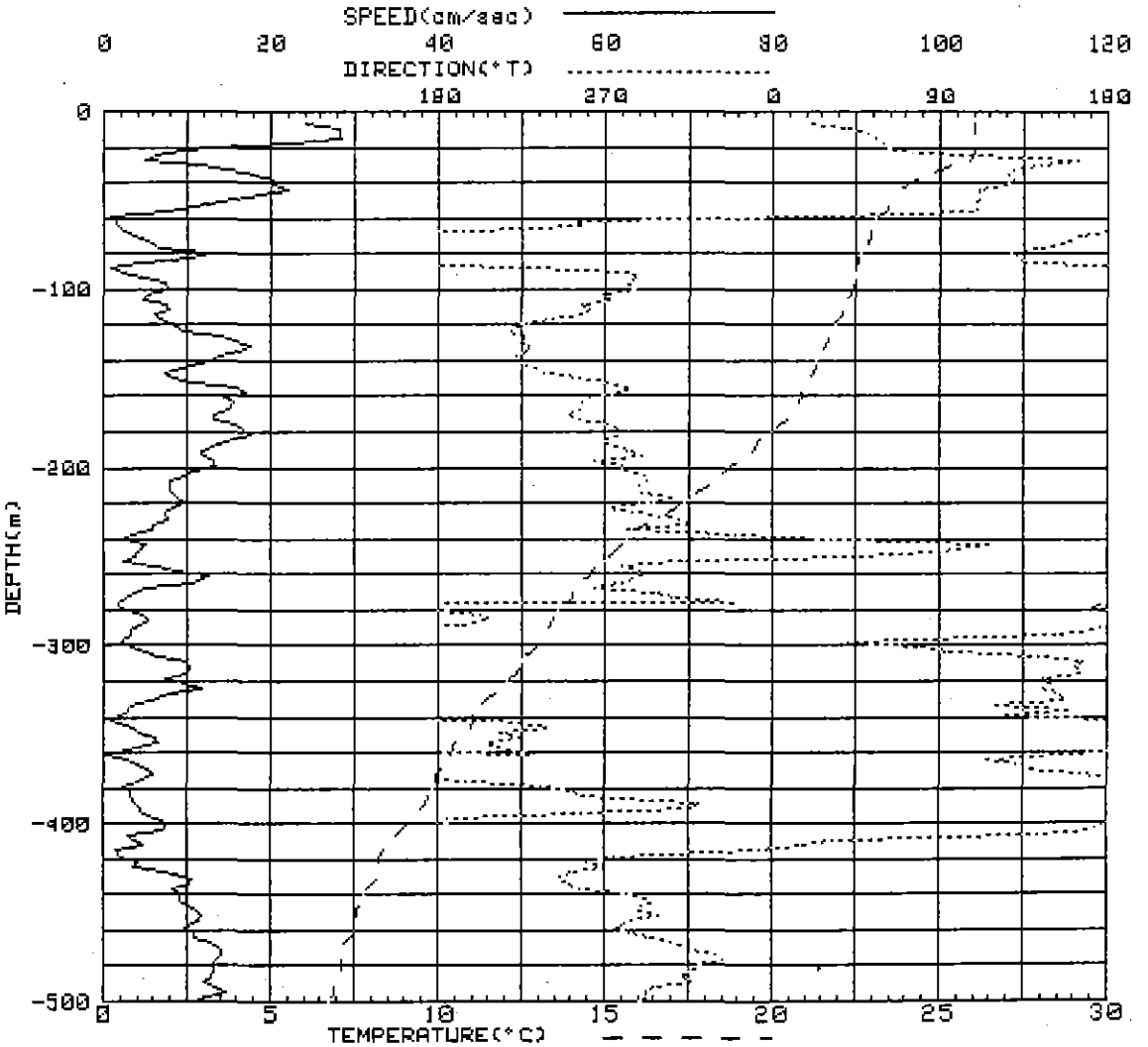
SURVEY 3 LEG 2 DROP 4

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1728

MEAN SPEED BELOW 500m (cm/sec) 11.4 DIRECTION(°T) 19.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	15.3	76
50-100	2.0	157
100-150	10.6	237
150-200	15.8	271
200-250	5.9	292
250-300	4.1	261
300-350	5.7	163
350-400	2.7	216
400-450	4.7	265
450-500	12.2	303



LATITUDE: 20°30'15"N LONGITUDE: 156°02'40"W

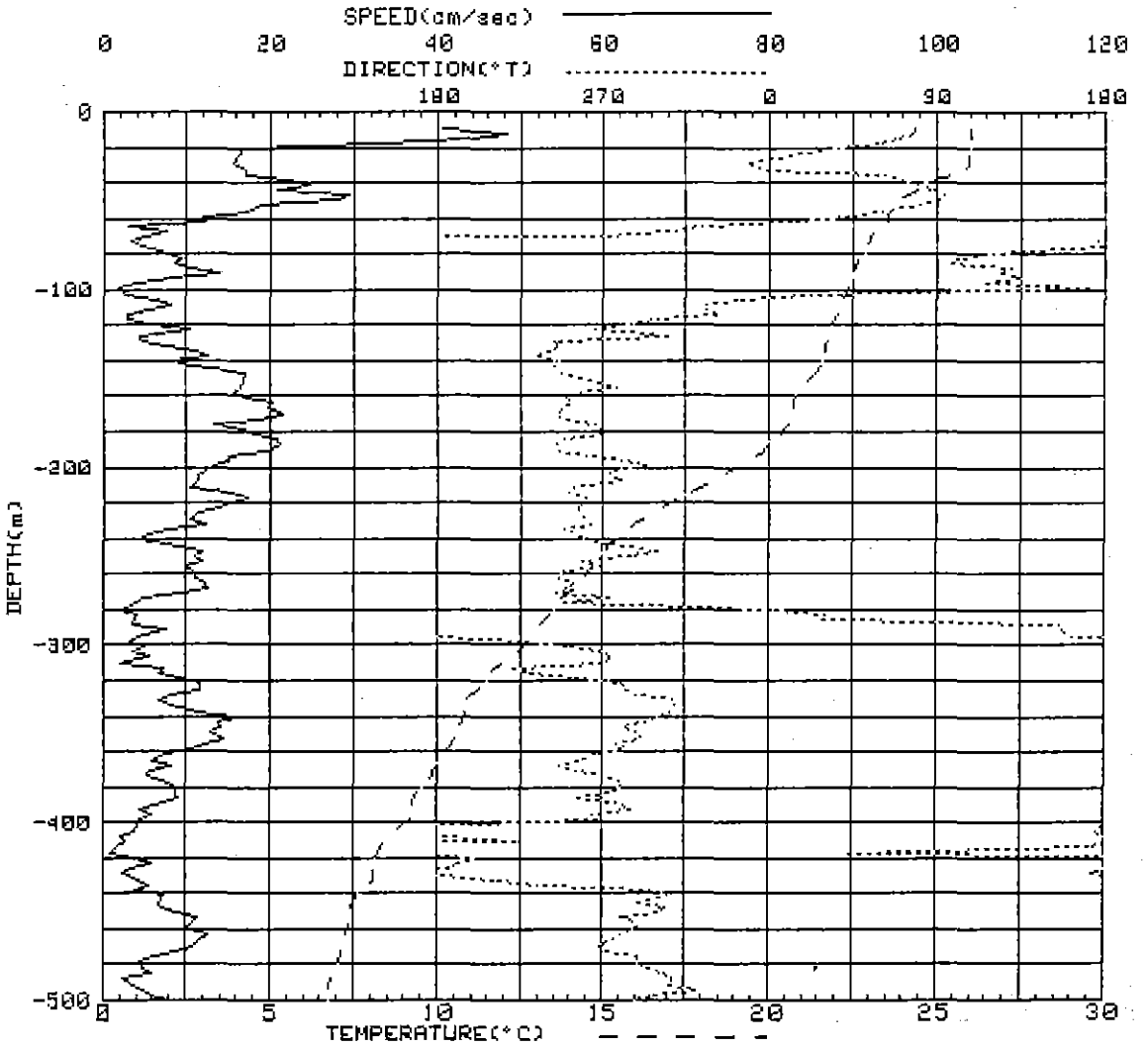
SURVEY 3 LEG 2 DROP 5

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1748

MEAN SPEED BELOW 500m (cm/sec) 5.1 DIRECTION(°T) 223.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	25.9	69
50-100	4.3	93
100-150	7.1	263
150-200	18.3	258
200-250	11.2	266
250-300	5.0	247
300-350	8.4	282
350-400	7.4	269
400-450	2.7	243
450-500	8.2	288



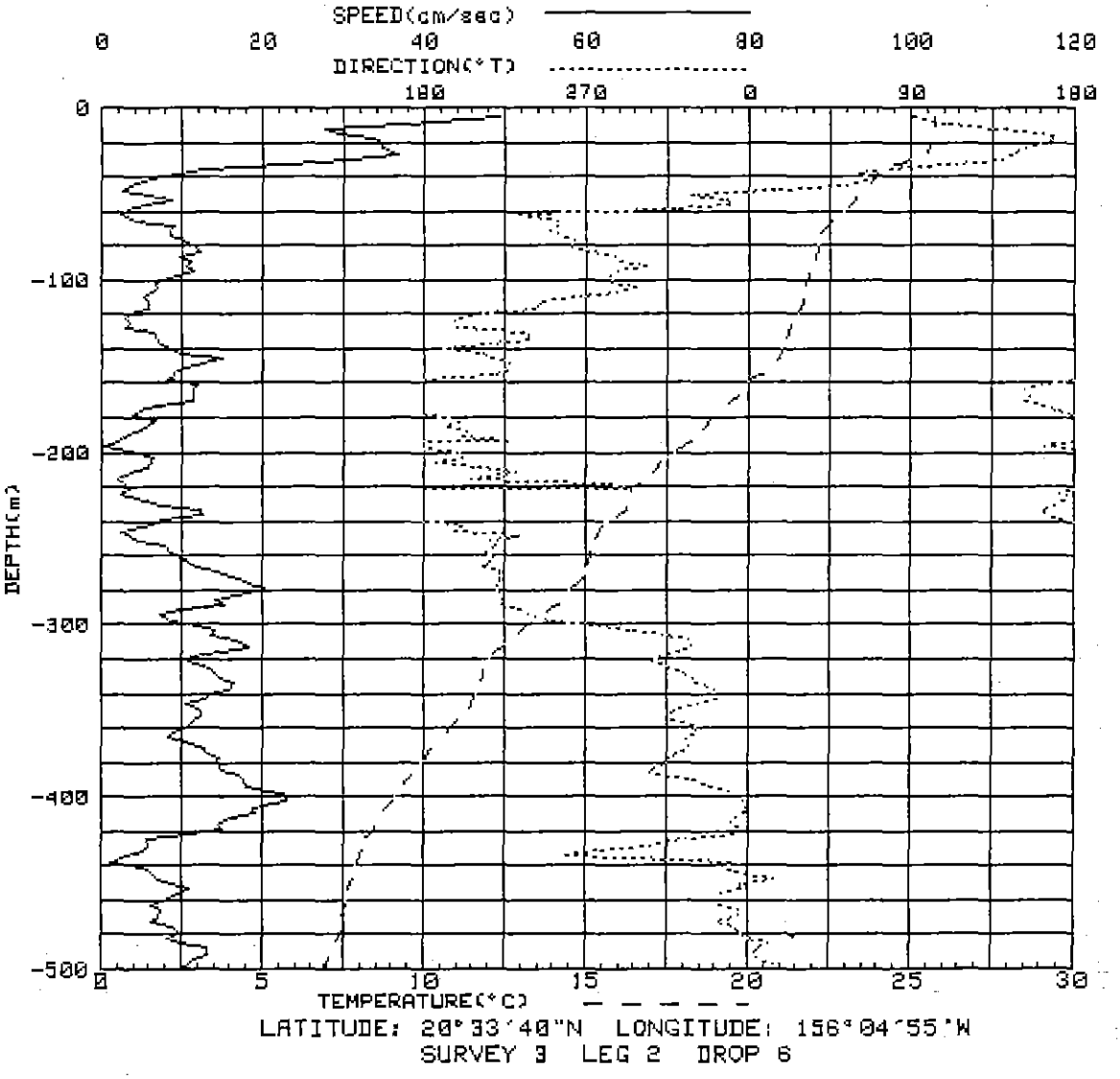
LATITUDE: 20°29'25"N LONGITUDE: 156°02'07"W
SURVEY 3 LEG 2 DROP 5A

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1655

MEAN SPEED BELOW 500m (cm/sec) 5.1 DIRECTION(°T) 280.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	21.7	128
50-100	7.3	281
100-150	6.4	232
150-200	6.4	187
200-250	4.8	197
250-300	13.0	224
300-350	14.1	323
350-400	14.3	326
400-450	8.7	347
450-500	9.4	355



LATITUDE: 20°33'40"N LONGITUDE: 156°04'55"W

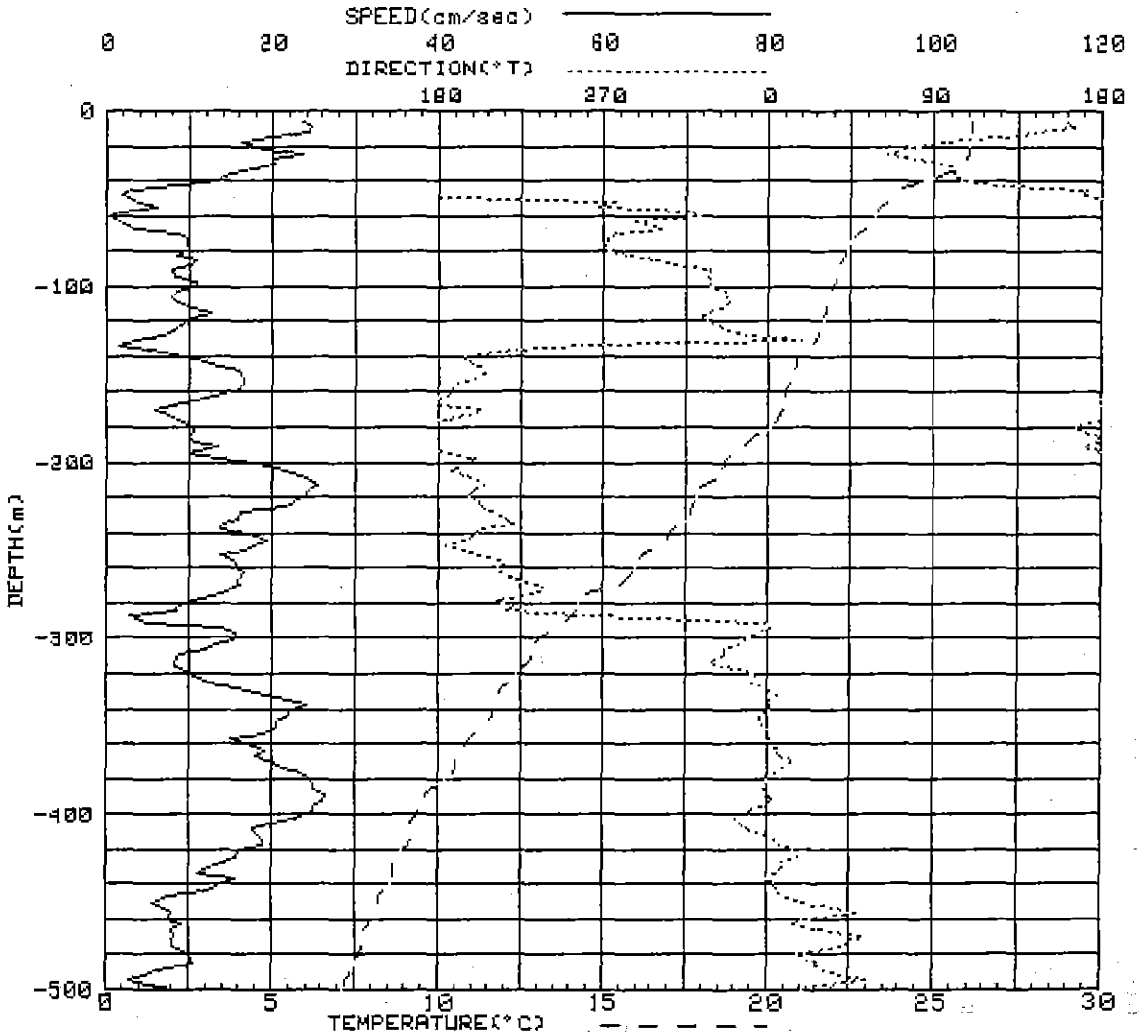
SURVEY 3 LEG 2 DROP 6

RESULTS WITH THEORETICAL EKMAN AND MEAN CURRENTS SUBTRACTED

SURVEY DATE: AUGUST 28, 1985 DROP TIME: 1635

MEAN SPEED BELOW 500m (cm/sec) 8.8 DIRECTION(°T) 315.0

RANGE(m)	AVG SPEED(cm/sec)	AVG DIRECTION(°T)
0-50	15.3	115
50-100	7.1	294
100-150	4.2	289
150-200	11.4	184
200-250	20.2	200
250-300	9.3	231
300-350	15.9	352
350-400	22.6	0
400-450	14.8	3
450-500	8.1	28



LATITUDE: 20°35'40"N LONGITUDE: 156°06'15"W

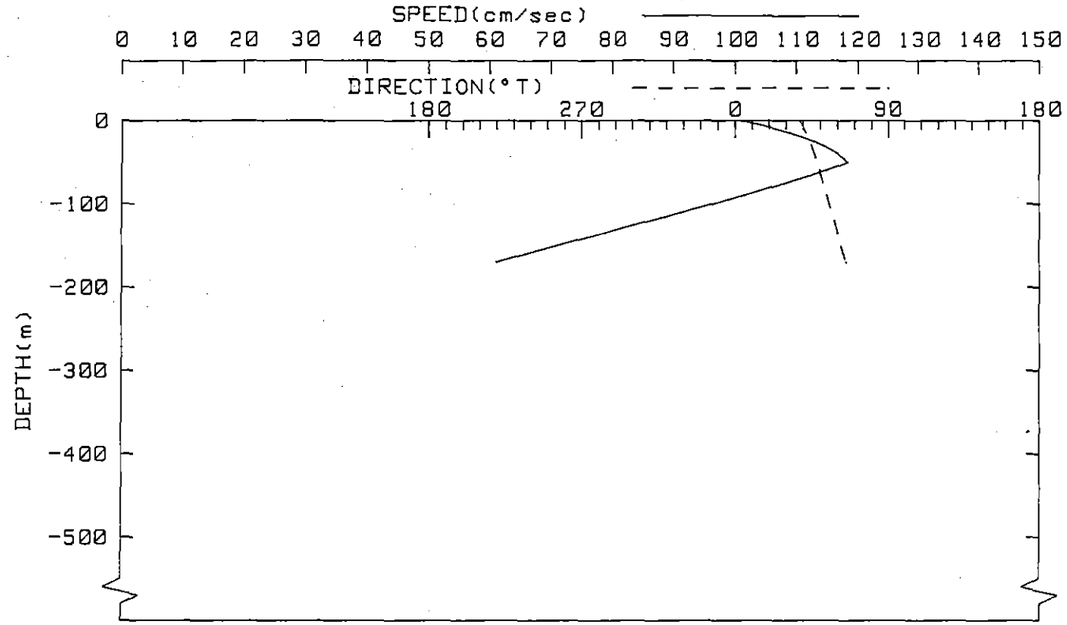
SURVEY 3 LEG 2 DROP 7

APPENDIX E

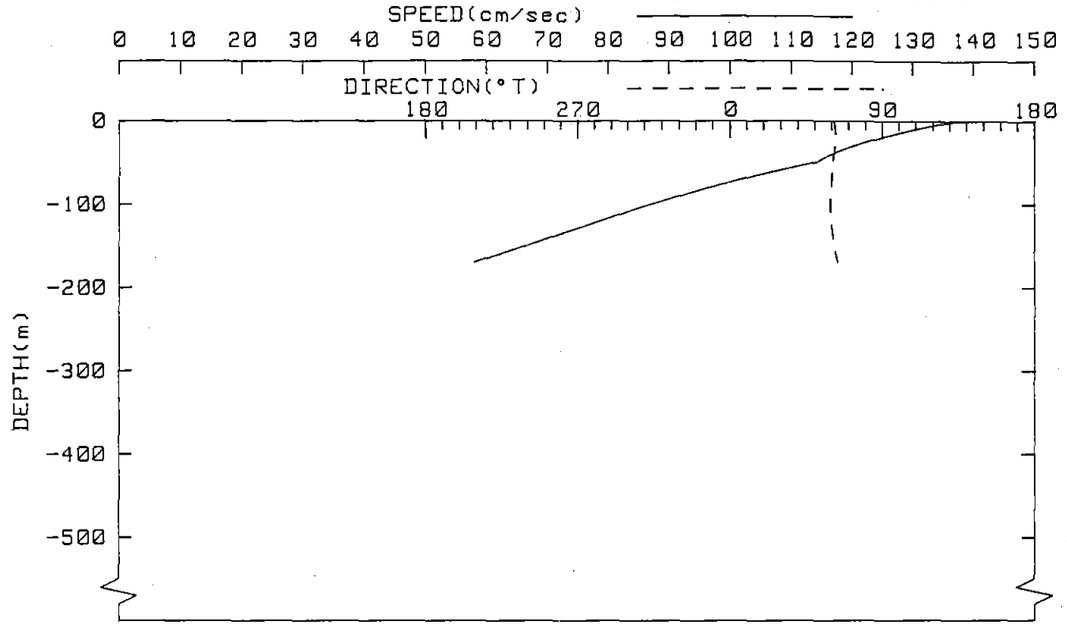
OPERATIONAL DESIGN CURRENT PROFILES FOR VARIOUS LOCATIONS ALONG THE PROPOSED CABLE ROUTE, ALENUIHAHA CHANNEL

LOCATION: 170m DEPTH HAWAII SIDE

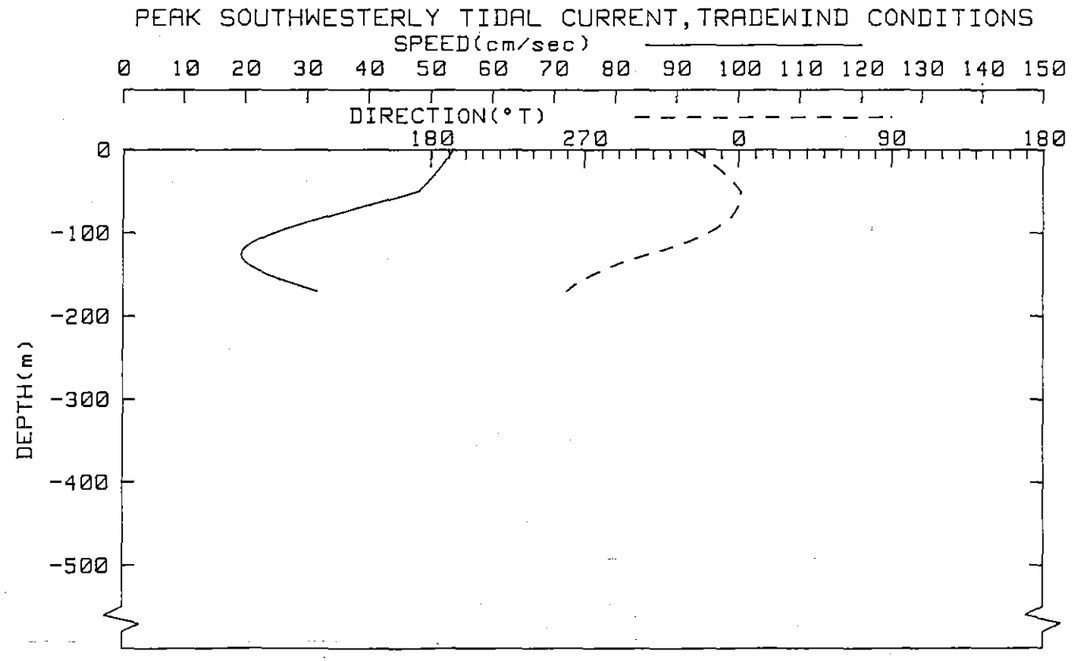
PEAK NORTHEASTERLY TIDAL CURRENT, TRADEWIND CONDITIONS



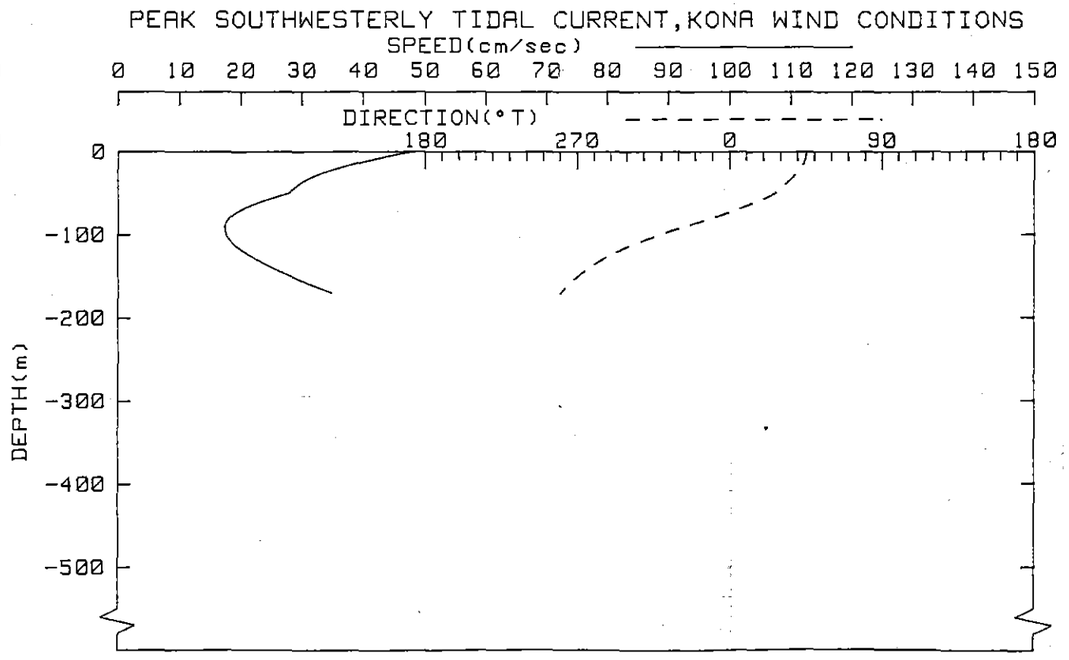
PEAK NORTHEASTERLY TIDAL CURRENT, KONA WIND CONDITIONS



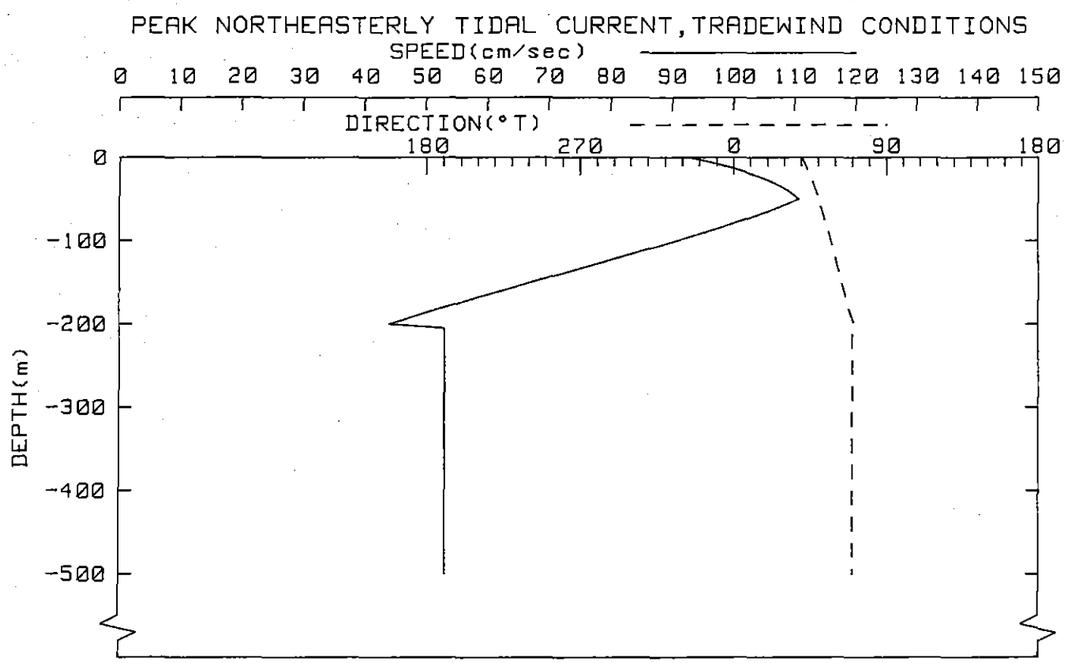
PEAK SOUTHWESTERLY TIDAL CURRENT, TRADEWIND CONDITIONS

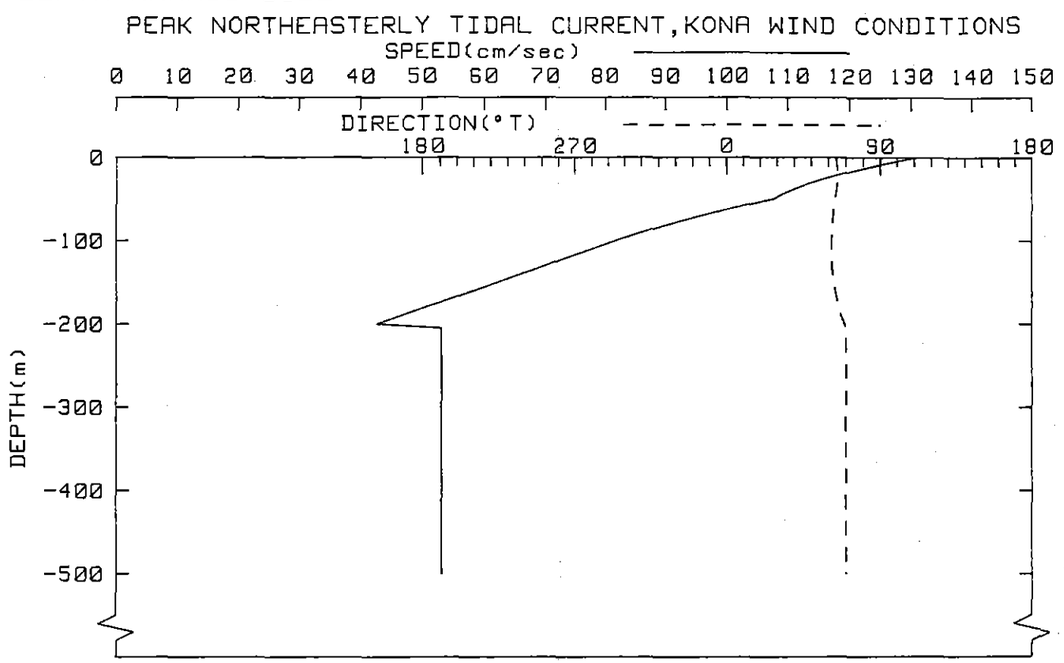


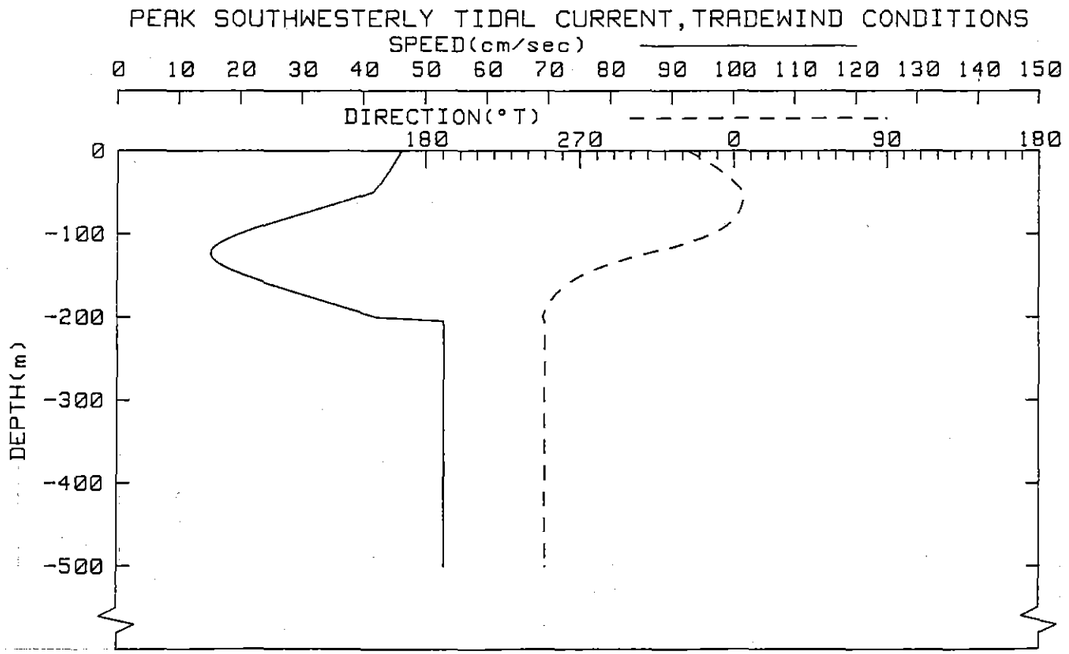
PEAK SOUTHWESTERLY TIDAL CURRENT, KONA WIND CONDITIONS

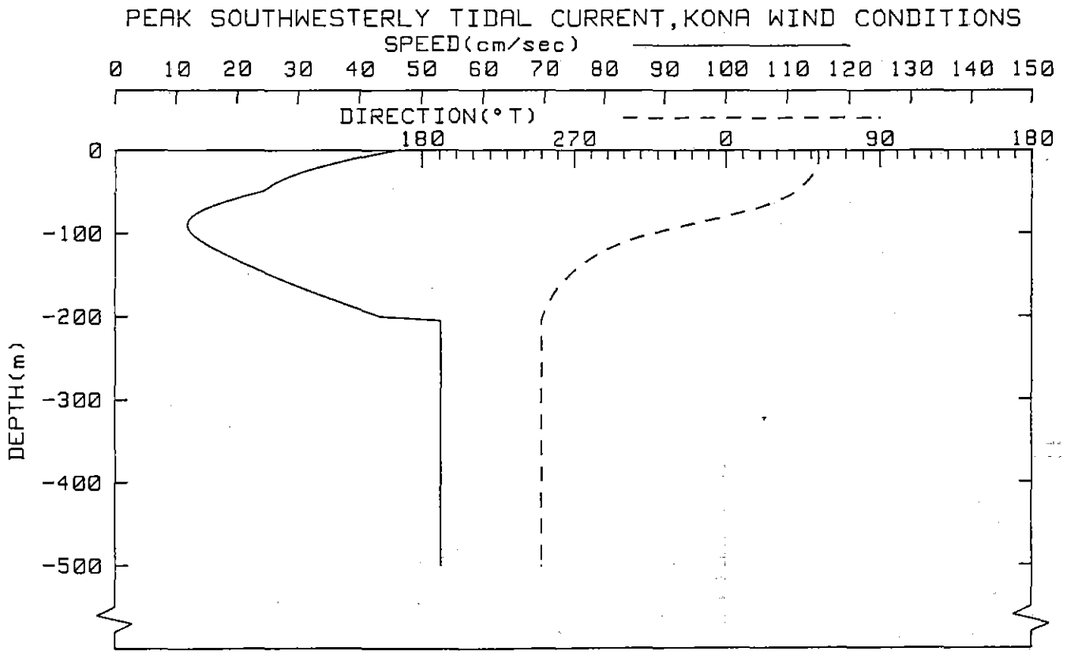


LOCATION: 500m DEPTH HAWAII SIDE

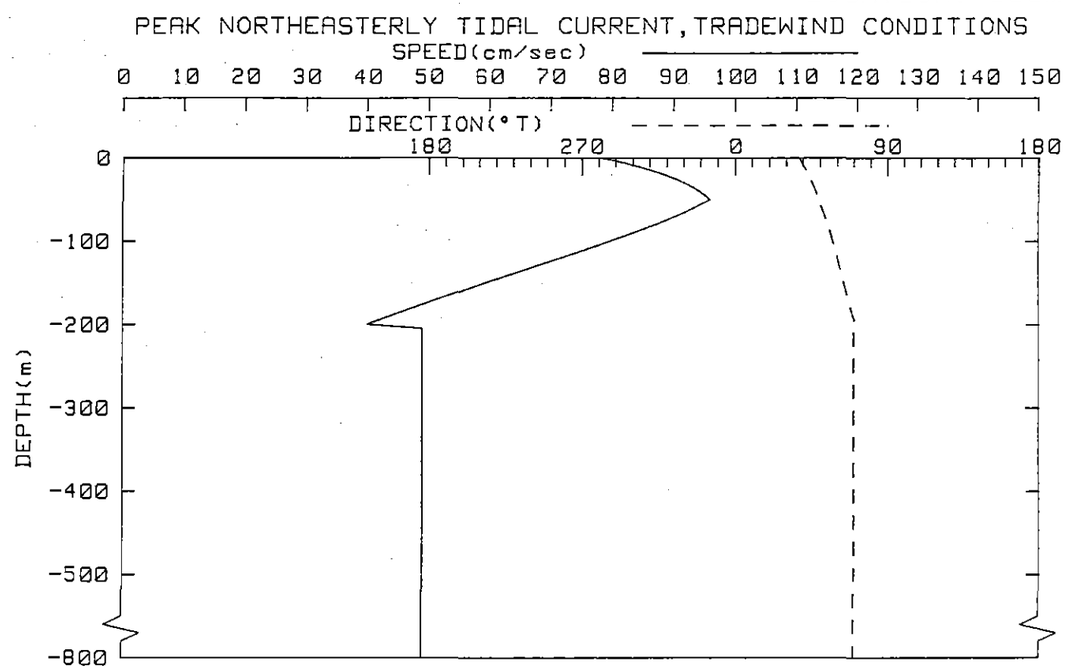


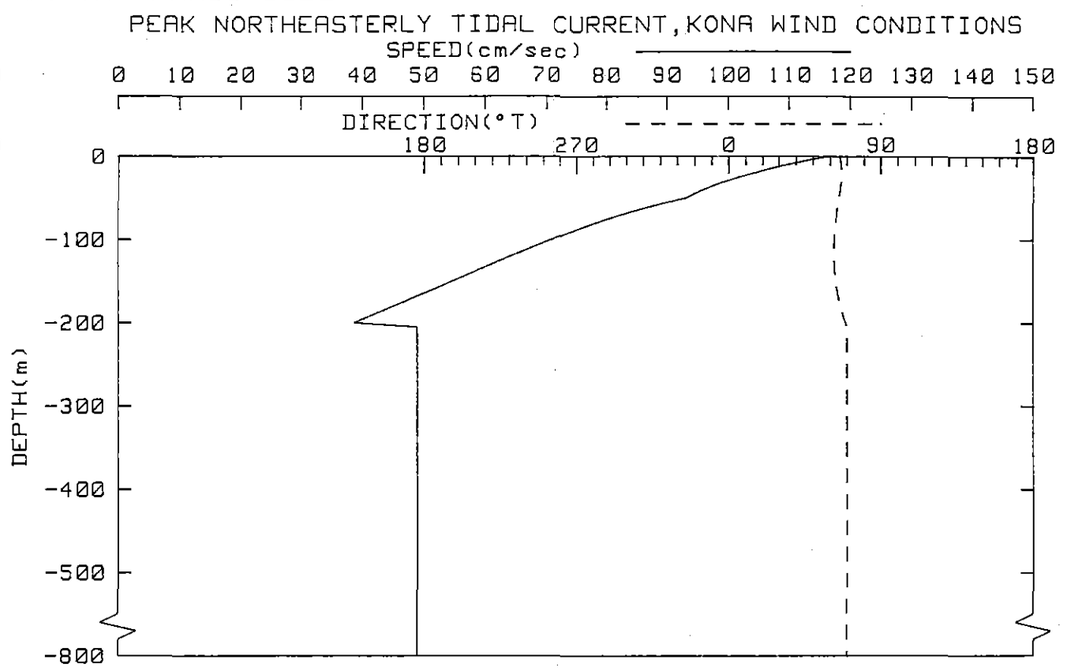


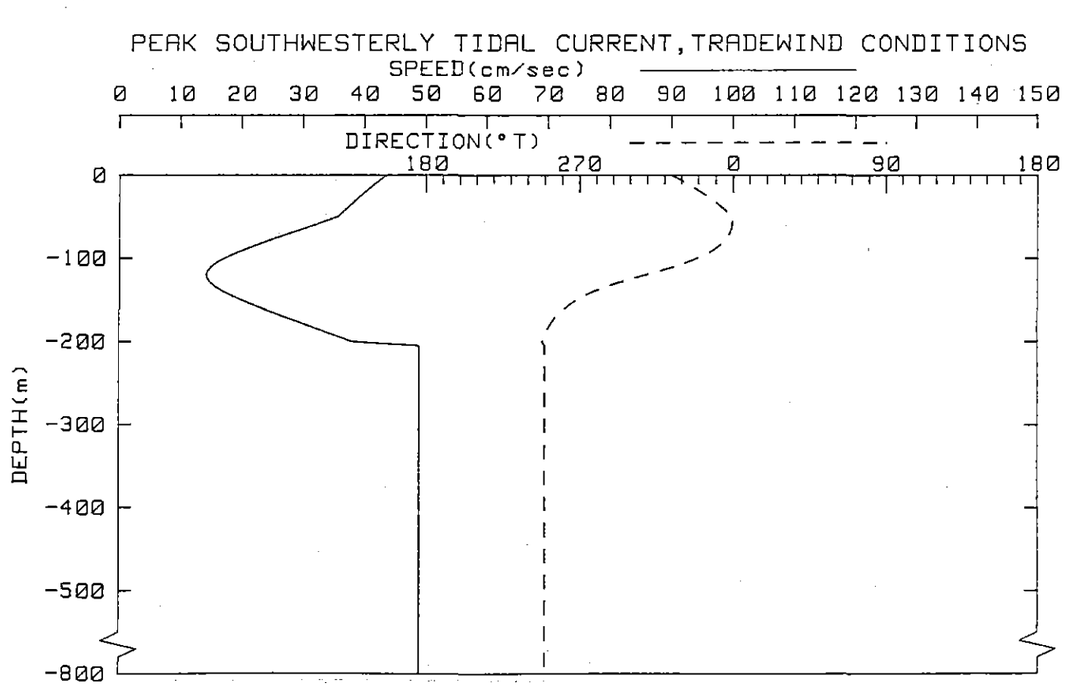


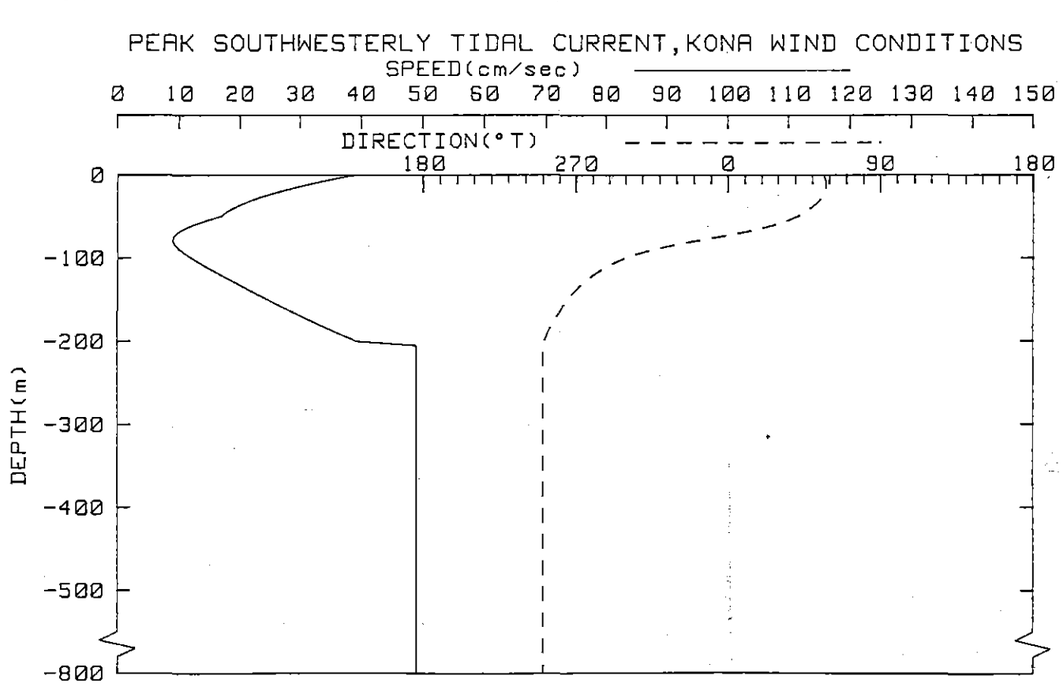


LOCATION: 800m DEPTH HAWAII SIDE



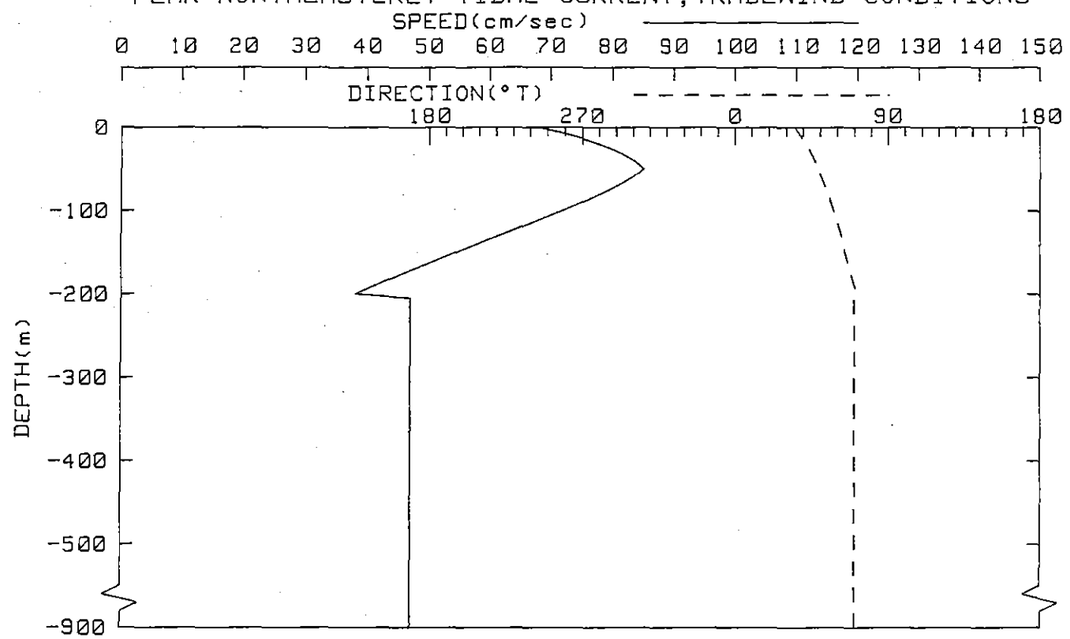




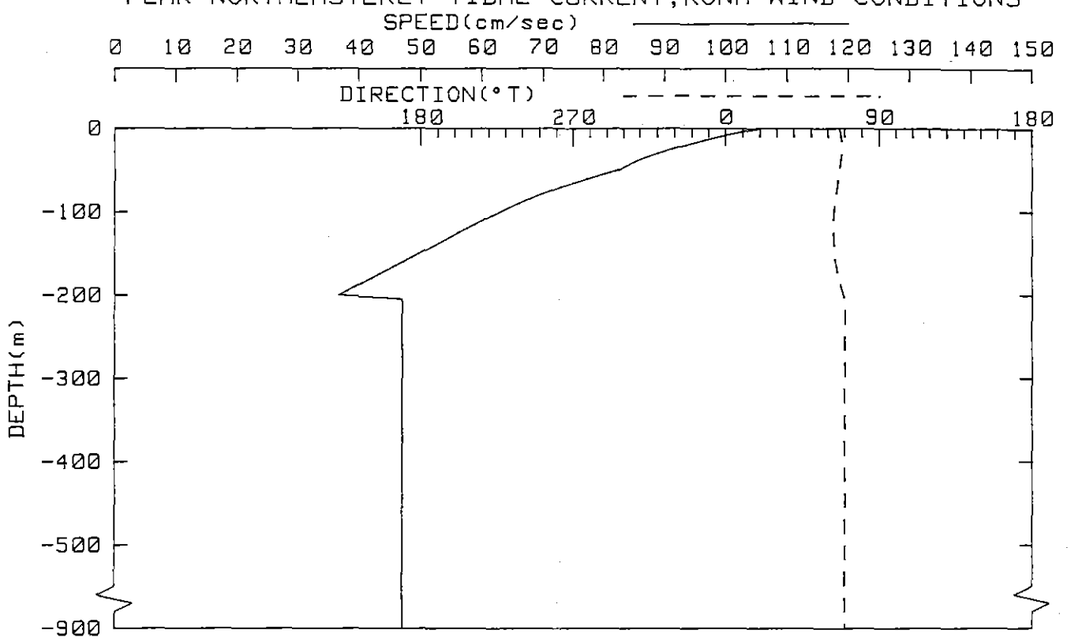


LOCATION: 900m DEPTH TOP OF KOHALA SLOPE

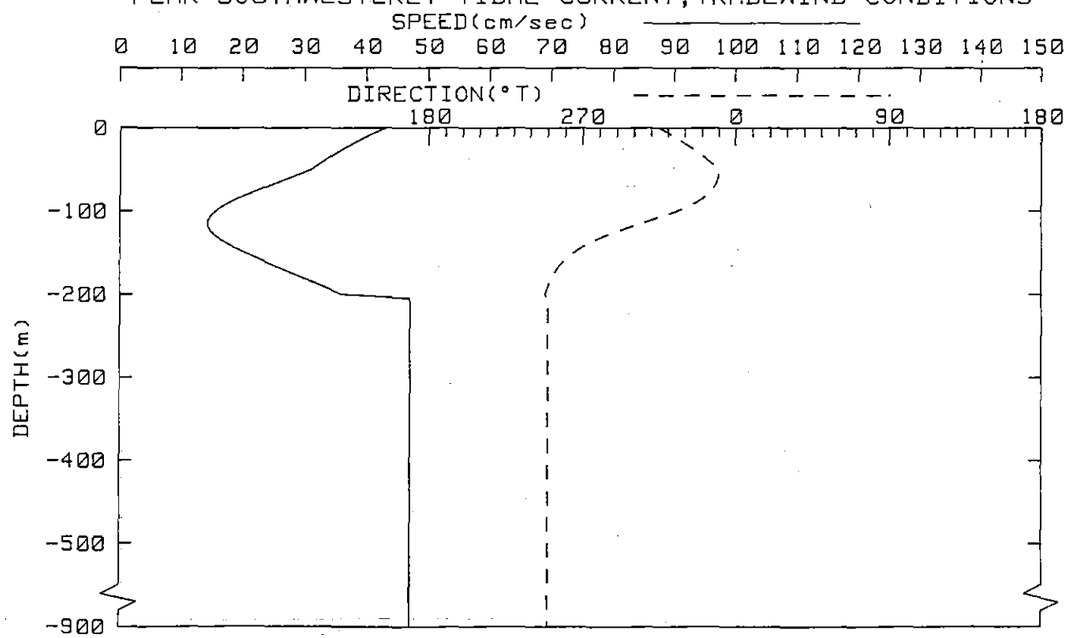
PEAK NORTHEASTERLY TIDAL CURRENT, TRADEWIND CONDITIONS



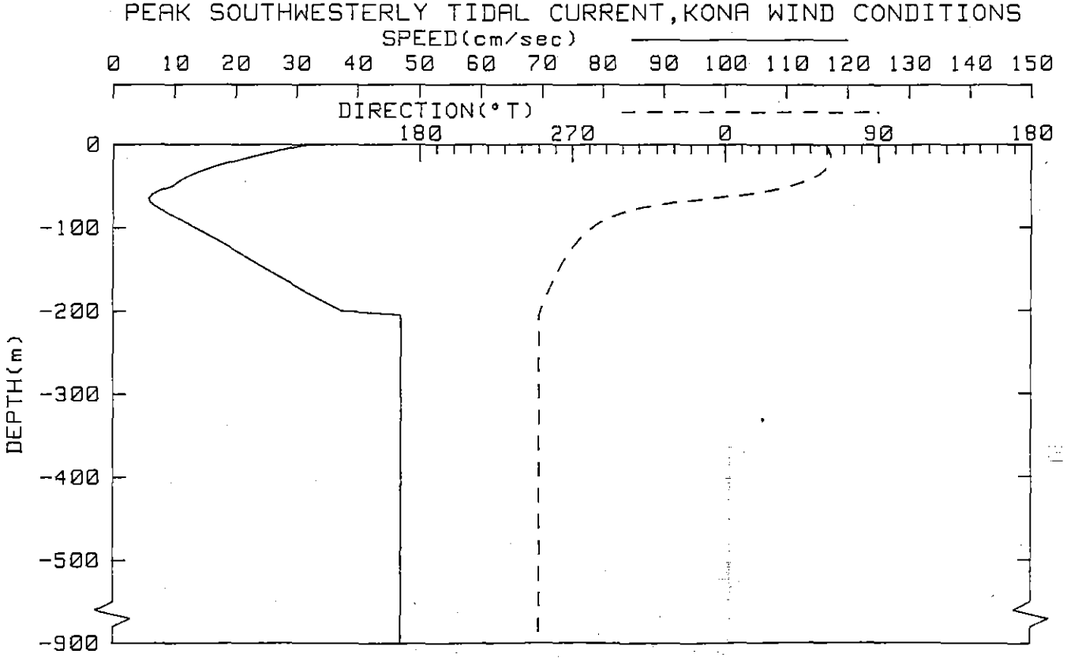
PEAK NORTHEASTERLY TIDAL CURRENT, KONA WIND CONDITIONS



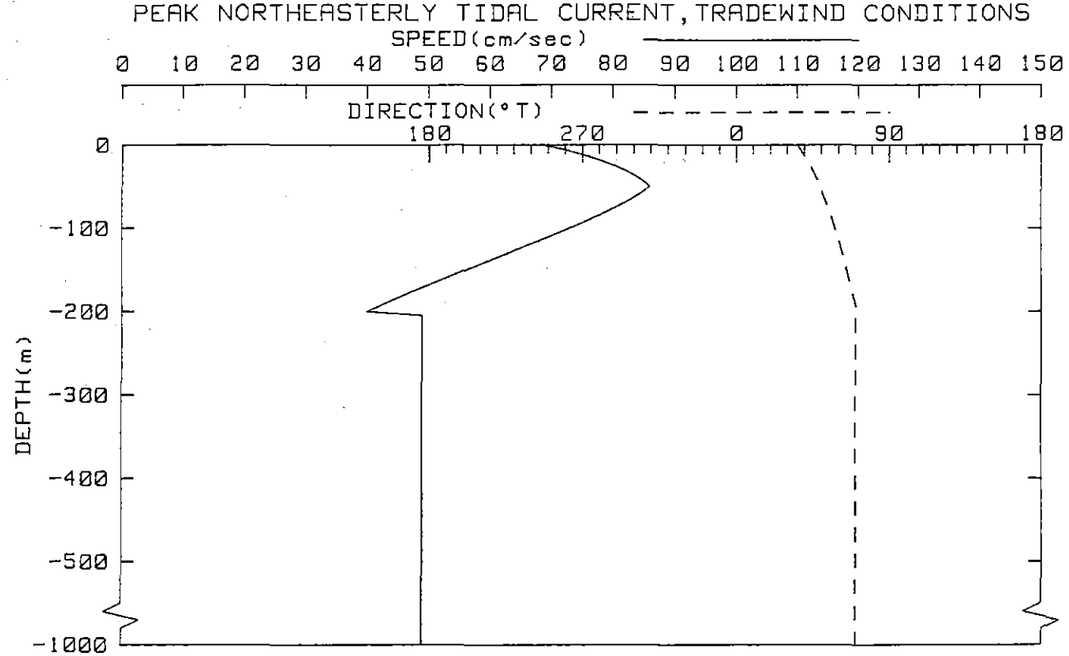
PEAK SOUTHWESTERLY TIDAL CURRENT, TRADEWIND CONDITIONS

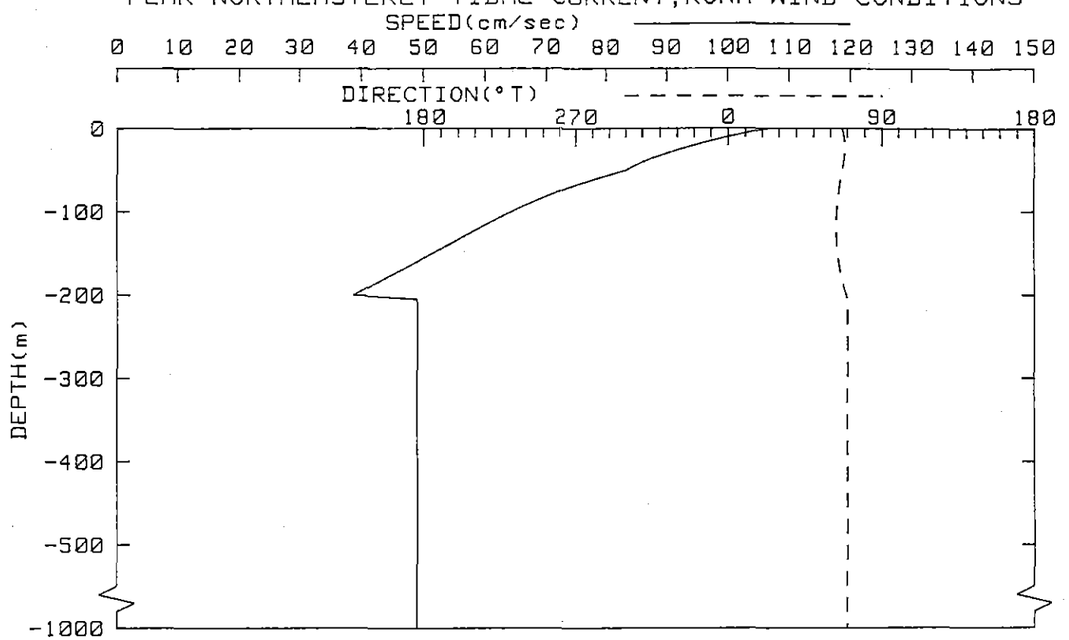


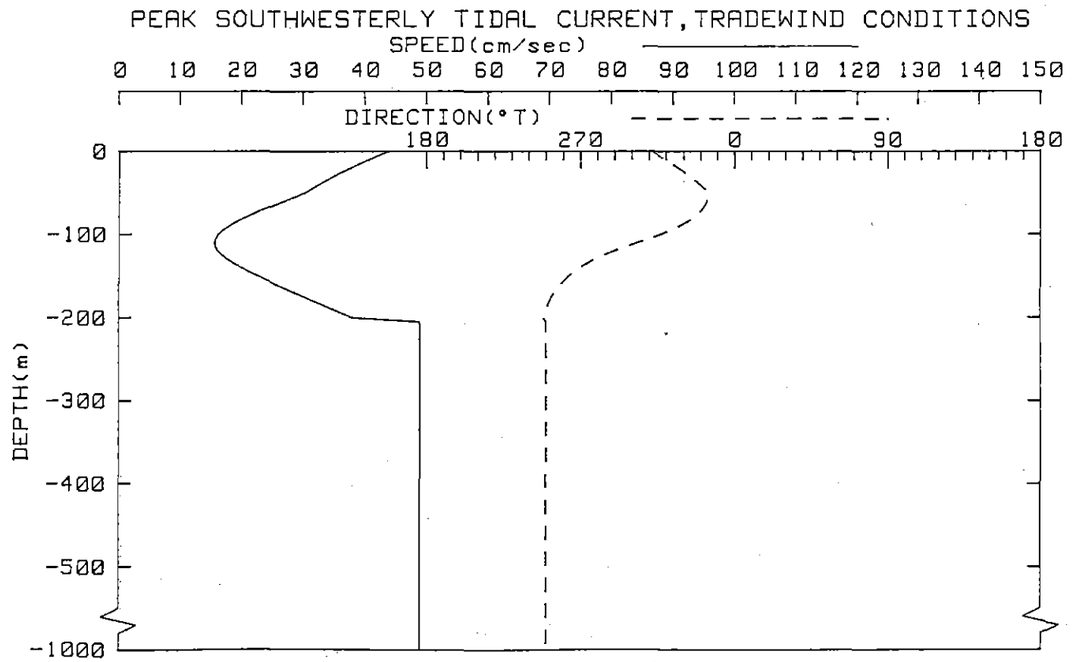
PEAK SOUTHWESTERLY TIDAL CURRENT, KONA WIND CONDITIONS

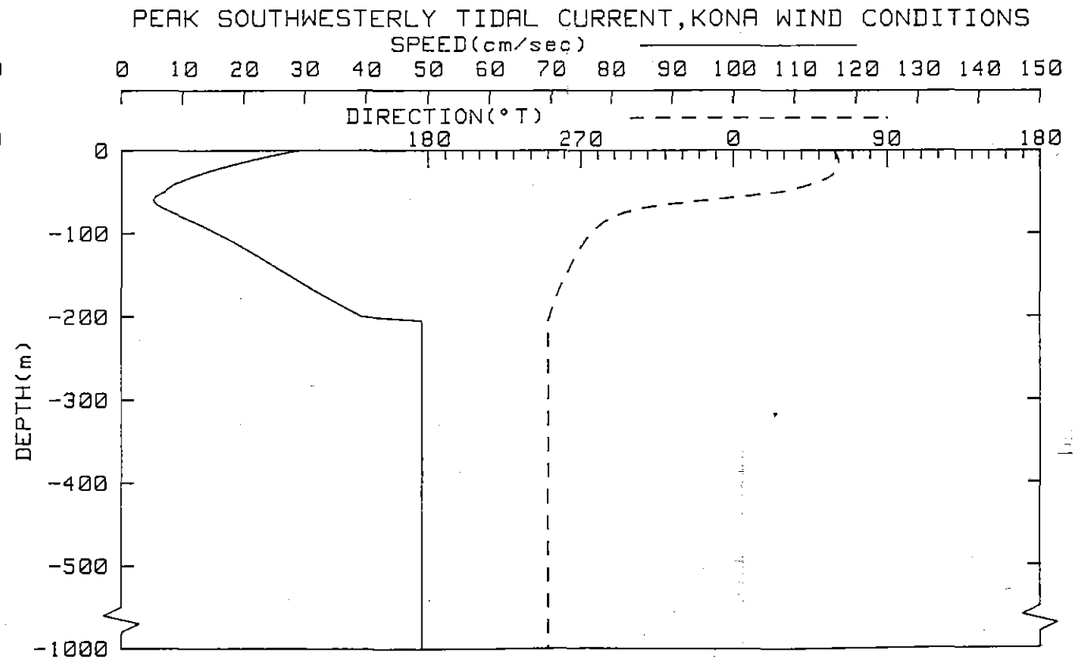


LOCATION: 1000m DEPTH ON KOHALA SLOPE

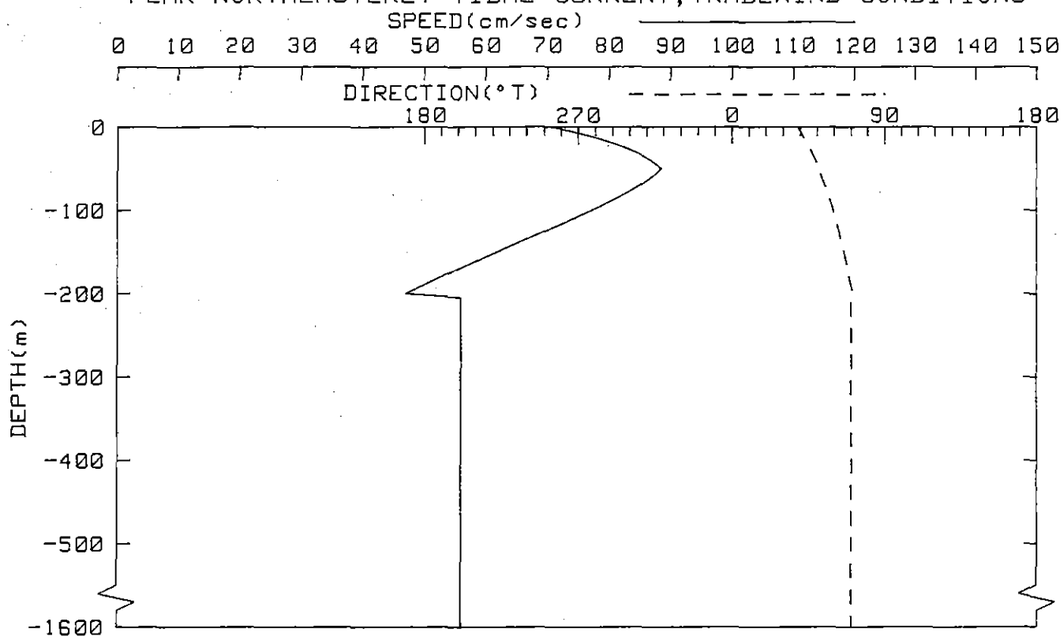


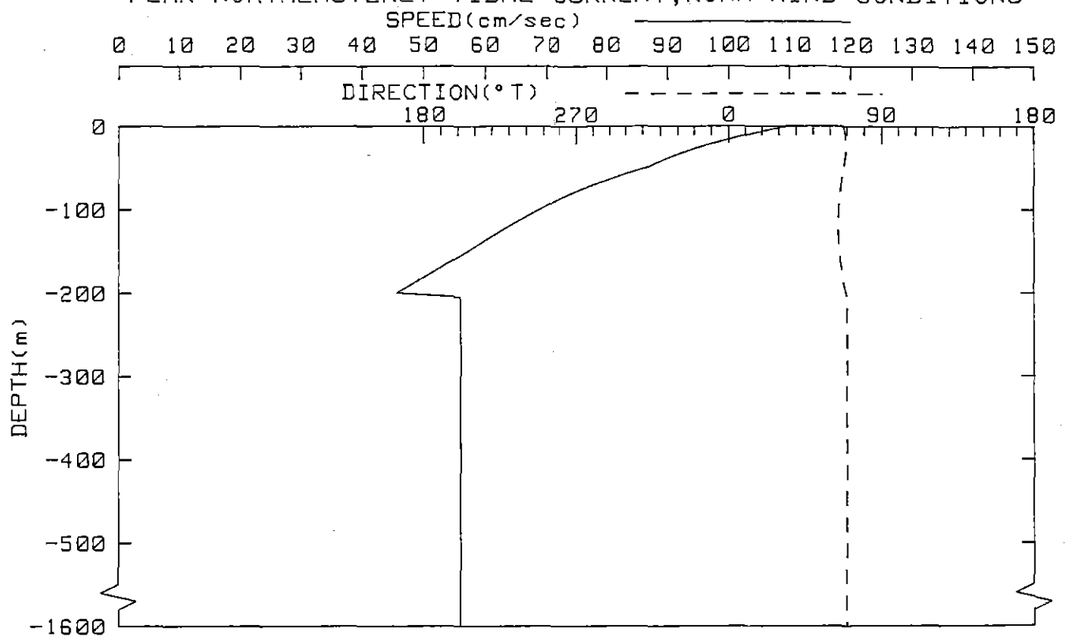


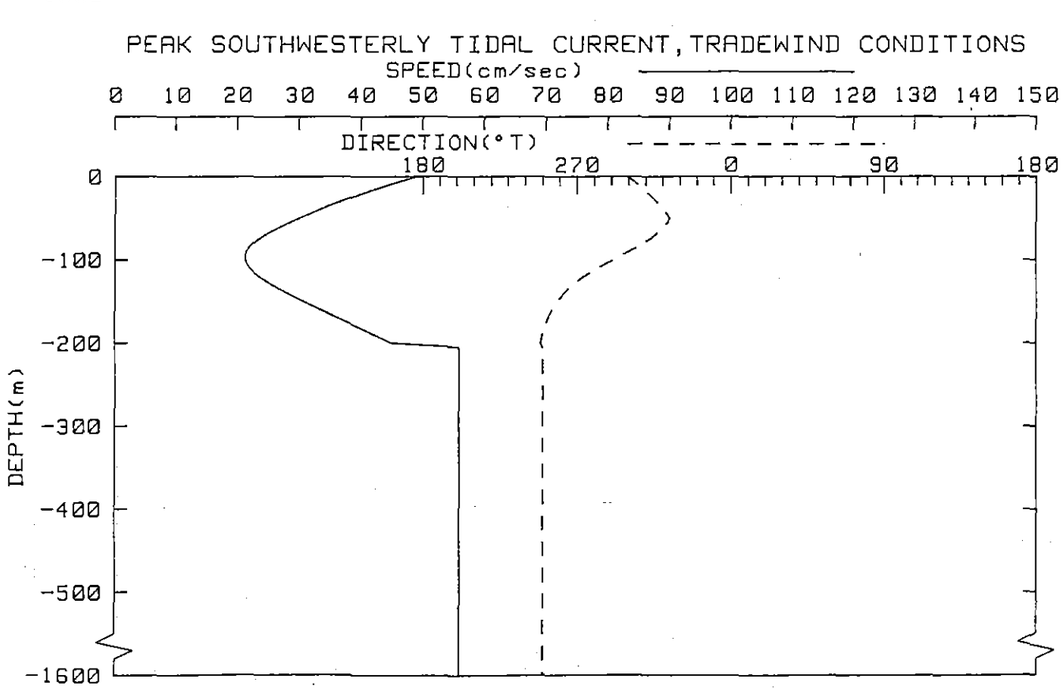


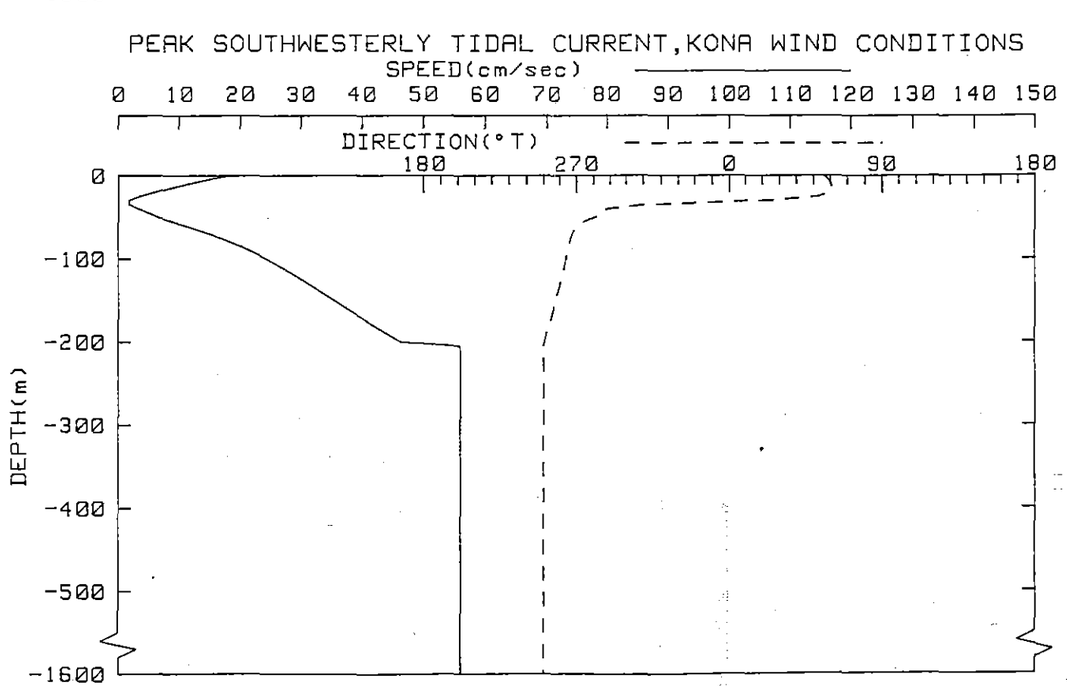


LOCATION: 1600m DEPTH ON KOHALA SLOPE



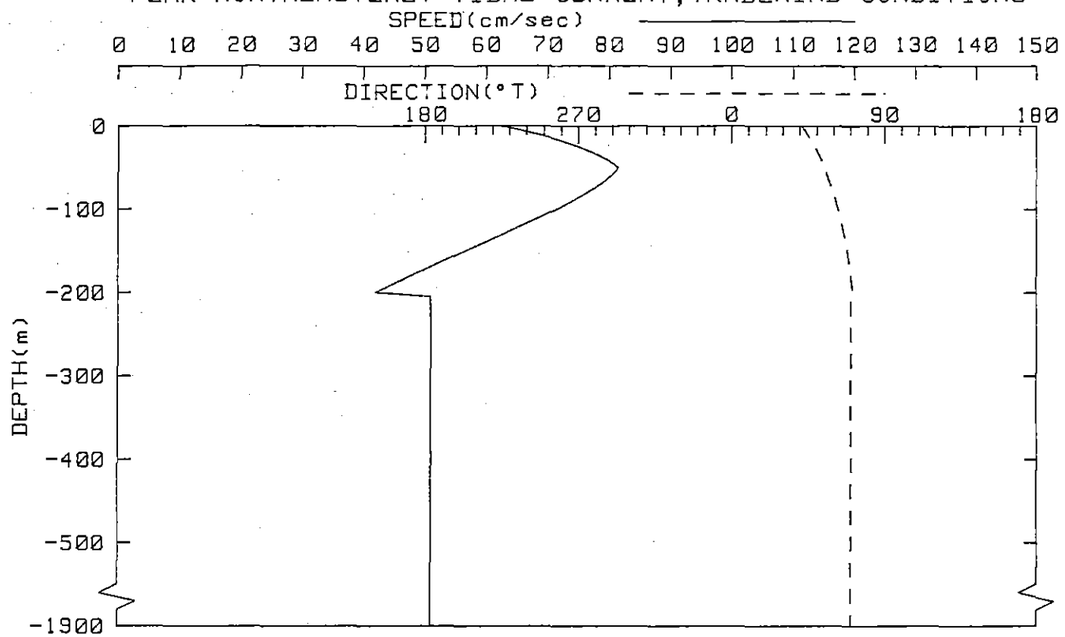




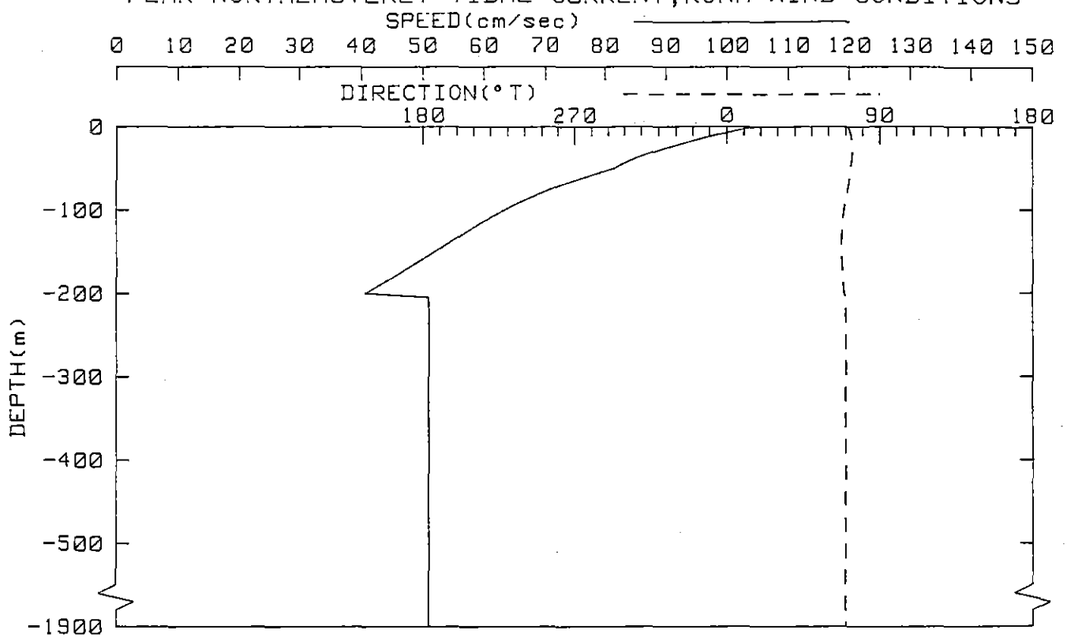


LOCATION: 1900m DEPTH BOTTOM OF KOHALA SLOPE

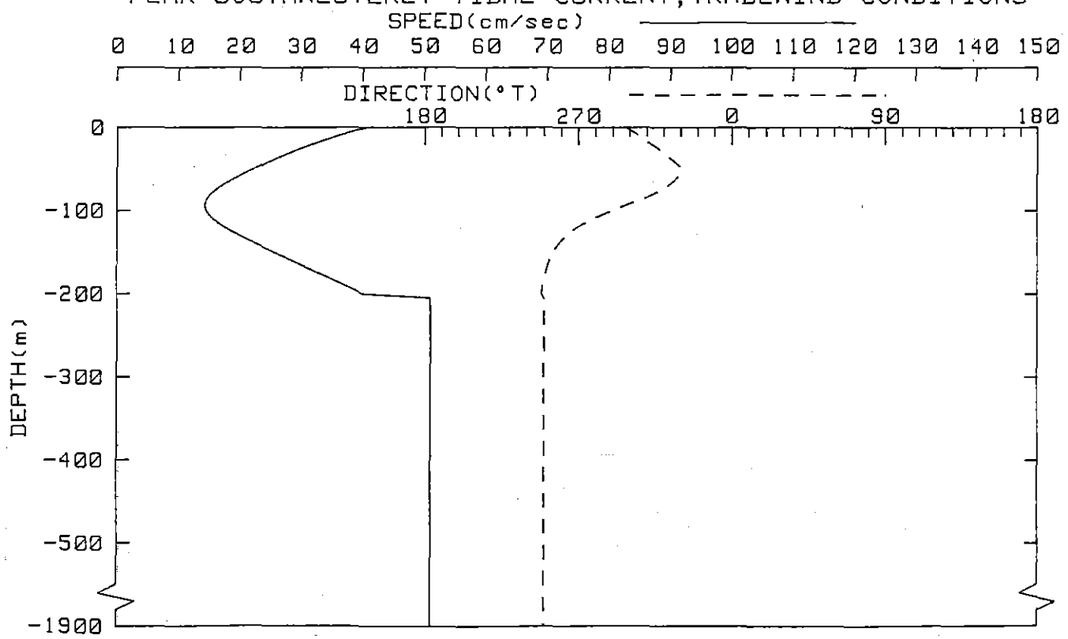
PEAK NORTHEASTERLY TIDAL CURRENT, TRADEWIND CONDITIONS



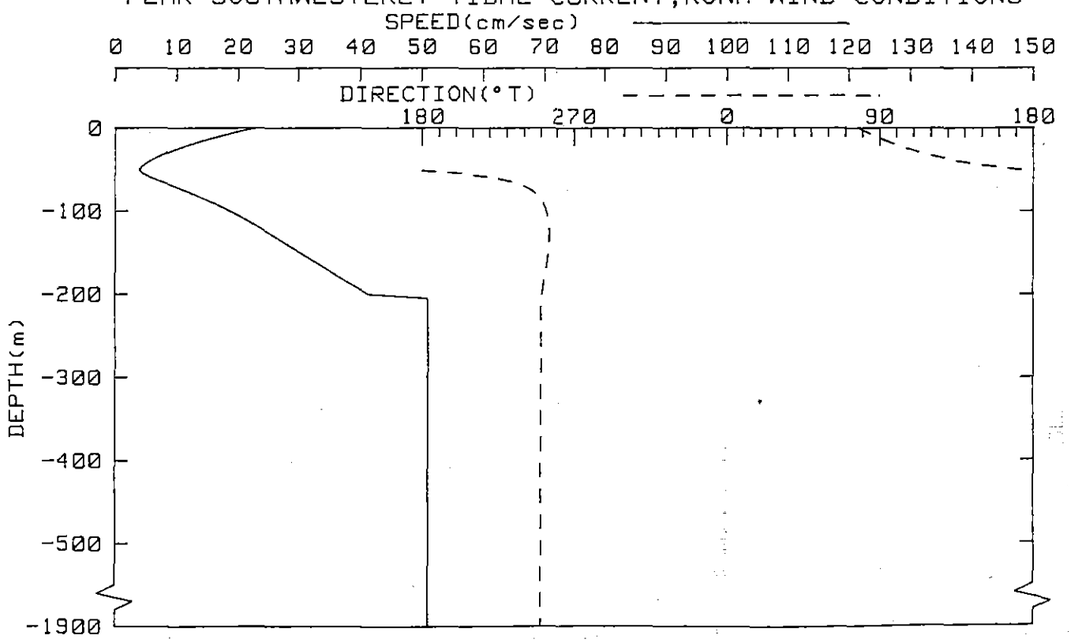
PEAK NORTHEASTERLY TIDAL CURRENT, KONA WIND CONDITIONS



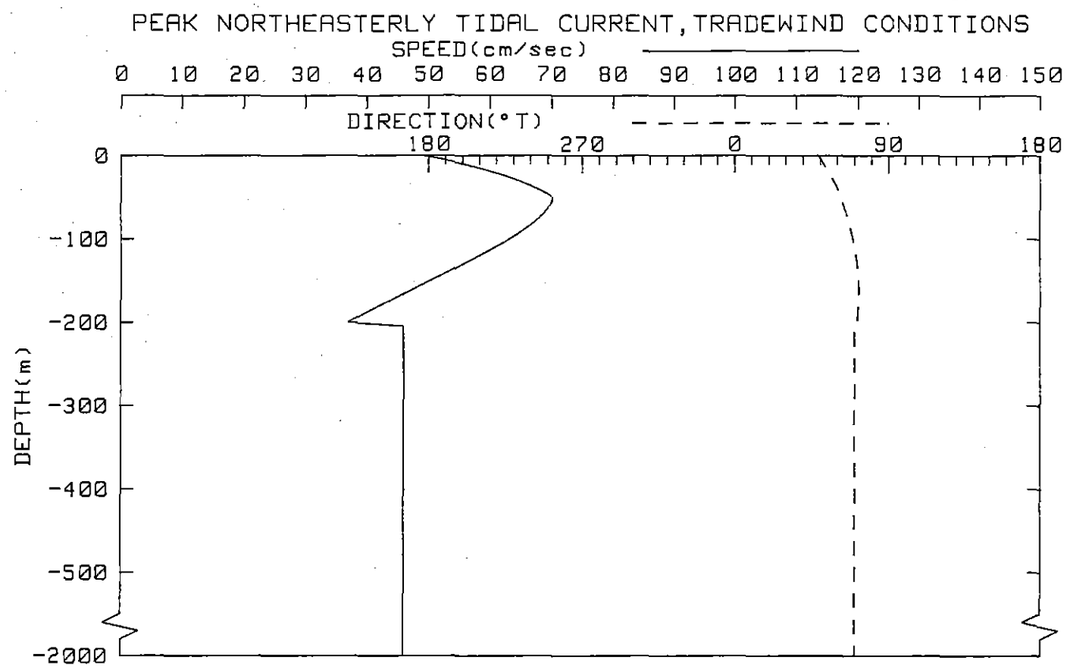
PEAK SOUTHWESTERLY TIDAL CURRENT, TRADEWIND CONDITIONS

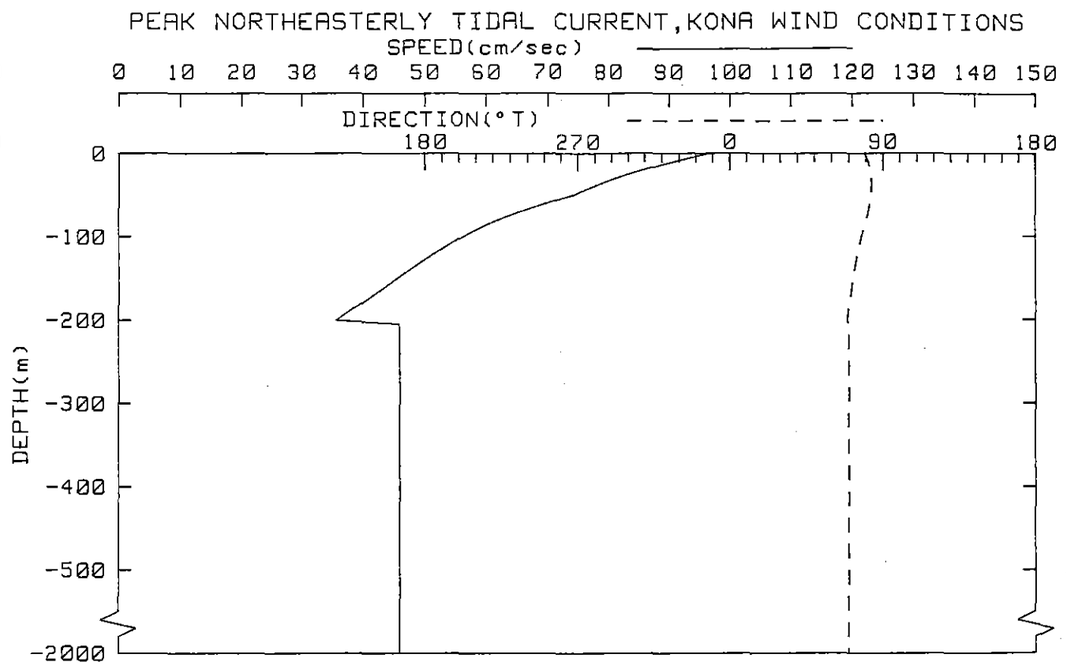


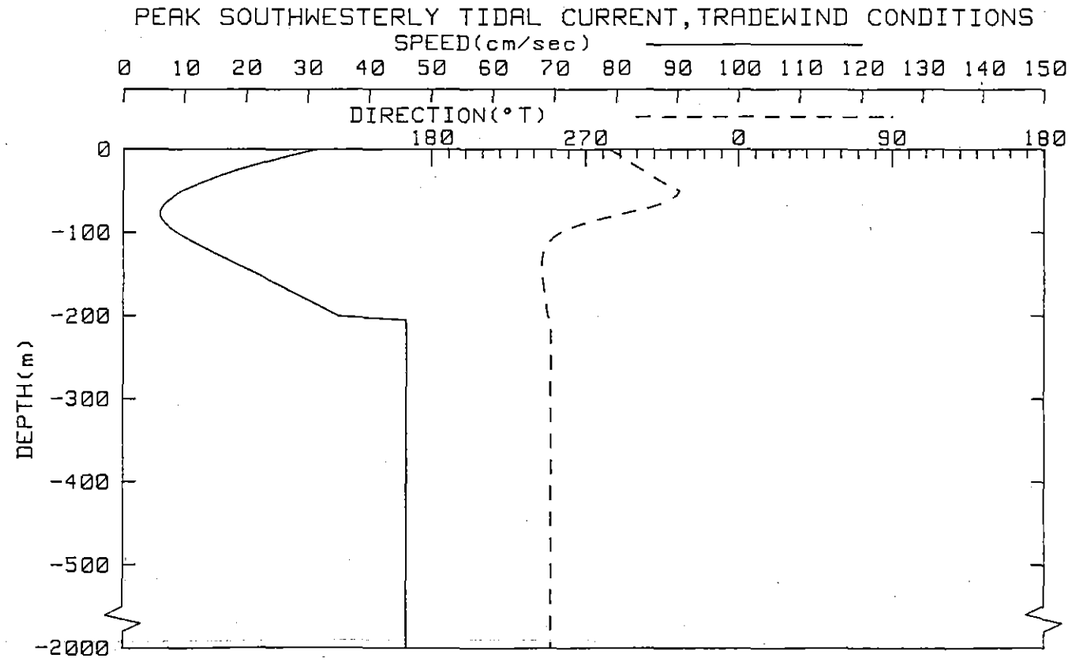
PEAK SOUTHWESTERLY TIDAL CURRENT, KONA WIND CONDITIONS

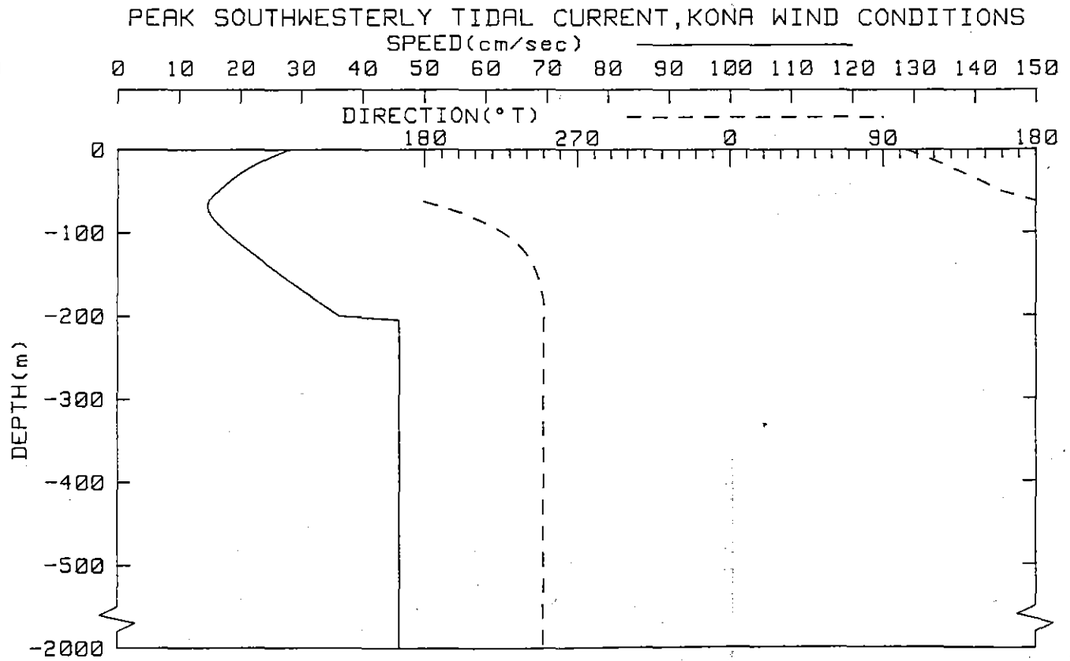


LOCATION: 2000m DEPTH

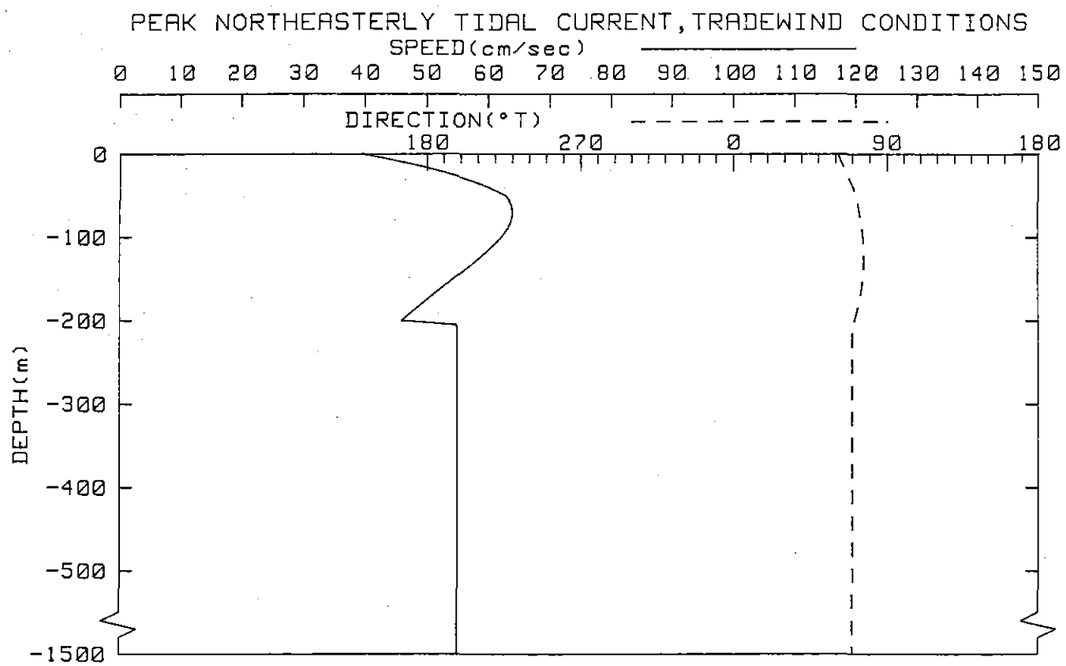


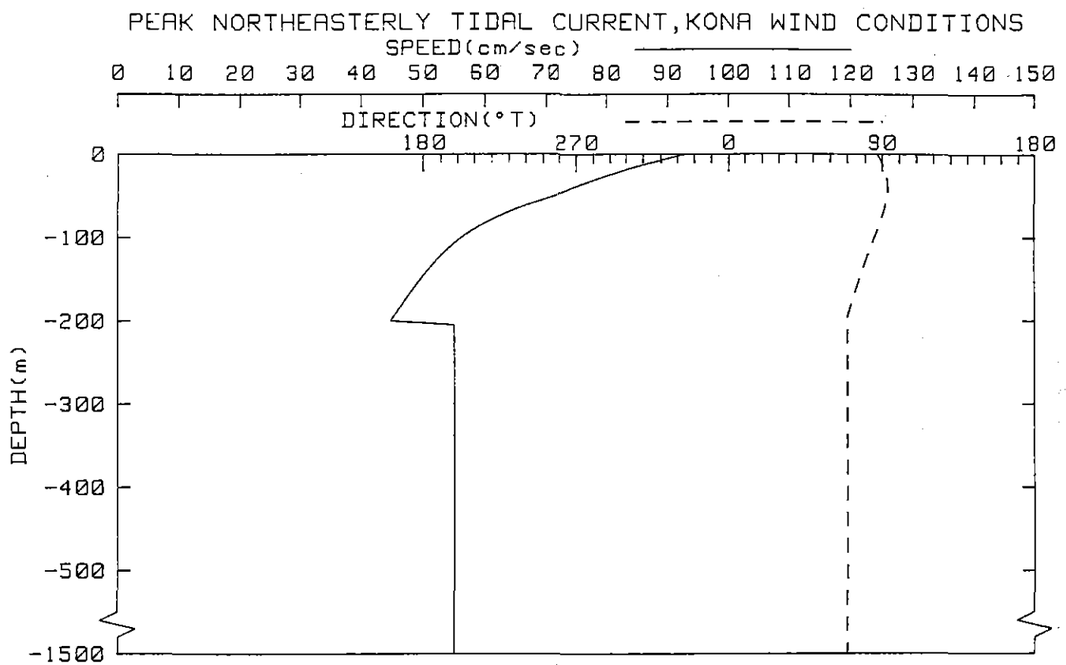


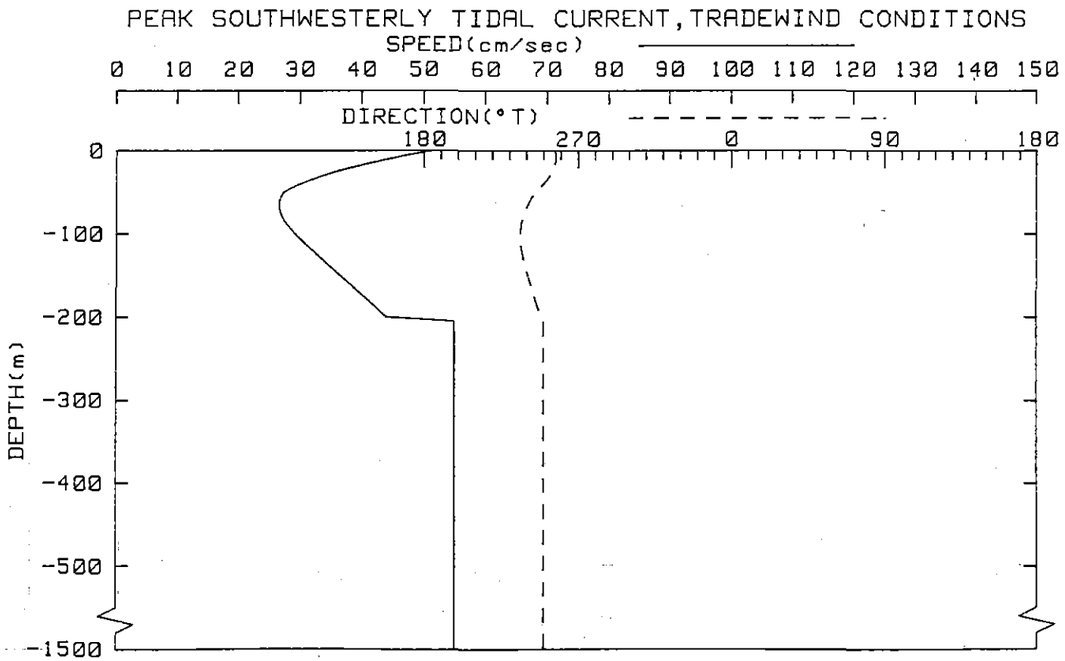


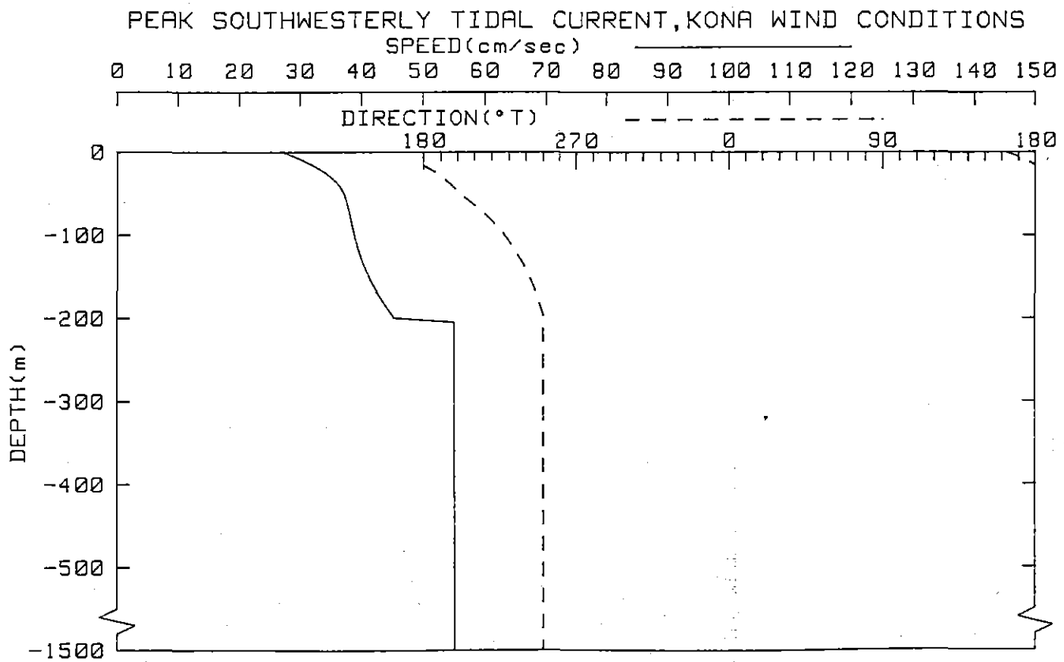


LOCATION: 1500m DEPTH MAUI SIDE



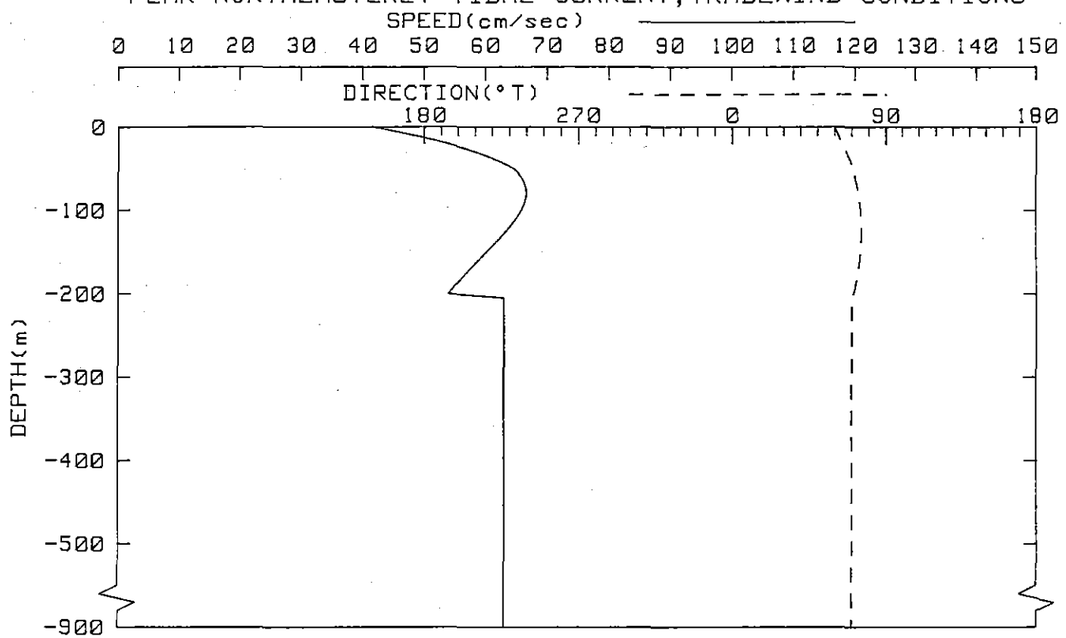




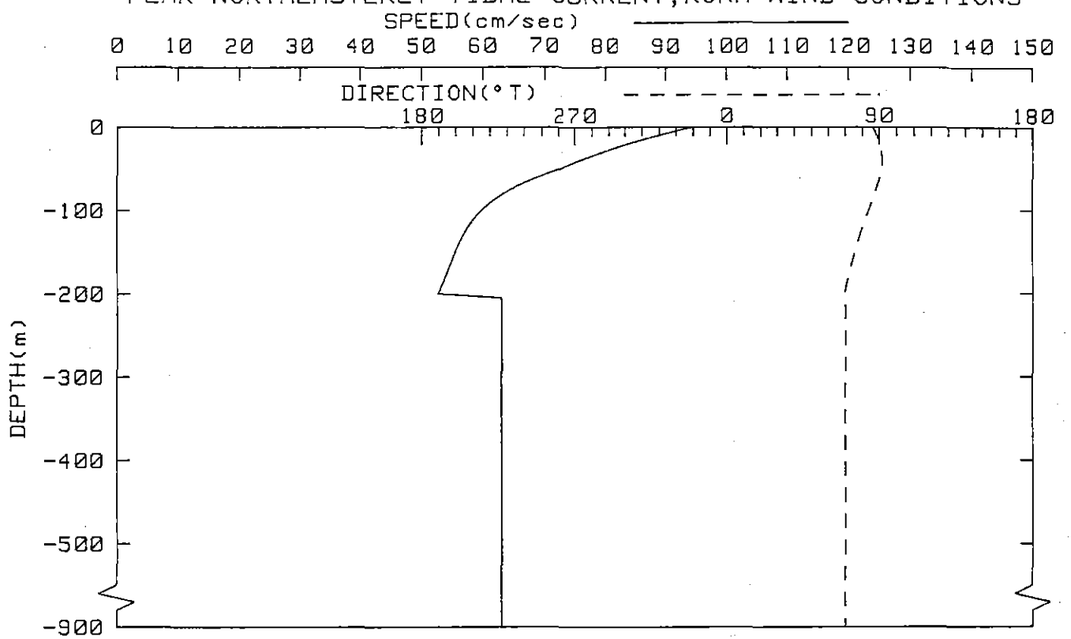


LOCATION: 900m DEPTH MAUI SIDE

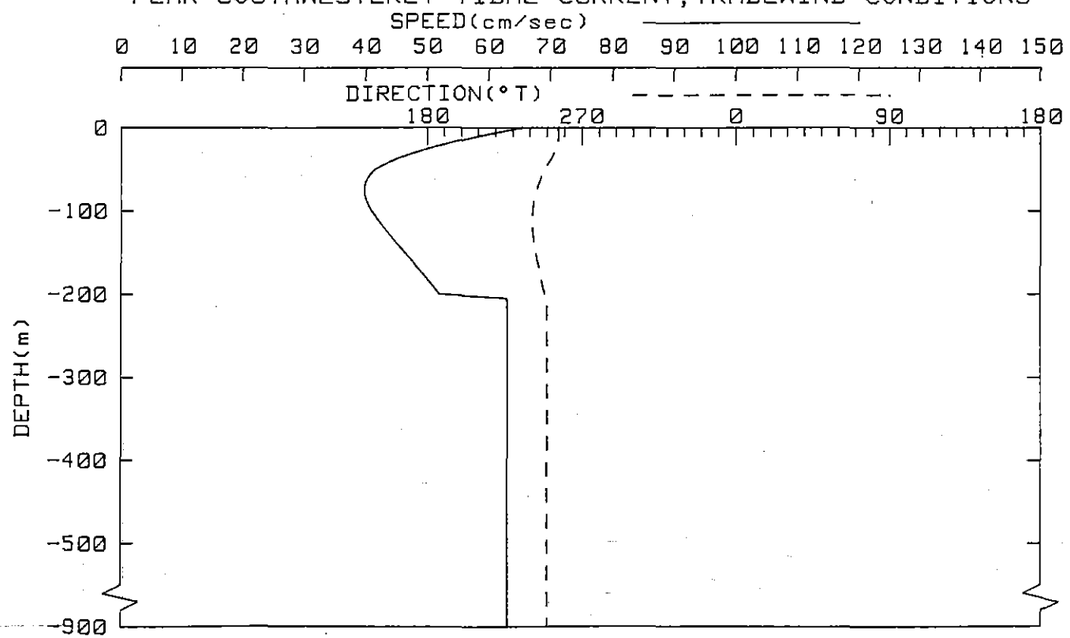
PEAK NORTHEASTERLY TIDAL CURRENT, TRADEWIND CONDITIONS



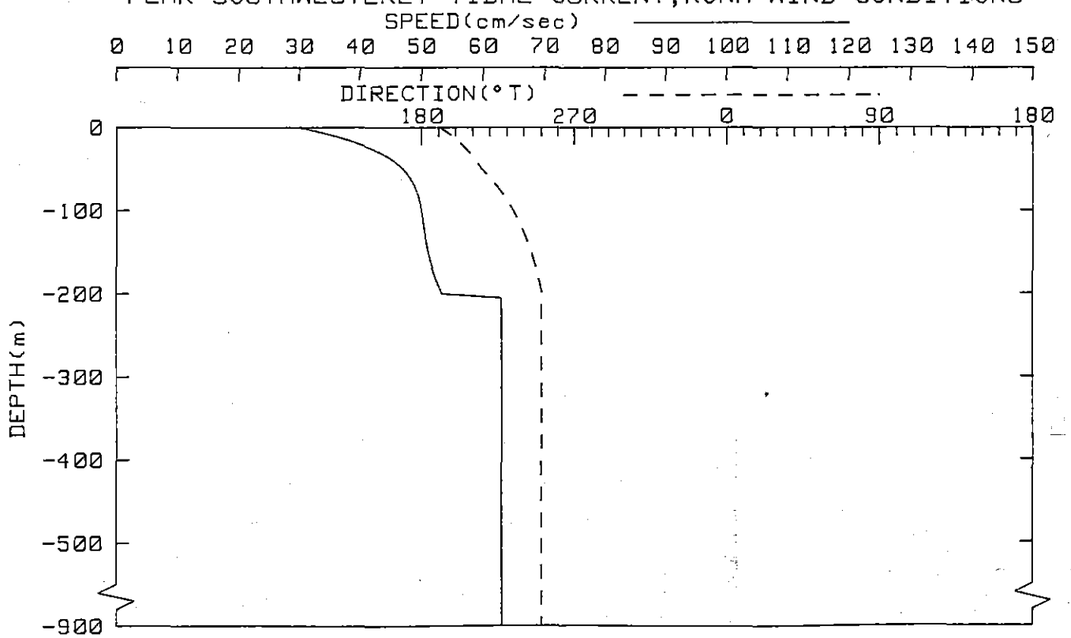
PEAK NORTHEASTERLY TIDAL CURRENT, KONA WIND CONDITIONS



PEAK SOUTHWESTERLY TIDAL CURRENT, TRADEWIND CONDITIONS

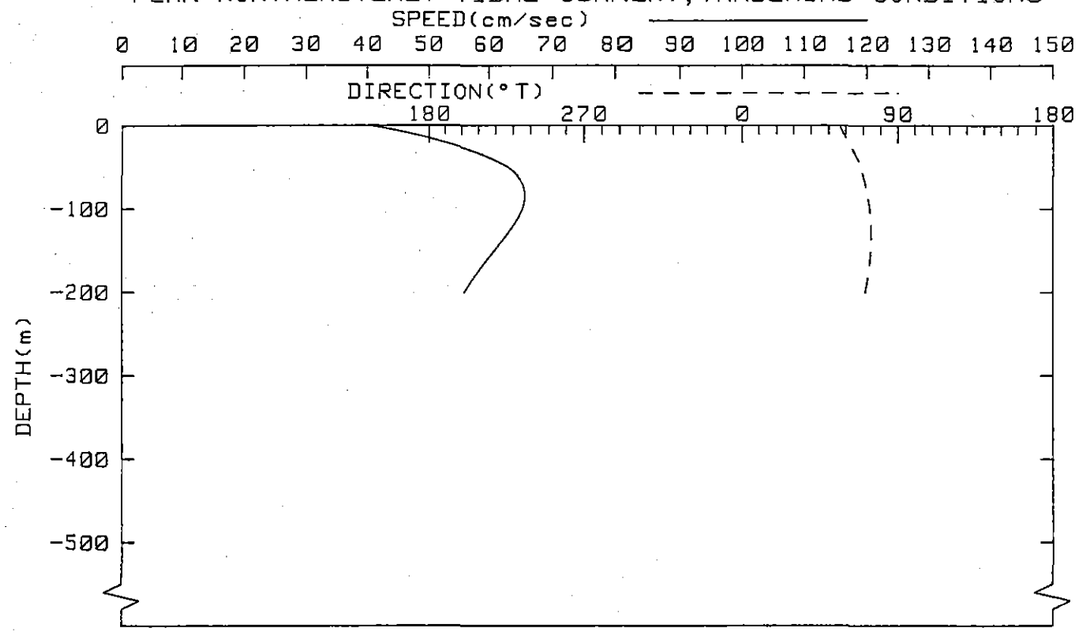


PEAK SOUTHWESTERLY TIDAL CURRENT, KONA WIND CONDITIONS

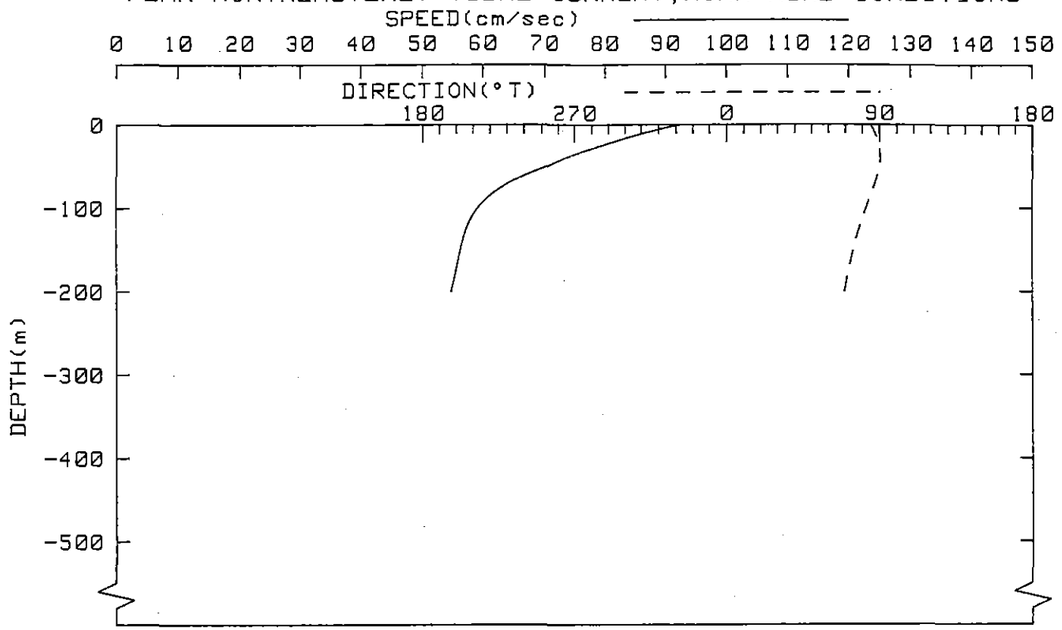


LOCATION: 200m DEPTH MAUI SIDE

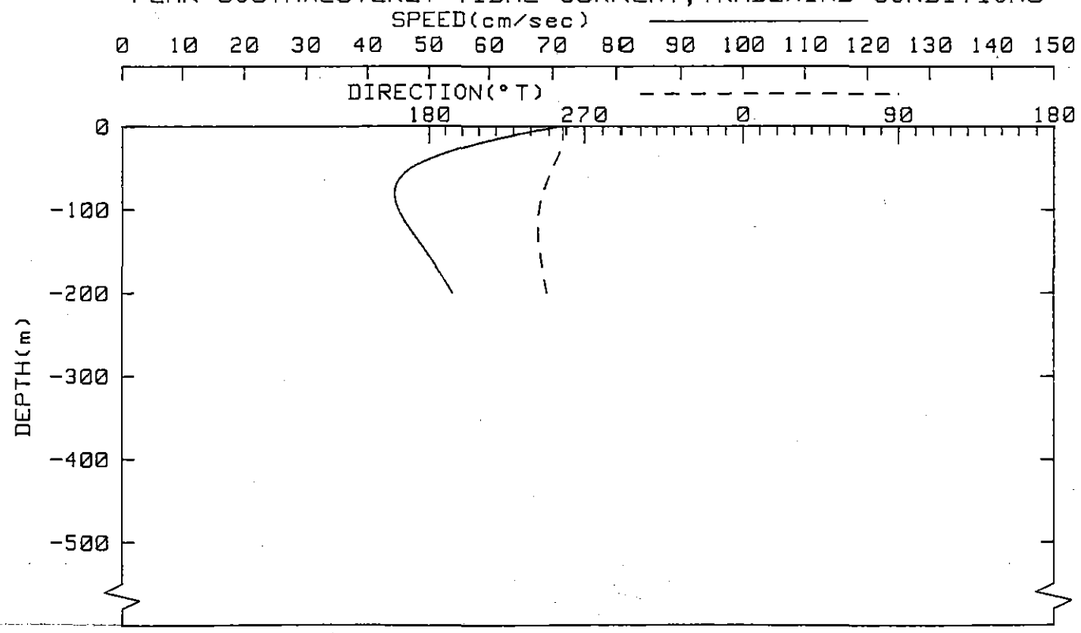
PEAK NORTHEASTERLY TIDAL CURRENT, TRADEWIND CONDITIONS



PEAK NORTHEASTERLY TIDAL CURRENT, KONA WIND CONDITIONS



PEAK SOUTHWESTERLY TIDAL CURRENT, TRADEWIND CONDITIONS



PEAK SOUTHWESTERLY TIDAL CURRENT, KONA WIND CONDITIONS