KAILUA BAY CIRCULATION (KB-5)

Hans-Jürgen Krock
Hari Sundararaghavan

PROJECT REPORT PR-94-08

October 1993

WATER RESOURCES RESEARCH CENTER
UNIVERSITY OF HAWAII AT MANOA
Honolulu, Hawaii 96822

REPORT DOCUMENTATION FORM

WATER RESOURCES RESEARCH CENTER
University of Hawaii at Manoa

[1] SERIES NUMBER: Project Report PR-94-08	[2] COWRR: 05-C
[3] TITLE: Kailua Bay circulation (KB-5)	[4] REPORT DATE: October 1993
	[5] NO. OF PAGES: x + 180
	[6] NO. OF TABLES: 0 / [7] NO. OF FIGURES: 11
[8] AUTHORS: Hans-Jürgen Krock, Hari Sundararaghavan	[9] GRANT AGENCY: Department of Wastewater Management, City and County of Honolulu
	[10] CONTRACT NUMBER: C62710

[11] DESCRIPTORS: water circulation, water transport, water currents, bacteria

IDENTIFIERS: current meters, drogue and dye, wind-induced transport, wastewater discharge, land-derived discharge, Mokapu Ocean Outfall, Kailua Bay, Oahu, Hawaii

[12] ABSTRACT (PURPOSE, METHOD, RESULTS, CONCLUSIONS)

The objective of this study is to describe the transport characteristics of Kailua Bay, Oahu, Hawaii. This will allow a comparison of the relative importance of the wastewater discharged through the Mokapu Ocean Outfall with land-derived discharges on the bacteriological conditions in the recreational area of Kailua Bay. Measurements were made with current meters and drogues and dye. The results show that land-derived discharges have a much greater influence on the bacteriological water quality off Kailua Beach than does the Mokapu outfall discharge. The outfall discharge transport is primarily in the northerly direction and away from Kailua Bay. However, when the wind is directly from the north or from north by northeast, a portion of the surface layer from the Mokapu diffuser area can be transported to the reef area off south Kailua Beach and off Lanikai. Even under these conditions, the resulting bacteriological effect on the waters is less than 1% of that from land-derived discharges.

2540 Dole Street • Honolulu, Hawaii 96822 • U.S.A. • (808) 956-7847

KAILUA BAY CIRCULATION (KB-5)

Hans-Jürgen Krock
Hari Sundararaghavan

Project Report PR-94-08

October 1993

PREPARED FOR
Department of Wastewater Management
City and County of Honolulu
Project Report
for
"Kailua Bay Studies: Water Quality and Water Circulation"
Project No.: C62710
Project Period: 1 July 1990–31 October 1993
Principal Investigator: Roger S. Fujioka

WATER RESOURCES RESEARCH CENTER
University of Hawaii at Manoa
Honolulu, Hawaii 96822

ACKNOWLEDGMENTS

We thank the following organizations and individuals for their help during this study: boat services by Sea Engineering, Inc. and Kala Kukea, by the City and County of Honolulu and Alvin Muranaka and his crew, by the Hawaii Institute of Marine Biology and Bob Mau and his crew, and by Edwin Hayashi; field work by Roland Kanno, Steve Sakata, Steve Oney, Shung Sheng Fu, and others; and instrument preparation by the Hawaii Institute of Geophysics electronics shop and Jeff Bosel and his crew, and by Ray Cote of the Look Laboratory electronics shop.

Report preparation was done primarily by Edith Katada and Kim Matsuki of the Department of Ocean Engineering and Look Laboratory, with editing services done by Karen Tanoue and graphics by April Kam of the Water Resources Research Center.

ABSTRACT

The objective of this study is to describe the transport characteristics of Kailua Bay, O'ahu, Hawai'i. This will allow a comparison of the relative importance of the wastewater discharged through the Mokapu Ocean Outfall with land-derived discharges on the bacteriological conditions in the recreational area of Kailua Bay. Measurements were made with current meters and drogues and dye. The results show that land-derived discharges have a much greater influence on the bacteriological water quality off Kailua Beach than does the Mokapu outfall discharge. The outfall discharge transport is primarily in the northerly direction and away from Kailua Bay. However, when the wind is directly from the north or from north by northeast, a portion of the surface layer from the Mokapu diffuser area can be transported to the reef area off south Kailua Beach and off Lanikai. Even under these conditions, the resulting bacteriological effect on the waters is less than 1% of that from land-derived discharges.

CONTENTS

INTRODUCTION 1

Background 1

Approach 4

Objectives 5

MATERIALS AND METHODS 5

Direct Measurements 5

Observations 11

Calculations 12

RESULTS 13

Nearshore Transport 13

Offshore Transport 15

Wind Effect 18

CONCLUSIONS 23

REFERENCES CITED 24

APPENDIXES 25

Appendix A. Current Measurements for First Deployment: April–August 1991

Appendix B. Current Measurements for Second Deployment: March–May 1992

Appendix C. Current Measurements for Third Deployment: April–May 1993

Appendix D. Current Meter String Designs and Specifications

Appendix E. Drogue, Dye, and Depth Measurements

Appendix F. Tide Charts: 1991–1993

Figures

1. Aerial photo montage of Kailua Bay 2

2. Bathymetric profile at center of Kailua Bay and three transport zones 3

3. Current meter locations for first deployment, Kailua Bay 6

4. Current meter locations for second deployment, Kailua Bay 7

5. Current meter locations for third deployment, Kailua Bay 8

6. Kailua Bay drainage basin 14
7. Kailua Bay nearshore circulation pattern 16
8. Large-scale current effect on mixed layer transport at Kailua Bay 17
9. Predominant wind effect on surface layer at Kailua Bay 20
10. Kaneohe Marine Corps Air Station wind rose 21
11. North and north by northeast wind effect on surface layer at Kailua Bay 22

INTRODUCTION

This study is part of the assessment of the bacteriological conditions in Kailua Bay, on the windward coast of O'ahu, with respect to the relative contributions from the Mokapu Ocean Outfall and from land-derived inputs. The assessment is an undertaking by University of Hawaii researchers under a contract between the Water Resources Research Center (WRRC) of the University of Hawaii at Manoa and the City and County of Honolulu Department of Wastewater Management.

This study seeks to describe the physical processes responsible for the transport of seawater, wastewater, groundwater, and surface drainage through Kailua Bay.

Background

Kailua Bay is an indentation in the coastline of windward O'ahu, bounded by Mōkapu Point at the north end and Wailea Point at the south end. As can be seen in Figure 1, Kailua Bay does not fit the classical definition of an embayment because it has no restricted mouth and, hence, is susceptible on the seaward side to open coastal transport conditions.

The two ends of Kailua Bay are significantly different. The south end is a reef flat area contiguous with Waimānalo Bay, whereas the north end at Mōkapu Peninsula has no adjacent reef flat but, instead, has deep water close to shore.

For transport description purposes, Kailua Bay is divided into three zones (Figure 2). The first is essentially the reef flat area, which is shallower than the 5-m (16.4-ft) bathymetric contour. In this zone, the major forces causing transport are (1) the tide, (2) breaking waves, (3) the freshwater inflow-induced gradient, and (4) wind stress. The second zone is the surface layer (down to about 5 m) outside the 5-m bathymetric contour. The main forces causing transport here are (1) the underlying alongshore current and (2) wind stress. The third zone is the lower layer outside the 5-m bathymetric contour, where the primary force causing transport is the tide-related along shore current that generally runs parallel to the bathymetric contours.

The description of the transport processes in Kailua Bay is based on a general theoretical

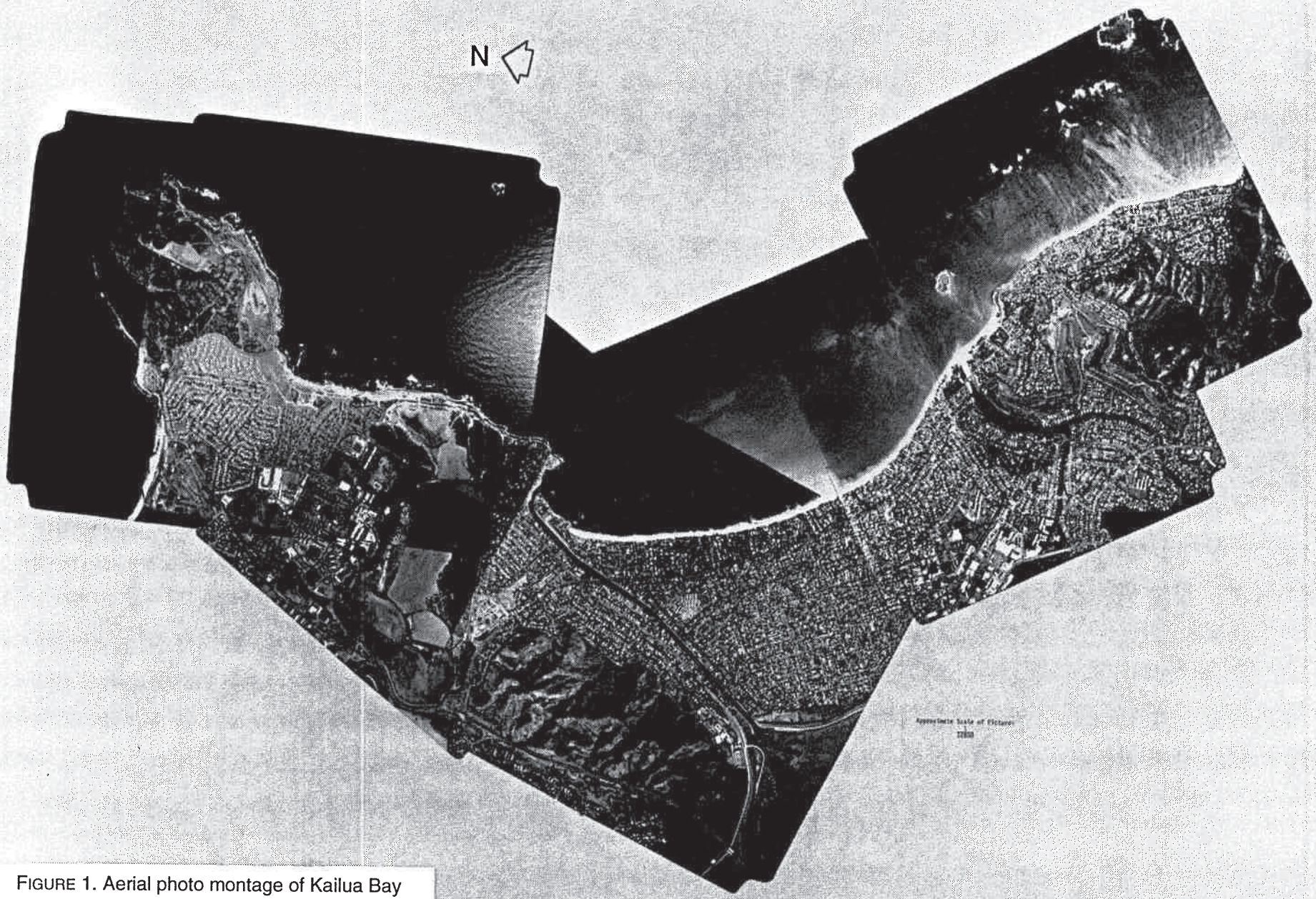


FIGURE 1. Aerial photo montage of Kailua Bay

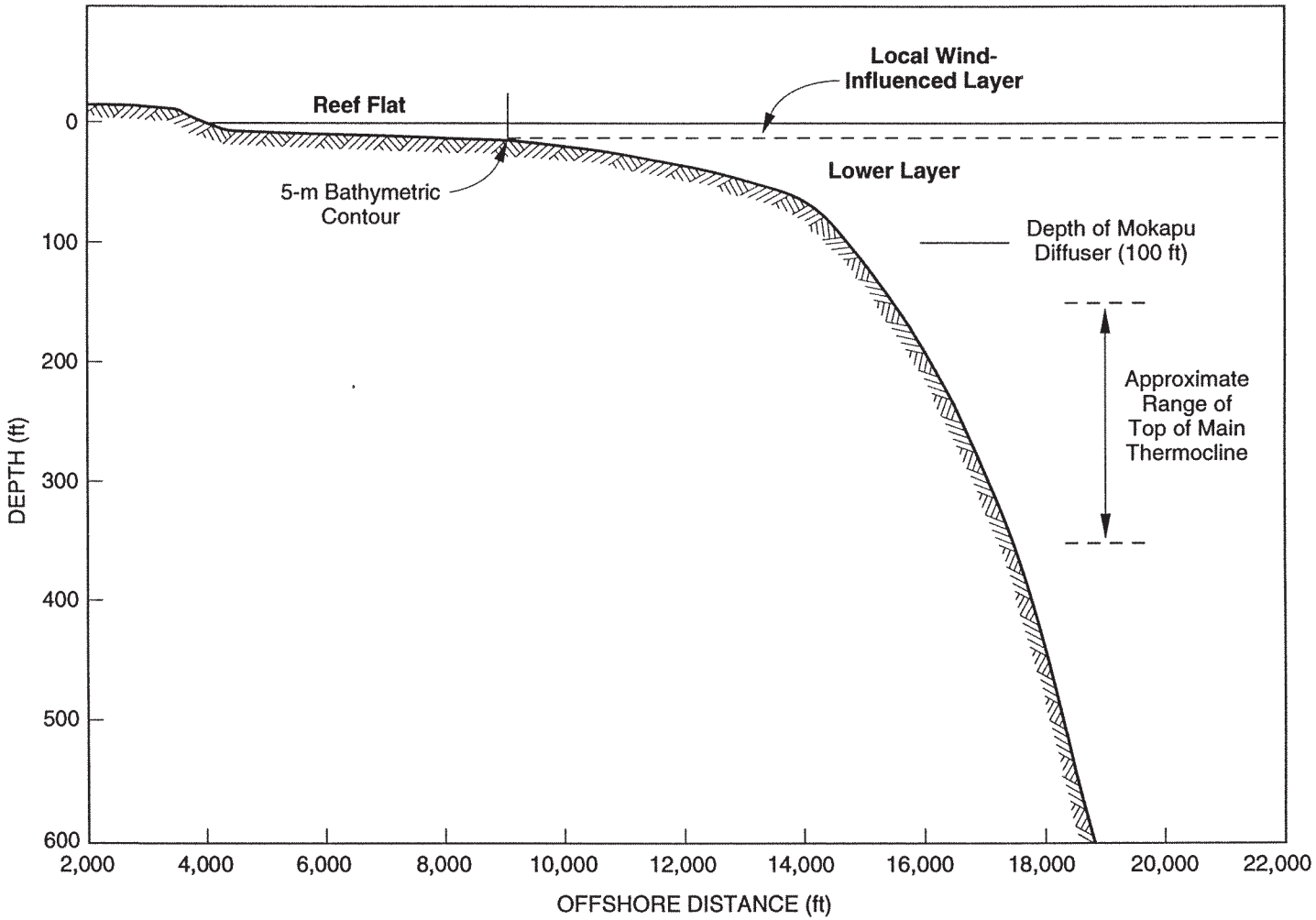


FIGURE 2. Bathymetric profile at the center of Kailua Bay and three transport zones (reef flat, wind-influenced surface layer outside 5-m bathymetric contour, and lower layer outside 5-m bathymetric contour)

understanding of the forces that cause the transport. This theoretical understanding is applied to the available data sets that have been taken, over the years, by several investigators. These data sets show that the water motion in Kailua Bay is complex enough to require a stochastic (statistical) approach; however, the general pattern is explainable by applying our theoretical understanding of the forces causing the transport.

Approach

The data required to describe the transport phenomena in Kailua Bay include those available from standard sources and those from direct measurements. Standard sources provide information on the wind field, tide, rainfall pattern, and bathymetry and morphology of the bay. Direct measurements taken during this study were accomplished through current meter deployments and drogue and dye studies. In addition, direct observations were made of the nearshore transport patterns using kayaks and of the initial dilution process from the Mōkapu outfall diffuser using scuba.

The current meter data were analyzed using standard statistical techniques and interpreted in the context of the bathymetry and coastal morphology and orientation. Drogue and dye measurements taken outside the 5-m bathymetric contour provided information on the combined effect of the underlying tide-related current and the wind field-induced flow as it approaches the reef area. Drogue and dye observations made inside the 5-m bathymetric contour showed the transport pattern off the Kailua Beach area to be classical for such a curved beach—the seawater comes in from both sides and goes out through the middle of the bay. Further, the inflow of freshwater from the land at both ends of Kailua Beach adds to the offshore gradient as it mixes with the seawater and follows the same transport pattern.

The probability of some of the discharge from the Mōkapu outfall reaching the recreational area is assessed on the basis of the transport pattern measured and observed during this study. The expected concentrations of enteric indicator organisms are then calculated by taking into account the effects of dilution and time of exposure in the marine environment as the portion of the discharge follows the transport path from the outfall to the recreational area. A

comparison is then made with the concentrations and pathways of discharges from the Kawainui Canal and Ka'elepulu Stream.

Objectives

The following three objectives are defined for this study:

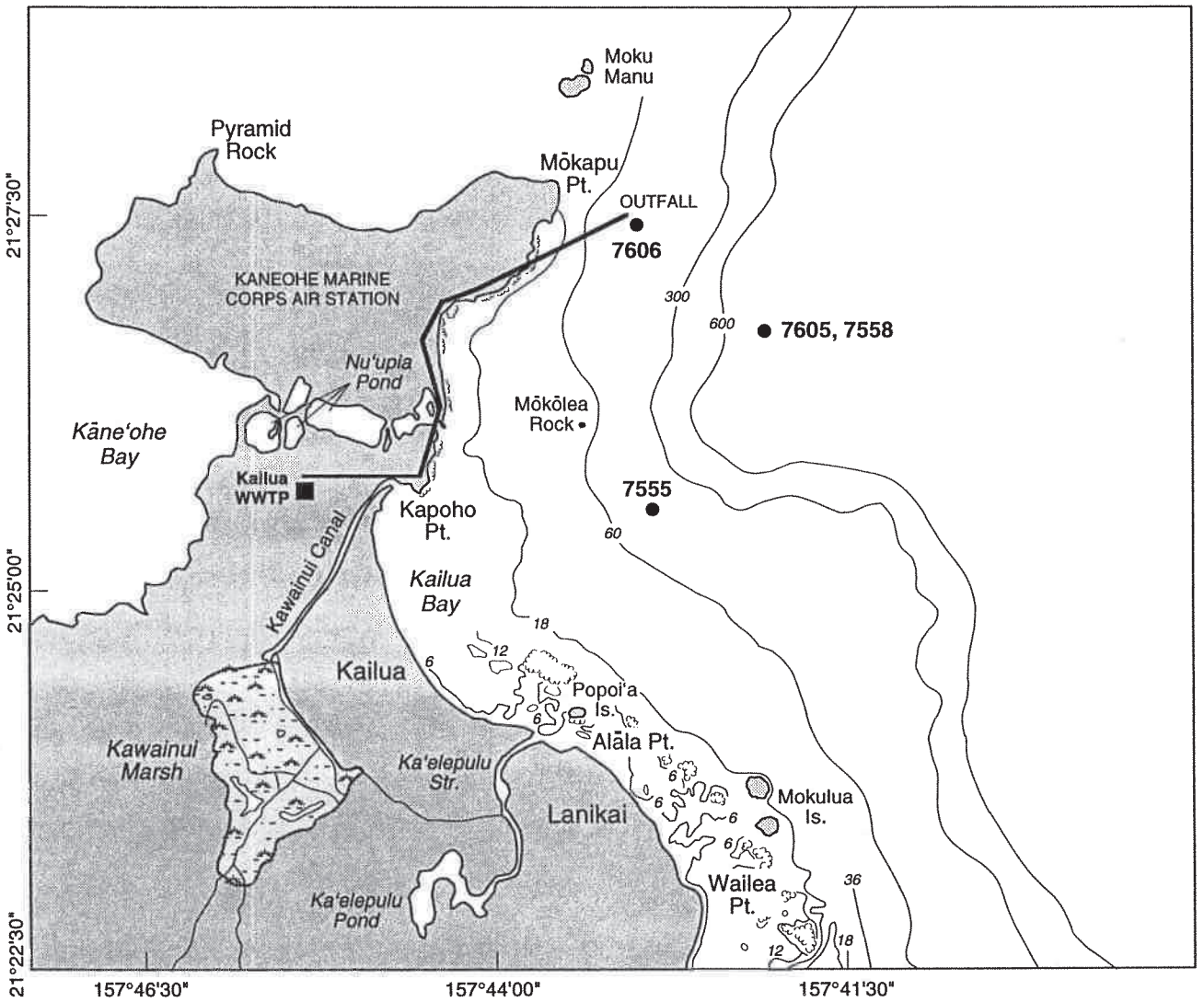
1. To characterize the transport pattern in Kailua Bay, both inside and outside of the 5-m bathymetric contour
2. To calculate the probability of the discharge from the Mokapu Ocean Outfall reaching the recreational area and, if that occurs, to estimate the concentration of bacterial indicator organisms
3. To ascertain the probability of surface discharge from Kawainui Canal and from Ka'elepulu Stream reaching the recreational area, and to estimate the concentrations of bacterial indicator organisms from these sources

MATERIALS AND METHODS

Direct Measurements

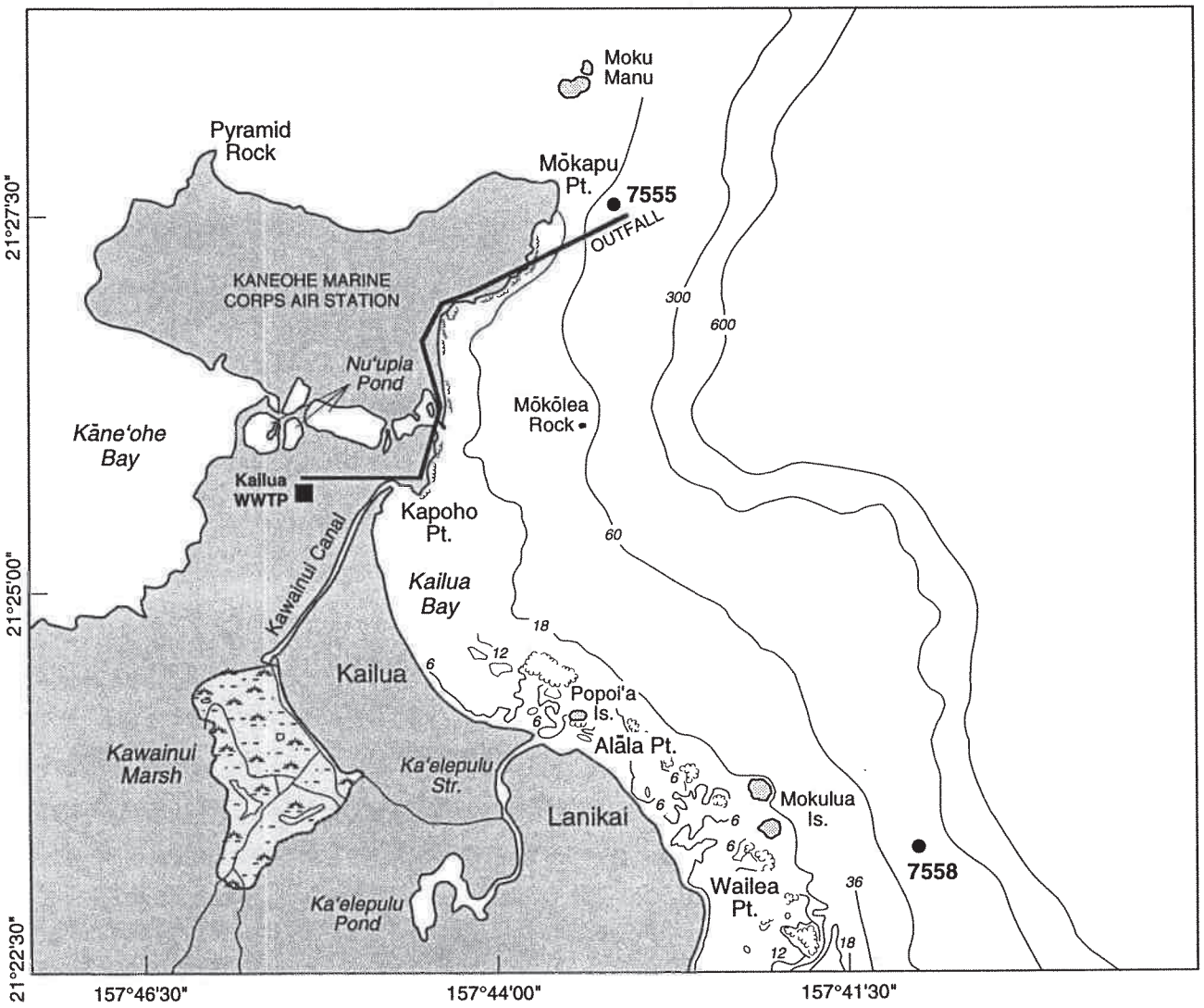
Taut line-moored current meters were deployed at several locations on three occasions to measure the time history of the underlying current in the deeper area of Kailua Bay. The locations of these meter strings are shown in Figures 3, 4, and 5.

The first deployment (in April, May, and June of 1991) consisted of five strings of current meters (Appendix A). One current meter string was in the deep canyon southeast of the Mōkapu diffuser. The purpose of this string was to measure the dynamics of the thermocline, since this has been observed at other locations to be important in explaining the current structure. The other four strings of the first deployment were located across the mouth of Kailua Bay at the depth of the Mōkapu diffuser. Unfortunately, two of these meter strings were removed by vandals; however, one was recovered later. The objective here was to see if the current pattern changes with location. The results of this deployment showed that there was some change with location along the mouth of Kailua Bay and that the temperature variation in



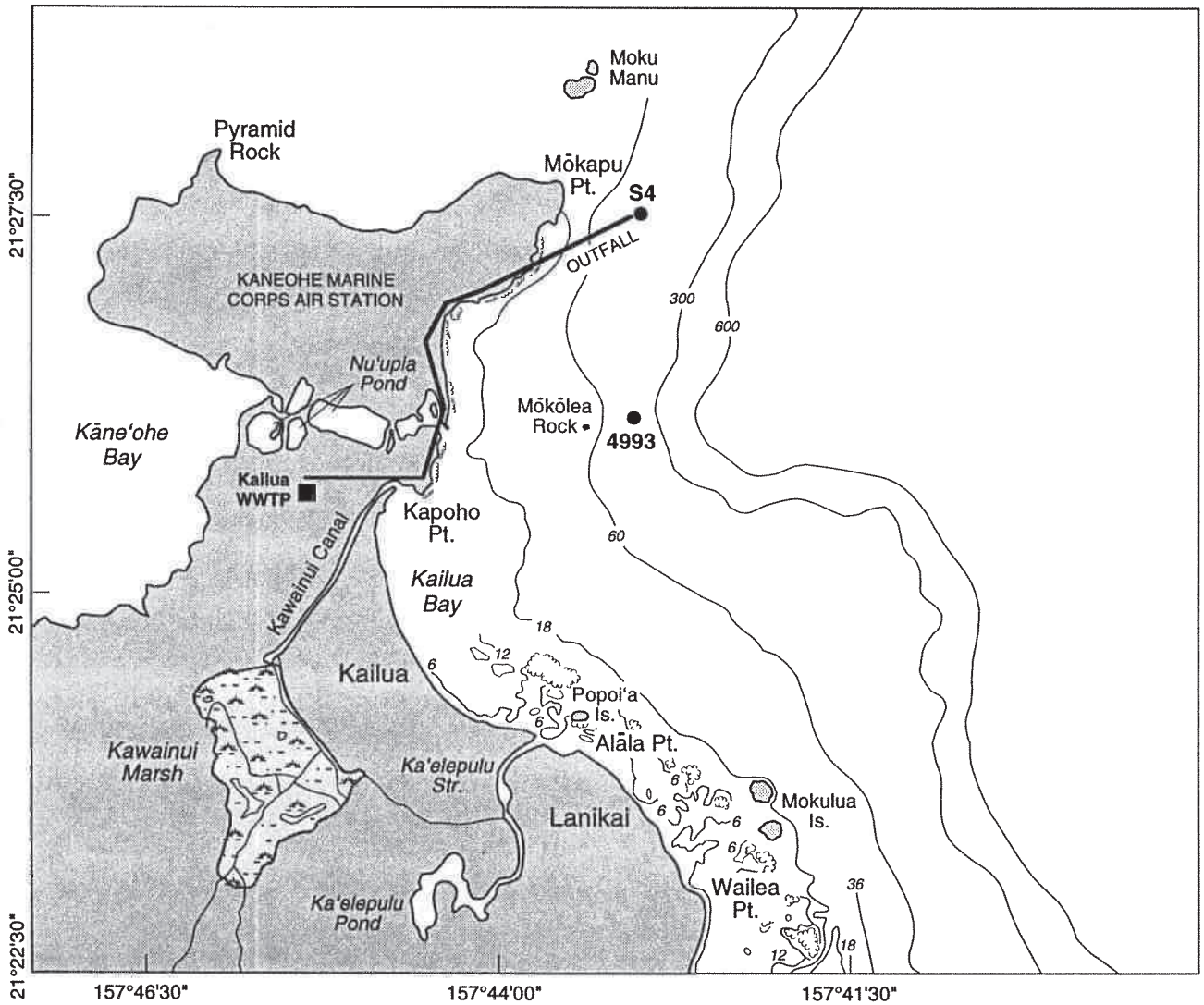
SOURCE: USGS base map, 1:24 000 scale.
NOTE: Bathymetry in feet.

FIGURE 3. Current meter locations for first deployment, Kailua Bay



SOURCE: USGS base map, 1:24 000 scale.
NOTE: Bathymetry in feet.

FIGURE 4. Current meter locations for second deployment, Kailua Bay



SOURCE: USGS base map, 1:24 000 scale.
NOTE: Bathymetry in feet.

FIGURE 5. Current meter locations for third deployment, Kailua Bay

the underwater canyon did indicate a vertical dynamic that affected the horizontal current pattern. This information was used to design the current meter placement for subsequent deployments.

The second deployment (in March and April of 1992) consisted of four strings of current meters across the mouth of Kailua Bay at the bathymetric contour line at the diffuser depth (Appendix B). The current meters were located at approximately the mid-water depth. The data from two of the meters were not usable because of mechanical failure. However, the data from the two remaining strings showed a similar current pattern to that of the first deployment.

The third deployment (in April and May of 1993) used two strings of current meters—one at the Mōkapu diffuser and another seaward of Mōkōlea Rock (Appendix C). The current pattern from this deployment was similar to that of the first two deployments. It was also similar to that measured in October 1989 by Edward K. Noda & Associates (1990).

The strings were designed to hold the current meter within a vertical range of 1 m, in a 1-knot current, and not move off site in high waves. They were also designed to be deployable and retrievable from a small boat with the aid of scuba divers. The designs of the strings used in this study are shown in Appendix D. The major elements of this design include subsurface floats (either glass balls in steel-framed hardhats or pressure-resistant plastic balls); the current meter (or meters) connected with galvanized 1/4-in. wire rope, with appropriate connective hardware and swivels; and an anchor system, which includes reinforced concrete gravity blocks and a small anchor to prevent sliding. For those meter strings deployed at greater than diver depth, an acoustic release is included just above the anchor system.

Deployment proceeds after the desired site has been located horizontally by the global positioning system and verified vertically by a fathometer. The site is marked by a temporary buoy, and the deployment boat is positioned to approach the marker buoy heading into the waves. The current meter string is deployed behind the boat, while keeping the anchor system on board. When the deployment boat passes the marker buoy, the meter string anchor system is released, deploying the string. Divers check the deployment, verify the depth of the top of

the subsurface buoy, and retrieve the surface marker. The location is noted using line-ups for easy relocation during retrieval.

With one exception, Aandera RCM 4 current meters were used at all locations. That exception is the use of a new electromagnetic current meter (Inter-Ocean S4) at the Mōkapu diffuser during the third deployment.

The manufacturer's recommendations were followed in meter preparation, and there was a reasonably high rate of reliable data recovery. All data records were edited to eliminate the few obvious errors (especially those occurring on the first deployment). Records that were analyzed were limited to those taken during the first six to eight weeks. This limitation was necessary because after that period, attached marine growth began to significantly interfere with the meter function. (It should be noted that the greatest amount of marine growth occurred on the meter string deployed next to the Mōkapu diffuser.)

Drogue and dye studies were conducted both inside the 5-m bathymetric contour (using kayaks) and around the 30-m bathymetric contour (Appendix E). The drogue design used was the "window shade" type, which consists of a single sheet of plastic (4 ft by 6 ft [1.2 m by 1.8 m]) weighted with a rebar on the bottom and attached to a wooden dowel at the top. The depth of the drogue was determined by the length of the cord attaching the wooden dowel to the surface float. For the measurements inside the 5-m contour, the size of the drogue was reduced to 2 feet by 3 feet (0.6 m by 0.9 m). Fluorescein dye was used in conjunction with the drogues, both to give a direct measure of the motion of the surface layer and to provide a correction factor to the drogue path needed to vectorially subtract the sailing effect of the wind on the surface float. In this study, the dye was not used to measure the mixing or dispersion characteristics of the area.

Drogues were deployed at depths of 3, 15, 30, and 60 feet (0.9, 4.6, 9.1, and 18.3 m). The path of the 3-ft drogue was compared to the path of the dye patch, and a vector correction was determined that would bring this drogue to the dye. That vector correction was then applied to the paths of the other drogues in order to subtract the error caused by the direct wind

effect on the surface float.

In most cases, positions were determined using a Magellan Global Positioning System. An evaluation of the precision of this system done at Look Laboratory showed that 95% of the readings were within 20 m of the mean position.

Observations

In addition to direct measurements, there were opportunities to make some relevant observations of the physical processes important to mixing and transport conditions in Kailua Bay. The first of these observations involves the actual discharge conditions of the Mōkapu diffuser. The calculations for initial dilution specified by the U.S. Environmental Protection Agency (EPA) assume that the discharge occurs under quiescent conditions, with a steady current or no current. The results of calculations using this method are included in the 1990 report on the Mōkapu outfall by Edward K. Noda & Associates. Diver observations related to that report and especially for this study show that the discharge conditions assumed by EPA do not occur at the Mōkapu outfall and that the actual initial dilution process and plume rise height are significantly different from the result obtained using EPA's method. The location of the Mōkapu diffuser, off the steep-sided Mōkapu Peninsula, means that the diffuser area is subjected to not only the open-ocean wave spectrum but also to reflected longer-period waves. The observed result is that the discharges from the individual diffuser ports at Mōkapu are irregular and patchy, providing more "surface" area for the large amount of mixing energy found here. Consequently, the initial dilution is greater than calculated, and the frequency of surfacing is less. This is the same pattern observed in the bacteriological studies reported by Roger Fujioka on another phase of this project (Fujioka et al. 1993).

Another observation made during this study relates to the interaction of the wind direction with the coastal and reef morphology in Kailua Bay and adjacent Waimānalo Bay. The surface drifter study, which was conducted in the early 1970s and which was related to the design of the Mōkapu outfall, showed that floating objects discharged off Kailua Bay frequently come on shore, especially in Waimānalo Bay. This direct wind effect is important for floatables, but it

does not mean that surface waters follow the same path. Observations of dye patches and identifiable surface waters made during this study revealed that the predominant tradewind-related flow approaching the Kailua Bay–Waimānalo Bay coastal area diverges toward the north, off Kailua Bay, and then flows back toward the open ocean as it gets deflected by the Mōkapu Peninsula. This wind effect is superimposed on the underlying tide-related current. This means that under most conditions, the Mōkapu diffuser discharge, whether surfacing or not, is transported in a northerly direction away from Kailua Bay. It also means that the critical wind direction for surface water transport from the outfall to the shore is not directly onshore but from the north or from north by northeast. This wind direction occurs about 15% of the time.

Observations of the transport and circulation pattern inside the 5-m contour in the recreational area of Kailua Bay revealed that the dominant factor is the breaking wave-induced flow. Water from the upper 1 or 2 m just outside the irregular reef area from the Mokulua Islands, on the south, to north of Popoi'a Island is subject to transport over the outer reef by breaking waves. Similarly, breaking waves transport water into the nearshore waters at the northern end of the Kailua Beach area off Kapoho Point. The outflow balancing the input from these breaking waves occurs through the slightly deeper area off the middle of Kailua Beach. This pattern means that discharges from the Kawainui Canal and Ka'elepulu Stream tend to be held close to shore as they move toward the outflow area near the center of Kailua Beach. This also means that, in the past, flow from the Kailua wastewater outfall, located not far from Kapoho Point and discharging into 13 ft (4.0 m) of water, was almost always transported directly toward the beach. Wastewater from the Kailua Wastewater Treatment Plant now feeds into the Mokapu Ocean Outfall diffuser, which discharges at 5,083 ft (1 549 m) offshore at a depth of 105 ft (32 m).

Calculations

The principal objective of this study is to describe the transport characteristics of Kailua Bay so that a comparison can be made of the relative importance of the wastewater discharge

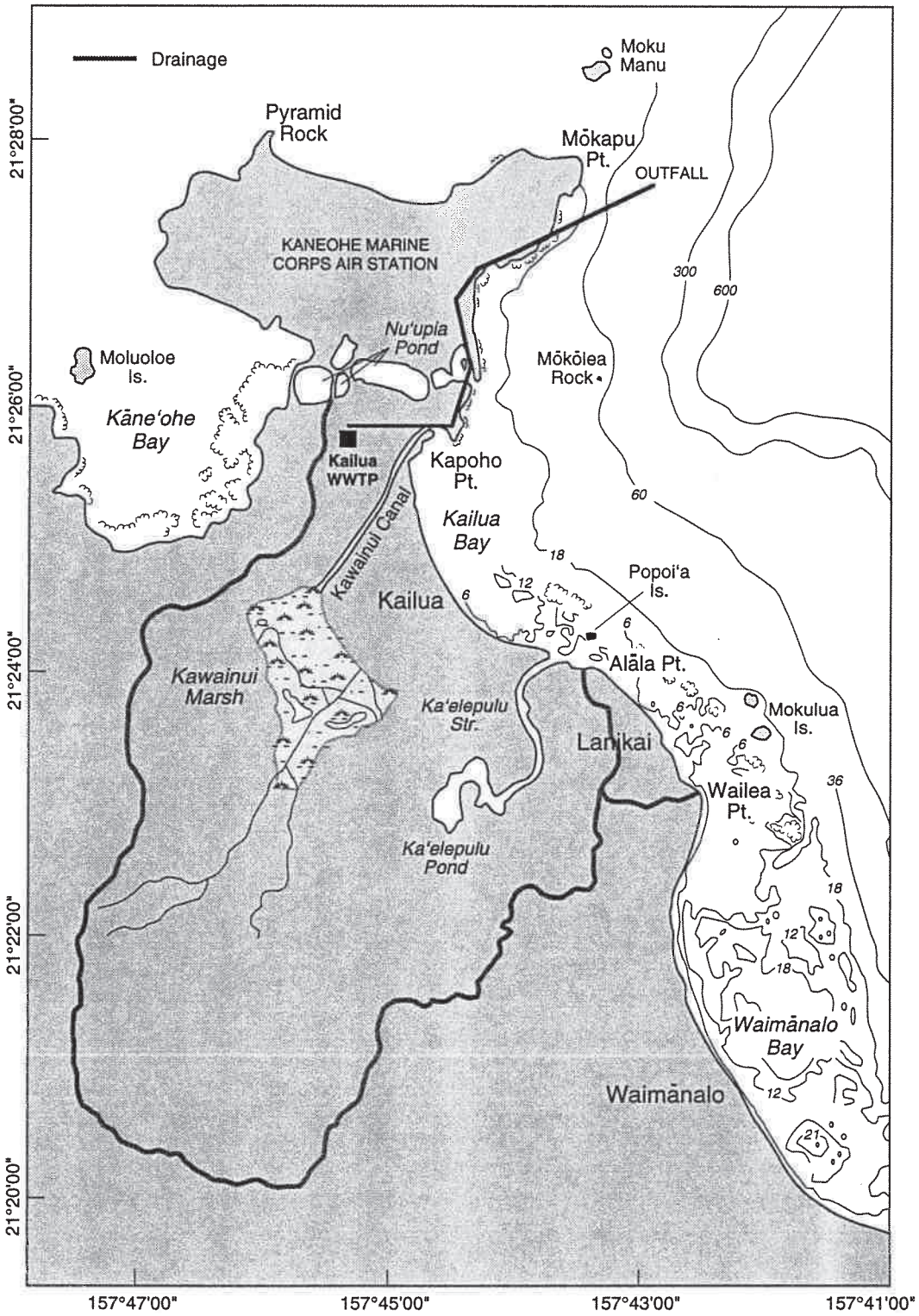
through the Mōkapu outfall with discharges from Kawainui Canal and Ka'elepulu Stream, with respect to the bacteriological conditions in the recreational area off Kailua Beach. The calculations related to this process involve frequency of occurrence estimates based on incomplete data and simplified mathematical models of complex hydrodynamic processes. Consequently, the result of this evaluation is only an approximation of the condition in Kailua Bay. However, since the same assumptions and simplifications are applied to both the Mōkapu outfall discharge and the discharges from land sources into Kailua Bay, the evaluation of the relative importance of these two sources can be expected to be much more accurate than initially thought.

RESULTS

The transport characteristics of Kailua Bay are evaluated for the reef flat area, the surface layer outside the 5-m bathymetric contour, and the lower layer outside the 5-m bathymetric contour. These three zones are shown in Figure 2, which shows a cross section of the center of Kailua Bay looking north.

Nearshore Transport

The first zone, the relatively wide reef flat area off Kailua Beach, is where most of the recreational activity occurs. The transport in this zone (as with most reef flat areas) is dominated by the breaking wave-induced input at the reef at both ends of the bay, with the outflow occurring primarily through the somewhat deeper area at the middle of the bay. Land-derived input occurs through the Kawainui Canal at the north end of the beach area, the Ka'elepulu Stream near the south end of the beach, local surface drainage, and groundwater inflow. The drainage basin for this area is shown in Figure 6. By proportionate comparison to the adjacent Kāne'ohe Bay drainage basin, which has a similar rainfall pattern and geomorphology, as well as a better database (Sunn Low, Tom & Hara, Inc. 1976), the overall average freshwater inflow to Kailua Bay is about 47 mgd; a significant fraction of this flow



SOURCE: USGS base map, 1:62 500 scale.
NOTE: Bathymetry in feet.

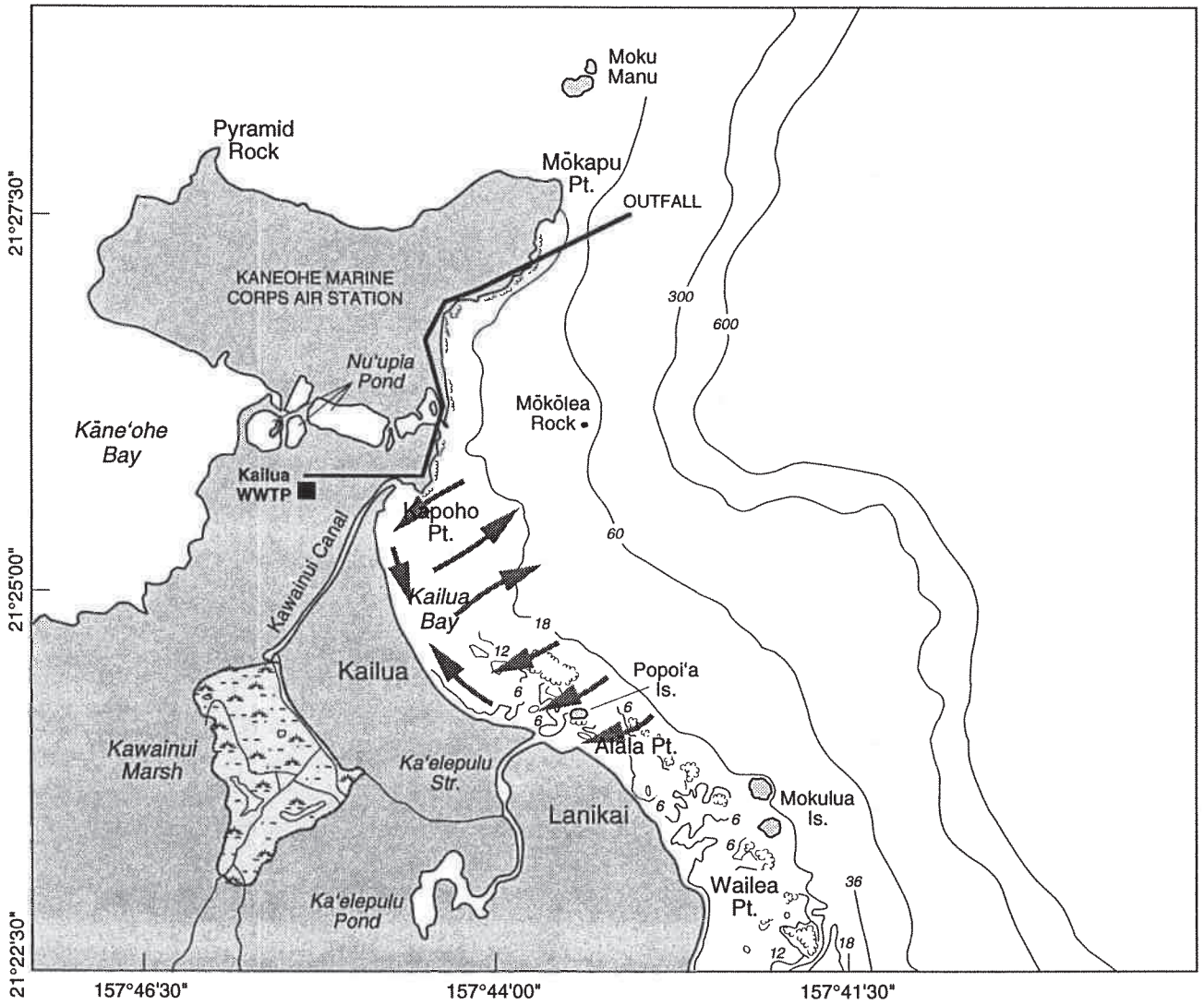
FIGURE 6. Kailua Bay Drainage Basin

occurs during a few storm events, leaving a "dry" weather flow of about 24 mgd.

The freshwater input mixes with the ambient seawater as it enters Kailua Bay at the shoreline. Because the resulting mixture is slightly less dense than the seawater, it tends to stay in the surface layer. The combination of local wind stress and the basic transport pattern tends to hold the land-derived discharge close to shore as it moves toward the center of the beach to the outflow area. This general pattern is shown in Figure 7. The average speed of the transport in this area, as indicated by the dye and drogue studies, is about 6 to 8 cm/second (Appendix E). This is relatively slow, and, when combined with the expected re-entrance over the reef of about 50% of the outflow from this zone, this means that the residence time in the reef flat is long enough to occasionally result in excessive algal growth. This algal growth is dependent on the mass emission rates of nutrients into this area and on the incubation time afforded by the Kawainui Canal and Ka'elepulu Pond and Stream.

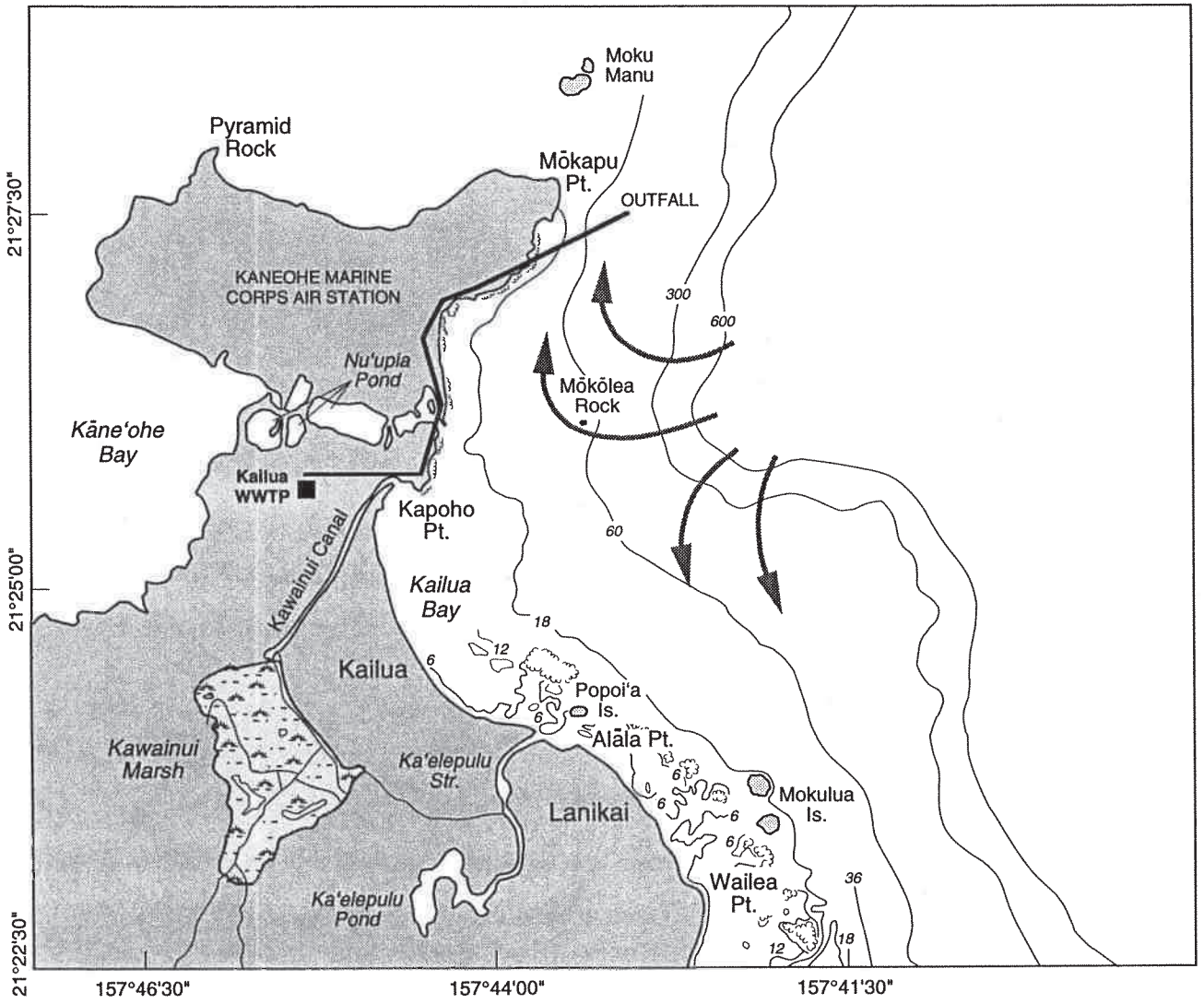
Offshore Transport

The base current above the thermocline off Kaneohe, Kailua, and Waimānalo is tide-related, reversing, and parallel to the bathymetric contours, with roughly equal transport in both directions. Tidal information for the periods of measurement is included in Appendix F. Evidence for this general current pattern was obtained from (1) current meter studies off the mouth of Kāne'ohe Bay, done in the late 1970s (Sunn, Low, Tom & Hara, Inc. 1977), to provide data for a computer model of that bay and (2) current meter studies done during this study off the Mokulua Islands (see Appendixes A, B, and C). This general pattern is altered off Kailua Bay, particularly near the Mōkapu Peninsula, by the effect of the canyon located directly seaward of Kailua Bay. North of the canyon (where the Mōkapu diffuser is located), there is an increase in the transport to the north, whereas south of the canyon (off Alāla Point), there is an increase in the transport to the south. An explanation for this change in the base current pattern might be the diversion to the left and right, caused by the upper lip of the canyon, of the large-scale mixed-layer ocean current that approaches the windward coastline from the east by northeast. This underwater canyon influence is shown in Figure 8.



SOURCE: USGS base map, 1:24 000 scale.
NOTE: Bathymetry in feet.

FIGURE 7. Nearshore circulation pattern at Kailua Bay



SOURCE: USGS base map, 1:24 000 scale.
NOTE: Bathymetry in feet.

FIGURE 8. Large scale current effefct on mixed layer transport at Kailua Bay

The evidence for the consistency of this net northerly transport in the vicinity of the Mōkapu diffuser is found in the current records taken by Edward K. Noda & Associates (1990) in October 1989 and by researchers of this study in all three deployments during 1991, 1992, and 1993. The net southerly transport in the mixed layer off Alāla Point is shown by the 1991 deployment. All of these data are included in the appendixes of this report.

This current pattern in the vicinity of the Mōkapu diffuser means that the discharge enters a transport regime that, in effect, takes two steps north for every one step south. This in turn means that very little of the wastewater being discharged through the Mōkapu outfall is susceptible to being transported to the recreational area in Kailua Bay.

Wind Effect

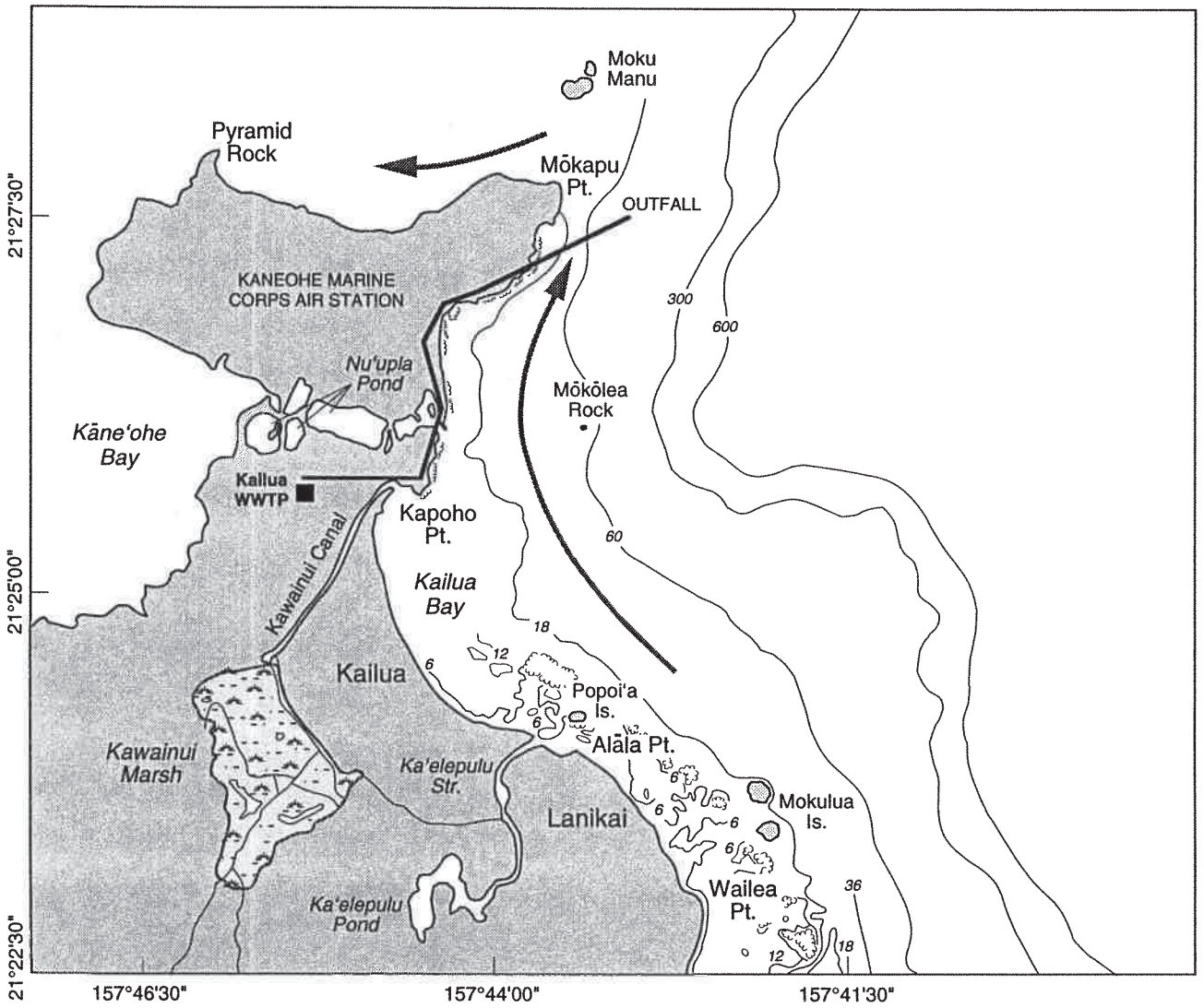
The surface layer of the water column is also susceptible to wind-induced transport. In the open ocean, away from the restrictions of the shoreline or the bottom, the wind creates a surface current with a speed of 2 to 3% of the wind speed, which decreases exponentially with depth and changes direction to the right (in the northern hemisphere) in the classic Eckman Spiral. Another manifestation of wind energy transfer to the water is Langmuir Circulation, which consists of pairs of converging vertical circulation cells that are evident from long lines of floating debris aligned with the wind direction.

In the vicinity of a coastline or in relatively shallow areas, however, the interactions among the wind field, water surface layer, and land are more complex and of a smaller scale. Measurements in Hawaii coastal waters using drogues and dye show that the local wind effect on transport is largely limited to the upper 5 m and is most evident in the upper 2 m of the water column. The direction of that transport is significantly affected by the wind direction with respect to the coastline or reef line. If the wind direction is offshore or parallel to the shore or reef, then the wind-induced transport in the upper few meters of the water will be directly downwind. If, however, the wind has a significant onshore component, then the wind-induced transport is diverted to the right or left and moves parallel to the bathymetric contours as it encounters the slightly higher water level that is due to the wind set-up. A slightly higher water

level near the shore or reef line can also occur (as it does in Kailua Bay) as a result of wave set-up and land-derived freshwater flow. When the shape of the shoreline includes a headland, such as Mōkapu Peninsula, the wind-induced transport continues to move parallel to the bathymetric contours into the wind. This condition occurs most of the time in Kailua Bay, where the tradewind-induced flow in the vicinity of the Mōkapu diffuser is in a northerly direction. This effect causes flow around Mōkapu Point and toward Pyramid Rock on the Kaneohe side. This means that the beach area on the north shore of Mōkapu Peninsula is much more likely to be affected by bacteriological components of the Mōkapu discharge than are the recreational areas of Kailua Bay. The predominant wind-induced transport pattern is shown in Figure 9.

Wind-induced transport toward the reef area off the south end of Kailua Beach and off Lanikai can occur when the wind is from the north or north by northeast. The wind rose from the Kaneohe Marine Corps Air Station (Figure 10) shows that this occurs about 17% of the time. However, since wind-induced transport is superimposed on the underlying tide-related current, actual transport to the reef area depends on a southerly current of several hours duration. The current meter records near the Mōkapu diffuser show that such a current exists about 20% of the time. Since only a surfacing plume is susceptible to wind-induced transport, the frequency of surfacing must be factored in. According to the frequency distribution of the vertical density gradient reported by Edward K. Noda & Associates in 1990, the present frequency of surfacing is about 50% and the initial dilution factor is about 300 to 1, under quiescent conditions. These numbers are conservative in that they do not include the observed wave-influenced discharge conditions or the current.

Since the wind, tide, and density gradient are essentially independent variables, the expected frequency of transport of a portion of the Mōkapu discharge toward the reef area in south Kailua Bay is (0.17 x 0.20 x 0.50)100 = 1.7% of the time. The wind transport to the reef area is shown in Figure 11. When this occurs, the expected dilution by the time the plume travels the 4 miles from the Mōkapu diffuser to the reef area is at least (300) x (1.5 dilution



SOURCE: USGS base map, 1:24 000 scale.
NOTE: Bathymetry in feet.

FIGURE 9. Predominant wind effect on surface layer at Kailua Bay

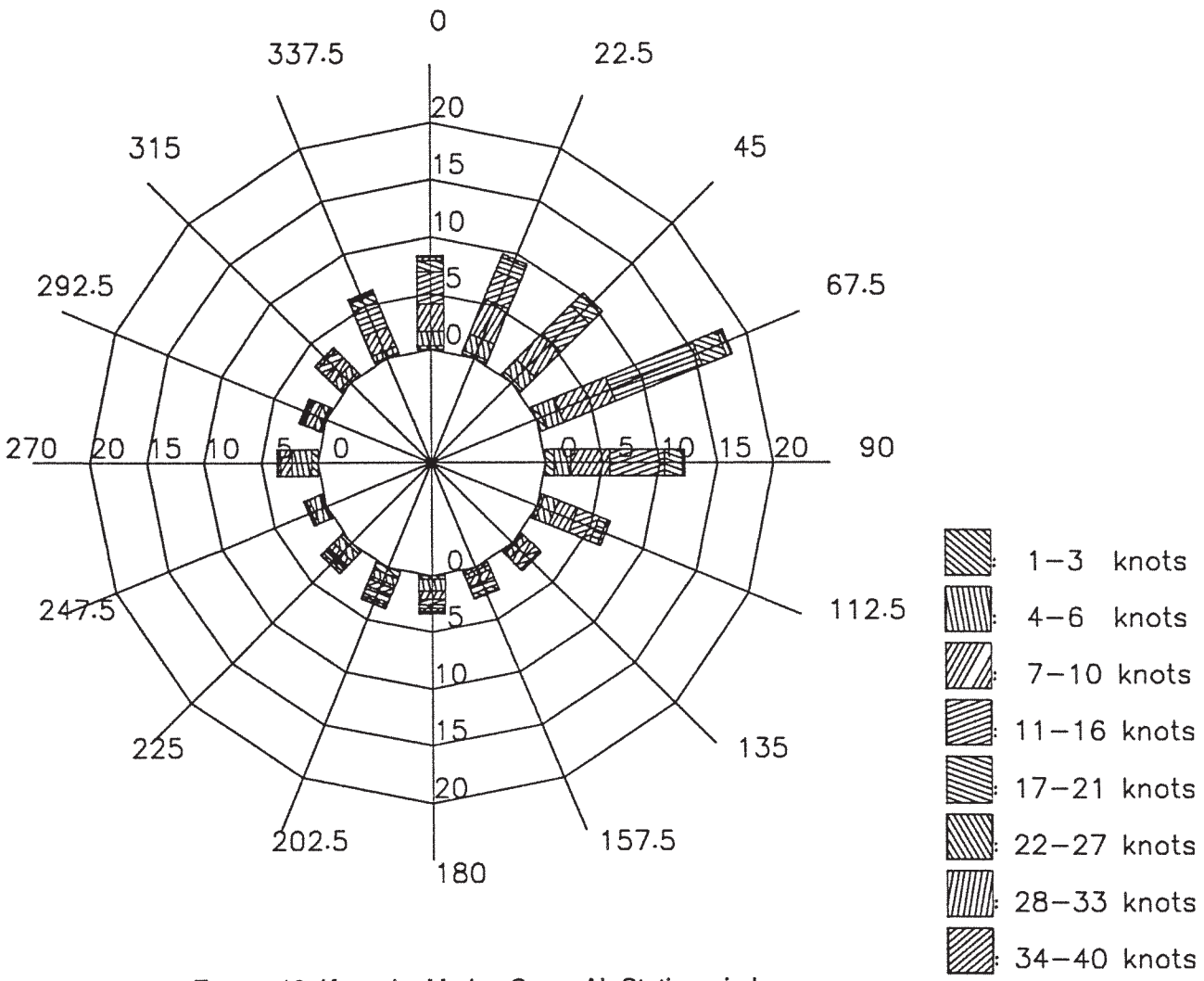
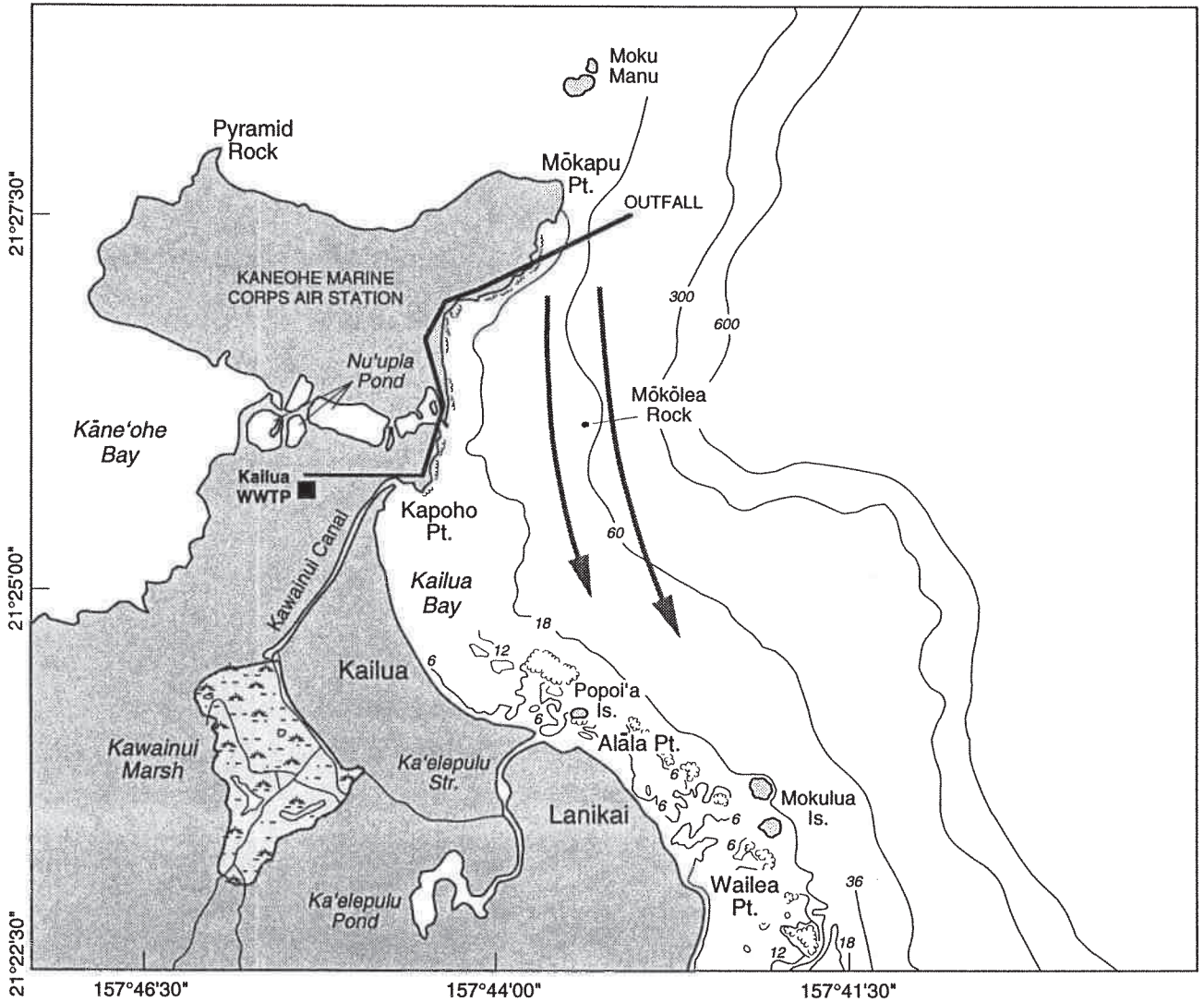


FIGURE 10. Kaneohe Marine Corps Air Station wind rose



SOURCE: USGS base map, 1:24 000 scale.
NOTE: Bathymetry in feet.

FIGURE 11. North and north by northeast wind effect on surface layer at Kailua Bay

factor due to current) x (20 dilution due to Eddy diffusion) = 9,000 to 1. In addition, the bacteriological indicator organisms are exposed to the seawater environment for a number of hours, causing inactivation. The travel time at an average rate of 10 cm/second is about 18 hours. This means that the concentration of indicator organisms will be significantly below the detection limit by the time the remnants of the plume reaches the reef area; thus no discernible bacteriological effect of the Mōkapu diffuser discharge is expected in the recreational area of Kailua Bay.

Of more direct concern is the discharge of floatables. Windward beaches are collection areas for floatables from vast expanses of ocean area. Floatables move primarily in direct response to the wind, with only a minor effect from the underlying current. Similarly, floatables discharged from the Mōkapu outfall, including oil and grease, are subject to transport into the recreational area of Kailua Bay under regular tradewind conditions. Consequently, treatment for removal of floatables should be the principal objective of the Kailua Wastewater Treatment Plant. In comparison, treatment for the reduction of oxygen demanding material (i.e., secondary treatment) is of much less importance.

CONCLUSIONS

The results of this study show that transport in the Kailua Bay area is due to the interaction of a number of factors and variables including rainfall, runoff, wind, tide, surface waves, coastal morphology, bathymetry, and density profile dynamics.

The transport in the nearshore recreational area within the 5-m bathymetric contour is due principally to the breaking wave-induced inflow and secondarily to land-derived freshwater inflow. Discharges from Kawainui Canal and Ka'elepulu Stream are held close to shore by the wind stress and circulation pattern and thereby directly influence the bacteriological concentrations and other water quality parameters in the area.

The transport conditions in the vicinity of the Mōkapu diffuser are dominated by the tide-related (through an internal wave field) current as altered by the shape of the bathymetric

contours—especially the nearby underwater canyon. The predominant transport direction here is northerly and away from the Kailua Bay area.

The dominant onshore wind results in transport of the surface layer parallel to the contour lines in Kailua Bay and around the corner at Mōkapu Peninsula toward Kāne'ohe Bay. Under north or north by northeast wind conditions, there is an estimated 1.7% frequency of occurrence of transport of a portion of the Mōkapu discharge toward the south Kailua Bay reef area. No discernible effect on the bacteriological quality of the recreational waters off Kailua Beach is expected because of the large dilution factor and inactivation owing to the long travel time.

Treatment for removal of floatable material should be the principal objective for the Kailua Wastewater Treatment Plant because of the shoreward transport of floatables during tradewind conditions.

Water quality in the recreational area of Kailua Bay is principally a factor of land-derived discharges.

REFERENCES CITED

Bathen, K.H. 1972. A descriptive study of the circulation and water quality in Kailua Bay, Oahu, Hawaii, during 1971 and 1972. Tech. Rep. No. 29, James K.K. Look Laboratory of Oceanographic Engineering, University of Hawaii.

Edward K. Noda & Associates, Inc. 1990. Preliminary engineering report, Mokapu Ocean Outfall, Mokapu Peninsula, Oahu.

Fujioka, R.S., C. Wu, and C.K. Fujioka. 1993. Assessing the impact of Mokapu sewage outfall on the shoreline water quality of Kailua Bay (KB-2). Project Rep. PR-94-05, Water Resources Research Center, University of Hawaii at Manoa, Honolulu, Hawaii. 143 pp.

Sunn, Low, Tom & Hara, Inc. 1976. Kaneohe Bay water resources data evaluation study.

Sunn, Low, Tom & Hara, Inc. 1977. Field investigation for Kaneohe Bay computer model. Prepared for the U.S. Army Corps of Engineers.

APPENDIXES

A. Current Measurements for First Deployment: April–August 1991 . . . . . A-1 through A-49

B. Current Measurements for Second Deployment: March–May 1992 . . . . . B-1 through B-23

C. Current Measurements for Third Deployment: April–May 1993 . . . . . C-1 through C-22

D. Current Meter String Designs and Specifications . . . . . D-1 through D-16

E. Droge, Dye, and Depth Measurements . . . . . E-1 through E-22

F. Tide Charts: 1991–1993 . . . . . F-1 through F-8

APPENDIX A

Current Measurements for First Deployment: April–August 1991

Meter No.: 7606 ..... A-1 through A-14

Meter No.: 7605 ..... A-15 through A-26

Meter No.: 7558 ..... A-27 through A-39

Meter No.: 7555 ..... A-40 through A-49

DATA INFORMATION

SITE NAME	: KAILUA-7606 1st DEP.
METER NUMBER	: 7606
METER POSITION	: TOP
LATITUDE	: 21.27.22N
LONGITUDE	: 157.42.76W
START DATE	: 12:18,23,APR,1991
END DATE	: 13:45, 6,AUG,1991
DEPLOY DATE	: 11:55,25,APR,1991
BOTTOM DEPTH	: 100 ft.
METER DEPTH	: 60 ft.
REV COUNT	: 4.00
TIME INTERVAL	: 10.00
DATA FILE	: 7606bin.DAT
TOTAL PTS	: 7852
START PT	: 265

VELOCITY DISTRIBUTION

SPEED	0 | 5	5 | 10	10 | 15	15 | 20	20 | 25	25 | 30	30 | 35	35 | 40	40 | 45	45 | 50
DIR										
0 - 15	6	78	315	417	259	175	62	32	5	0
15 - 30	4	108	214	123	76	36	20	5	0	0
30 - 45	5	82	120	39	5	1	1	0	0	0
45 - 60	3	71	78	14	4	1	0	0	0	0
60 - 75	5	66	50	8	8	1	0	0	1	0
75 - 90	2	40	46	6	4	0	1	0	0	0
90 - 105	1	44	41	9	6	0	0	0	0	0
105 - 120	2	68	91	15	6	3	0	0	0	0
120 - 135	3	48	87	35	19	3	0	1	1	0
135 - 150	4	55	137	55	33	12	4	2	0	0
150 - 165	4	43	174	85	64	26	16	8	2	0
165 - 180	6	63	114	106	66	35	19	11	4	3
180 - 195	4	56	128	80	47	18	15	11	1	0
195 - 210	2	45	73	36	15	5	3	2	0	0
210 - 225	1	37	76	16	4	1	0	0	0	0
225 - 240	1	44	50	3	0	0	0	0	0	0
240 - 255	0	42	58	8	0	0	0	0	0	0
255 - 270	1	28	39	14	3	1	1	0	0	0
270 - 285	0	31	50	14	7	2	3	1	0	0
285 - 300	1	37	63	8	0	0	0	0	0	0
300 - 315	4	40	120	20	5	0	1	0	0	0
315 - 330	3	37	161	60	9	3	0	0	0	0
330 - 345	9	56	283	166	34	9	0	1	0	0
345 - 360	9	75	401	389	161	90	12	11	2	0

SPEED	50 | 55	55 | 60	60 | 65	65 | 70	70 | 75	75 | 80	80 | 85	85 | 90	90 | 95	95 | 100
DIR										
0 - 15	0	0	0	0	0	0	0	0	0	0
15 - 30	0	0	0	0	0	0	0	0	0	0
30 - 45	0	0	0	0	0	0	0	0	0	0
45 - 60	0	0	0	0	0	0	0	0	0	0
60 - 75	0	0	0	0	0	0	0	0	0	0
75 - 90	0	0	0	0	0	0	0	0	0	0

90 - 105	0	0	0	0	0	0	0	0	0	0
105 - 120	0	0	0	0	0	0	0	0	0	0
120 - 135	0	0	0	0	0	0	0	0	0	0
135 - 150	0	0	0	0	0	0	0	0	0	0
150 - 165	0	0	0	0	0	0	0	0	0	0
165 - 180	0	0	0	0	0	0	0	0	0	0
180 - 195	0	0	0	0	0	0	0	0	0	0
195 - 210	0	0	0	0	0	0	0	0	0	0
210 - 225	0	0	0	0	0	0	0	0	0	0
225 - 240	0	0	0	0	0	0	0	0	0	0
240 - 255	0	0	0	0	0	0	0	0	0	0
255 - 270	0	0	0	0	0	0	0	0	0	0
270 - 285	0	0	0	0	0	0	0	0	0	0
285 - 300	0	0	0	0	0	0	0	0	0	0
300 - 315	0	0	0	0	0	0	0	0	0	0
315 - 330	0	0	0	0	0	0	0	0	0	0
330 - 345	0	0	0	0	0	0	0	0	0	0
345 - 360	0	0	0	0	0	0	0	0	0	0

DIRECTION [Degrees]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 15	1349	17.78
15 - 30	586	7.72
30 - 45	253	3.33
45 - 60	171	2.25
60 - 75	139	1.83
75 - 90	99	1.30
90 - 105	101	1.33
105 - 120	185	2.44
120 - 135	197	2.60
135 - 150	302	3.98
150 - 165	422	5.56
165 - 180	427	5.63
180 - 195	360	4.74
195 - 210	181	2.39
210 - 225	135	1.78
225 - 240	98	1.29
240 - 255	108	1.42
255 - 270	87	1.15
270 - 285	108	1.42
285 - 300	109	1.44
300 - 315	190	2.50
315 - 330	273	3.60
330 - 345	558	7.35
345 - 360	1150	15.16

SPEED [cm/sec]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 5	80	1.05
5 - 10	1294	17.05
10 - 15	2969	39.13
15 - 20	1726	22.75
20 - 25	835	11.00
25 - 30	422	5.56
30 - 35	158	2.08
35 - 40	85	1.12

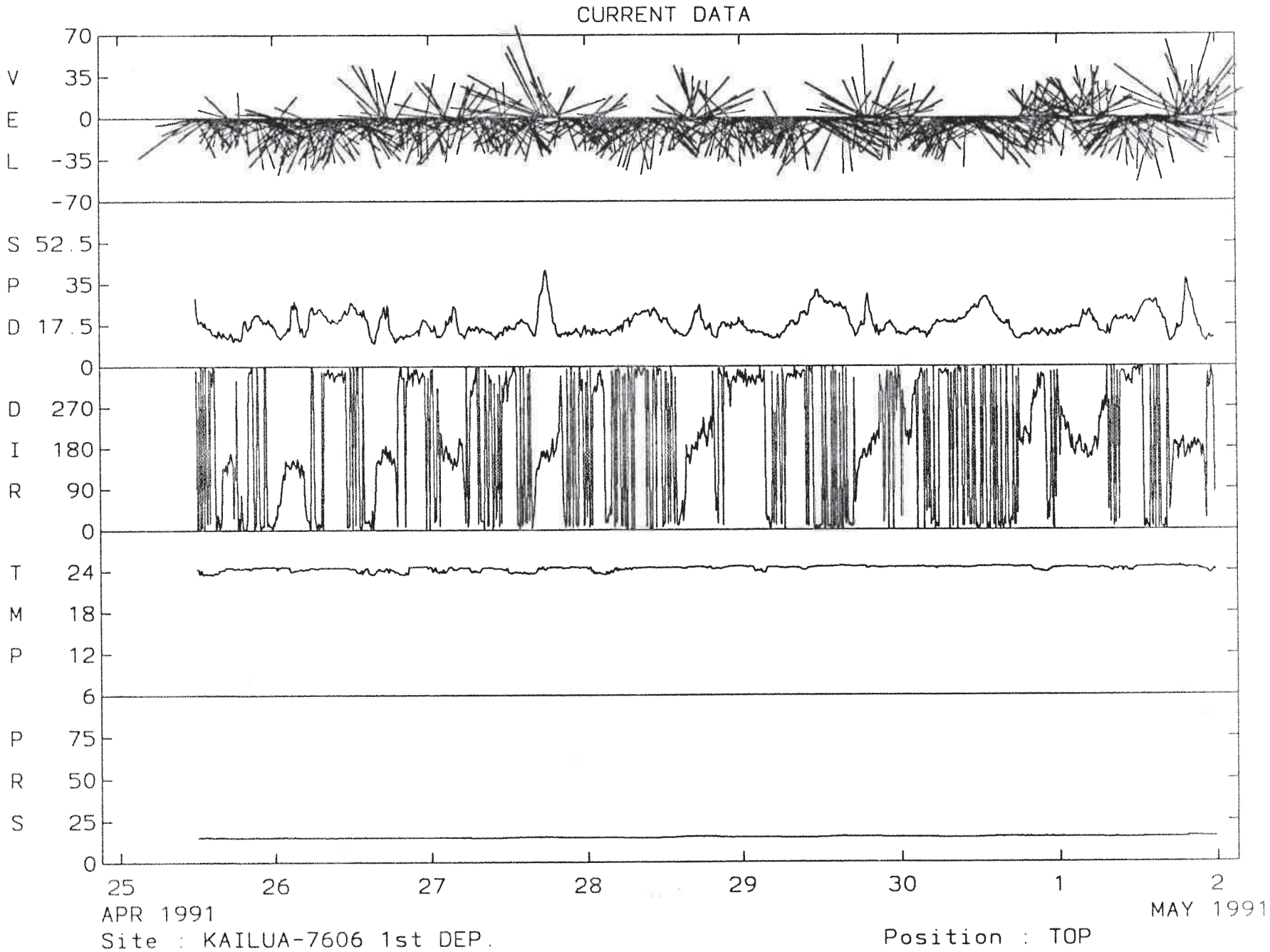
40 - 45	16	.21
45 - 50	3	.04

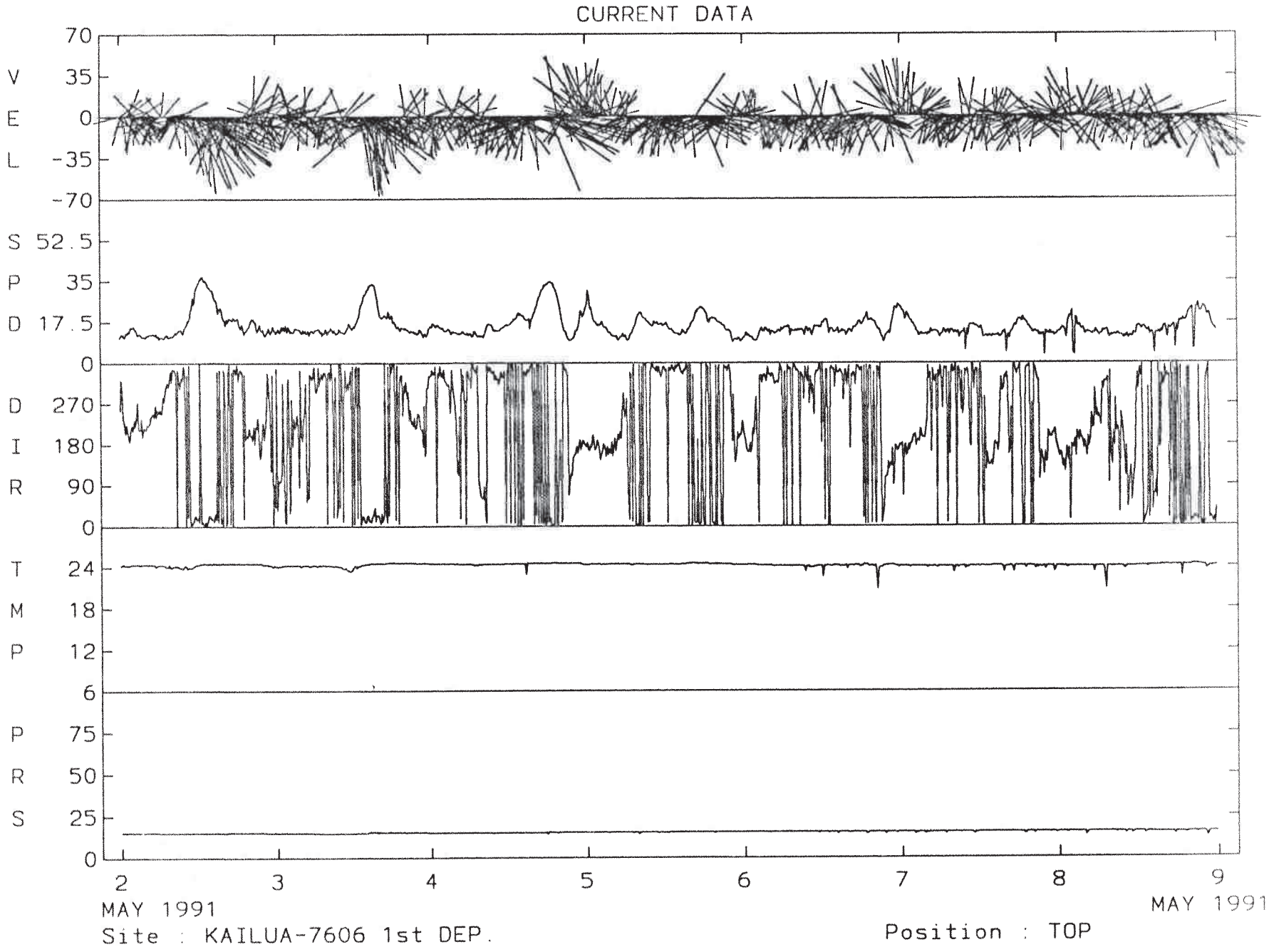
Total number of valid data points : 7588
Maximum Speed : 49.66 cm/s
Minimum Speed : 1.50 cm/s
Mean Speed : 15.46 cm/s
Range : 48.16 cm/s
Standard Deviation : .19 cm/s

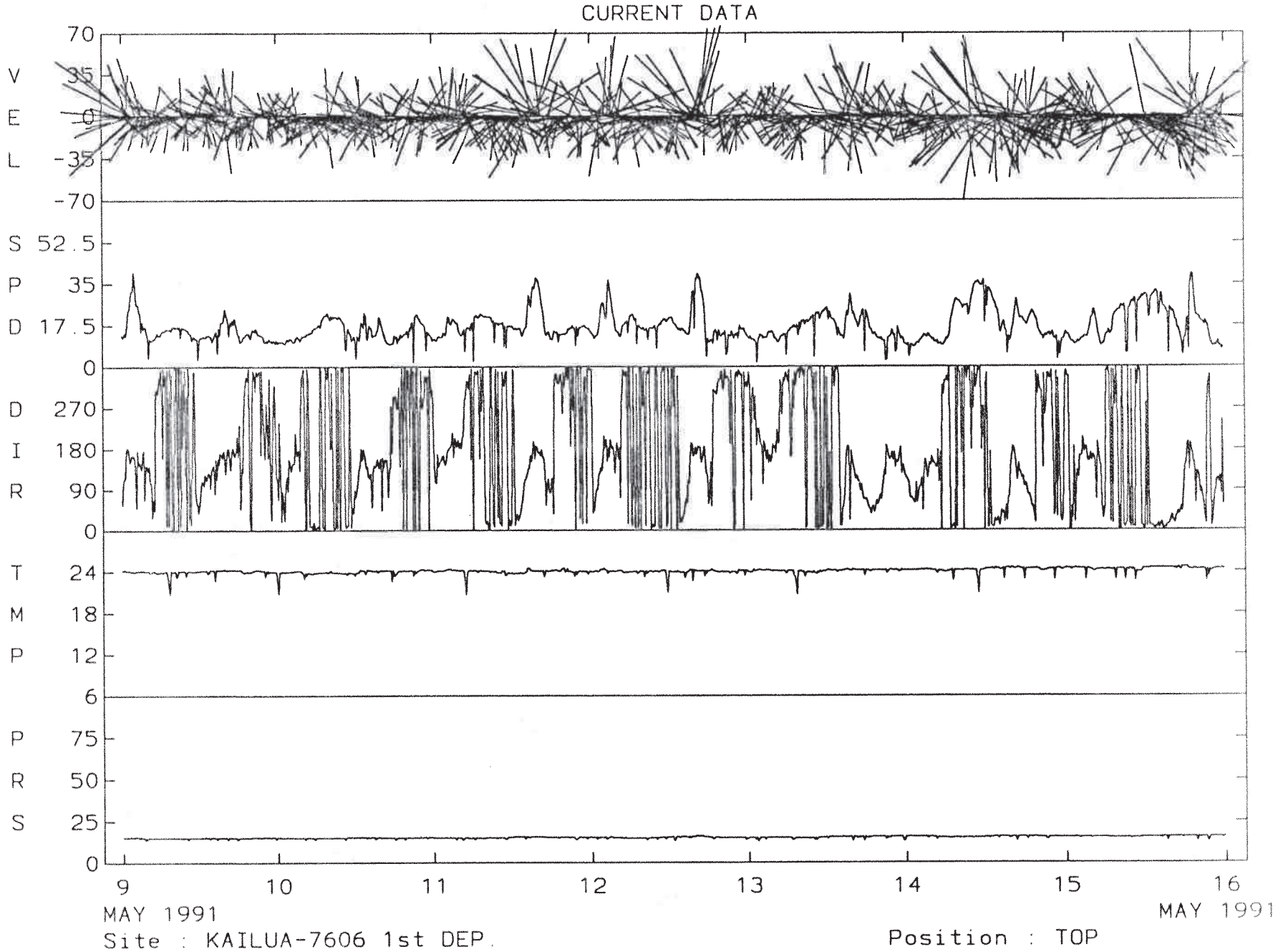
TEMPERATURE [Celcius]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 2	0	.00
2 - 4	0	.00
4 - 6	0	.00
6 - 8	0	.00
8 - 10	0	.00
10 - 12	0	.00
12 - 14	0	.00
14 - 16	0	.00
16 - 18	0	.00
18 - 20	2	.03
20 - 22	21	.28
22 - 24	858	11.31
24 - 26	6707	88.39
26 - 28	0	.00
28 - 30	0	.00

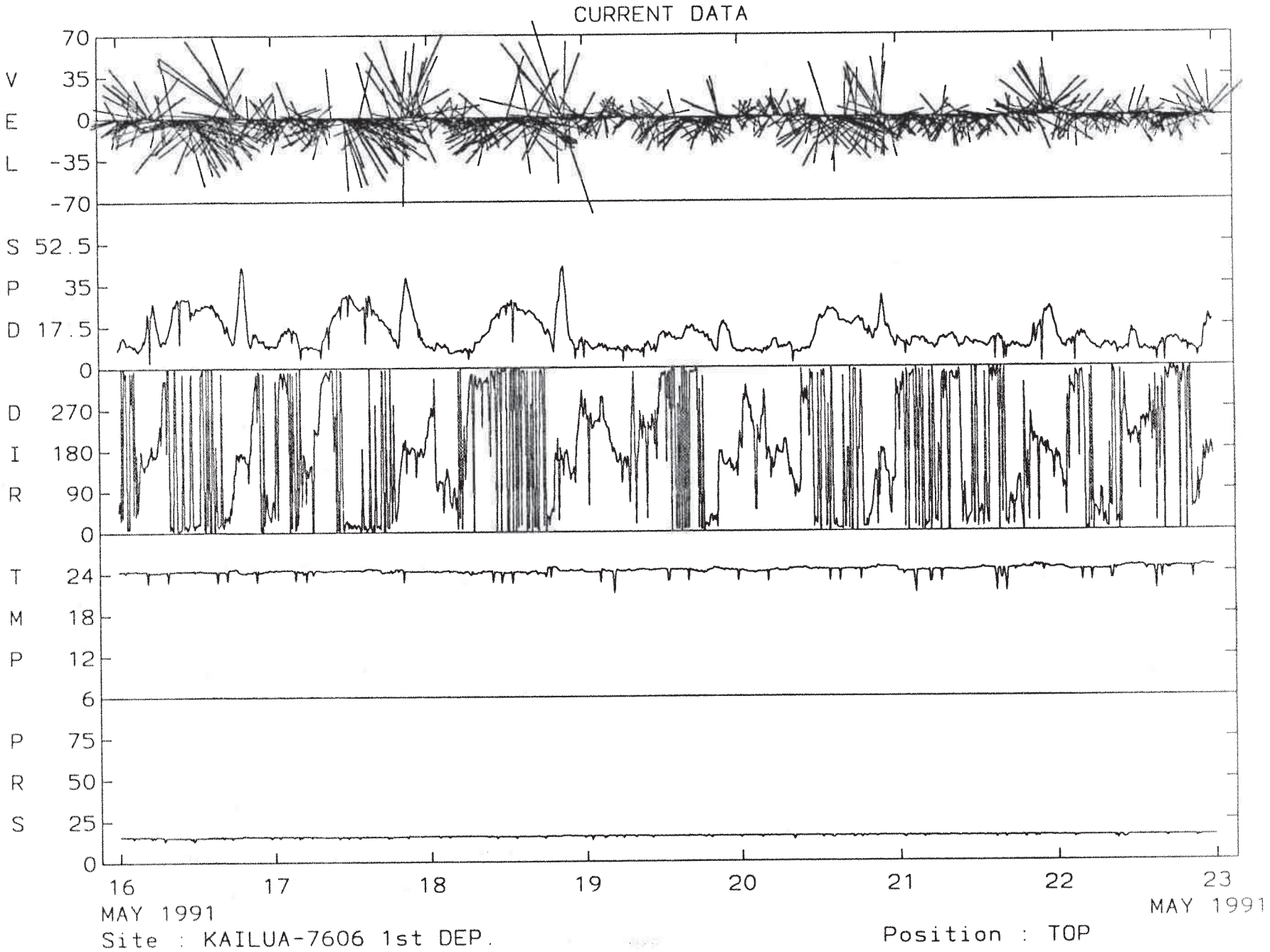
Total number of valid data points : 7588
Maximum Temperature : 25.51 °C
Minimum Temperature : 19.77 °C
Mean Temperature : 24.44 °C
Range : 5.74 °C
Standard Deviation : .28 °C

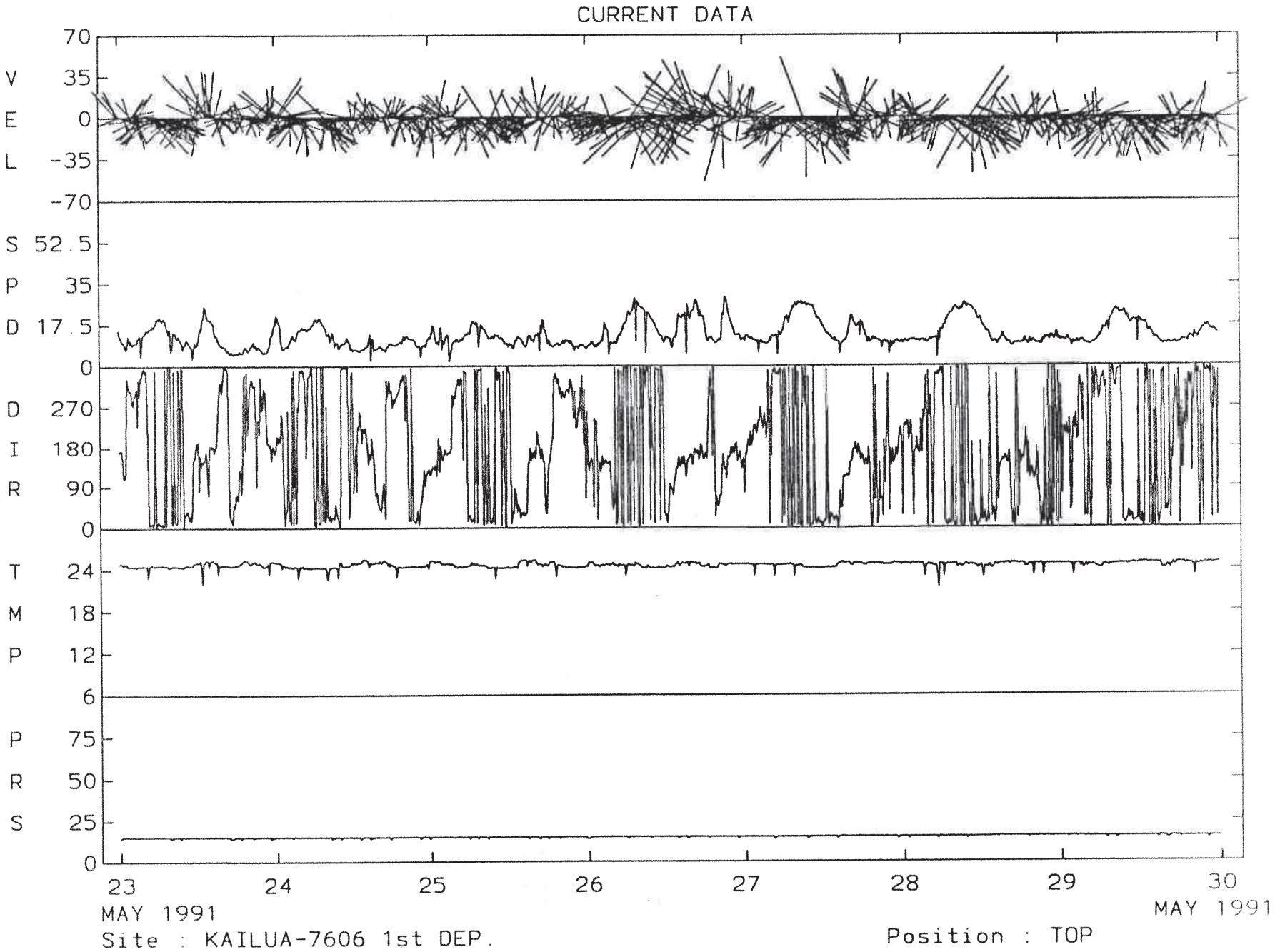
SPEED [cm/sec]	PERCENTAGE OBSERVATIONS LESS THAN
0 - 5	1.05
5 - 10	18.11
10 - 15	57.24
15 - 20	79.98
20 - 25	90.99
25 - 30	96.55
30 - 35	98.63
35 - 40	99.75
40 - 45	99.96
45 - 50	100.00

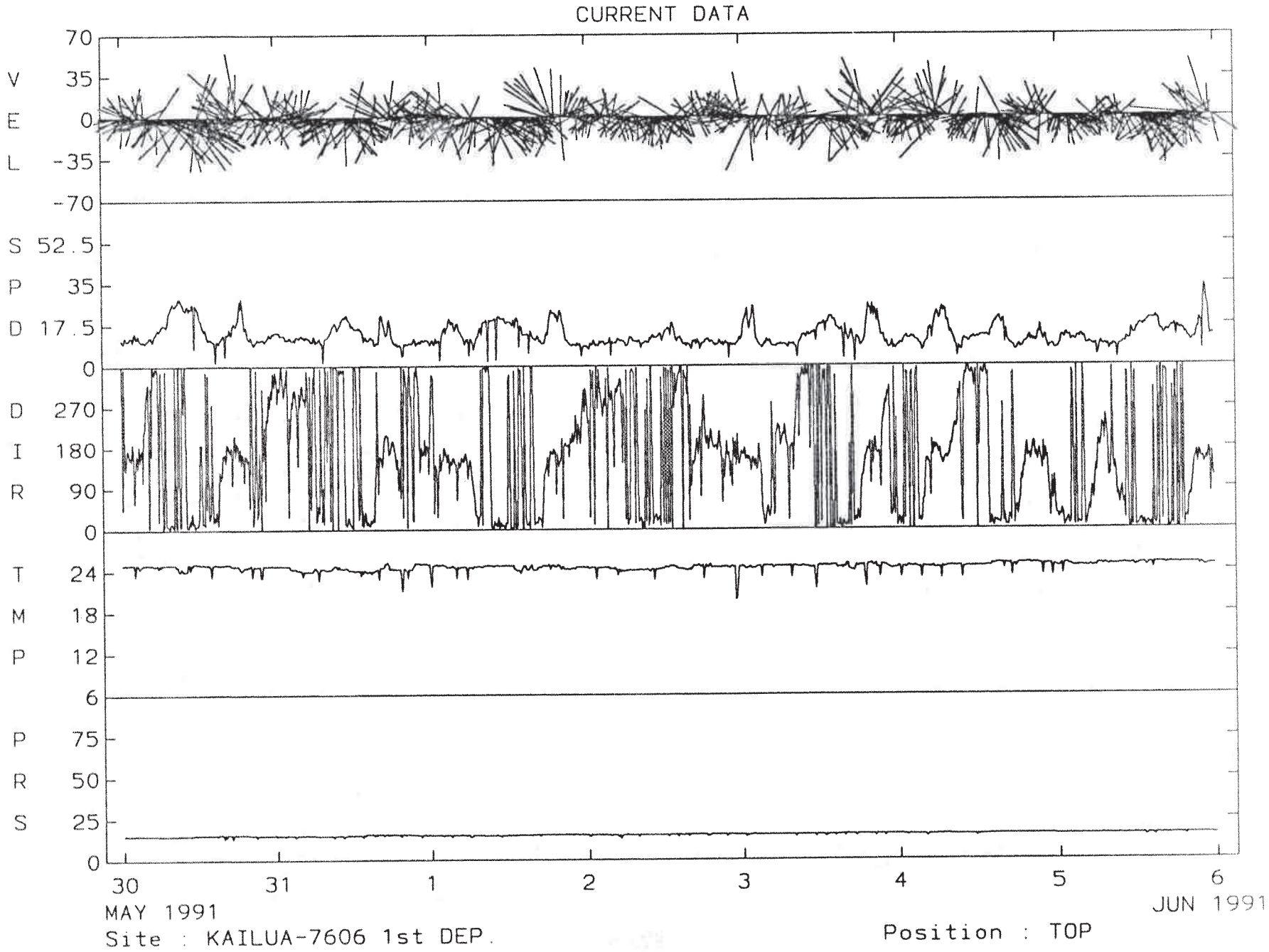

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
25
26
27
28
29
30
1
2
APR 1991
MAY 1991
Site : KAILUA-7606 1st DEP.
Position : TOP

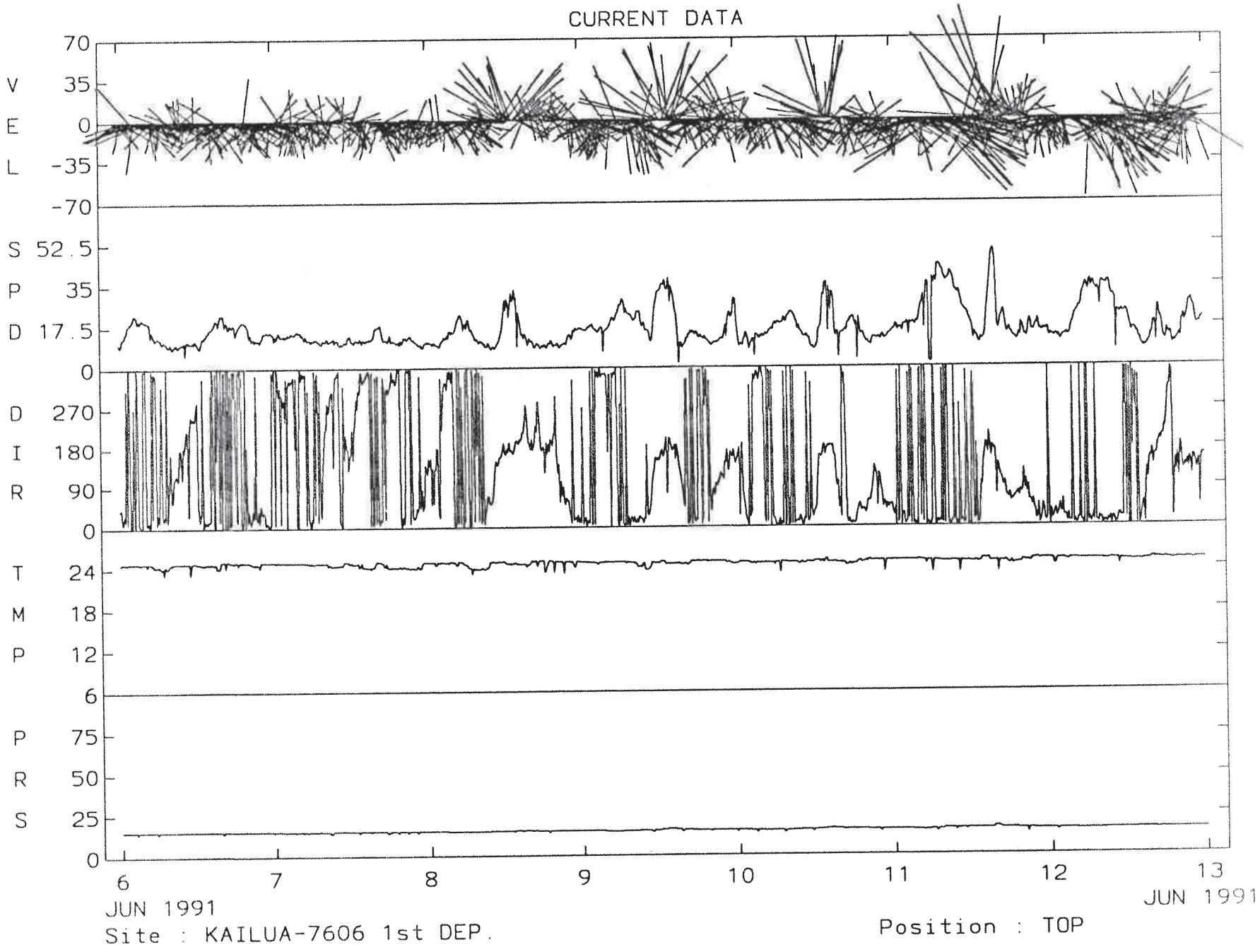

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
2
3
4
5
6
7
8
9
MAY 1991
MAY 1991
Site : KAILUA-7606 1st DEP.
Position : TOP

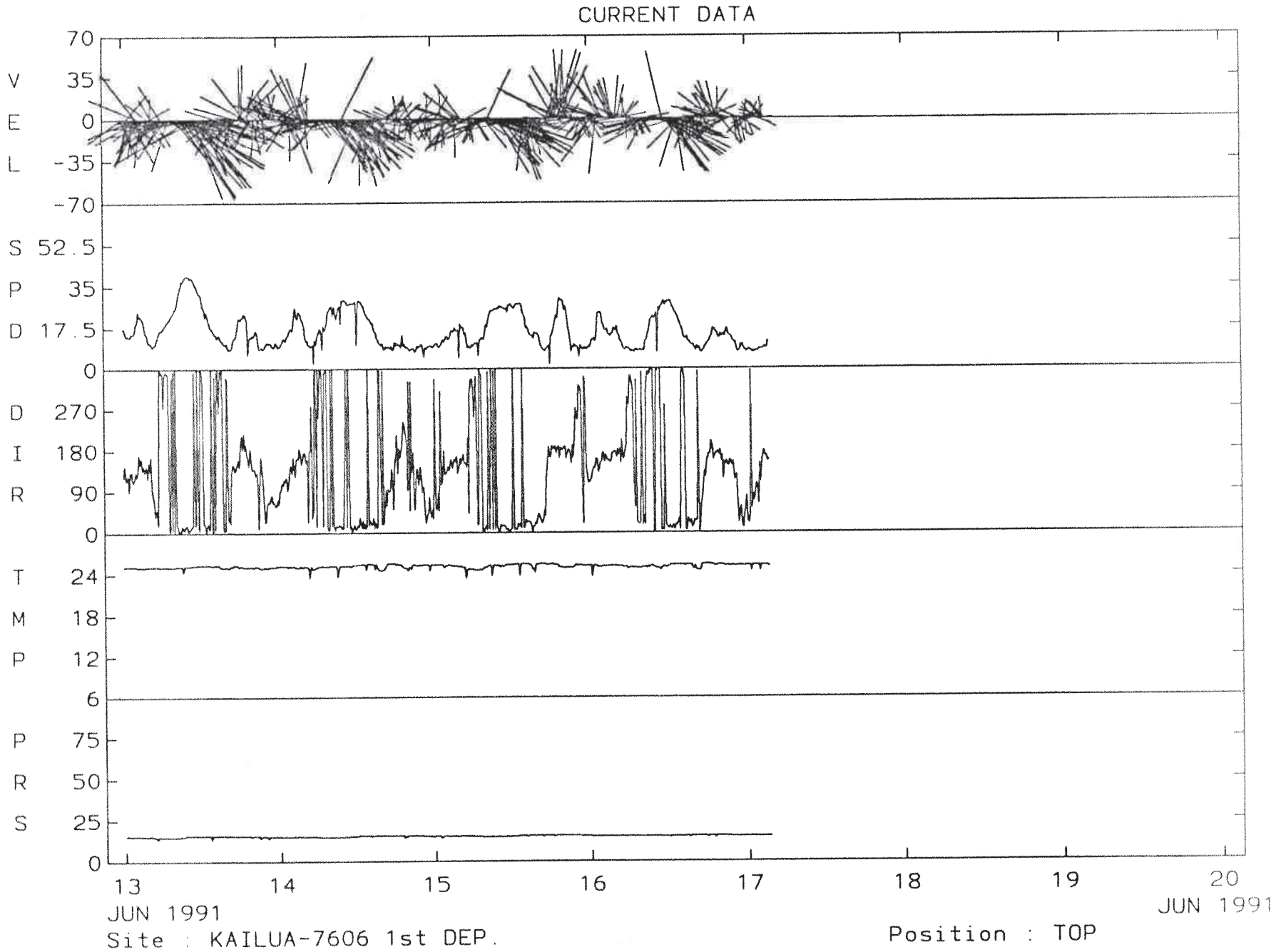

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
9
10
11
12
13
14
15
16
MAY 1991
MAY 1991
Site : KAILUA-7606 1st DEP.
Position : TOP


CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
16
17
18
19
20
21
22
23
MAY 1991
MAY 1991
Site : KAILUA-7606 1st DEP.
Position : TOP

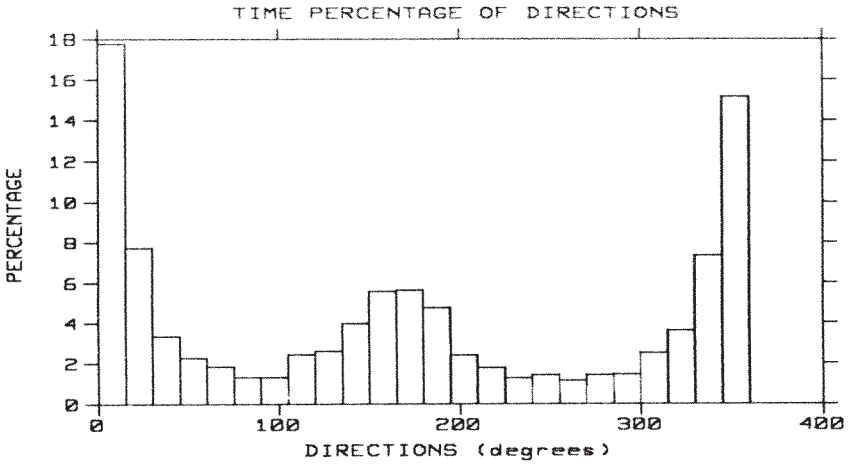

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
23
24
25
26
27
28
29
30
MAY 1991
MAY 1991
Site : KAILUA-7606 1st DEP.
Position : TOP

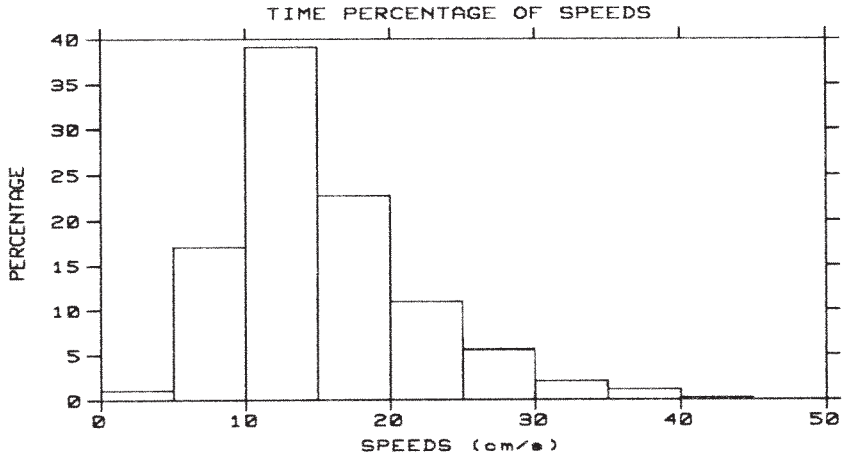

CURRENT DATA
70
VEL 35
0
-35
-70
SPD 52.5
35
17.5
0
DIR 270
180
90
0
TMP 24
18
12
6
PRS 75
50
25
0
30
31
1
2
3
4
5
6
MAY 1991
JUN 1991
Site : KAILUA-7606 1st DEP.
Position : TOP

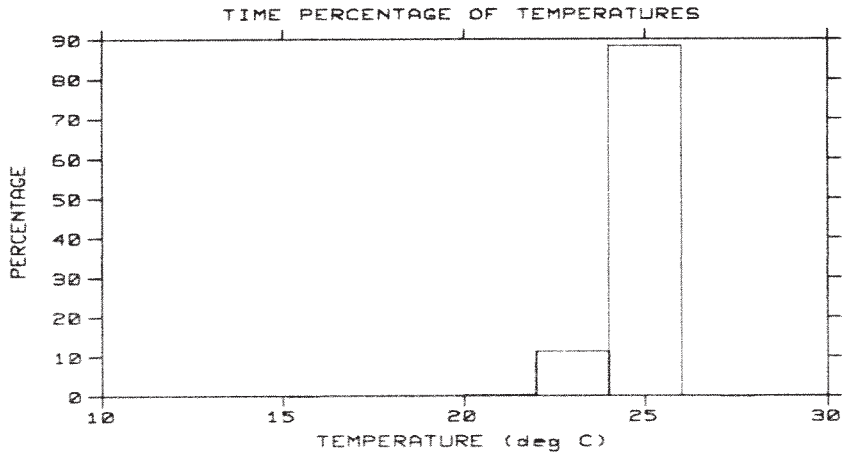

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
6
7
8
9
10
11
12
13
JUN 1991
JUN 1991
Site : KAILUA-7606 1st DEP.
Position : TOP

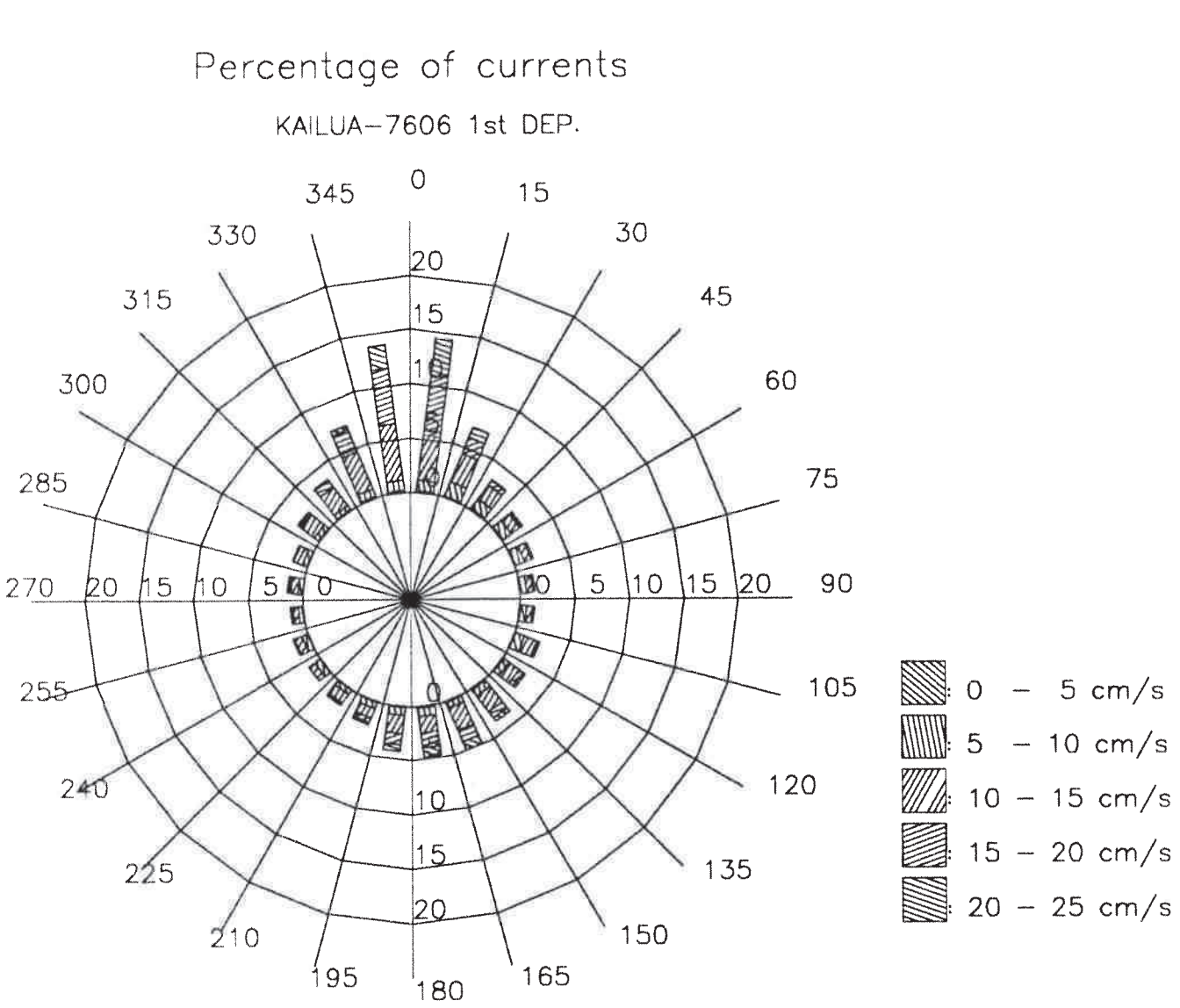

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
13
14
15
16
17
18
19
20
JUN 1991
JUN 1991
Site : KAILUA-7606 1st DEP.
Position : TOP

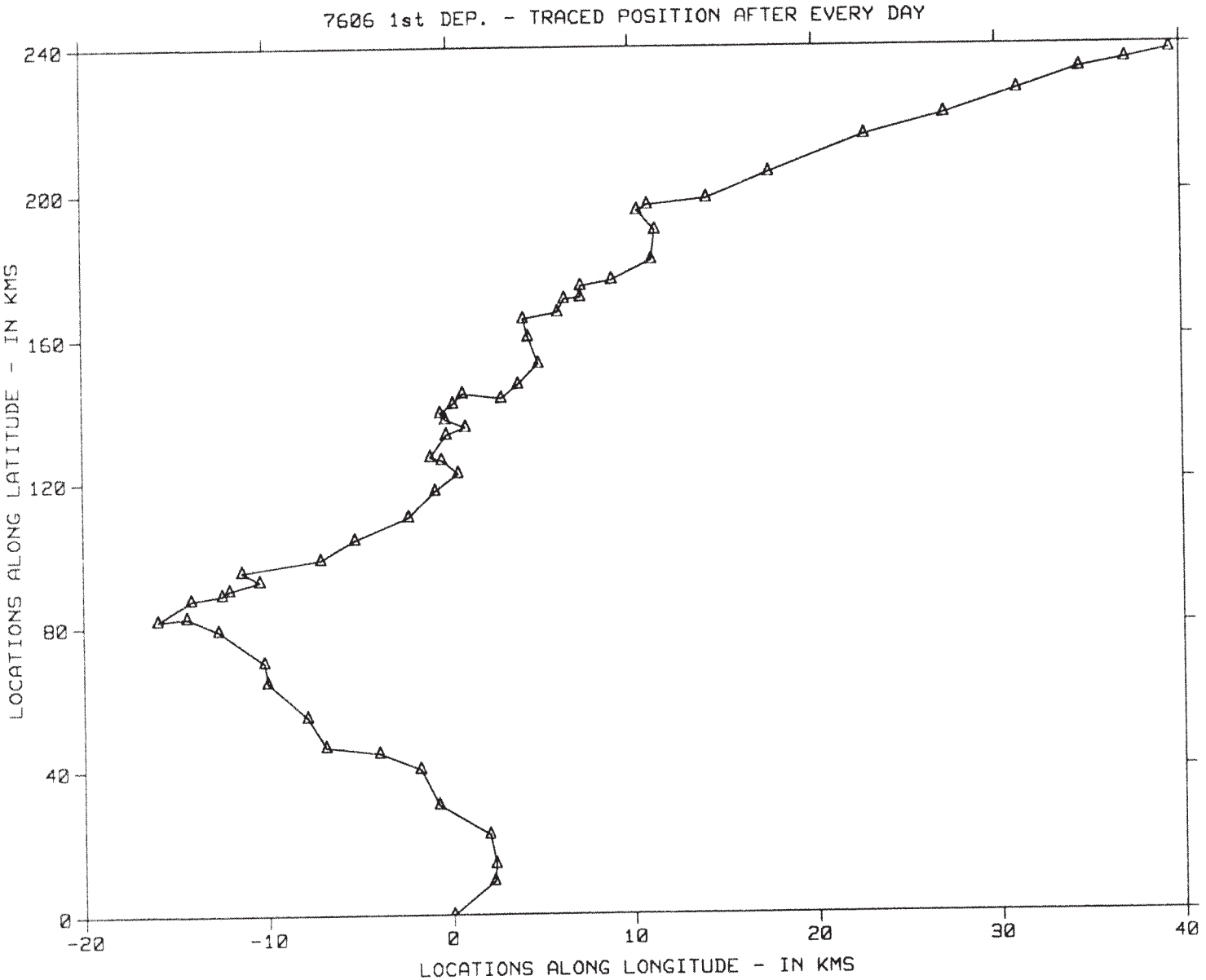
KAILUA-7606 1st DEP.








Percentage of currents
KAILUA–7606 1st DEP.
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
330
345
20
15
10
5
0
0 – 5 cm/s
5 – 10 cm/s
10 – 15 cm/s
15 – 20 cm/s
20 – 25 cm/s


7606 1st DEP. - TRACED POSITION AFTER EVERY DAY
LOCATIONS ALONG LATITUDE - IN KMS
240
200
160
120
80
40
0
-20
-10
0
10
20
30
40
LOCATIONS ALONG LONGITUDE - IN KMS

DATA INFORMATION

SITE NAME	: KAILUA-7605 1st DEP.
METER NUMBER	: 7605
METER POSITION	: BOTTOM
LATITUDE	: 21.26.47N
LONGITUDE	: 157.41.93W
START DATE	: 16:18,23,APR,1991
END DATE	: 10:45, 6,AUG,1991
DEPLOY DATE	: 13:58,25,APR,1991
BOTTOM DEPTH	: 870 ft.
METER DEPTH	: 530 ft.
REV COUNT	: 4.00
TIME INTERVAL	: 10.00
DATA FILE	: 7605bin.DAT
TOTAL PTS	: 5927
START PT	: 143

VELOCITY DISTRIBUTION

SPEED	0 | 5	5 | 10	10 | 15	15 | 20	20 | 25	25 | 30	30 | 35	35 | 40	40 | 45	45 | 50
DIR										
0 - 15	101	106	24	4	0	0	0	0	0	0
15 - 30	113	149	40	13	0	0	0	0	0	0
30 - 45	117	124	38	5	0	0	0	0	0	0
45 - 60	91	121	13	0	0	1	0	0	0	0
60 - 75	75	92	9	0	0	0	0	0	0	0
75 - 90	92	68	1	1	0	0	0	0	0	0
90 - 105	64	60	0	0	0	0	0	0	0	0
105 - 120	93	78	4	1	0	0	0	0	0	0
120 - 135	84	89	15	1	0	0	0	0	0	0
135 - 150	90	142	26	1	2	1	0	0	0	0
150 - 165	82	164	59	10	6	0	0	0	0	0
165 - 180	83	168	100	27	8	1	0	1	0	0
180 - 195	73	163	66	28	3	1	0	0	0	0
195 - 210	78	137	73	20	2	1	0	0	0	0
210 - 225	77	128	46	17	2	0	0	0	0	0
225 - 240	93	104	23	7	0	0	0	0	0	0
240 - 255	109	96	22	4	1	0	0	0	0	0
255 - 270	90	103	25	3	0	0	0	0	0	0
270 - 285	92	79	29	3	0	0	0	0	0	0
285 - 300	87	73	23	8	0	0	0	0	0	0
300 - 315	79	105	29	11	4	5	2	0	0	0
315 - 330	96	114	21	7	0	0	0	0	0	0
330 - 345	77	105	25	9	0	0	0	0	0	0
345 - 360	109	104	31	4	0	0	0	0	0	0

SPEED	50 | 55	55 | 60	60 | 65	65 | 70	70 | 75	75 | 80	80 | 85	85 | 90	90 | 95	95 | 100
DIR										
0 - 15	0	0	0	0	0	0	0	0	0	0
15 - 30	0	0	0	0	0	0	0	0	0	0
30 - 45	0	0	0	0	0	0	0	0	0	0
45 - 60	0	0	0	0	0	0	0	0	0	0
60 - 75	0	0	0	0	0	0	0	0	0	0
75 - 90	0	0	0	0	0	0	0	0	0	0

90 - 105	0	0	0	0	0	0	0	0	0	0
105 - 120	0	0	0	0	0	0	0	0	0	0
120 - 135	0	0	0	0	0	0	0	0	0	0
135 - 150	0	0	0	0	0	0	0	0	0	0
150 - 165	0	0	0	0	0	0	0	0	0	0
165 - 180	0	0	0	0	0	0	0	0	0	0
180 - 195	0	0	0	0	0	0	0	0	0	0
195 - 210	0	0	0	0	0	0	0	0	0	0
210 - 225	0	0	0	0	0	0	0	0	0	0
225 - 240	0	0	0	0	0	0	0	0	0	0
240 - 255	1	0	0	0	0	0	0	0	0	0
255 - 270	0	0	0	0	0	0	0	0	0	0
270 - 285	0	0	0	0	0	0	0	0	0	0
285 - 300	0	0	0	0	0	0	0	0	0	0
300 - 315	0	0	0	0	0	0	0	0	0	0
315 - 330	0	0	0	0	0	0	0	0	0	0
330 - 345	0	0	0	0	0	0	0	0	0	0
345 - 360	0	0	0	0	0	0	0	0	0	0

DIRECTION [Degrees]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 15	235	4.06
15 - 30	315	5.45
30 - 45	284	4.91
45 - 60	226	3.91
60 - 75	176	3.04
75 - 90	162	2.80
90 - 105	124	2.14
105 - 120	176	3.04
120 - 135	189	3.27
135 - 150	262	4.53
150 - 165	321	5.55
165 - 180	388	6.71
180 - 195	334	5.77
195 - 210	311	5.38
210 - 225	270	4.67
225 - 240	227	3.92
240 - 255	233	4.03
255 - 270	221	3.82
270 - 285	203	3.51
285 - 300	191	3.30
300 - 315	235	4.06
315 - 330	238	4.11
330 - 345	216	3.73
345 - 360	248	4.29

SPEED [cm/sec]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 5	2145	37.08
5 - 10	2672	46.19
10 - 15	742	12.83
15 - 20	184	3.18
20 - 25	28	.48
25 - 30	10	.17
30 - 35	2	.03
35 - 40	1	.02

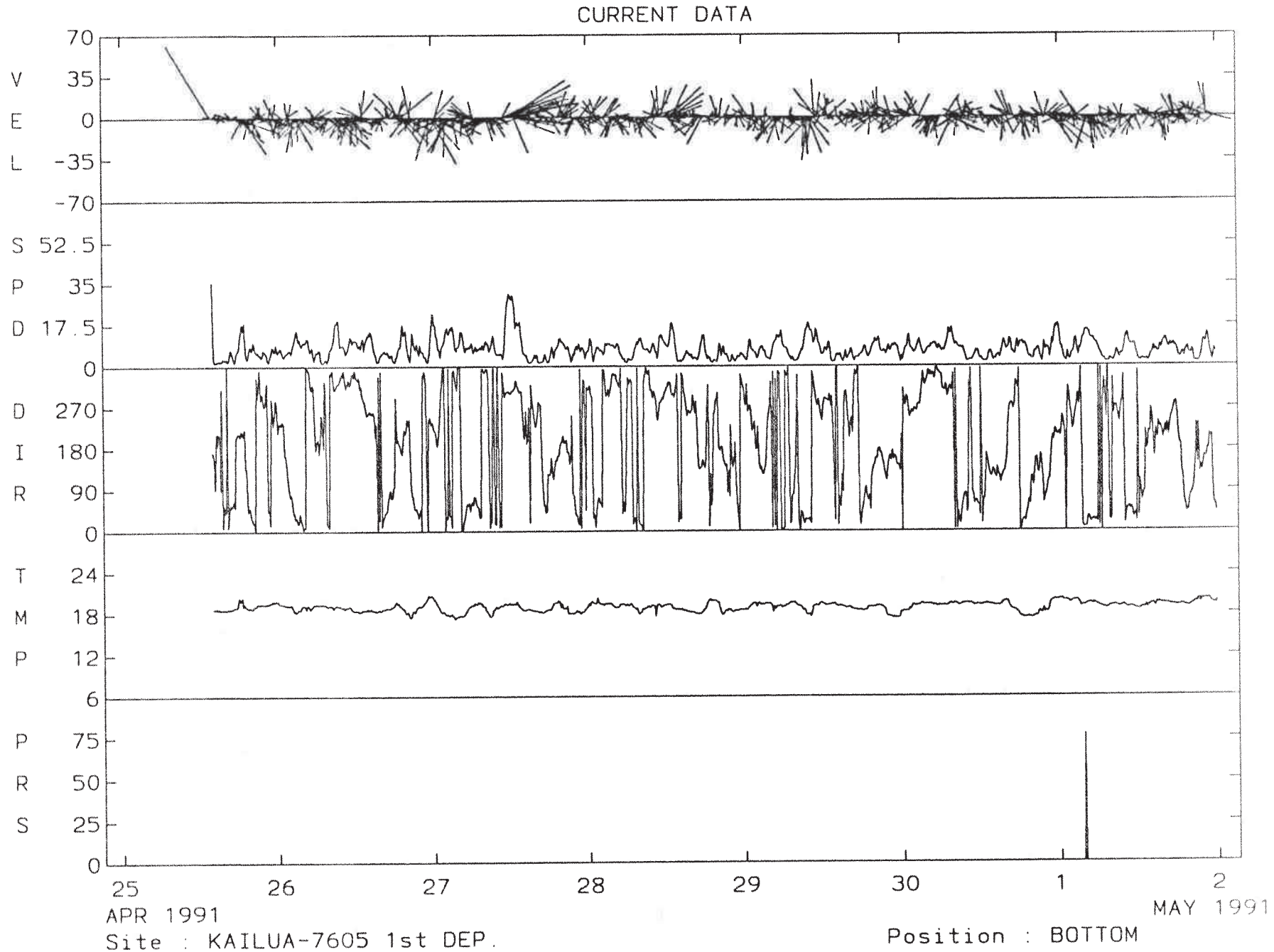
40 - 45	0	.00
45 - 50	0	.00

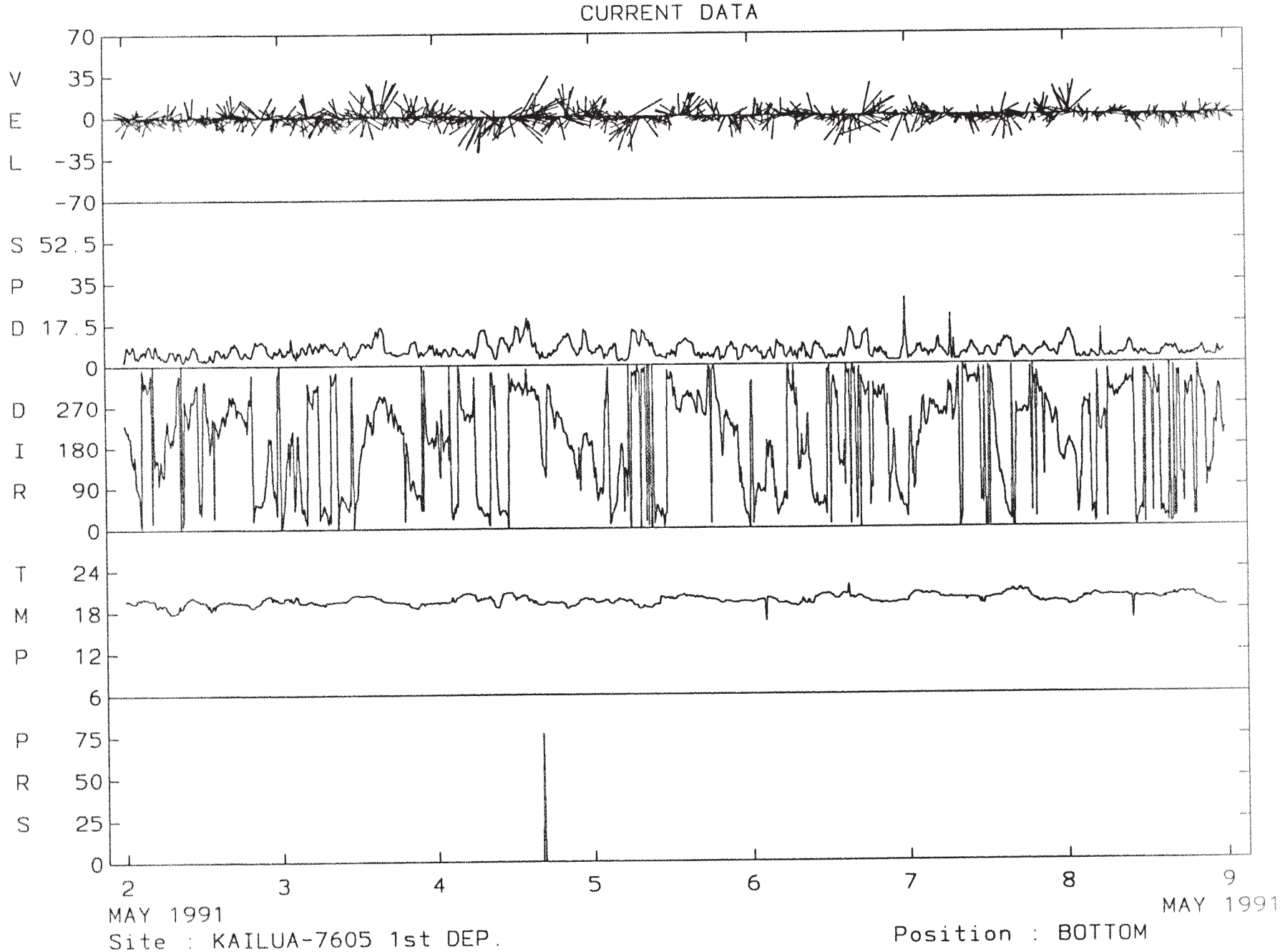
Total number of valid data points : 5785
Maximum Speed : 53.58 cm/s
Minimum Speed : 1.50 cm/s
Mean Speed : 6.81 cm/s
Range : 52.08 cm/s
Standard Deviation : .10 cm/s

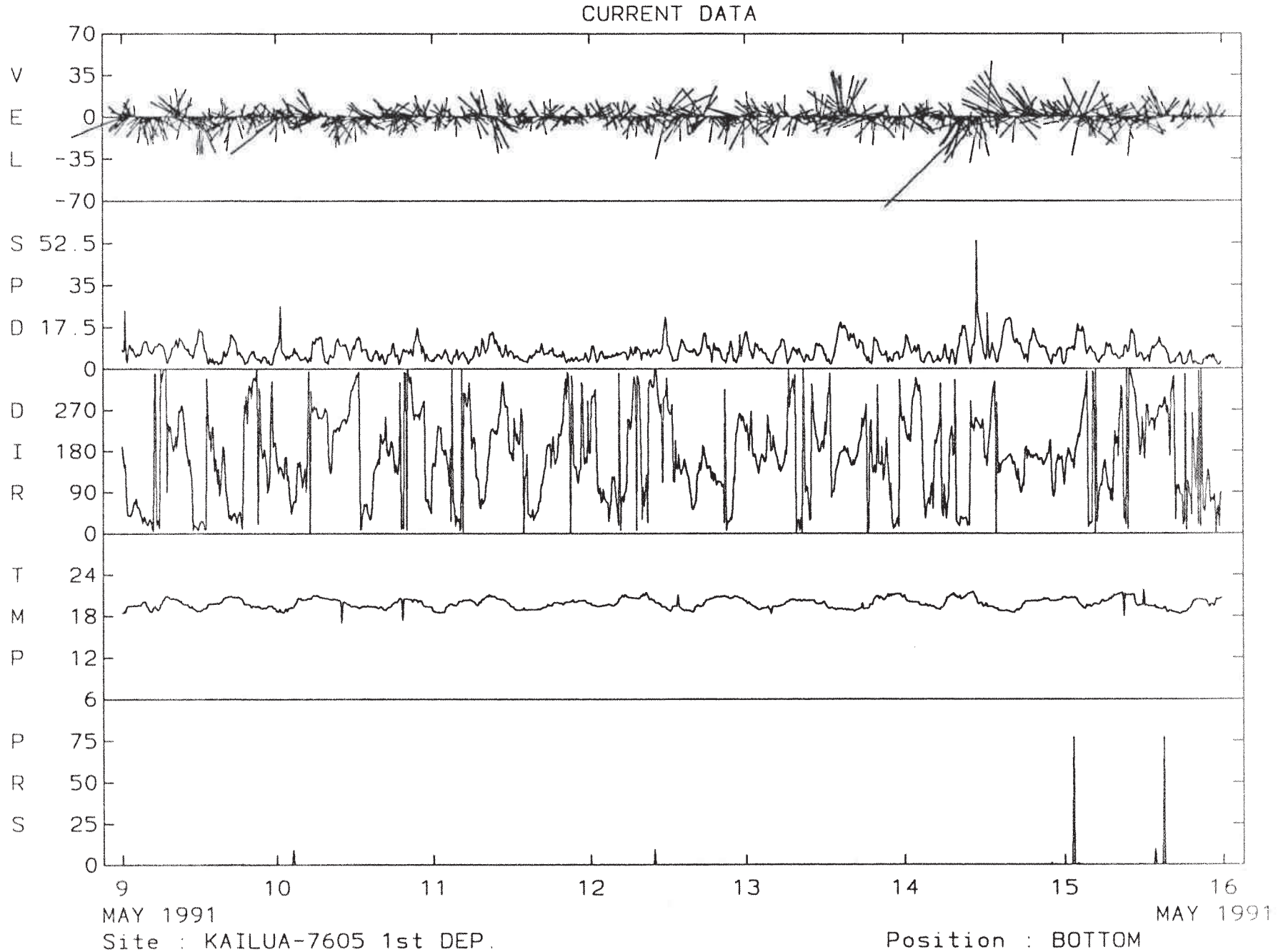
TEMPERATURE [Celcius]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 2	0	.00
2 - 4	0	.00
4 - 6	0	.00
6 - 8	0	.00
8 - 10	0	.00
10 - 12	0	.00
12 - 14	0	.00
14 - 16	0	.00
16 - 18	109	1.88
18 - 20	3917	67.71
20 - 22	1759	30.41
22 - 24	0	.00
24 - 26	0	.00
26 - 28	0	.00
28 - 30	0	.00

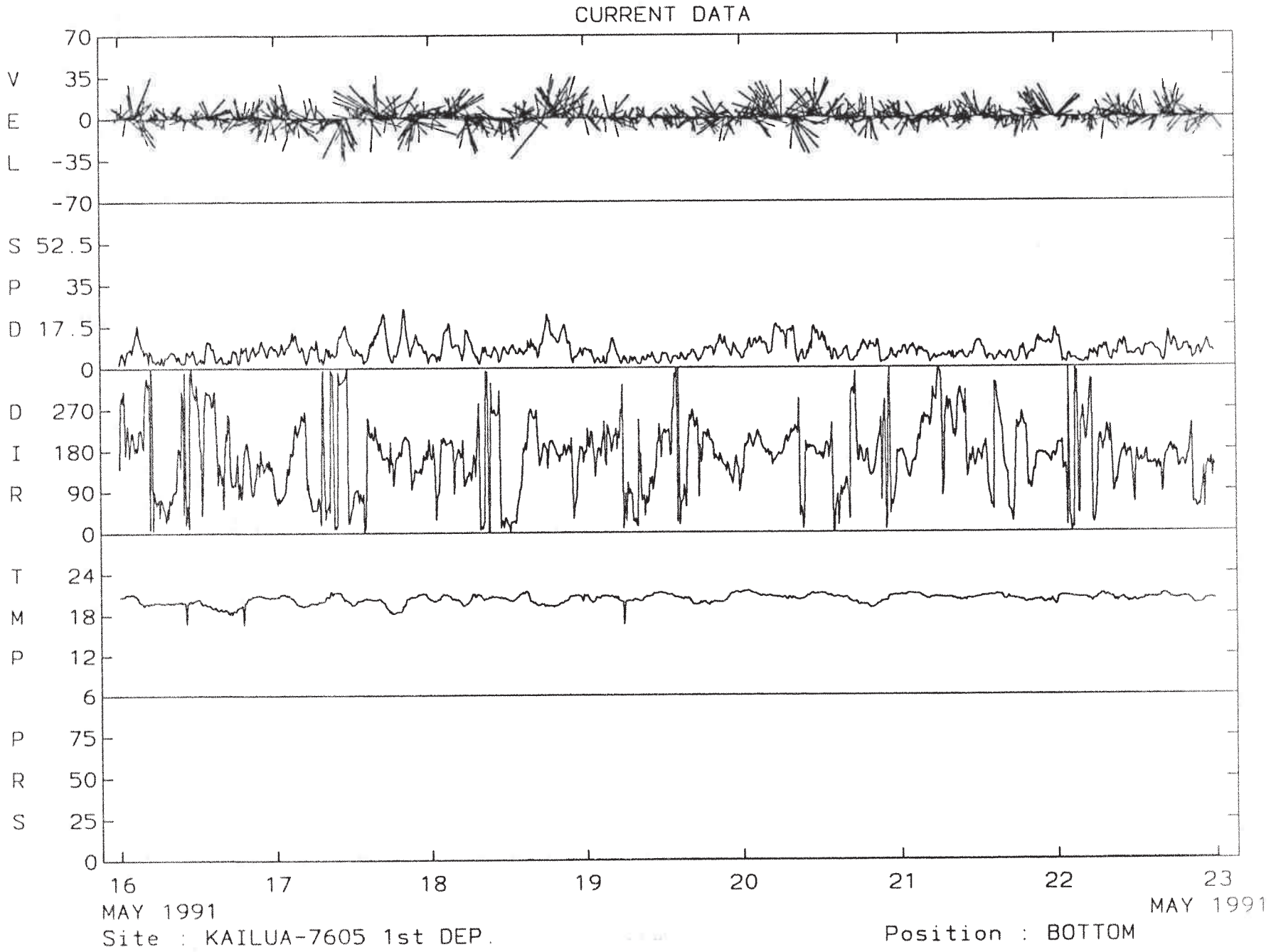
Total number of valid data points : 5785
Maximum Temperature : 21.81 °C
Minimum Temperature : 16.50 °C
Mean Temperature : 19.60 °C
Range : 5.31 °C
Standard Deviation : .26 °C

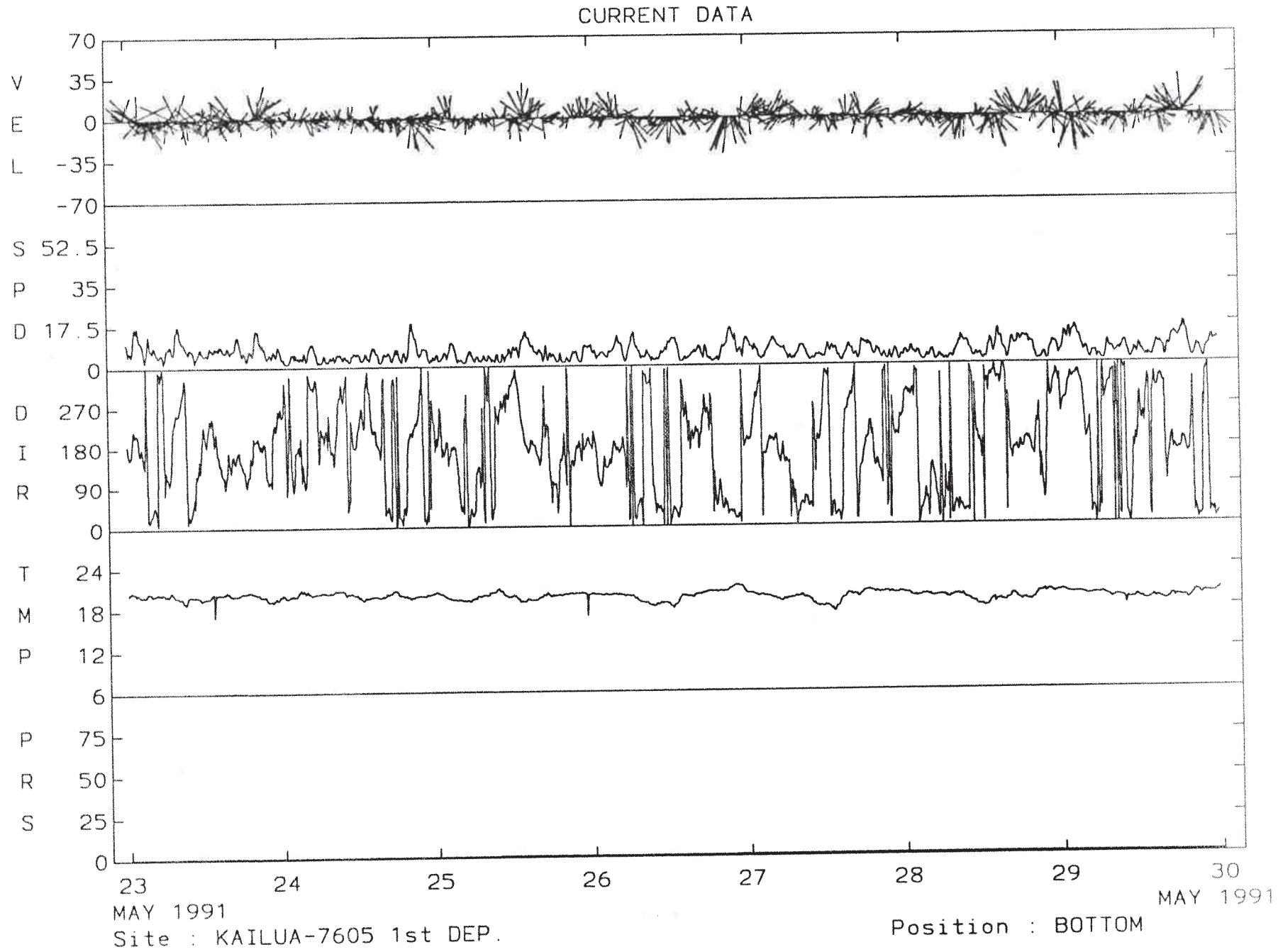
SPEED [cm/sec]	PERCENTAGE OBSERVATIONS LESS THAN
0 - 5	37.08
5 - 10	83.27
10 - 15	96.09
15 - 20	99.27
20 - 25	99.76
25 - 30	99.93
30 - 35	99.97
35 - 40	99.98
40 - 45	99.98
45 - 50	99.98

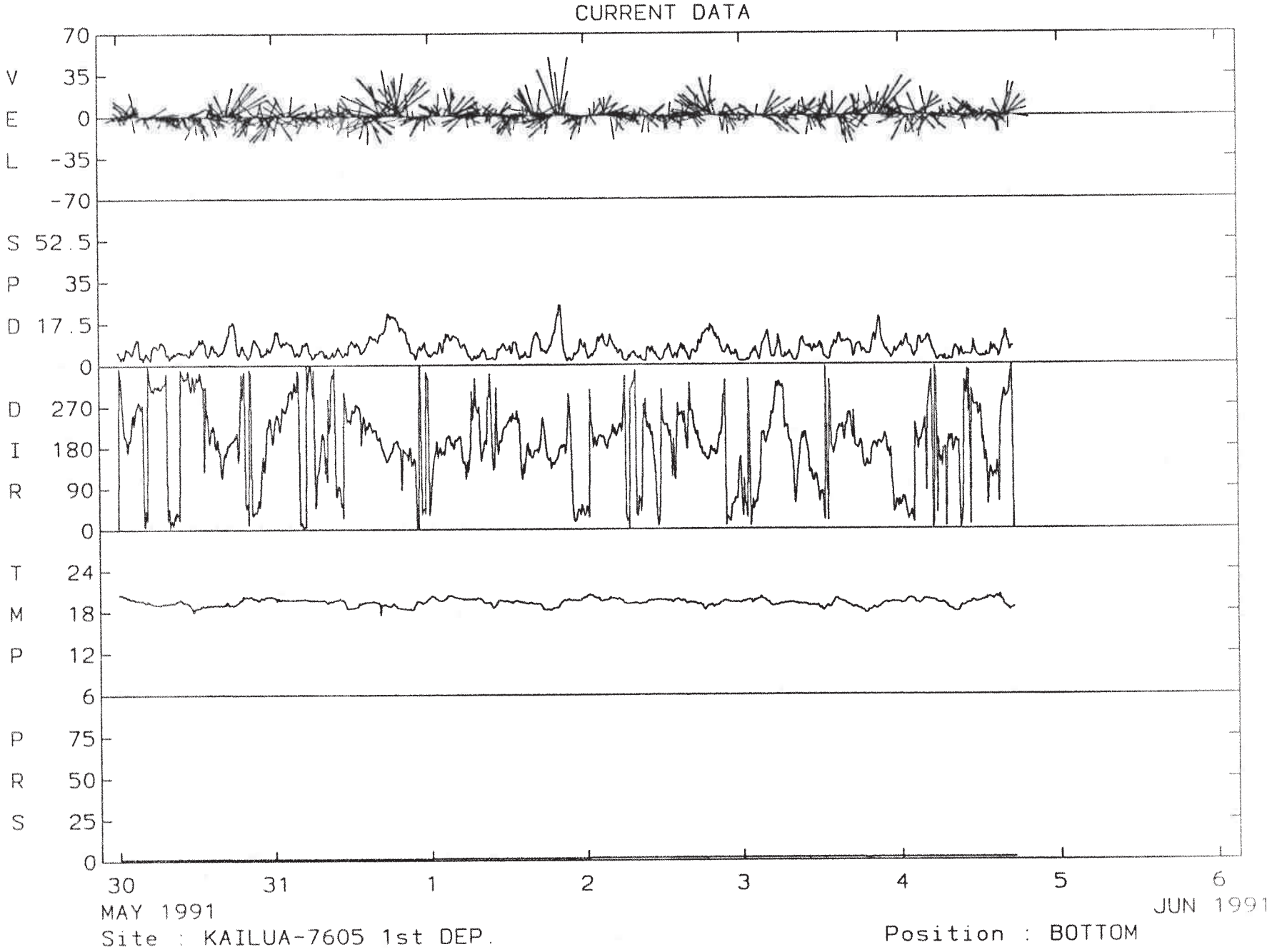

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
25
26
27
28
29
30
1
2
APR 1991
MAY 1991
Site : KAILUA-7605 1st DEP.
Position : BOTTOM


CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
2
3
4
5
6
7
8
9
MAY 1991
MAY 1991
Site : KAILUA-7605 1st DEP.
Position : BOTTOM

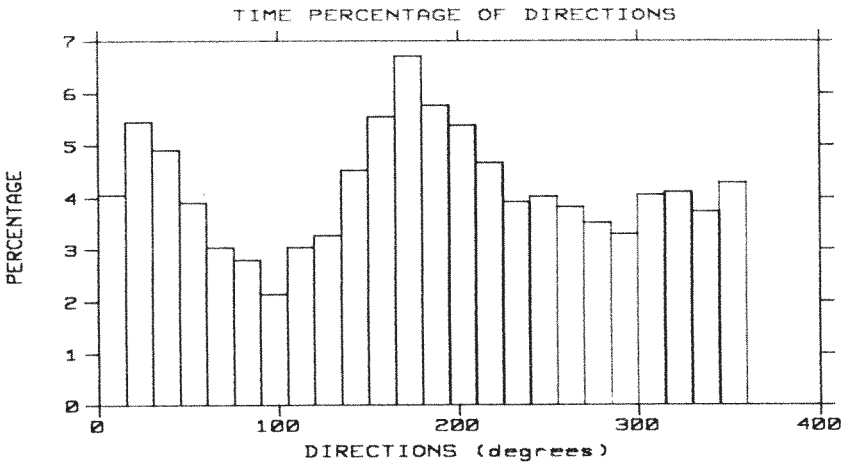

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
9
10
11
12
13
14
15
16
MAY 1991
MAY 1991
Site : KAILUA-7605 1st DEP.
Position : BOTTOM

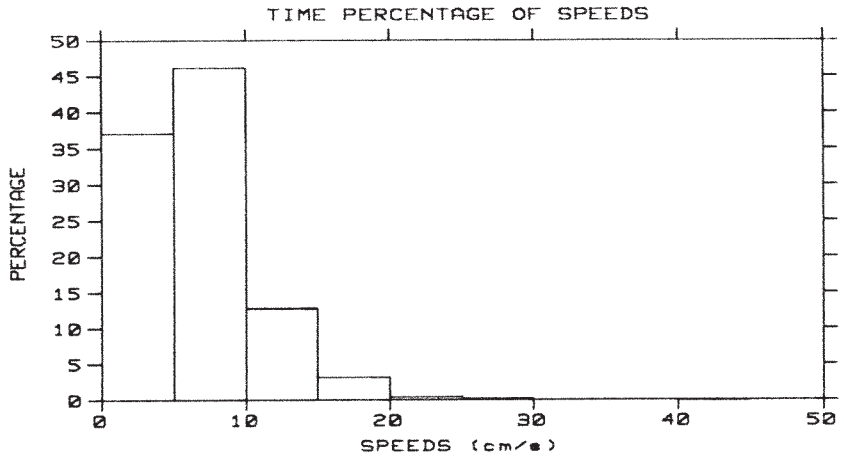

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
16
17
18
19
20
21
22
23
MAY 1991
MAY 1991
Site : KAILUA-7605 1st DEP.
Position : BOTTOM

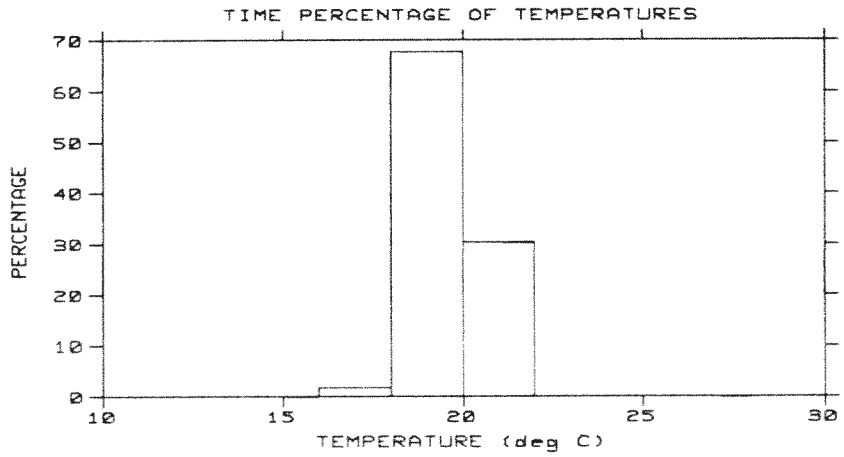

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
23
24
25
26
27
28
29
30
MAY 1991
MAY 1991
Site : KAILUA-7605 1st DEP.
Position : BOTTOM

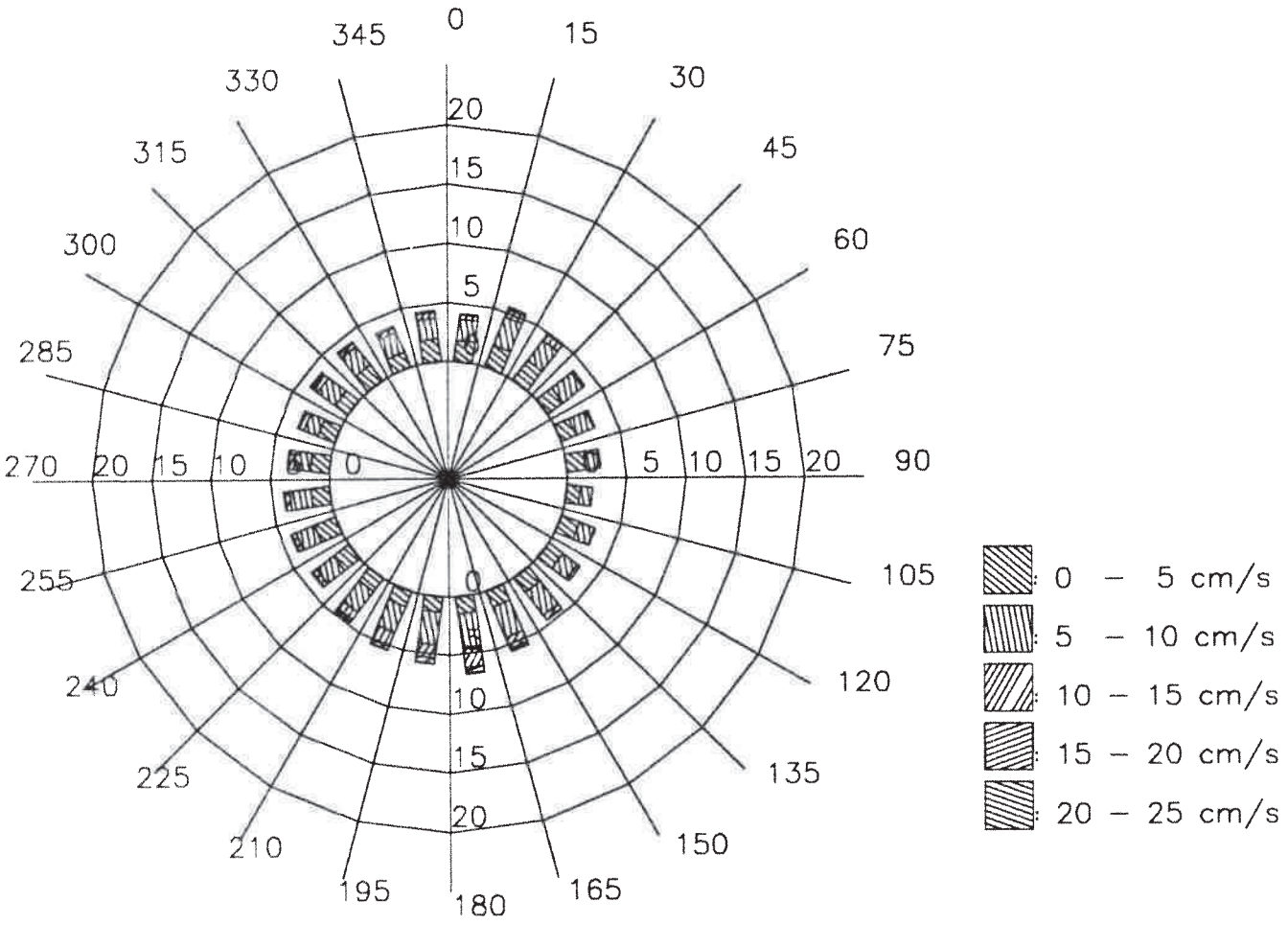

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
30
31
1
2
3
4
5
6
MAY 1991
JUN 1991
Site : KAILUA-7605 1st DEP.
Position : BOTTOM

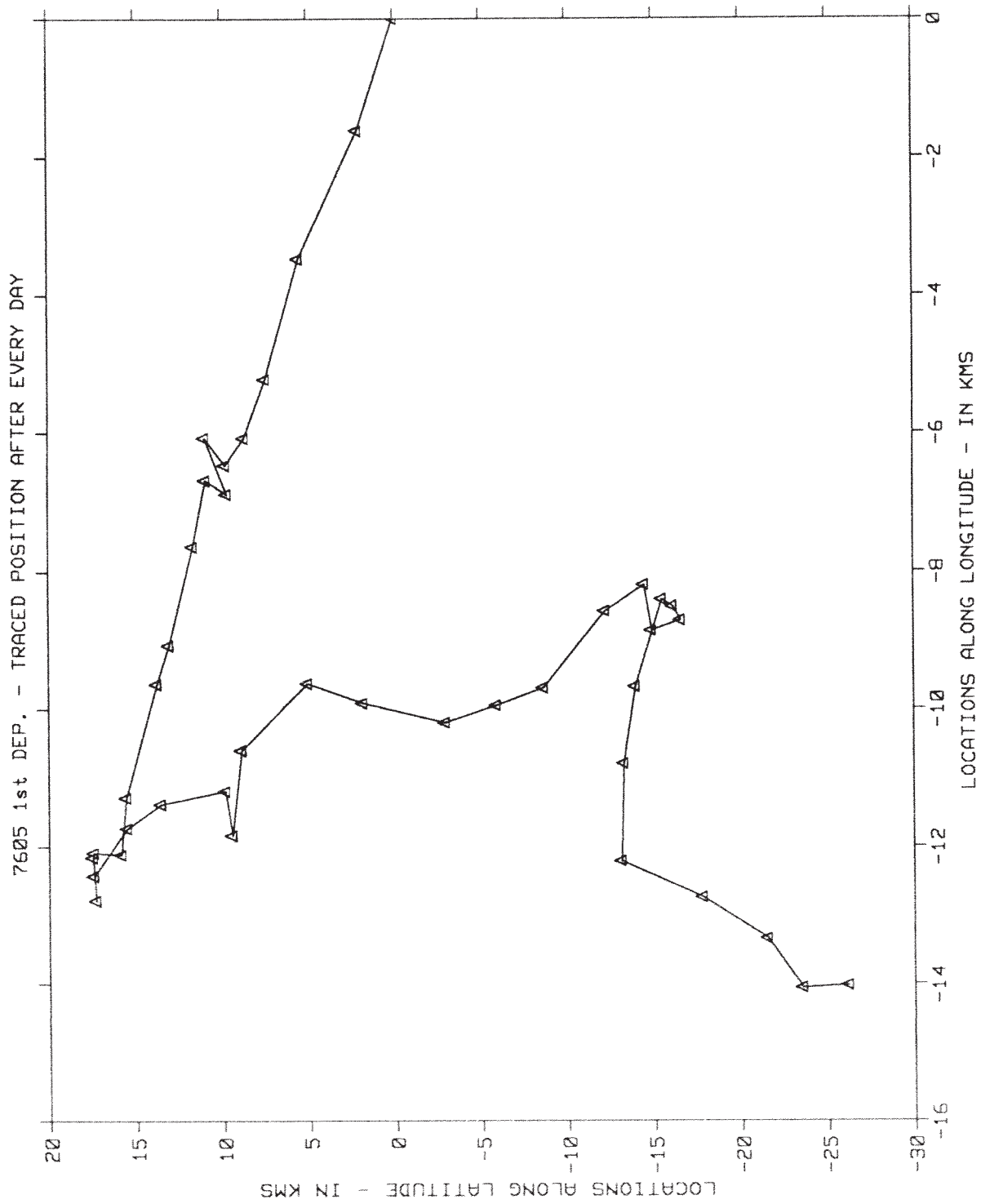
KAILUA-7605 1st DEP.








Percentage of currents
KAILUA–7605 1st DEP.
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
330
345
0
5
10
15
20
0 – 5 cm/s
5 – 10 cm/s
10 – 15 cm/s
15 – 20 cm/s
20 – 25 cm/s


7605 1st DEP. - TRACED POSITION AFTER EVERY DAY
LOCATIONS ALONG LONGITUDE - IN KMS
LOCATIONS ALONG LATITUDE - IN KMS
20
15
10
5
0
-5
-10
-15
-20
-25
-30
0
-2
-4
-6
-8
-10
-12
-14
-16

DATA INFORMATION

SITE NAME	: KAILUA-7558 1st DEP.
METER NUMBER	: 7558
METER POSITION	: TOP
LATITUDE	: 21.26.47N
LONGITUDE	: 157.41.93W
START DATE	: 10:42,24,APR,1991
END DATE	: 10:49, 6,AUG,1991
DEPLOY DATE	: 13:58,25,APR,1991
BOTTOM DEPTH	: 870 ft.
METER DEPTH	: 120 ft.
REV COUNT	: 4.00
TIME INTERVAL	: 10.00
DATA FILE	: 7558bin.DAT
TOTAL PTS	: 6298
START PT	: 310

VELOCITY DISTRIBUTION

SPEED	0 | 5	5 | 10	10 | 15	15 | 20	20 | 25	25 | 30	30 | 35	35 | 40	40 | 45	45 | 50
DIR										
0 - 15	53	121	94	61	53	29	14	4	1	0
15 - 30	36	83	49	16	8	2	0	0	0	0
30 - 45	29	38	12	6	0	0	0	0	0	0
45 - 60	23	41	6	1	0	0	0	0	0	0
60 - 75	16	27	4	2	0	0	0	0	0	0
75 - 90	14	34	7	0	0	0	0	0	0	0
90 - 105	27	34	0	3	0	0	0	0	0	0
105 - 120	29	29	4	3	0	0	0	0	0	0
120 - 135	20	50	6	0	0	0	0	0	0	0
135 - 150	41	88	19	4	0	0	0	0	0	0
150 - 165	40	125	44	3	0	0	0	0	0	0
165 - 180	46	109	55	25	6	0	0	0	0	0
180 - 195	59	125	75	30	9	5	2	0	0	0
195 - 210	44	80	66	31	12	8	1	0	0	0
210 - 225	40	81	50	22	6	1	1	0	0	0
225 - 240	40	100	33	11	1	1	0	0	0	0
240 - 255	38	93	31	6	0	0	0	0	0	0
255 - 270	35	109	27	5	0	0	0	0	0	0
270 - 285	39	139	24	8	2	0	0	0	0	0
285 - 300	40	131	52	43	1	2	0	0	0	0
300 - 315	45	131	99	62	27	11	3	3	0	1
315 - 330	48	143	153	124	97	61	28	5	4	0
330 - 345	61	161	130	157	126	94	52	27	12	0
345 - 360	51	129	153	125	75	75	43	15	5	0

SPEED	50 | 55	55 | 60	60 | 65	65 | 70	70 | 75	75 | 80	80 | 85	85 | 90	90 | 95	95 | 100
DIR										
0 - 15	0	0	0	0	0	0	0	0	0	0
15 - 30	0	0	0	0	0	0	0	0	0	0
30 - 45	0	0	0	0	0	0	0	0	0	0
45 - 60	0	0	0	0	0	0	0	0	0	0
60 - 75	0	0	0	0	0	0	0	0	0	0
75 - 90	0	0	0	0	0	0	0	0	0	0

90 - 105	0	0	0	0	0	0	0	0	0	0
105 - 120	0	0	0	0	0	0	0	0	0	0
120 - 135	0	0	0	0	0	0	0	0	0	0
135 - 150	0	0	0	0	0	0	0	0	0	0
150 - 165	0	0	0	0	0	0	0	0	0	0
165 - 180	0	0	0	0	0	0	0	0	0	0
180 - 195	0	0	0	0	0	0	0	0	0	0
195 - 210	0	0	0	0	0	0	0	0	0	0
210 - 225	0	0	0	0	0	0	0	0	0	0
225 - 240	0	0	0	0	0	0	0	0	0	0
240 - 255	0	0	0	0	0	0	0	0	0	0
255 - 270	0	0	0	0	0	0	0	0	0	0
270 - 285	0	0	0	0	0	0	0	0	0	0
285 - 300	0	0	0	0	0	0	0	0	0	0
300 - 315	0	0	0	0	0	0	0	0	0	0
315 - 330	0	0	0	0	0	0	0	0	0	0
330 - 345	0	0	0	0	0	0	0	0	0	0
345 - 360	0	0	0	0	0	0	0	0	0	0

DIRECTION [Degrees]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 15	430	7.18
15 - 30	194	3.24
30 - 45	85	1.42
45 - 60	71	1.19
60 - 75	49	.82
75 - 90	55	.92
90 - 105	64	1.07
105 - 120	65	1.09
120 - 135	76	1.27
135 - 150	152	2.54
150 - 165	212	3.54
165 - 180	241	4.02
180 - 195	305	5.09
195 - 210	242	4.04
210 - 225	201	3.36
225 - 240	186	3.11
240 - 255	168	2.81
255 - 270	176	2.94
270 - 285	212	3.54
285 - 300	269	4.49
300 - 315	382	6.38
315 - 330	663	11.07
330 - 345	820	13.69
345 - 360	671	11.20

SPEED [cm/sec]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 5	914	15.26
5 - 10	2201	36.75
10 - 15	1193	19.92
15 - 20	748	12.49
20 - 25	423	7.06
25 - 30	289	4.83
30 - 35	144	2.40
35 - 40	54	.90

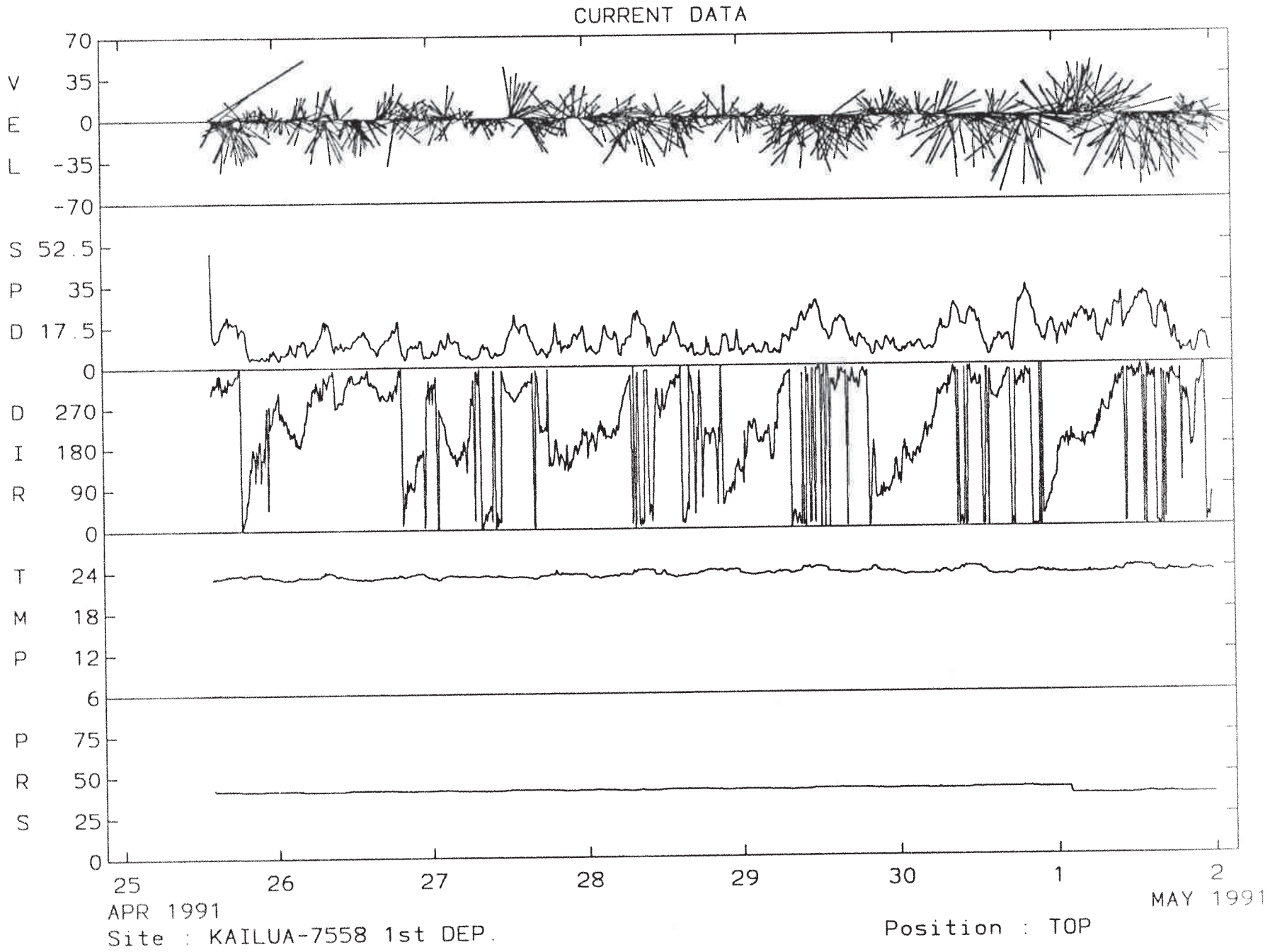
40 - 45	22	.37
45 - 50	1	.02

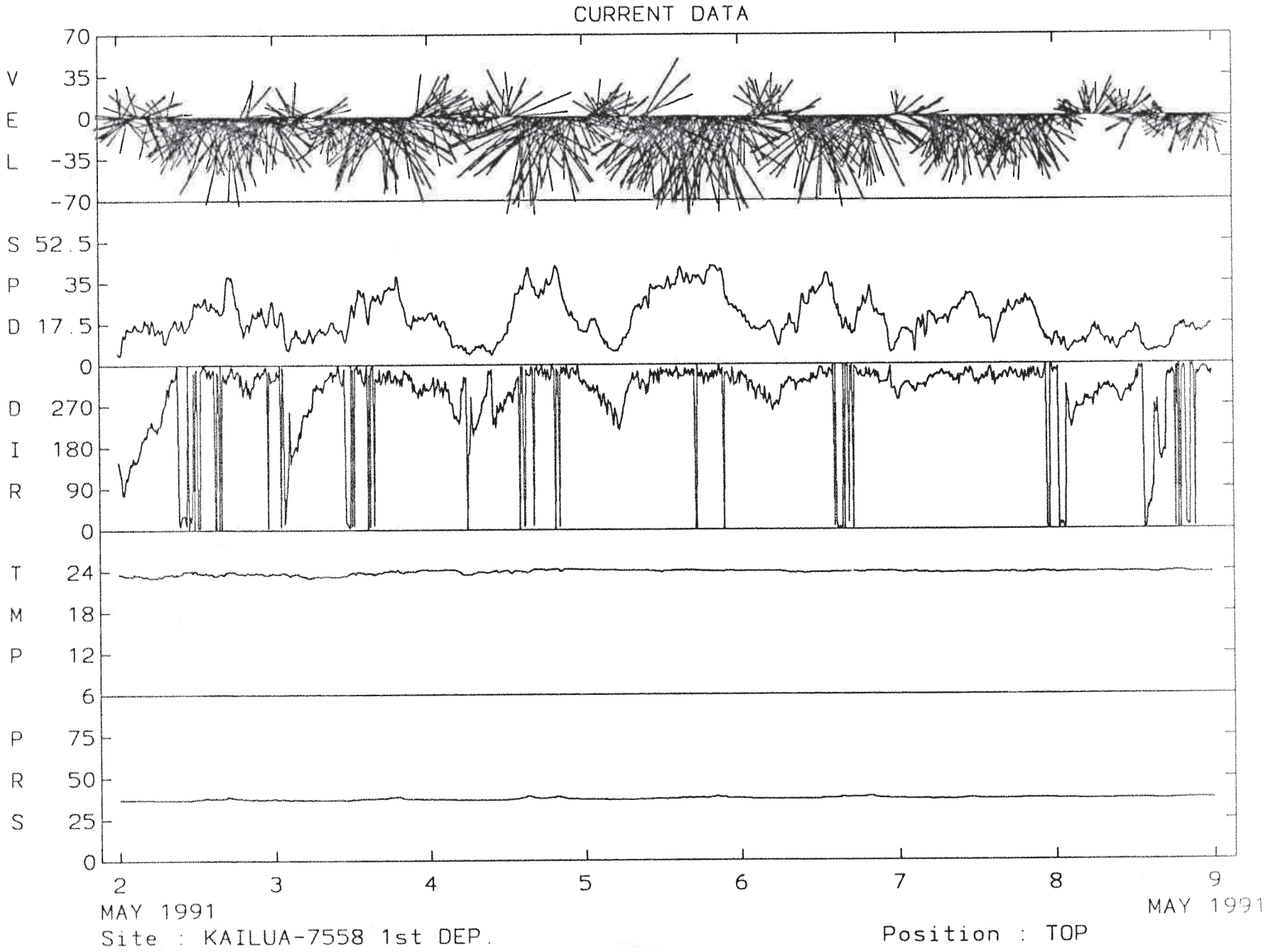
Total number of valid data points : 5989
Maximum Speed : 49.10 cm/s
Minimum Speed : 2.34 cm/s
Mean Speed : 12.06 cm/s
Range : 46.76 cm/s
Standard Deviation : .19 cm/s

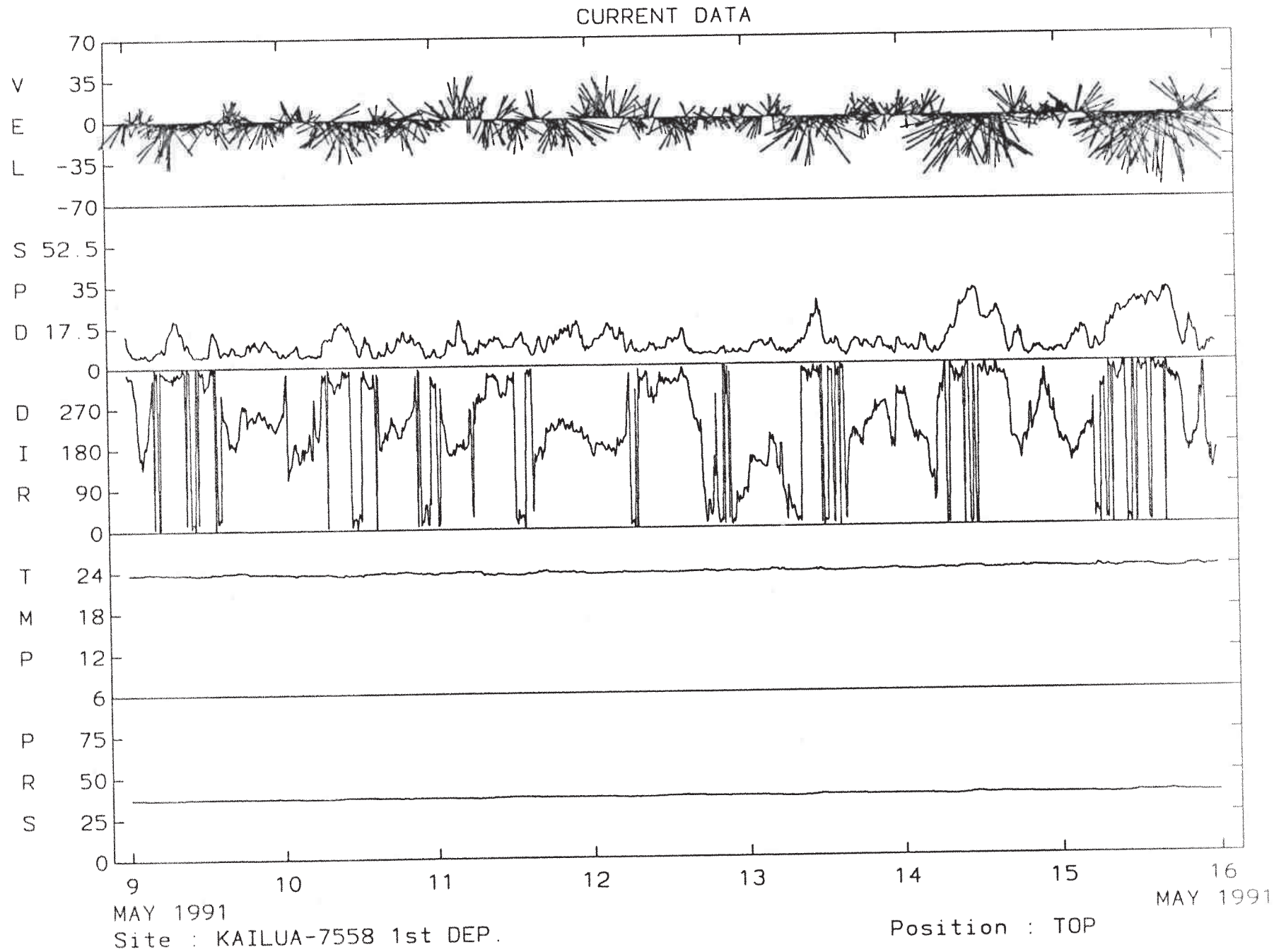
TEMPERATURE [Celcius]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 2	0	.00
2 - 4	0	.00
4 - 6	0	.00
6 - 8	0	.00
8 - 10	0	.00
10 - 12	0	.00
12 - 14	0	.00
14 - 16	0	.00
16 - 18	0	.00
18 - 20	0	.00
20 - 22	0	.00
22 - 24	4874	81.38
24 - 26	1115	18.62
26 - 28	0	.00
28 - 30	0	.00

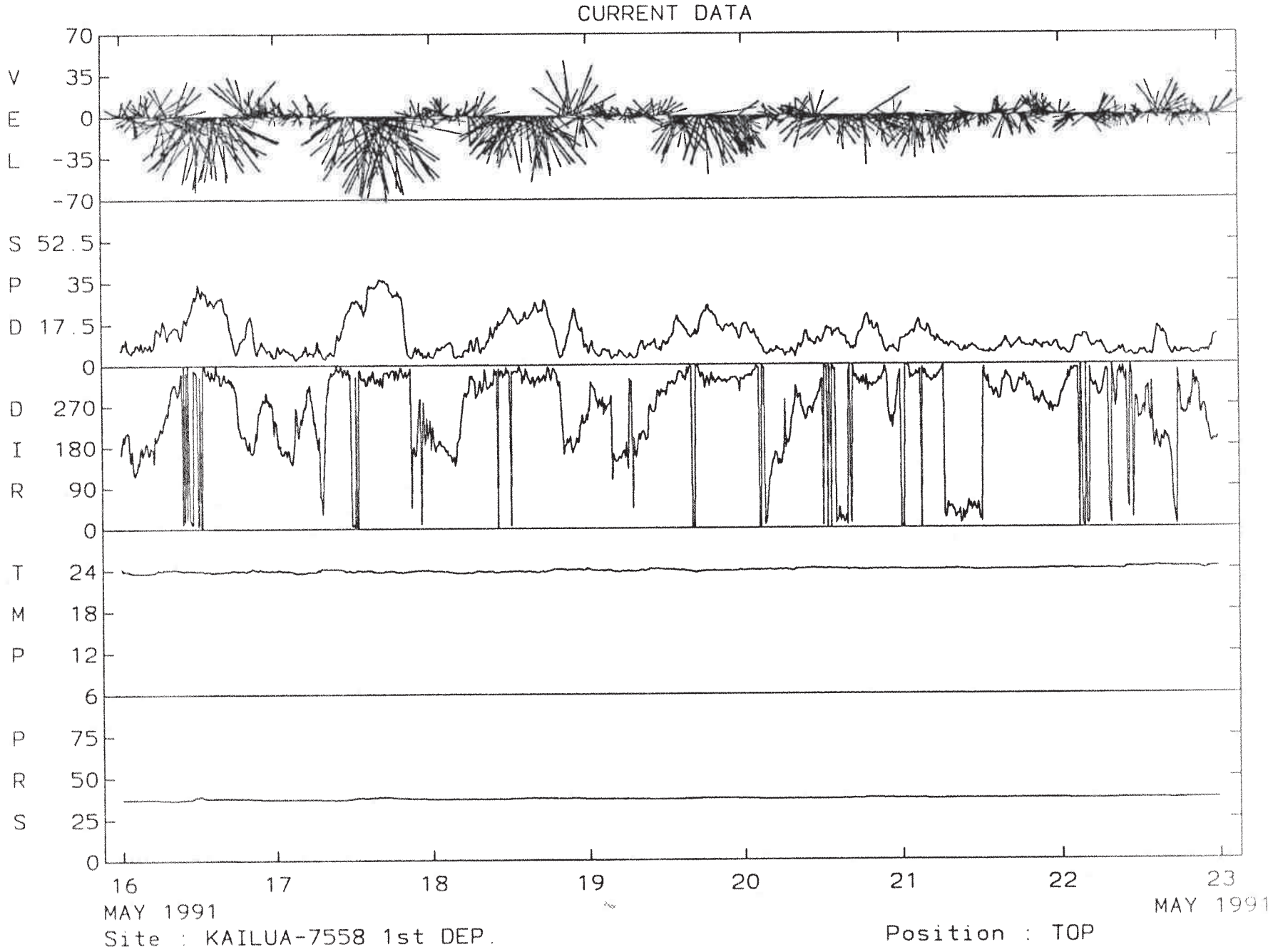
Total number of valid data points : 5989
Maximum Temperature : 24.59 °C
Minimum Temperature : 22.66 °C
Mean Temperature : 23.75 °C
Range : 1.93 °C
Standard Deviation : .31 °C

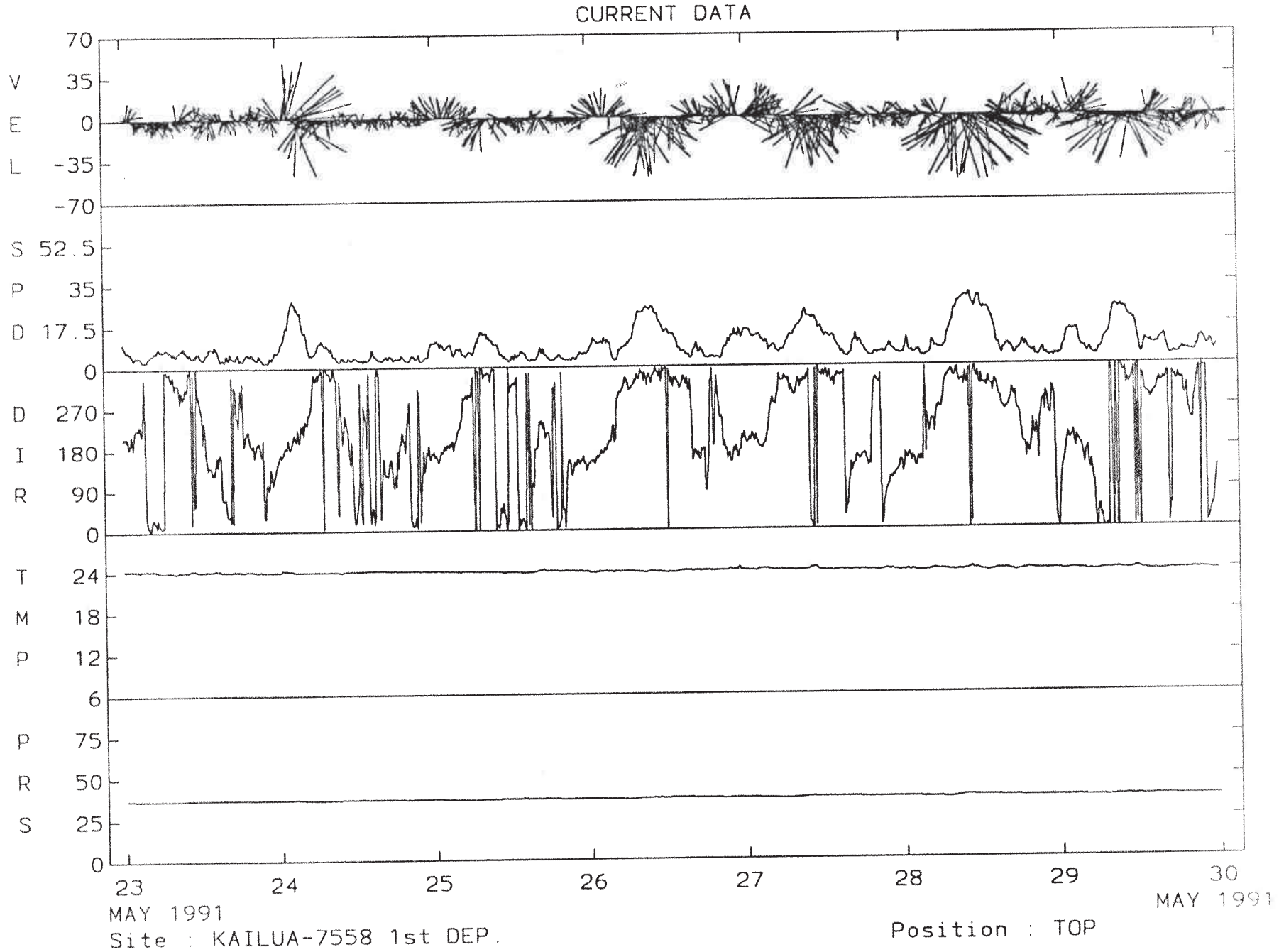
SPEED [cm/sec]	PERCENTAGE OBSERVATIONS LESS THAN
0 - 5	15.26
5 - 10	52.01
10 - 15	71.93
15 - 20	84.42
20 - 25	91.48
25 - 30	96.31
30 - 35	98.71
35 - 40	99.62
40 - 45	99.98
45 - 50	100.00

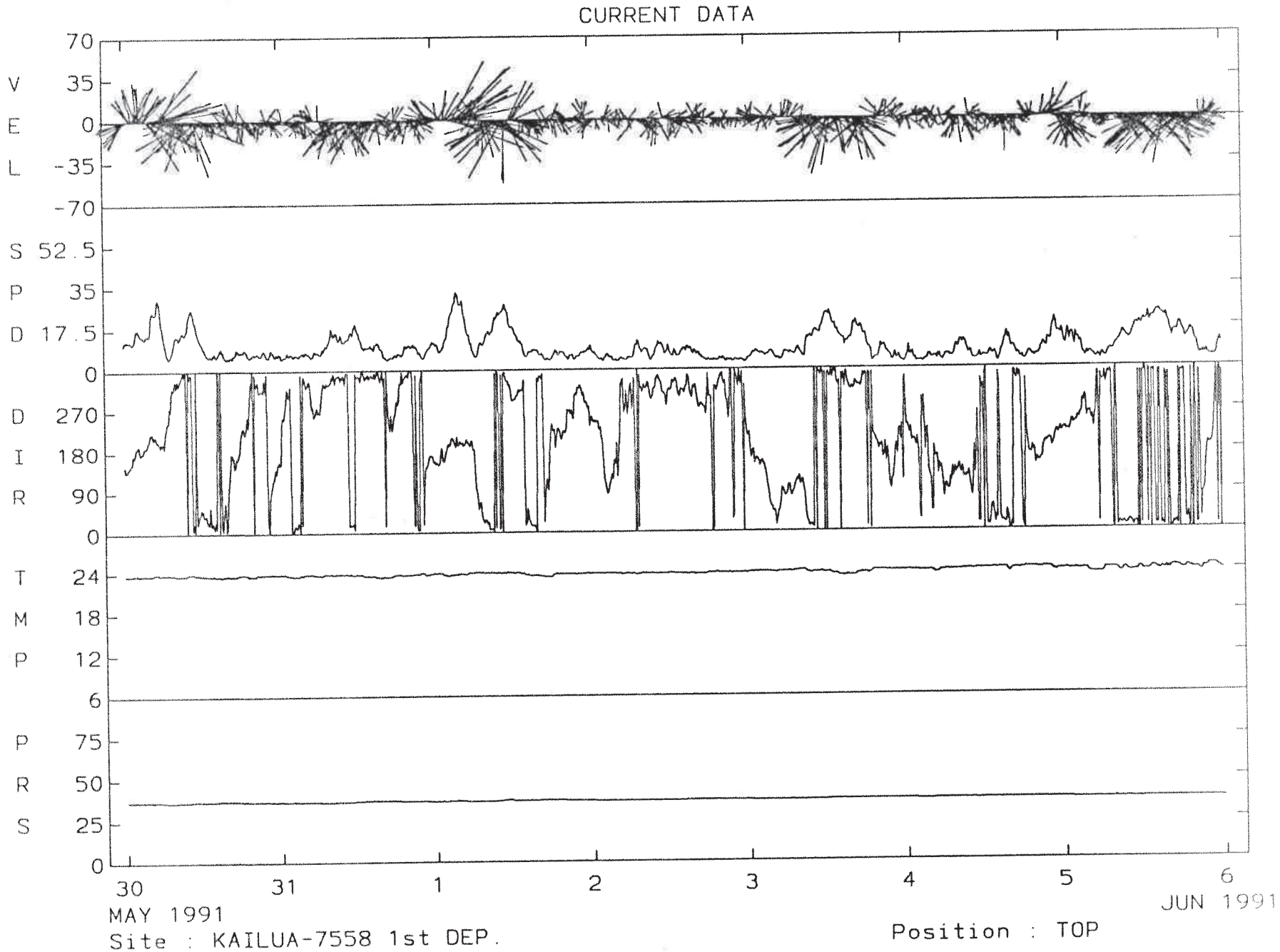

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
25
26
27
28
29
30
1
2
APR 1991
MAY 1991
Site : KAILUA-7558 1st DEP.
Position : TOP

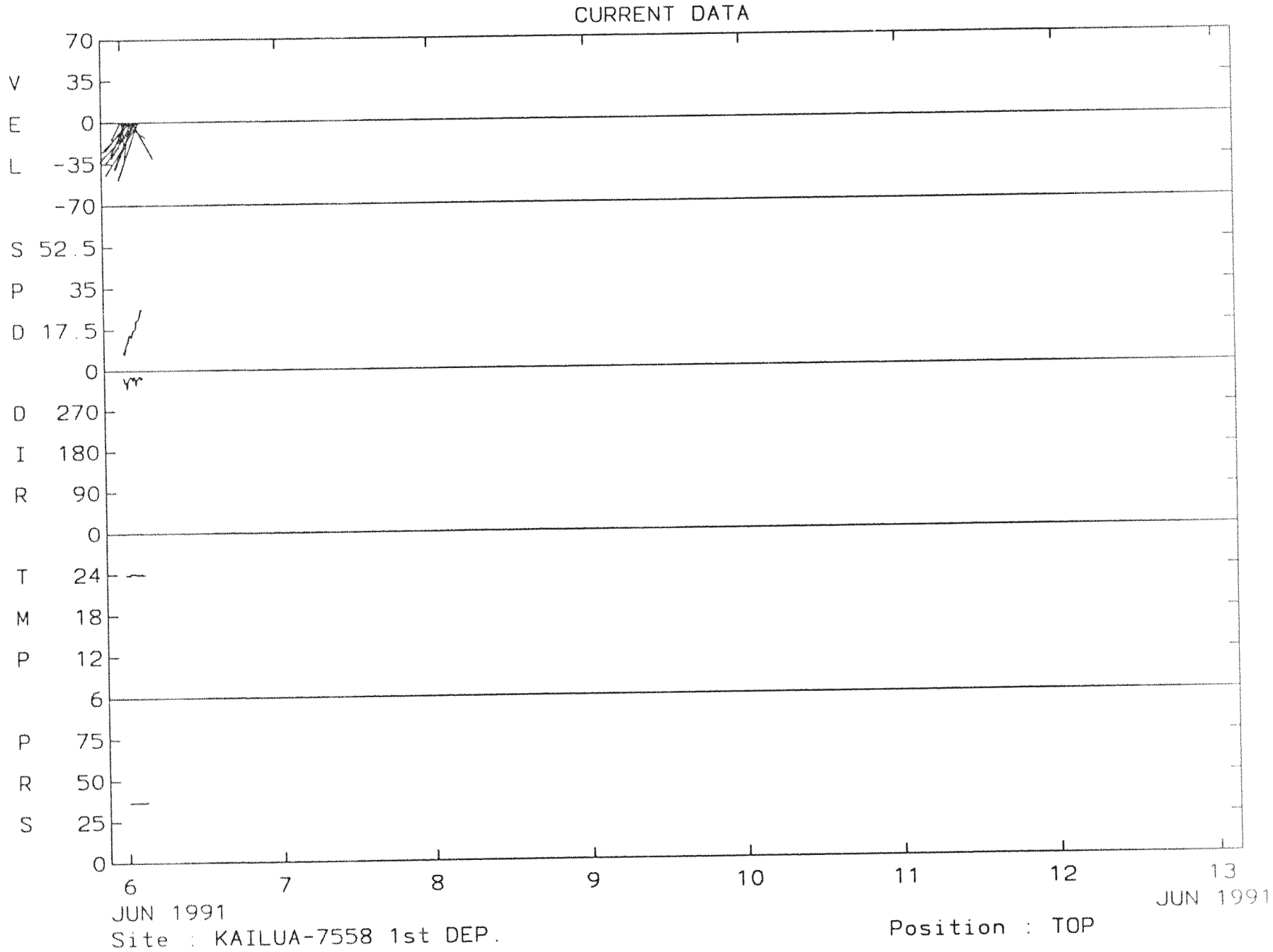

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
2
3
4
5
6
7
8
9
MAY 1991
MAY 1991
Site : KAILUA-7558 1st DEP.
Position : TOP


CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
9
10
11
12
13
14
15
16
MAY 1991
MAY 1991
Site : KAILUA-7558 1st DEP.
Position : TOP

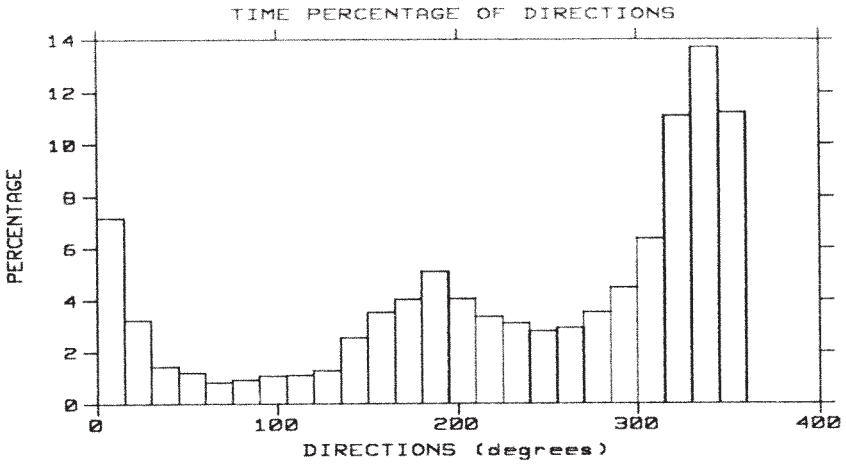

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
16
17
18
19
20
21
22
23
MAY 1991
MAY 1991
Site : KAILUA-7558 1st DEP.
Position : TOP

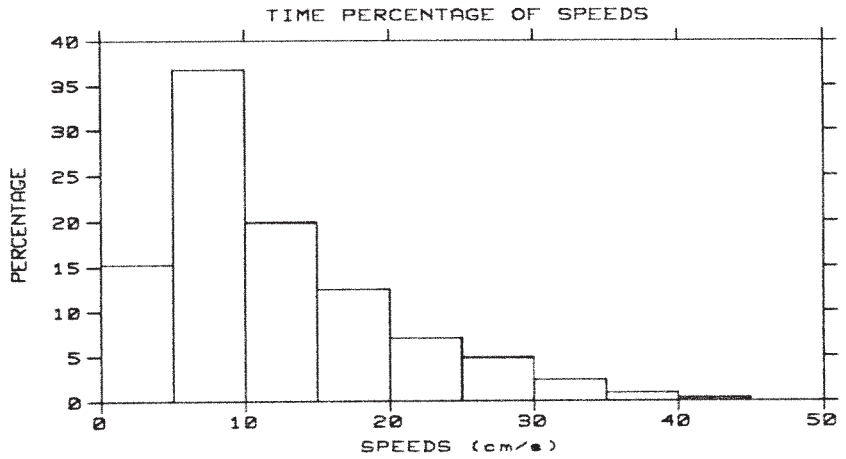

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
23
24
25
26
27
28
29
30
MAY 1991
MAY 1991
Site : KAILUA-7558 1st DEP.
Position : TOP

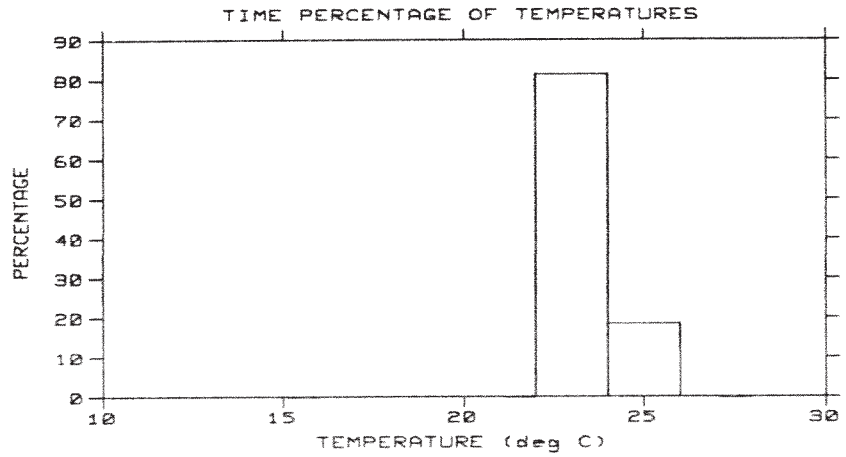

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
30
31
1
2
3
4
5
6
MAY 1991
JUN 1991
Site : KAILUA-7558 1st DEP.
Position : TOP


CURRENT DATA
VEL 70 35 0 -35 -70
SPD 52.5 35 17.5 0
DIR 270 180 90 0
TMP 24 18 12 6
PRS 75 50 25 0
6 7 8 9 10 11 12 13
JUN 1991
JUN 1991
Site : KAILUA-7558 1st DEP.
Position : TOP

KAILUA-7558 1st DEP.

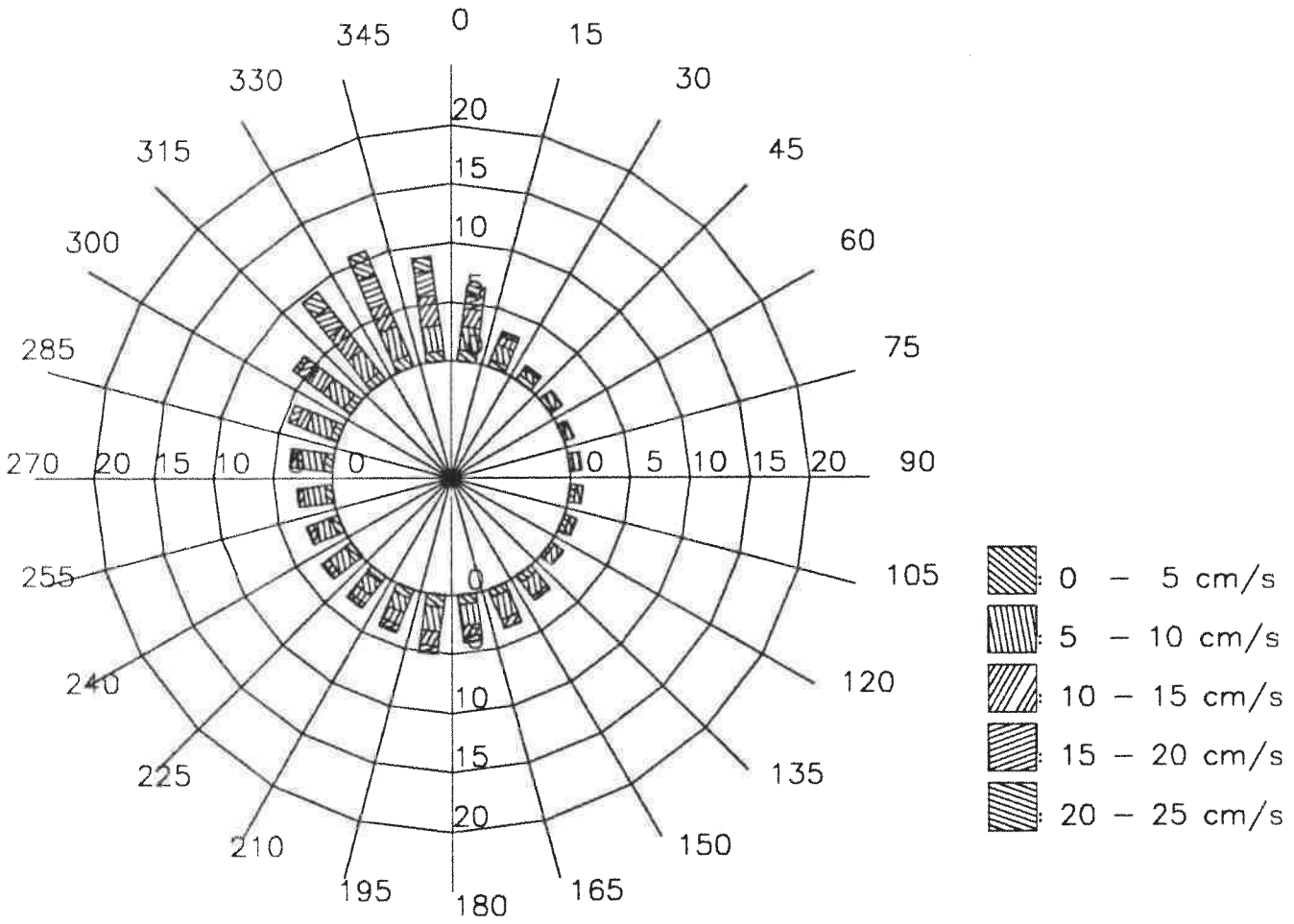


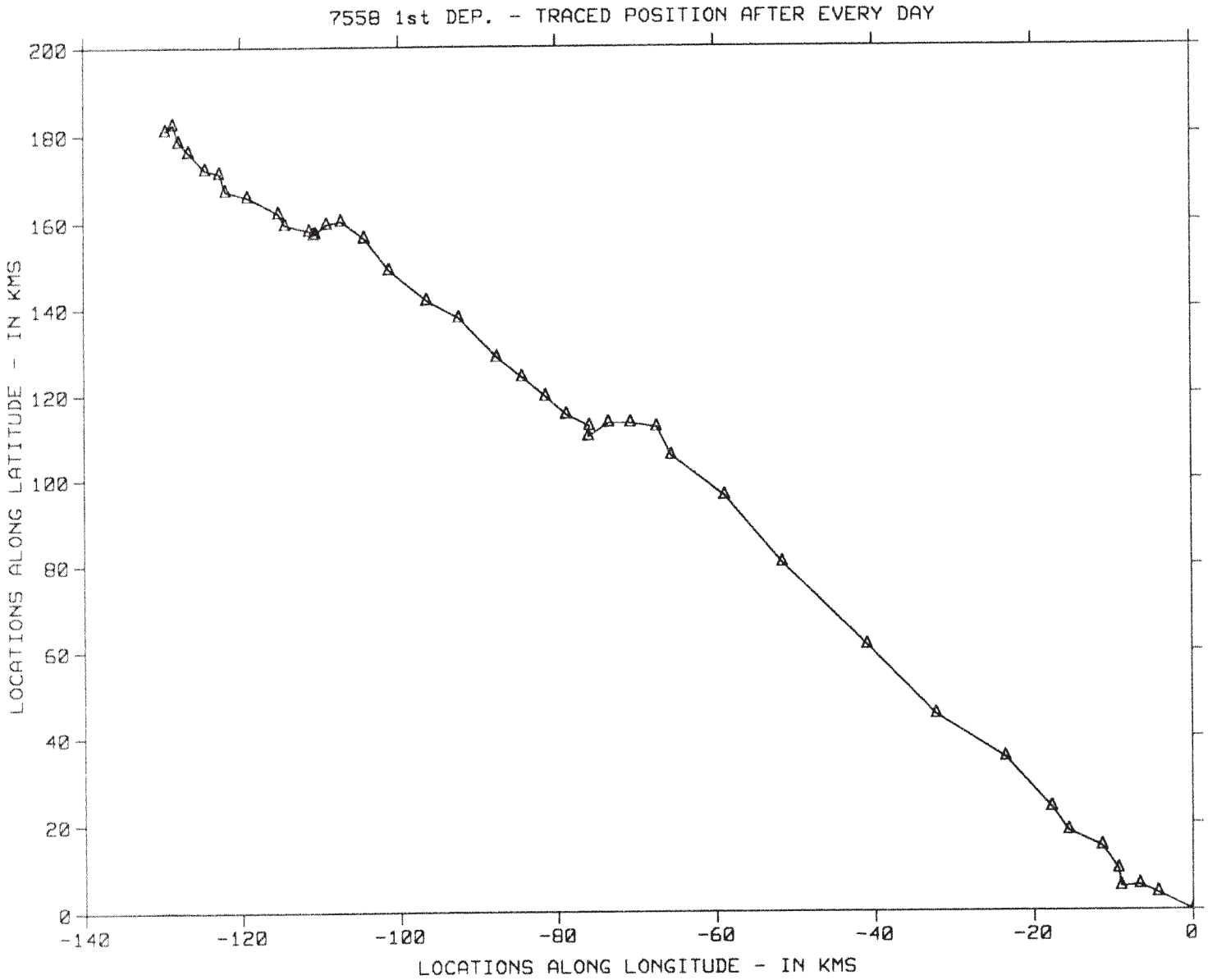




Percentage of currents

KAILUA–7558 1st DEP.




7558 1st DEP. - TRACED POSITION AFTER EVERY DAY
LOCATIONS ALONG LATITUDE - IN KMS
200
180
160
140
120
100
80
60
40
20
0
-140
-120
-100
-80
-60
-40
-20
0
LOCATIONS ALONG LONGITUDE - IN KMS

DATA INFORMATION

SITE NAME	: KAILUA-7555-1st DEP.
METER NUMBER	: 7555
METER POSITION	: TOP
LATITUDE	: 21.25.32N
LONGITUDE	: 157.42.74W
START DATE	: 10:53,23,APR,1991
END DATE	: 10:20, 6,AUG,1991
DEPLOY DATE	: 11:20,25,APR,1991
BOTTOM DEPTH	: 100 ft
METER DEPTH	: 60 ft
REV COUNT	: 4.00
TIME INTERVAL	: 10.00
DATA FILE	: 7555bin.dat
TOTAL PTS	: 3600
START PT	: 225

VELOCITY DISTRIBUTION

SPEED / DIR	0 | 5	5 | 10	10 | 15	15 | 20	20 | 25	25 | 30	30 | 35	35 | 40	40 | 45	45 | 50
0 - 15	0	32	86	14	0	0	0	0	0	0
15 - 30	1	18	61	9	0	0	0	0	0	0
30 - 45	0	14	24	5	0	0	0	0	0	0
45 - 60	0	20	20	1	0	0	0	0	0	0
60 - 75	0	14	13	0	0	0	0	0	0	0
75 - 90	0	22	22	0	0	0	0	0	0	0
90 - 105	0	27	26	3	0	0	0	0	0	0
105 - 120	0	29	55	6	1	0	0	0	0	0
120 - 135	0	41	161	27	4	1	0	0	0	0
135 - 150	1	56	252	64	21	6	0	0	0	0
150 - 165	1	67	332	122	37	16	0	0	1	0
165 - 180	1	52	295	61	10	9	0	0	0	0
180 - 195	1	36	116	27	2	0	0	0	0	0
195 - 210	0	31	29	4	2	0	0	0	0	0
210 - 225	0	15	19	3	0	0	0	0	0	0
225 - 240	0	10	12	0	0	0	0	0	0	0
240 - 255	0	15	15	0	0	0	0	0	0	0
255 - 270	0	19	22	0	0	0	0	0	0	0
270 - 285	0	16	30	3	0	1	0	0	0	0
285 - 300	0	26	63	4	3	0	1	0	0	0
300 - 315	0	25	86	8	2	3	1	0	0	0
315 - 330	0	28	89	32	0	3	1	0	0	0
330 - 345	1	58	114	45	5	6	1	0	0	0
345 - 360	0	48	107	24	2	1	0	0	0	0

SPEED / DIR	50 | 55	55 | 60	60 | 65	65 | 70	70 | 75	75 | 80	80 | 85	85 | 90	90 | 95	95 | 100
0 - 15	0	0	0	0	0	0	0	0	0	0
15 - 30	0	0	0	0	0	0	0	0	0	0
30 - 45	0	0	0	0	0	0	0	0	0	0
45 - 60	0	0	0	0	0	0	0	0	0	0
60 - 75	0	0	0	0	0	0	0	0	0	0
75 - 90	0	0	0	0	0	0	0	0	0	0

90 - 105	0	0	0	0	0	0	0	0	0	0
105 - 120	0	0	0	0	0	0	0	0	0	0
120 - 135	0	0	0	0	0	0	0	0	0	0
135 - 150	0	0	0	0	0	0	0	0	0	0
150 - 165	0	0	0	0	0	0	0	0	0	0
165 - 180	0	0	0	0	0	0	0	0	0	0
180 - 195	0	0	0	0	0	0	0	0	0	0
195 - 210	0	0	0	0	0	0	0	0	0	0
210 - 225	0	0	0	0	0	0	0	0	0	0
225 - 240	0	0	0	0	0	0	0	0	0	0
240 - 255	0	0	0	0	0	0	0	0	0	0
255 - 270	0	0	0	0	0	0	0	0	0	0
270 - 285	0	0	0	0	0	0	0	0	0	0
285 - 300	0	0	0	0	0	0	0	0	0	0
300 - 315	0	0	0	0	0	0	0	0	0	0
315 - 330	0	0	0	0	0	0	0	0	0	0
330 - 345	0	0	0	0	0	0	0	0	0	0
345 - 360	0	0	0	0	0	0	0	0	0	0

DIRECTION [Degrees]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 15	132	3.91
15 - 30	89	2.64
30 - 45	43	1.27
45 - 60	41	1.21
60 - 75	27	.80
75 - 90	44	1.30
90 - 105	56	1.66
105 - 120	91	2.70
120 - 135	234	6.93
135 - 150	400	11.85
150 - 165	576	17.06
165 - 180	428	12.68
180 - 195	182	5.39
195 - 210	66	1.95
210 - 225	37	1.10
225 - 240	22	.65
240 - 255	30	.89
255 - 270	41	1.21
270 - 285	50	1.48
285 - 300	97	2.87
300 - 315	125	3.70
315 - 330	153	4.53
330 - 345	230	6.81
345 - 360	182	5.39

SPEED [cm/sec]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 5	6	.18
5 - 10	719	21.30
10 - 15	2049	60.69
15 - 20	462	13.68
20 - 25	89	2.64
25 - 30	46	1.36
30 - 35	4	.12
35 - 40	0	.00

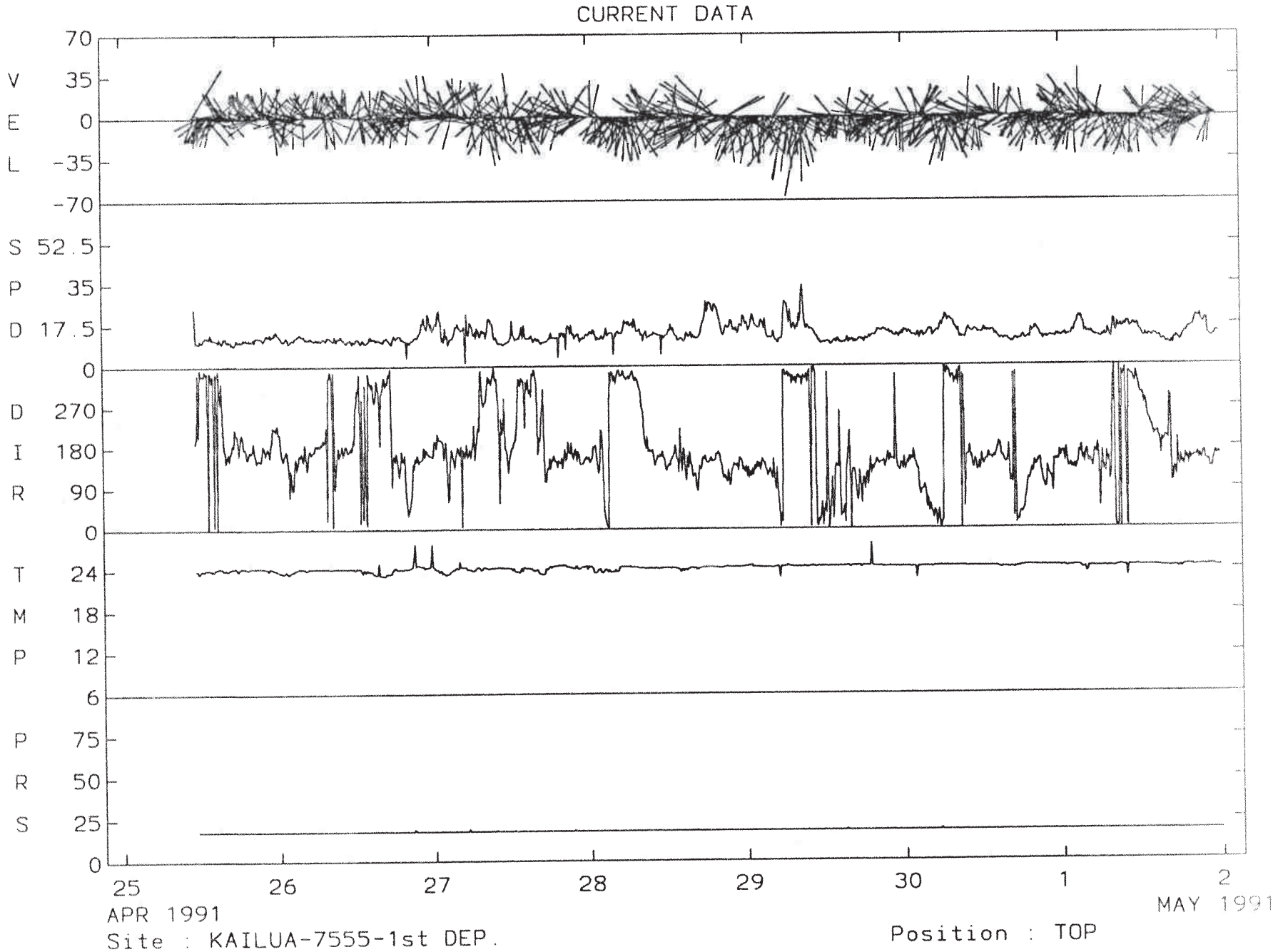
40 - 45	1	.03
45 - 50	0	.00

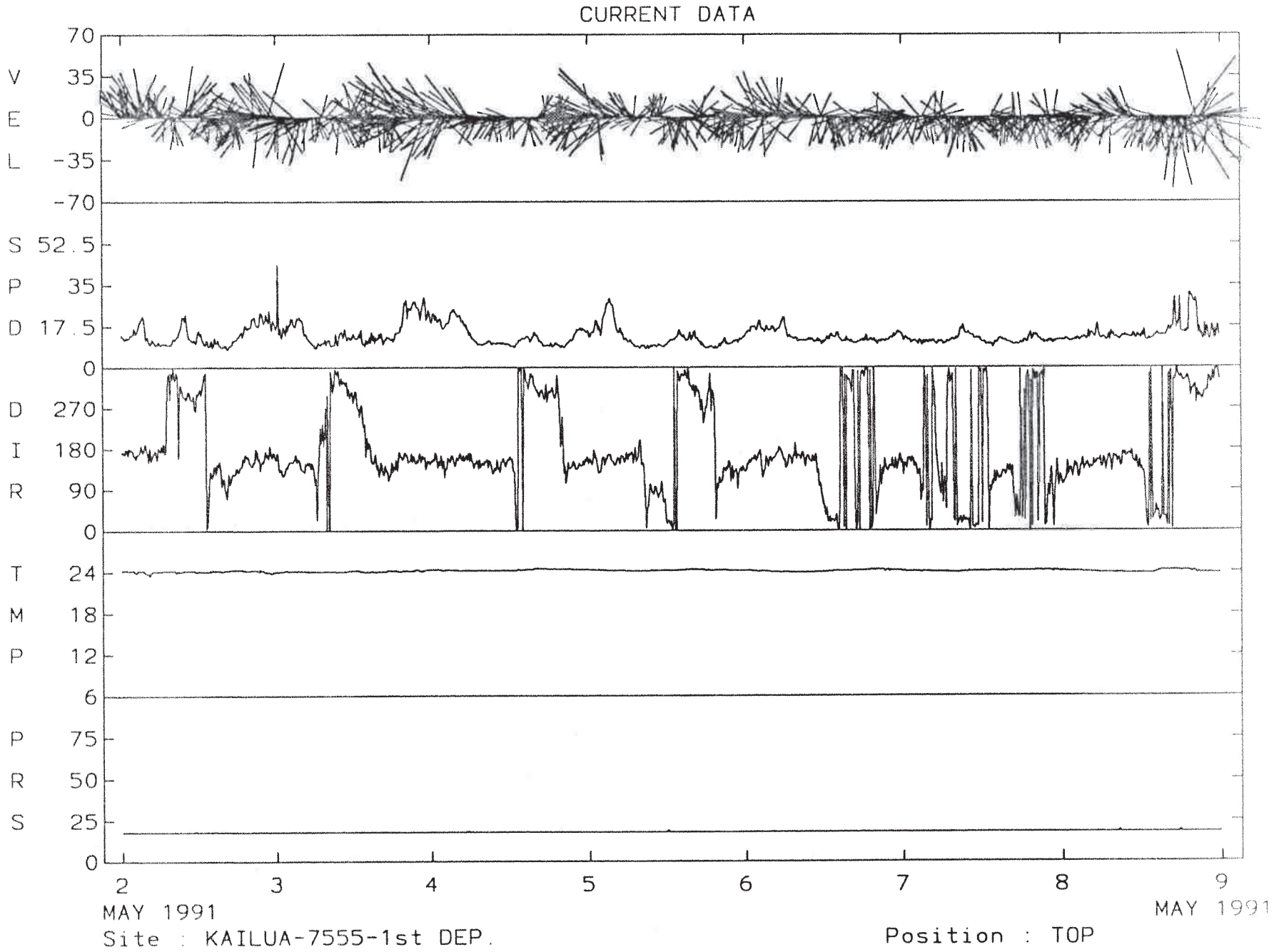
Total number of valid data points : 3376
Maximum Speed : 43.50 cm/s
Minimum Speed : 1.50 cm/s
Mean Speed : 12.51 cm/s
Range : 42.00 cm/s
Standard Deviation : .22 cm/s

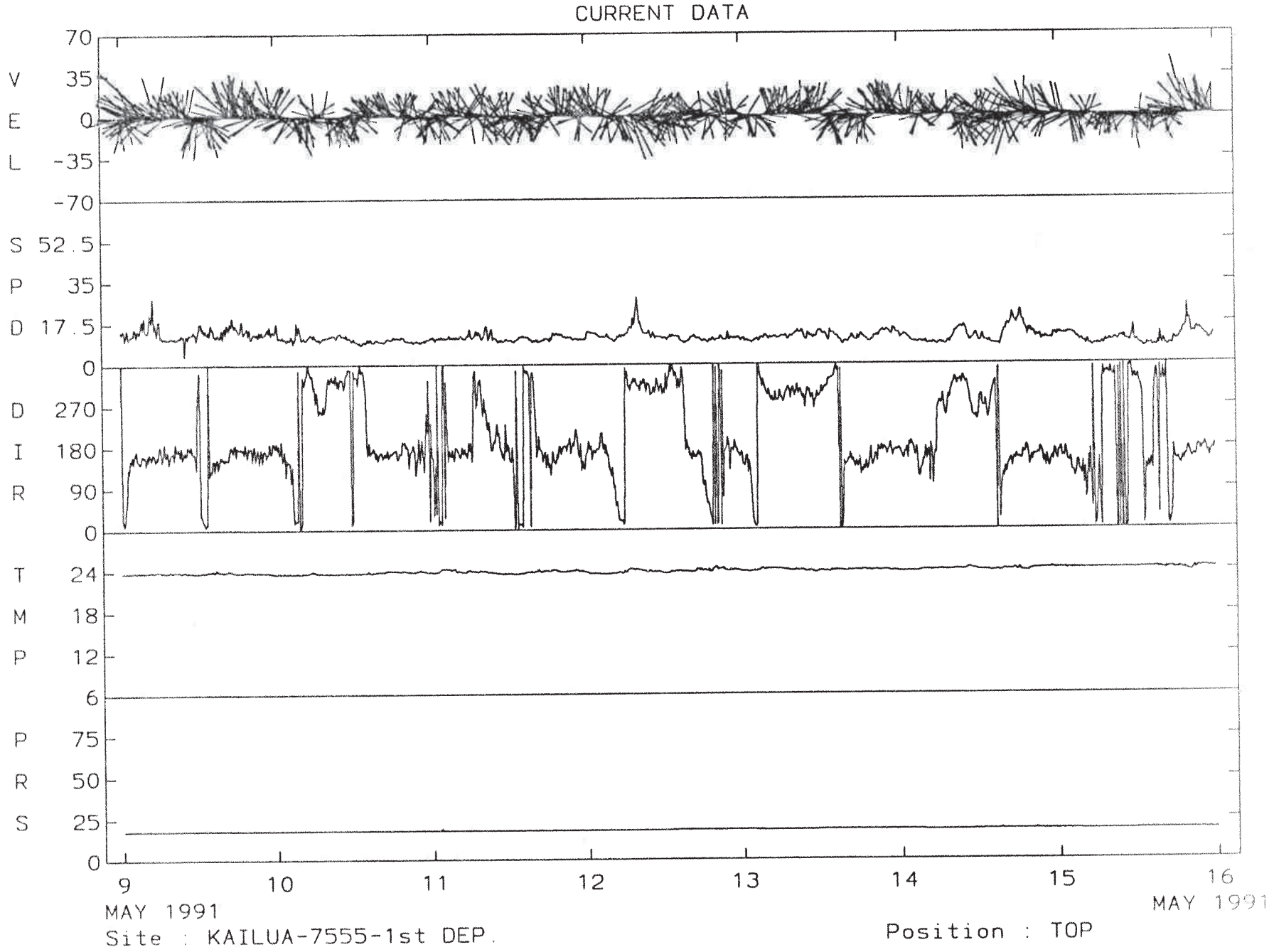
TEMPERATURE [Celcius]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 2	0	.00
2 - 4	0	.00
4 - 6	0	.00
6 - 8	0	.00
8 - 10	0	.00
10 - 12	0	.00
12 - 14	0	.00
14 - 16	0	.00
16 - 18	0	.00
18 - 20	0	.00
20 - 22	0	.00
22 - 24	1153	34.15
24 - 26	2219	65.73
26 - 28	4	.12
28 - 30	0	.00

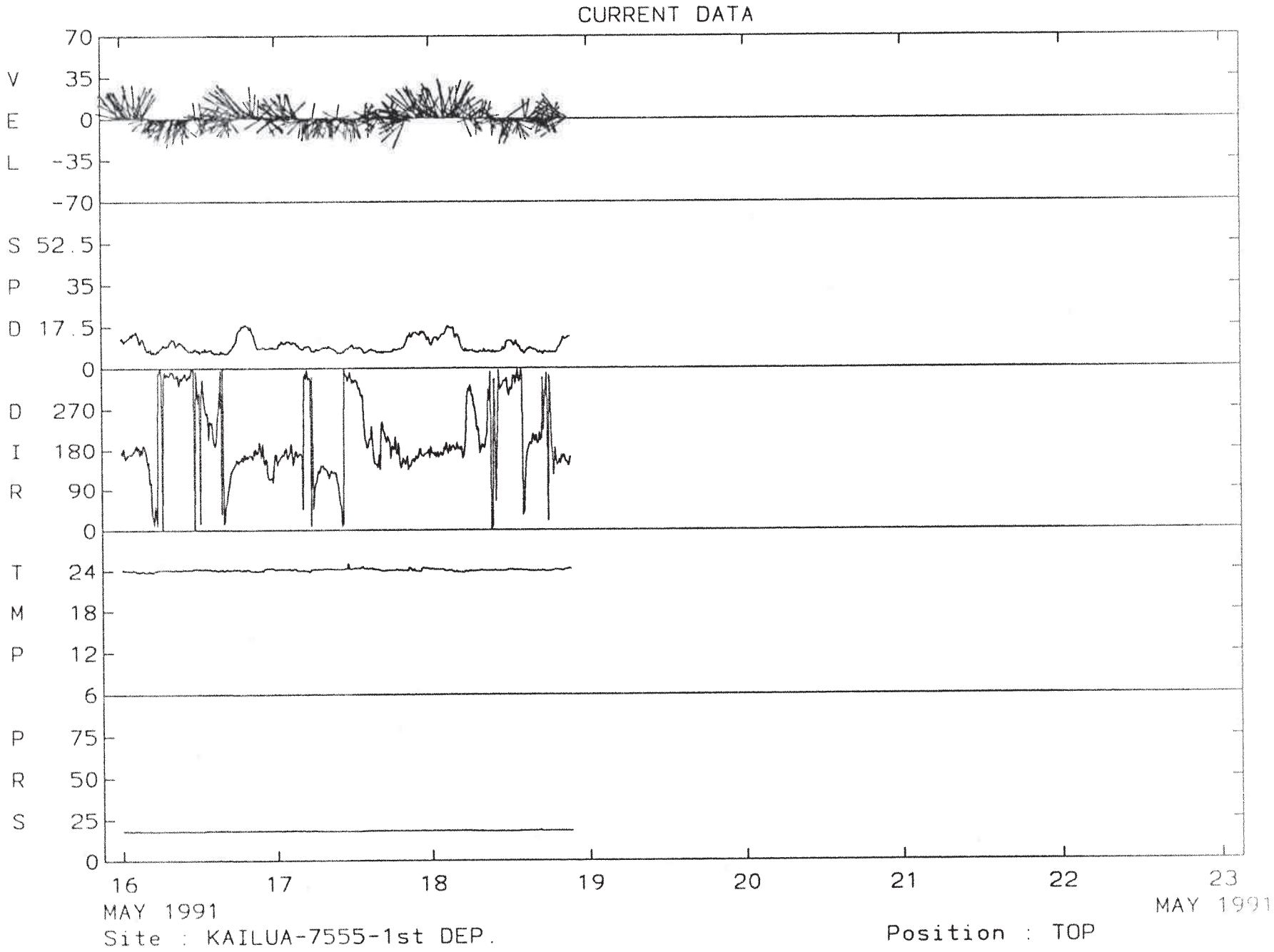
Total number of valid data points : 3376
Maximum Temperature : 27.72 °C
Minimum Temperature : 22.68 °C
Mean Temperature : 24.07 °C
Range : 5.04 °C
Standard Deviation : .41 °C

SPEED [cm/sec]	PERCENTAGE OBSERVATIONS LESS THAN
0 - 5	.18
5 - 10	21.48
10 - 15	82.17
15 - 20	95.85
20 - 25	98.49
25 - 30	99.85
30 - 35	99.97
35 - 40	99.97
40 - 45	100.00
45 - 50	100.00

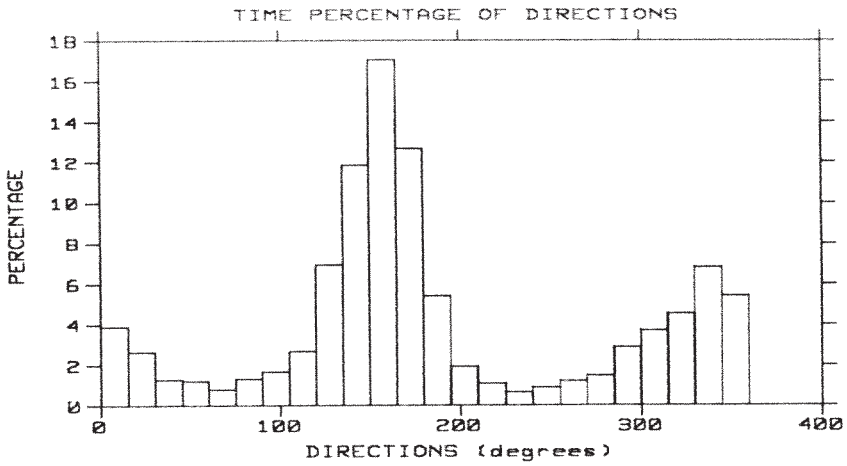

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
25
26
27
28
29
30
1
2
APR 1991
MAY 1991
Site : KAILUA-7555-1st DEP.
Position : TOP

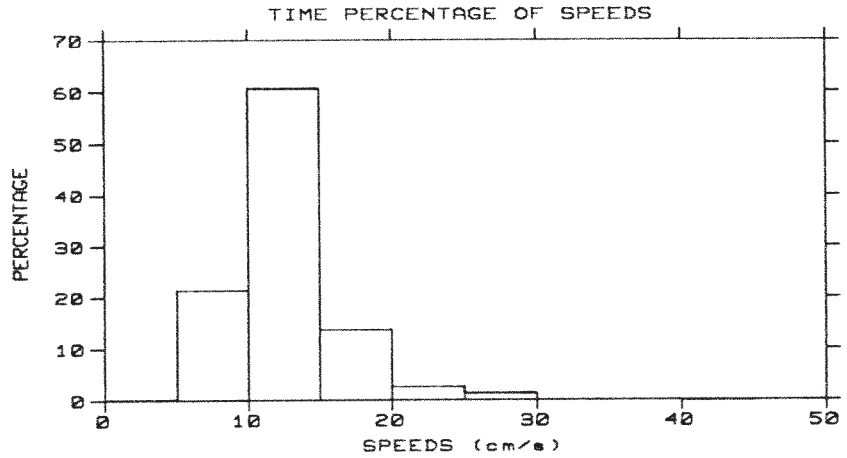

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
2
3
4
5
6
7
8
9
MAY 1991
MAY 1991
Site : KAILUA-7555-1st DEP.
Position : TOP

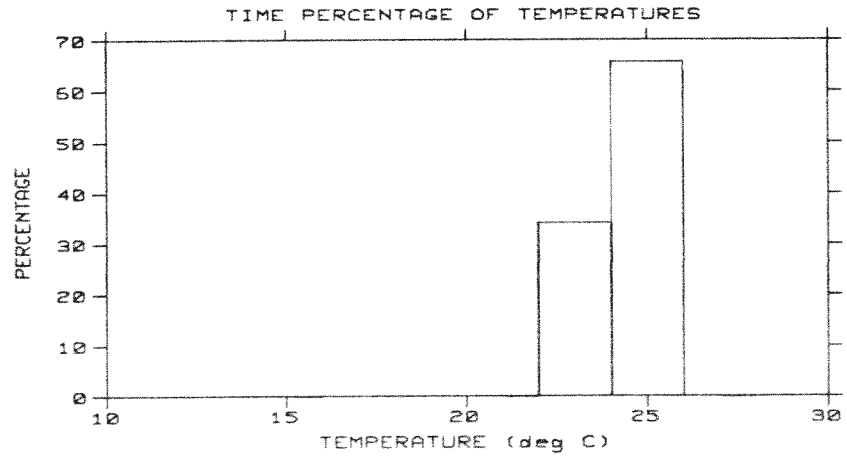

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
9
10
11
12
13
14
15
16
MAY 1991
MAY 1991
Site : KAILUA-7555-1st DEP.
Position : TOP


CURRENT DATA
70
V 35
E 0
L -35
-70
S 52.5
P 35
D 17.5
0
D 270
I 180
R 90
0
T 24
M 18
P 12
6
P 75
R 50
S 25
0
16
17
18
19
20
21
22
23
MAY 1991
MAY 1991
Site : KAILUA-7555-1st DEP.
Position : TOP

KAILUA-7555-1st DEP.

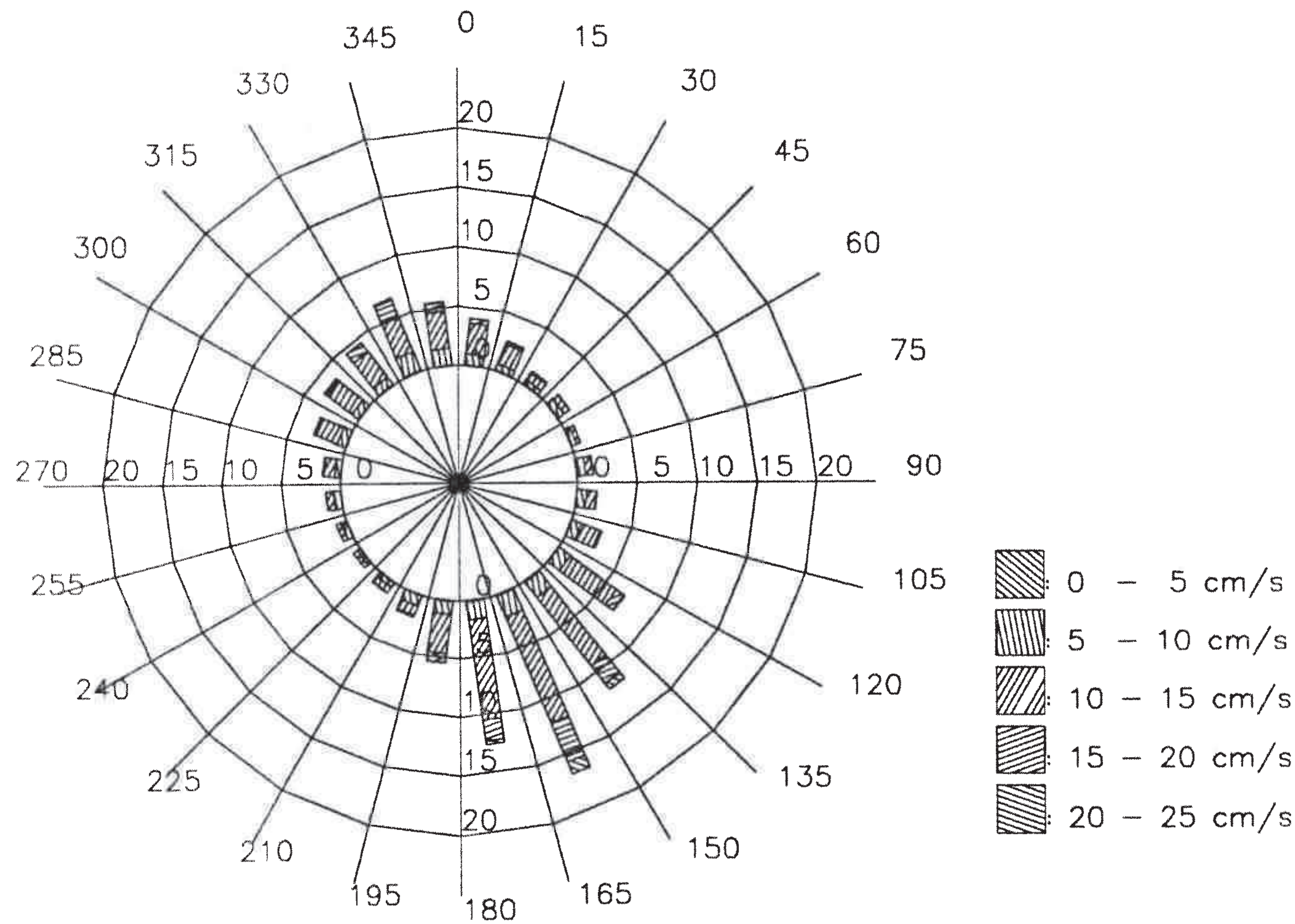


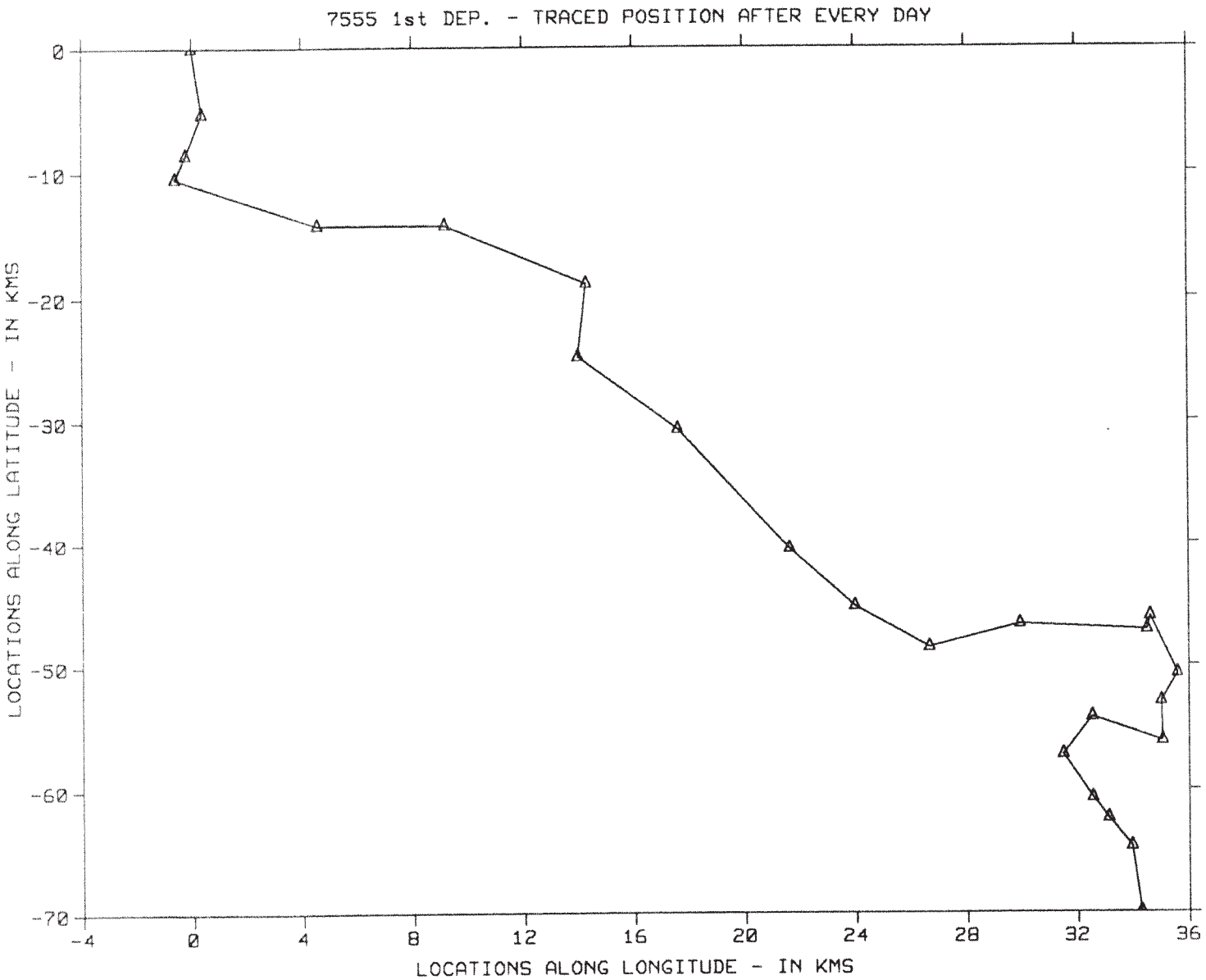




Percentage of currents

KAILUA-7555-1st DEP.




7555 1st DEP. - TRACED POSITION AFTER EVERY DAY
LOCATIONS ALONG LATITUDE - IN KMS
0
-10
-20
-30
-40
-50
-60
-70
LOCATIONS ALONG LONGITUDE - IN KMS
-4
0
4
8
12
16
20
24
28
32
36

APPENDIX B

Current Measurements for Second Deployment: March–May 1992

Meter No.: 7555 ..... B-1 through B-9

Meter No.: 7558 ..... B-10 through B-23

DATA INFORMATION

SITE NAME	: KAILUA-7555-2nd DEP.
METER NUMBER	: 7555
METER POSITION	: TOP
LATITUDE	: 21.27.2804N
LONGITUDE	: 157.42.9074W
START DATE	: 10:53, 5,MAR,1992
END DATE	: 15: 9,29,MAY,1992
DEPLOY DATE	: 11:26, 6,MAR,1992
BOTTOM DEPTH	: 110 ft.
METER DEPTH	: 70 ft.
REV COUNT	: 4.00
TIME INTERVAL	: 10.00
DATA FILE	: 7555bin2.dat
TOTAL PTS	: 2690
START PT	: 97

VELOCITY DISTRIBUTION

DIR \ SPEED	0 | 5	5 | 10	10 | 15	15 | 20	20 | 25	25 | 30	30 | 35	35 | 40	40 | 45	45 | 50
0 - 15	9	37	102	124	64	72	32	6	5	6
15 - 30	16	49	60	64	24	20	9	1	1	3
30 - 45	26	44	31	20	6	2	0	0	0	0
45 - 60	22	23	15	8	2	0	0	0	0	0
60 - 75	21	17	11	1	0	0	0	0	0	0
75 - 90	17	19	14	1	0	0	0	0	0	0
90 - 105	19	17	15	4	0	0	0	0	0	0
105 - 120	7	17	24	4	2	0	0	0	0	0
120 - 135	9	21	24	7	5	1	0	0	0	0
135 - 150	2	22	20	13	7	0	2	1	1	0
150 - 165	5	26	14	23	26	15	9	3	2	0
165 - 180	3	14	39	34	33	23	13	10	6	1
180 - 195	2	23	30	25	15	11	7	4	8	1
195 - 210	0	13	9	5	5	3	5	1	2	0
210 - 225	3	11	2	1	0	0	0	1	0	0
225 - 240	2	9	7	0	0	0	0	0	0	0
240 - 255	3	7	6	0	0	0	0	0	0	0
255 - 270	5	4	9	0	0	0	0	0	0	0
270 - 285	2	1	7	0	0	0	0	0	0	0
285 - 300	4	5	9	0	0	0	0	0	0	0
300 - 315	2	8	17	1	1	0	0	0	0	0
315 - 330	8	13	37	21	5	0	0	0	0	0
330 - 345	10	37	85	53	37	21	4	0	0	0
345 - 360	12	44	119	87	56	72	19	5	2	1

DIR \ SPEED	50 | 55	55 | 60	60 | 65	65 | 70	70 | 75	75 | 80	80 | 85	85 | 90	90 | 95	95 | 100
0 - 15	0	0	0	0	0	0	0	0	0	0
15 - 30	0	0	0	0	0	0	0	0	0	0
30 - 45	0	0	0	0	0	0	0	0	0	0
45 - 60	0	0	0	0	0	0	0	0	0	0
60 - 75	0	0	0	0	0	0	0	0	0	0
75 - 90	0	0	0	0	0	0	0	0	0	0

90 - 105	0	0	0	0	0	0	0	0	0	0
105 - 120	0	0	0	0	0	0	0	0	0	0
120 - 135	0	0	0	0	0	0	0	0	0	0
135 - 150	0	0	0	0	0	0	0	0	0	0
150 - 165	1	0	0	0	0	0	0	0	0	0
165 - 180	1	0	0	0	0	0	0	0	0	0
180 - 195	1	0	0	0	0	0	0	0	0	0
195 - 210	0	0	0	0	0	0	0	0	0	0
210 - 225	0	0	0	0	0	0	0	0	0	0
225 - 240	0	0	0	0	0	0	0	0	0	0
240 - 255	0	0	0	0	0	0	0	0	0	0
255 - 270	0	0	0	0	0	0	0	0	0	0
270 - 285	0	0	0	0	0	0	0	0	0	0
285 - 300	0	0	0	0	0	0	0	0	0	0
300 - 315	0	0	0	0	0	0	0	0	0	0
315 - 330	0	0	0	0	0	0	0	0	0	0
330 - 345	0	0	0	0	0	0	0	0	0	0
345 - 360	0	0	0	0	0	0	0	0	0	0

DIRECTION [Degrees]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 15	457	17.62
15 - 30	247	9.52
30 - 45	129	4.97
45 - 60	70	2.70
60 - 75	50	1.93
75 - 90	51	1.97
90 - 105	55	2.12
105 - 120	54	2.08
120 - 135	67	2.58
135 - 150	68	2.62
150 - 165	124	4.78
165 - 180	177	6.82
180 - 195	127	4.90
195 - 210	43	1.66
210 - 225	18	.69
225 - 240	18	.69
240 - 255	16	.62
255 - 270	18	.69
270 - 285	10	.39
285 - 300	18	.69
300 - 315	29	1.12
315 - 330	84	3.24
330 - 345	247	9.52
345 - 360	417	16.08

SPEED [cm/sec]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 5	209	8.06
5 - 10	481	18.54
10 - 15	706	27.22
15 - 20	496	19.12
20 - 25	288	11.10
25 - 30	240	9.25
30 - 35	100	3.86
35 - 40	32	1.23

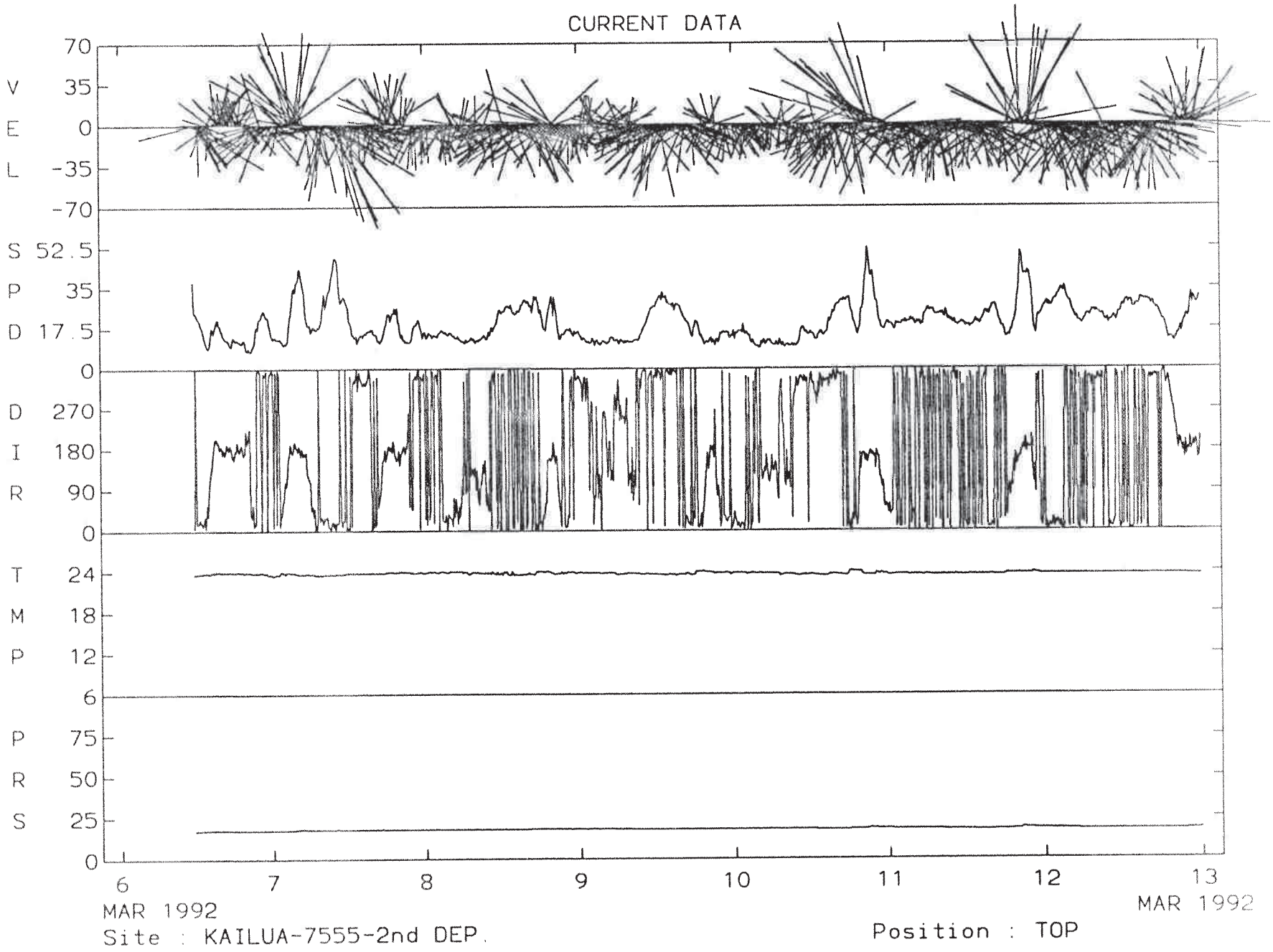
40 - 45	27	1.04
45 - 50	12	.46

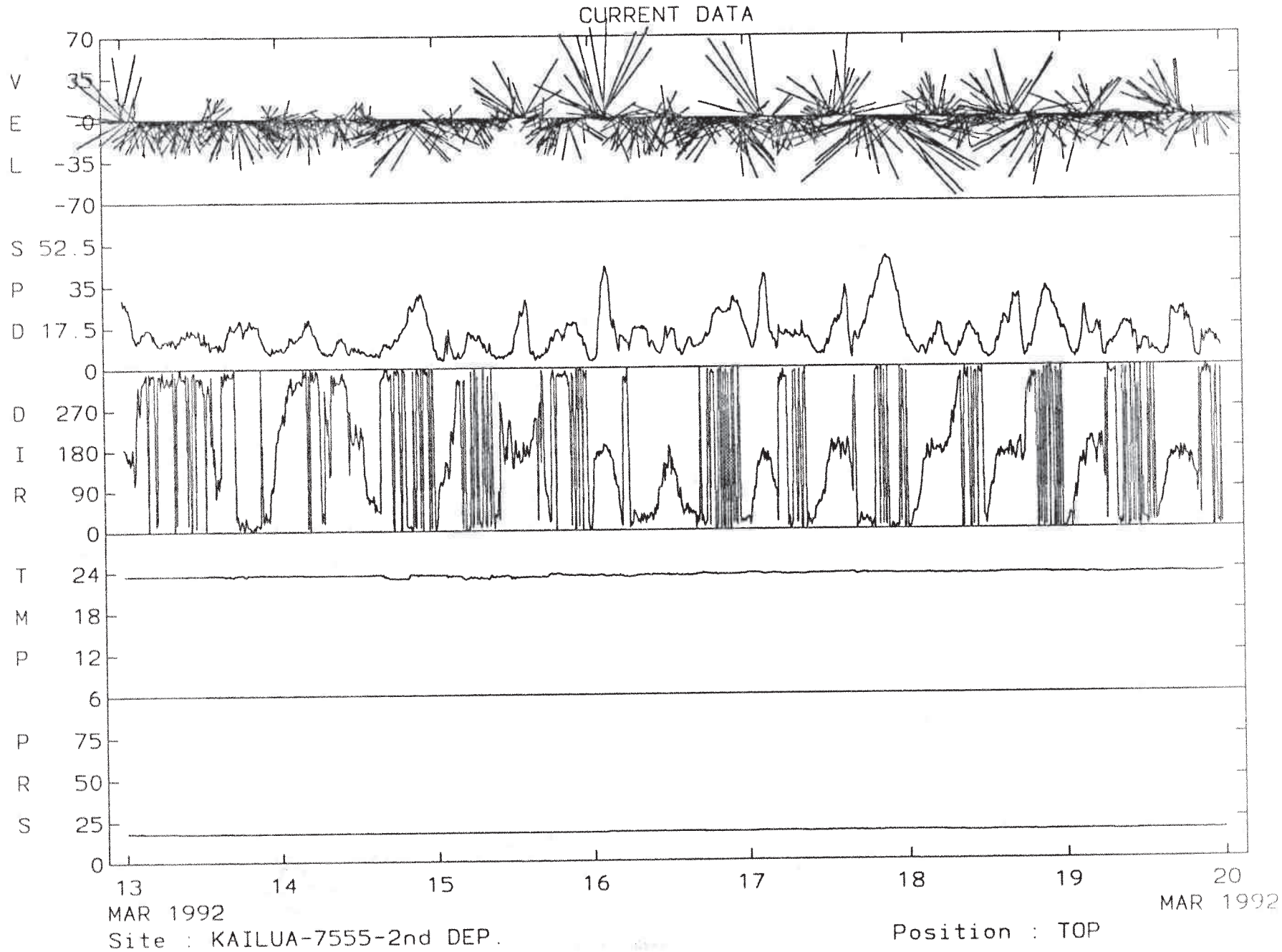
Total number of valid data points : 2594
Maximum Speed : 52.18 cm/s
Minimum Speed : 2.06 cm/s
Mean Speed : 15.86 cm/s
Range : 50.12 cm/s
Standard Deviation : .36 cm/s

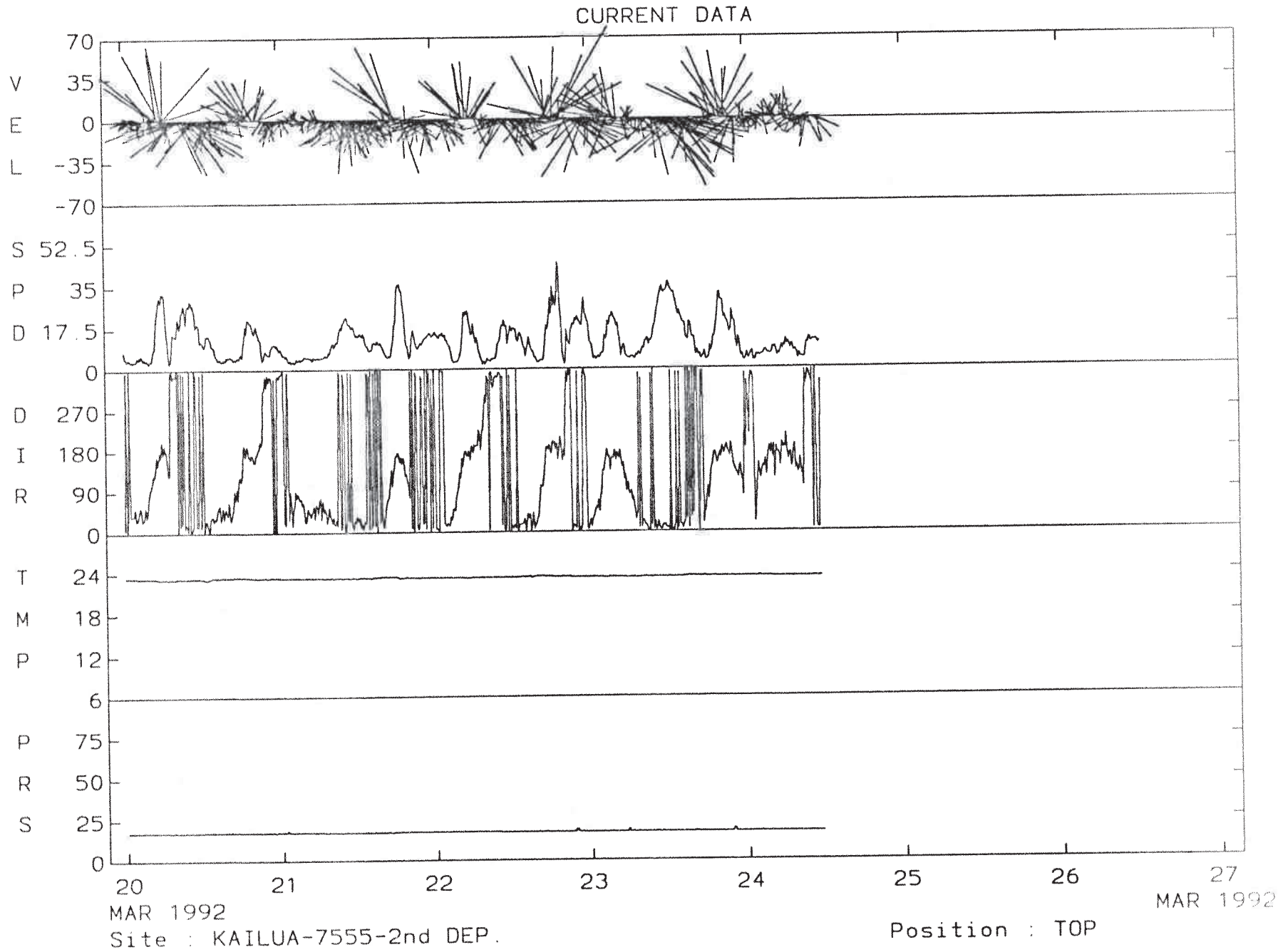
TEMPERATURE [Celcius]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 2	0	.00
2 - 4	0	.00
4 - 6	0	.00
6 - 8	0	.00
8 - 10	0	.00
10 - 12	0	.00
12 - 14	0	.00
14 - 16	0	.00
16 - 18	0	.00
18 - 20	0	.00
20 - 22	0	.00
22 - 24	2560	98.69
24 - 26	34	1.31
26 - 28	0	.00
28 - 30	0	.00

Total number of valid data points : 2594
Maximum Temperature : 24.08 °C
Minimum Temperature : 22.83 °C
Mean Temperature : 23.50 °C
Range : 1.25 °C
Standard Deviation : .46 °C

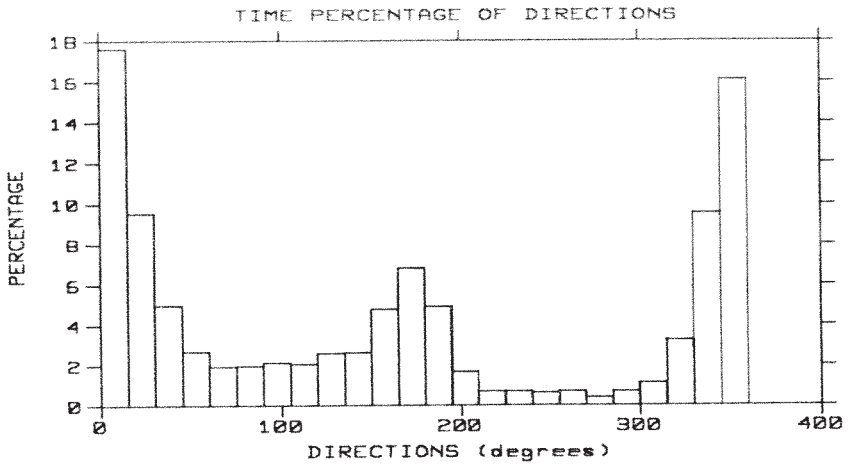
SPEED [cm/sec]	PERCENTAGE OBSERVATIONS LESS THAN
0 - 5	8.06
5 - 10	26.60
10 - 15	53.82
15 - 20	72.94
20 - 25	84.04
25 - 30	93.29
30 - 35	97.15
35 - 40	98.38
40 - 45	99.42
45 - 50	99.88

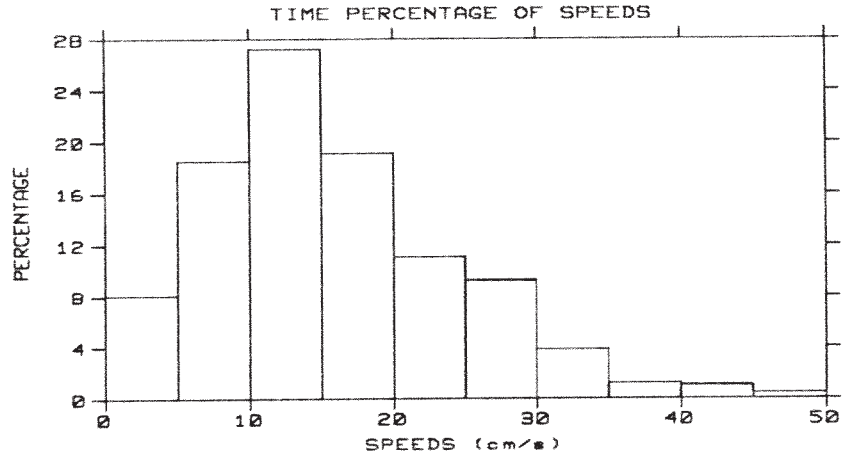

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
6
7
8
9
10
11
12
13
MAR 1992
MAR 1992
Site : KAILUA-7555-2nd DEP.
Position : TOP

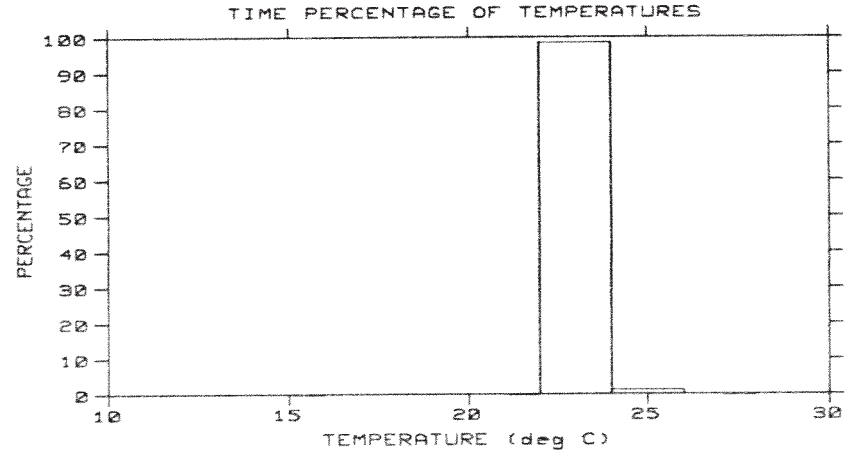

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
13
14
15
16
17
18
19
20
MAR 1992
MAR 1992
Site : KAILUA-7555-2nd DEP.
Position : TOP


CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
20
21
22
23
24
25
26
27
MAR 1992
MAR 1992
Site : KAILUA-7555-2nd DEP.
Position : TOP

KAILUA-7555-2nd DEP.

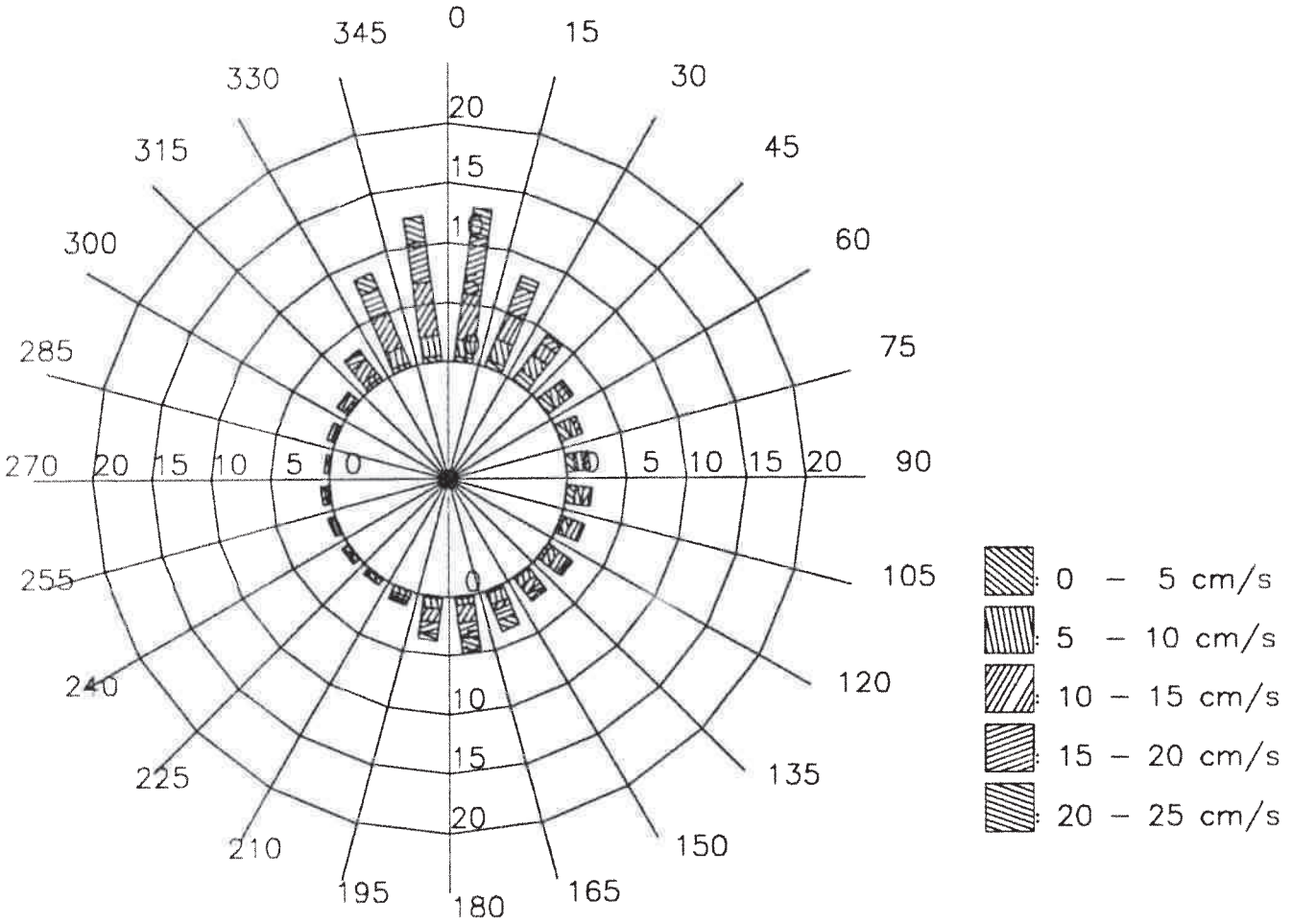


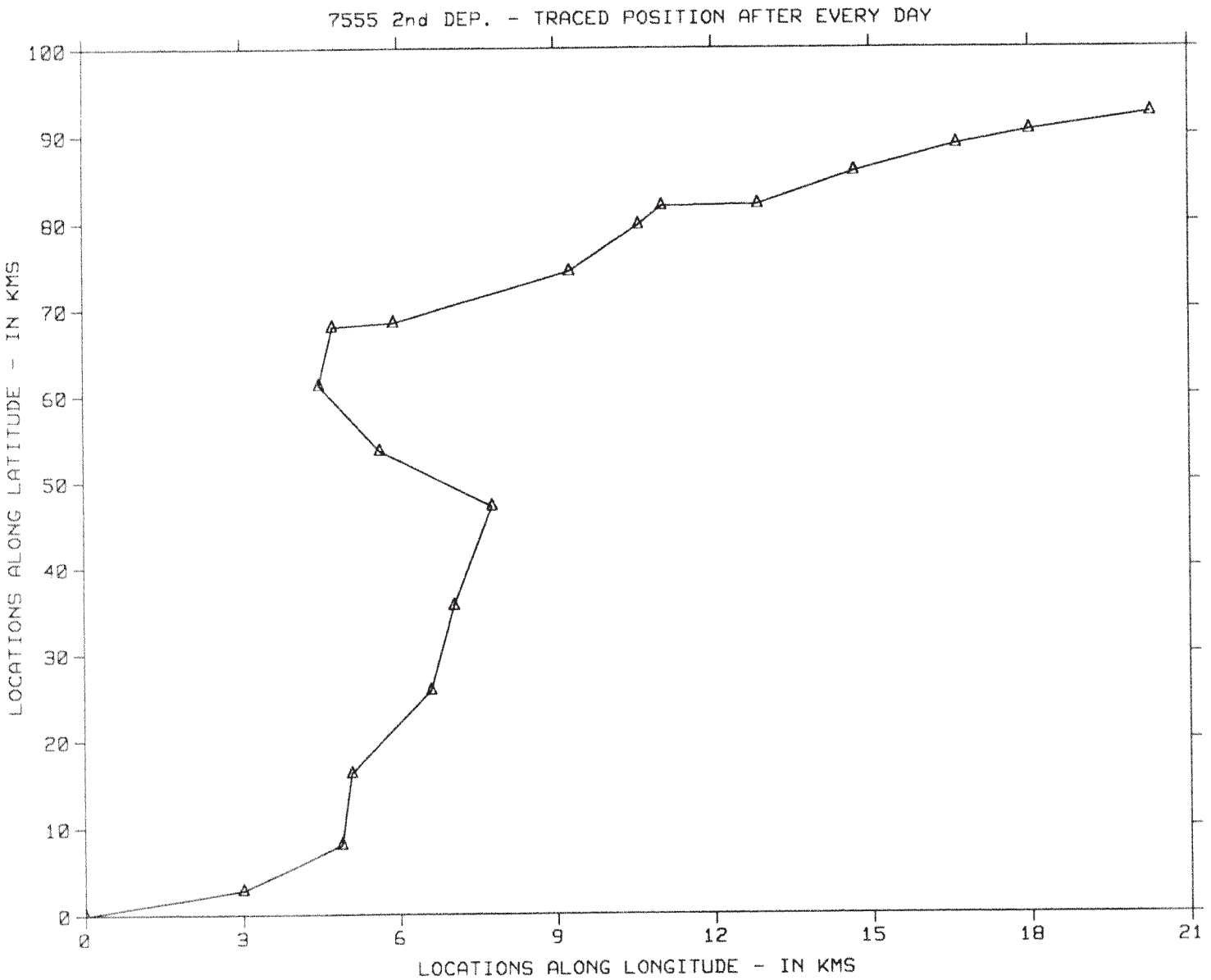




Percentage of currents

KAILUA–7555–2nd DEP.




7555 2nd DEP. - TRACED POSITION AFTER EVERY DAY
LOCATIONS ALONG LATITUDE - IN KMS
LOCATIONS ALONG LONGITUDE - IN KMS
0
10
20
30
40
50
60
70
80
90
100
0
3
6
9
12
15
18
21

DATA INFORMATION

SITE NAME	: KAILUA-7558-2nd DEP.
METER NUMBER	: 7558
METER POSITION	: TOP
LATITUDE	: 21.23.0946N
LONGITUDE	: 157.40.8245W
START DATE	: 10:42, 2,MAR,1992
END DATE	: 15: 9,29,MAY,1992
DEPLOY DATE	: 13:44, 6,MAR,1992
BOTTOM DEPTH	: 110 ft.
METER DEPTH	: 70 ft.
REV COUNT	: 4.00
TIME INTERVAL	: 10.00
DATA FILE	: 7558bin2.dat
TOTAL PTS	: 7819
START PT	: 111

VELOCITY DISTRIBUTION

SPEED	0 | 5	5 | 10	10 | 15	15 | 20	20 | 25	25 | 30	30 | 35	35 | 40	40 | 45	45 | 50
DIR										
0 - 15	1	110	117	59	28	14	5	0	0	0
15 - 30	0	64	44	11	0	1	0	0	0	0
30 - 45	0	49	38	3	0	0	0	0	0	0
45 - 60	0	29	14	1	0	0	0	0	0	0
60 - 75	0	23	14	0	0	0	0	0	0	0
75 - 90	0	33	18	0	0	0	0	0	0	0
90 - 105	1	48	20	0	0	0	0	0	0	0
105 - 120	0	114	43	3	2	0	0	0	0	0
120 - 135	0	118	125	31	20	9	3	1	0	0
135 - 150	0	142	238	130	86	56	33	6	0	0
150 - 165	0	117	325	218	187	130	61	12	0	0
165 - 180	0	124	244	164	116	45	21	3	0	0
180 - 195	0	113	150	53	27	6	1	0	0	0
195 - 210	0	90	52	8	1	0	0	0	0	0
210 - 225	0	88	13	0	1	0	0	0	0	0
225 - 240	1	68	5	0	0	0	0	0	0	0
240 - 255	0	58	13	0	0	0	1	0	0	0
255 - 270	0	74	14	0	0	0	0	0	0	0
270 - 285	0	82	21	0	0	0	0	0	0	0
285 - 300	0	140	54	1	1	0	0	0	0	0
300 - 315	0	153	149	35	11	1	0	0	0	0
315 - 330	1	184	271	130	74	35	3	0	0	0
330 - 345	0	186	324	243	154	110	66	2	0	0
345 - 360	0	129	247	156	99	74	56	6	2	0

SPEED	50 | 55	55 | 60	60 | 65	65 | 70	70 | 75	75 | 80	80 | 85	85 | 90	90 | 95	95 | 100
DIR										
0 - 15	0	0	0	0	0	0	0	0	0	0
15 - 30	0	0	0	0	0	0	0	0	0	0
30 - 45	0	0	0	0	0	0	0	0	0	0
45 - 60	0	0	0	0	0	0	0	0	0	0
60 - 75	0	0	0	0	0	0	0	0	0	0
75 - 90	0	0	0	0	0	0	0	0	0	0

90 - 105	0	0	0	0	0	0	0	0	0	0
105 - 120	0	0	0	0	0	0	0	0	0	0
120 - 135	0	0	0	0	0	0	0	0	0	0
135 - 150	0	0	0	0	0	0	0	0	0	0
150 - 165	0	0	0	0	0	0	0	0	0	0
165 - 180	0	0	0	0	0	0	0	0	0	0
180 - 195	0	0	0	0	0	0	0	0	0	0
195 - 210	0	0	0	0	0	0	0	0	0	0
210 - 225	0	0	0	0	0	0	0	0	0	0
225 - 240	0	0	0	0	0	0	0	0	0	0
240 - 255	0	0	0	0	0	0	0	0	0	0
255 - 270	0	0	0	0	0	0	0	0	0	0
270 - 285	0	0	0	0	0	0	0	0	0	0
285 - 300	0	0	0	0	0	0	0	0	0	0
300 - 315	0	0	0	0	0	0	0	0	0	0
315 - 330	0	0	0	0	0	0	0	0	0	0
330 - 345	0	0	0	0	0	0	0	0	0	0
345 - 360	0	0	0	0	0	0	0	0	0	0

DIRECTION [Degrees]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 15	334	4.33
15 - 30	120	1.56
30 - 45	90	1.17
45 - 60	44	.57
60 - 75	37	.48
75 - 90	51	.66
90 - 105	69	.90
105 - 120	162	2.10
120 - 135	307	3.98
135 - 150	691	8.96
150 - 165	1050	13.62
165 - 180	717	9.30
180 - 195	350	4.54
195 - 210	151	1.96
210 - 225	102	1.32
225 - 240	74	.96
240 - 255	72	.93
255 - 270	88	1.14
270 - 285	103	1.34
285 - 300	196	2.54
300 - 315	349	4.53
315 - 330	698	9.05
330 - 345	1085	14.07
345 - 360	769	9.98

SPEED [cm/sec]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 5	4	.05
5 - 10	2336	30.30
10 - 15	2553	33.12
15 - 20	1246	16.16
20 - 25	807	10.47
25 - 30	481	6.24
30 - 35	250	3.24
35 - 40	30	.39

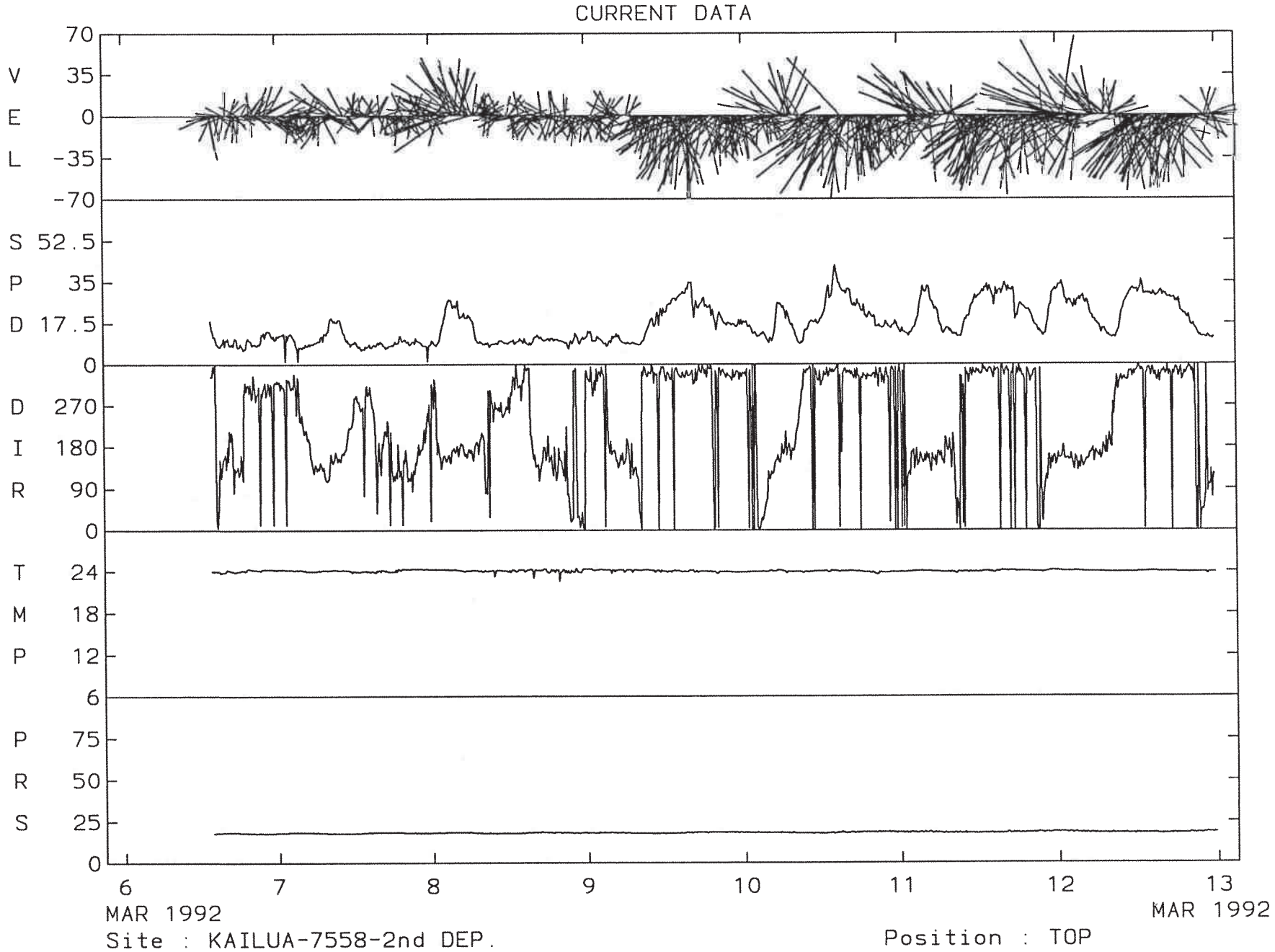
40 - 45	2	.03
45 - 50	0	.00

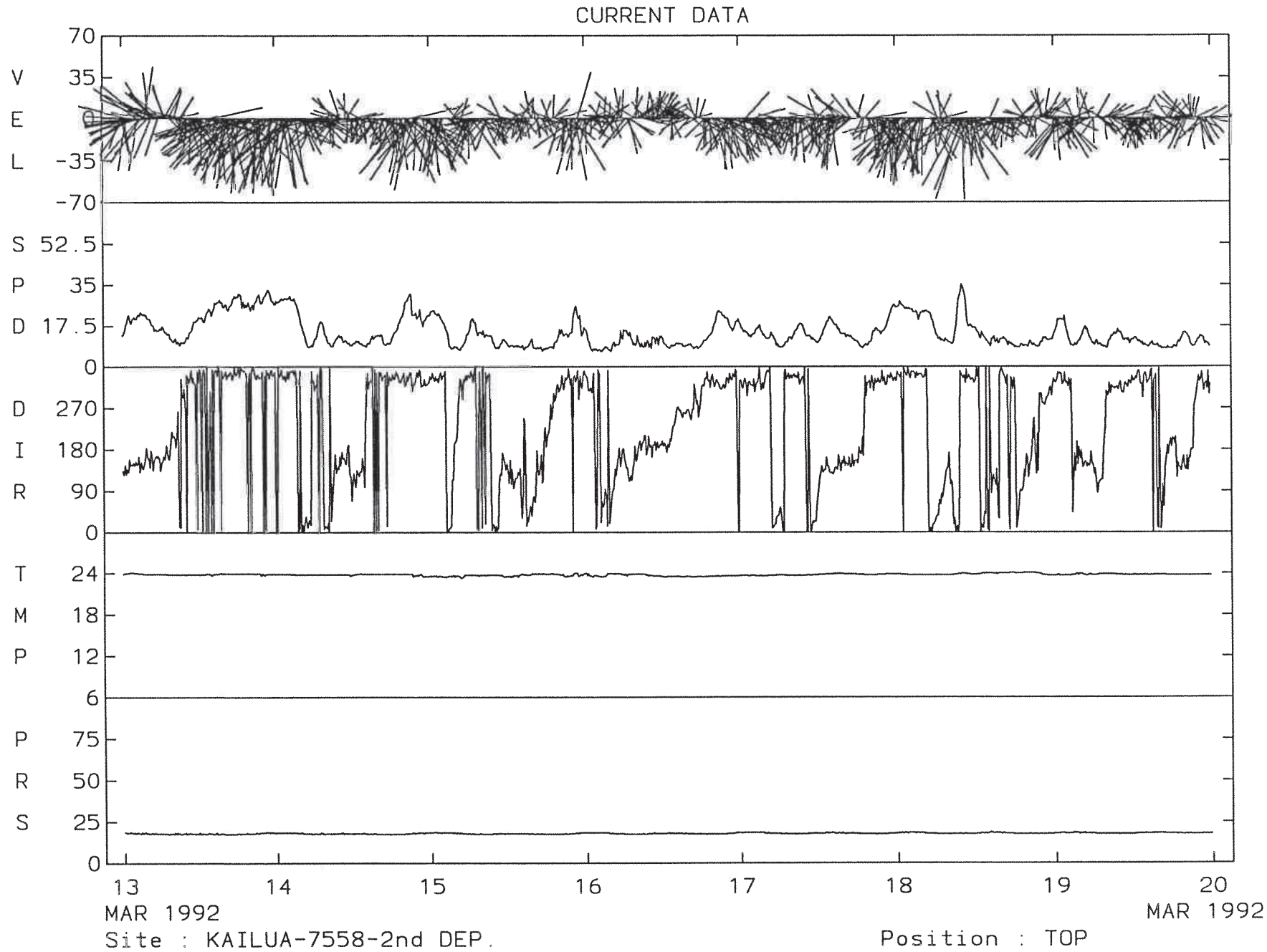
Total number of valid data points : 7709
Maximum Speed : 42.10 cm/s
Minimum Speed : 1.50 cm/s
Mean Speed : 14.62 cm/s
Range : 40.60 cm/s
Standard Deviation : .18 cm/s

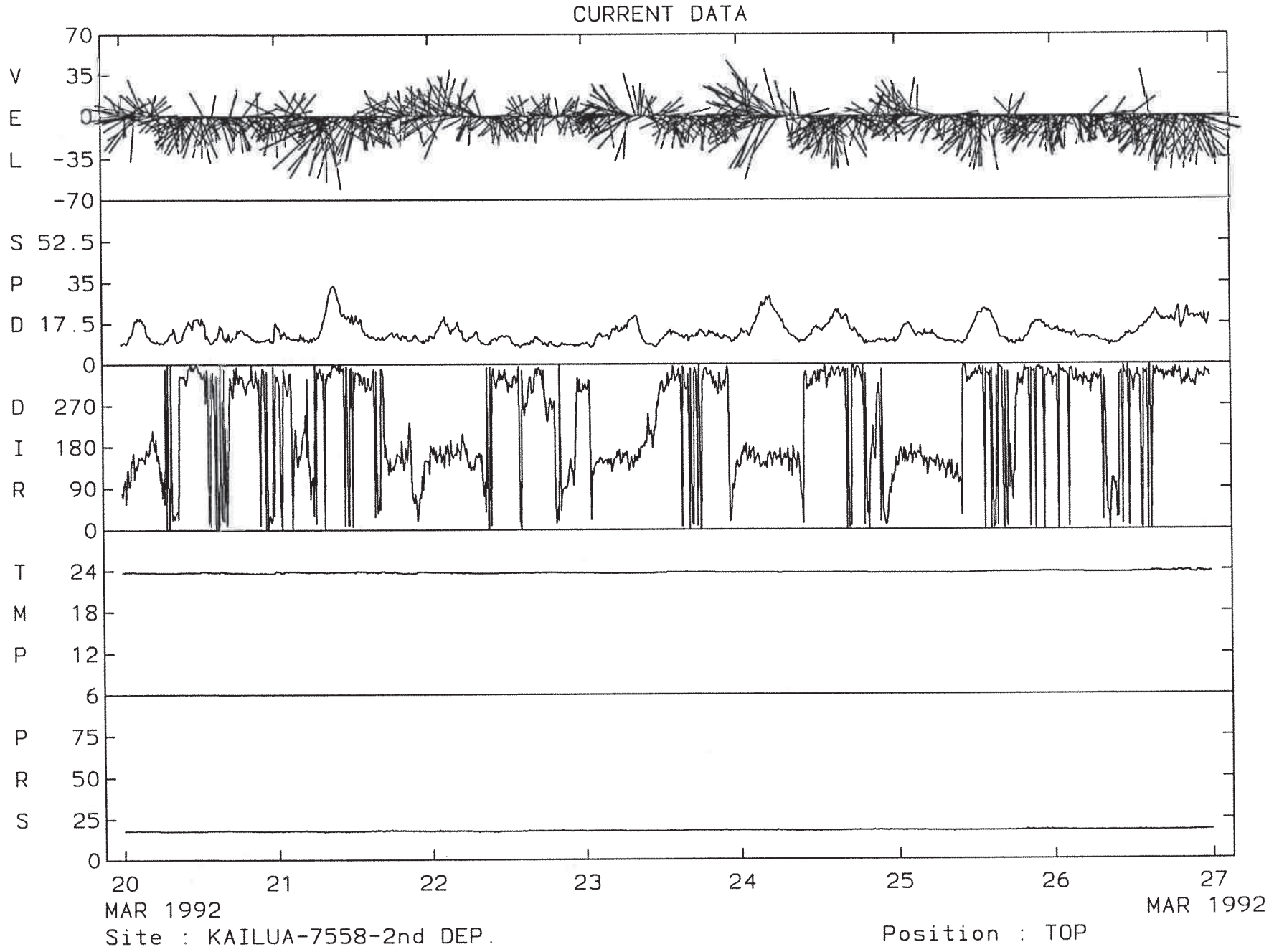
TEMPERATURE [Celcius]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 2	0	.00
2 - 4	0	.00
4 - 6	0	.00
6 - 8	0	.00
8 - 10	0	.00
10 - 12	0	.00
12 - 14	0	.00
14 - 16	0	.00
16 - 18	0	.00
18 - 20	0	.00
20 - 22	0	.00
22 - 24	3010	39.05
24 - 26	4699	60.95
26 - 28	0	.00
28 - 30	0	.00

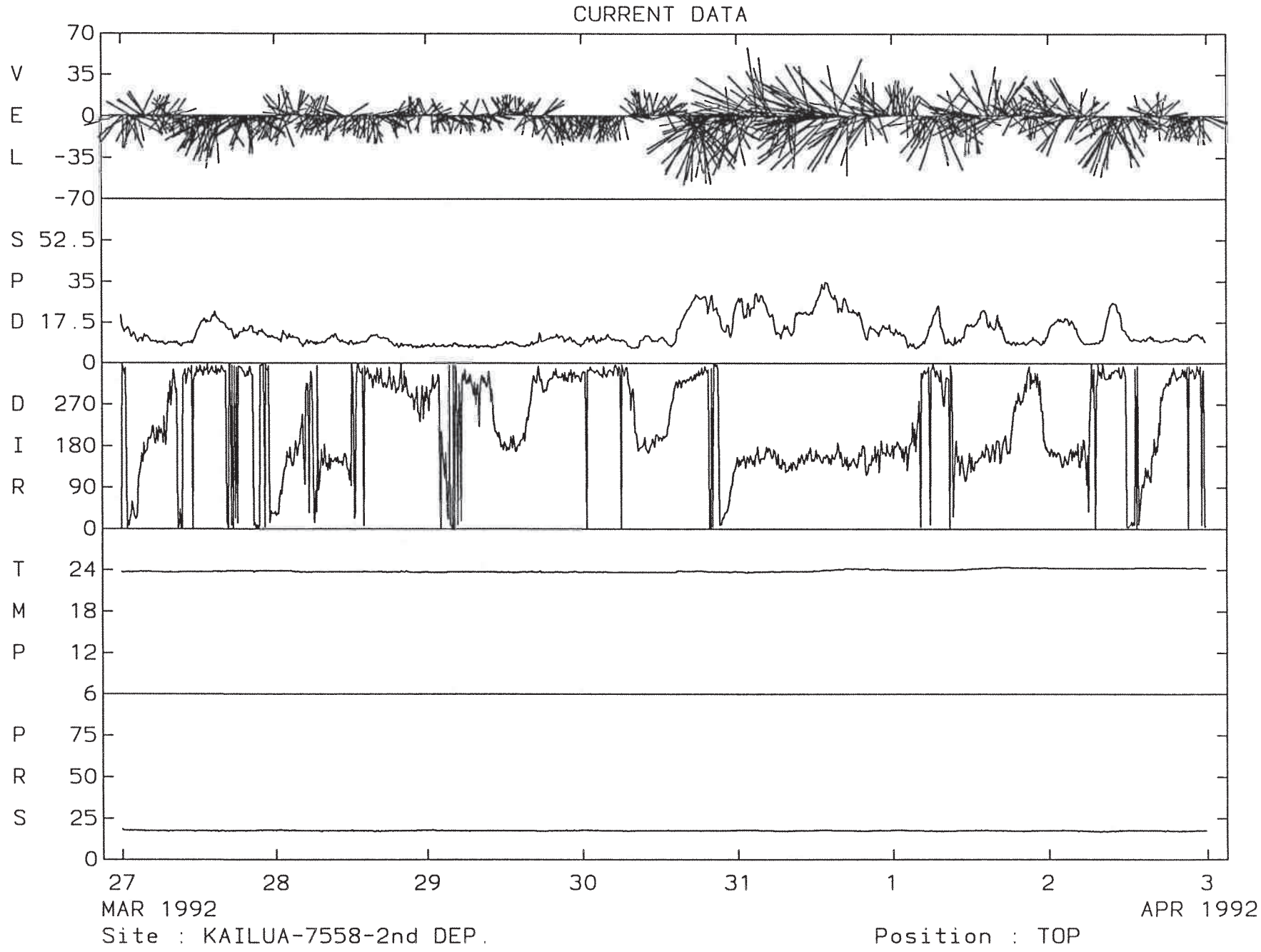
Total number of valid data points : 7709
Maximum Temperature : 25.20 °C
Minimum Temperature : 22.65 °C
Mean Temperature : 24.24 °C
Range : 2.55 °C
Standard Deviation : .28 °C

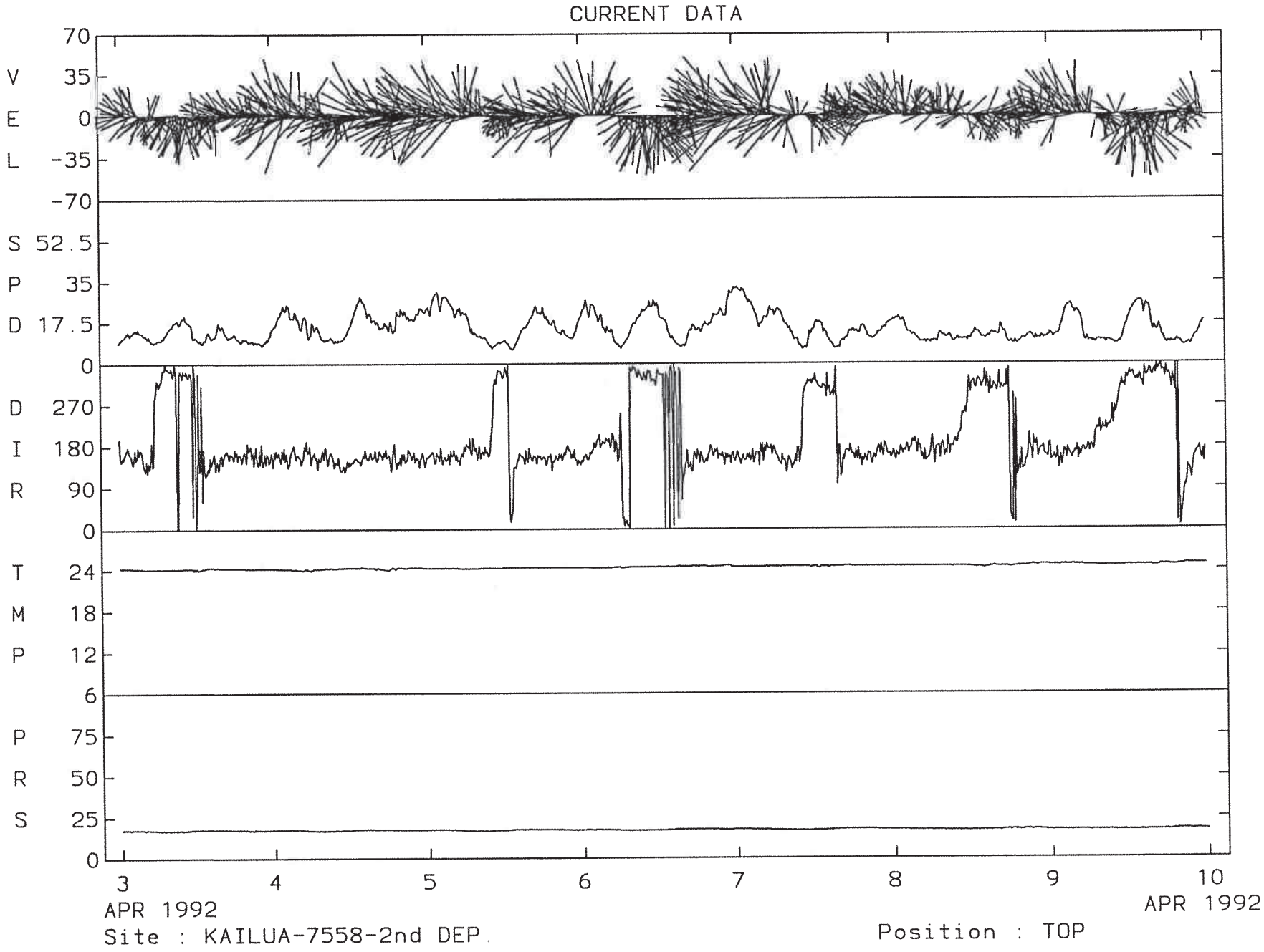
SPEED [cm/sec]	PERCENTAGE OBSERVATIONS LESS THAN
0 - 5	.05
5 - 10	30.35
10 - 15	63.47
15 - 20	79.63
20 - 25	90.10
25 - 30	96.34
30 - 35	99.58
35 - 40	99.97
40 - 45	100.00
45 - 50	100.00

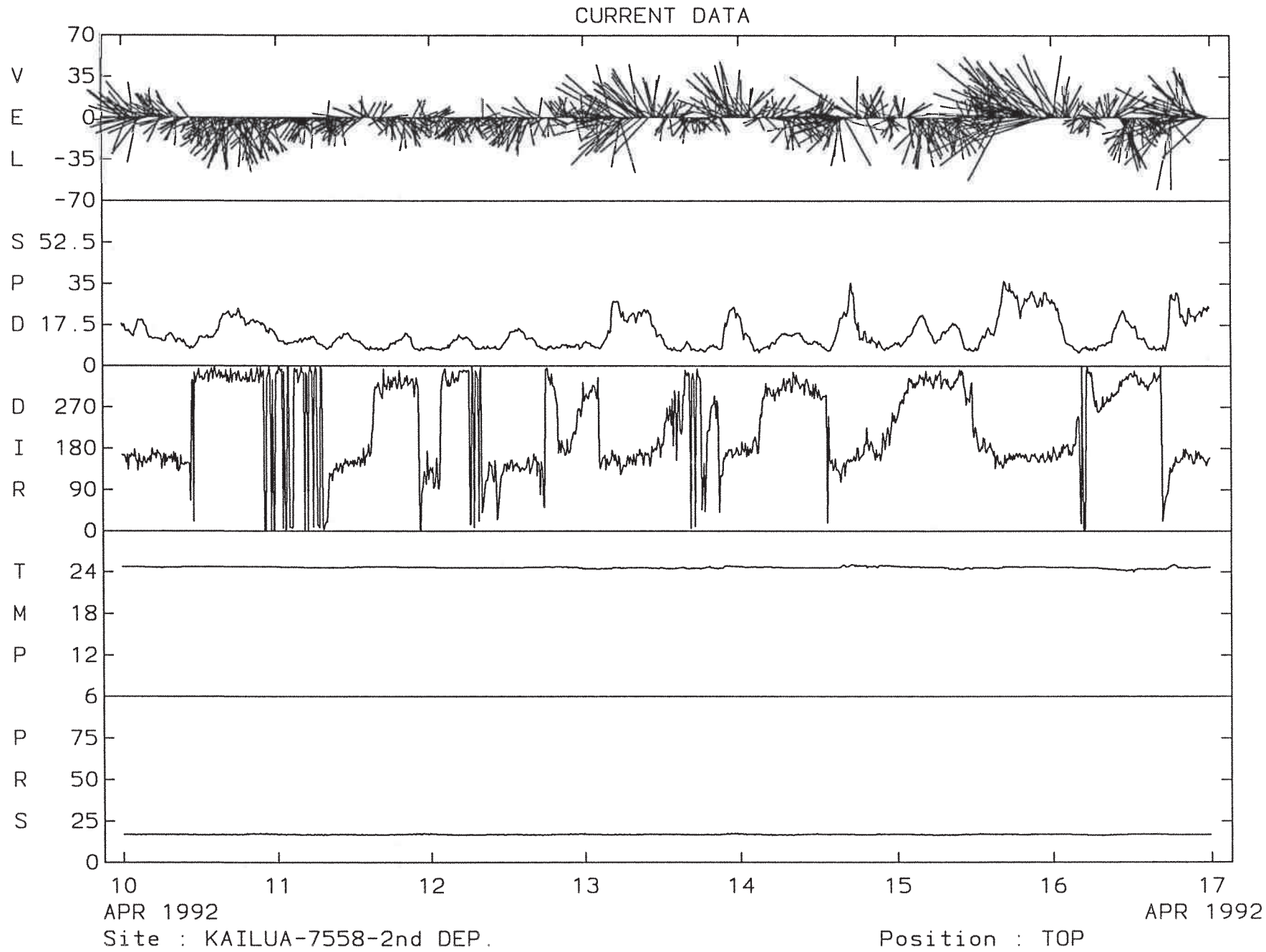

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
6
7
8
9
10
11
12
13
MAR 1992
MAR 1992
Site : KAILUA-7558-2nd DEP.
Position : TOP

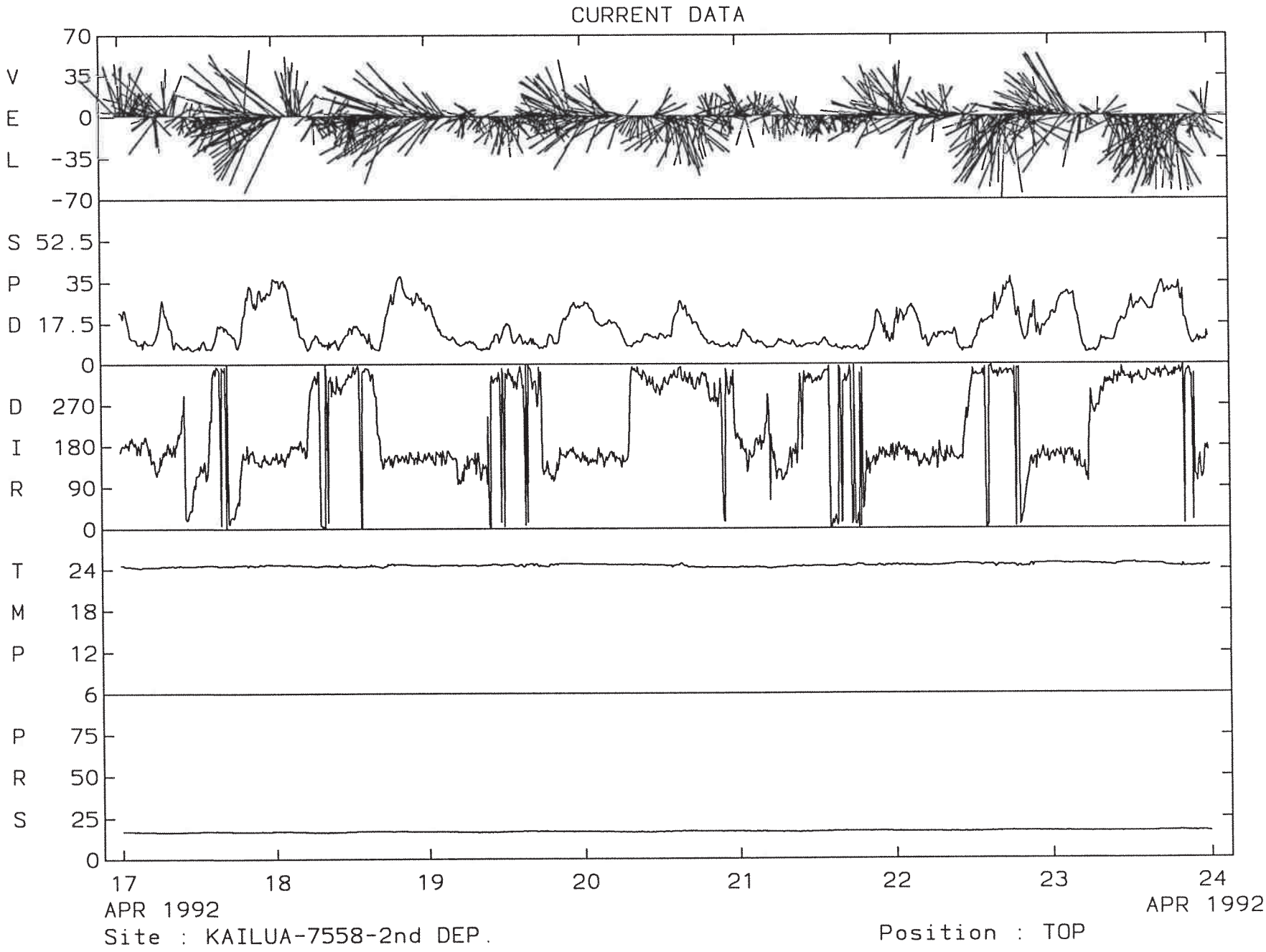

CURRENT DATA
70
V 35
E
L -35
-70
S 52.5
P 35
D 17.5
0
D 270
I 180
R 90
0
T 24
M 18
P 12
6
P 75
R 50
S 25
0
13
14
15
16
17
18
19
20
MAR 1992
MAR 1992
Site : KAILUA-7558-2nd DEP.
Position : TOP

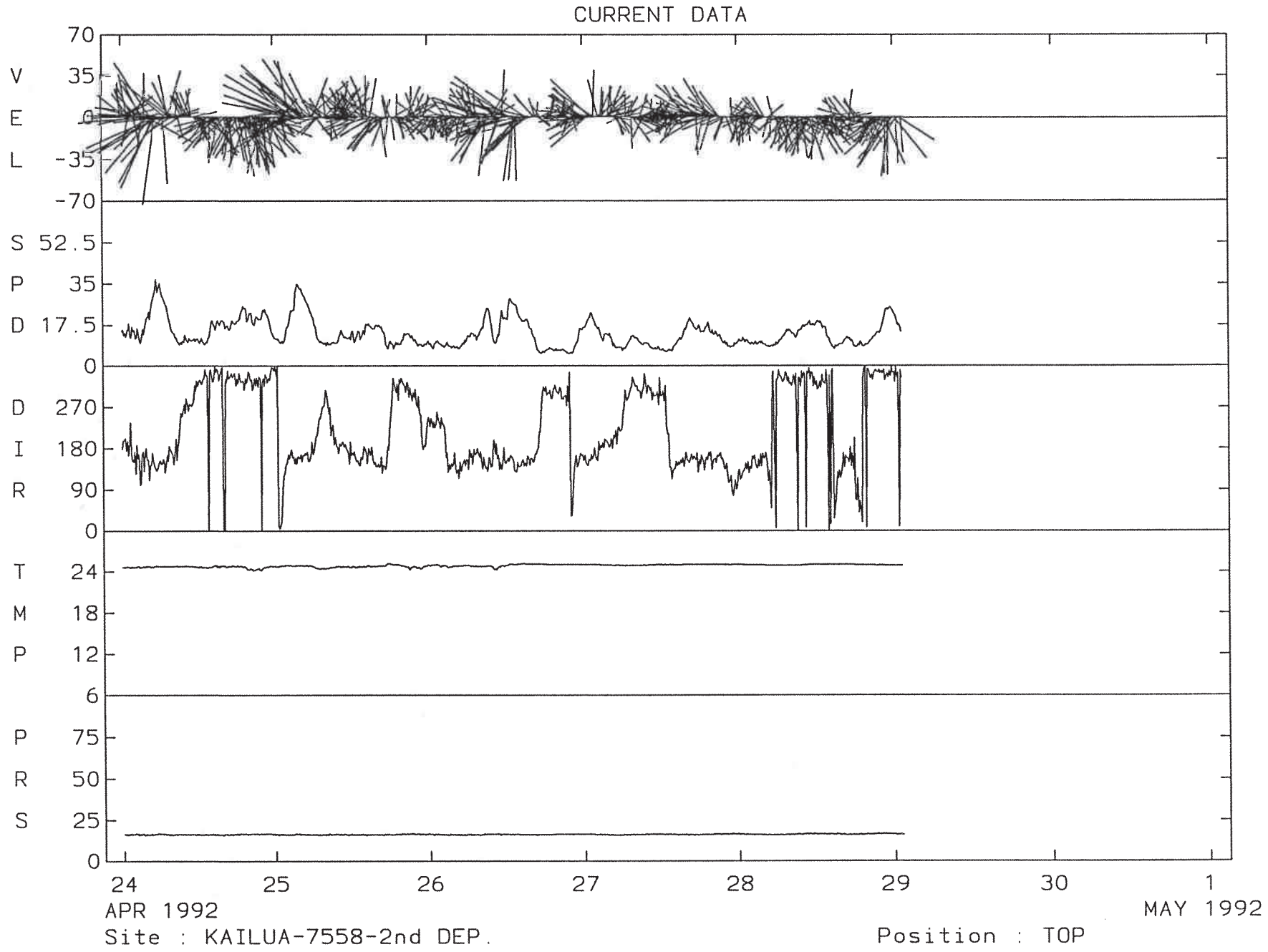

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
20
21
22
23
24
25
26
27
MAR 1992
MAR 1992
Site : KAILUA-7558-2nd DEP.
Position : TOP


CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
27
28
29
30
31
1
2
3
MAR 1992
APR 1992
Site : KAILUA-7558-2nd DEP.
Position : TOP

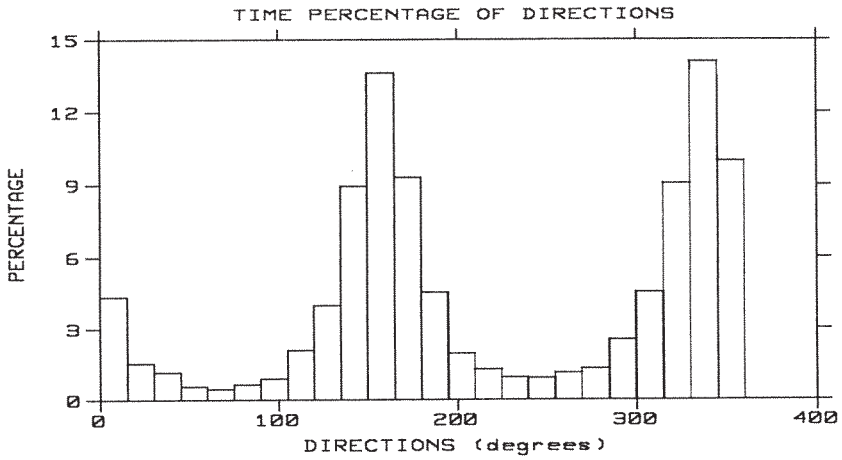

CURRENT DATA
V E L
70
35
0
-35
-70
S P D
52.5
35
17.5
0
D I R
270
180
90
0
T M P
24
18
12
6
P R S
75
50
25
0
3
4
5
6
7
8
9
10
APR 1992
APR 1992
Site : KAILUA-7558-2nd DEP.
Position : TOP

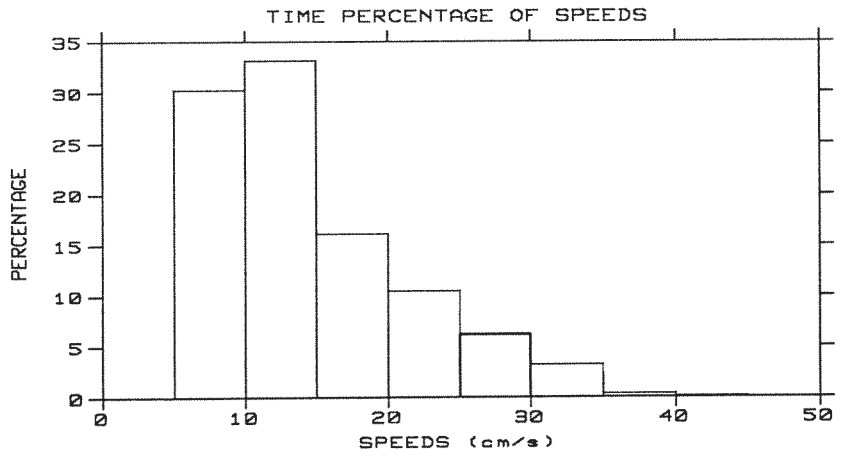

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
10
APR 1992
11
12
13
14
15
16
17
APR 1992
Site : KAILUA-7558-2nd DEP.
Position : TOP

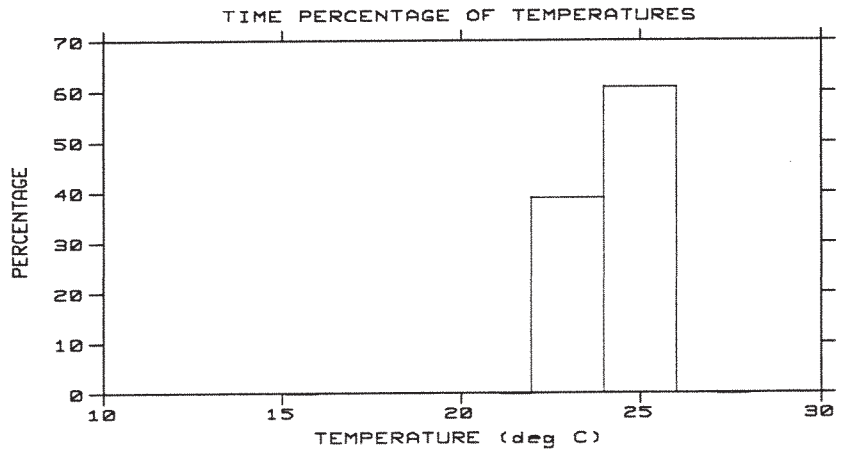

CURRENT DATA
70
V 35
E 0
L -35
-70
S 52.5
P 35
D 17.5
0
D 270
I 180
R 90
0
T 24
M 18
P 12
6
P 75
R 50
S 25
0
17
18
19
20
21
22
23
24
APR 1992
APR 1992
Site : KAILUA-7558-2nd DEP.
Position : TOP

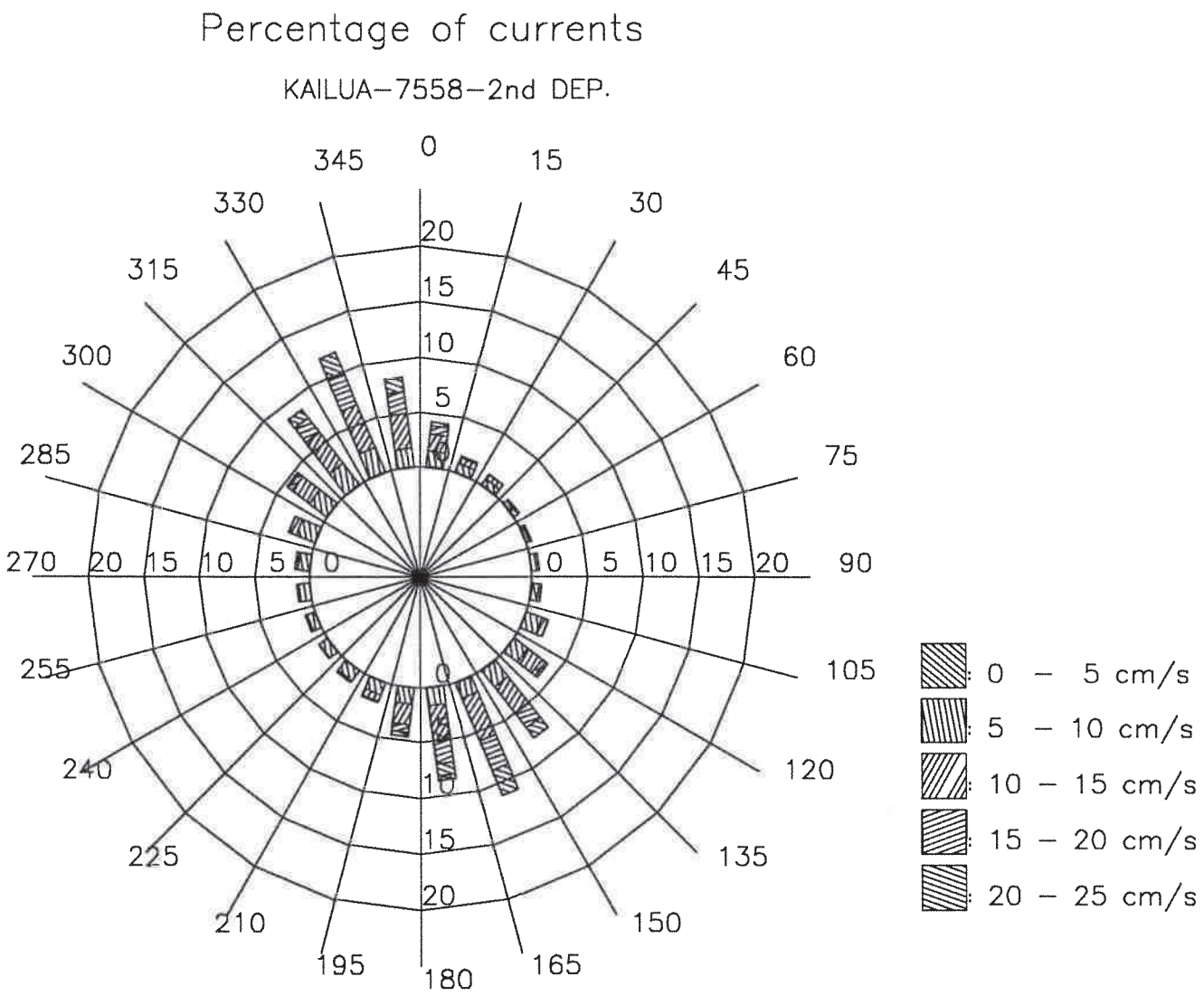

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
24
25
26
27
28
29
30
1
APR 1992
MAY 1992
Site : KAILUA-7558-2nd DEP.
Position : TOP

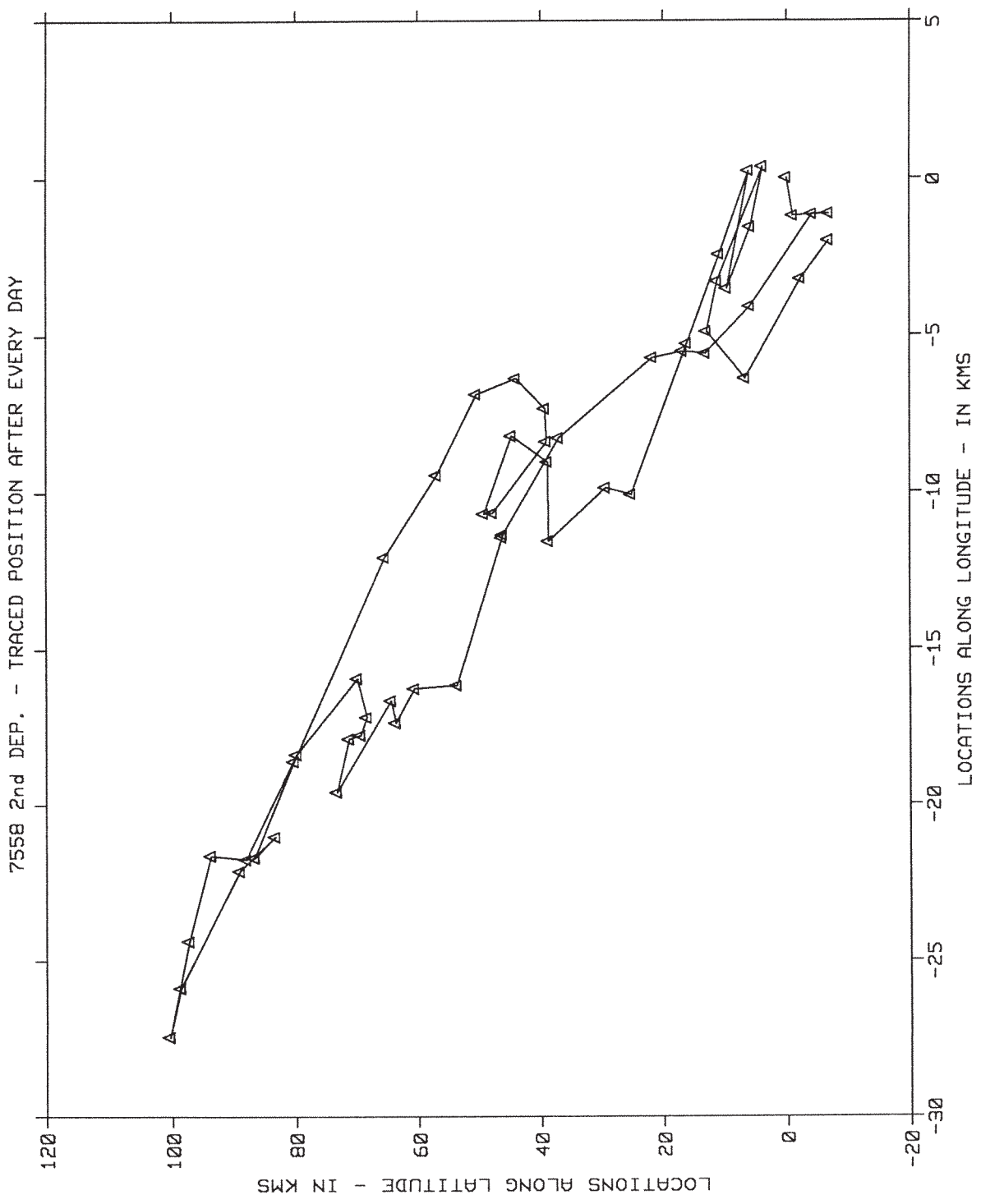
KAILUA-7558-2nd DEP.








Percentage of currents
KAILUA–7558–2nd DEP.
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
330
345
0
5
10
15
20
0 – 5 cm/s
5 – 10 cm/s
10 – 15 cm/s
15 – 20 cm/s
20 – 25 cm/s


7558 2nd DEP. - TRACED POSITION AFTER EVERY DAY
LOCATIONS ALONG LATITUDE - IN KMS
LOCATIONS ALONG LONGITUDE - IN KMS
120
100
80
60
40
20
0
-20
5
0
-5
-10
-15
-20
-25
-30

APPENDIX C

Current Measurements for Third Deployment: April–May 1993

Meter No.: S4 . . . . . C-1 through C-12

Meter No.: 4993 . . . . . C-13 through C-22

DATA INFORMATION

SITE NAME	: KAILUA-S4-3rd DEP.
METER NUMBER	: S4
METER POSITION	: TOP
LATITUDE	: 21-27-21 N
LONGITUDE	: 157-43-14 W
START DATE	: 16:55,16,APR,1993
END DATE	: 12:12,31,MAY,1993
DEPLOY DATE	: 9:46,17,APR,1993
BOTTOM DEPTH	: 105 ft.
METER DEPTH	: 35 ft.
REV COUNT	: 4.00
TIME INTERVAL	: 10.00
DATA FILE	: kaihea.bin
TOTAL PTS	: 5928
START PT	: 103

VELOCITY DISTRIBUTION

DIR \ SPEED	0 | 5	5 | 10	10 | 15	15 | 20	20 | 25	25 | 30	30 | 35	35 | 40	40 | 45	45 | 50
0 - 15	44	107	122	84	61	22	10	0	0	0
15 - 30	23	63	40	20	21	2	0	0	0	0
30 - 45	15	38	17	5	8	1	0	0	0	0
45 - 60	22	18	4	4	1	1	0	0	0	0
60 - 75	18	11	6	2	1	0	0	0	0	0
75 - 90	14	29	5	1	0	0	0	0	0	0
90 - 105	21	22	7	1	0	0	0	0	0	0
105 - 120	16	33	12	7	1	0	0	0	0	0
120 - 135	22	29	11	9	8	1	0	1	0	0
135 - 150	27	35	24	21	10	10	2	1	1	0
150 - 165	23	35	32	35	24	13	21	14	9	4
165 - 180	24	43	46	38	46	11	19	5	2	0
180 - 195	53	59	52	34	16	18	1	1	0	0
195 - 210	32	57	38	14	5	2	0	0	0	0
210 - 225	32	59	26	6	4	0	0	0	0	0
225 - 240	37	36	14	8	0	1	0	0	0	0
240 - 255	47	28	16	2	3	0	0	0	0	0
255 - 270	22	31	17	5	2	0	0	0	0	0
270 - 285	57	59	21	17	2	0	0	0	0	0
285 - 300	41	78	26	18	1	0	0	0	0	0
300 - 315	38	120	67	35	16	3	0	0	0	0
315 - 330	52	128	172	152	55	7	2	1	0	0
330 - 345	61	150	253	314	169	74	50	14	2	0
345 - 360	37	113	161	234	270	189	107	52	10	0

DIR \ SPEED	50 | 55	55 | 60	60 | 65	65 | 70	70 | 75	75 | 80	80 | 85	85 | 90	90 | 95	95 | 100
0 - 15	0	0	0	0	0	0	0	0	0	0
15 - 30	0	0	0	0	0	0	0	0	0	0
30 - 45	0	0	0	0	0	0	0	0	0	0
45 - 60	0	0	0	0	0	0	0	0	0	0
60 - 75	0	0	0	0	0	0	0	0	0	0
75 - 90	0	0	0	0	0	0	0	0	0	0

90 - 105	0	0	0	0	0	0	0	0	0	0
105 - 120	0	0	0	0	0	0	0	0	0	0
120 - 135	0	0	0	0	0	0	0	0	0	0
135 - 150	0	0	0	0	0	0	0	0	0	0
150 - 165	0	0	0	0	0	0	0	0	0	0
165 - 180	0	0	0	0	0	0	0	0	0	0
180 - 195	0	0	0	0	0	0	0	0	0	0
195 - 210	0	0	0	0	0	0	0	0	0	0
210 - 225	0	0	0	0	0	0	0	0	0	0
225 - 240	0	0	0	0	0	0	0	0	0	0
240 - 255	0	0	0	0	0	0	0	0	0	0
255 - 270	0	0	0	0	0	0	0	0	0	0
270 - 285	0	0	0	0	0	0	0	0	0	0
285 - 300	0	0	0	0	0	0	0	0	0	0
300 - 315	0	0	0	0	0	0	0	0	0	0
315 - 330	0	0	0	0	0	0	0	0	0	0
330 - 345	0	0	0	0	0	0	0	0	0	0
345 - 360	0	0	0	0	0	0	0	0	0	0

DIRECTION [Degrees]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 15	450	7.72
15 - 30	169	2.90
30 - 45	84	1.44
45 - 60	50	.86
60 - 75	38	.65
75 - 90	49	.84
90 - 105	51	.88
105 - 120	69	1.18
120 - 135	81	1.39
135 - 150	131	2.25
150 - 165	210	3.60
165 - 180	234	4.02
180 - 195	234	4.02
195 - 210	148	2.54
210 - 225	127	2.18
225 - 240	96	1.65
240 - 255	96	1.65
255 - 270	77	1.32
270 - 285	156	2.68
285 - 300	164	2.81
300 - 315	279	4.79
315 - 330	569	9.77
330 - 345	1087	18.66
345 - 360	1173	20.13

SPEED [cm/sec]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 5	778	13.35
5 - 10	1381	23.70
10 - 15	1189	20.41
15 - 20	1066	18.30
20 - 25	726	12.46
25 - 30	357	6.13
30 - 35	212	3.64
35 - 40	89	1.53

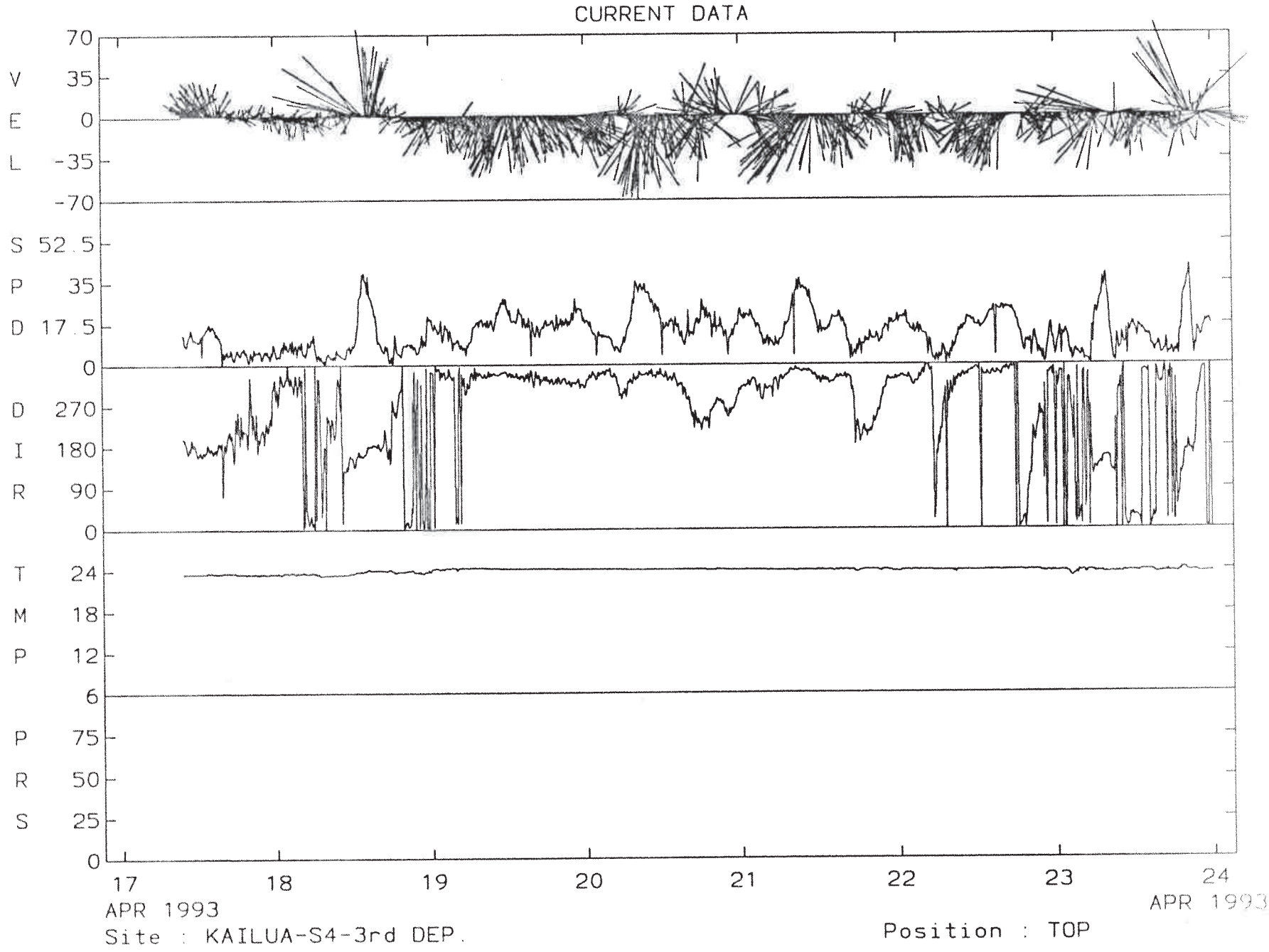
40 - 45	24	.41
45 - 50	4	.07

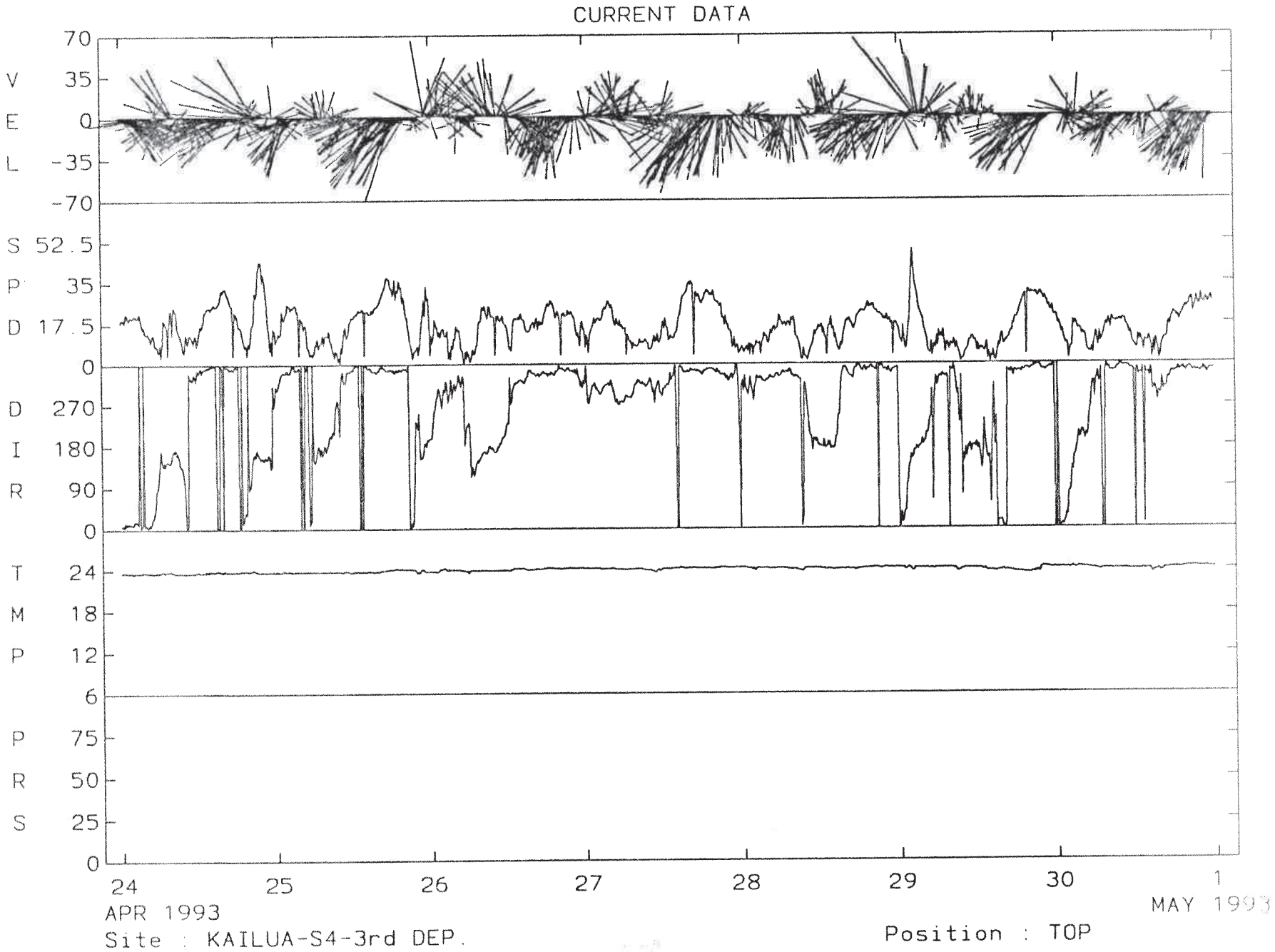
Total number of valid data points : 5826
Maximum Speed : 48.80 cm/s
Minimum Speed : .00 cm/s
Mean Speed : 14.25 cm/s
Range : 48.80 cm/s
Standard Deviation : .22 cm/s

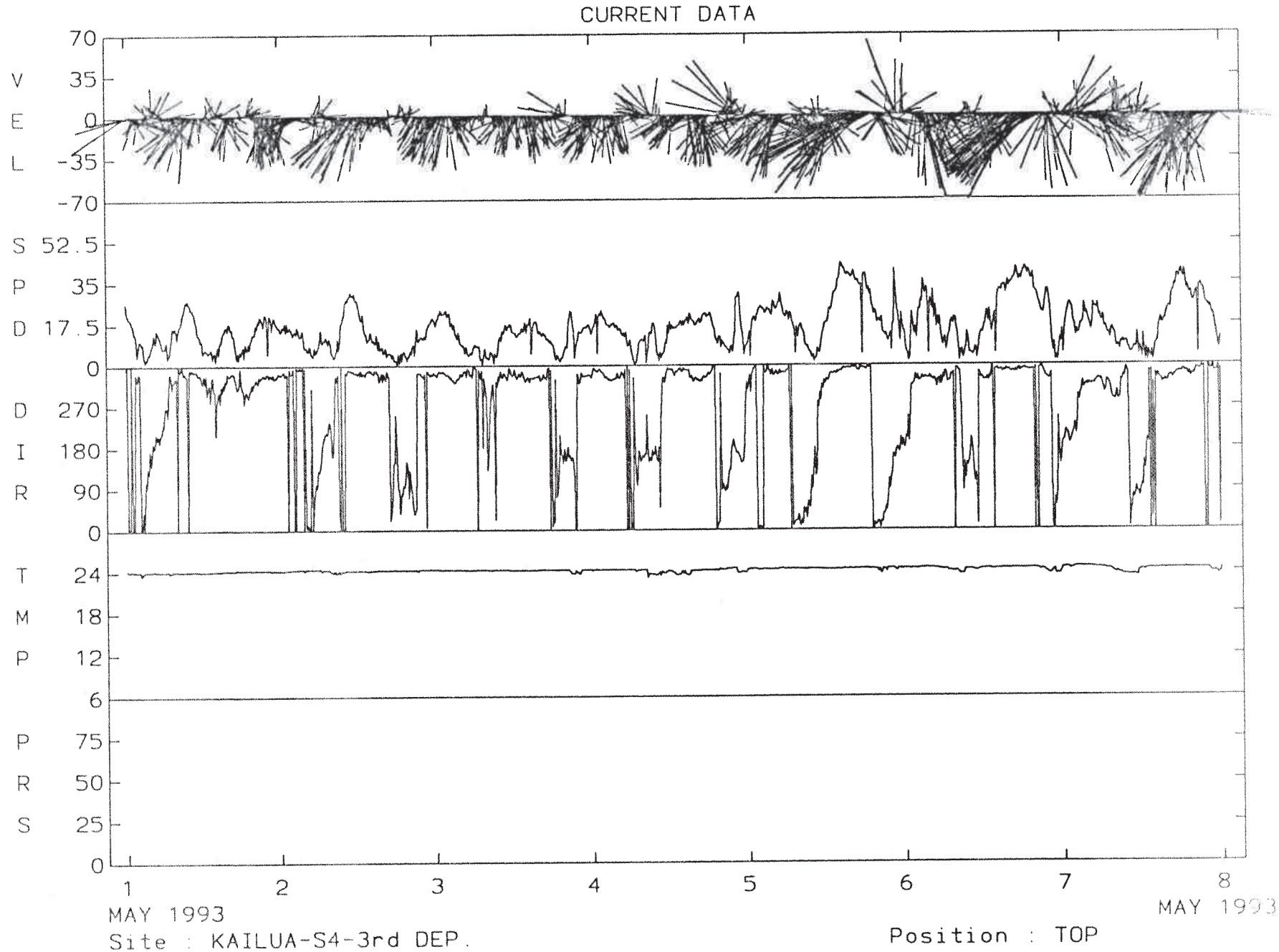
TEMPERATURE [Celcius]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 2	0	.00
2 - 4	0	.00
4 - 6	0	.00
6 - 8	0	.00
8 - 10	0	.00
10 - 12	0	.00
12 - 14	0	.00
14 - 16	0	.00
16 - 18	0	.00
18 - 20	0	.00
20 - 22	0	.00
22 - 24	1388	23.82
24 - 26	4438	76.18
26 - 28	0	.00
28 - 30	0	.00

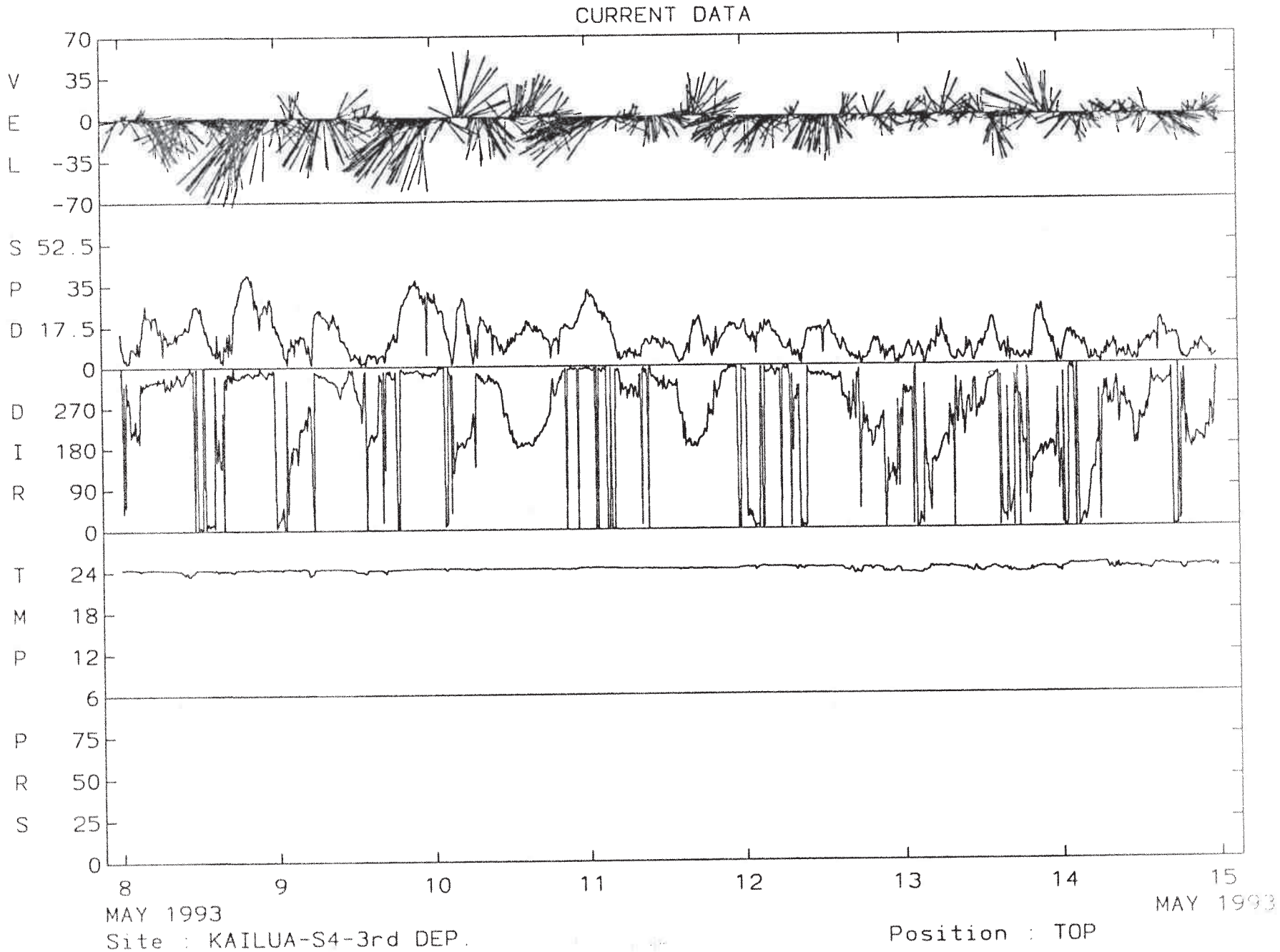
Total number of valid data points : 5826
Maximum Temperature : 25.06 °C
Minimum Temperature : 23.01 °C
Mean Temperature : 24.22 °C
Range : 2.05 °C
Standard Deviation : .32 °C

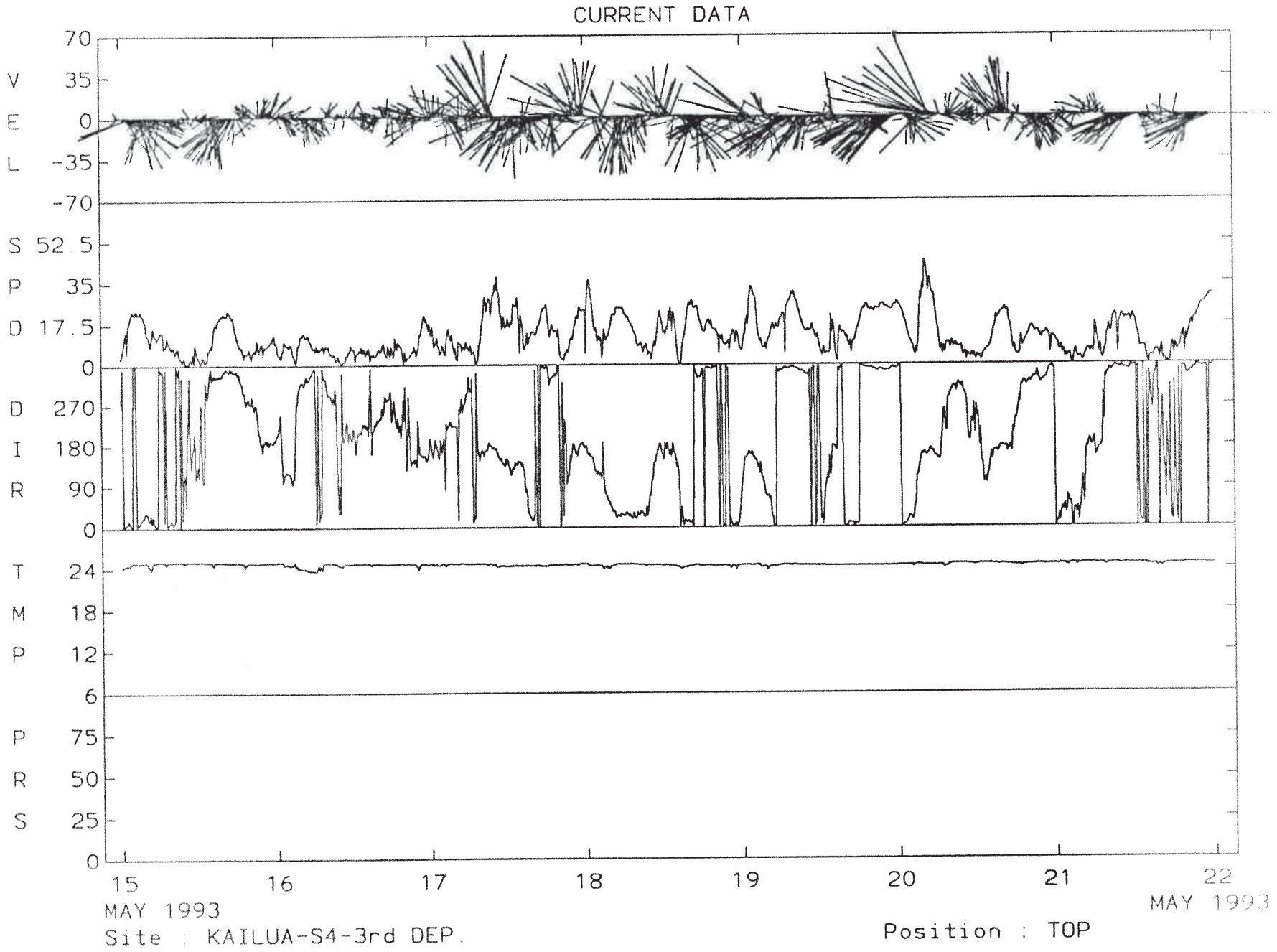
SPEED [cm/sec]	PERCENTAGE OBSERVATIONS LESS THAN
0 - 5	13.35
5 - 10	37.06
10 - 15	57.47
15 - 20	75.76
20 - 25	88.23
25 - 30	94.35
30 - 35	97.99
35 - 40	99.52
40 - 45	99.93
45 - 50	100.00

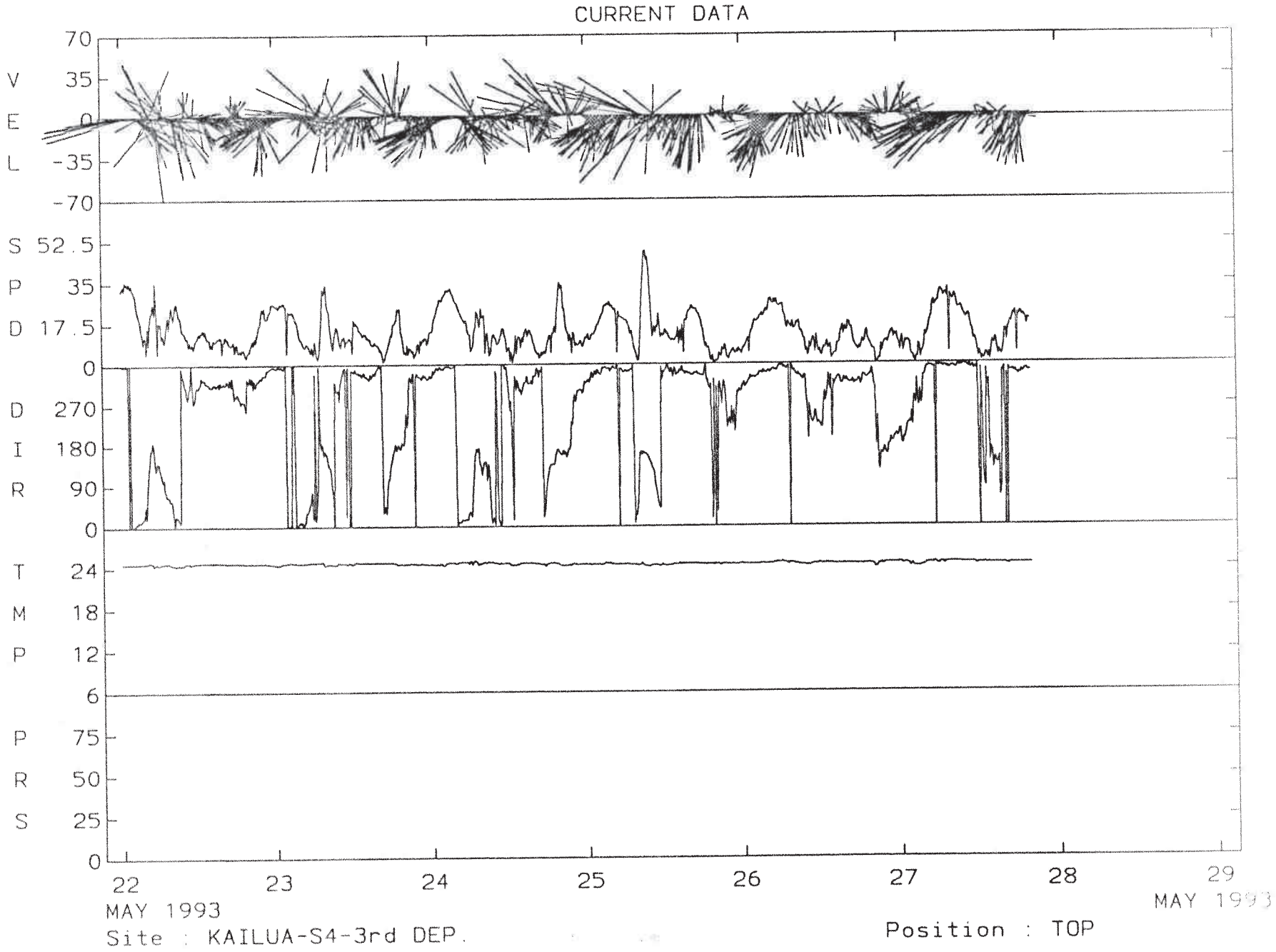

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
17
18
19
20
21
22
23
24
APR 1993
APR 1993
Site : KAILUA-S4-3rd DEP.
Position : TOP


CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
24
25
26
27
28
29
30
1
APR 1993
MAY 1993
Site : KAILUA-S4-3rd DEP.
Position : TOP

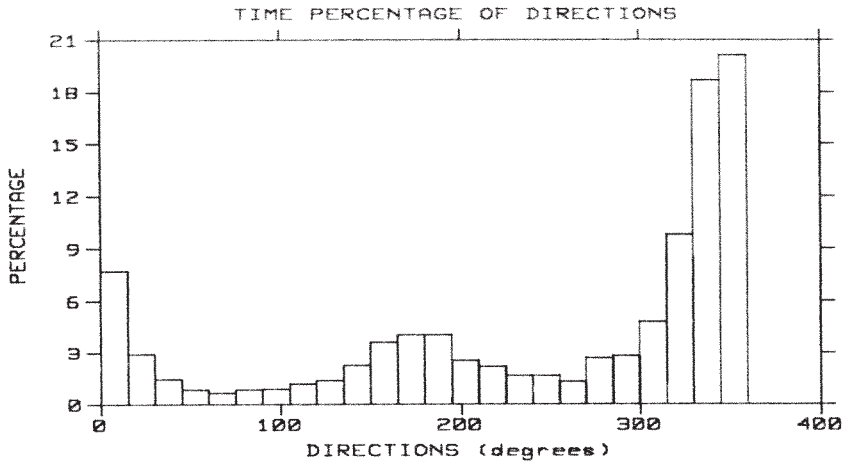

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
1
2
3
4
5
6
7
8
MAY 1993
MAY 1993
Site : KAILUA-S4-3rd DEP.
Position : TOP

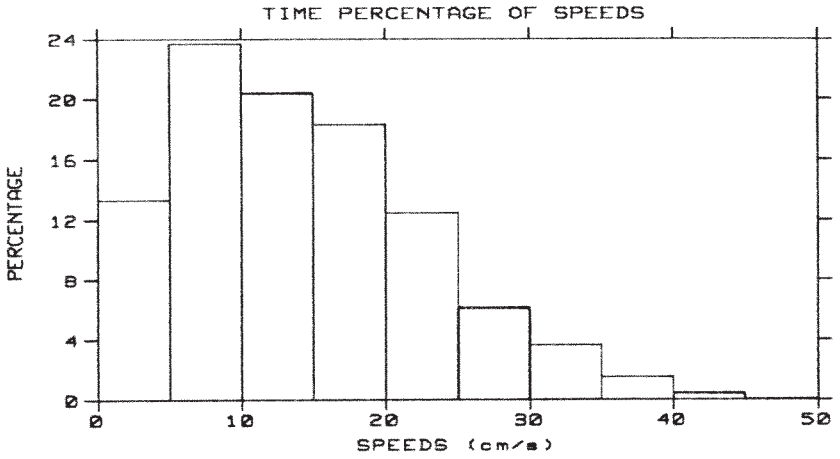

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
8
9
10
11
12
13
14
15
MAY 1993
MAY 1993
Site : KAILUA-S4-3rd DEP.
Position : TOP

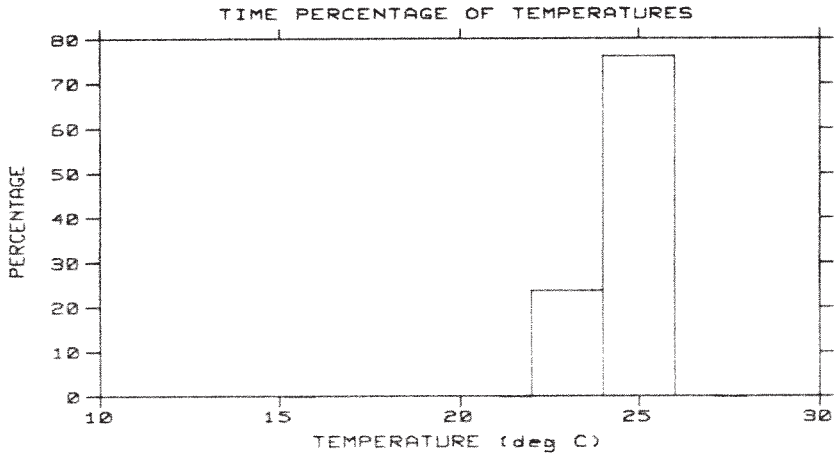

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
15
16
17
18
19
20
21
22
MAY 1993
MAY 1993
Site : KAILUA-S4-3rd DEP.
Position : TOP


CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
22
23
24
25
26
27
28
29
MAY 1993
MAY 1993
Site : KAILUA-S4-3rd DEP.
Position : TOP

KAILUA-S4-3rd DEP.

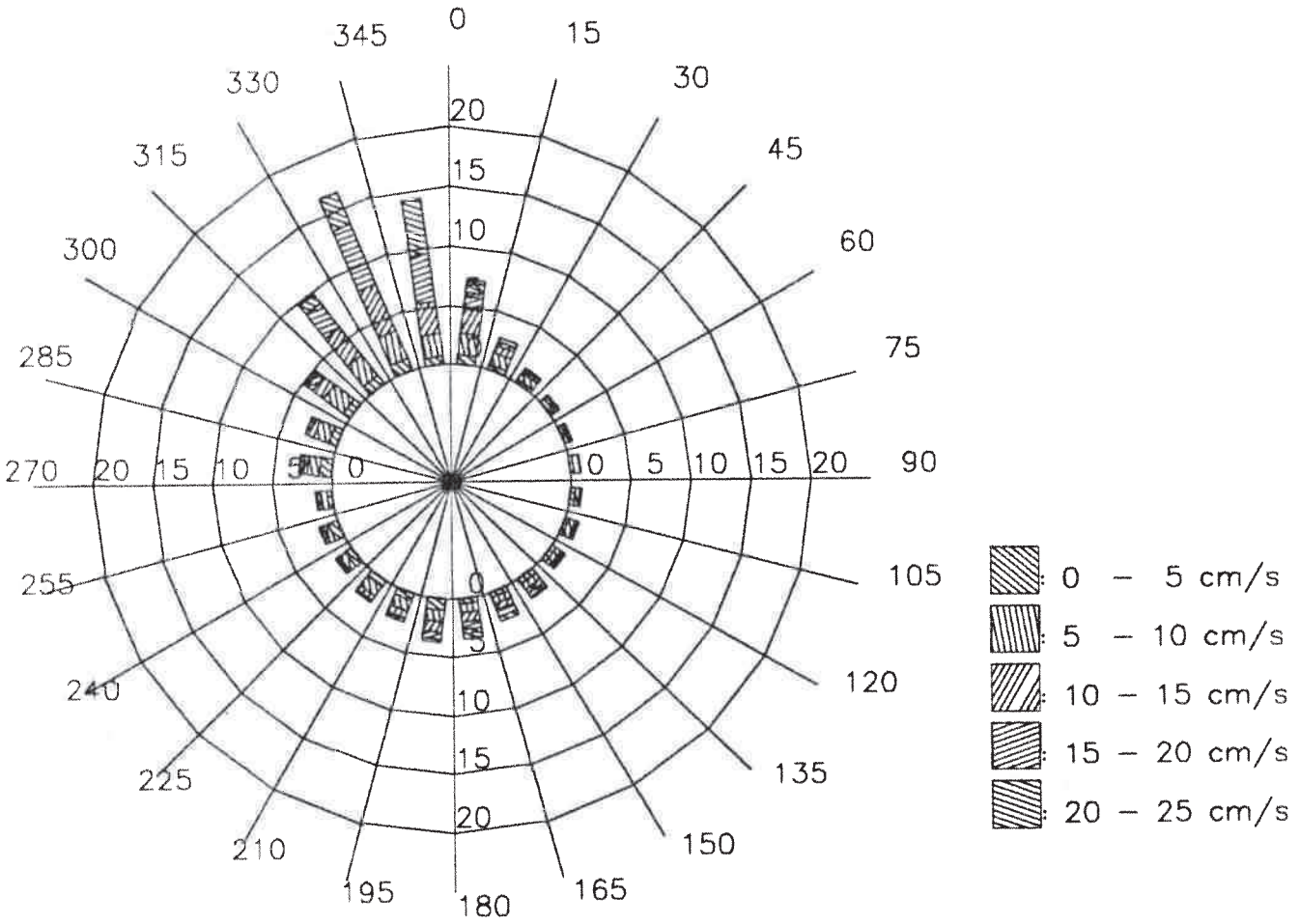


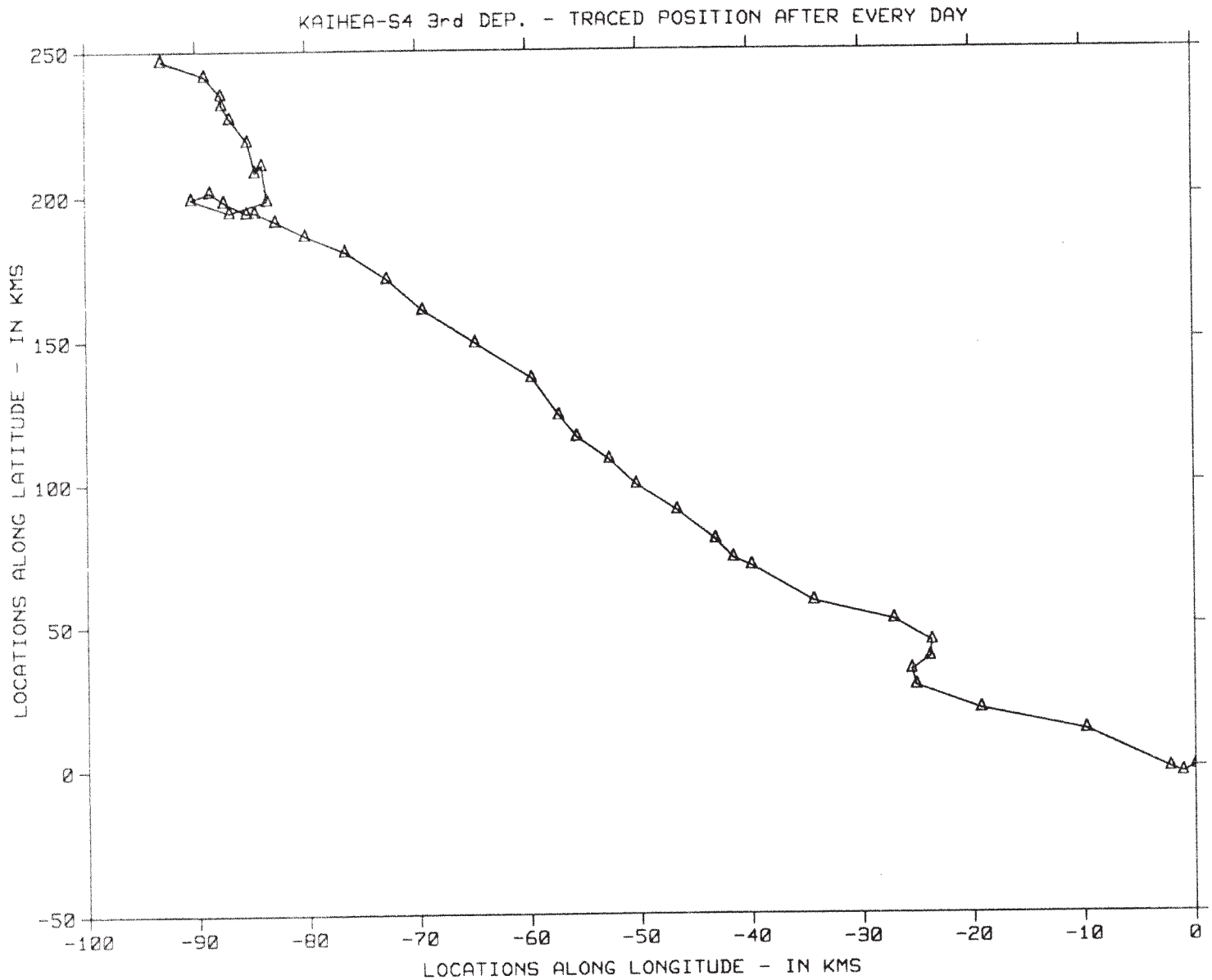




Percentage of currents

KAILUA–S4–3rd DEP.




KAIHEA-S4 3rd DEP. - TRACED POSITION AFTER EVERY DAY
LOCATIONS ALONG LATITUDE - IN KMS
250
200
150
100
50
0
-50
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
LOCATIONS ALONG LONGITUDE - IN KMS

DATA INFORMATION

SITE NAME	: KAILUA-4993-3rd DEP.
METER NUMBER	: 4993
METER POSITION	: TOP
LATITUDE	: 21-26-7 N
LONGITUDE	: 157-43-2 W
START DATE	: 17: 0,16,APR,1993
END DATE	: 12: 0,27,MAY,1993
DEPLOY DATE	: 10:20,17,APR,1993
BOTTOM DEPTH	: 105 ft.
METER DEPTH	: 70 ft.
REV COUNT	: 4.00
TIME INTERVAL	: 10.00
DATA FILE	: 4993.bin
TOTAL PTS	: 3620
START PT	: 104

VELOCITY DISTRIBUTION

SPEED	0 | 5	5 | 10	10 | 15	15 | 20	20 | 25	25 | 30	30 | 35	35 | 40	40 | 45	45 | 50
DIR										
0 - 15	42	134	108	22	2	0	0	0	0	0
15 - 30	55	73	44	3	2	0	0	0	0	0
30 - 45	48	36	6	0	0	0	0	0	0	0
45 - 60	32	27	7	0	0	0	0	0	0	0
60 - 75	35	22	2	0	0	0	0	0	0	0
75 - 90	26	9	0	0	0	0	0	0	0	0
90 - 105	21	12	0	0	0	0	0	0	0	0
105 - 120	28	12	0	1	0	0	0	0	0	0
120 - 135	28	31	6	4	4	2	1	0	0	0
135 - 150	43	64	21	21	17	9	1	0	0	0
150 - 165	47	75	62	44	30	7	1	0	0	0
165 - 180	36	91	89	34	22	3	0	0	0	0
180 - 195	39	74	59	30	1	0	0	0	0	0
195 - 210	36	58	22	4	0	0	0	0	0	0
210 - 225	31	48	4	0	0	0	0	0	0	0
225 - 240	32	31	0	0	0	0	0	0	0	0
240 - 255	26	16	0	0	0	0	0	0	0	0
255 - 270	43	16	3	0	0	0	0	0	0	0
270 - 285	47	26	1	0	0	0	0	0	0	0
285 - 300	37	40	0	0	0	0	0	0	0	0
300 - 315	51	61	7	0	0	0	0	0	0	0
315 - 330	64	159	39	5	0	0	0	0	0	0
330 - 345	50	195	111	15	1	0	0	0	0	0
345 - 360	40	202	151	39	1	0	0	0	0	0

SPEED	50 | 55	55 | 60	60 | 65	65 | 70	70 | 75	75 | 80	80 | 85	85 | 90	90 | 95	95 | 100
DIR										
0 - 15	0	0	0	0	0	0	0	0	0	0
15 - 30	0	0	0	0	0	0	0	0	0	0
30 - 45	0	0	0	0	0	0	0	0	0	0
45 - 60	0	0	0	0	0	0	0	0	0	0
60 - 75	0	0	0	0	0	0	0	0	0	0
75 - 90	0	0	0	0	0	0	0	0	0	0

90 - 105	0	0	0	0	0	0	0	0	0	0
105 - 120	0	0	0	0	0	0	0	0	0	0
120 - 135	0	0	0	0	0	0	0	0	0	0
135 - 150	0	0	0	0	0	0	0	0	0	0
150 - 165	0	0	0	0	0	0	0	0	0	0
165 - 180	0	0	0	0	0	0	0	0	0	0
180 - 195	0	0	0	0	0	0	0	0	0	0
195 - 210	0	0	0	0	0	0	0	0	0	0
210 - 225	0	0	0	0	0	0	0	0	0	0
225 - 240	0	0	0	0	0	0	0	0	0	0
240 - 255	0	0	0	0	0	0	0	0	0	0
255 - 270	0	0	0	0	0	0	0	0	0	0
270 - 285	0	0	0	0	0	0	0	0	0	0
285 - 300	0	0	0	0	0	0	0	0	0	0
300 - 315	0	0	0	0	0	0	0	0	0	0
315 - 330	0	0	0	0	0	0	0	0	0	0
330 - 345	0	0	0	0	0	0	0	0	0	0
345 - 360	0	0	0	0	0	0	0	0	0	0

DIRECTION [Degrees]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 15	308	8.76
15 - 30	177	5.03
30 - 45	90	2.56
45 - 60	66	1.88
60 - 75	59	1.68
75 - 90	35	1.00
90 - 105	33	.94
105 - 120	41	1.17
120 - 135	76	2.16
135 - 150	176	5.00
150 - 165	266	7.56
165 - 180	275	7.82
180 - 195	203	5.77
195 - 210	120	3.41
210 - 225	83	2.36
225 - 240	63	1.79
240 - 255	42	1.19
255 - 270	62	1.76
270 - 285	74	2.10
285 - 300	77	2.19
300 - 315	119	3.38
315 - 330	267	7.59
330 - 345	372	10.58
345 - 360	433	12.31

SPEED [cm/sec]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 5	937	26.64
5 - 10	1512	42.99
10 - 15	742	21.10
15 - 20	222	6.31
20 - 25	80	2.27
25 - 30	21	.60
30 - 35	3	.09
35 - 40	0	.00

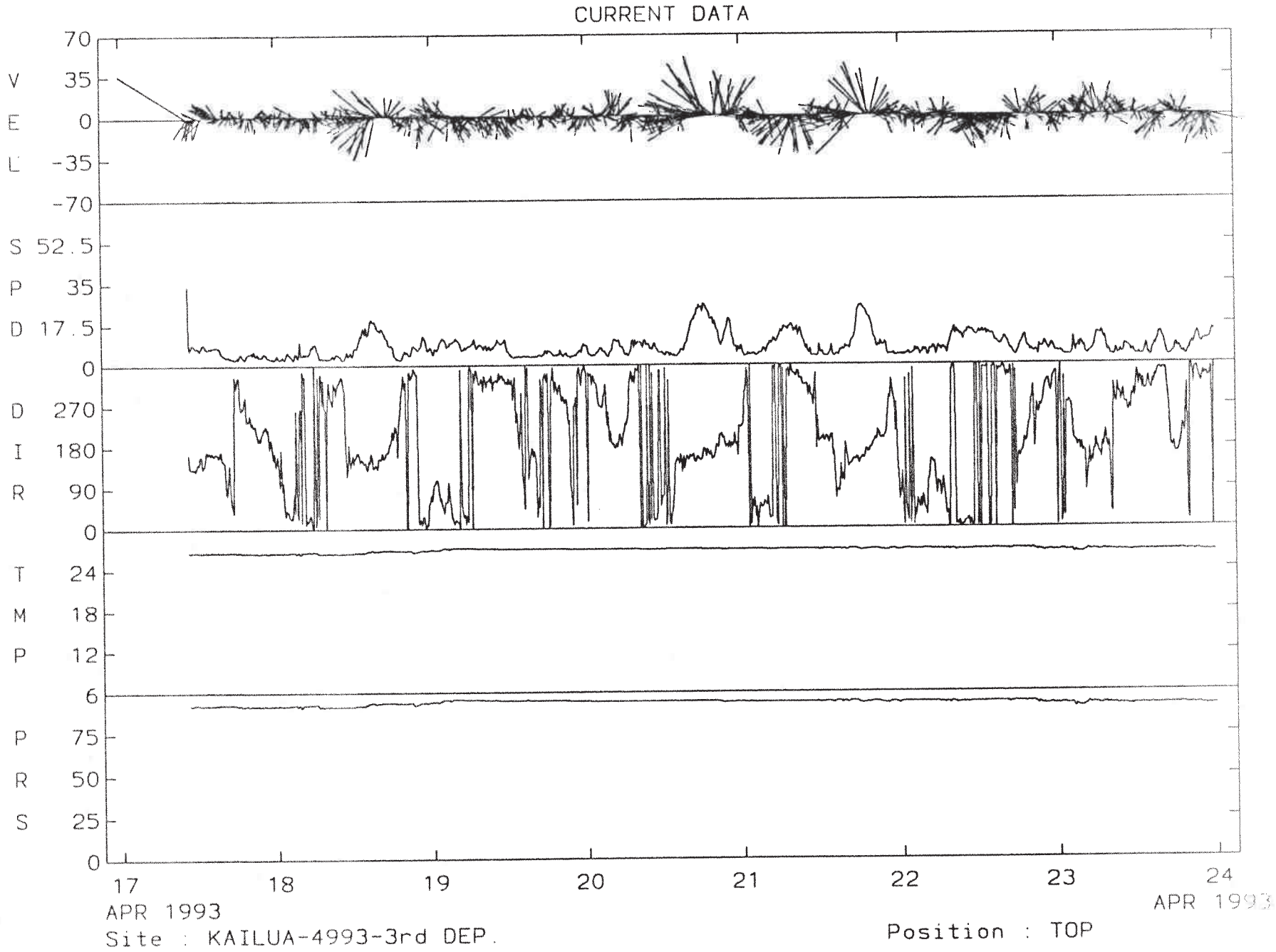
40 - 45	0	.00
45 - 50	0	.00

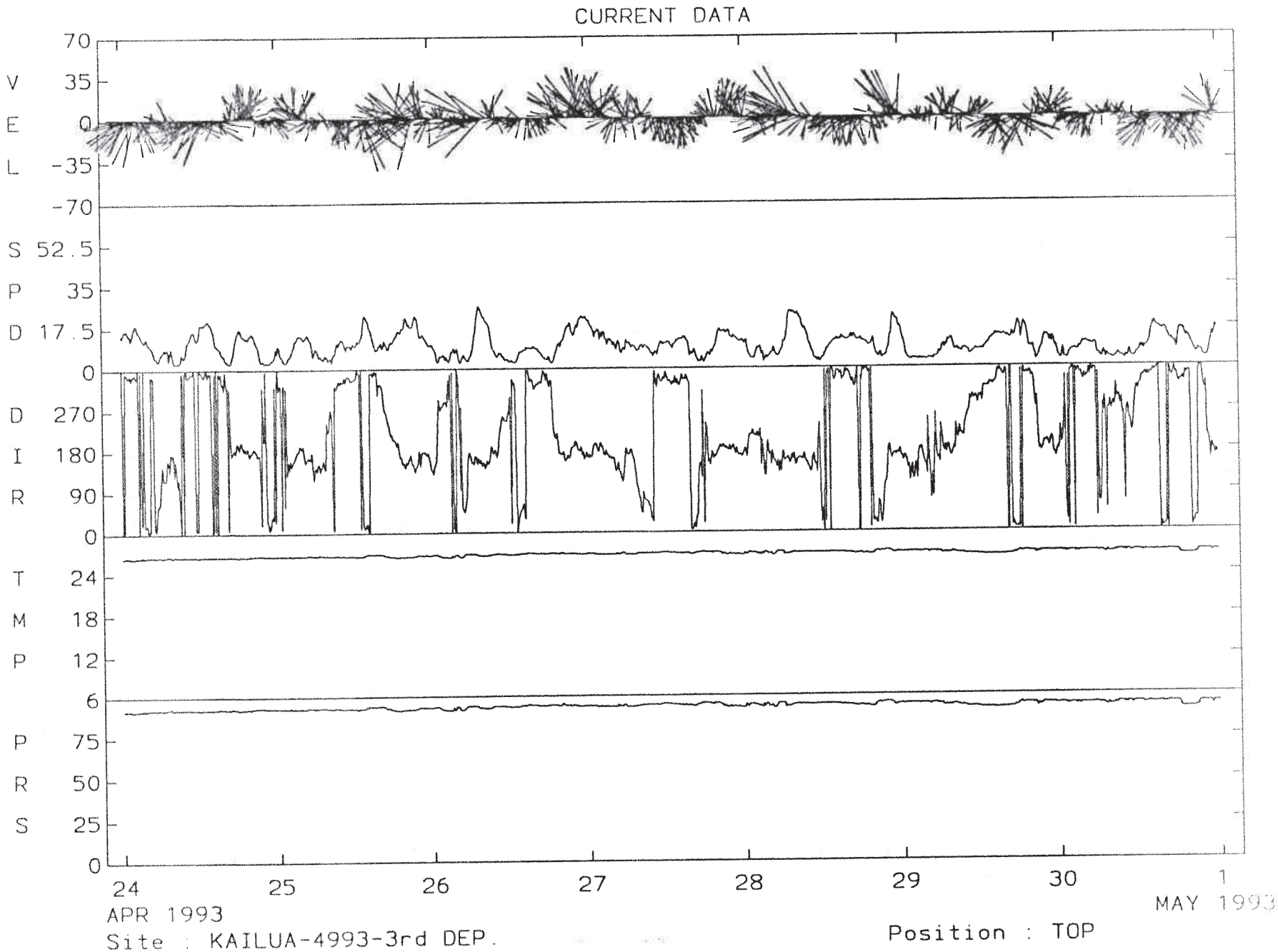
Total number of valid data points : 3517
Maximum Speed : 33.98 cm/s
Minimum Speed : 2.34 cm/s
Mean Speed : 8.53 cm/s
Range : 31.64 cm/s
Standard Deviation : .16 cm/s

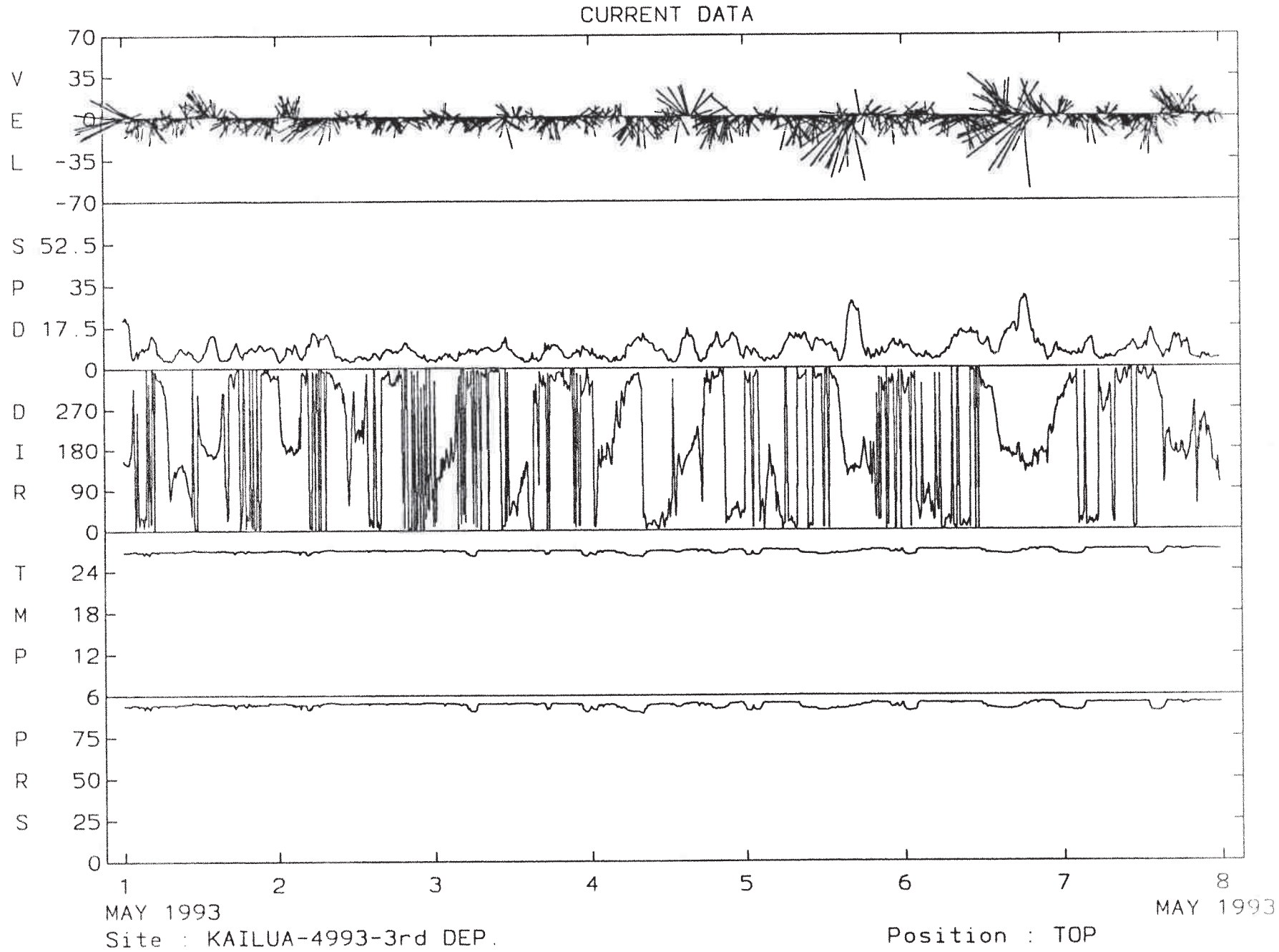
TEMPERATURE [Celcius]	TOTAL OBSERVATIONS	PERCENTAGE
0 - 2	0	.00
2 - 4	0	.00
4 - 6	0	.00
6 - 8	0	.00
8 - 10	0	.00
10 - 12	0	.00
12 - 14	0	.00
14 - 16	0	.00
16 - 18	0	.00
18 - 20	0	.00
20 - 22	0	.00
22 - 24	0	.00
24 - 26	0	.00
26 - 28	3517	100.00
28 - 30	0	.00

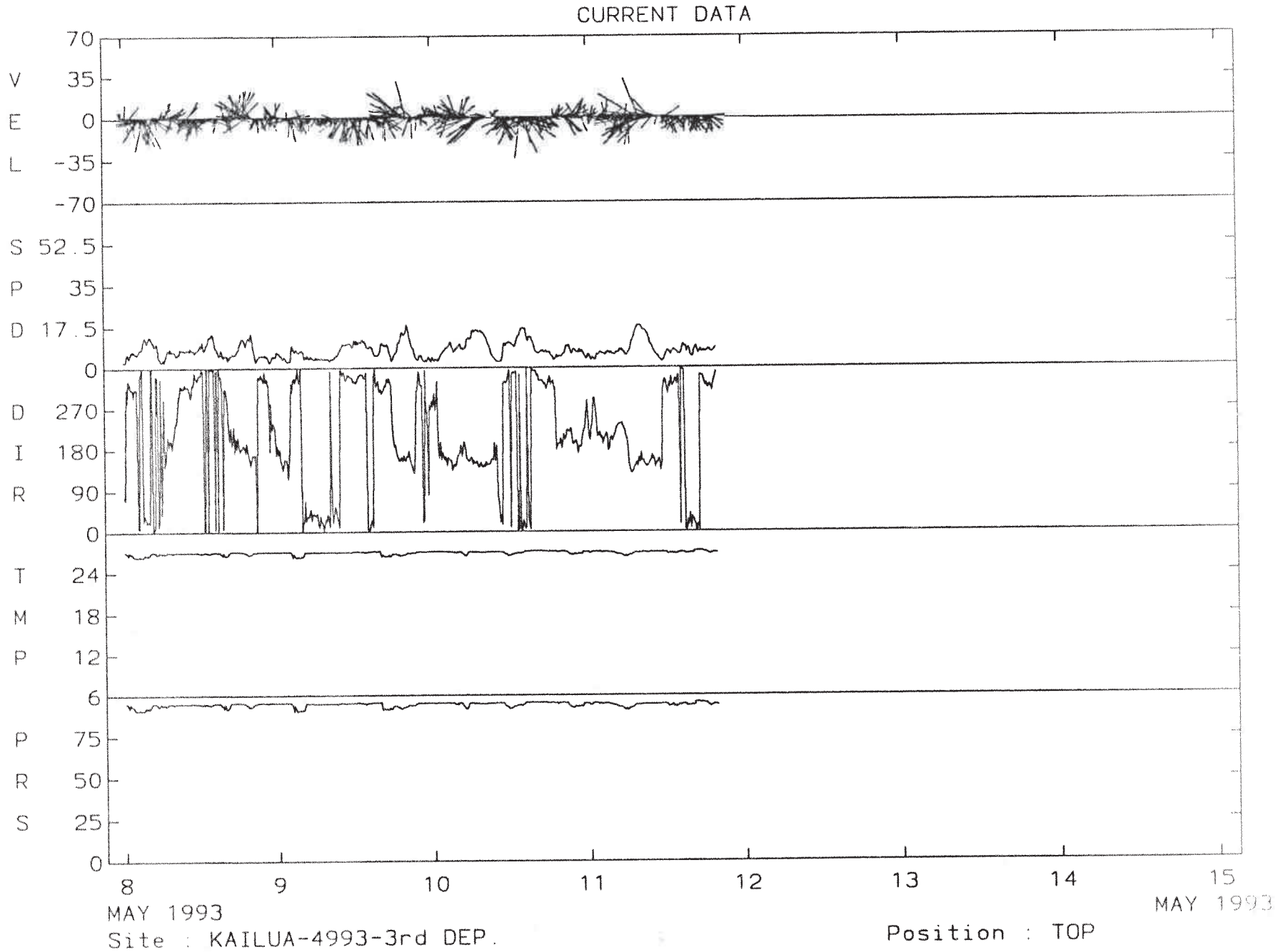
Total number of valid data points : 3517
Maximum Temperature : 27.18 °C
Minimum Temperature : 26.03 °C
Mean Temperature : 26.81 °C
Range : 1.15 °C
Standard Deviation : .45 °C

SPEED [cm/sec]	PERCENTAGE OBSERVATIONS LESS THAN
0 - 5	26.64
5 - 10	69.63
10 - 15	90.73
15 - 20	97.04
20 - 25	99.32
25 - 30	99.91
30 - 35	100.00
35 - 40	100.00
40 - 45	100.00
45 - 50	100.00

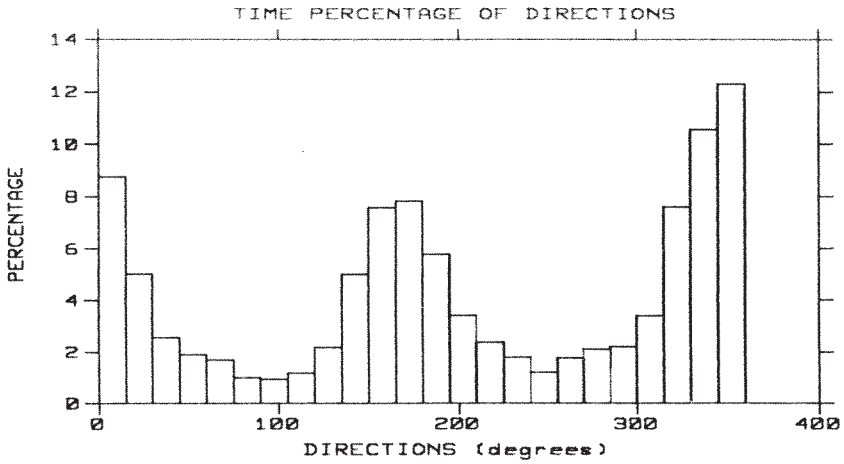

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
17
APR 1993
18
19
20
21
22
23
24
APR 1993
Site : KAILUA-4993-3rd DEP.
Position : TOP

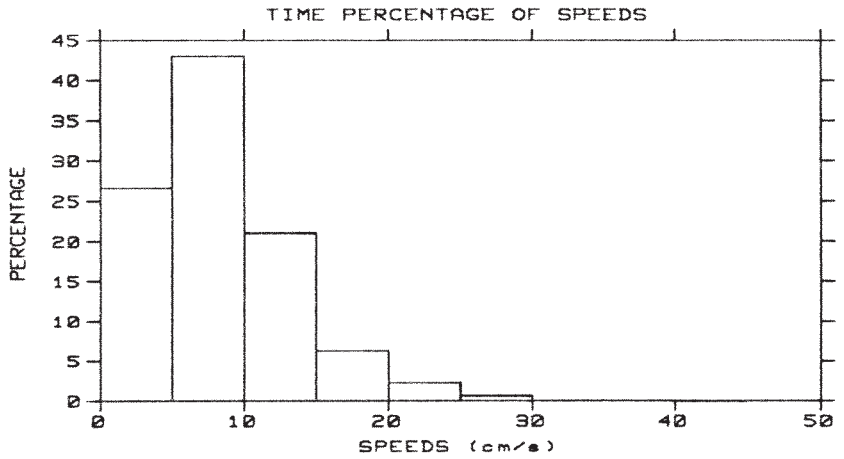

CURRENT DATA
70
V 35
E 0
L -35
-70
S 52.5
P 35
D 17.5
0
D 270
I 180
R 90
0
T 24
M 18
P 12
6
P 75
R 50
S 25
0
24
25
26
27
28
29
30
1
APR 1993
MAY 1993
Site : KAILUA-4993-3rd DEP.
Position : TOP

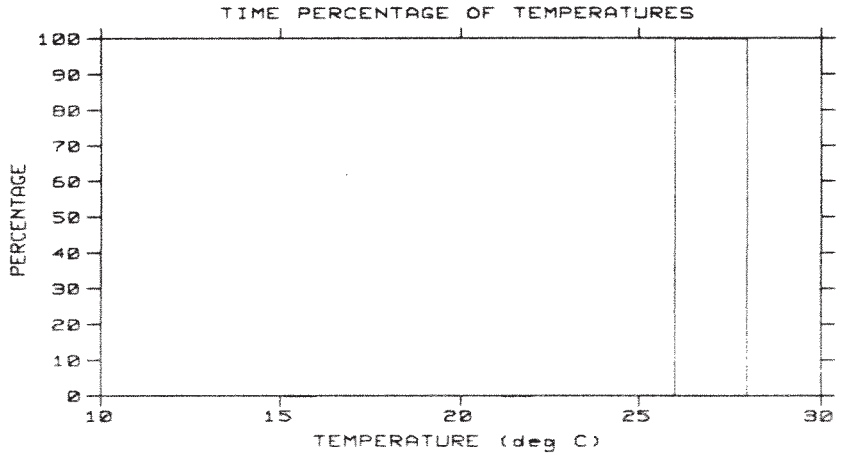

CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
1
2
3
4
5
6
7
8
MAY 1993
MAY 1993
Site : KAILUA-4993-3rd DEP.
Position : TOP


CURRENT DATA
VEL
70
35
0
-35
-70
SPD
52.5
35
17.5
0
DIR
270
180
90
0
TMP
24
18
12
6
PRS
75
50
25
0
8
9
10
11
12
13
14
15
MAY 1993
MAY 1993
Site : KAILUA-4993-3rd DEP.
Position : TOP

KAILUA-4993-3rd DEP.

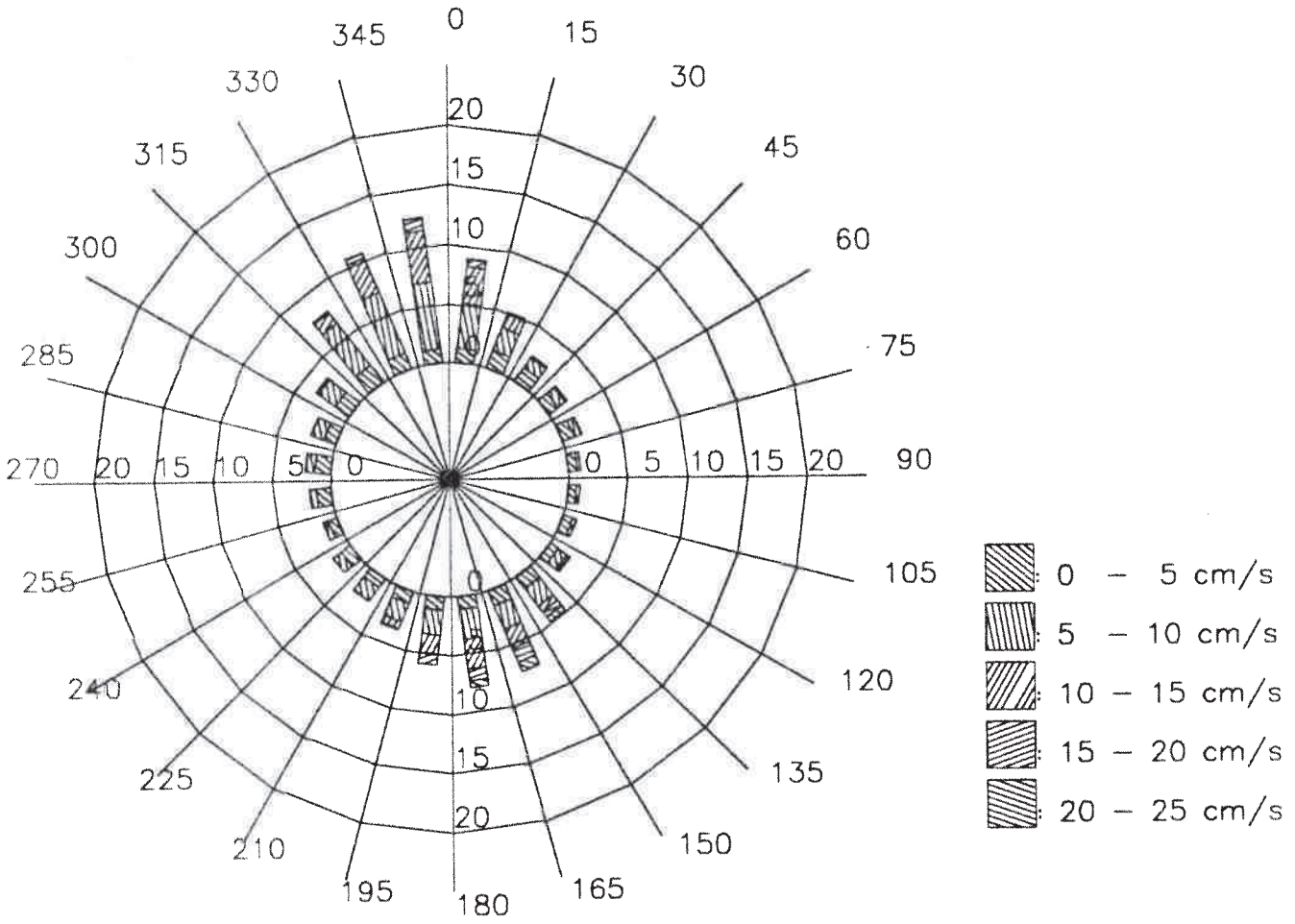


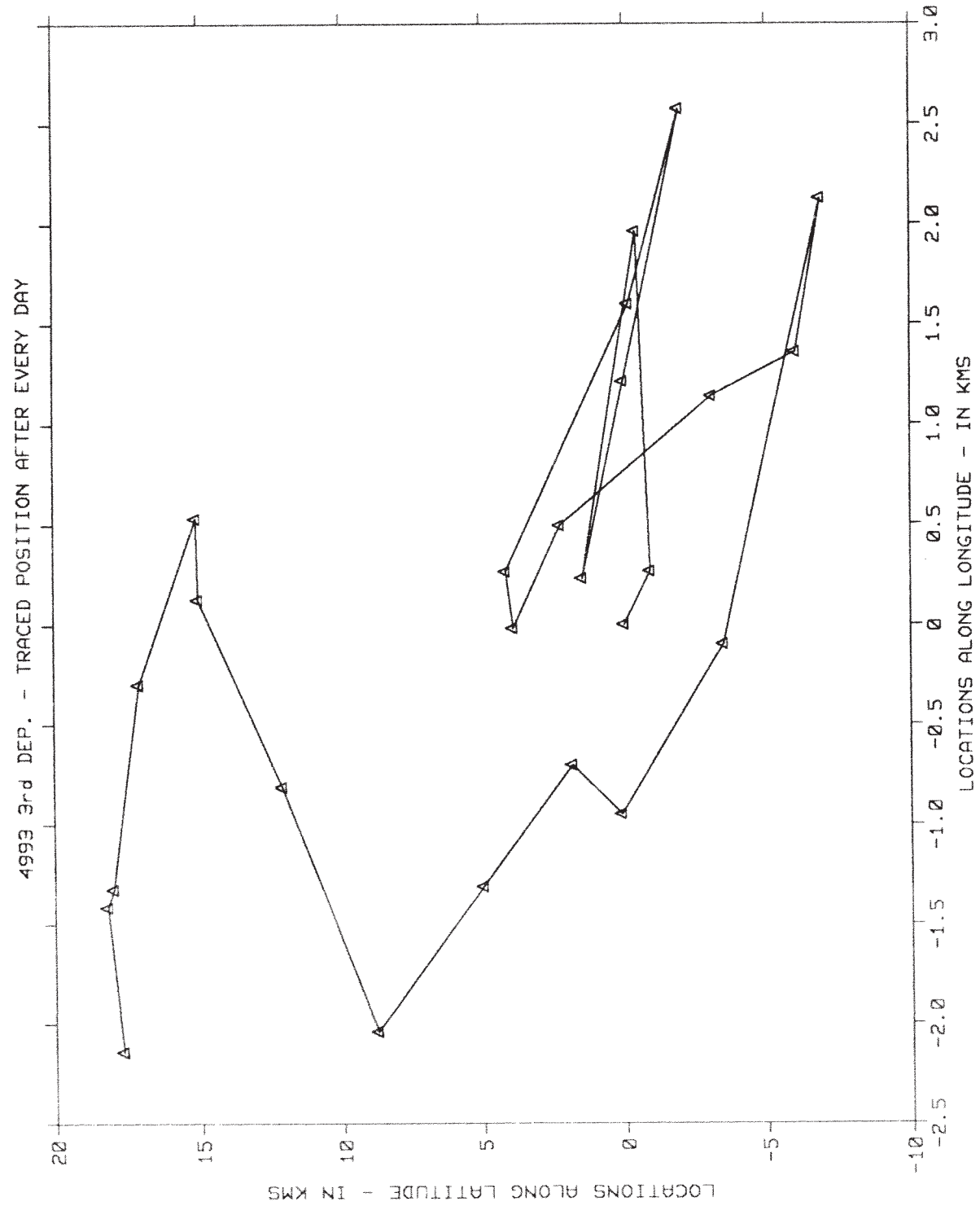




Percentage of currents

KAILUA–4993–3rd DEP.




4993 3rd DEP. - TRACED POSITION AFTER EVERY DAY
LOCATIONS ALONG LONGITUDE - IN KMS
LOCATIONS ALONG LATITUDE - IN KMS
20
15
10
5
0
-5
-10
-2.5
-2.0
-1.5
-1.0
-0.5
0
0.5
1.0
1.5
2.0
2.5
3.0

APPENDIX D

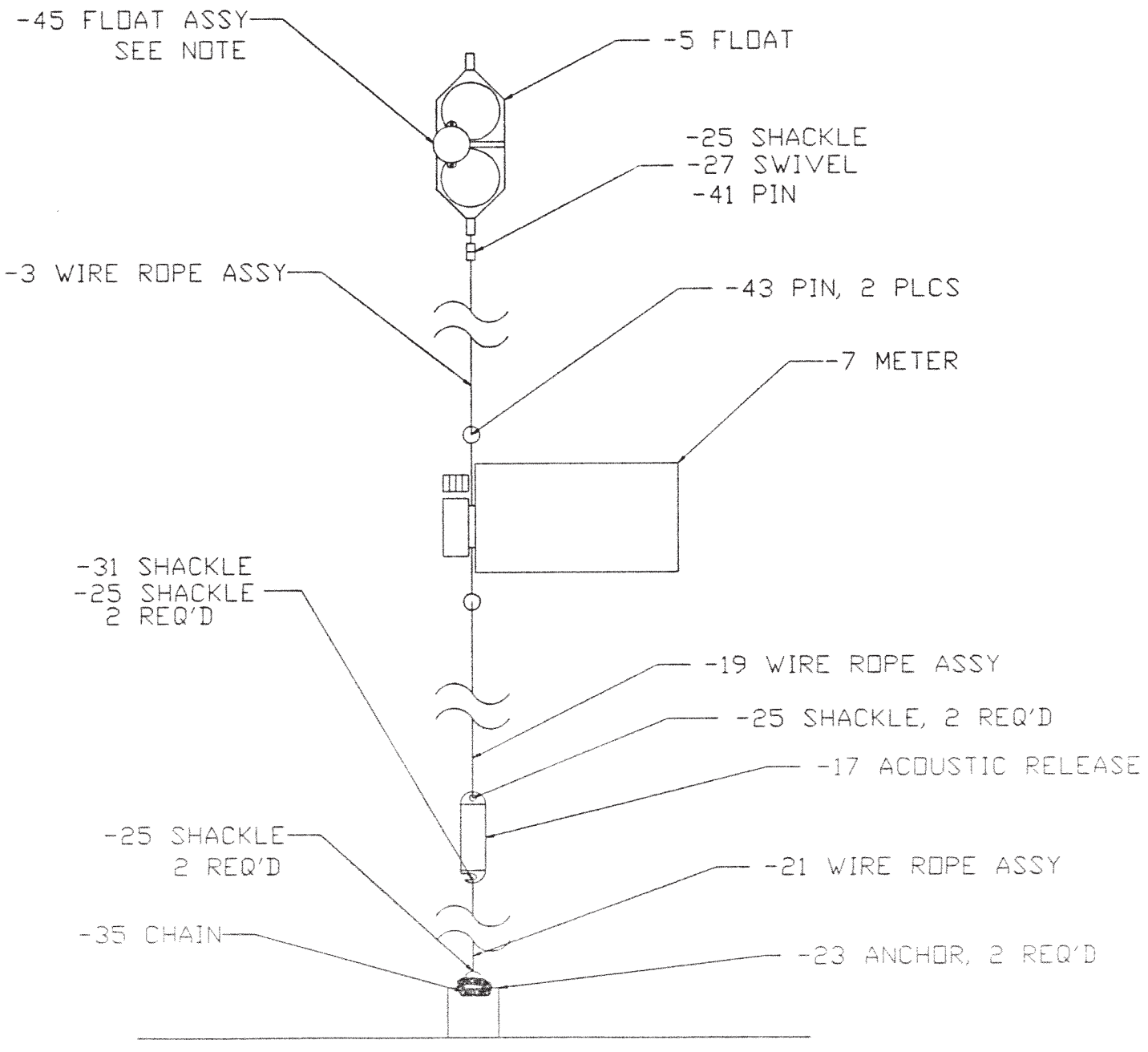
Current Meter String Designs and Specifications

String Designs and Lengths . . . . . D-1 through D-9

Design Details . . . . . D-10 through D-13

Parts List . . . . . D-14 through D-16

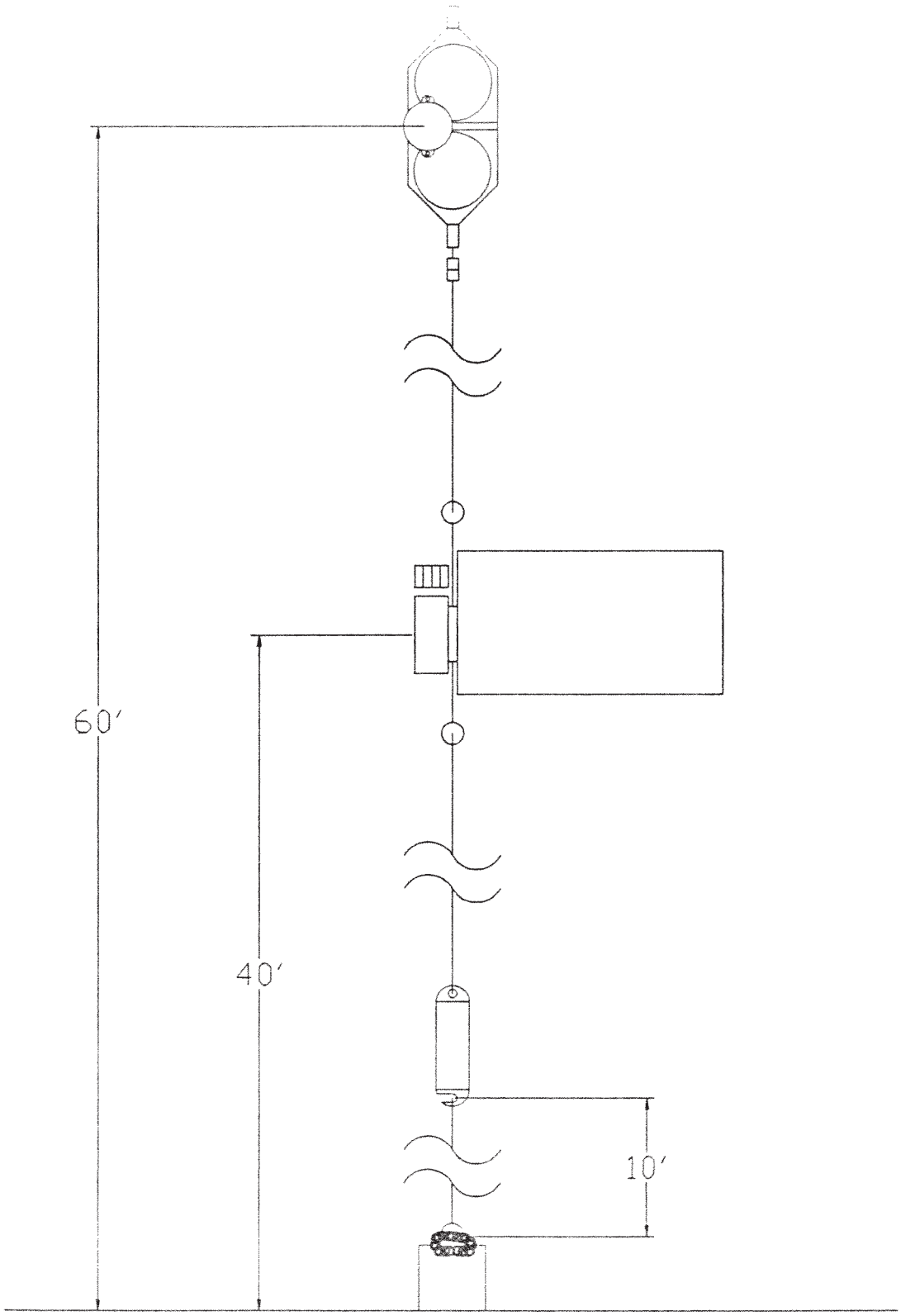
NOTE: ATTACH -45 TO -5 WITH
TWO (2) SHACKLES, BOTH ENDS



-1 METER STRING

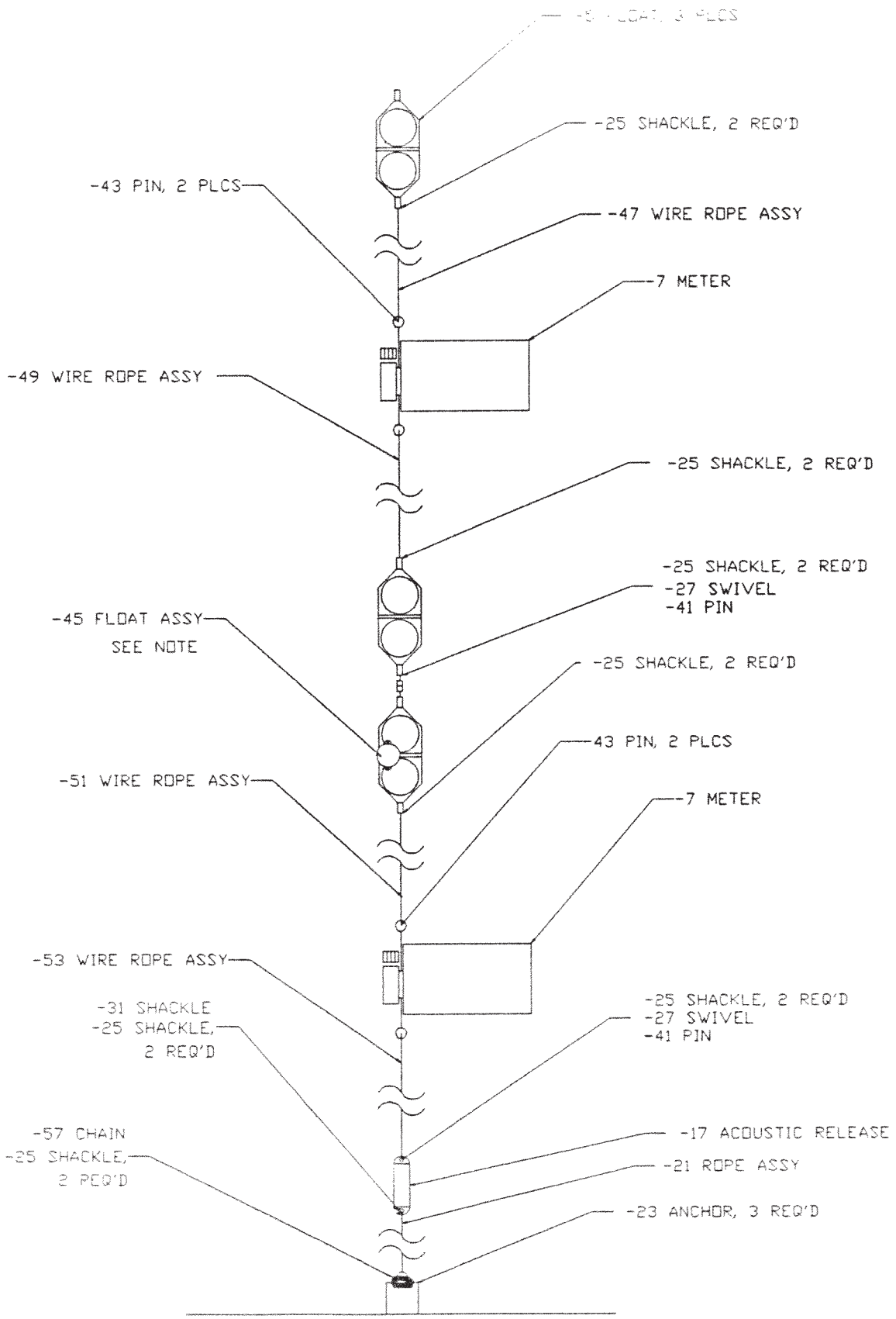
SCALE: NONE

REV. (-)



-1 DEPTH

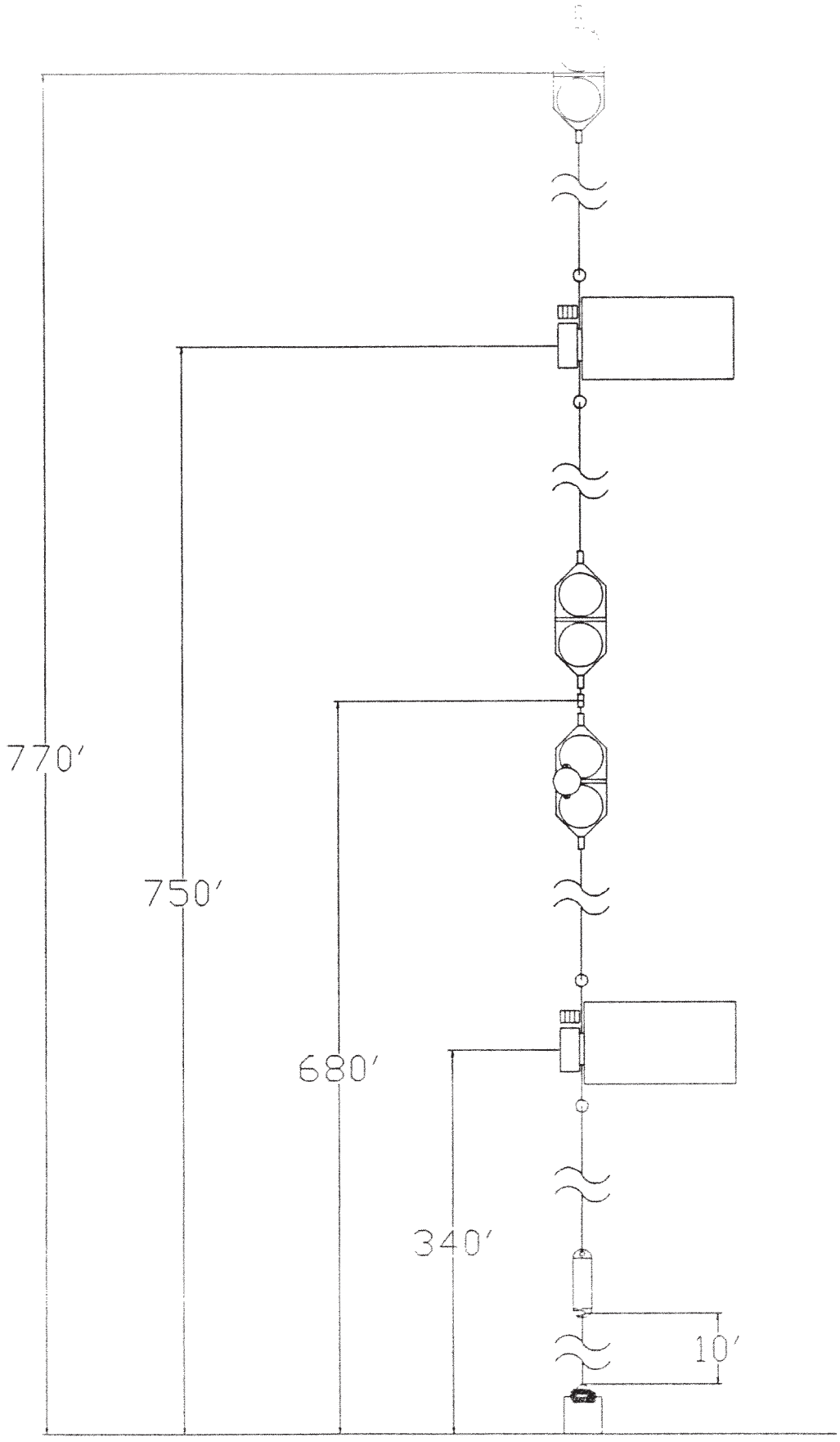
SCALE: NONE



-501 METER STRING

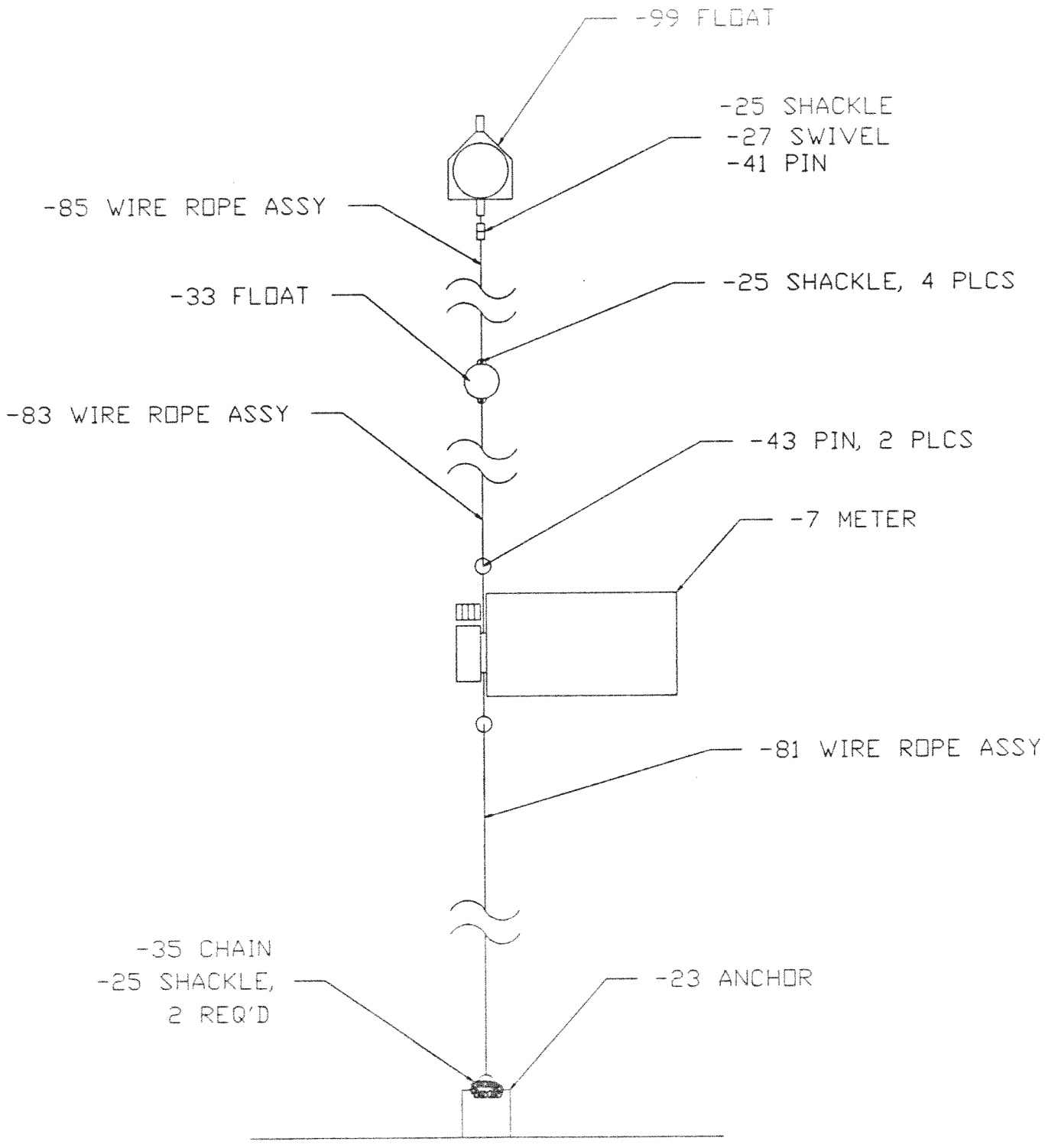
SCALE: NONE

REV (-)



-501 DEPTH

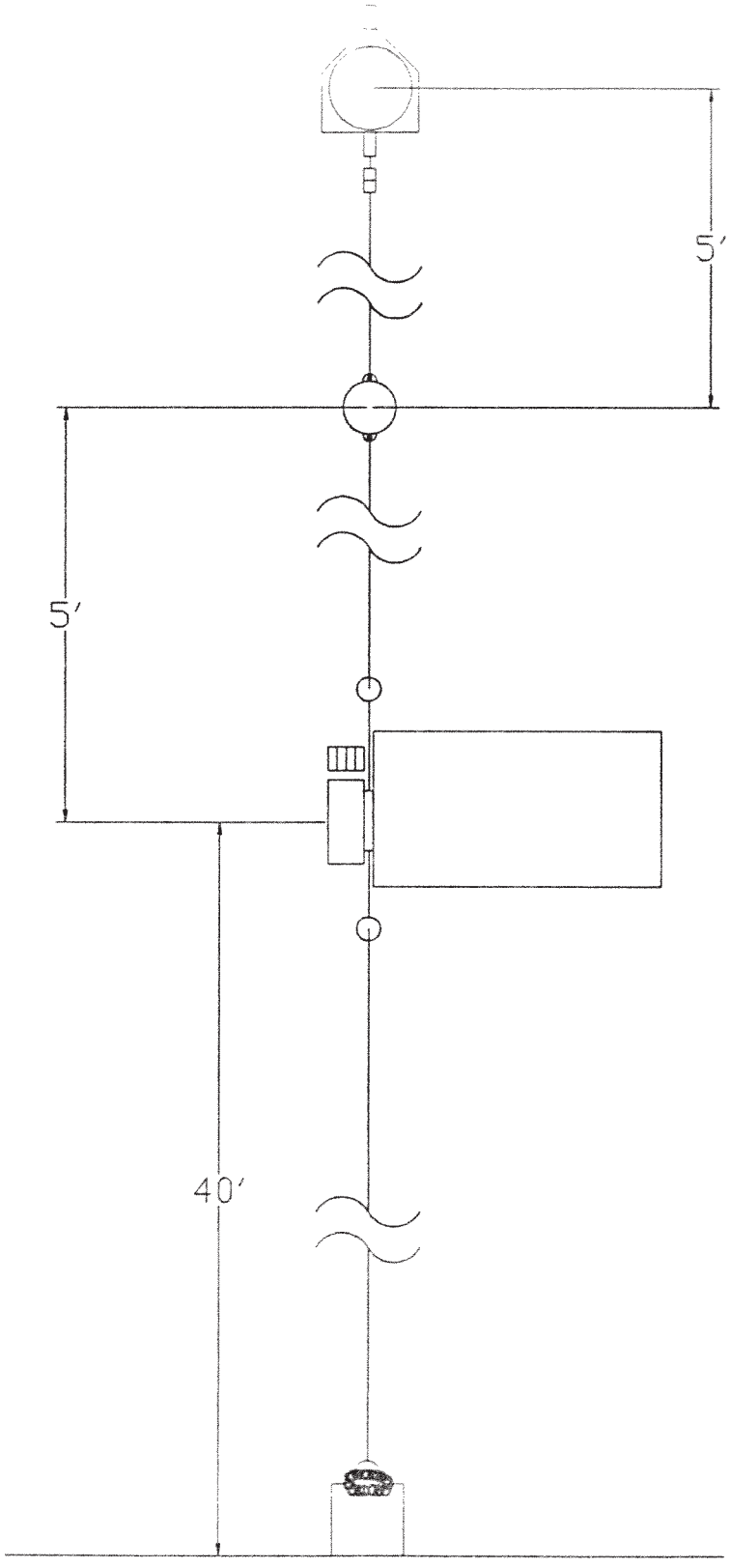
SCALE NONE



-503 METER STRING

SCALE: NONE

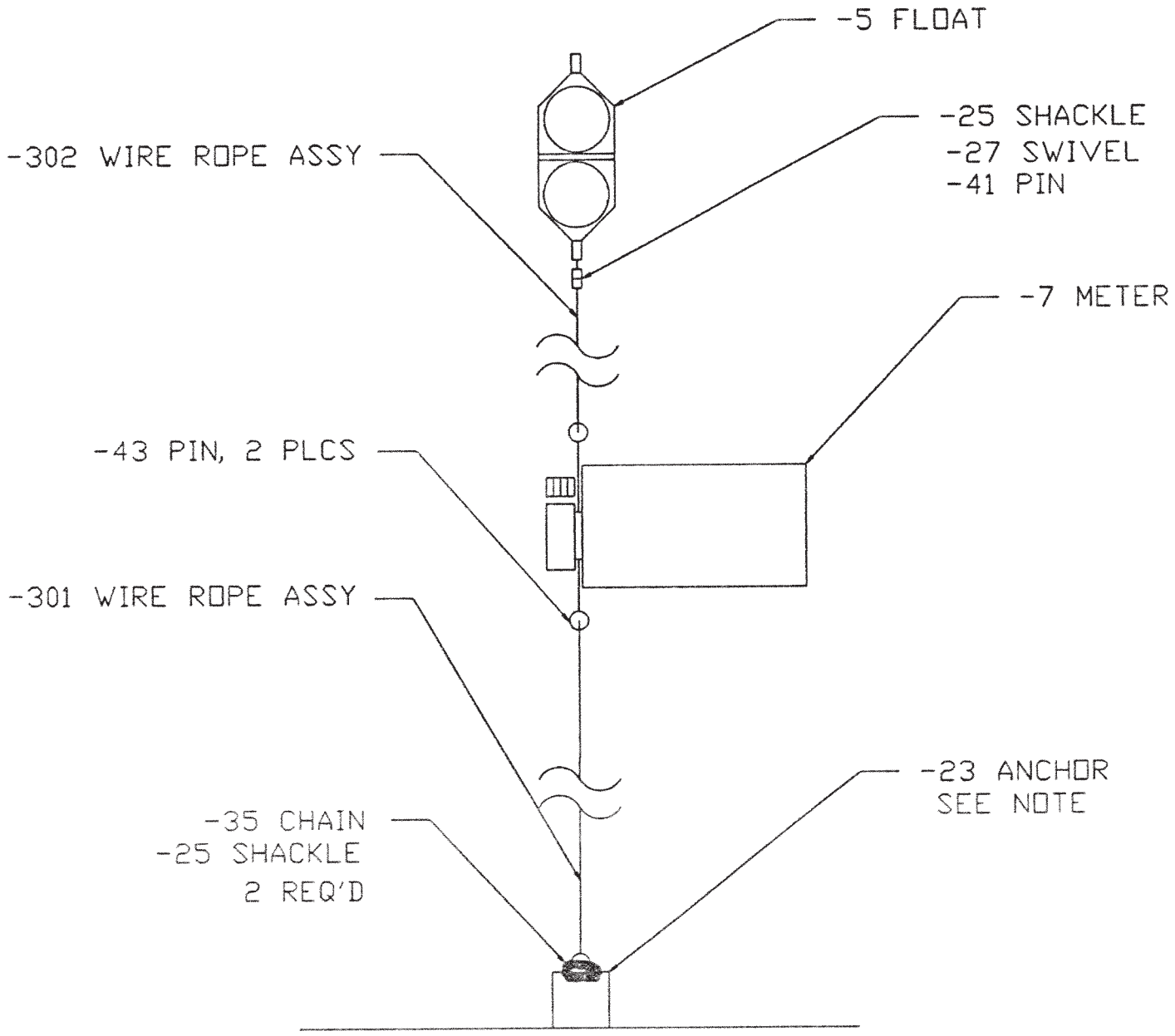
REV (-)



-503 DEPTH

SCALE: NONE

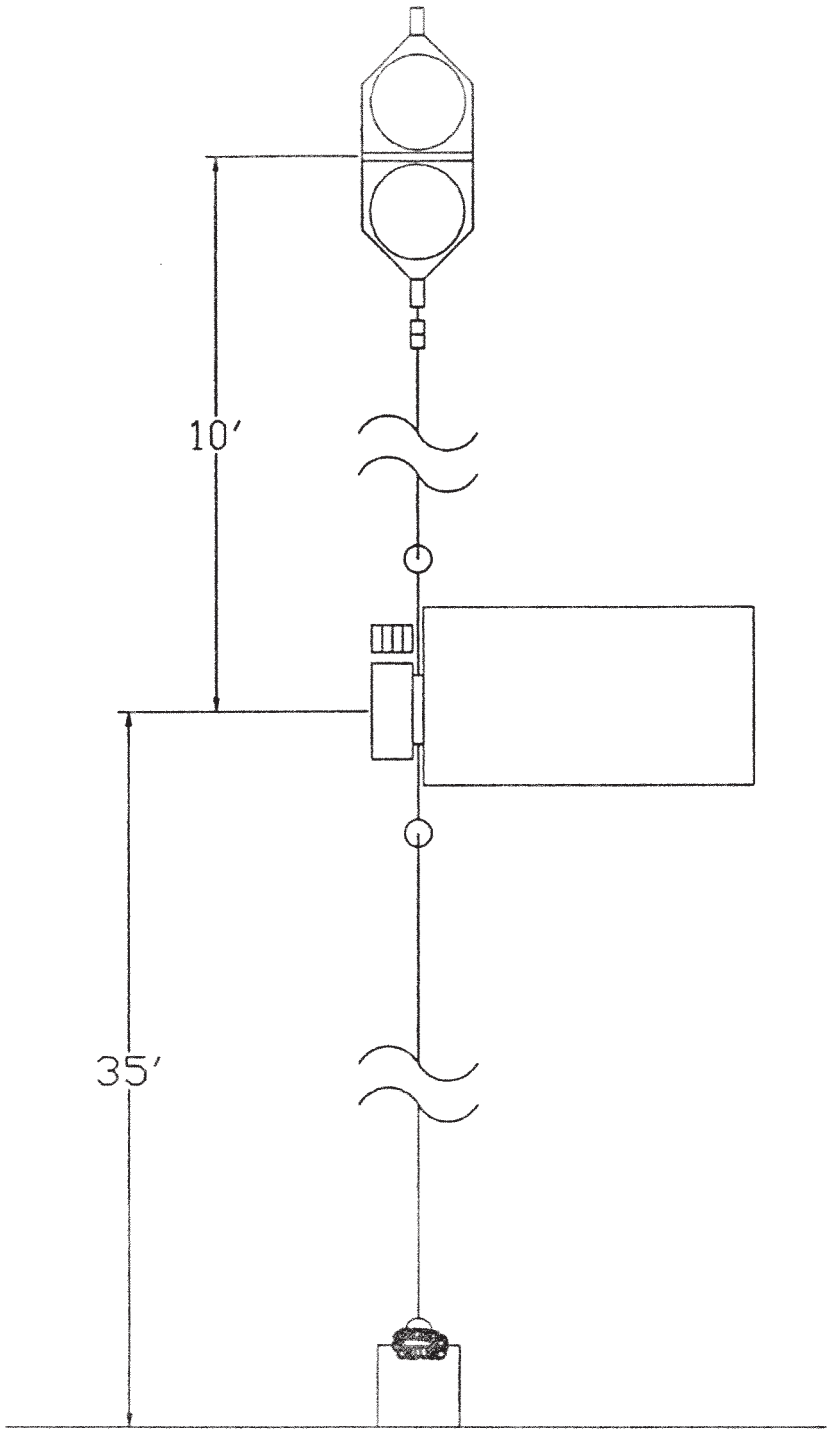
NOTE: ANCHOR TO BOTTOM
AS REQUIRED



-505 METER STRING

SCALE: NONE

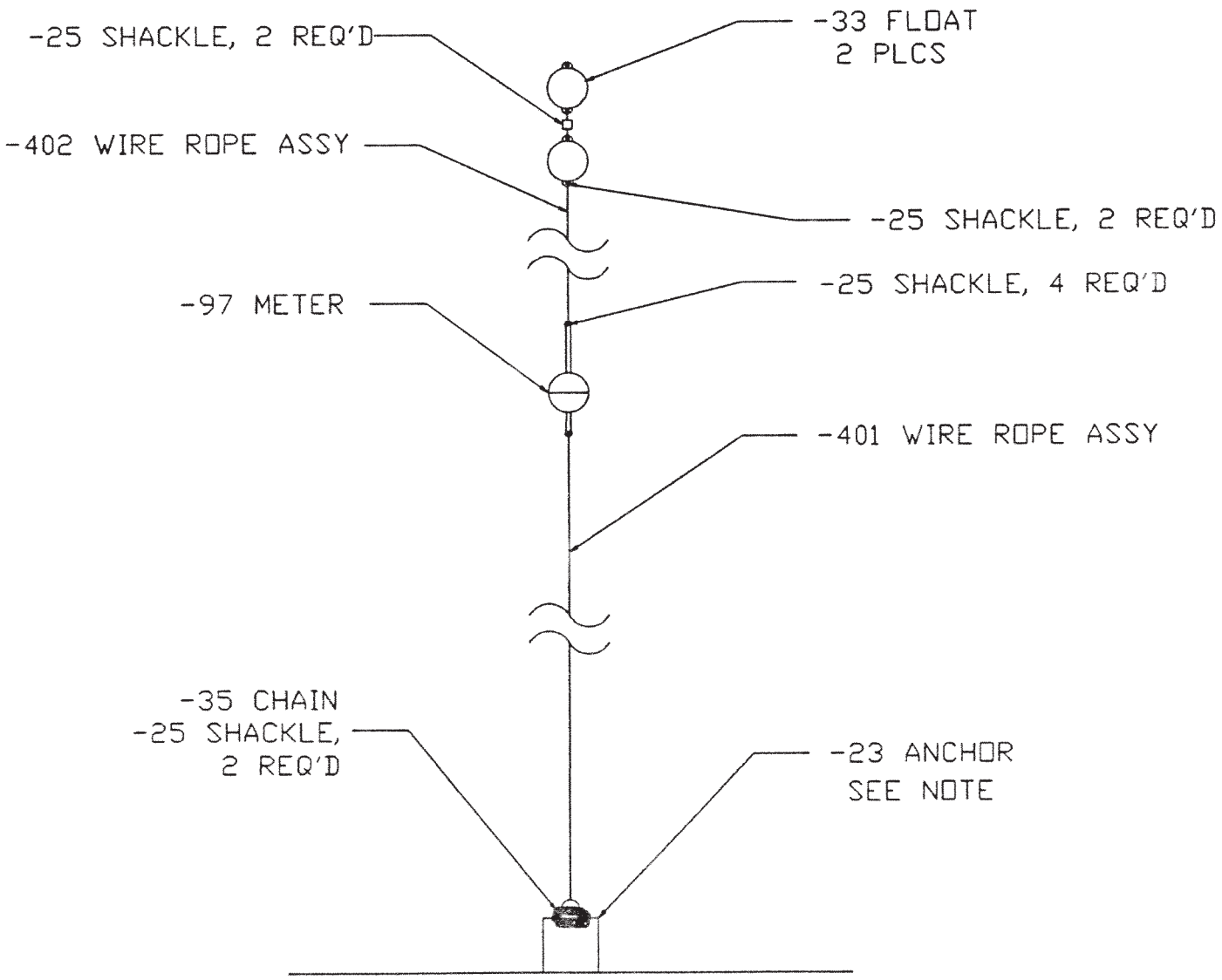
REV (-)



-505 DEPTH

SCALE: NONE

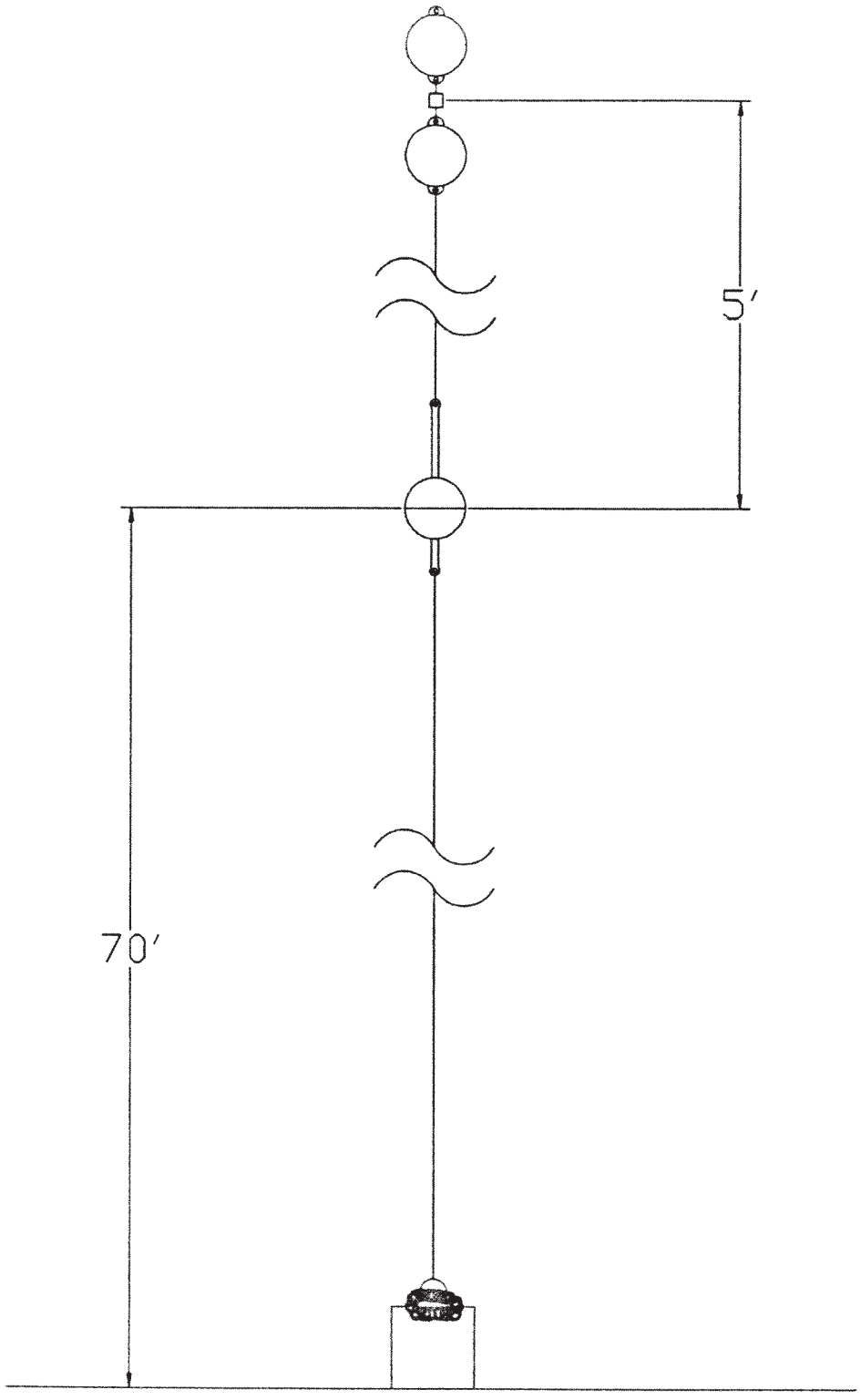
NOTE: ANCHOR TO BOTTOM
AS REQUIRED



-507 METER STRING

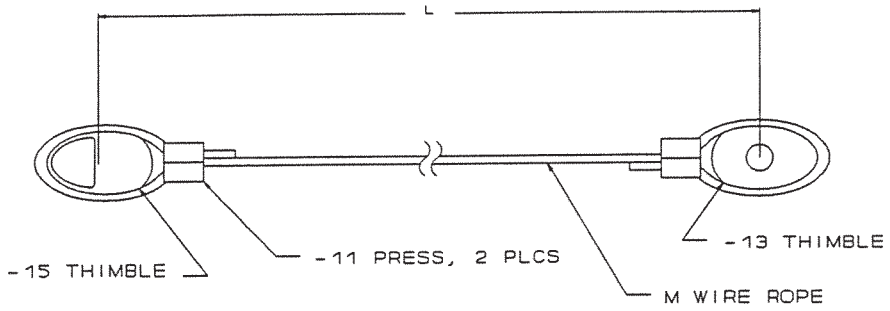
SCALE: NONE

REV (-)



-507 DEPTH

SCALE: NONE

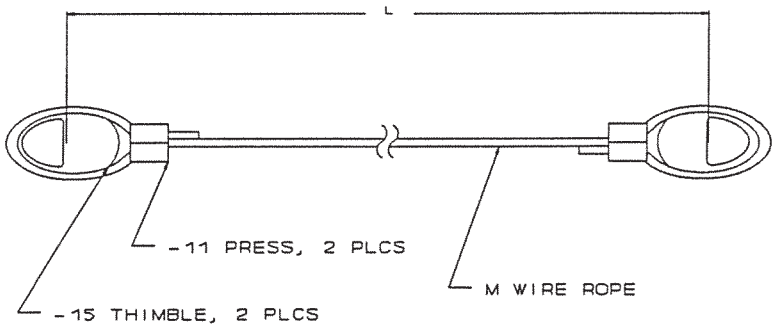


DETAIL WIRE ROPE ASSY

SCALE: NONE

REV (-)

Detail Number	Length [L]	M Wire Rope
-3 Wire Rope Assy	15′ - 6½"	-9 Wire Rope
-19 Wire Rope Assy	25′ - 8"	-37 Wire Rope
-47 Wire Rope Assy	16′ - 2½"	-55 Wire Rope
-49 Wire Rope Assy	63′ - 9½"	-29 Wire Rope
-51 Wire Rope Assy	333′ - 4½"	-59 Wire Rope
-81 Wire Rope Assy	38′ - 6"	-82 Wire Rope
-83 Wire Rope Assy	3′ - 8"	-84 Wire Rope
-301 Wire Rope Assy	32′ - 7"	-201 Wire Rope
-302 Wire Rope Assy	7′ - 4"	-202 Wire Rope
-53 Wire Rope Assy	325′ - 11"	-61 Wire Rope

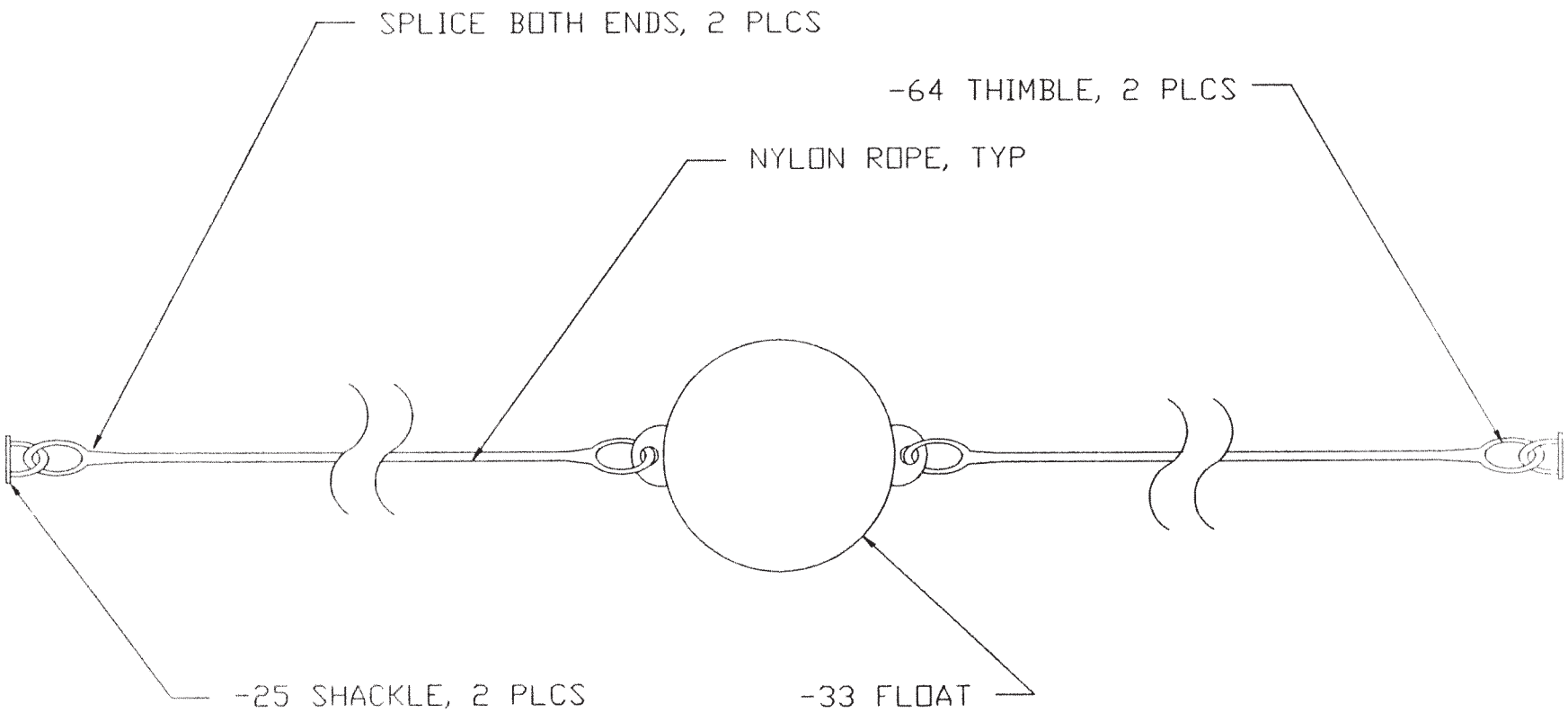


DETAIL WIRE ROPE ASSY

SCALE: NONE

REV (-)

Detail Number	Length [L]	M Wire Rope
-21 Wire Rope Assy	9' - 2"	-39 Wire Rope
-85 Wire Rope Assy	3' - 5"	-86 Wire Rope
-402 Wire Rope Assy	3' - 8"	-204 Wire Rope
-401 Wire Rope Assy	68' - 4"	-203 Wire Rope



-45 FLOAT ASSY

SCALE: NONE

REV (-)

CONFIGURATION							PART NUMBER	SIZE	DESCRIPTION	MATERIAL	WEIGHT
	-507	-505	-45	-503	-501	-1					(*H20)
						1	-3		WIRE ROPE ASSY		
		1			3	1	-5		FLOAT		-100# *
		1		1	2	1	-7		METER, AANDERAA RCM 4/5		38.15# *
					1	1	-17		ACOUSTIC RELEASE		55# *
						1	-19		WIRE ROPE ASSY		
					1	1	-21		WIRE ROPE ASSY		
	1	1		1	3	2	-23	1'X 1'X 1'	ANCHOR	CONCRETE	95# *
	10	3	2	7	14	7	-25	1/2"	SHACKLE - STRAIGHT	GALVANIZED	.72#
		1		1	2	1	-27	1/2"	SWIVEL, PIN	GALVANIZED	1.2#
					1	1	-31		SHACKLE, SACRIFICIAL	CRES	
	1	1		1		1	-35	1/2"-32 1/2"	PROOF COIL CHAIN, 21 LINKS	G-30 ISO, HOT GALV	7.5 #
		1		1	2	1	-41	1/8"-1 1/2"	PIN, COTTER	CRES	
		2		2	4	2	-43	5/16"-1 3/4"	PIN, COTTER, AANDERAA PN: 66044	CRES	
					1	1	-45		FLOAT ASSY		
					1		-47		WIRE ROPE ASSY		
					1		-49		WIRE ROPE ASSY		
					1		-51		WIRE ROPE ASSY		
					1		-53		WIRE ROPE ASSY		
					1		-57	1/2"-4'	PROOF COIL CHAIN	G-30 ISO, HOT GALV	
	2		1	1			-33	360mm, DIA	PLASTIC FLOAT - SPHERICAL		-44# *
			2				-63	1/2"-4'	NYLON ROPE		
			2				-64	1/2"	THIMBLE	GALVANIZED	
	1						-97		METER, INTER-OCEAN, MODEL S4		

CONFIGURATION							PART	SIZE	DESCRIPTION	MATERIAL	WEIGHT
	-507	-49	-47	-21	-19	-3	NUMBER				(*H20)
						1	-9	1/4"X16'-10 1/	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
		2	2	2	2	2	-11		NICO PRESS, WIRE CLAMP		0.072#
		1	1		1	1	-13		THIMBLE - AANDERAA #935021		
		1	1	2	1	1	-15	5/16"	THIMBLE	NYLON	
					1		-37	1/4"X27'-1/8"	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
				1			-39	1/4"X10'-6"	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
			1				-55	1/4"X17'-7 5/8	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
		1					-29	1/4"X65'-1 1/2	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
	1						-401				
	1						-402				
			-505	-503	-53	-51	*******	**********	**********	**********	*********
					2	2	-11		NICO PRESS, WIRE CLAMP		0.072#
					1	1	-13		THIMBLE - AANDERAA #935021		
					1	1	-15	5/16"	THIMBLE	NYLON	
						1	-59	1/4"X334'-8 1/	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
					1		-61	1/4"X327'-3 1/	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
				1			-99		910601-1 FLOAT ASSEMBLY		-50# *
				1			-81		WIRE ROPE ASSEMBLY		4.4#
				1			-83		WIRE ROPE ASSEMBLY		0.6#
				1			-85		WIRE ROPE ASSEMBLY		0.55#
			1				-302		WIRE ROPE ASSEMBLY		
			1				-301		WIRE ROPE ASSEMBLY		

CONFIGURATION							PART	SIZE	DESCRIPTION	MATERIAL	WEIGHT
-402	-401	-302	-301	-85	-83	-81	NUMBER				(*H20)
		2	2	2	2	2	-11		NICO PRESS, WIRE CLAMP		0.072#
		1	1		1	1	-13		THIMBLE - AANDERAA #935021		
2	2	1	1	2	1	1	-15	5/16"	THIMBLE	NYLON	
						1	-82	1/4" X 38'-6"	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
					1		-84	1/4" X 3'- 8"	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
				1			-86	1/4" X 3'- 5"	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
			1				-201	1/4" X 33'- 8"	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
		1					-202	1/4" X 8'- 5"	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
	1						-203	1/4" X 69'- 5"	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *
1							-204	1/4" X 4'- 9"	WIRE ROPE, 6 X 19 ORDINARY	GALVANIZED	.11#/FT *

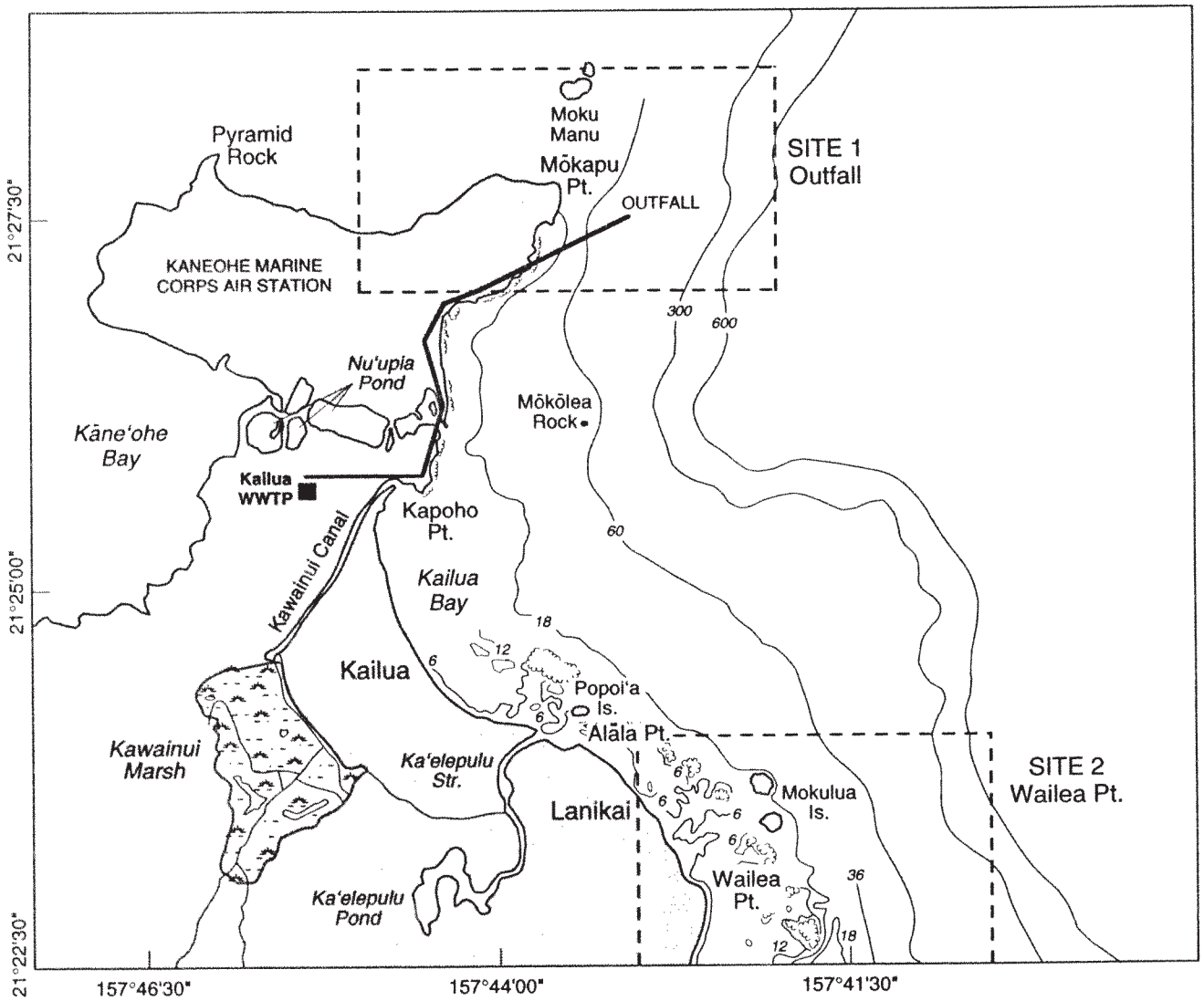
APPENDIX E
Drogue, Dye, and Depth Measurements

Map of Offshore Drogue and Dye Measurements Areas E-1

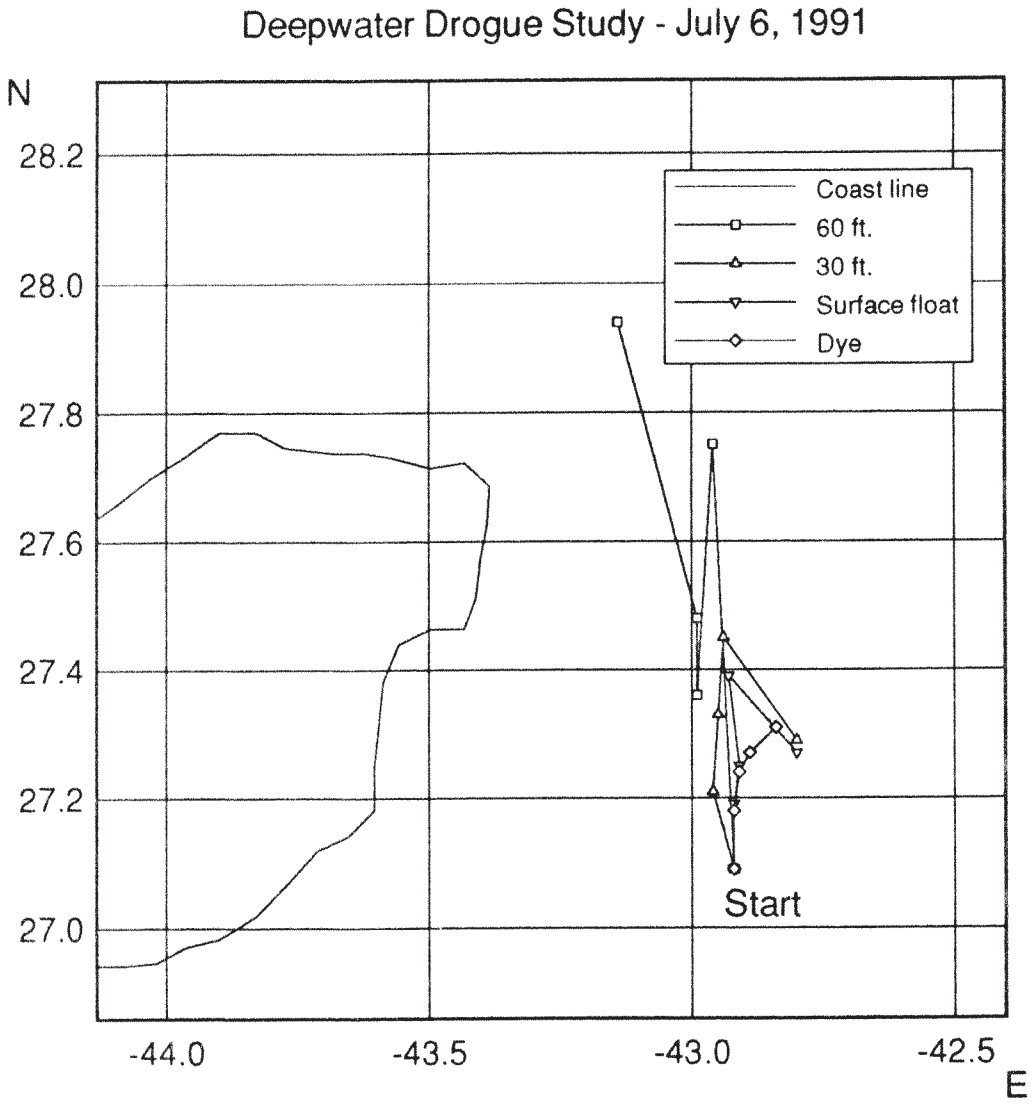
Offshore Drogue and Dye Tracks . . . . . E-2 through E-5

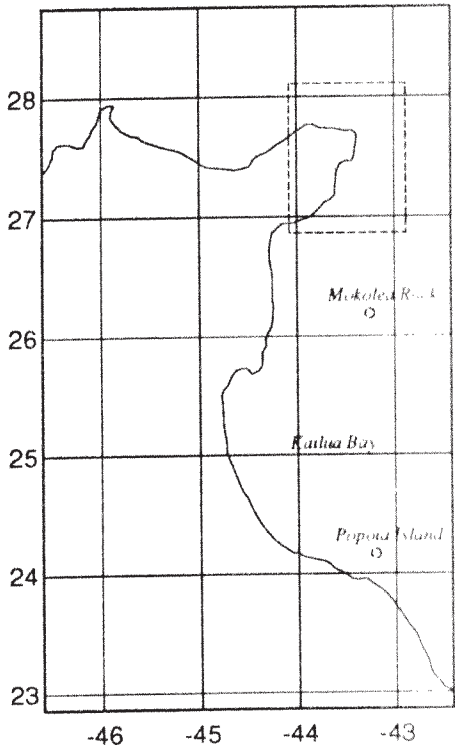
Nearshore Drogue and Dye Tracks . . . . . E-6 through E-11

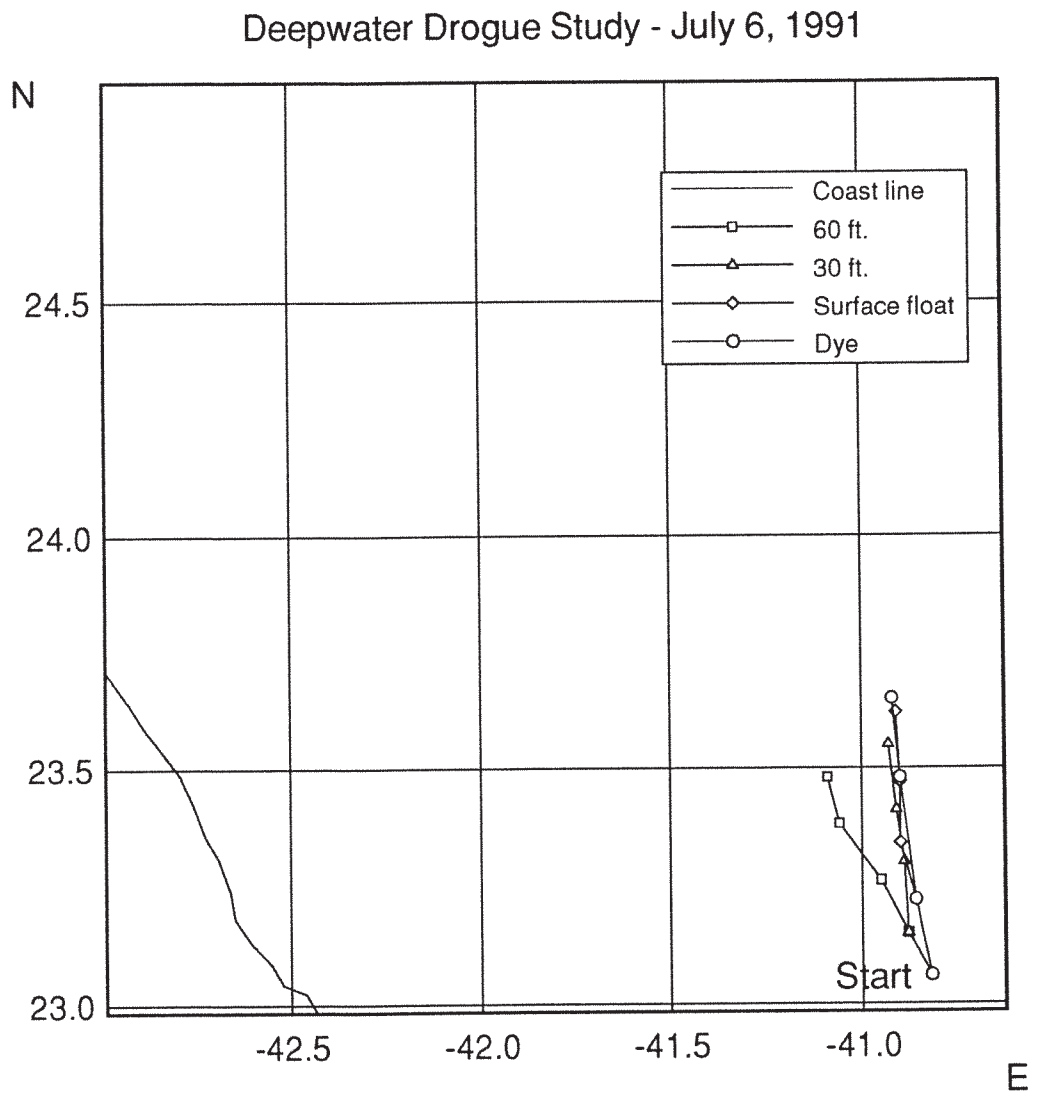
Drogue, Dye, and Depth Data Tables . . . . . E-12 through E-22

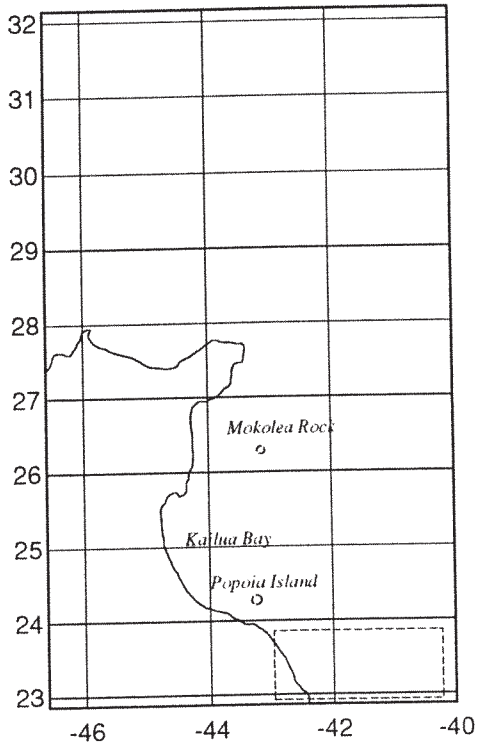


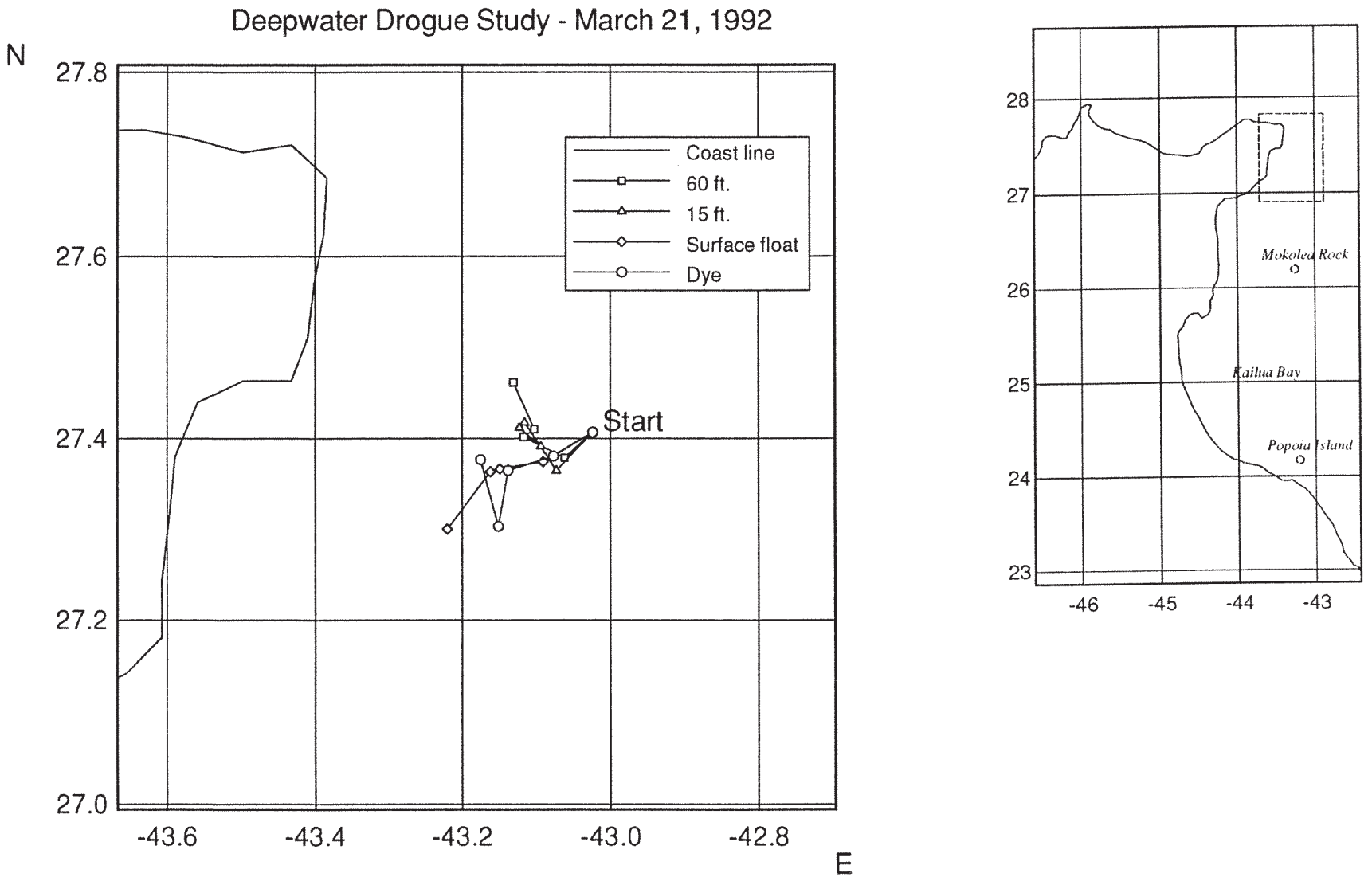
SOURCE: USGS base map, 1:24 000 scale.
NOTE: Bathymetry in ft.

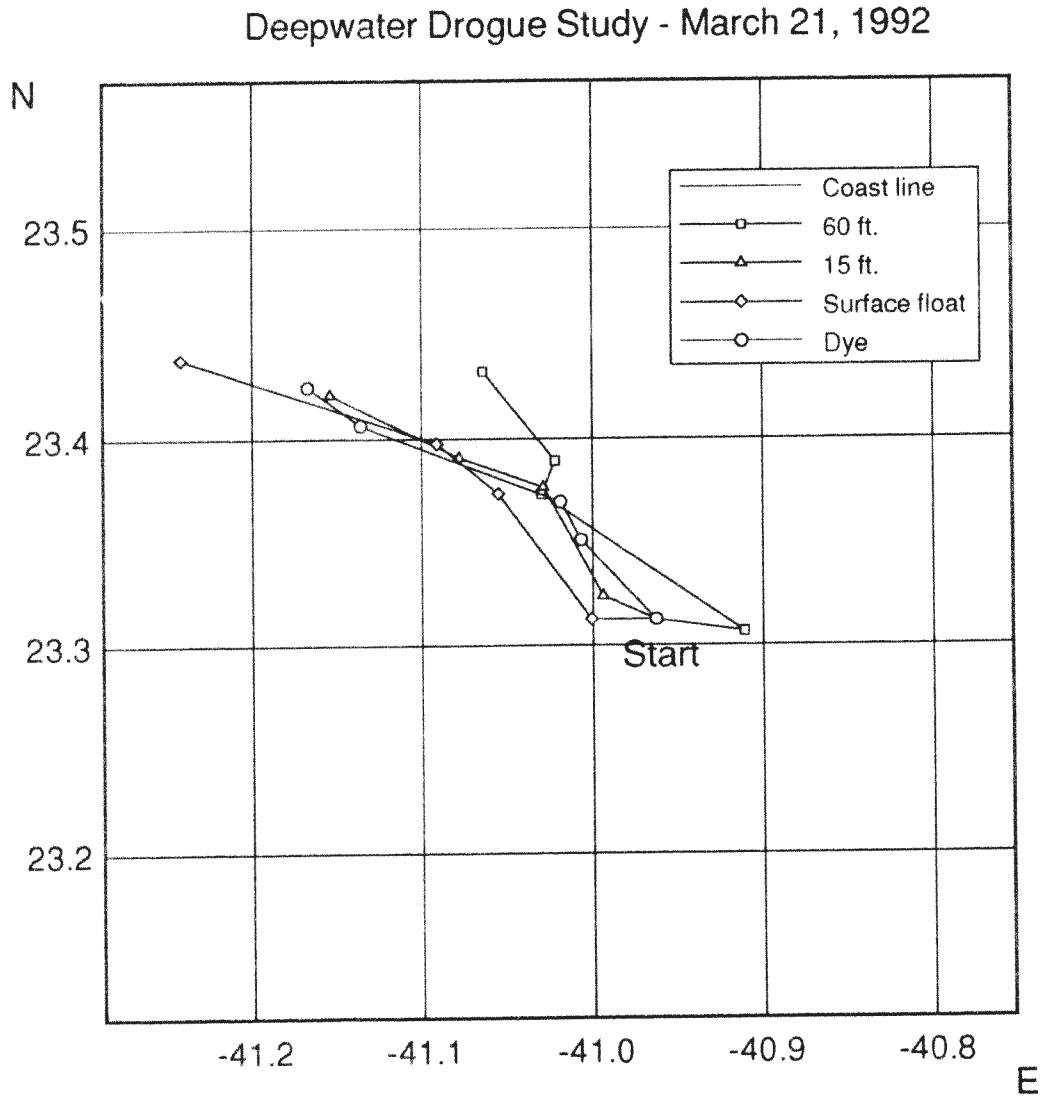

Deepwater Drogue Study - July 6, 1991
N
28.2
28.0
27.8
27.6
27.4
27.2
27.0
-44.0
-43.5
-43.0
-42.5
E
Coast line
60 ft.
30 ft.
Surface float
Dye
Start

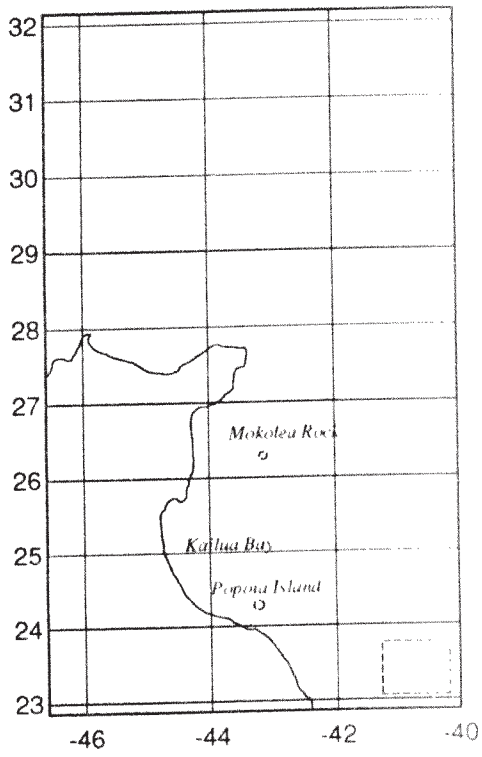

28
27
26
25
24
23
-46
-45
-44
-43
Kaihua Bay


Deepwater Drogue Study - July 6, 1991
N
24.5
24.0
23.5
23.0
-42.5
-42.0
-41.5
-41.0
E
Coast line
60 ft.
30 ft.
Surface float
Dye
Start

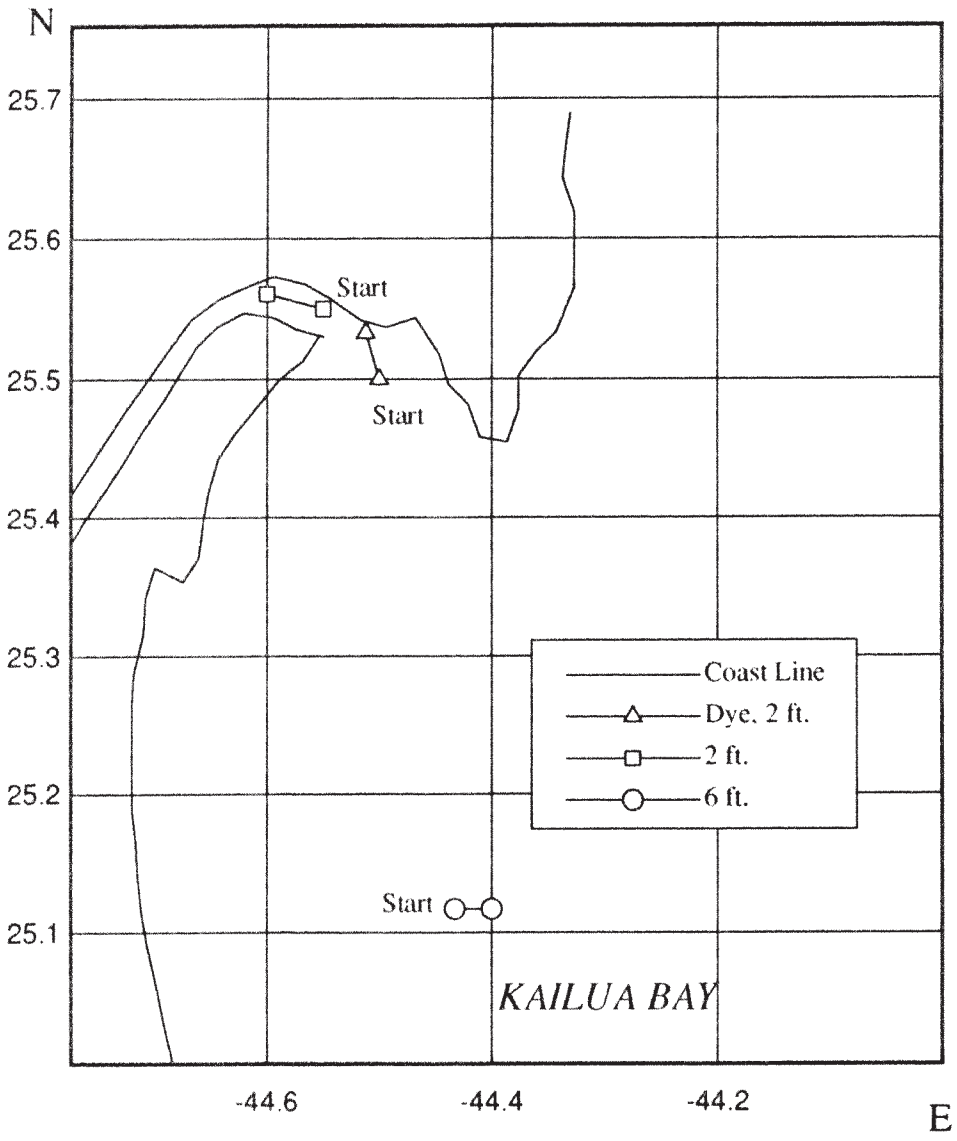

32
31
30
29
28
27
26
25
24
23
-46
-44
-42
-40
Mokolea Rock
Kailua Bay
Popoia Island

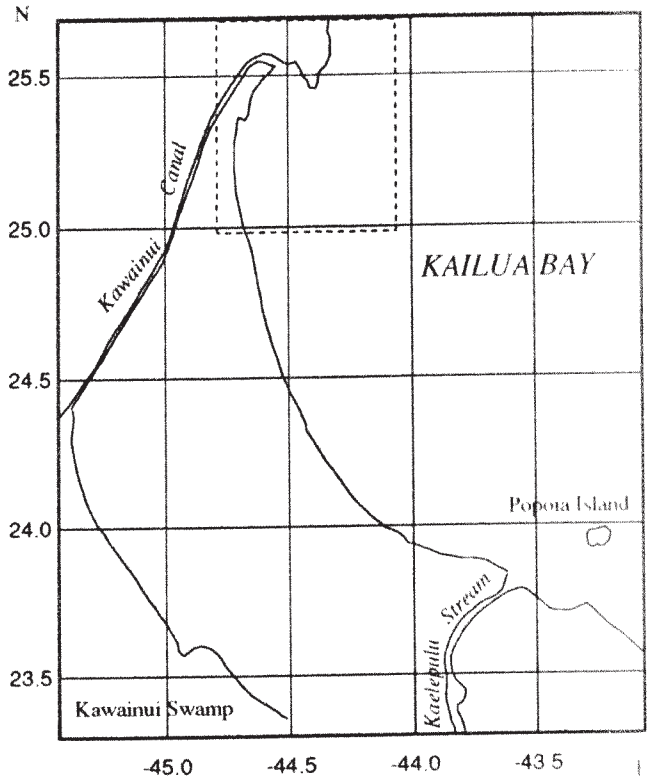

Deepwater Drogue Study - March 21, 1992
N
27.8
27.6
27.4
27.2
27.0
-43.6
-43.4
-43.2
-43.0
-42.8
E
Coast line
60 ft.
15 ft.
Surface float
Dye
Start
28
27
26
25
24
23
-46
-45
-44
-43
Mokoleo Rock
Kailua Bay
Popoia Island

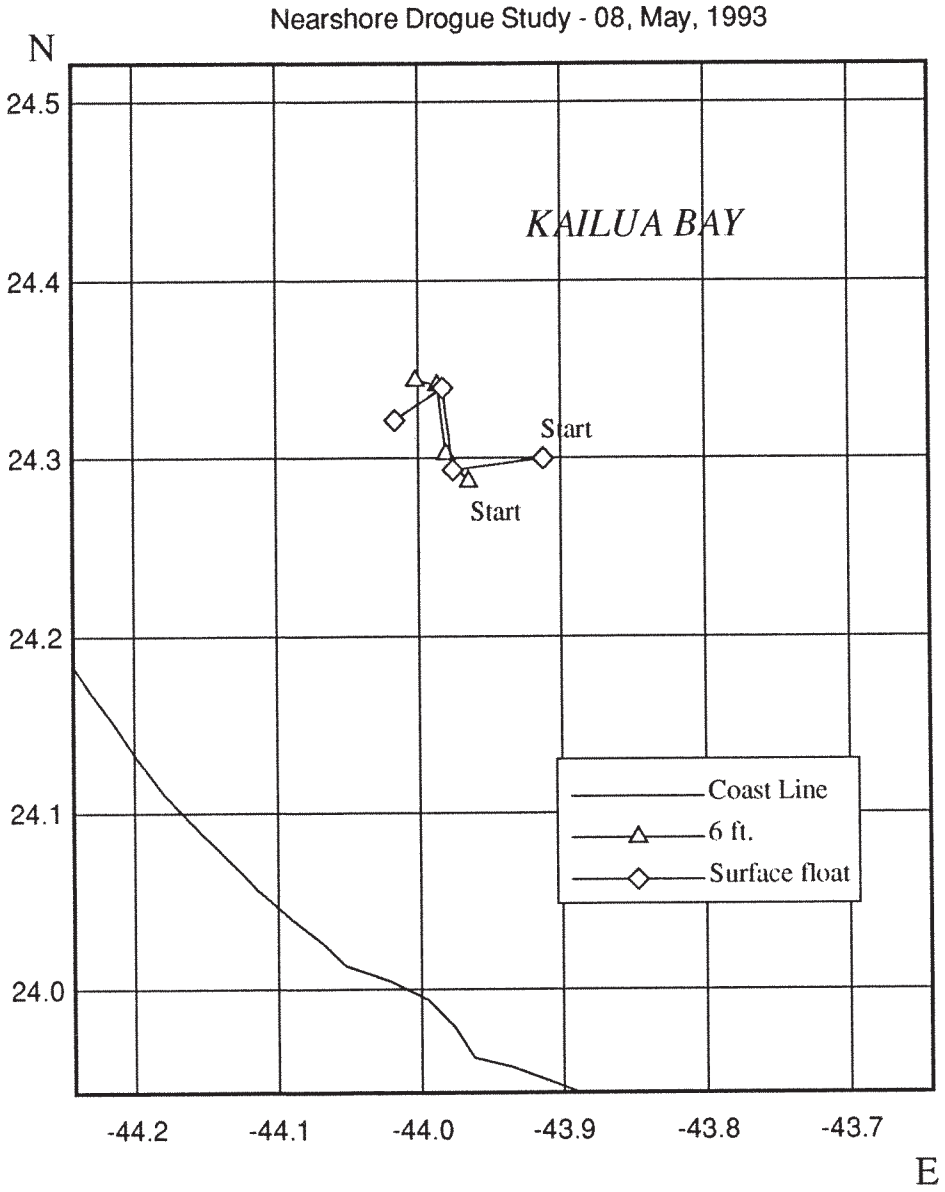

Deepwater Drogue Study - March 21, 1992
N
23.5
23.4
23.3
23.2
-41.2
-41.1
-41.0
-40.9
-40.8
E
Coast line
60 ft.
15 ft.
Surface float
Dye
Start

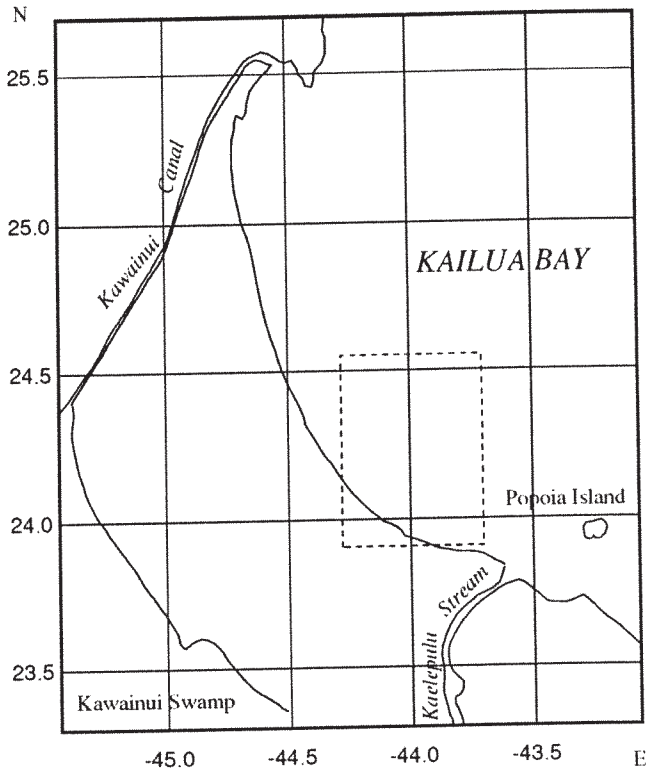

32
31
30
29
28
27
26
25
24
23
-46
-44
-42
-40
Mokolea Rock
Kailua Bay
Popoia Island

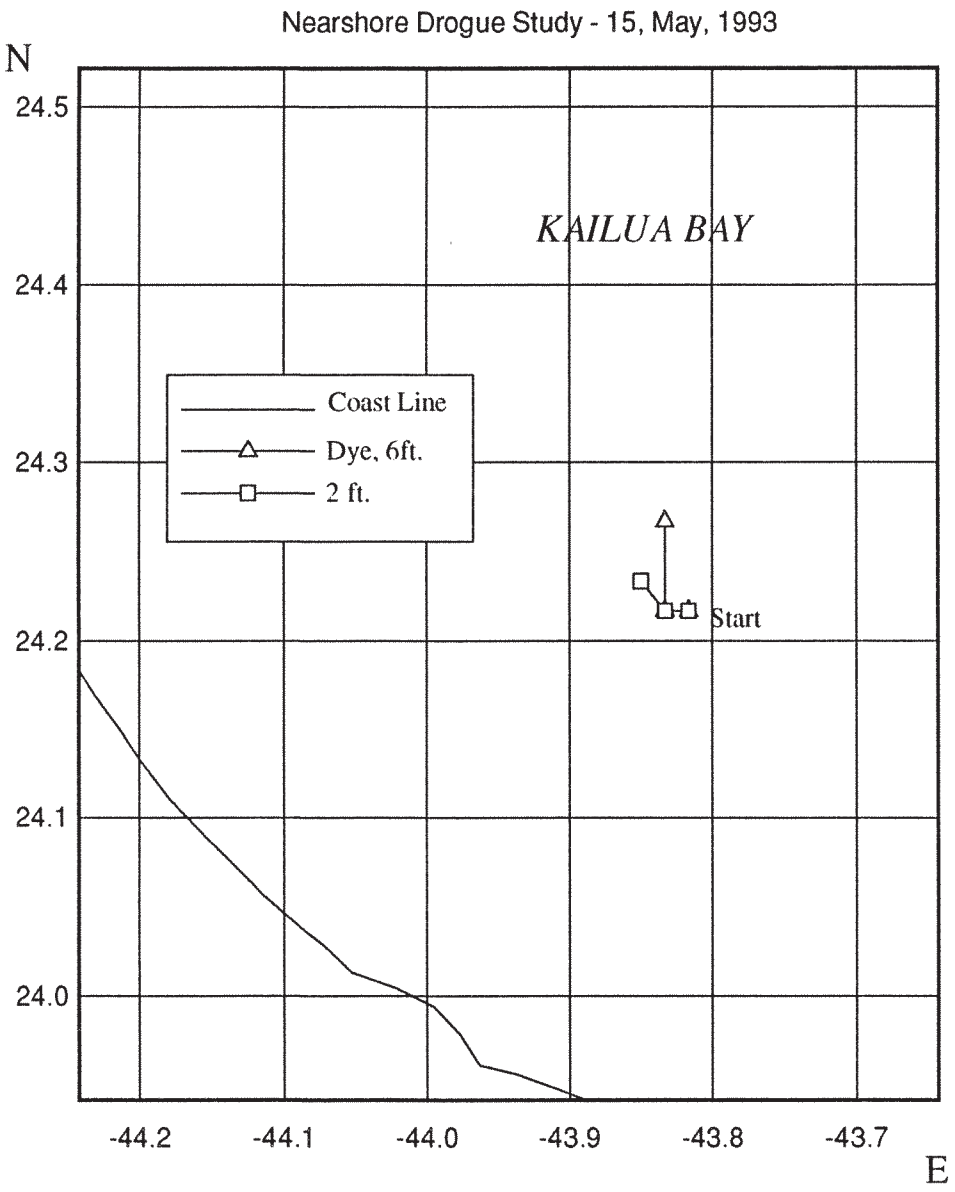
Nearshore Drogue Study - 24, APRIL, 1993

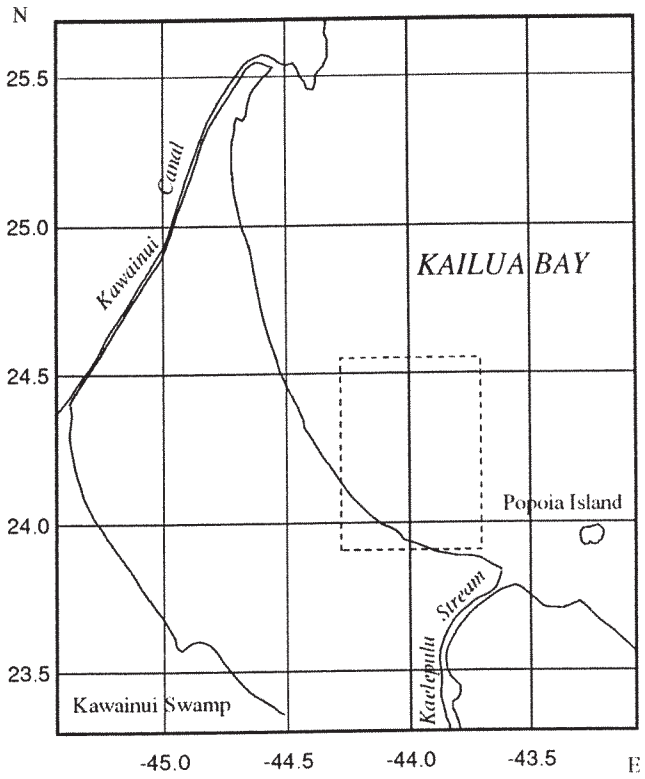




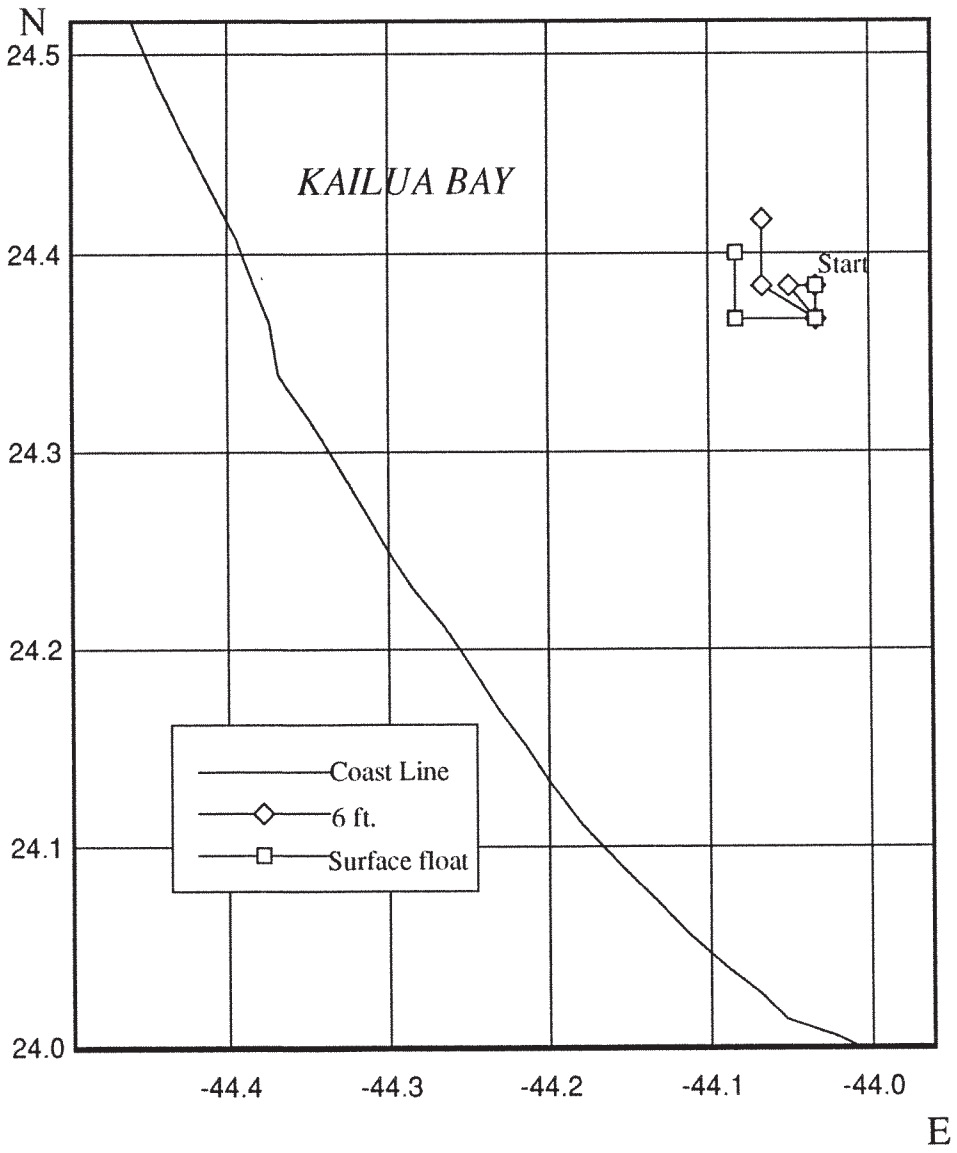

Nearshore Drogue Study - 08, May, 1993
N
24.5
24.4
24.3
24.2
24.1
24.0
KAILUA BAY
Start
Start
Coast Line
6 ft.
Surface float
-44.2
-44.1
-44.0
-43.9
-43.8
-43.7
E

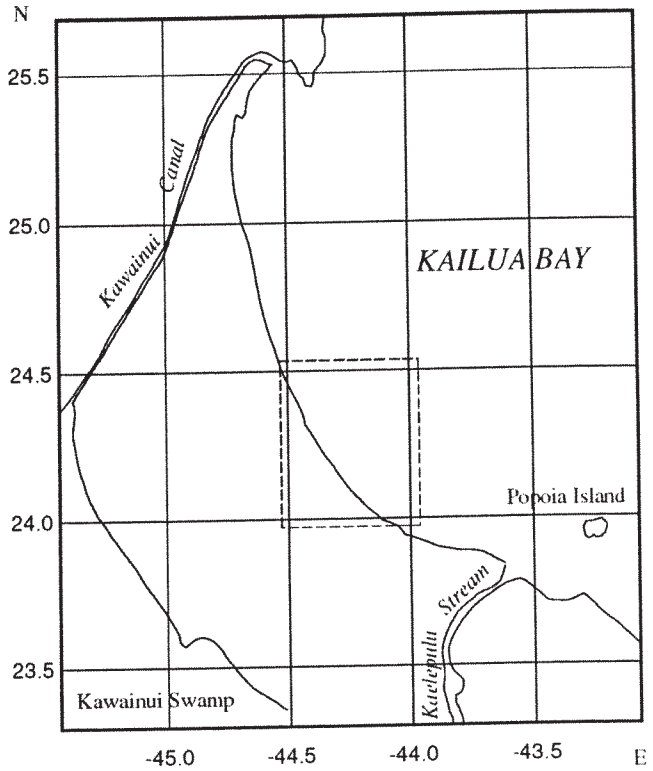

N
25.5
25.0
24.5
24.0
23.5
Canal
Kawainui
KAILUA BAY
Popoia Island
Stream
Kaelepulu
Kawainui Swamp
-45.0
-44.5
-44.0
-43.5
E


Nearshore Drogue Study - 15, May, 1993
N
24.5
24.4
24.3
24.2
24.1
24.0
KAILUA BAY
Coast Line
Dye, 6ft.
2 ft.
Start
-44.2
-44.1
-44.0
-43.9
-43.8
-43.7
E

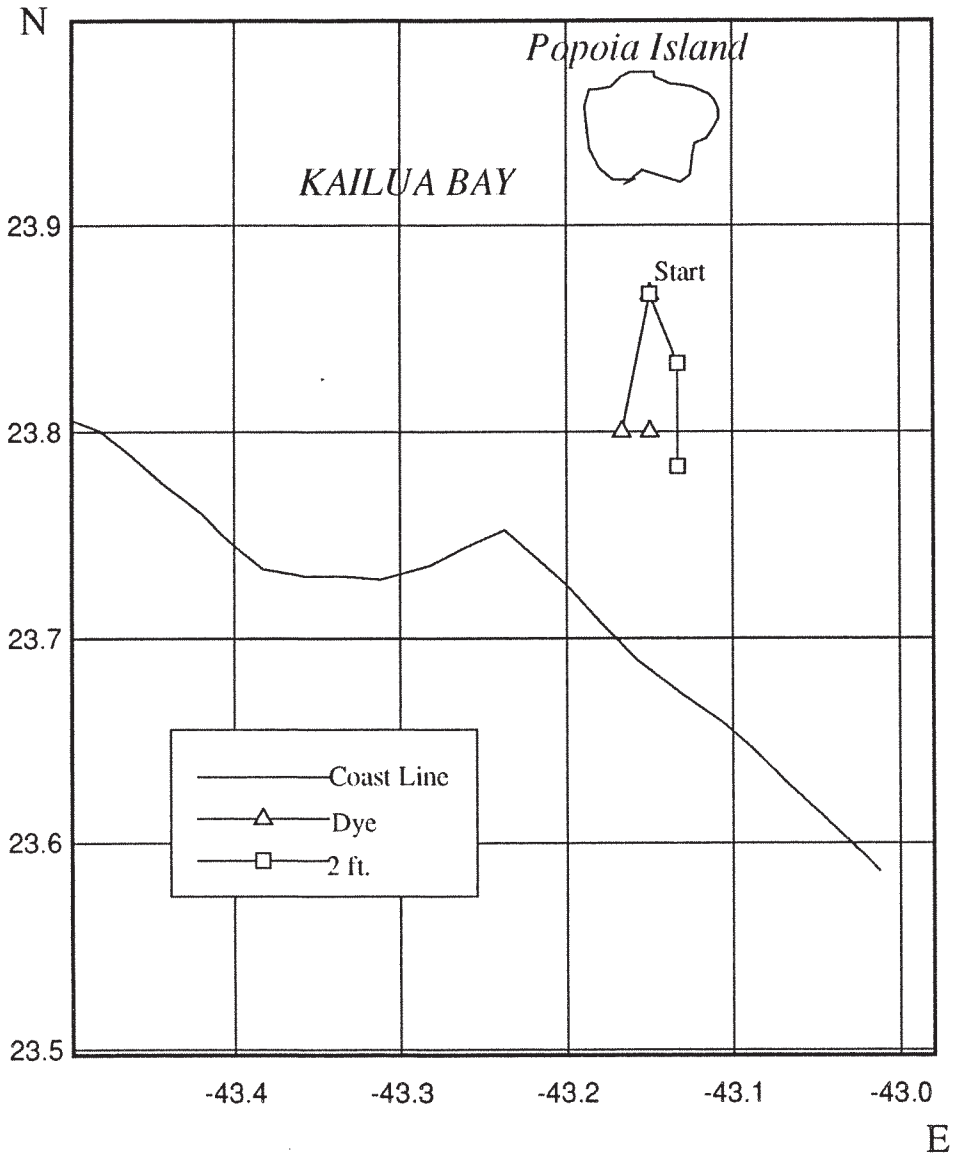

N
25.5
25.0
24.5
24.0
23.5
Kawainui Canal
KAILUA BAY
Popoia Island
Kawainui Swamp
Kaelepulu Stream
-45.0
-44.5
-44.0
-43.5
E

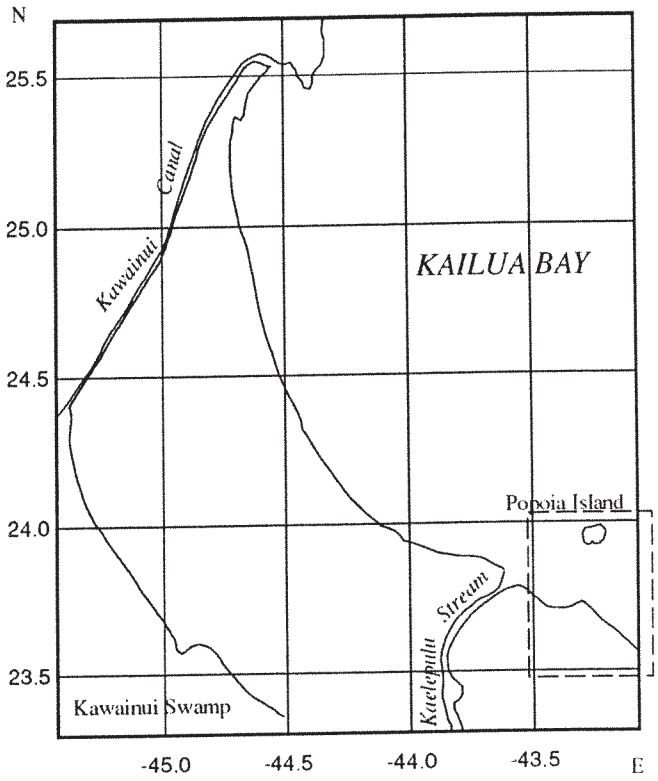
Nearshore Drogue Study - 22, May, 1993



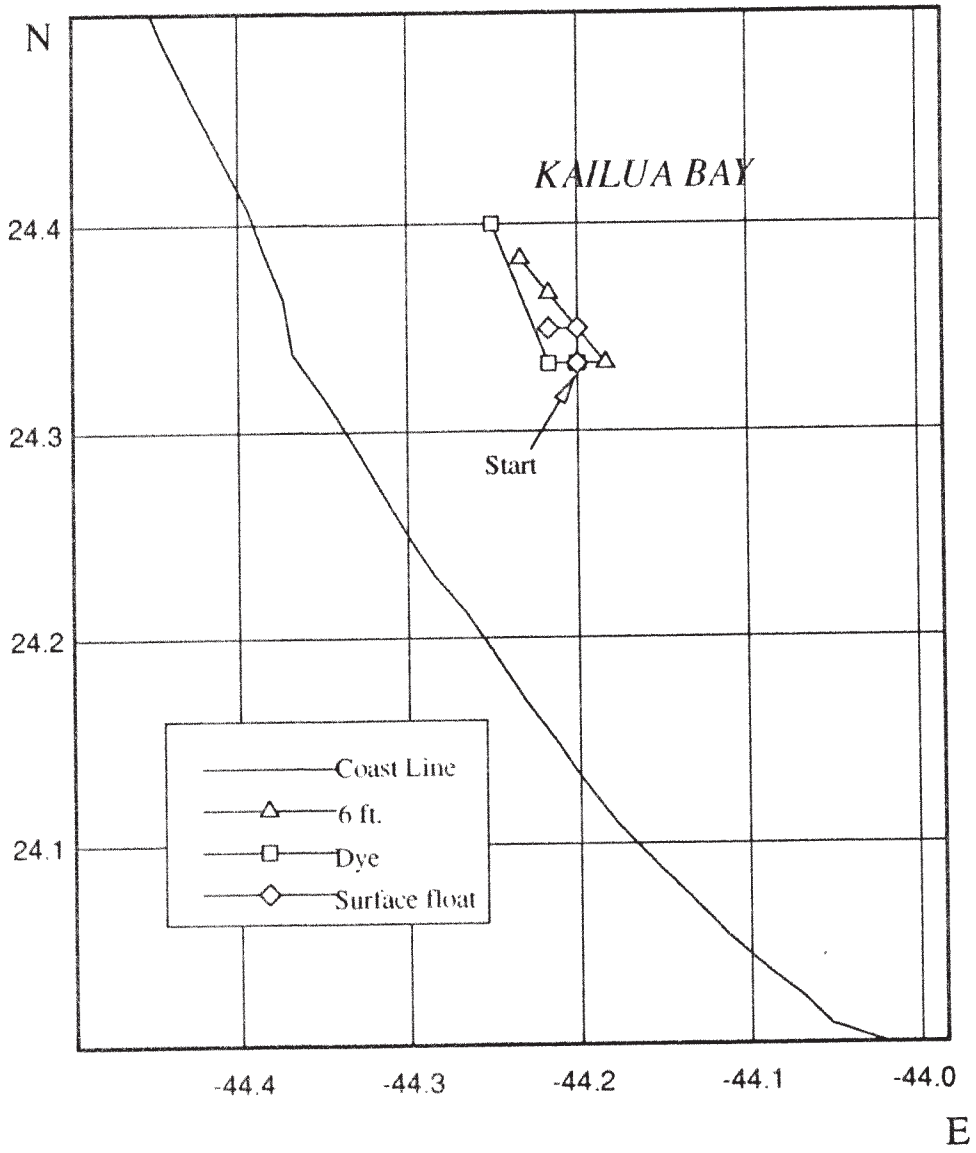


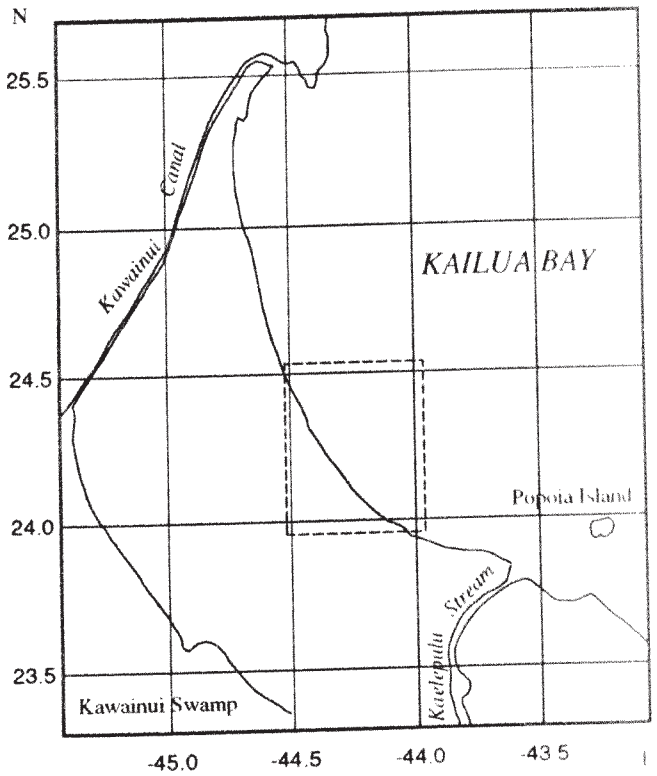
Nearshore Drogue Study - 22, May, 1993





Nearshore Drogue Study - 23, May, 1993





KAILUA BAY DEEP DROGUE STUDY
JULY 6, 1991

Drogue	Time	Deg. Min. Sec. Lat	Deg. Min. Sec. Long	Wind Velocity
60'	0936	21°27'09"N	157°42'92"W	5.3mph/95°
30'	0936	21°27'09"N	157°42'92"W	5.3mph/95°
Surface	0936	21°27'09"N	157°42'92"W	5.3mph/95°
Dye	0936	21°27'09"N	157°42'92"W	5.3mph/95°
60'	0956	21°27'75"N	157°42'96"W	5.2mph/65°
30'	0956	21°27'21"N	157°42'96"W	5.2mph/65°
Surface	0957	21°27'19"N	157°42'92"W	5.2mph/65°
Dye	0957	21°27'18N	157°42'92"W	5.2mph/65°
60'	1016	21°27'36"N	157°42'99"W	7.0mph/95°
30'	1017	21°27'33"N	157°42'95"W	7.0mph/95°
Surface	1018	21°27'25"N	157°42'91"W	7.0mph/95°
Dye	1019	21°27'24"N	157°42'91"W	7.0mph/65°
60'	1036	21°27'48"N	157°42'99"W	6.0mph/85°
30'	1037	21°27'45"N	157°42'94"W	6.0mph/85°
Surface	1038	21°27'39"N	157°42'93"W	6.0mph/85°
Dye	1039	21°27'27"N	157°42'89"W	6.0mph/85°
60'	1058	21°27'94"N	157°43'14"W	7.2mph/85°
30'	1102	21°27'29"N	157°42'80"W	7.2mph/85°
Surface	1107	21°27'27"N	157°42'80"W	7.2mph/85°
Dye	1109	21°27'31"N	157°42'84"W	7.2mph/85°
60'	1324	21°23'06"N	157°40'82"W	7.3mph/34°
30'	1324	21°23'06"N	157°40'82"W	7.3mph/34°
Surface	1324	21°23'06"N	157°40'82"W	7.3mph/34°
Dye	1324	21°23'06"N	157°40'82"W	7.3mph/34°
60'	1344	21°23'15"N	157°40'88"W	6.0mph/62°

30’	1345	21°23’15"N	157°40’88"W	6.0mph/62°
Surface	1347	21°23’22’N	157°40’86"W	6.0mph/62°
Dye	1347	21°23’22"N	157°40’86"W	6.0mph/62°
60’	1403	21°23’26"N	157°40’95"W	6.5mph/80°
30’	1405	21°23’30"N	157°40’89"W	6.5mph/80°
Surface	1406	21°23’34"N	157°40’90"W	6.5mph/80°
Dye	1407	21°23’35"N	157°40’90"W	6.5mph/80°
60’	1423	21°23’38"N	157°41’06"W	7.2mph/75°
30’	1424	21°23’41"N	157°40’91"W	7.2mph/75°
Surface	1425	21°23’47"N	157°40’90"W	7.2mph/75°
Dye	1426	21°23’48"N	157°40’90"W	7.2mph/75°
60’	1443	21°23’48"N	157°41’09"W	7.6mph/45°
30’	1447	21°23’55"N	157°40’93"W	7.6mph/45°
Surface	1449	21°23’62"N	157°40’91"W	7.6mph/45°
Dye	1450	21°23’65"N	157°40’92"W	7.6mph/45°

KAILUA BAY DEEP DROGUE STUDY
MARCH 21, 1992

Drogue	Time	Deg. Min. Lat	Deg. Min. Long	Wind Velocity
60'	0938	21°27.4070'	157°43.0243'	
15'	0938	21°27.4070'	157°43.0243'	
Surface	0938	21°27.4070'	157°43.0243'	
Dye	0938	21°27.4070'	157°43.0243'	
60'	0949	21°27.3787'	157°43.0624'	
15'	0950	21°27.3649'	157°43.0731'	
Surface	0951	21°27.3746'	157°43.0910'	
Dye	0952	21°27.3807'	157°43.0778'	
60'	1002	21°27.4017'	157°43.1173'	
15'	1003	21°27.4175'	157°43.1162'	
Surface	1005	21°27.3670'	157°43.1492'	
Dye	1005	21°27.3651'	157°43.1381'	
60'	1018	21°27.4100'	157°43.1030'	
15'	1019	21°27.3911'	157°43.0941'	
Surface	1020	21°27.3637'	157°43.1621'	
Dye	1025	21°27.3036'	157°43.1510'	
60'	1032	21°27.4618'	157°43.1313'	
15'	1036	21°27.4117'	157°43.1233'	
Surface	1046	21°27.3003'	157°43.2207'	
Dye	1041	21°27.3768'	157°43.1753'	
60'	1126	21°23.3125'	157°40.9639'	
15'	1126	21°23.3125'	157°40.9639'	
Surface	1126	21°23.3125'	157°40.9639'	
Dye	1126	21°23.3125'	157°40.9639'	
60'	1138	21°23.3066'	157°40.9117'	

15'	1139	21°23.3241'	157°40.9940'	
Surface	1140	21°23.3127'	157°41.0011'	
Dye	1140	21°23.3512'	157°41.0073'	
60'	1154	21°23.3734'	157°41.0302'	
15'	1152	21°23.3768'	157°41.0290'	
Surface	1151	21°23.3736'	157°41.0553'	
Dye	1152	21°23.3697'	157°41.0195'	
60'	1207	21°23.3893'	157°41.0224'	
15'	1200	21°23.3910'	157°41.0786'	
Surface	1205	21°23.3977'	157°41.0915'	
Dye	1205	21°23.4064'	157°41.1365'	
60'	1222	21°23.4322'	157°41.0642'	
15'	1220	21°23.4211'	157°41.1543'	
Surface	1218	21°23.4382'	157°41.2422'	
Dye	1220	21°23.4249'	157°41.1677'	

Kailua Bay Bathymetric Survey

3/27/93

Time	Feet Depth	21°N Latitude	157°W Longitude
10:33	5.3	23.977	43.588
10:37	5.9	23.994	43.646
10:44	5.5	23.986	43.462
10:48	8.8	23.983	43.379
10:52	4.0	23.937	43.324
10:55	0 edge of island	23.933	43.256
11:00	9.2	24.069	43.425
11:12	5.0	24.153	43.570
11:16	9.9	24.161	43.677
11:20	9.2	24.088	43.807
11:23	9.2	24.093	43.858
11:27	9.9	24.202	43.952
11:34	8.2	24.102	44.015
11:38	8.2	24.008	43.977
11:43	6.7	24.000	43.862
11:49	5.0	23.930	43.678

Kailua Bay
Beach Line - MSL

3/28/93

Time	Location	Latitude	Longitude
9:54	South End	23.752	43.244
9:58	Boat Ramp	23.712	43.314
10:04	Enchanted Lakes Outlet	23.857	43.505
10:08	Tree Roots	23.869	43.647
10:12	Wood Piles	23.921	43.785
10:17	Next	23.985	43.940
10:22	Big House	24.083	44.062
10:28	Next	24.172	44.232
10:34	Next	24.366	44.357
10:38	Blue Tile +	24.547	44.433
10:44	Big House	24.703	44.550
10:50	Next	24.962	44.618
10:55	Next	25.150	44.613
11:01	North End Of Beach	25.382	44.639

Kailua Bay

Canal and Enchanted Lakes

4/4/93

Time	Feet Depth	Location	21°N Latitude	157°W Longitude
10:09	2.5	Edge of Sandbar	23.787	43.692
10:14	5.0		23.688	43.755
10:44	5.5	Edge of Lake	22.779	43.957

KAILUA BAY DYE - DROGUE
SMALL SWELL - SOUTH END OF BAY
5/15/93

TIME	WATER	DROGUE	LAT	LONG
11:00	12.5	2,6, DYE	24'13"	43'49"
11:15	10.9	2	24'13"	43'50"
		WIND 45°M	8.5 KNOTS	
11:19	10.9	6 DYE	24'13"	43'50"
11:27		2	24'14"	43'51"
11:32	10.5	6 + DYE	24'16"	43'50"

KAILUA BAY DYE - DROGUE
SMALL SWELL - SOUTH END OF BAY
5/15/93

TIME	DEPTH	DROGUE DYE	LAT	LONG
10:51	7.8	2' + D	23'52"	43'09"
		WIND 6 KNOTS	FROM 10°M	
11:10	9.4	D	23'48"	43'10"
11:12	6.8	2	23'50"	43'08"
11:27	8.4	D	23'48"	43'09"
11:29	6.1	2	23'47"	43'08"
		WIND 7 KNOTS	FROM 5°	

KAILUA BAY INSIDE
SMALL SWELL LIGHT TRADES
5/23/93

TIME	DEPTH	DROGUE DYE	LAT	LONG
9:21	9.0		24'19"	44'09"

KAILUA BAY NEARSHORE DROGUE STUDY

Run No	Date	Deg. Min. Lat	Deg. Min. Long	Time	Depth	Drogue
1	24 Apr 93	21°25.3000'	157°44.3000'	1252	9.4	dye
2	24 Apr 93	21°25.3200'	157°44.3100'	1306	4.6	dye
3	24 Apr 93	21°25.3300'	157°44.3300'	1313	6.8	dye
4	24 Apr 93	21°25.3400'	157°44.3600'	1323	10.3	dye
5	24 Apr 93	21°25.3000'	157°44.3000'	1252	9.4	2
6	24 Apr 93	21°25.3200'	157°44.3100'	1306	4.6	2
7	24 Apr 93	21°25.3300'	157°44.3300'	1313	6.8	2
8	24 Apr 93	21°25.3400'	157°44.3600'	1323	10.3	2
9	24 Apr 93	21°25.3400'	157°44.3600'	1323	10.3	6
10	24 Apr 93	21°25.3200'	157°44.3700'	1339	9	6
11	24 Apr 93	21°25.0700'	157°44.2600'	1400	12.7	6
12	24 Apr 93	21°25.0700'	157°44.2400'	1415	9.7	6
13	23 May 93	21°24.2000'	157°44.1200'	924	8	deep
14	23 May 93	21°24.2000'	157°44.1100'	943	8.4	deep
15	23 May 93	21°24.2200'	157°44.1300'	1001	8.4	deep
16	23 May 93	21°24.2300'	157°44.1400'	1011	9.2	deep
17	23 May 93	21°24.2000'	157°44.1200'	924	8	dye
18	23 May 93	21°24.2000'	157°44.1200'	941	8.3	dye
19	23 May 93	21°24.2000'	157°44.1300'	959	8.2	dye
20	23 May 93	21°24.2400'	157°44.1500'	1009	8.4	dye
21	23 May 93	21°24.2000'	157°44.1200'	924	8	sfc
22	23 May 93	21°24.2100'	157°44.1200'	940	8.4	sfc
23	23 May 93	21°24.2100'	157°44.1300'	954	7.4	sfc
24	15 May 93	21°24.1300'	157°43 4900	1100	12.5	dye
25	15 May 93	21°24.1300'	157°43.5000'	1119	10.9	dye
26	15 May 93	21°24.1600'	157°43.5000'	1132	10.5	dye

27	15 May 93	21°24.1300'	157°43.4900'	1100	12.5	2
28	15 May 93	21°24.1300'	157°43.5000'	1115	10.9	2
29	15 May 93	21°24.1400'	157°43.5100'	1127		2
30	15 May 93	21°24.1300'	157°43.4900'	1100	12.5	6
31	15 May 93	21°24.1300'	157°43.5000'	1119	10.9	6
32	15 May 93	21°24.1600'	157°43.5000'	1132	10.5	6
33	22 May 93	21°23.5200'	157°43.0900'	1051	7.8	dye
34	22 May 93	21°23.4800'	157°43.1000'	1110	9.4	dye
35	22 May 93	21°23.4800'	157°43.0900'	1127	8.4	dye
36	22 May 93	21°23.5200'	157°43.0900'	1051	7.8	2
37	22 May 93	21°23.5000'	157°43.0800'	1112	6.8	2
38	22 May 93	21°23.4700'	157°43.0800'	1129	6.1	2
39	08 May 93	21°24.1720'	157°43.5788'	1112	9.6	deep
40	08 May 93	21°24.1813'	157°43.5884'	1131	11.5	deep
41	08 May 93	21°24.2048'	157°43.5920'	1145	11.3	deep
42	08 May 93	21°24.2064'	157°44.0012'	1157	10.3	deep
43	08 May 93	21°24.1874'	157°43.5810'	1135	10.3	depth
44	08 May 93	21°24.1799'	157°43.5472'	1107	11.5	sfc
45	08 May 93	21°24.1759'	157°43.5855'	1122	10.3	sfc
46	08 May 93	21°24.2039'	157°43.5897'	1140	9.6	sfc
47	08 May 93	21°24.1928'	157°44.0100'	1150	10.7	sfc
48	15 May 93	21°24.0928'	157°43.4713'	1055	10.7	deep
49	15 May 93	21°24.0754'	157°43.4741'	1117	10.1	deep
50	15 May 93	21°24.0900'	157°43.4700'	1158	11.5	deep
51	15 May 93	21°24.0800'	157°43.4800'	1210	11.3	deep
52	15 May 93	21°24.0938'	157°43.4833'	1058	10.5	depth
53	15 May 93	21°24.0757'	157°43.4849'	1100	11.7	depth
54	15 May 93	21°24.0935'	157°43.4550'	1103	10.3	depth
55	15 May 93	21°24.1114'	157°43.4858'	1106	13.8	depth
56	15 May 93	21°24.1234'	157°43.4806'	1120	12.1	depth

57	15 May 93	21°24.0976'	157°43.4859'	1121	10.5	depth
58	15 May 93	21°24.0078'	157°43.4001'	1045	6.2	sfc
59	15 May 93	21°24.1048'	157°43.4643'	1110	11.9	sfc
60	15 May 93	21°24.0500'	157°43.4600'	1153	9.1	sfc
61	15 May 93	21°24.0300'	157°43.4600'	1207	10.7	sfc
62	22 May 93	21°24.2300'	157°44.0200'	849	10.7	deep
63	22 May 93	21°24.2300'	157°44.0300'	908	11.5	deep
64	22 May 93	21°24.2200'	157°44.0200'	923	10.3	deep
65	22 May 93	21°24.2300'	157°44.0400'	940	9	deep
66	22 May 93	21°24.2500'	157°44.0400'	957	7.8	deep
67	22 May 93	21°24.2000'	157°44.0100'	844	10.1	depth
68	22 May 93	21°24.2100'	157°44.0300'	852	9.6	depth
69	22 May 93	21°24.2500'	157°44.0100'	900	10.7	depth
70	22 May 93	21°24.2500'	157°44.0100'	913	12.3	depth
71	22 May 93	21°24.2500'	157°44.0300'	914	9.2	depth
72	22 May 93	21°24.2300'	157°44.0200'	849	10.7	sfc
73	22 May 93	21°24.2200'	157°44.0200'	906	11.3	sfc
74	22 May 93	21°24.2200'	157°44.0500'	921	12.7	sfc
75	22 May 93	21°24.2200'	157°44.0500'	937	11.1	sfc
76	22 May 93	21°24.2400'	157°44.0500'	952	11.9	sfc

APPENDIX F
Tide Charts: 1991–1993

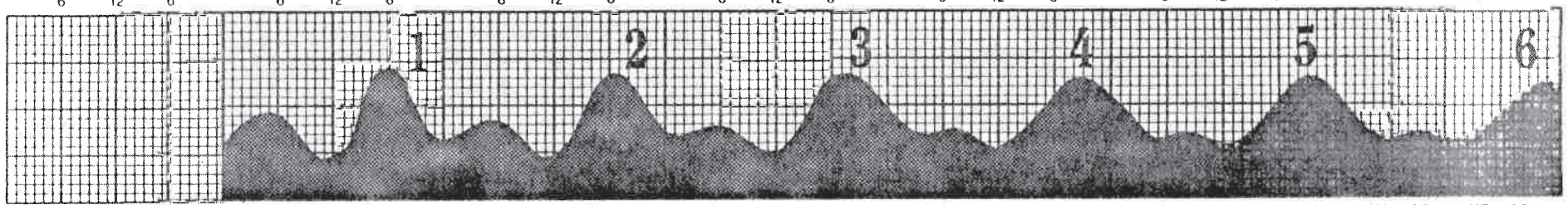
Tide Chart 1991: April, May, June, July ..... F-1 through F-4

Tide Chart 1992: March, April ..... F-5 through F-6

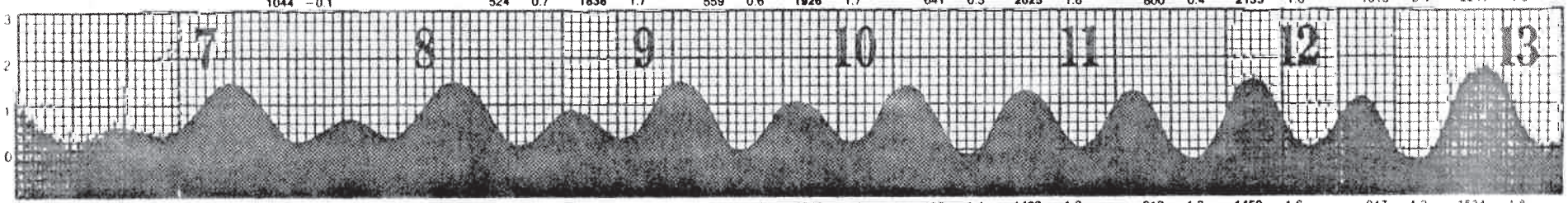
Tide Chart 1993: April, May ..... F-7 through F-8

April Apelila 91

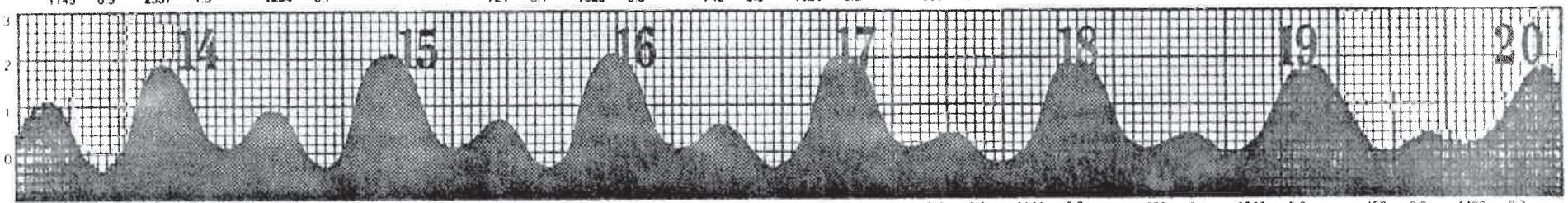
SUNDAY *Lapule*	MONDAY *Poakahi*	TUESDAY *Poalua*	WEDNESDAY *Poakolu*	THURSDAY *Poaha*	FRIDAY *Poalima*	SATURDAY *Poaono*
6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6



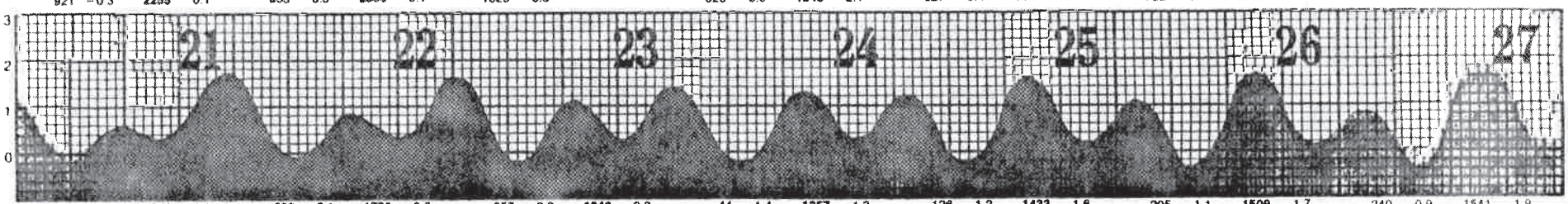
452	0.9	1752	1.8	45	0.3	1109	−0.1	154	0.4	1137	0.0	323	0.4	1212	0.1	500	0.3	1254	0.2	609	0.3	1417	0.3
1044	−0.1			524	0.7	1838	1.7	559	0.6	1926	1.7	641	0.5	2025	1.6	800	0.4	2135	1.6	1013	0.4	2241	1.5



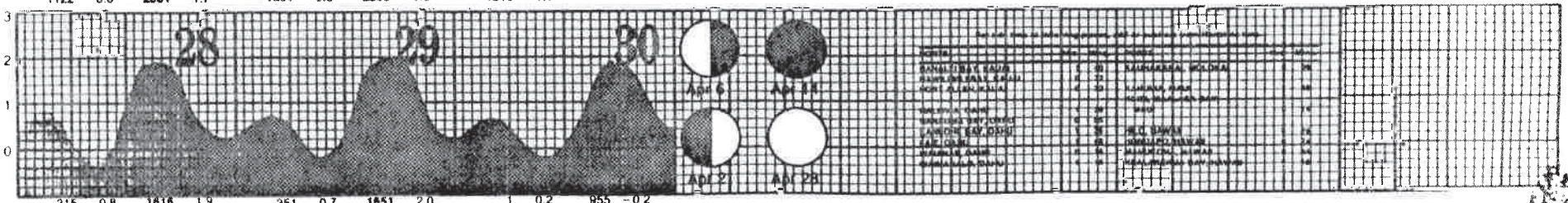
644	0.2	1600	0.3	706	0.2	1726	0.3	23	1.5	1313	0.9	102	1.5	1345	1.1	137	1.4	1423	1.3	212	1.3	1459	1.6	247	1.2	1534	1.8
1145	0.5	2337	1.5	1234	0.7			724	0.1	1828	0.3	745	0.0	1924	0.2	808	−0.1	2017	0.1	828	−0.2	2109	0.1	853	−0.2	2200	0.1



325	1.1	1616	1.9	401	0.9	1701	2.1	443	0.7	1750	2.1	103	0.1	1103	−0.3	219	0.1	1144	−0.2	339	0.1	1241	0.0	453	0.0	1400	0.2
921	−0.3	2255	0.1	953	−0.3	2356	0.1	1025	−0.3			528	0.6	1843	2.1	627	0.4	1944	2.0	752	0.4	2050	1.9	945	0.4	2157	1.8



543	0.0	1543	0.3	625	−0.1	1723	0.3	657	−0.2	1842	0.3	44	1.4	1357	1.3	126	1.2	1433	1.6	205	1.1	1509	1.7	240	0.9	1541	1.9
1122	0.6	2301	1.7	1231	0.8	2355	1.6	1316	1.1			724	−0.2	1948	0.3	749	−0.2	2046	0.2	814	−0.3	2138	0.2	837	−0.3	2227	0.2



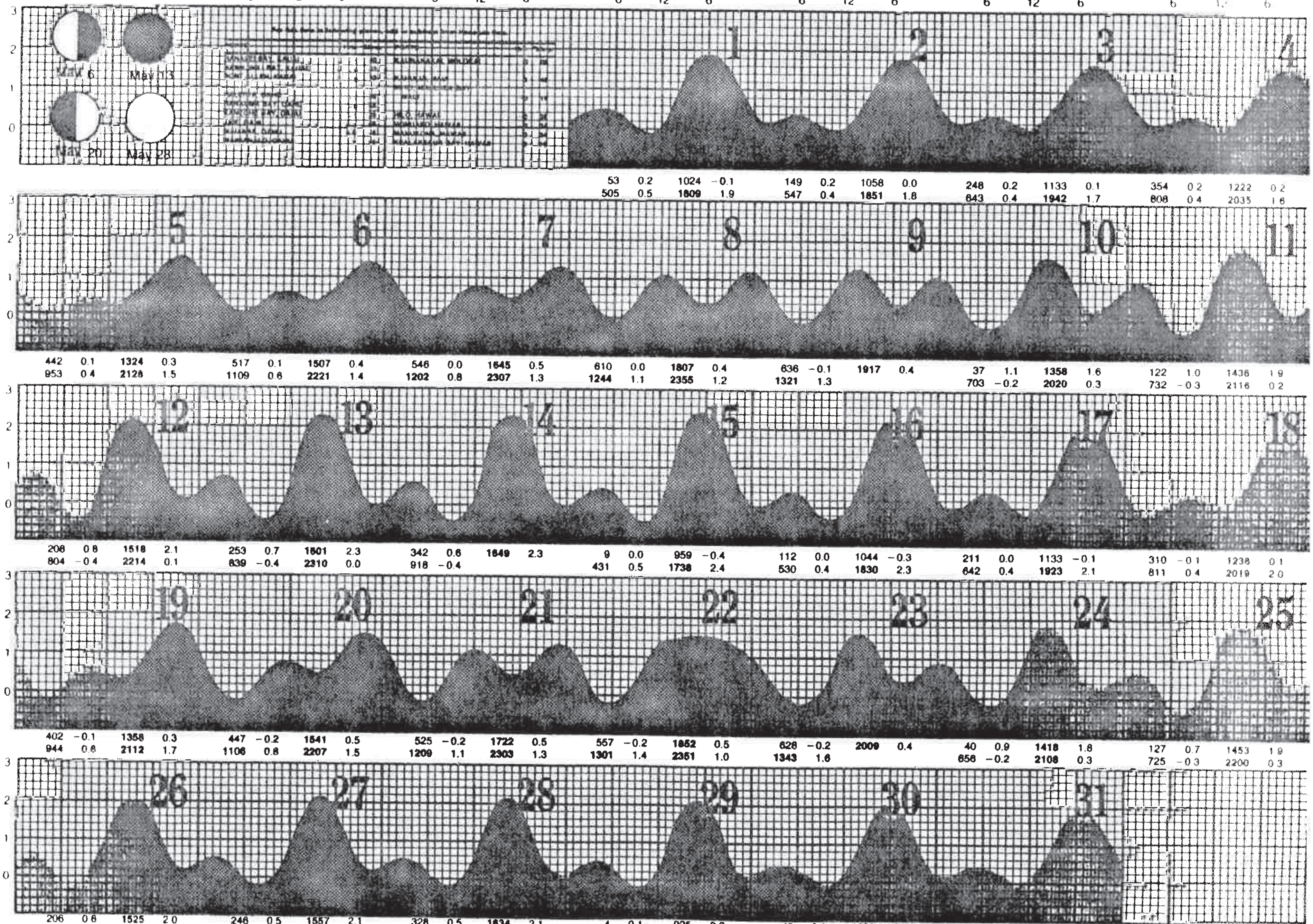
315	0.8	1616	1.9	351	0.7	1651	2.0	1	0.2	955	−0.2
902	−0.3	2311	0.2	929	−0.2			426	0.6	1727	1.9

On chart above: light figures A.M., dark figures P.M. Heights are in feet. Graph and figures for reference only. Not recommended for navigation.

May Mei '91

Molokini - B. ABRAHA

SUNDAY *Lapule* | MONDAY *Poakahi* | TUESDAY *Poalua* | WEDNESDAY *Poakolu* | THURSDAY *Poaha* | FRIDAY *Poalima* | SATURDAY *Poaono*



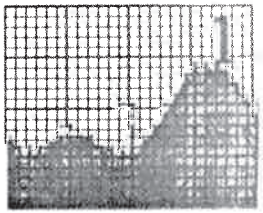
Day	Tides	
1	53 0.2 1024 −0.1	505 0.5 1809 1.9
2	149 0.2 1058 0.0	547 0.4 1851 1.8
3	248 0.2 1133 0.1	643 0.4 1942 1.7
4	354 0.2 1222 0.2	808 0.4 2035 1.6
5	442 0.1 1324 0.3	953 0.4 2128 1.5
6	517 0.1 1507 0.4	1109 0.6 2221 1.4
7	546 0.0 1645 0.5	1202 0.8 2307 1.3
8	610 0.0 1807 0.4	1244 1.1 2355 1.2
9	636 −0.1 1917 0.4	1321 1.3
10	37 1.1 1358 1.6	703 −0.2 2020 0.3
11	122 1.0 1436 1.9	732 −0.3 2116 0.2
12	208 0.8 1518 2.1	804 −0.4 2214 0.1
13	253 0.7 1601 2.3	839 −0.4 2310 0.0
14	342 0.6 1649 2.3	918 −0.4
15	9 0.0 959 −0.4	431 0.5 1738 2.4
16	112 0.0 1044 −0.3	530 0.4 1830 2.3
17	211 0.0 1133 −0.1	642 0.4 1923 2.1
18	310 −0.1 1238 0.1	811 0.4 2019 2.0
19	402 −0.1 1358 0.3	944 0.8 2112 1.7
20	447 −0.2 1541 0.5	1106 0.8 2207 1.5
21	525 −0.2 1722 0.5	1209 1.1 2303 1.3
22	557 −0.2 1852 0.5	1301 1.4 2351 1.0
23	628 −0.2 2009 0.4	1343 1.6
24	40 0.9 1418 1.8	656 −0.2 2108 0.3
25	127 0.7 1453 1.9	725 −0.3 2200 0.3
26	206 0.6 1525 2.0	753 −0.2 2242 0.2
27	246 0.5 1557 2.1	821 −0.2 2324 0.2
28	328 0.5 1634 2.1	853 −0.2
29	4 0.1 925 −0.2	409 0.5 [illegible]08 2.1
30	45 0.1 1000 −0.1	451 0.4 1746 2.0
31	127 0.1 1036 0.0	541 0.4 1825 1.9

June

June '91

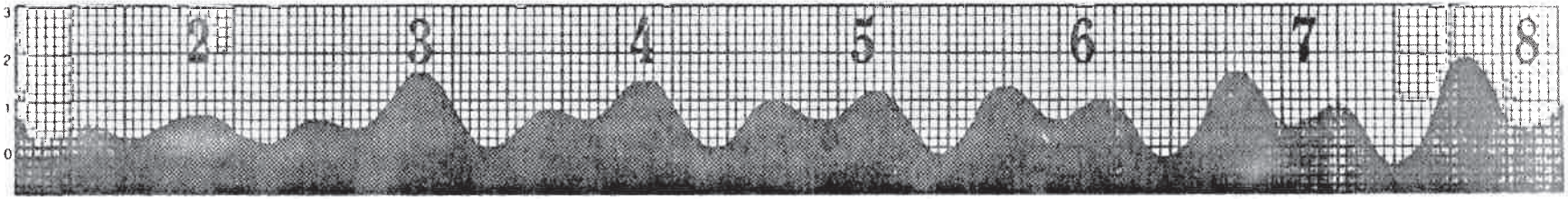
SATURDAY *Poaono*

6 12 6

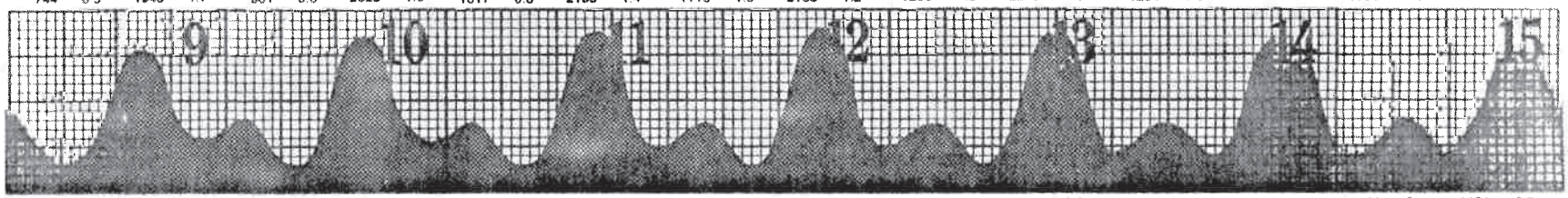


209 0.1 1115 0.1
637 0.4 1901 1.8

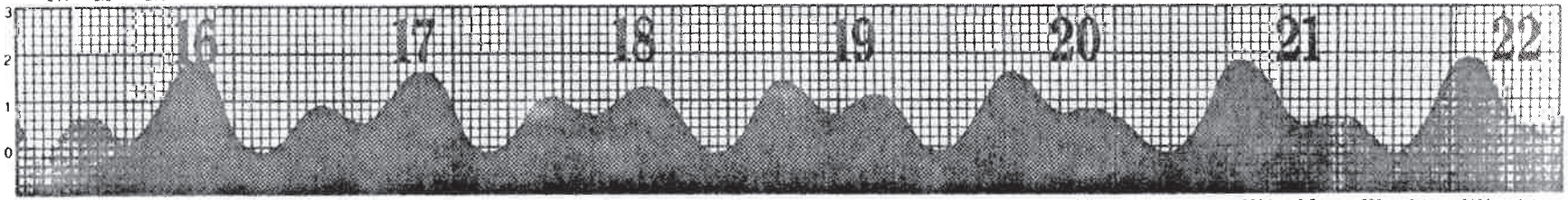
SUNDAY *Lapule*	MONDAY *Poakahi*	TUESDAY *Poalua*	WEDNESDAY *Poakolu*	THURSDAY *Poaha*	FRIDAY *Poalima*
6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6



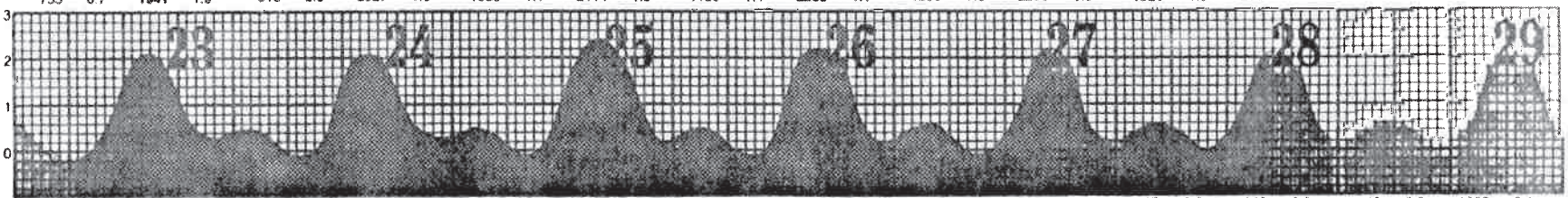
247 0.1 1203 0.2 325 0.1 1302 0.4 358 0.0 1428 0.6 429 0.0 1611 0.6 501 -0.1 1756 0.6 533 -0.2 1921 0.5 605 -0.3 2031 0.4
744 0.5 1943 1.7 901 0.6 2023 1.6 1017 0.8 2105 1.4 1118 1.0 2153 1.2 1208 1.3 2245 1.0 1254 1.6 2341 0.9 1336 1.9



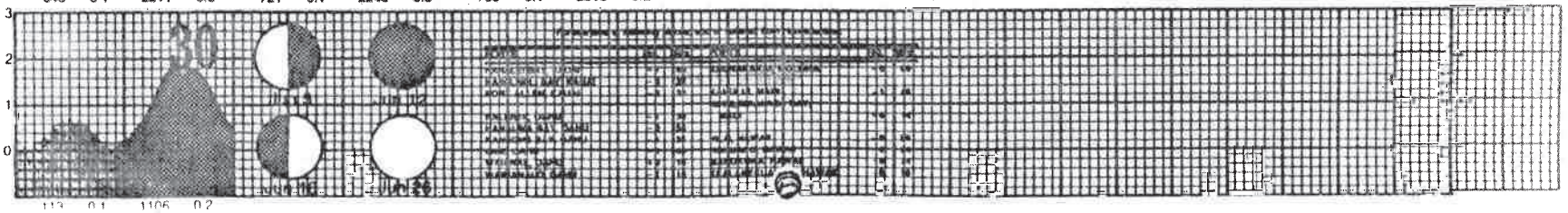
37 0.7 1421 2.1 137 0.6 1506 2.4 234 0.5 1551 2.5 330 0.5 1636 2.6 4 0.0 947 -0.4 51 -0.1 1036 -0.2 141 -0.1 1131 0.0
844 -0.3 2131 0.2 726 -0.4 2230 0.1 809 -0.4 2315 0.0 855 -0.4 430 0.5 1723 2.5 532 0.5 1809 2.4 641 0.6 1855 2.2



223 -0.1 1237 0.2 306 -0.1 1354 0.5 343 -0.1 1533 0.7 422 -0.1 1728 0.7 458 -0.1 1914 0.7 533 -0.1 2034 0.5 609 -0.1 2129 0.4
755 0.7 1941 1.9 915 0.9 2027 1.6 1033 1.1 2114 1.3 1139 1.4 2203 1.1 1235 1.6 2259 0.8 1321 1.8 2354 0.7 1358 1.9



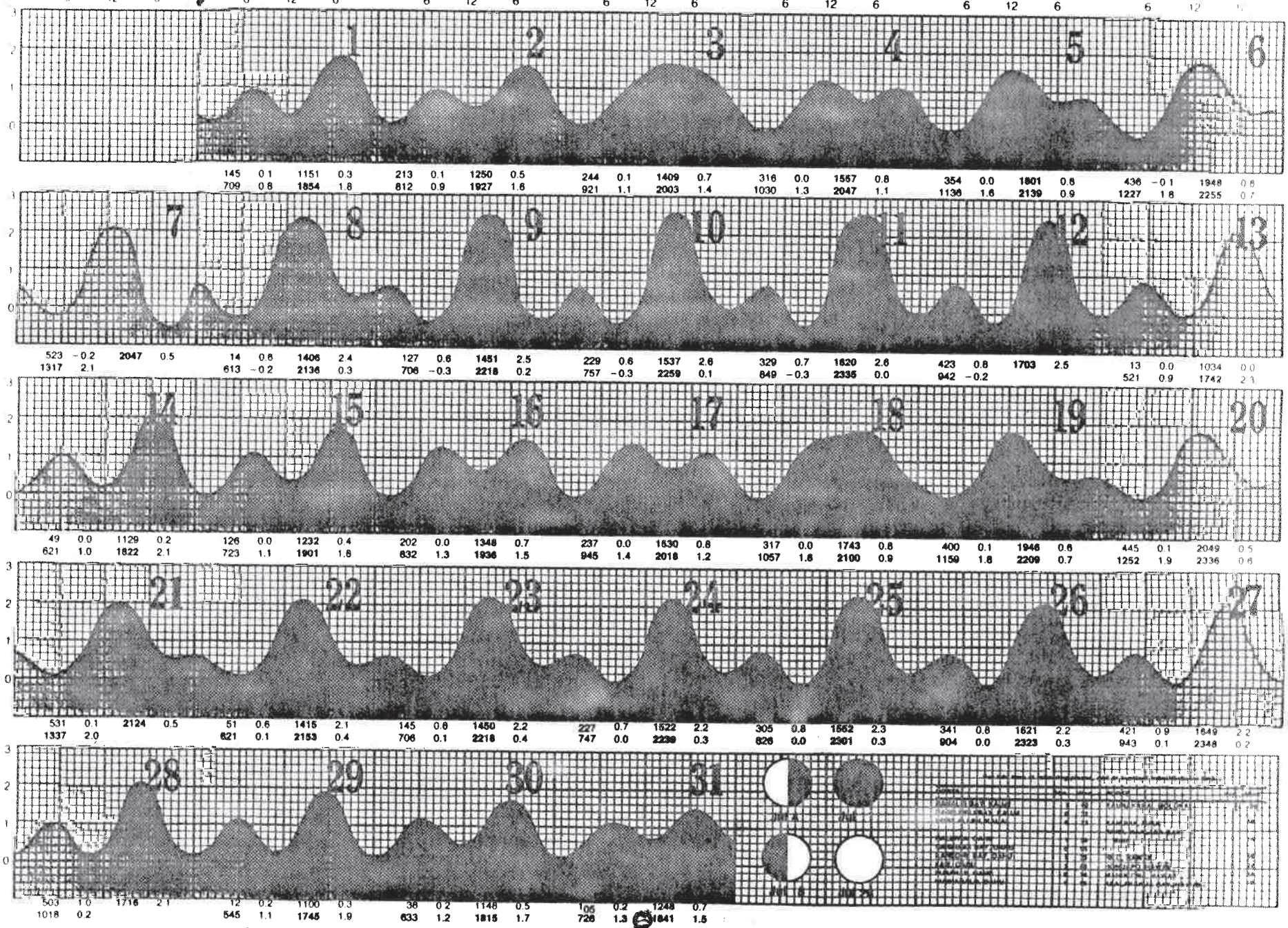
100 0.6 1434 2.1 146 0.5 1510 2.1 234 0.5 1542 2.2 316 0.5 1615 2.2 355 0.6 1647 2.2 12 0.2 948 0.0 43 0.2 1027 0.1
645 -0.1 2211 0.3 721 -0.1 2243 0.3 759 -0.1 2315 0.2 834 -0.1 2344 0.2 913 -0.1 439 0.6 1719 2.1 522 0.6 1754 2.1



113 0.1 1106 0.2

July Iulai '91

SUNDAY *Lapule*	MONDAY *Poakahi*	TUESDAY *Poalua*	WEDNESDAY *Poakolu*	THURSDAY *Poaha*	FRIDAY *Poalima*	SATURDAY *Poaono*
6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12

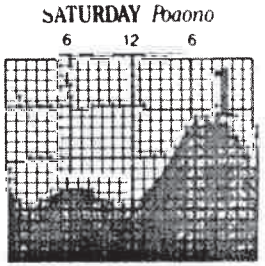


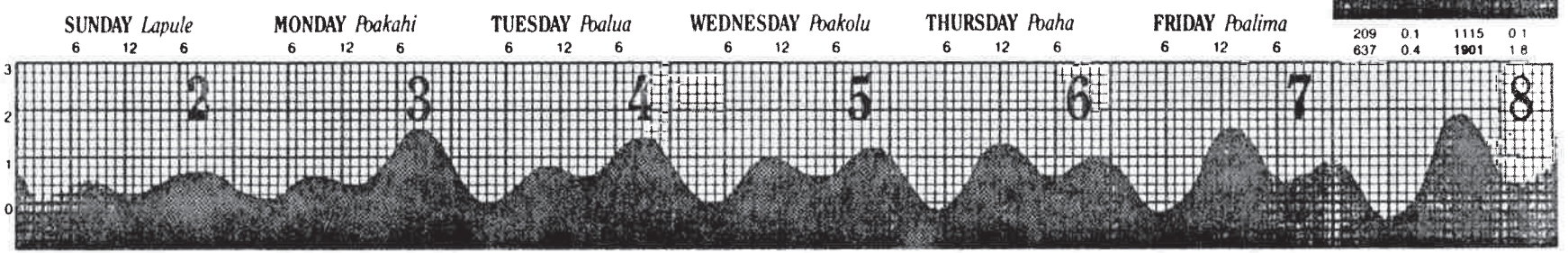
				145	0.1	1151	0.3	213	0.1	1250	0.5	244	0.1	1409	0.7	316	0.0	1557	0.8	354	0.0	1801	0.6	436	−0.1	1948	0.8
				709	0.8	1854	1.8	812	0.9	1927	1.6	921	1.1	2003	1.4	1030	1.3	2047	1.1	1136	1.6	2139	0.9	1227	1.8	2255	0.7
523	−0.2	2047	0.5	14	0.8	1406	2.4	127	0.6	1451	2.5	229	0.6	1537	2.6	329	0.7	1620	2.6	423	0.8	1703	2.5	13	0.0	1034	0.0
1317	2.1			613	−0.2	2136	0.3	706	−0.3	2218	0.2	757	−0.3	2259	0.1	849	−0.3	2335	0.0	942	−0.2			521	0.9	1742	2.1
49	0.0	1129	0.2	126	0.0	1232	0.4	202	0.0	1348	0.7	237	0.0	1530	0.8	317	0.0	1743	0.8	400	0.1	1946	0.6	445	0.1	2049	0.5
621	1.0	1822	2.1	723	1.1	1901	1.8	832	1.3	1936	1.5	945	1.4	2016	1.2	1057	1.6	2100	0.9	1159	1.8	2209	0.7	1252	1.9	2336	0.6
531	0.1	2124	0.5	51	0.6	1415	2.1	145	0.8	1450	2.2	227	0.7	1522	2.2	305	0.8	1562	2.3	341	0.8	1621	2.2	421	0.9	1649	2.2
1337	2.0			621	0.1	2153	0.4	706	0.1	2218	0.4	747	0.0	2239	0.3	826	0.0	2301	0.3	904	0.0	2323	0.3	943	0.1	2348	0.2
503	1.0	1716	2.1	12	0.2	1100	0.3	38	0.2	1148	0.5	105	0.2	1248	0.7												
1018	0.2			545	1.1	1745	1.9	633	1.2	1815	1.7	726	1.3	1841	1.5												

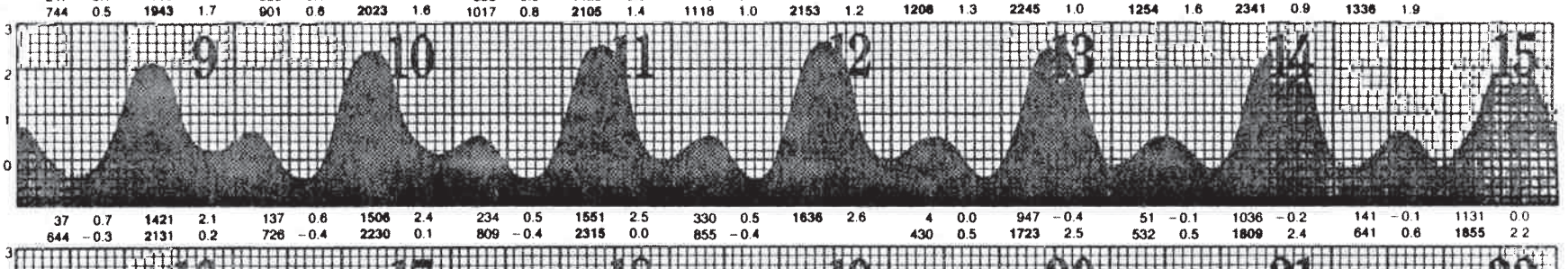
On chart above: light figures A.M., dark figures P.M. Heights are in feet. Graph and figures for reference only. Not recommended for navigation.

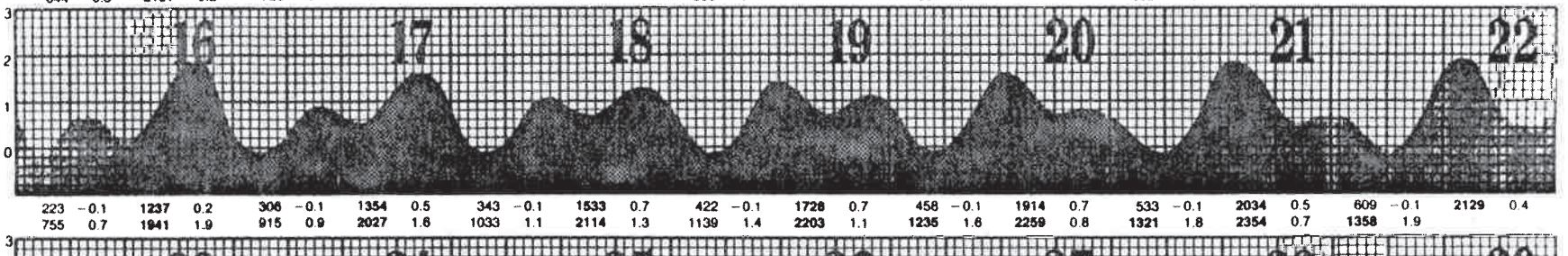
June

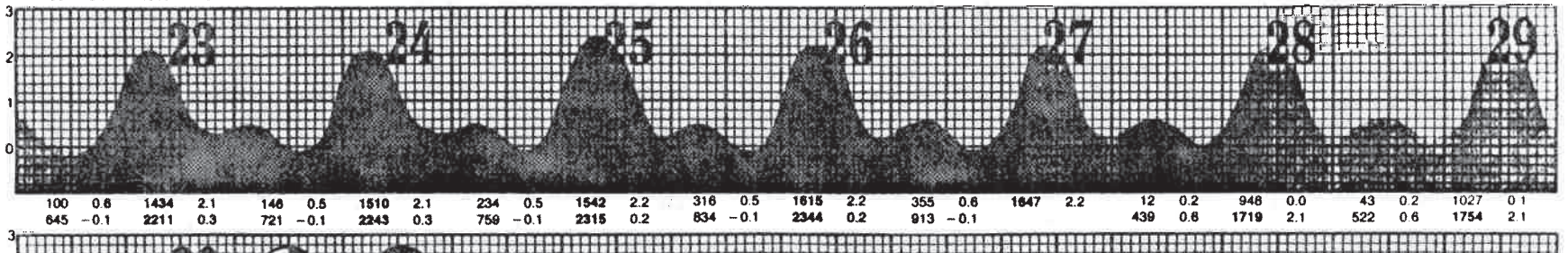
June '91

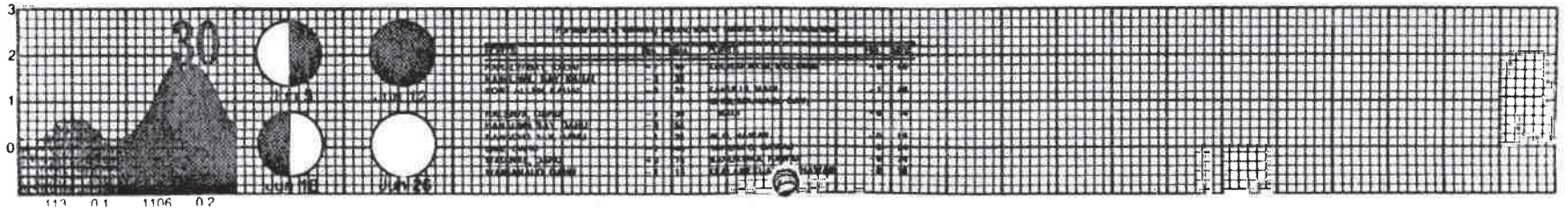

SATURDAY Poaono
6 12 6
1
209 0.1 1115 0.1
637 0.4 1901 1.8


SUNDAY Lapule
MONDAY Poakahi
TUESDAY Poalua
WEDNESDAY Poakolu
THURSDAY Poaha
FRIDAY Poalima
6 12 6
2
3
4
5
6
7
8
247 0.1 1203 0.2 325 0.1 1302 0.4 358 0.0 1428 0.6 429 0.0 1611 0.6 501 -0.1 1756 0.6 533 -0.2 1921 0.5 605 -0.3 2031 0.4
744 0.5 1943 1.7 901 0.6 2023 1.6 1017 0.8 2105 1.4 1118 1.0 2153 1.2 1208 1.3 2245 1.0 1254 1.6 2341 0.9 1336 1.9


9
10
11
12
13
14
15
37 0.7 1421 2.1 137 0.6 1506 2.4 234 0.5 1551 2.5 330 0.5 1636 2.6 4 0.0 947 -0.4 51 -0.1 1036 -0.2 141 -0.1 1131 0.0
644 -0.3 2131 0.2 726 -0.4 2230 0.1 809 -0.4 2315 0.0 855 -0.4 430 0.5 1723 2.5 532 0.5 1809 2.4 641 0.6 1855 2.2

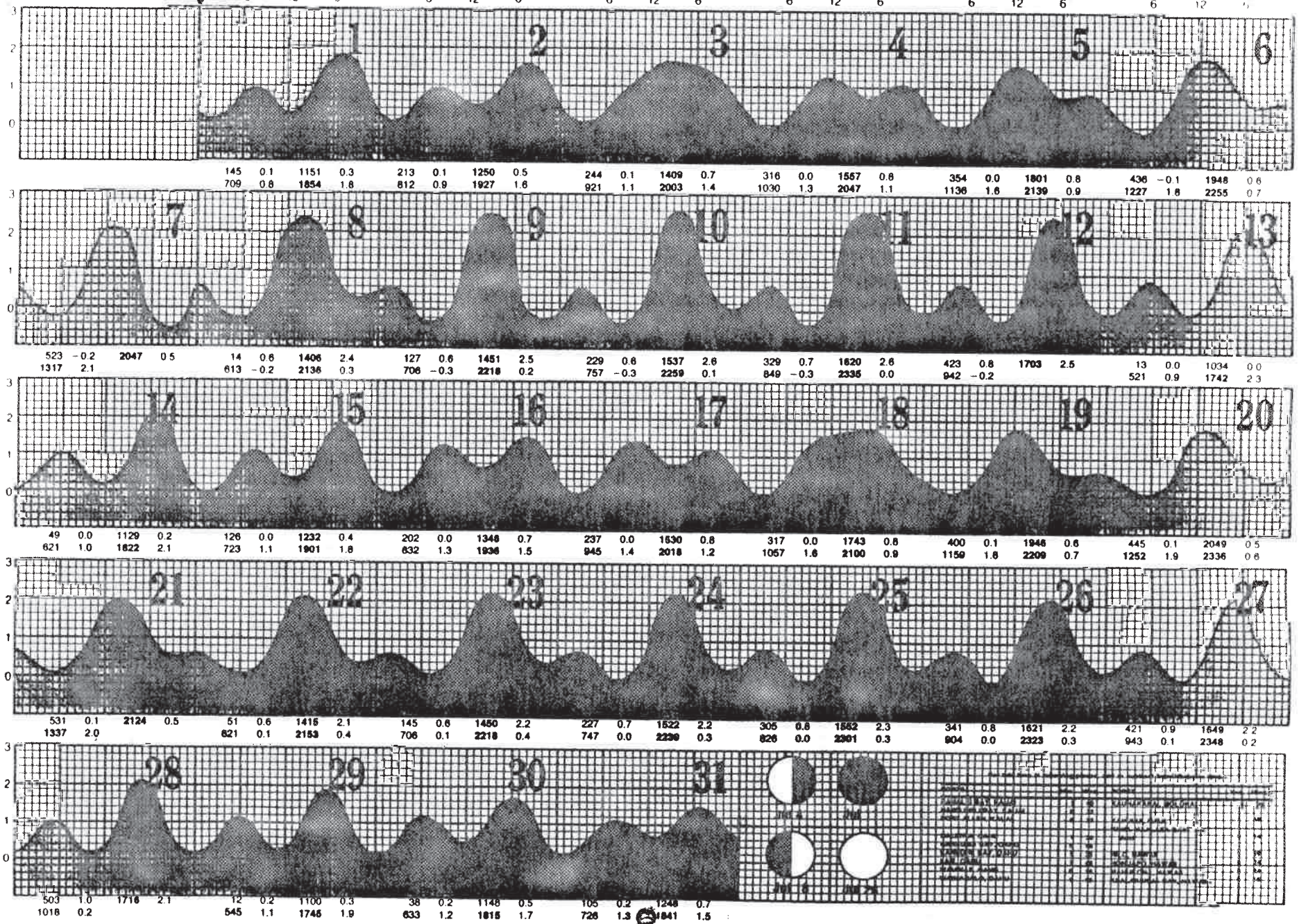

16
17
18
19
20
21
22
223 -0.1 1237 0.2 306 -0.1 1354 0.5 343 -0.1 1533 0.7 422 -0.1 1728 0.7 458 -0.1 1914 0.7 533 -0.1 2034 0.5 609 -0.1 2129 0.4
755 0.7 1941 1.9 915 0.9 2027 1.6 1033 1.1 2114 1.3 1139 1.4 2203 1.1 1235 1.6 2259 0.8 1321 1.8 2354 0.7 1358 1.9


23
24
25
26
27
28
29
100 0.6 1434 2.1 146 0.5 1510 2.1 234 0.5 1542 2.2 316 0.5 1615 2.2 355 0.6 1647 2.2 12 0.2 948 0.0 43 0.2 1027 0.1
645 -0.1 2211 0.3 721 -0.1 2243 0.3 759 -0.1 2315 0.2 834 -0.1 2344 0.2 913 -0.1 439 0.6 1719 2.1 522 0.6 1754 2.1


30
JUNE 3
JUNE 10
JUNE 18
JUNE 26
113 0.1 1106 0.2

July Iulai '91

SUNDAY *Lapule*	MONDAY *Poakahi*	TUESDAY *Poalua*	WEDNESDAY *Poakolu*	THURSDAY *Poaha*	FRIDAY *Poalima*	SATURDAY *Poaono*
6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6



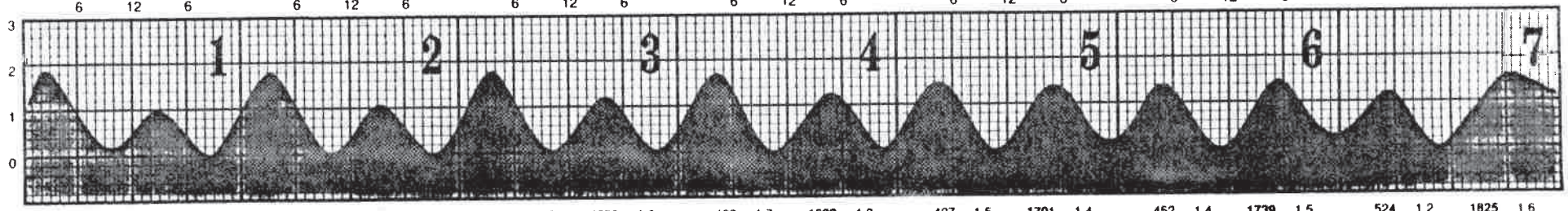
145	0.1	1151	0.3	213	0.1	1250	0.5	244	0.1	1409	0.7	316	0.0	1557	0.8	354	0.0	1801	0.8	436	−0.1	1948	0.6
709	0.8	1854	1.8	812	0.9	1927	1.6	921	1.1	2003	1.4	1030	1.3	2047	1.1	1136	1.6	2139	0.9	1227	1.8	2255	0.7
523	−0.2	2047	0.5	14	0.6	1406	2.4	127	0.6	1451	2.5	229	0.6	1537	2.6	329	0.7	1620	2.6	423	0.8	1703	2.5	13	0.0	1034	0.0
1317	2.1			613	−0.2	2136	0.3	706	−0.3	2218	0.2	757	−0.3	2259	0.1	849	−0.3	2335	0.0	942	−0.2			521	0.9	1742	2.3
49	0.0	1129	0.2	126	0.0	1232	0.4	202	0.0	1348	0.7	237	0.0	1530	0.8	317	0.0	1743	0.6	400	0.1	1946	0.6	445	0.1	2049	0.5
621	1.0	1822	2.1	723	1.1	1901	1.8	632	1.3	1936	1.5	945	1.4	2018	1.2	1057	1.6	2100	0.9	1159	1.8	2209	0.7	1252	1.9	2336	0.6
531	0.1	2124	0.5	51	0.6	1415	2.1	145	0.6	1450	2.2	227	0.7	1522	2.2	305	0.8	1562	2.3	341	0.8	1621	2.2	421	0.9	1649	2.2
1337	2.0			821	0.1	2153	0.4	706	0.1	2218	0.4	747	0.0	2239	0.3	826	0.0	2301	0.3	904	0.0	2323	0.3	943	0.1	2348	0.2
503	1.0	1716	2.1	12	0.2	1100	0.3	38	0.2	1148	0.5	105	0.2	1248	0.7												
1018	0.2			545	1.1	1745	1.9	633	1.2	1815	1.7	726	1.3	1841	1.5												

On chart above: light figures A.M., dark figures P.M. Heights are in feet. Graph and figures for reference only. Not recommended for navigation.

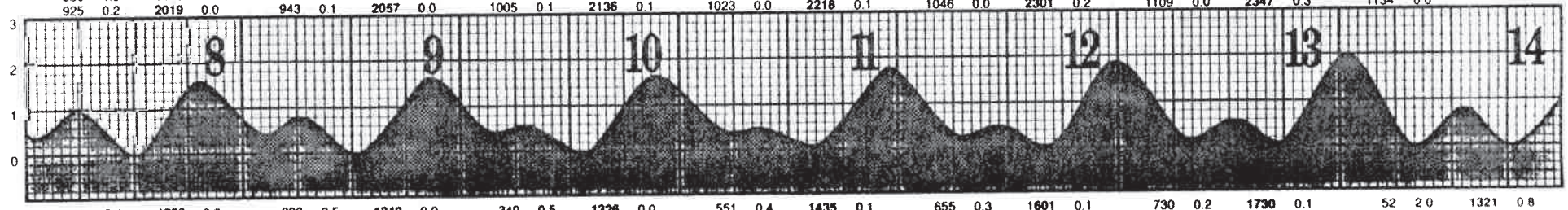
Undulated Moray Eel-Photo by G. Cummings

March Malaki '92

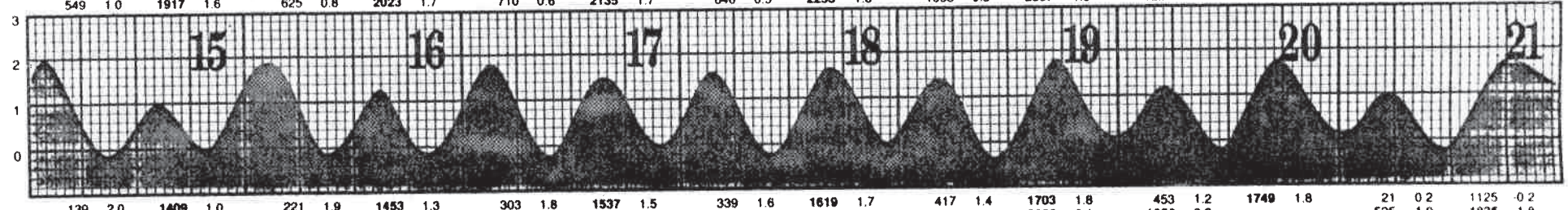
SUNDAY *Lapule*	MONDAY *Poakahi*	TUESDAY *Poalua*	WEDNESDAY *Poakolu*	THURSDAY *Poaha*	FRIDAY *Poalima*	SATURDAY *Poaono*
6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6



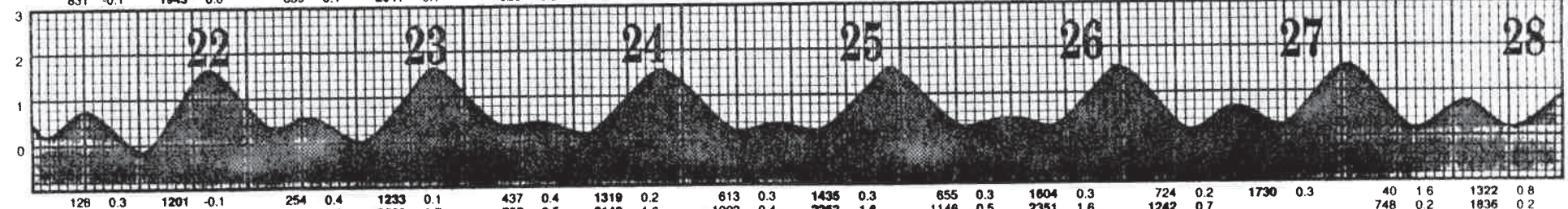
236	1.9	1443	1.0	308	1.8	1515	1.1	333	1.8	1550	1.2	402	1.7	1622	1.3	427	1.5	1701	1.4	452	1.4	1739	1.5	524	1.2	1825	1.6
925	0.2	2019	0.0	943	0.1	2057	0.0	1005	0.1	2136	0.1	1023	0.0	2218	0.1	1046	0.0	2301	0.2	1109	0.0	2347	0.3	1134	0.0		



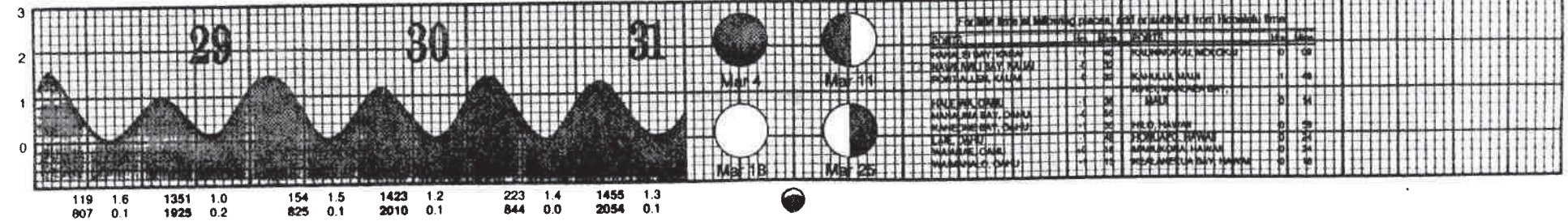
43	0.4	1203	0.0	200	0.5	1240	0.0	349	0.5	1326	0.0	551	0.4	1435	0.1	655	0.3	1601	0.1	730	0.2	1730	0.1	52	2.0	1321	0.8
549	1.0	1917	1.6	625	0.8	2023	1.7	710	0.8	2135	1.7	846	0.5	2253	1.8	1053	0.5	2357	1.9	1221	0.6			806	0.0	1839	0.0



139	2.0	1409	1.0	221	1.9	1453	1.3	303	1.8	1537	1.5	339	1.6	1619	1.7	417	1.4	1703	1.8	453	1.2	1749	1.8	21	0.2	1125	-0.2
831	-0.1	1943	0.0	859	-0.1	2041	-0.1	928	-0.2	2134	0.0	957	-0.2	2228	0.0	1026	-0.3	2323	0.1	1056	-0.2			525	1.0	1835	1.8



128	0.3	1201	-0.1	254	0.4	1233	0.1	437	0.4	1319	0.2	613	0.3	1435	0.3	655	0.3	1604	0.3	724	0.2	1730	0.3	40	1.6	1322	0.8
606	0.8	1931	1.7	648	0.6	2032	1.7	757	0.5	2142	1.6	1003	0.4	2253	1.6	1146	0.5	2351	1.6	1242	0.7			748	0.2	1836	0.2



119	1.6	1351	1.0	154	1.5	1423	1.2	223	1.4	1455	1.3
807	0.1	1925	0.2	825	0.1	2010	0.1	844	0.0	2054	0.1

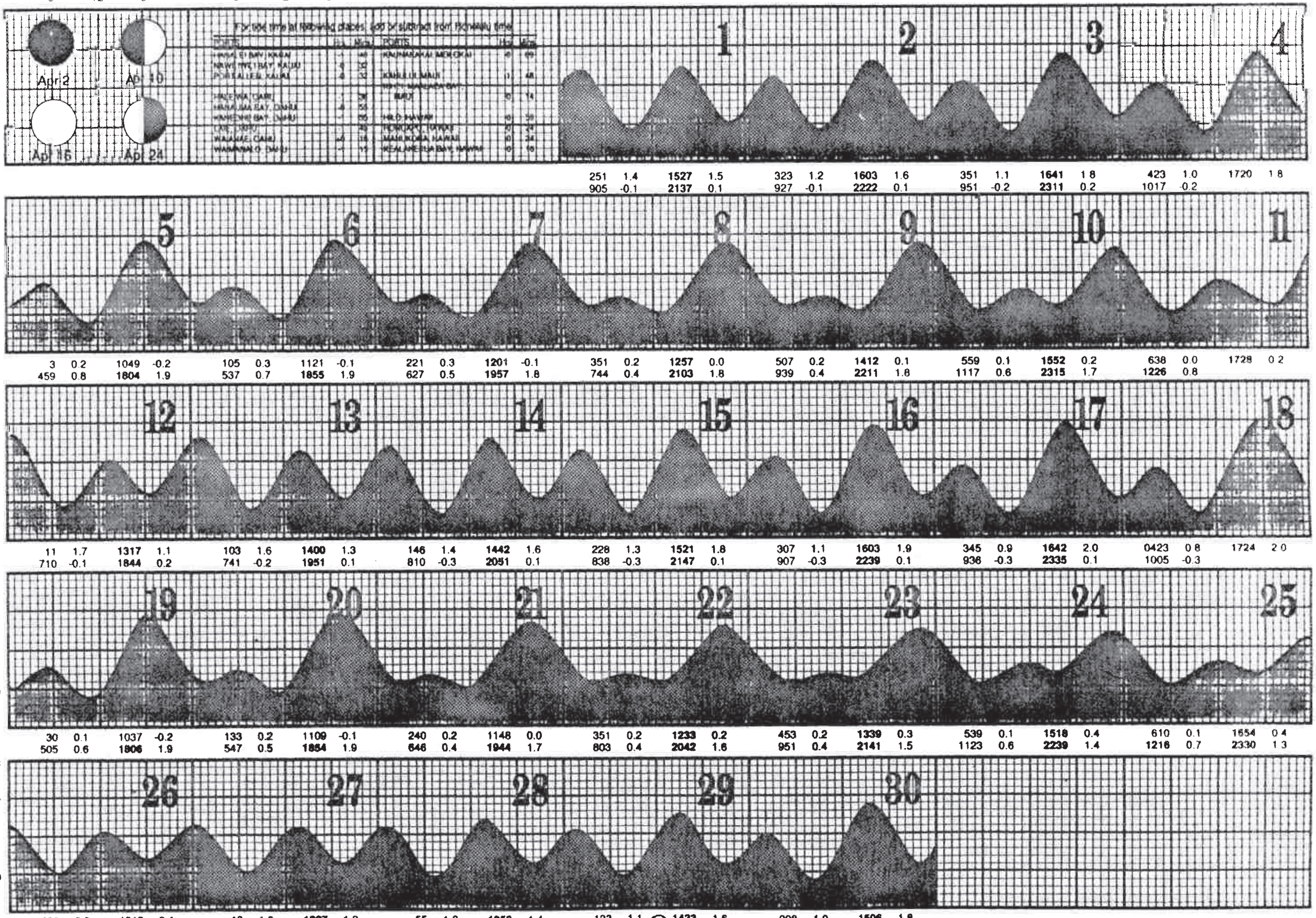
Tidal time at following places add or subtract from Honolulu time

PLACE	Hrs.	Min.	PLACE	Hrs.	Min.
HANA, E. MAUI, HAWAII	-1	30	KAUMALAPAU, MOLOKAI	0	09
KAHULUI BAY, MAUI	-5	30			
PORT ALLEN, KAUAI	-4	30	KAHULUI, MAUI	-1	48
			HONOLULU HARBOR		
HALEIWA, OAHU	-1	30	MAUI	0	14
MANUKAI BAY, OAHU	-4	30			
WAIKIKI BEACH, OAHU	-3	30	HILO, HAWAII	0	09
LEIE, OAHU	-3	30	KOHALA POINT, HAWAII	0	24
WAIANAE, OAHU	-4	30	KAILUA BAY, HAWAII	0	24
WAIMANALO, OAHU	-1	30	KEALAKEKUA BAY, HAWAII	0	09

Lemon Butterflyfish-Photo by Ed Robinson

April Apelila '92

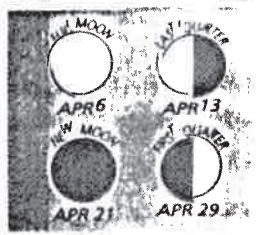
SUNDAY *Lapule* | MONDAY *Poakahi* | TUESDAY *Poalua* | WEDNESDAY *Poakolu* | THURSDAY *Poaha* | FRIDAY *Poalima* | SATURDAY *Poaono*

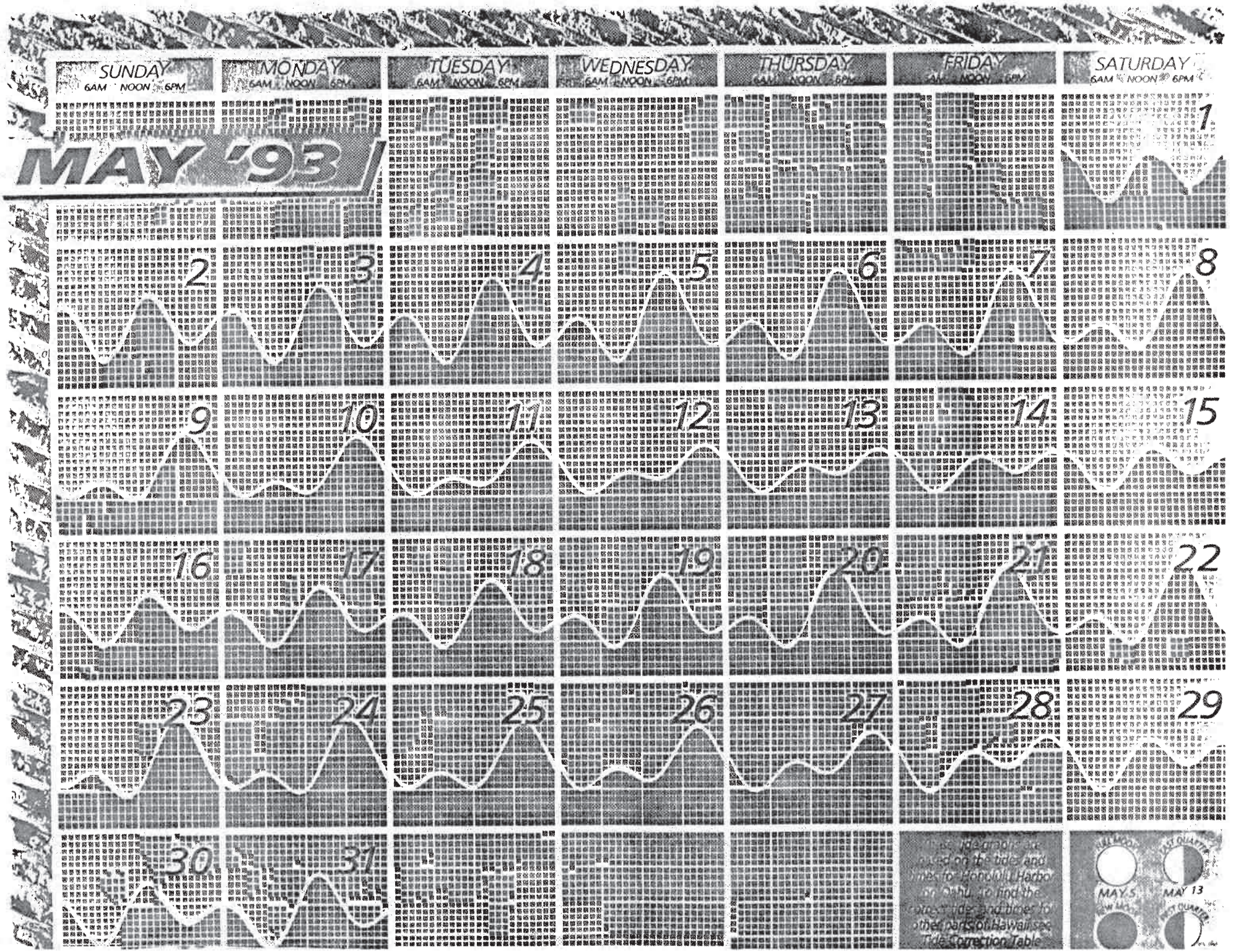


Date								
1	251	1.4	905	-0.1	1527	1.5	2137	0.1
2	323	1.2	927	-0.1	1603	1.6	2222	0.1
3	351	1.1	951	-0.2	1641	1.8	2311	0.2
4	423	1.0	1017	-0.2	1720	1.8		
5	3	0.2	459	0.8	1049	-0.2	1804	1.9
6	105	0.3	537	0.7	1121	-0.1	1855	1.9
7	221	0.3	627	0.5	1201	-0.1	1957	1.8
8	351	0.2	744	0.4	1257	0.0	2103	1.8
9	507	0.2	939	0.4	1412	0.1	2211	1.8
10	559	0.1	1117	0.6	1552	0.2	2315	1.7
11	638	0.0	1226	0.8	1728	0.2		
12	11	1.7	710	-0.1	1317	1.1	1844	0.2
13	103	1.6	741	-0.2	1400	1.3	1951	0.1
14	146	1.4	810	-0.3	1442	1.6	2051	0.1
15	228	1.3	838	-0.3	1521	1.8	2147	0.1
16	307	1.1	907	-0.3	1603	1.9	2239	0.1
17	345	0.9	936	-0.3	1642	2.0	2335	0.1
18	0423	0.8	1005	-0.3	1724	2.0		
19	30	0.1	505	0.6	1037	-0.2	1806	1.9
20	133	0.2	547	0.5	1109	-0.1	1854	1.9
21	240	0.2	646	0.4	1148	0.0	1944	1.7
22	351	0.2	803	0.4	1233	0.2	2042	1.6
23	453	0.2	951	0.4	1339	0.3	2141	1.5
24	539	0.1	1123	0.6	1518	0.4	2239	1.4
25	610	0.1	1216	0.7	1654	0.4	2330	1.3
26	636	0.0	1255	0.9	1810	0.4		
27	13	1.3	700	0.0	1327	1.2	1913	0.3
28	55	1.2	721	-0.1	1358	1.4	2006	0.3
29	133	1.1	745	-0.1	1433	1.6	2054	0.2
30	208	1.0	809	-0.2	1506	1.8	2144	0.2

APRIL '93

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
6AM NOON 6PM	6AM NOON 6PM	6AM NOON 6PM	6AM NOON 6PM	6AM NOON 6PM	6AM NOON 6PM	6AM NOON 6PM
These tide graphs are based on the tides and times for Honolulu Harbor on Oahu. To find the correct tides and times for other parts of Hawaii see Tide Correction Table inside front cover.				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	




SUNDAY
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
6AM NOON 6PM
MAY '93
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
Tide graphs are based on the tides and times for Honolulu Harbor on Oahu. To find the approximate tide times for other parts of Hawaii see Tide Correction Table
MAY 5
MAY 13