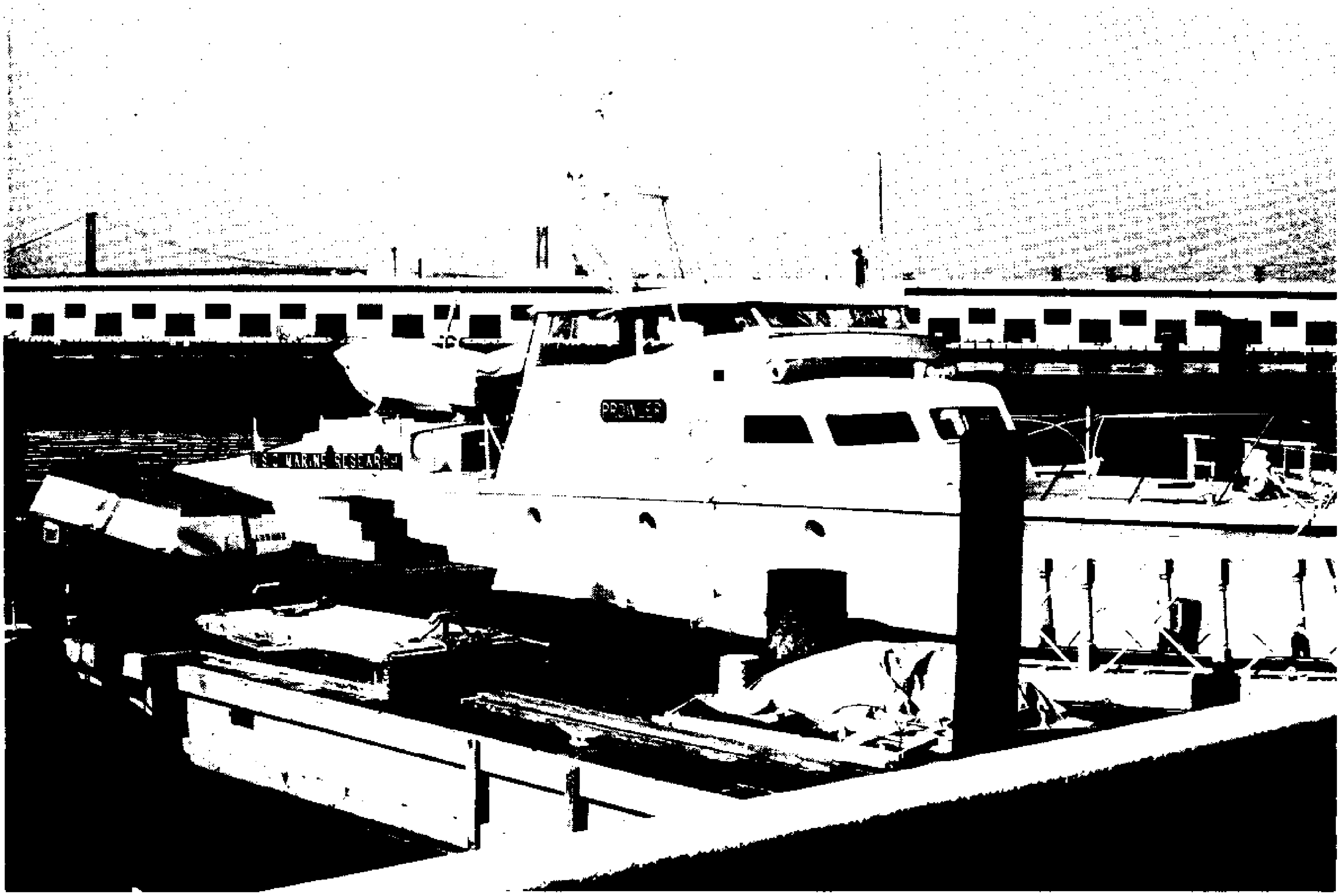
Marine Studies of San Pedro Bay, California

PART VI

CIRCULATION INVESTIGATIONS



Edited by
Dorothy F. Soule
and
Mikihiko Oguri

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Part VI, Circulation Investigations

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Current Measurements in the Outer Los Angeles Harbor

Kendal Robinson
and
Harold Porath

Allan Hancock Foundation
University of Southern California

MARINE STUDIES OF SAN PEDRO BAY, CALIFORNIA. PART VI.

CURRENT MEASUREMENTS IN THE OUTER LOS ANGELES HARBOR

by
Kendal S. Robinson
and
Harold Porath

Allan Hancock Foundation
University of Southern California
Los Angeles, California 90007

ABSTRACT: Surface currents in the Los Angeles Harbor were measured by three current meters. The main current producing forces appear to be tide and wind with the resulting current modified by the geometry of the basin. Current speeds were generally 0.1 to 0.2 knots at the surface and were more variable at stations near the outer breakwater than at stations near Terminal Island. A large counter-clockwise gyre was found during one period of observation, followed by a period of divergence in the same area one week later.

ACKNOWLEDGMENTS: The authors wish to thank Bruce Adams, Cary Dritz, Montgomery Lew, Paul Pyle, David Schomisch, and James McSweeney for their help with the field work. Our thanks go to Michael Fadley, Captain of the R/V Golden West, and Nicholas Condap, who did the computer programming. Thanks also to Jeffrey Naumann of the Los Angeles Harbor Department, who helped in many ways. Special thanks to Mikihiko Oguri and Dr. Dorothy Soule, who read the manuscript and made many suggestions.

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Cover photograph by John Soule

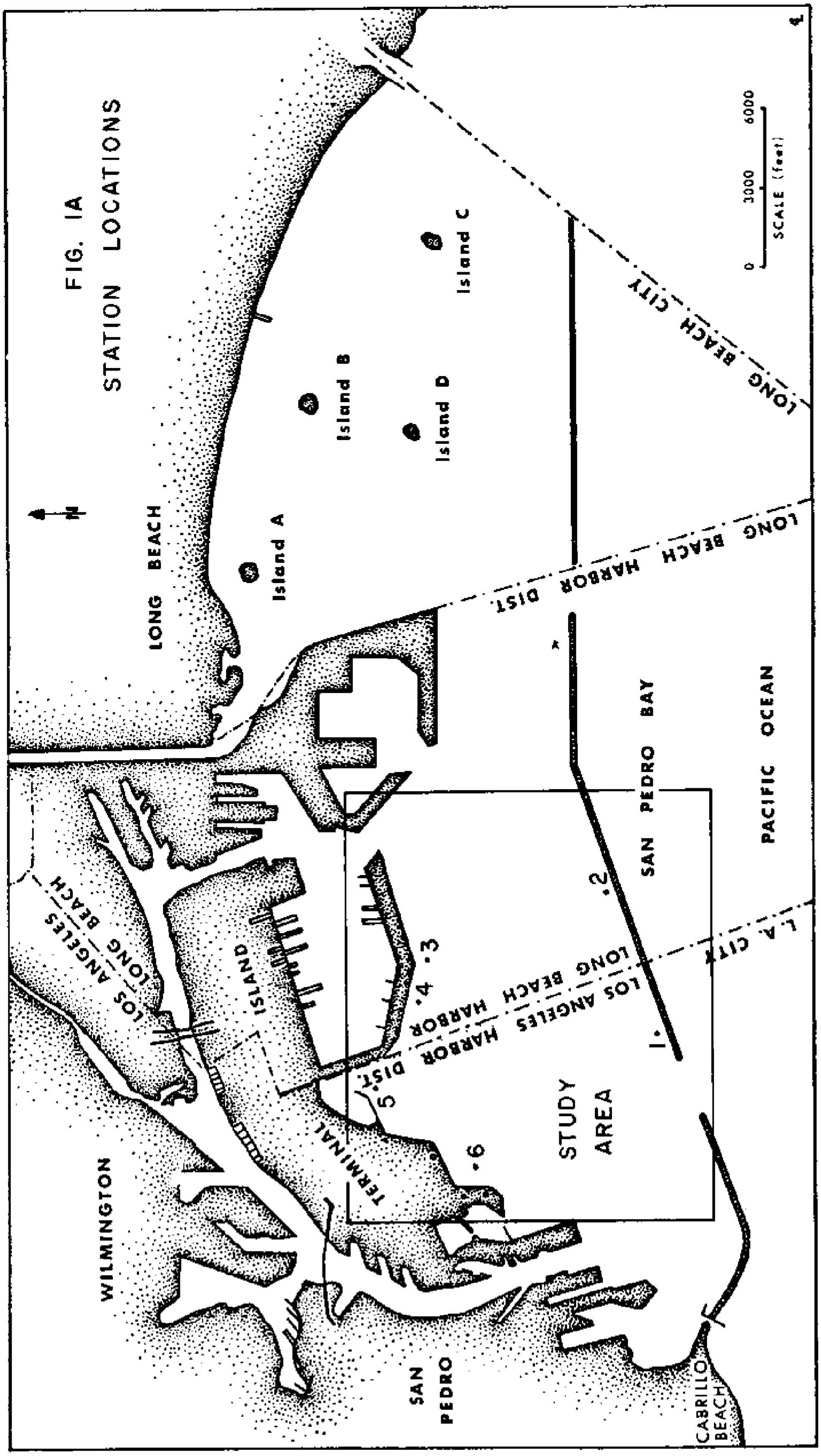
FIG. 1A
STATION LOCATIONS
N
LONG BEACH
Island A
Island B
Island C
Island D
0
3000
6000
SCALE (feet)
LONG BEACH CITY
LONG BEACH HARBOR DIST
SAN PEDRO BAY
PACIFIC OCEAN
LOS ANGELES LONG BEACH
TERMINAL
ISLAND
LONG BEACH HARBOR DIST
LOS ANGELES HARBOR DIST
L.A. CITY
STUDY
AREA
1
2
3
4
5
6
WILMINGTON
SAN
PEDRO
CABRILLO
BEACH

CURRENT MEASUREMENTS IN THE OUTER LOS ANGELES HARBOR

INTRODUCTION. As part of a study to determine the impact of a proposed liquid natural gas terminal in the Los Angeles Harbor, an effort has been made to determine the currents in the outer Los Angeles Harbor (see Figure 1A). An understanding of the currents in the area is important since circulation and exchange with the coastal waters will influence the residence time and dilution of any pollutant that is introduced into the harbor.

The needs of public agencies for information is also pressing, because the planning for future harbor development includes deepening of channels and alternative land fill configurations. Decisions made without additional field data will be poorly based, and the dearth of sufficient actual field measurements in the past has led to compounding rather than solving some problems. Studies are being continued at present, under the constraints of limited budgets and equipment, as a public service by Harbor Environmental Projects.

PROCEDURES. Starting in June 1973 current meters were placed in Los Angeles Harbor for periods of two days to nine days, in order to define the circulation in the outer harbor. In this study three Hydro-Products Model 505 in situ recording systems for current speed, direction and temperature were used. For the first three deployments (5-7 June, 13-19 June, 11-19 July) the meters recorded on Rustrak recorders. Later the current meters were modified and all subsequent records are on magnetic tape. As of this time only the data from the original three deployments have been analyzed. The locations of deployment are shown in Figure 1. Wind data, plotted hourly as a rose showing speed and direction, were obtained from a recorder located at the Los Angeles Harbor Pilot's Station. Unfortunately there were gaps in the wind data, because the pens were not regularly supplied with ink. The gusting of the winds also made the record somewhat difficult to read so that an average value was recorded for each hour.

The meters were anchored to the bottom with a 100 lb. concrete weight. From the weight, a ½ inch nylon line was attached to the base of the current meter, the length varying according to the depth at which the current meter was to be suspended. Another length of nylon line ran from the top of the meter to a subsurface float made from a 55 gal. drum filled with styrofoam. Another length of line ran from the subsurface float up to a small surface float. Attached to each current meter was a 27 khz, battery powered, pinger to assist in relocating the meters on occasions when the surface marking float was carried away.

The current meters were placed above the seasonal thermocline, usually about 12-15 feet beneath the surface. On one occasion a subsurface float was damaged and the current meter sank to the bottom in an upright, operating condition (1235 hrs., 17 July 1973 at the last mile marker on the inside of the Los Angeles breakwater).

DISCUSSION. Geostrophic calculations for flow cannot be used because the assumptions do not apply in shallow water. In shallow waters, such as the harbor, boundary conditions of friction, shape of the basin, winds, and tides are the major factors in establishing the patterns of water circulation (Jones, 1971).

Wind induced currents are not always to the right of the wind, as would be expected from Ekman's theory, but can be to the left, a condition that appears to be dictated by topography and slope currents (Johnson, 1970). The presence of a seasonal thermocline decouples the surface water from the water beneath and diminishes the downward flux of momentum (Holloman, 1970). The study of this effect will require placing two current meters in the same location, one above and one below the seasonal thermocline when it is well developed (Gaul and Stewart, 1960). This type of study will be done as soon as possible.

By neglecting geostrophic flow, two current producing forces remain that should dominate in the shallow waters of the harbor. The two forces are the tides and the winds, but the separation of these two forces can be difficult (Gaul and Stewart, 1960). When certain wind conditions are met, i.e., calm or of nearly constant velocity, it would be possible to get a general idea of the tidal component. Unfortunately, as of this time, these conditions have not been met during monitoring.

The winds off southern California are usually of the diurnal monsoon type; that is, on shore during the day and off shore at night, and of low velocity. This cycle can be seen in some of the data from Los Angeles harbor. Another type of wind that is less common but of higher velocity is the Santa Ana condition, which usually occurs in the late summer or early fall. This condition consists of a strong northerly to northeasterly wind which commonly lasts from two to three days. The final important wind stress would be that of the winter storms, which usually have a strong southeasterly wind associated with them. As of this time, there is insufficient information to define adequately the reaction of the harbor surface water to these various wind stresses.

The winds are displayed graphically, as roses, in Appendix Two. The inner ring represents ten miles per hour and the outer ring twenty miles per hour. It can be seen that the wind is generally less than ten miles per hour, and usually from the west (on June 17, 1973 no speed data was recorded; the data outside the twenty mile per hour ring indicated direction).

So far, little theoretical work has been done on wind induced current in shallow water (Jones, 1971).

The tide in the Los Angeles Harbor has diurnal and semi-diurnal components, and thus is a mixed tide, producing two highs and two lows each day. The tidal wave is in the form of a Kelvin wave, with maximum amplitude at the coastline and decreasing offshore. The effect the tide has on the currents is difficult to assess because of the masking effect of the wind.

The tide range was about 4½-5 feet during the 5-7 June deployment of the meters, and about 6-6½ feet during both the 13-19 June and 11-19 July deployments.

It has been possible, however, to see in a qualitative manner, which of the two major current producing forces seems to dominate in the outer harbor area at any given time. This was done by two sets of plots. One of these plots, given in Appendix Two, was in the form of current and wind roses in which both the wind and water currents were plotted at an instant in time (in this case, an hourly interval was used), showing both speed and direction. While this is less than completely satisfactory due to lag of wind effects at the air-water interface, it is useful if the wind is reasonably constant.

The other form of plots show current speed and direction in relation to the tide and are given in Appendix Three.

From the plots it was obvious that those stations near the breakwater in the outer harbor are more strongly influenced by tidal action than those near Terminal Island.

During the 5-7 June deployment, the main feature was a large counter-clockwise gyre, a feature also noted in Soule and Oguri, 1972, between the breakwater on the south and Terminal Island to the north (Figs. 1-3). At the time the wind was blowing from the west. It appears that the westerly wind may be responsible for this gyre. There are two possible explanations for this response to the wind by the harbor surface water.

The first explanation lies in the shape of the basin. The configuration of the harbor is such that the area approaching the breakwater has a considerably longer fetch than does the area near Fish Harbor entrance because of the obstruction by Reservation Point. This causes the current near the breakwater to be driven faster, resulting in a shear effect that could be responsible for the gyre.

A second possible explanation is that increased wind drag over warm surface waters that have been displaced to the right of the wind, causes a shear to be developed, as reported by Emery and Csanady (1973). The smallest example cited by those authors was larger than the Los Angeles Harbor by an order of magnitude. Since a review of surface temperature data has revealed no significant temperature differences, it seems likely that the first possibility, namely harbor configuration, is the primary cause of the gyre circulation pattern.

During the 13-19 June deployment, a different pattern was evident. At the stations along the inside of the breakwater, a fairly well developed divergence appeared (Figs. 4-10). The winds at that time were less constant in direction and slightly weaker than the 5-7 June period. The effect of the tide was more pronounced at the breakwater, however, and there was also some tidal effect at the station by the seaplane anchorage. This is understandable because the tidal ranges were greater during the 13-19 June period than during the 5-7 June period. The current speeds in the area of the seaplane anchorage were nearly as great as those near the breakwater.

During the 11-19 July period, the winds were more variable and the tide range was greater than during the 5-7 June period. The tide seemed to be the major determinant of currents during that period also.

In general, for all three deployment periods, most values for current speed fall between 0.1 and 0.2 knots (0.17-0.34 feet per second). Only by the breakwater do values exceed 0.2 knots for more than a short period of time.

At the east mile marker station on 17 July at 1235 hours, the 55 gallon drum supporting the current meter was sunk and the current meter sank to the bottom in about 50 feet of water in an upright, operating condition. The event appeared quite clearly as a sharp drop in temperature on the graph shown in Appendix Three. It can be seen that after this event occurred only one value exceeded 0.1 knot (0.17 feet per second) and most are closer to 0.05 knots (0.08 feet per second) (Figs. 18 and 19).

CONCLUSIONS. To date, there is insufficient information to define the reaction of the harbor currents to all tide and wind conditions clearly. However, it can be established that the currents are usually between 0.1 and 0.2 knots. The currents by the breakwater are somewhat stronger, with a high value of 0.80 knots at the west mile marker, but more are variable in direction. The variability in direction of the currents by the breakwater may be a function of increased tidal influence at those stations. It should be noted that the meter that was sunk did not show variability of the bottom current, and also showed that the bottom current there averaged only about 0.05 knots (0.08 feet per second).

At present there are not enough data to explain the divergence that is evident along the breakwater for much of the 11-19 July deployment.

When the wind seems to be the major current producing factor, the current speed appears to be about one one-hundredth of the wind speed.

The geometry of Los Angeles Harbor appears to be exerting a large influence on circulation pattern. The presence of obstructions tend to channel and restrict the wind and tidal forces; an example is the obstruction of the west wind by Reservation Point. The breakwater channels the tidal current to some extent, with free access through Angel's Gate, Queen's Gate and through the entrance to Long Beach Harbor east of the Long Beach breakwater.

The high values for current speed in the area of the seaplane anchorage may be caused by the presence of the small mole around the anchorage which channels the tidal current into and out of the anchorage. It should be noted that the sediment in this area is a hard sand, which indicates that a moderate current is sweeping fine material away.

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APPENDIX 1

STATION LOCATIONS

5-7 June 1973

WEST MILE MARKER OF LOS ANGELES BREAKWATER (Station 1)

Longitude	118 14'31" west
Latitude	33 42'45" north
Water depth	46 feet
Sensor depth	15 feet

5-7 June 1973

NAVY MOLE (Station 4)

Longitude	118 14'13" west
Latitude	33 44'25" north
Water depth	24 feet
Sensor depth	15 feet

5-7 June 1973

DISPOSAL AREA (Station 6)

Longitude	118 15'23" west
Latitude	33 43'59" north
Water depth	17 feet
Sensor depth	12 feet

13-19 June 1973

WEST MILE MARKER OF LOS ANGELES BREAKWATER (Station 1)

Longitude	118 14'31" west
Latitude	33 42'45" north
Water depth	46 feet
Sensor depth	15 feet

13-19 June 1973

EAST MILE MARKER OF LOS ANGELES BREAKWATER (Station 2)

Longitude	118 13'11" west
Latitude	33 43'11" north
Water depth	48 feet
Sensor depth	15 feet

13-19 June 1973

OUTSIDE SEAPLANE ANCHORAGE (Station 5)

Longitude	118 14'47" west
Latitude	33 44'42" north
Water depth	17 feet
Sensor depth	12 feet

11-19 July 1973

EAST MILE MARKER OF LOS ANGELES BREAKWATER (Station 2)

Longitude	118 13'11" west
Latitude	33 43'11" north
Water depth	48 feet
Sensor depth	15 feet

11-19 July 1973

BEND IN NAVY MOLE (Station 3)

Longitude	118 13'42" west
Latitude	33 44'22" north
Water depth	46 feet
Sensor depth	15 feet

APPENDIX 2

SURFACE WIND AND CURRENT PLOTS

On the following graphs the inner circle of the wind rose represents ten miles per hour, and the outer circle twenty miles per hour. The inner circle of the current rose is equal to 0.1 knots, and the outer circle is equal to 0.2 knots.

5-7 JUNE 1973

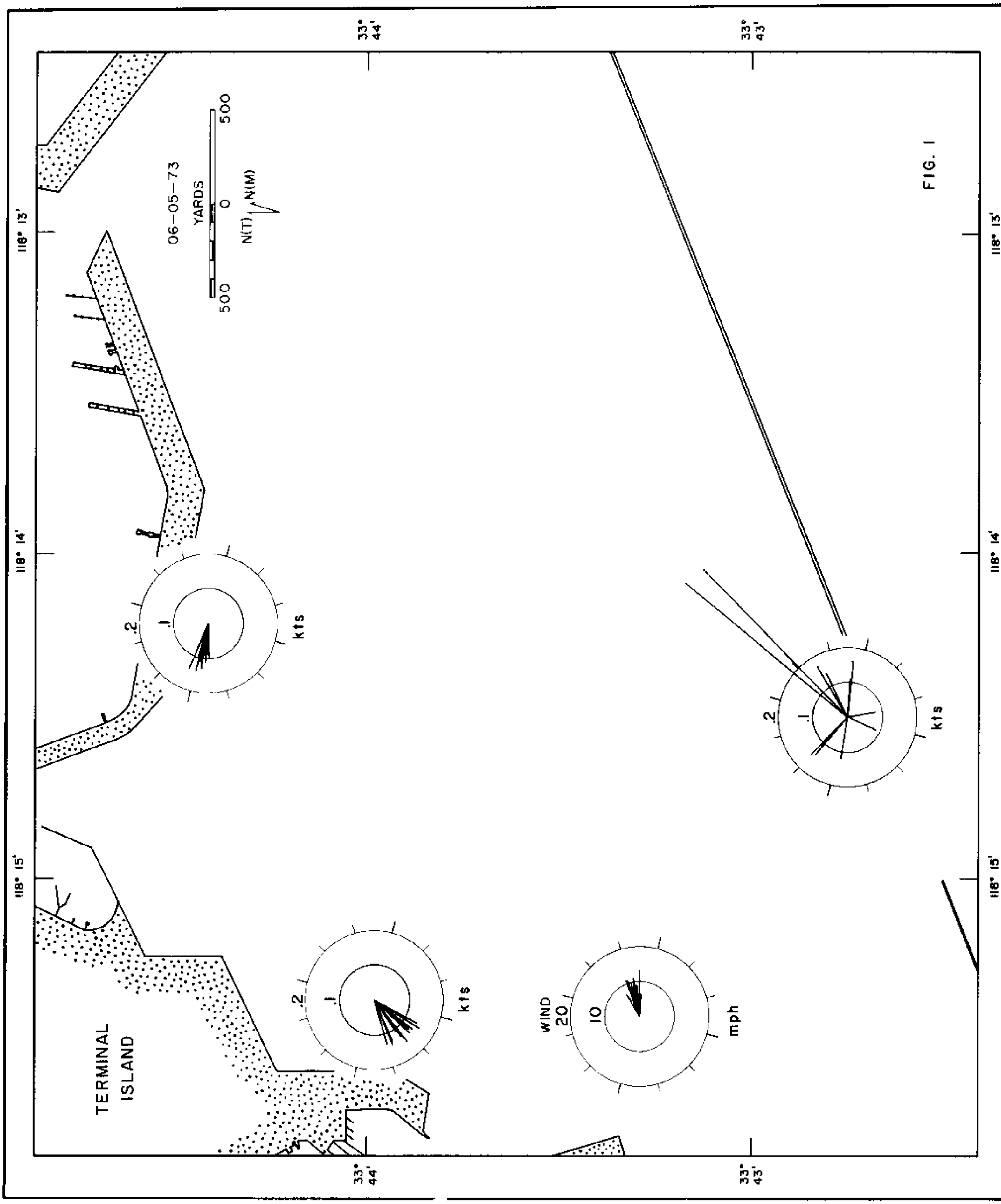

06-05-73
YARDS
500 0 500
N(T) N(M)
TERMINAL ISLAND
kts
.1
.2
WIND
20
10
mph
118° 13'
118° 14'
118° 15'
33° 44'
33° 43'

FIG. 1

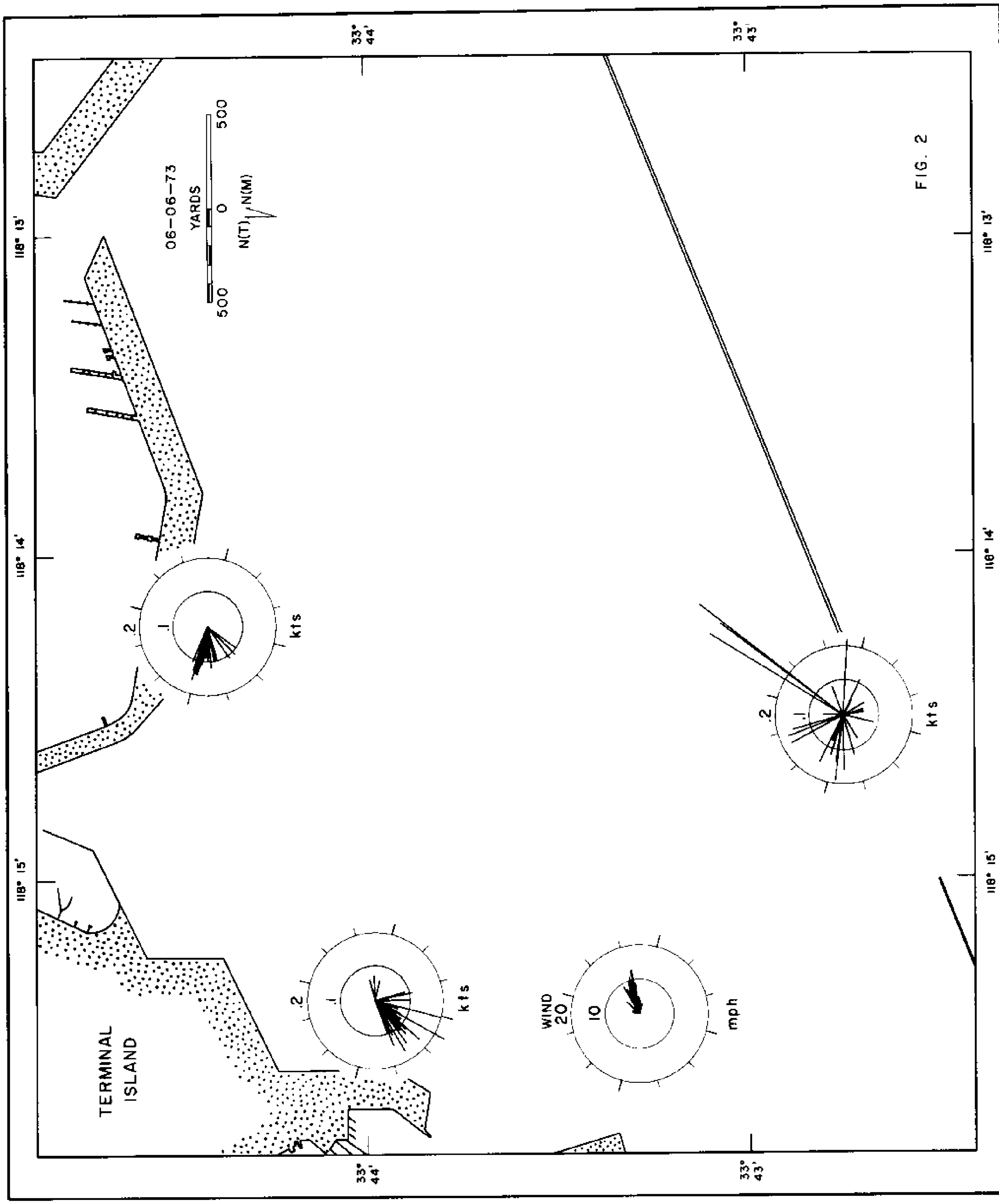

06-06-73
YARDS
500 0 500
N(T) N(M)
118° 13'
118° 14'
118° 15'
33° 44'
33° 43'
TERMINAL ISLAND
2
1
kts
WIND
20
10
mph

FIG. 2

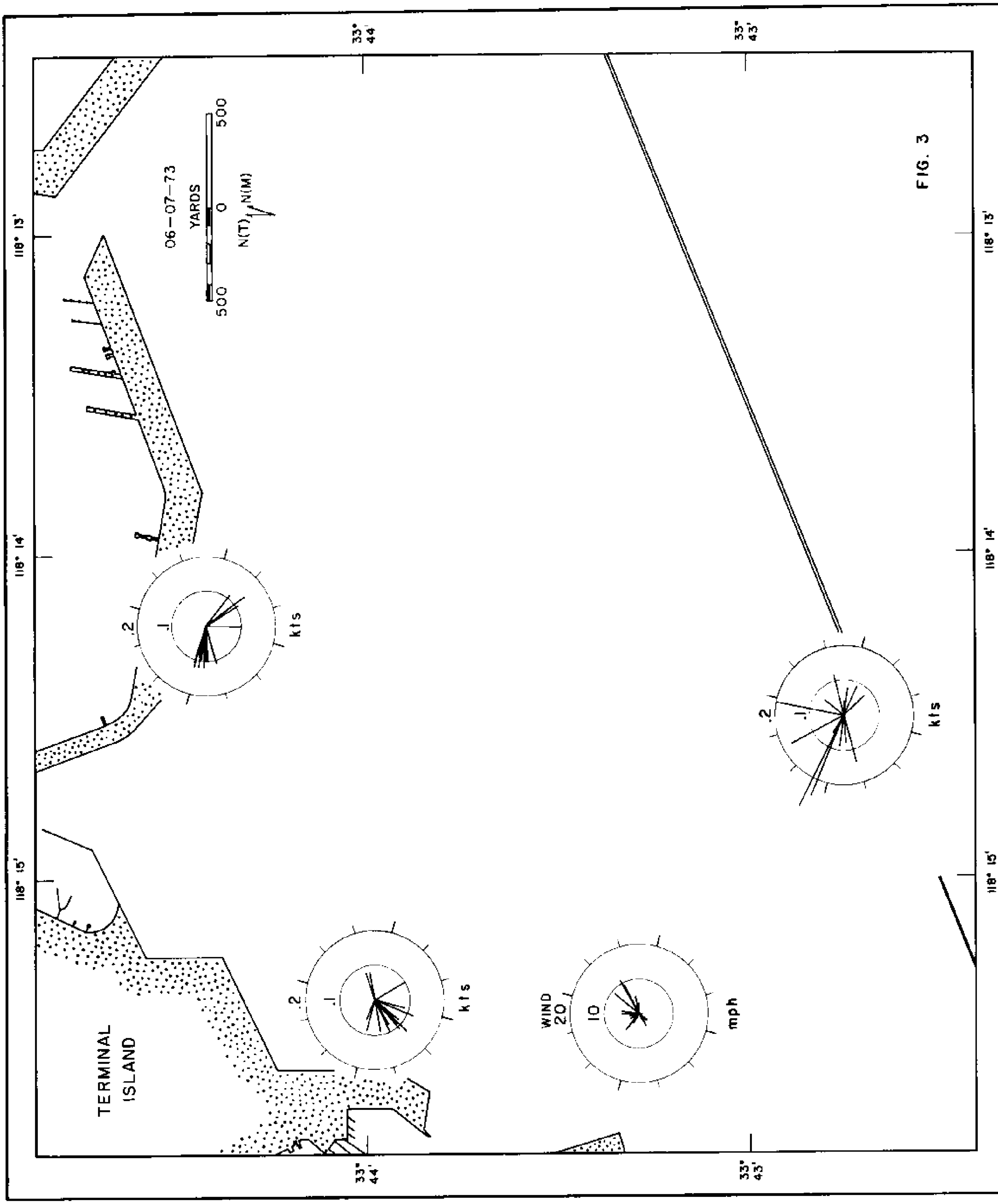

06-07-73
YARDS
500 0 500
N(T) N(M)
TERMINAL ISLAND
WIND
20
10
mph
.1
.2
kts
118° 13'
118° 14'
118° 15'
33° 44'
33° 43'

FIG. 3

13-19 JUNE 1973

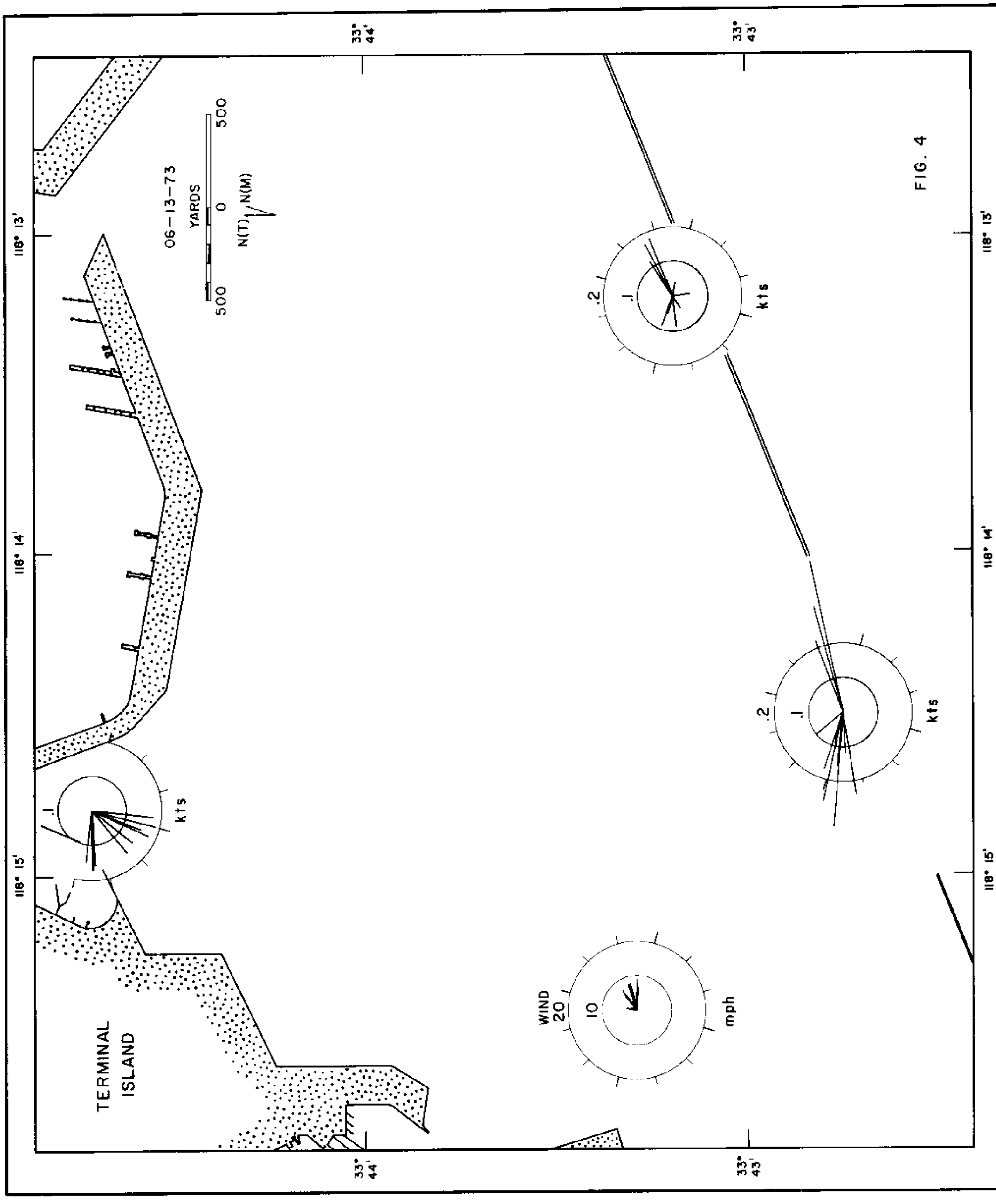
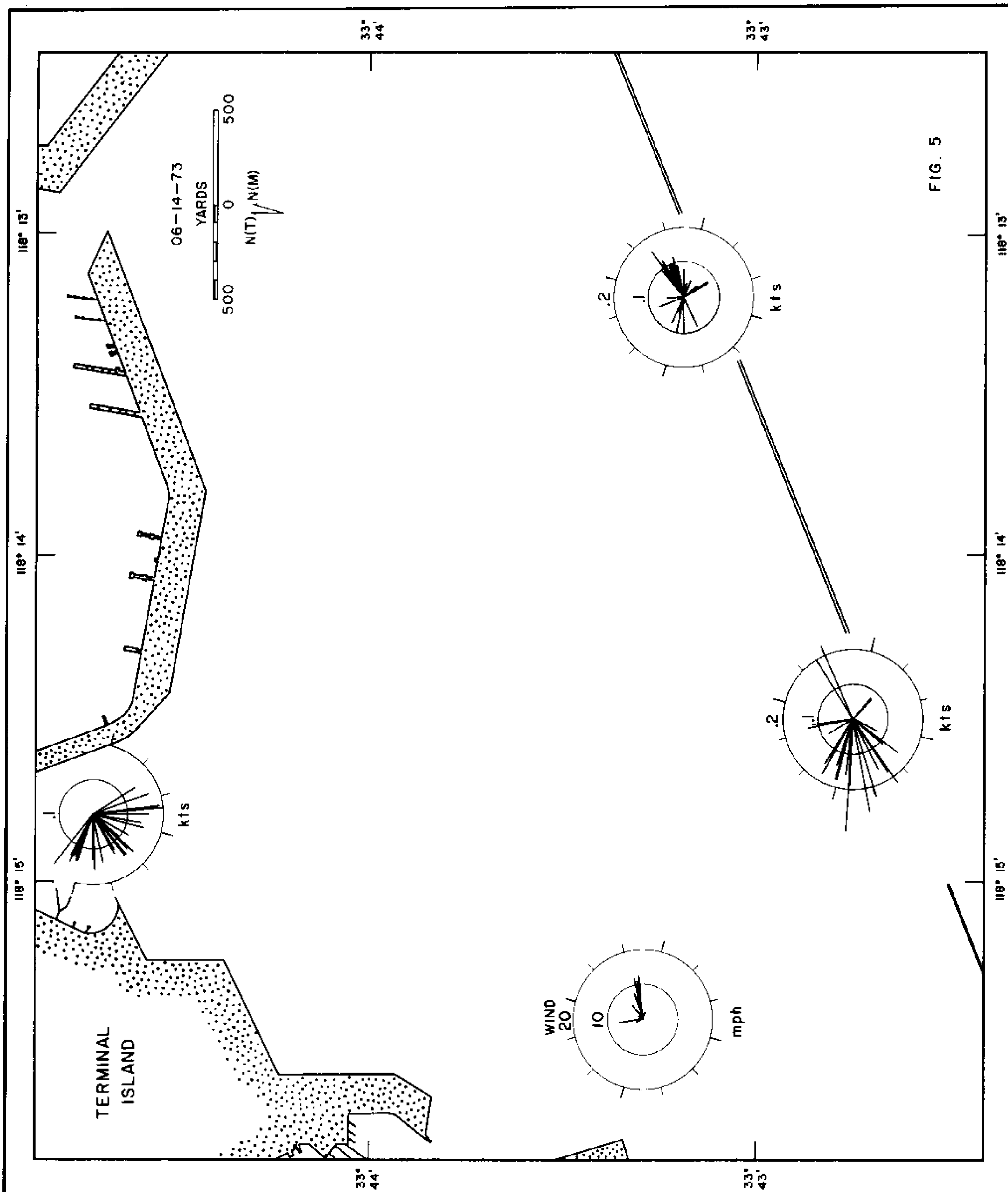

06-13-73
YARDS
500 0 500
N(T) N(M)
118° 13'
118° 14'
118° 15'
33° 44'
33° 43'
.2
.1
kts
WIND
20
10
mph
TERMINAL ISLAND

FIG. 4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YARDS
500 0 500
N(T) N(M)
TERMINAL ISLAND
WIND
20
10
mph
kts
.1
.2
118° 13'
118° 14'
118° 15'
33° 44'
33° 43'

FIG. 5

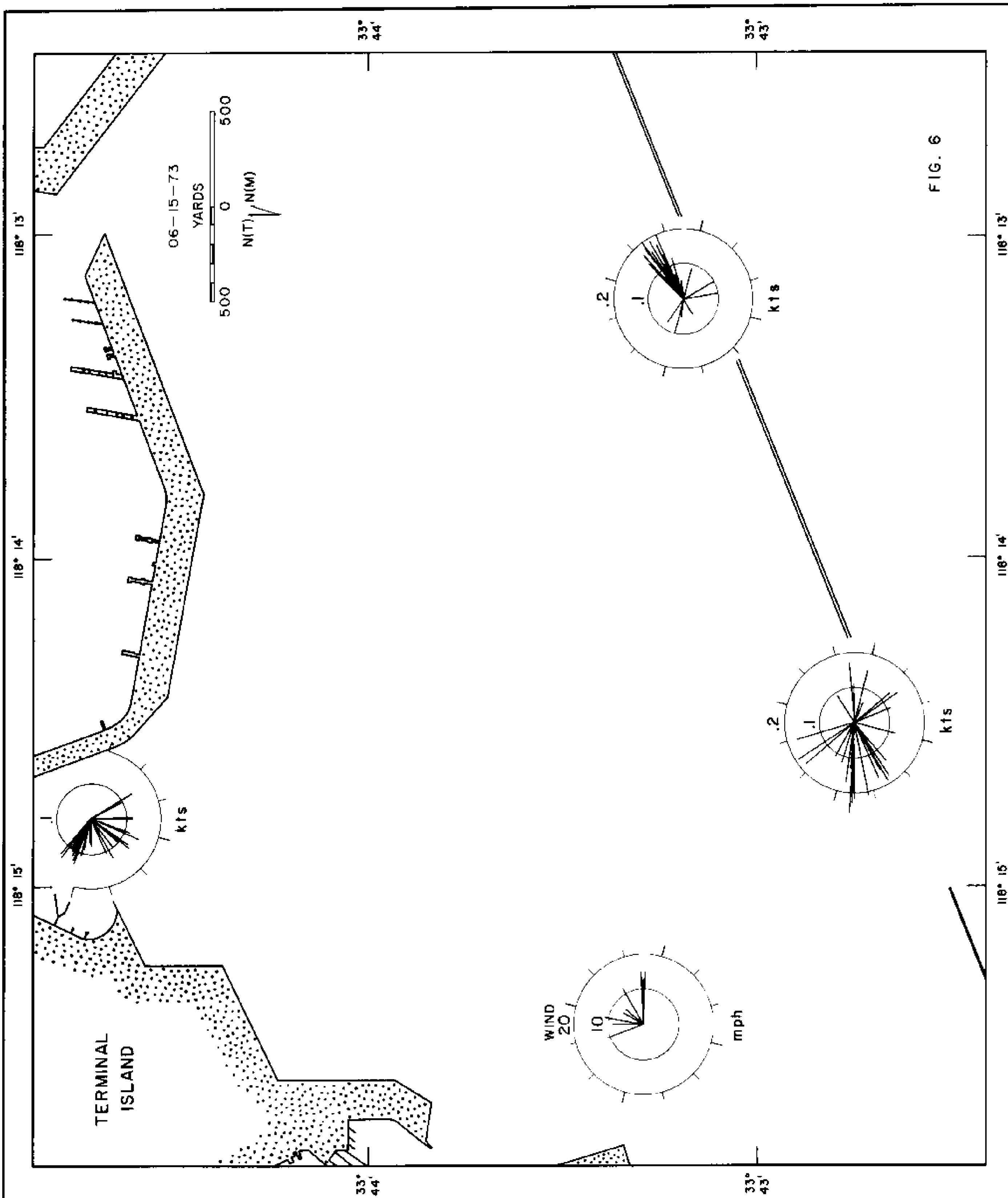

06-15-73
YARDS
500 0 500
N(T) N(M)
118° 13'
118° 14'
118° 15'
33° 44'
33° 43'
.1
.2
kts
WIND
20
10
mph
TERMINAL
ISLAND

FIG. 6

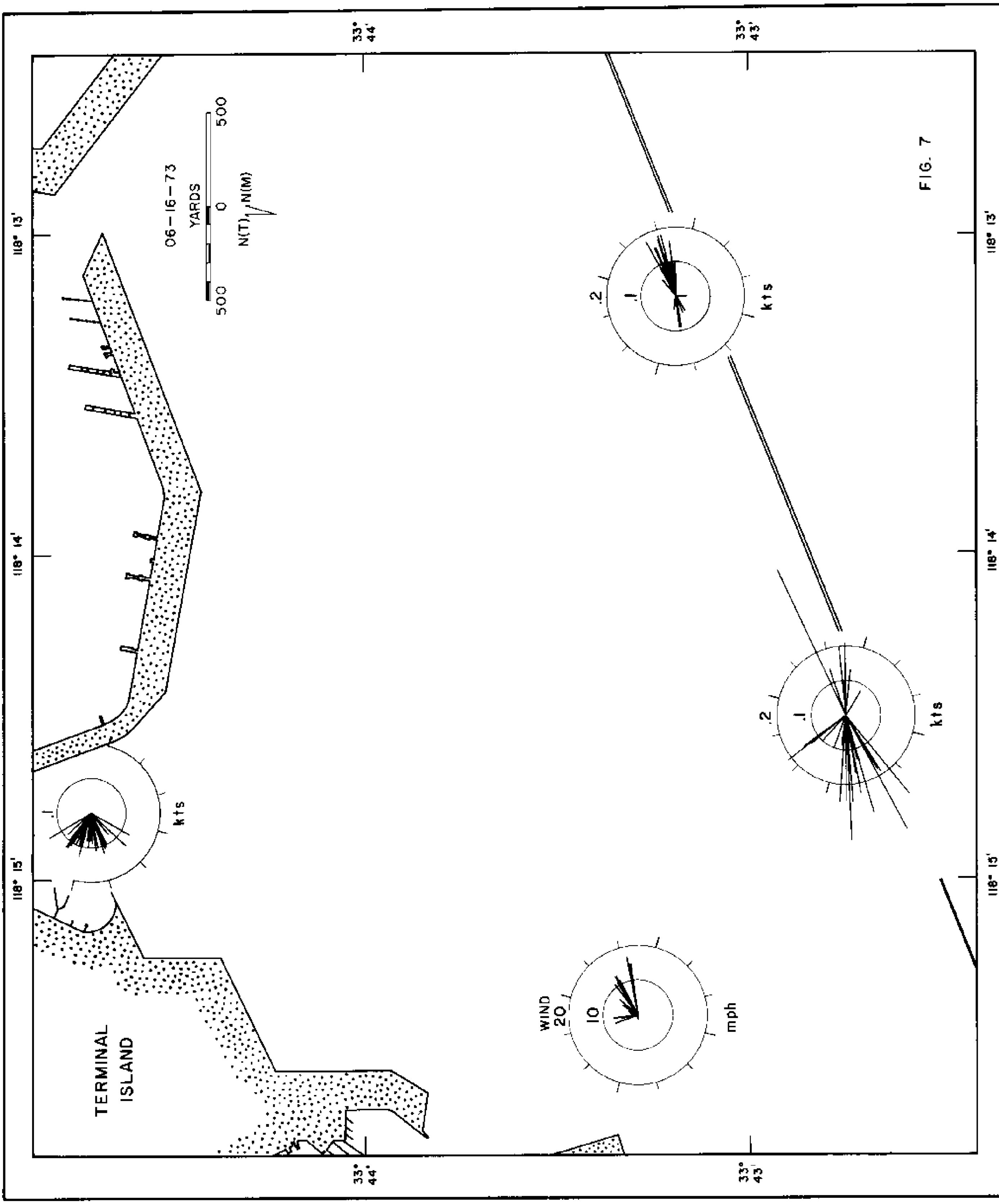

06-16-73
YARDS
500 0 500
N(T)
N(M)
33° 44'
33° 43'
118° 13'
118° 14'
118° 15'
.1
.2
kts
WIND
20
10
mph
TERMINAL ISLAND

FIG. 7

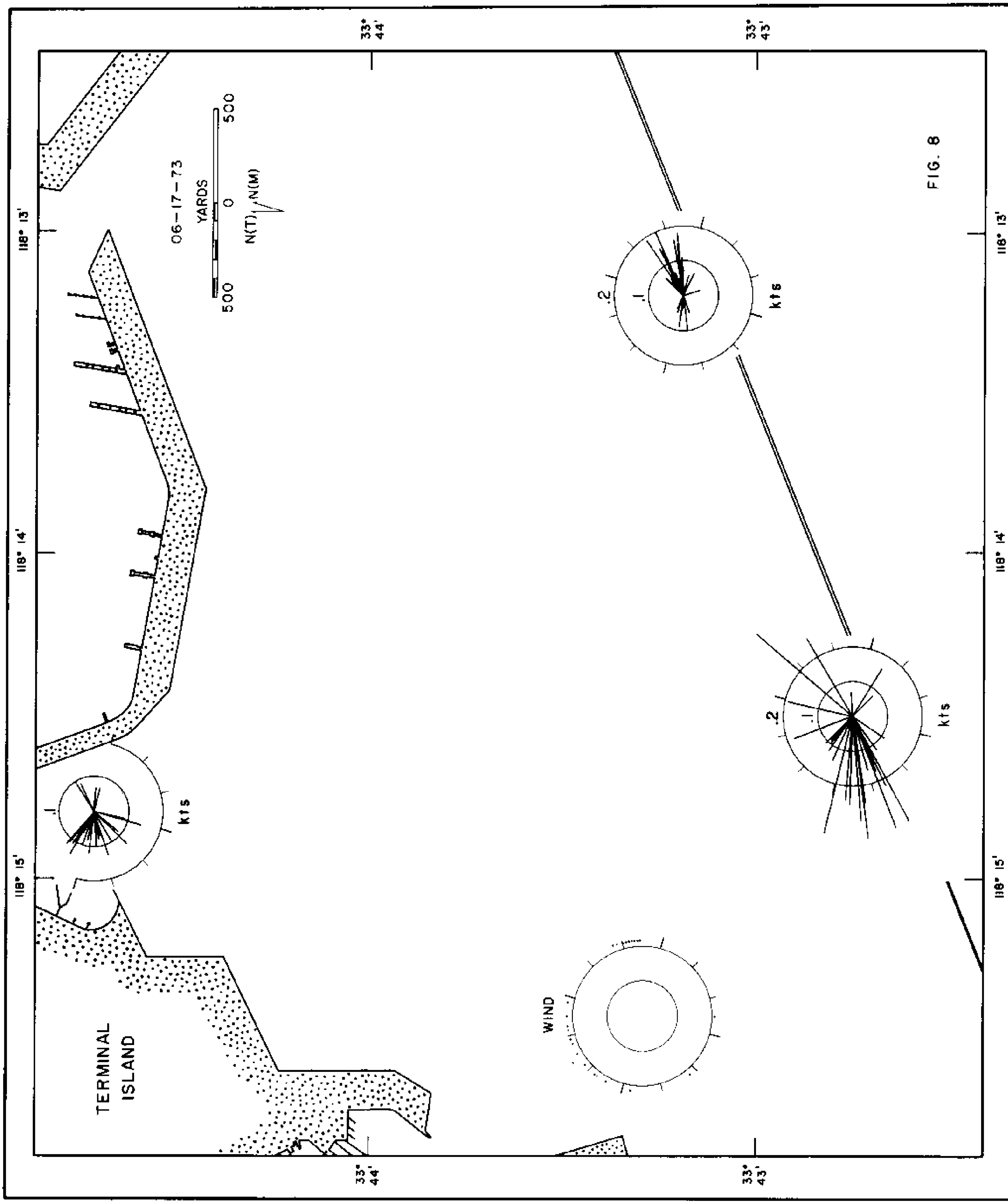

06-17-73
YARDS
500
0
500
N(T)
N(M)
118° 13'
118° 14'
118° 15'
33° 44'
33° 43'
.2
.1
kts
WIND
TERMINAL ISLAND

FIG. 8

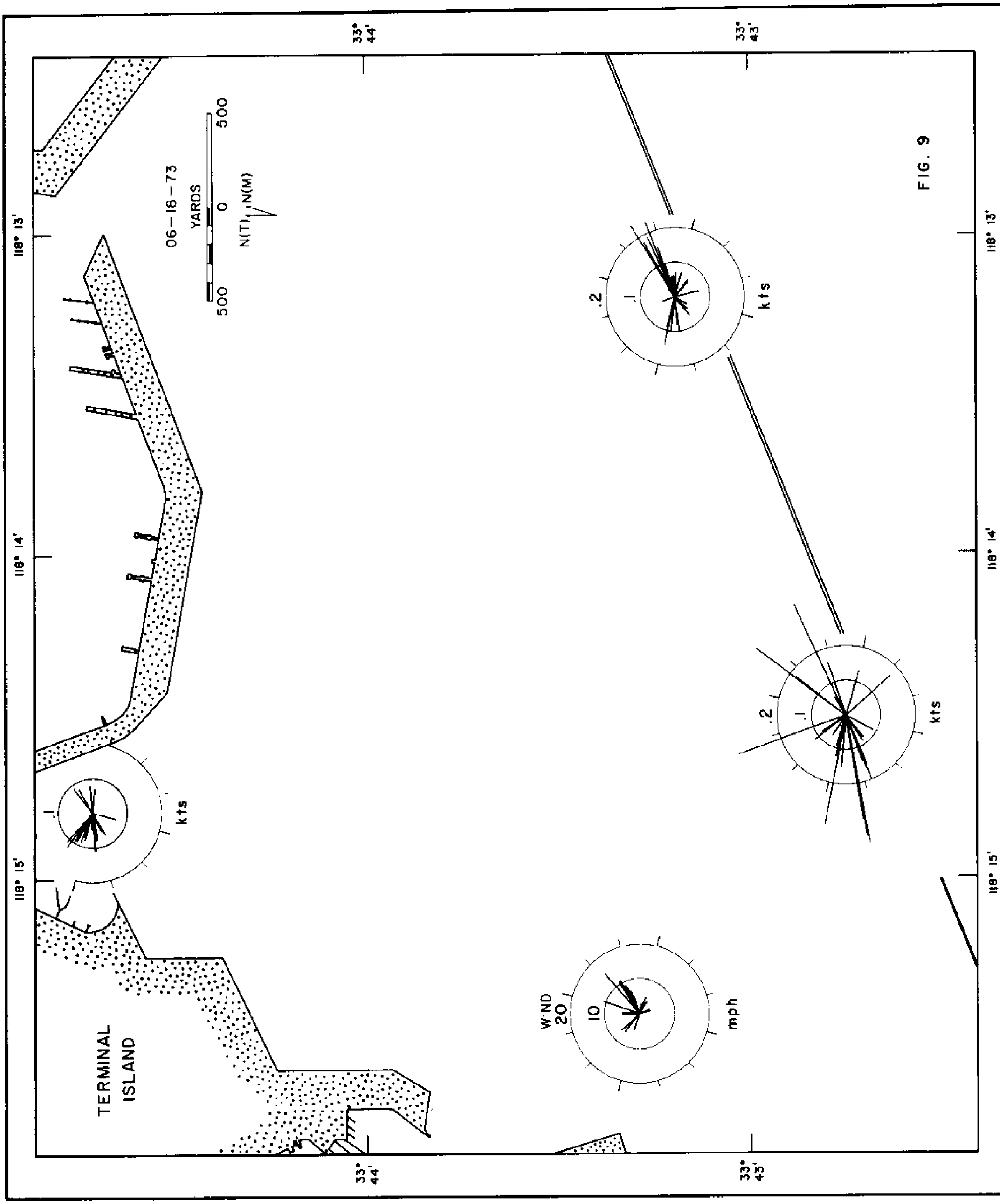

06-18-73
YARDS
500
0
500
N(T)
N(M)
33° 44'
33° 43'
118° 13'
118° 14'
118° 15'
.1
.2
kts
WIND
20
10
mph
TERMINAL ISLAND

FIG. 9

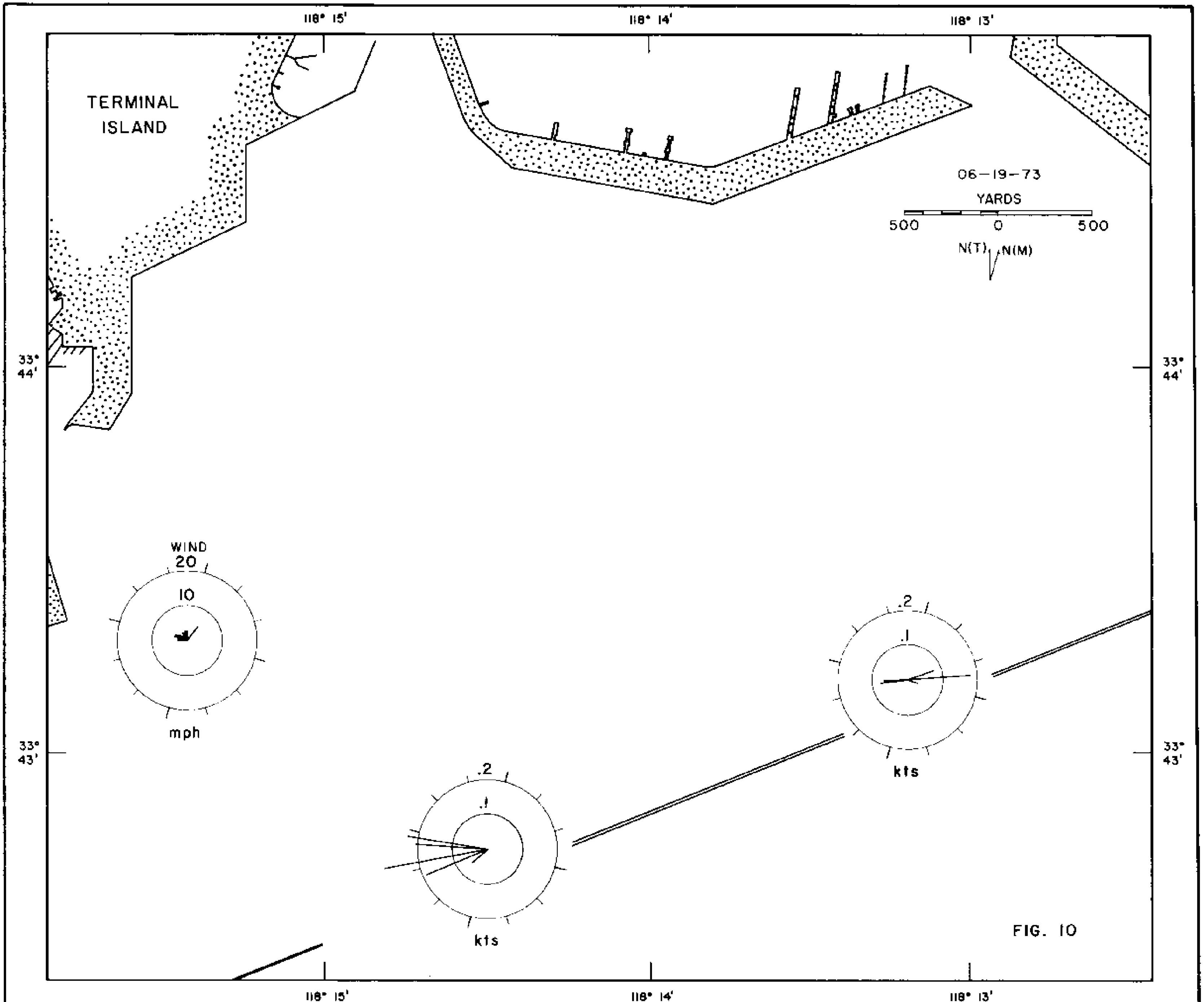

118° 15'
118° 14'
118° 13'
TERMINAL ISLAND
06-19-73
YARDS
500 0 500
N(T) N(M)
33° 44'
33° 43'
WIND
20
10
mph
.2
.1
kts
.2
.1
kts
118° 15'
118° 14'
118° 13'

FIG. 10

11-19 JULY 1973

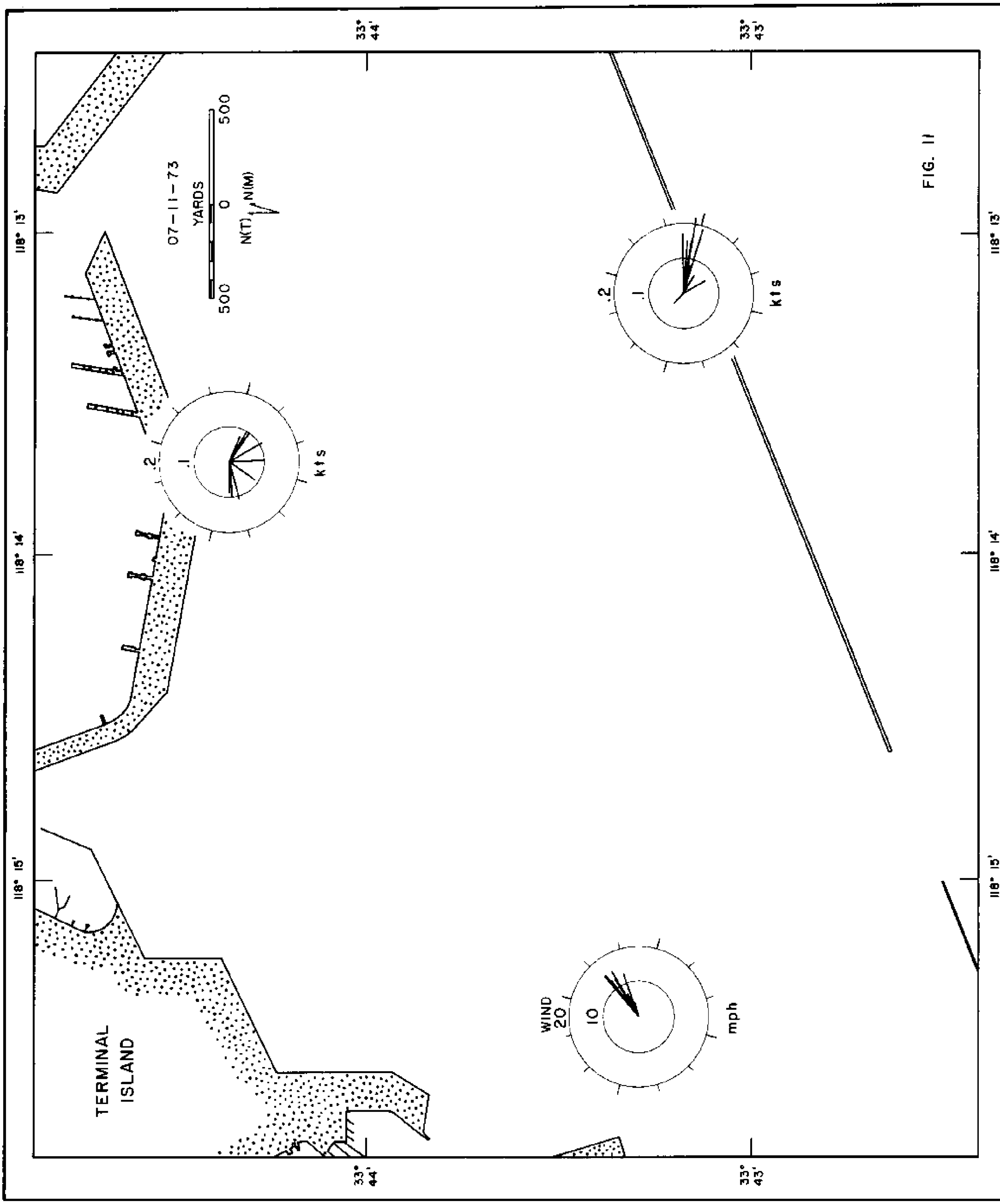
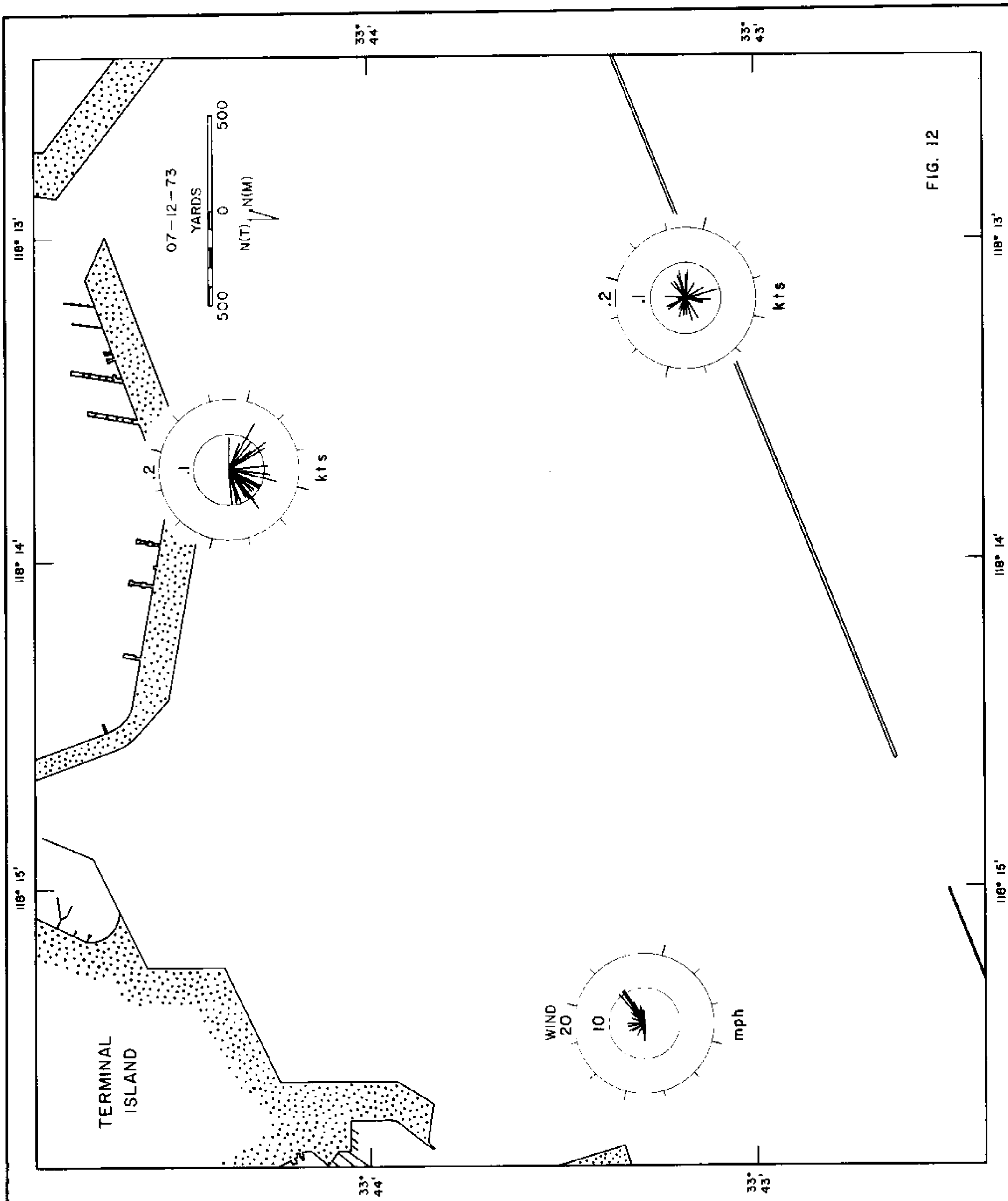
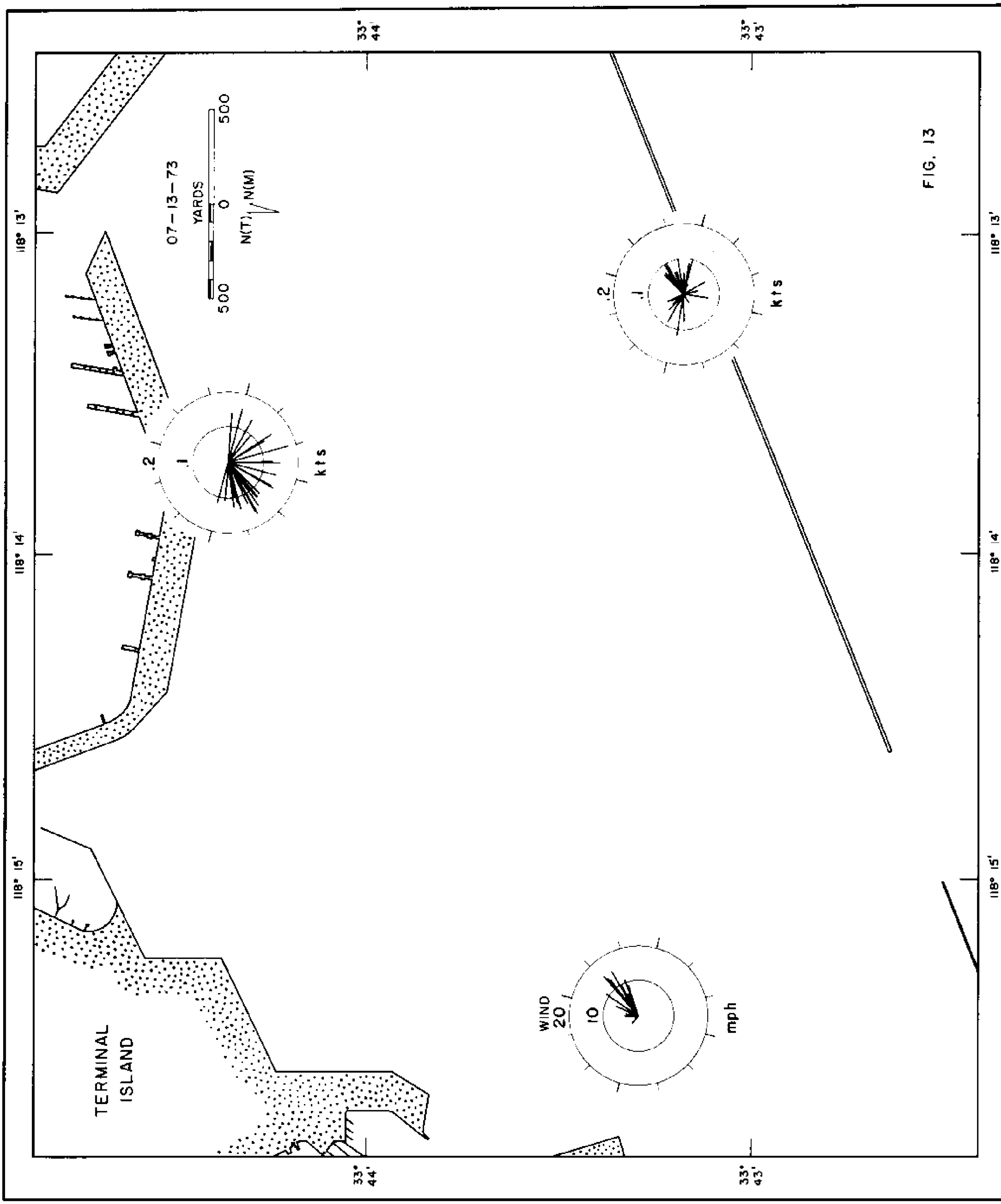

07-11-73
YARDS
500
0
500
N(T)
N(M)
TERMINAL
ISLAND
WIND
20
10
mph
.2
.1
kts
.2
.1
kts
118° 13'
118° 14'
118° 15'
33° 44'
33° 43'

FIG. 11



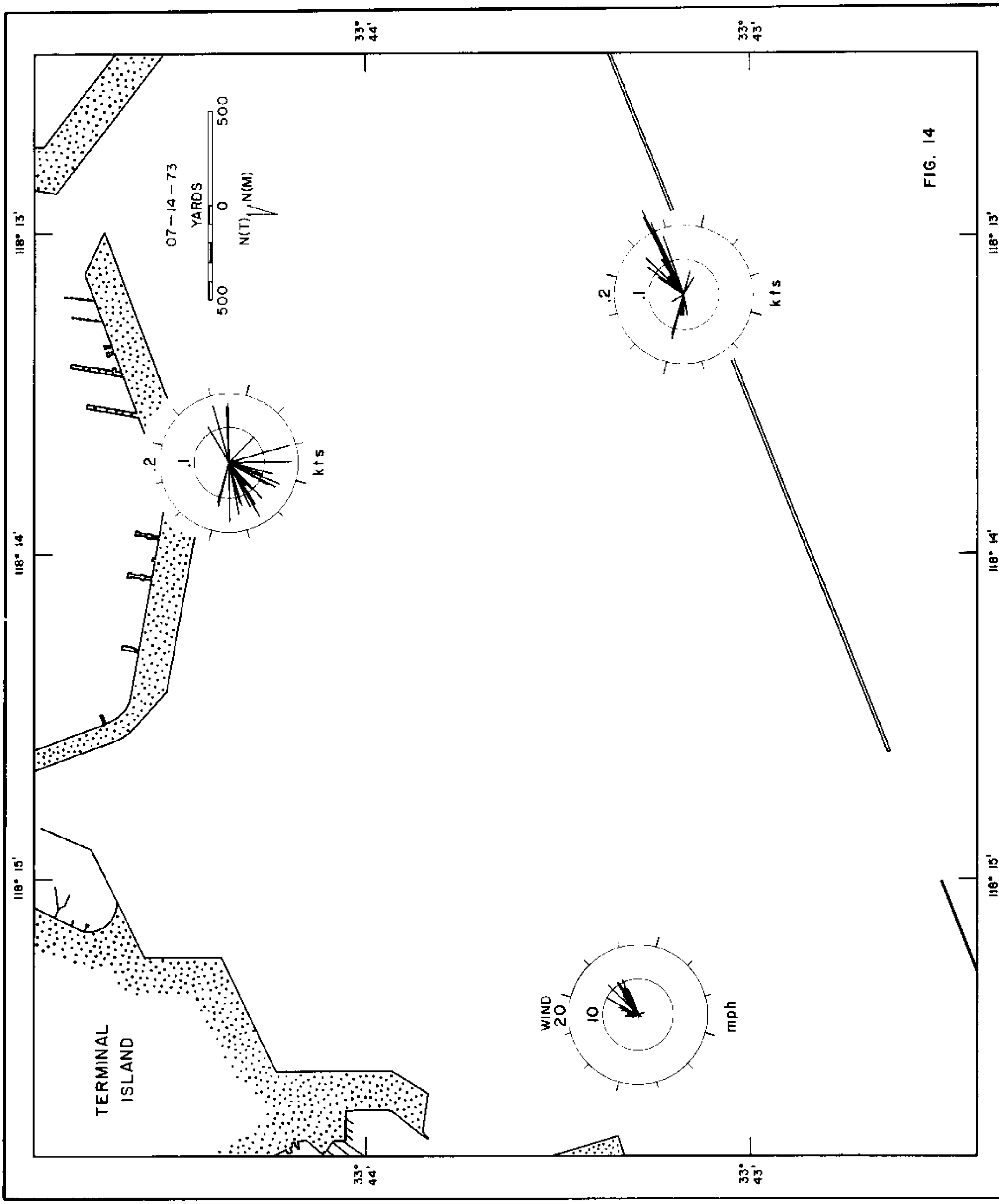
07 – 12 – 73
YARDS
500 0 500
N(T) N(M)
.2
.1
kts
WIND
20
10
mph
TERMINAL ISLAND
33° 44'
33° 43'
118° 13'
118° 14'
118° 15'

FIG. 12



07-13-73
YARDS
500
0
500
N(T)
N(M)
.2
.1
kts
.2
.1
kts
WIND
20
10
mph
TERMINAL
ISLAND
118° 13'
118° 14'
118° 15'
33° 44'
33° 43'

FIG. 13



33° 44'
33° 43'
118° 13'
118° 14'
118° 15'
07 – 14 – 73
YARDS
500
0
500
N(T)
N(M)
.2
.1
kts
.2
.1
kts
WIND
20
10
mph
TERMINAL ISLAND

FIG. 14

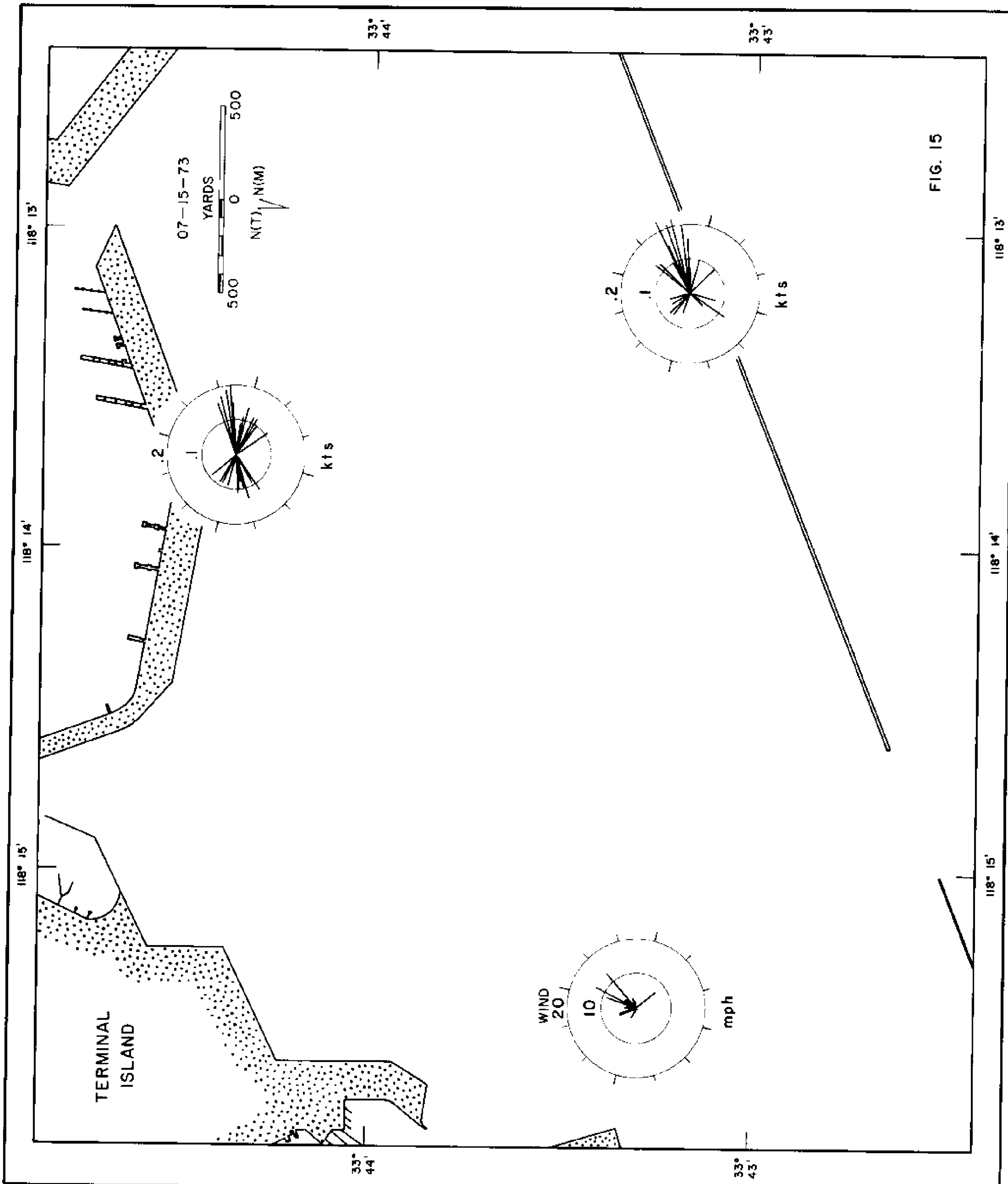

07-15-73
YARDS
500 0 500
N(T) N(M)
.2
.1
kts
.2
.1
kts
WIND
20
10
mph
TERMINAL
ISLAND
118° 13'
118° 14'
118° 15'
33° 44'
33° 43'

FIG. 15

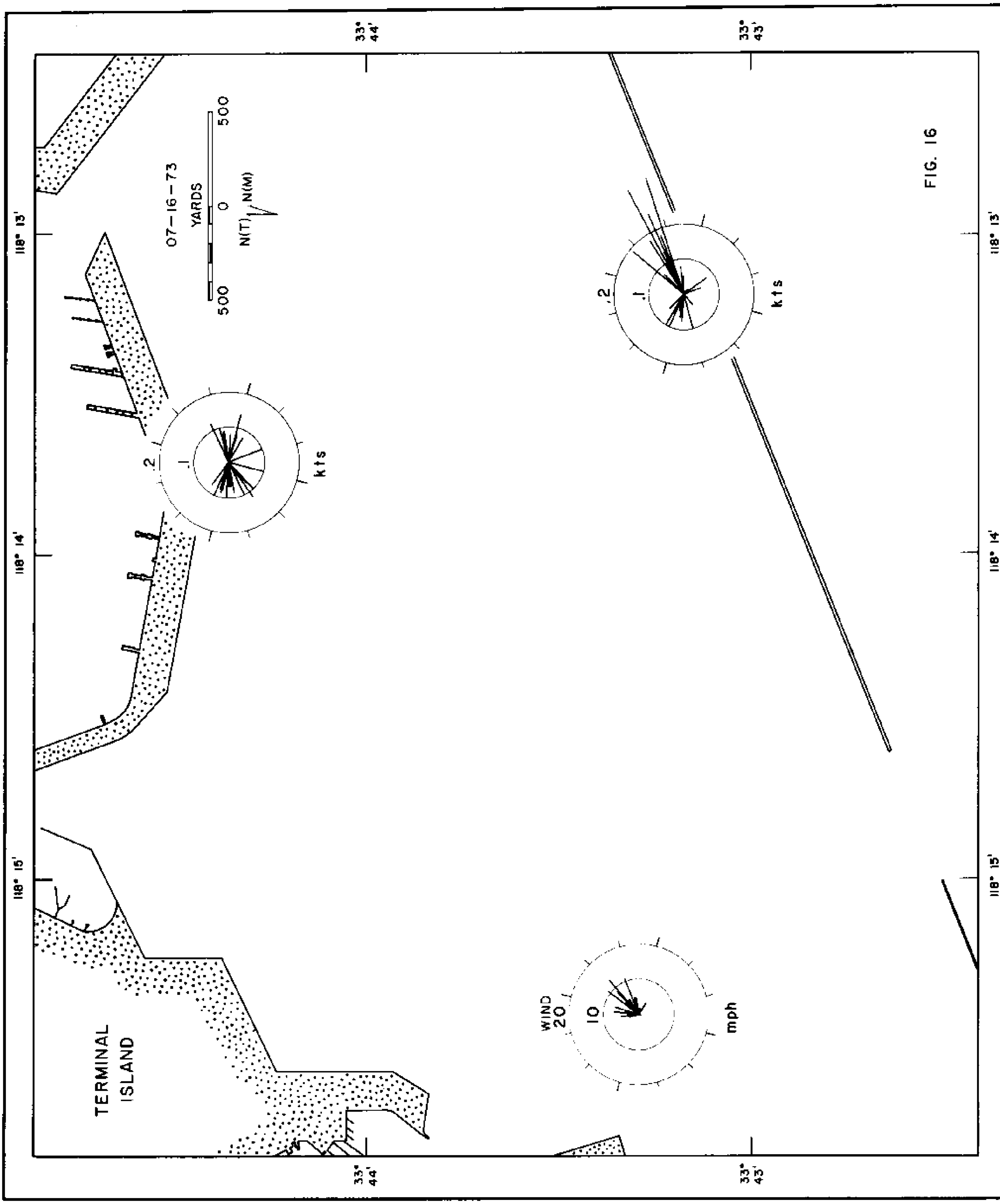

33° 44'
33° 43'
118° 13'
118° 14'
118° 15'
07-16-73
YARDS
500
0
500
N(T)
N(M)
.2
.1
kts
.2
.1
kts
WIND
20
10
mph
TERMINAL ISLAND

FIG. 16

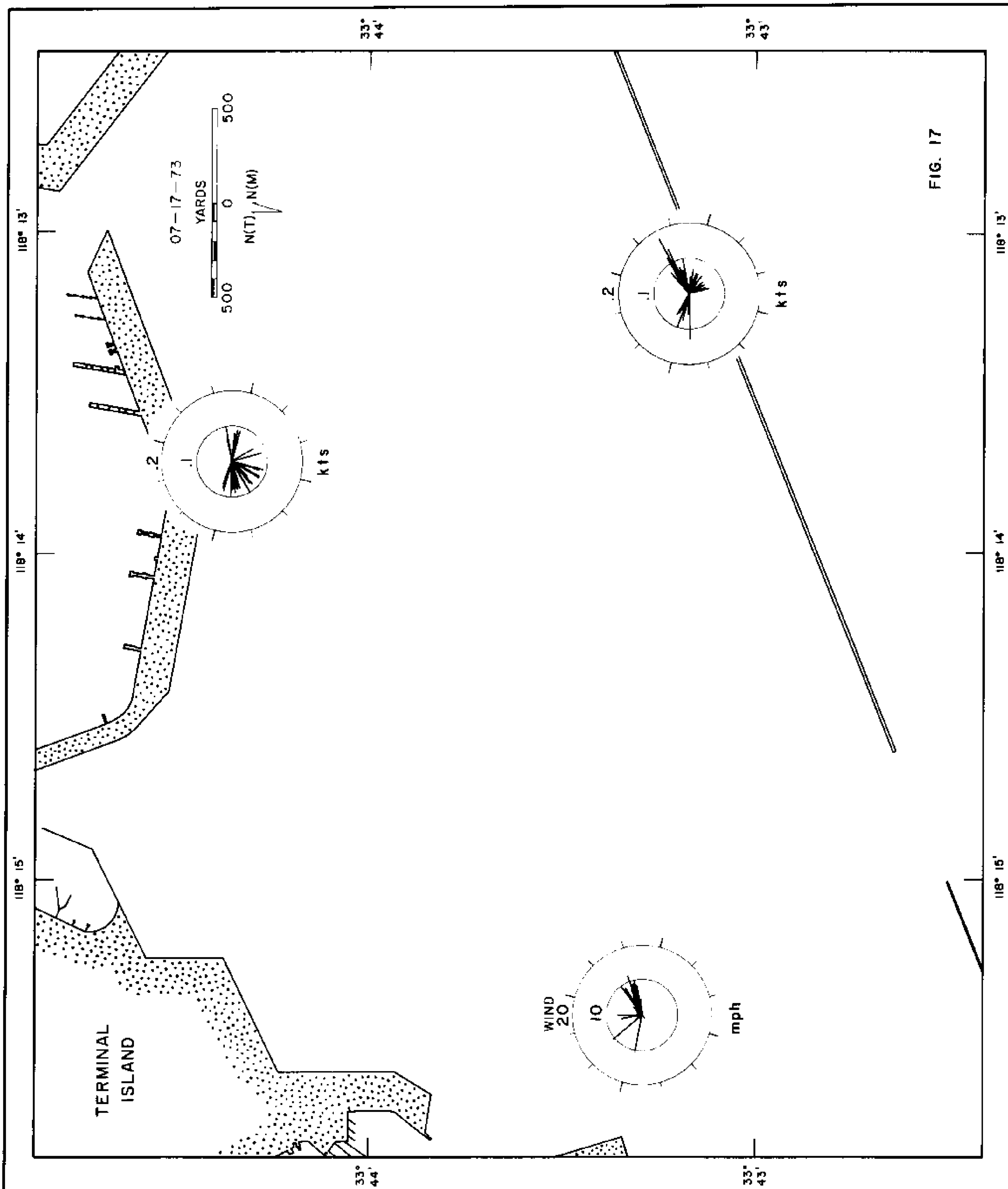

33° 44'
33° 43'
118° 13'
118° 14'
118° 15'
07 – 17 – 73
YARDS
500 0 500
N(T) N(M)
.2
.1
kts
WIND
20
10
mph
TERMINAL ISLAND

FIG. 17

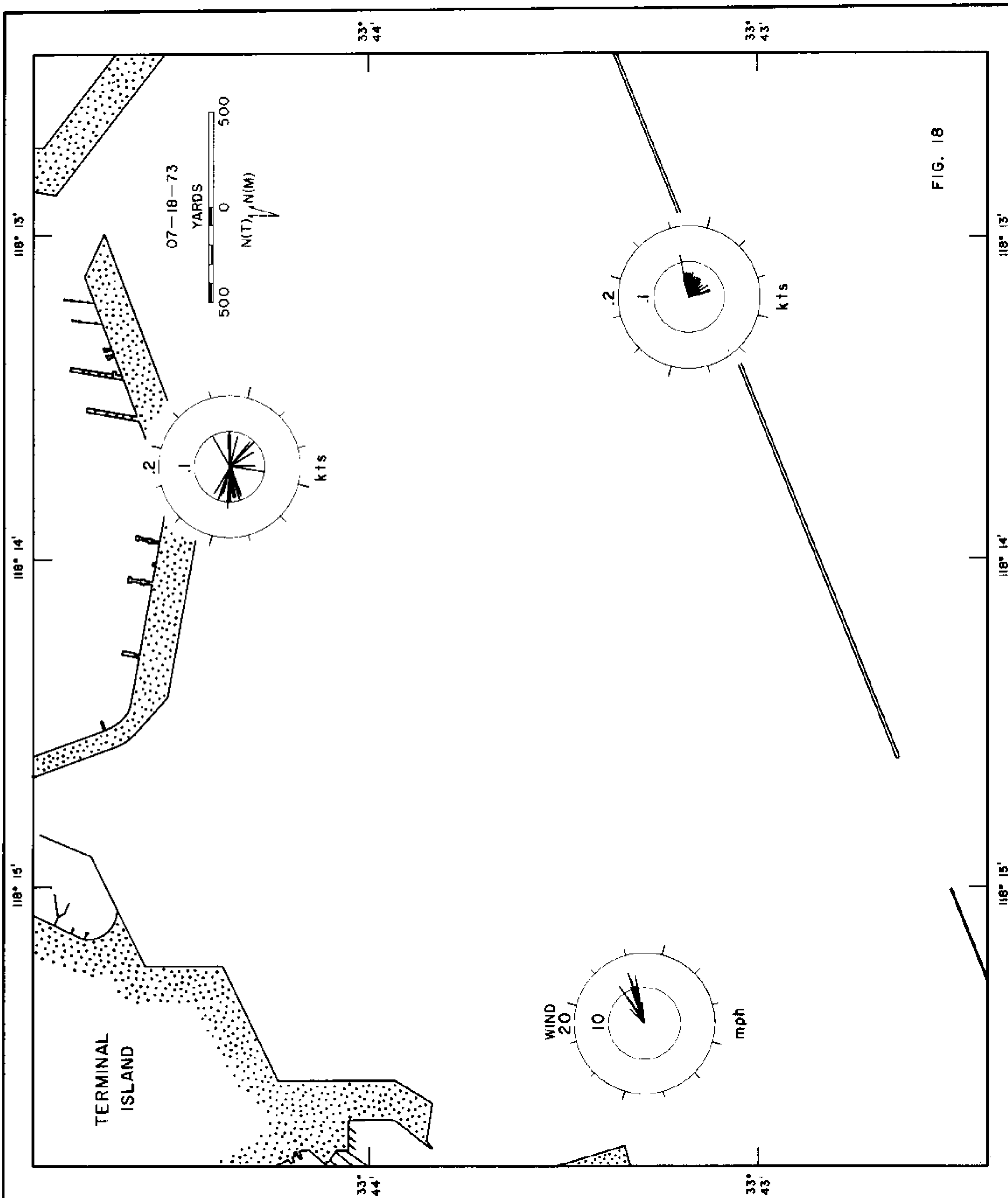

07—18—73
YARDS
500
0
500
N(T)
N(M)
33° 44'
33° 43'
118° 13'
118° 14'
118° 15'
.2
.1
kts
WIND
20
10
mph
TERMINAL ISLAND

FIG. 18

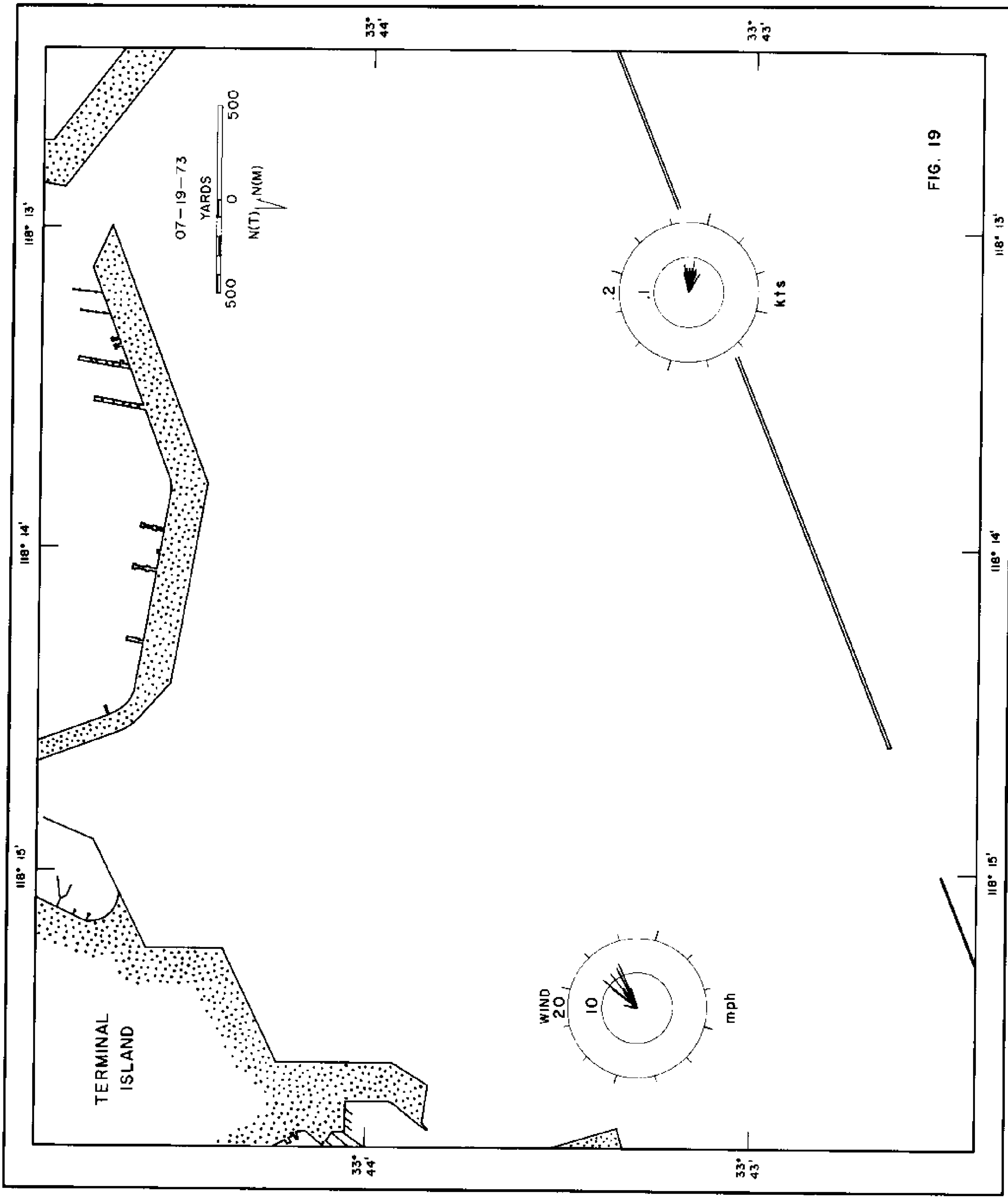

07-19-73
YARDS
500 0 500
N(T)
N(M)
.2
.1
kts
WIND
20
10
mph
TERMINAL ISLAND
118° 13'
118° 14'
118° 15'
33° 44'
33° 43'

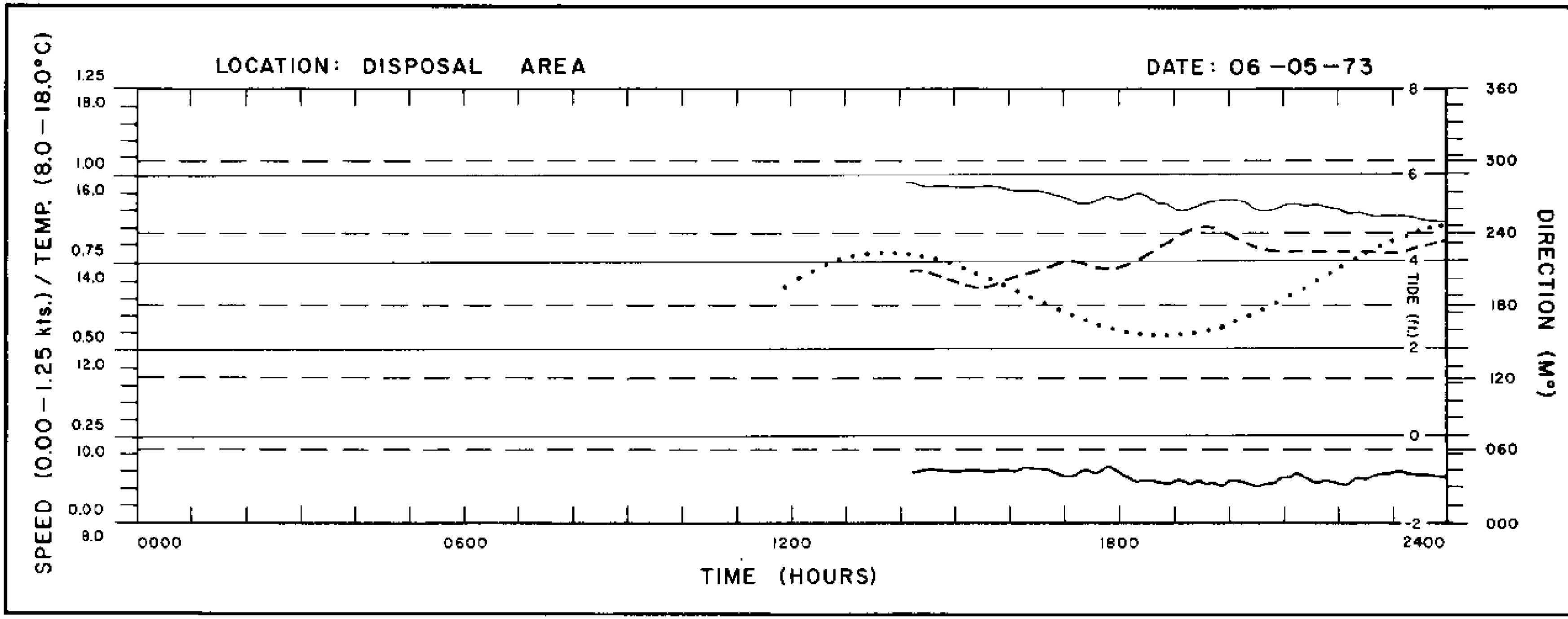
FIG. 19

APPENDIX 3

TIDE, TEMPERATURE, CURRENT SPEED, AND CURRENT DIRECTION PLOTS

5-7 JUNE 1973

DISPOSAL AREA



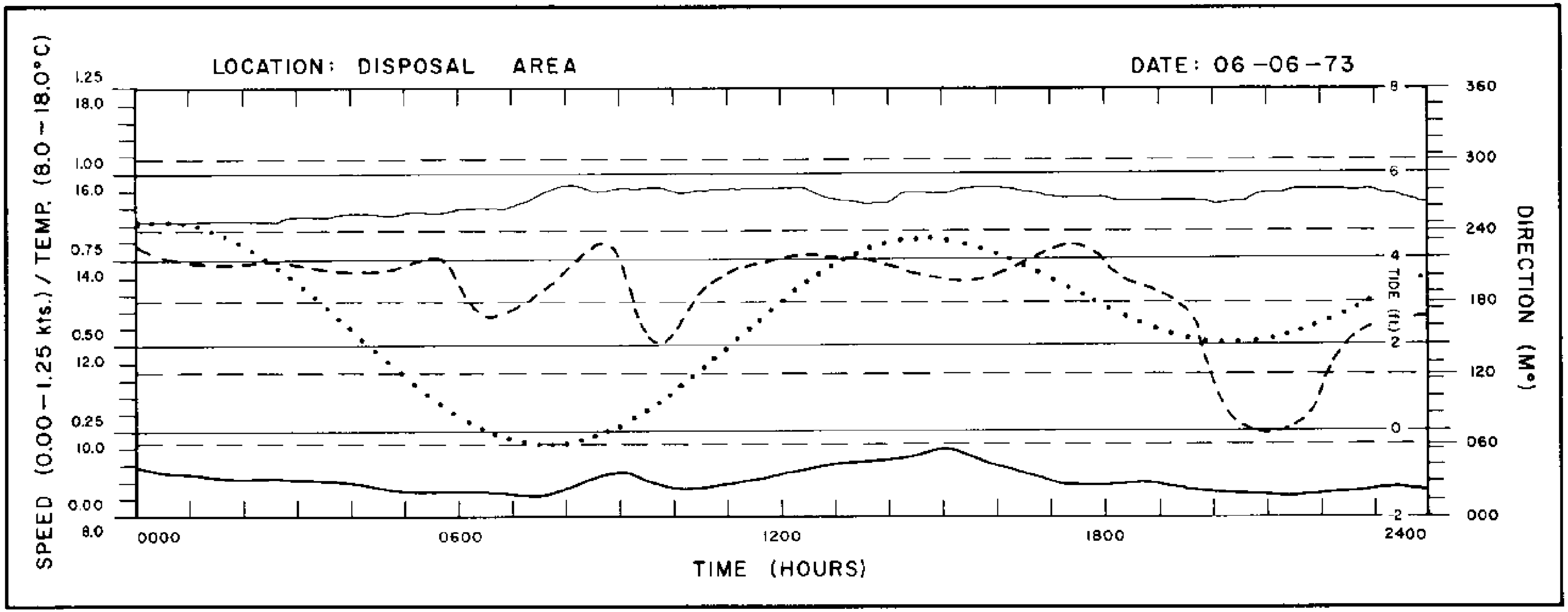
CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 20



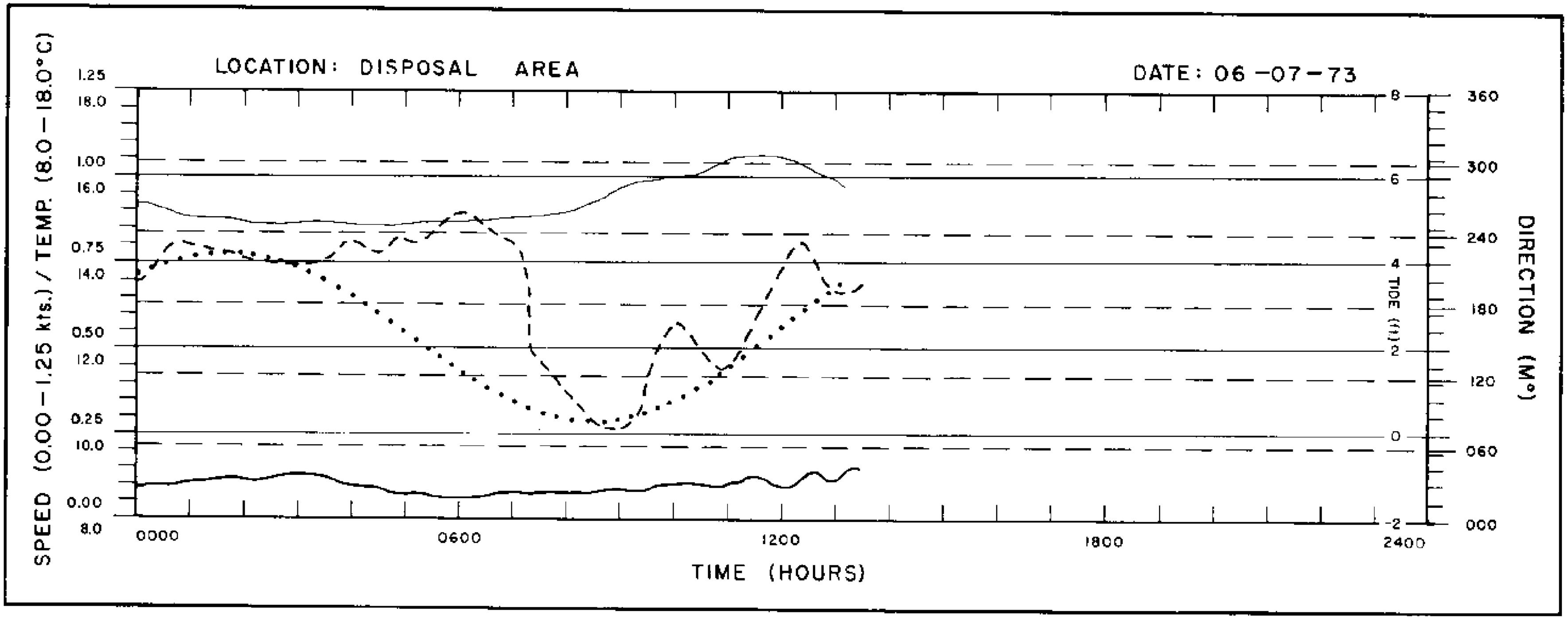
CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 21



CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

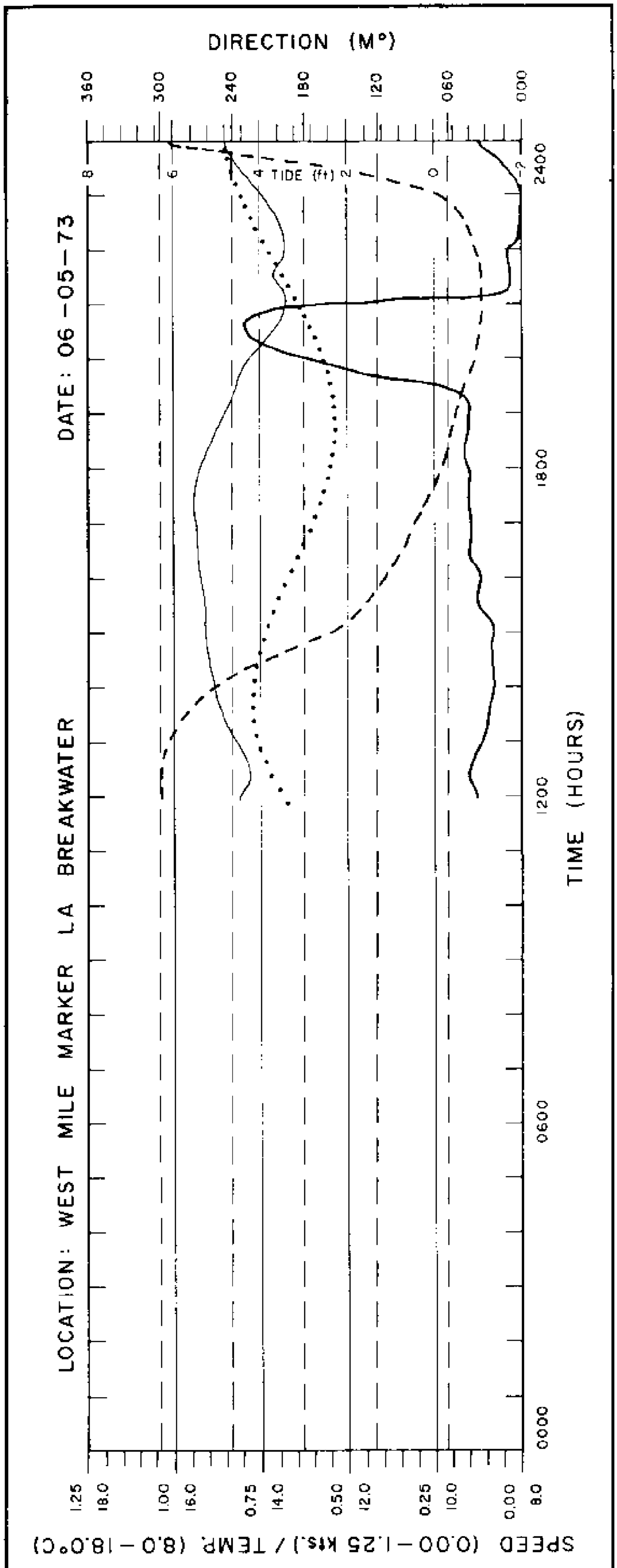
CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 22

5-7 JUNE 1973

WEST MILE MARKER OF LOS ANGELES BREAKWATER



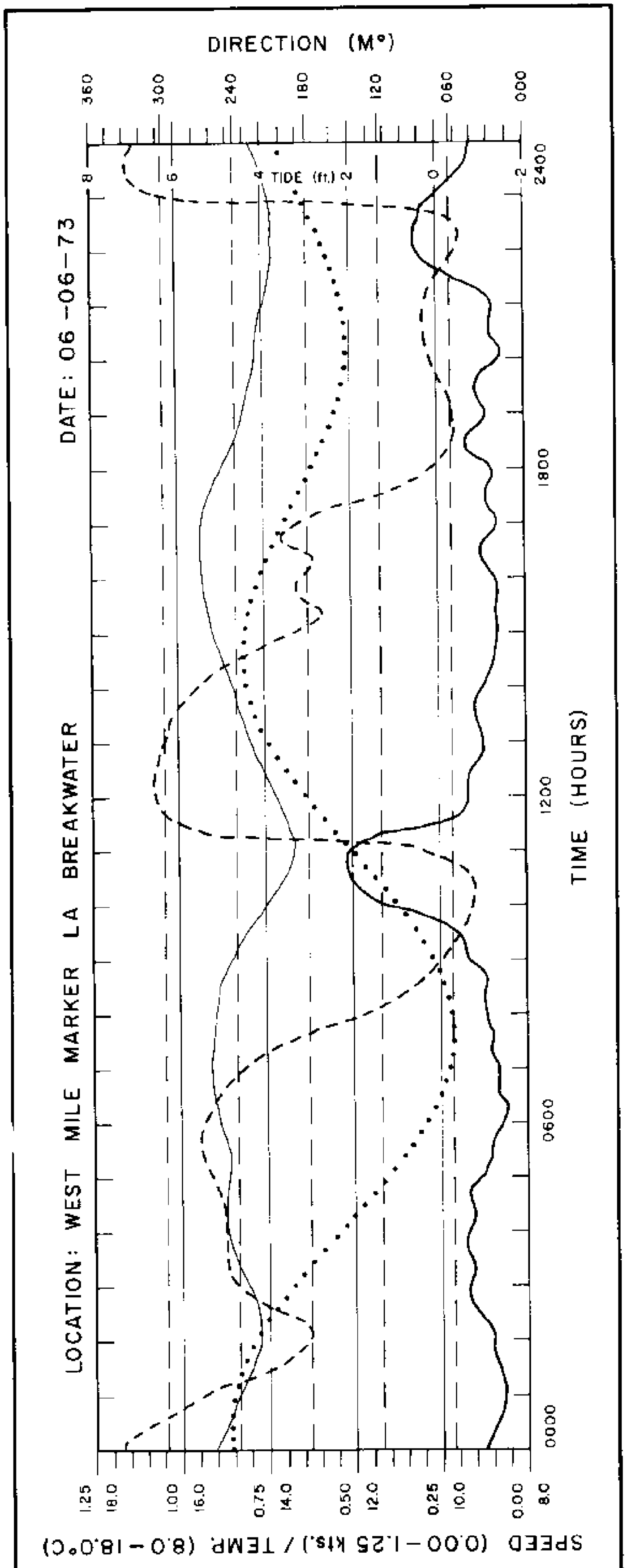
CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 23



CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 24

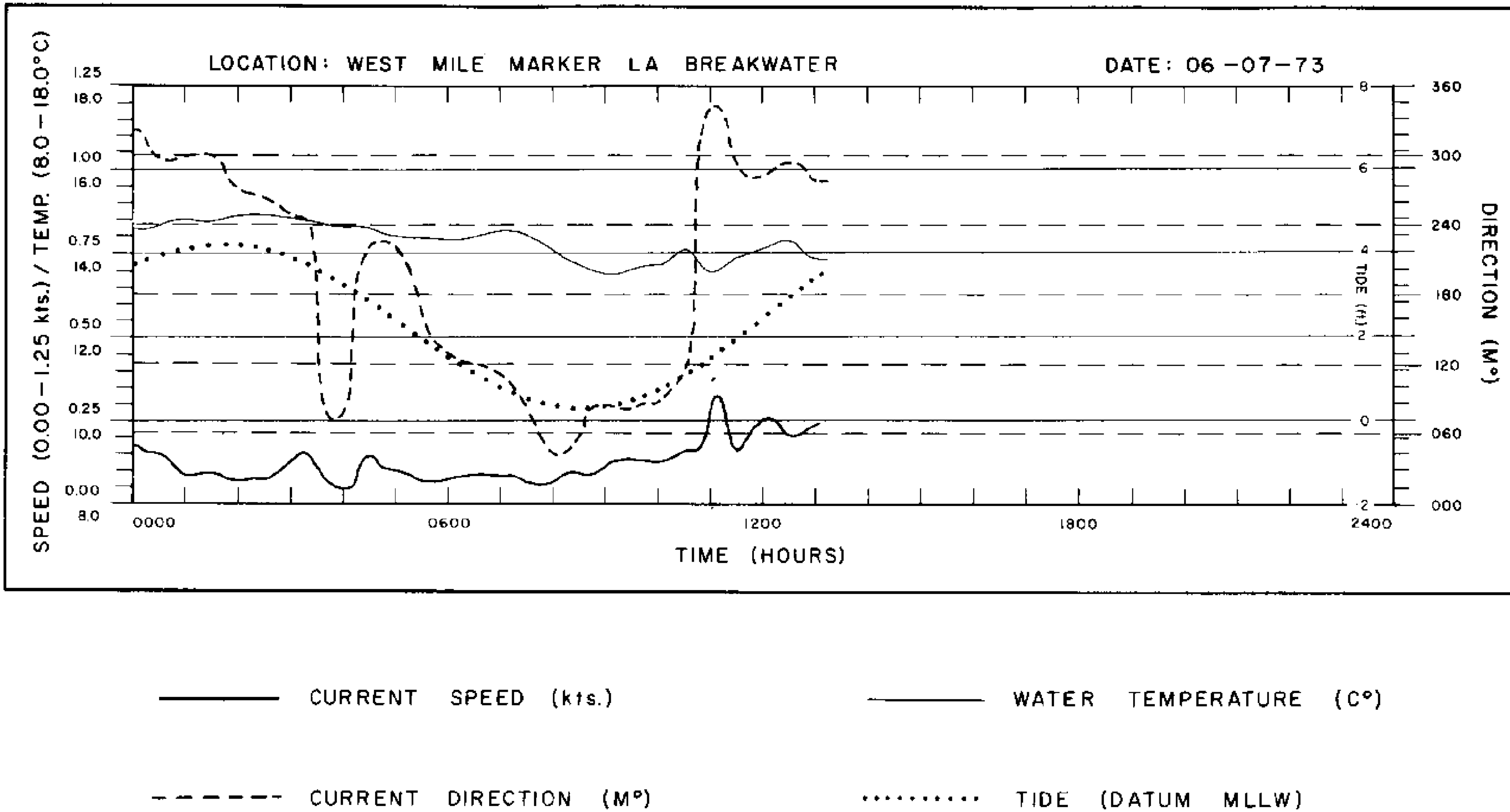

LOCATION: WEST MILE MARKER LA BREAKWATER
DATE: 06-07-73
SPEED (0.00 – 1.25 kts.) / TEMP. (8.0 – 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
0000
0600
1200
1800
2400
TIME (HOURS)
TIDE (ft)
8
6
4
2
0
-2
DIRECTION (M°)
360
300
240
180
120
060
000
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 25

5-7 JUNE 1973

NAVY MOLE

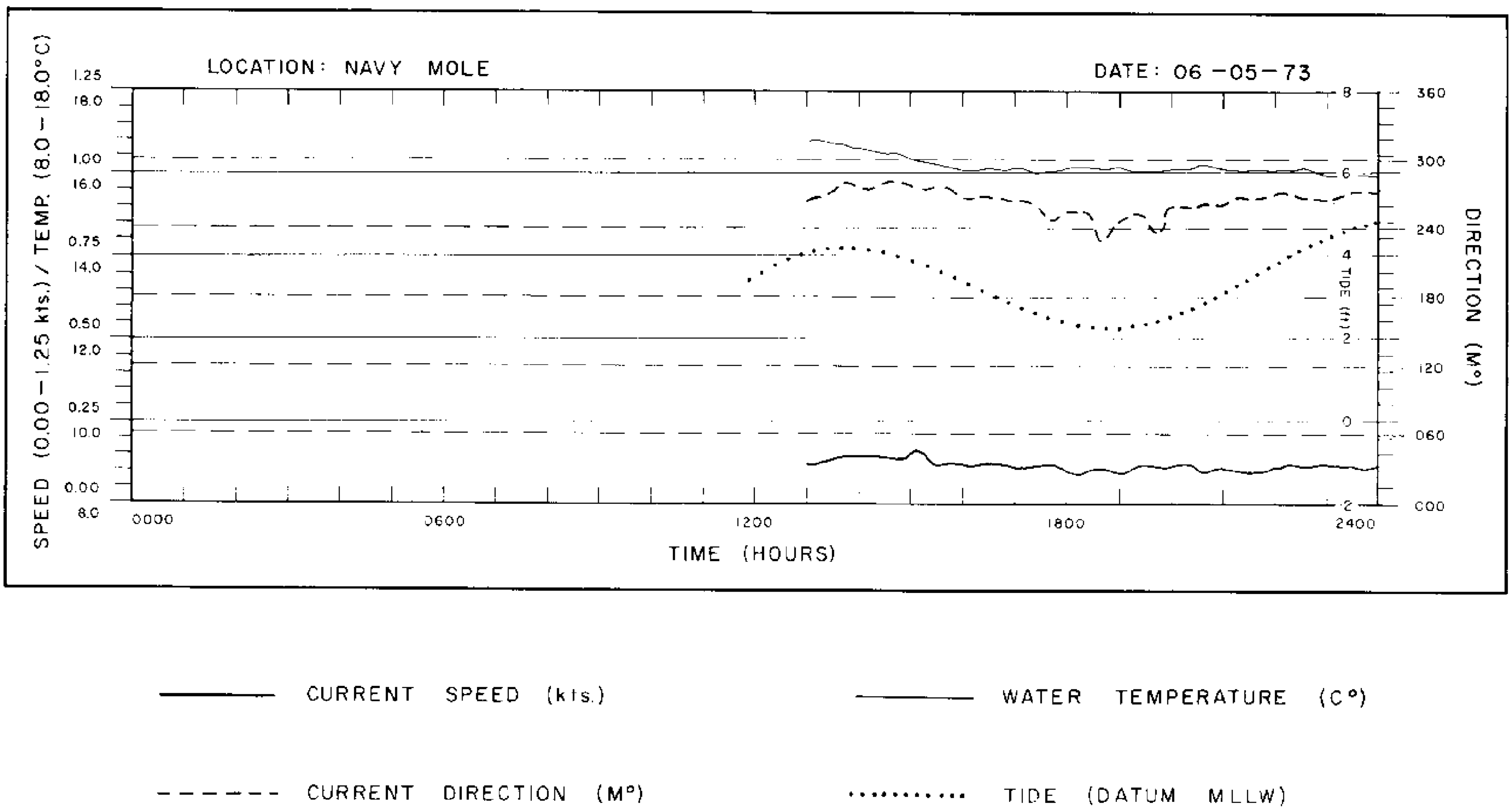

LOCATION: NAVY MOLE
DATE: 06-05-73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
DIRECTION (M°)
360
300
240
180
120
060
000
TIDE (ft)
8
6
4
2
0
-2
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 26

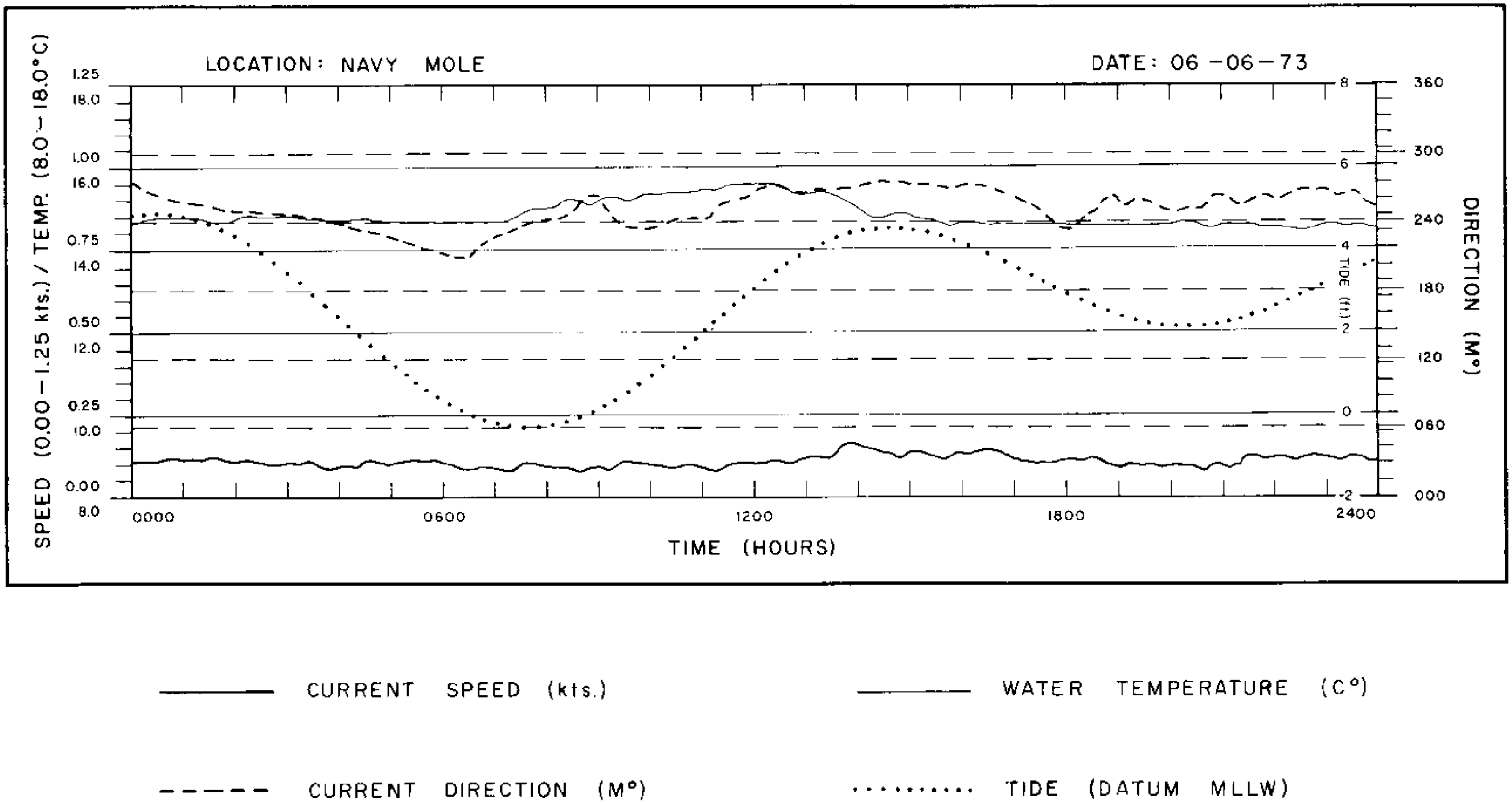
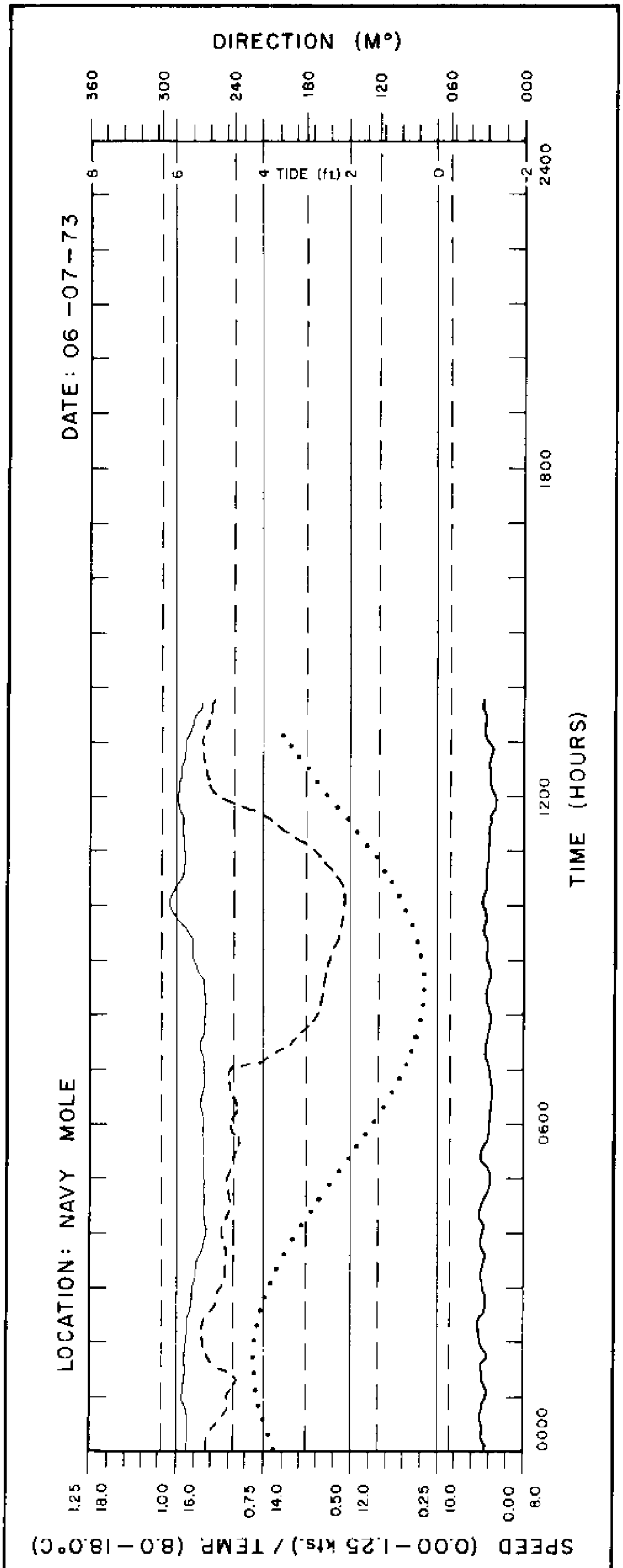

LOCATION: NAVY MOLE
DATE: 06 -06-73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
DIRECTION (M°)
360
300
240
180
120
060
000
TIDE (ft.)
8
6
4
2
0
-2
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 27



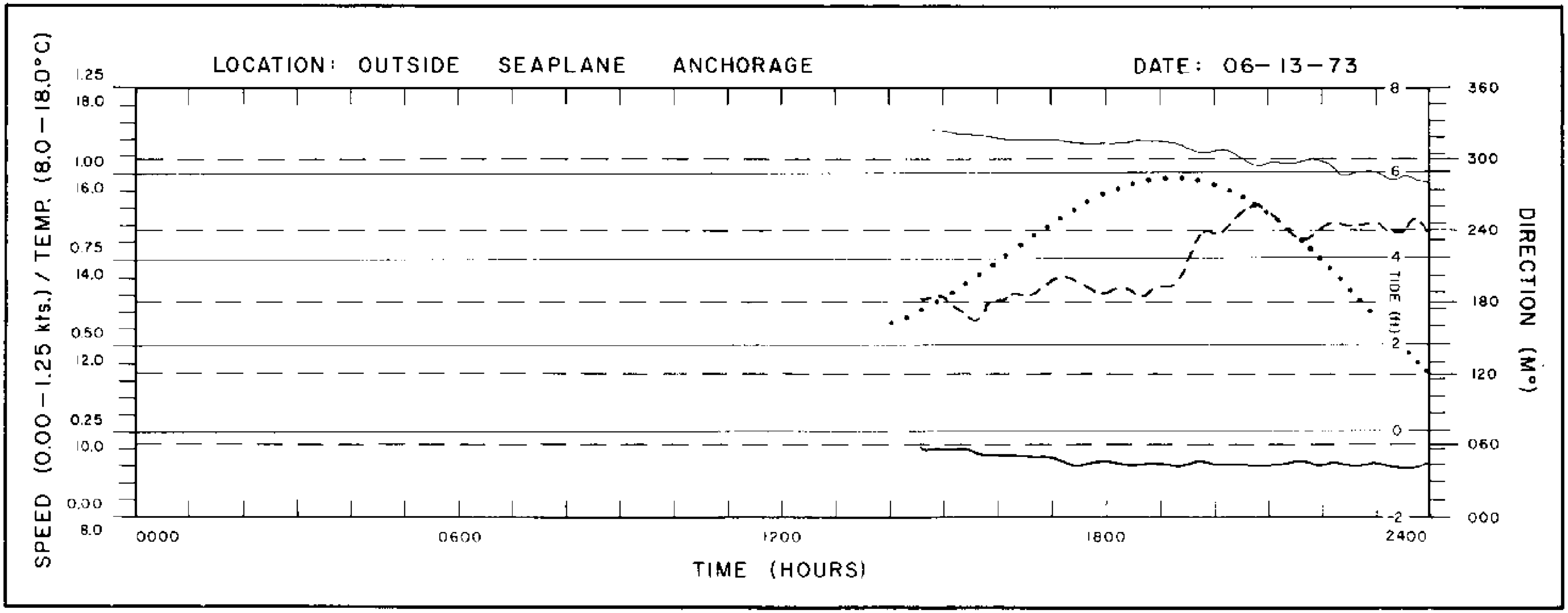
—— CURRENT SPEED (kts.)   —— WATER TEMPERATURE (C°)

- - - CURRENT DIRECTION (M°)   .... TIDE (DATUM MLLW)

FIG. 28

13-19 JUNE 1973

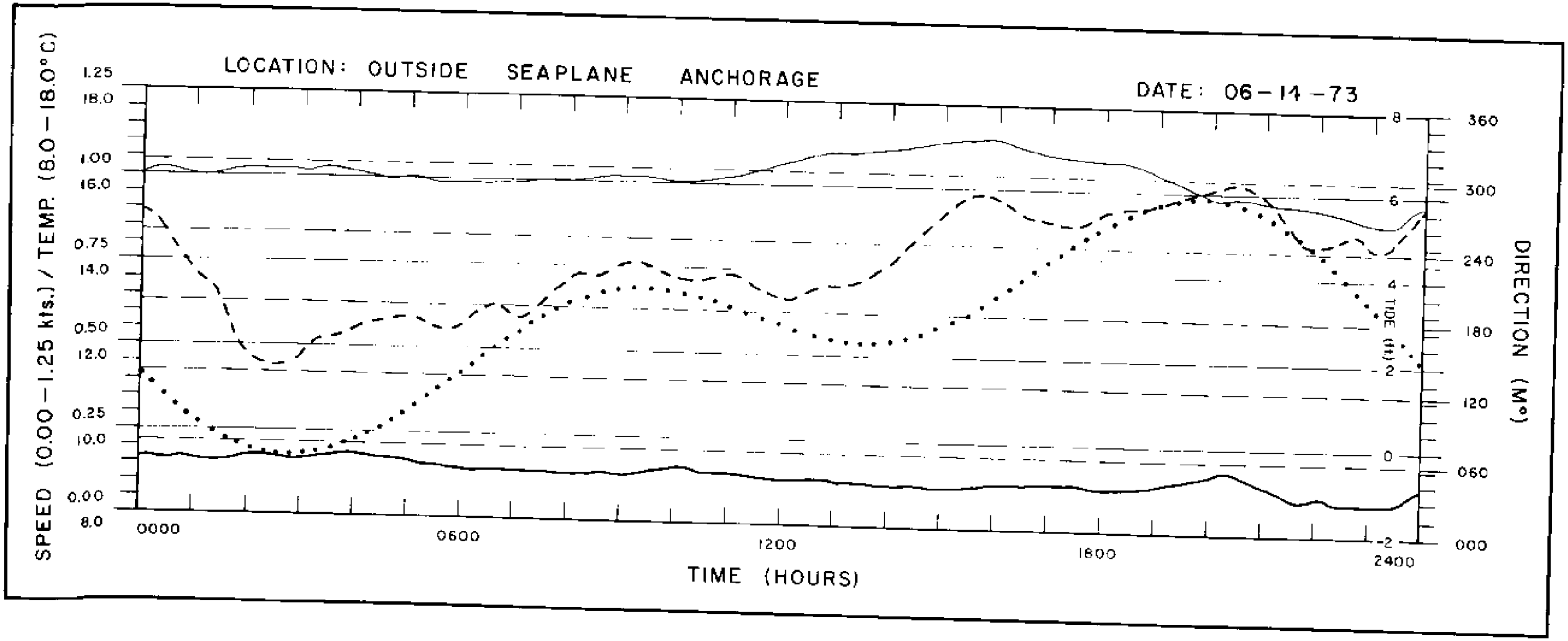
OUTSIDE SEAPLANE ANCHORAGE



——— CURRENT SPEED (kts.)　　——— WATER TEMPERATURE (C°)

– – – – – CURRENT DIRECTION (M°)　　··········· TIDE (DATUM MLLW)

FIG. 29



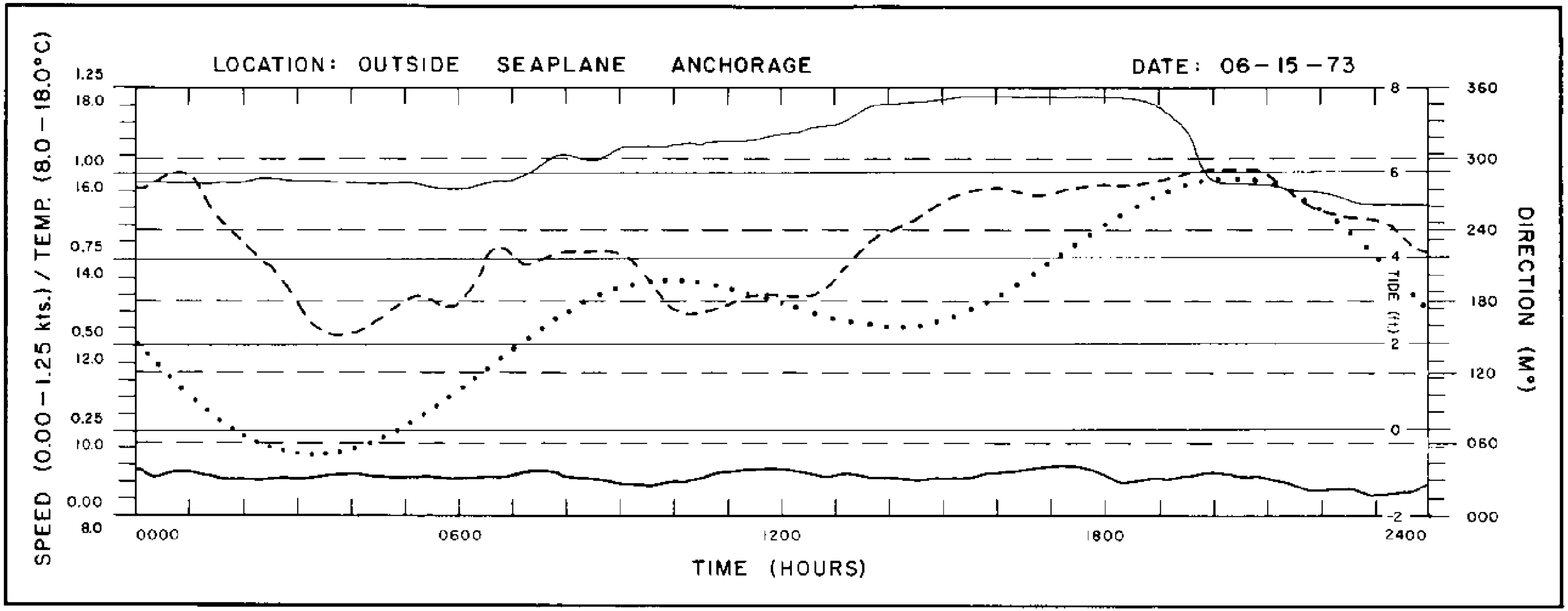
CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 30



CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 31

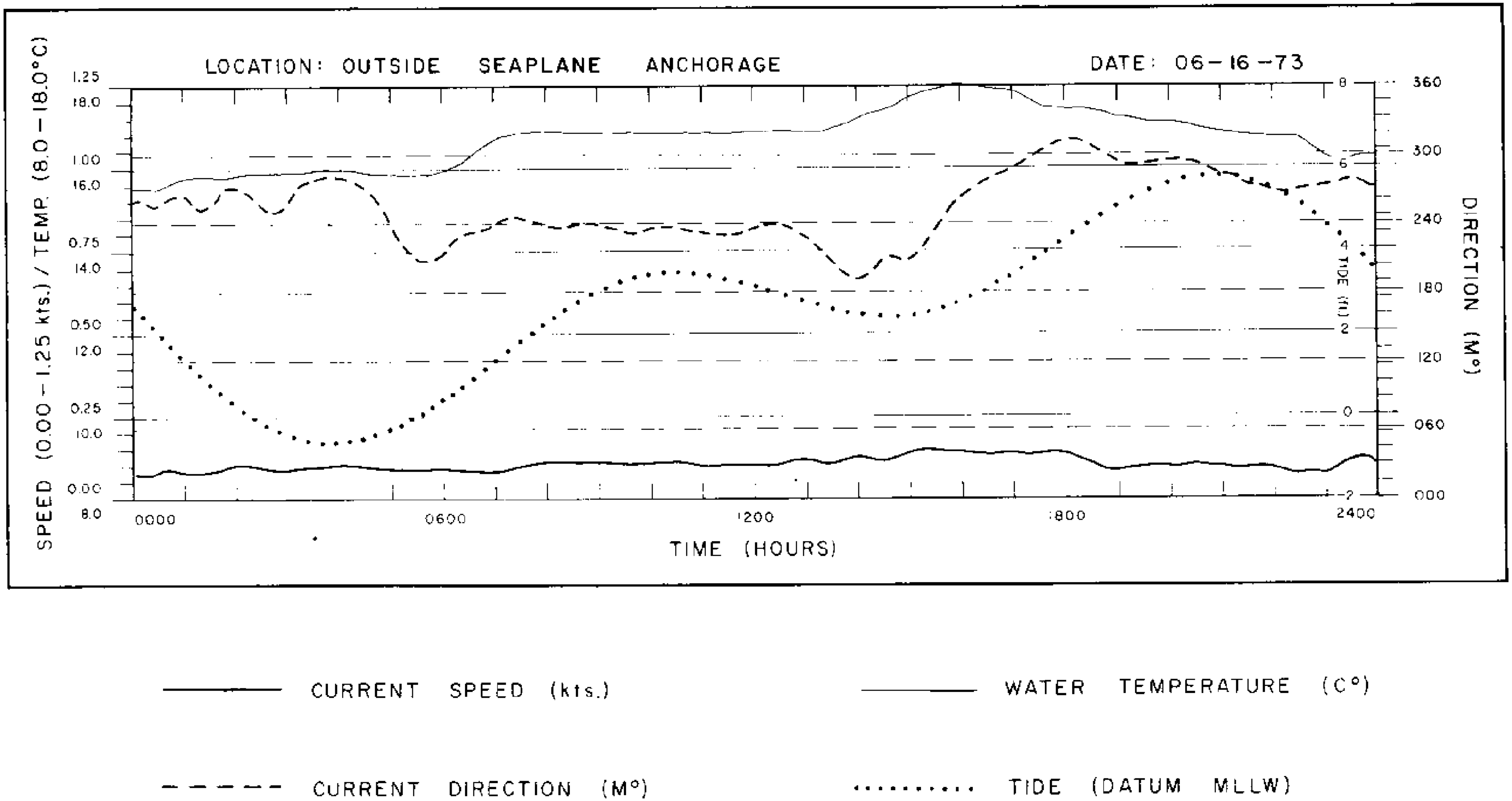

LOCATION: OUTSIDE SEAPLANE ANCHORAGE
DATE: 06-16-73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
DIRECTION (M°)
360
300
240
180
120
060
000
TIDE (ft)
8
6
4
2
0
-2
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 32

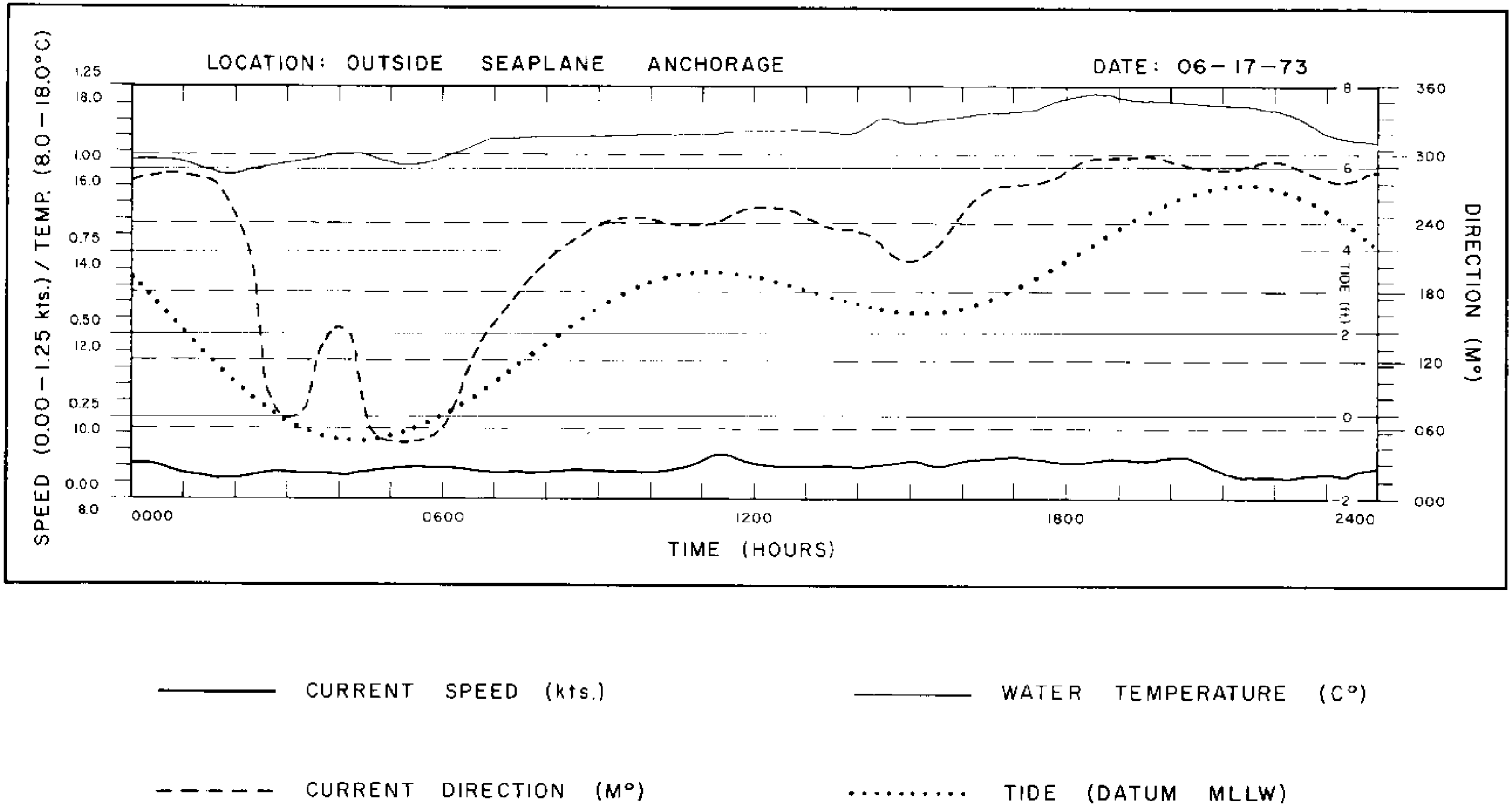

LOCATION: OUTSIDE SEAPLANE ANCHORAGE
DATE: 06-17-73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
DIRECTION (M°)
360
300
240
180
120
060
000
TIDE (ft)
8
6
4
2
0
-2
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 33

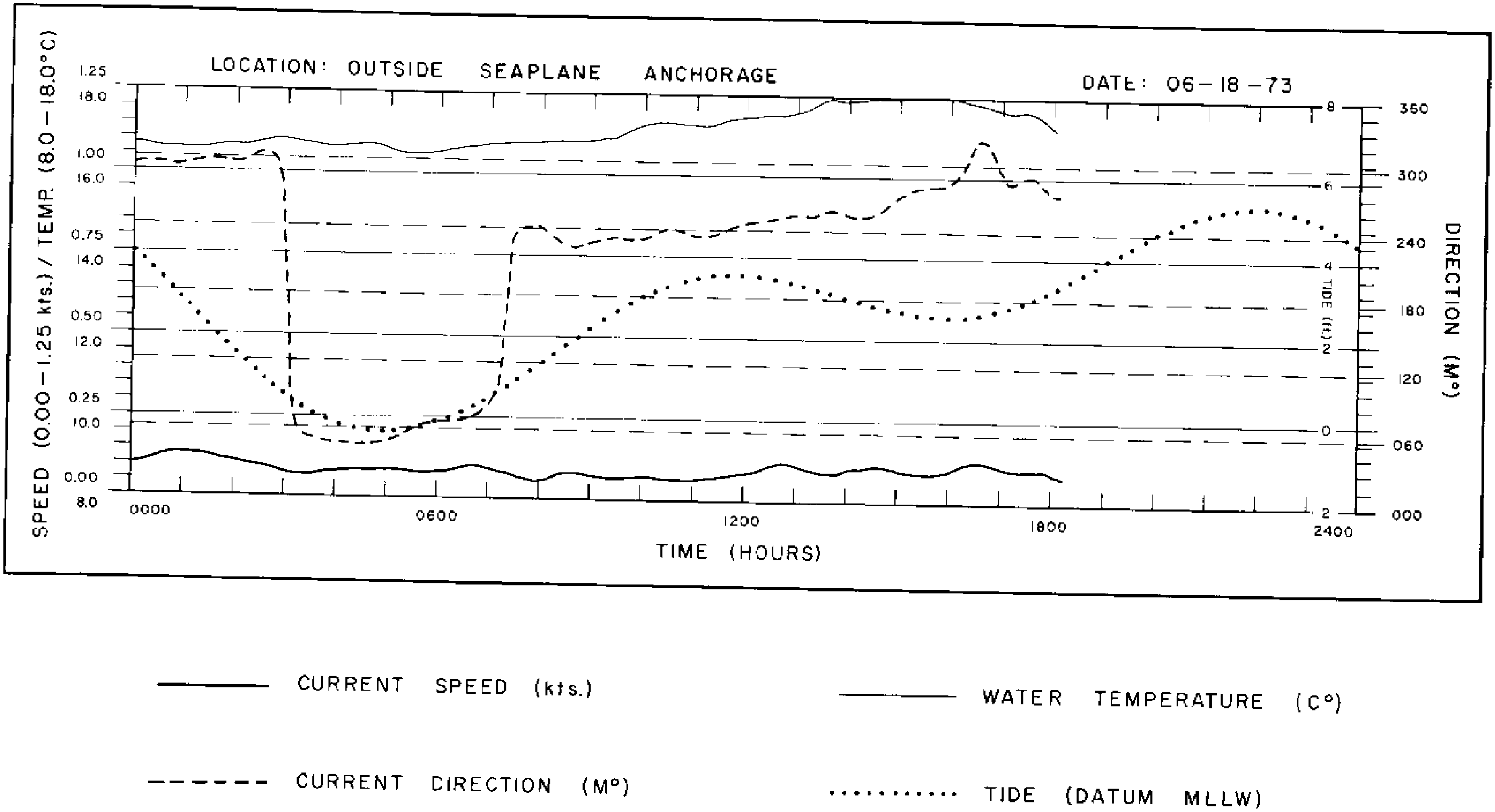
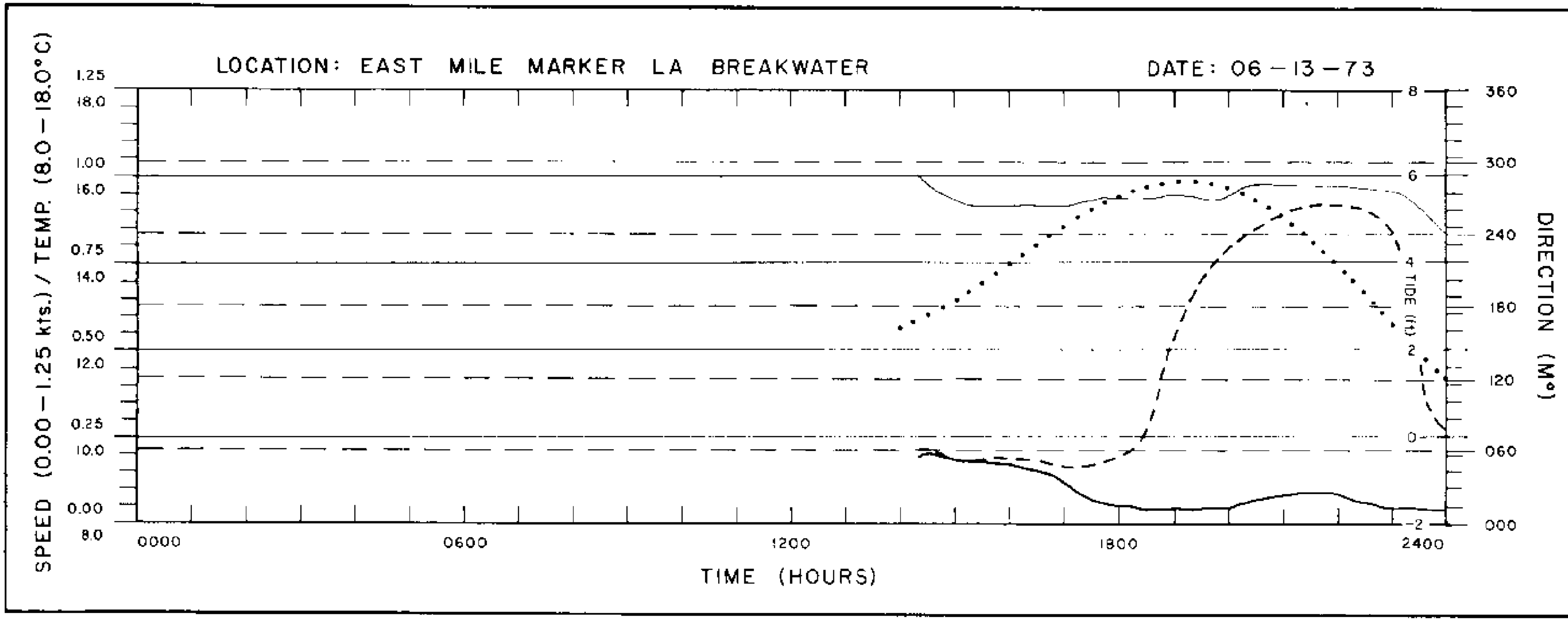

LOCATION: OUTSIDE SEAPLANE ANCHORAGE
DATE: 06-18-73
SPEED (0.00-1.25 kts.) / TEMP. (8.0-18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
0000
0600
1200
1800
2400
TIME (HOURS)
TIDE (ft)
8
6
4
2
0
-2
DIRECTION (M°)
360
300
240
180
120
060
000
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 34

13-19 JUNE 1973

EAST MILE MARKER OF LOS ANGELES BREAKWATER



CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 35

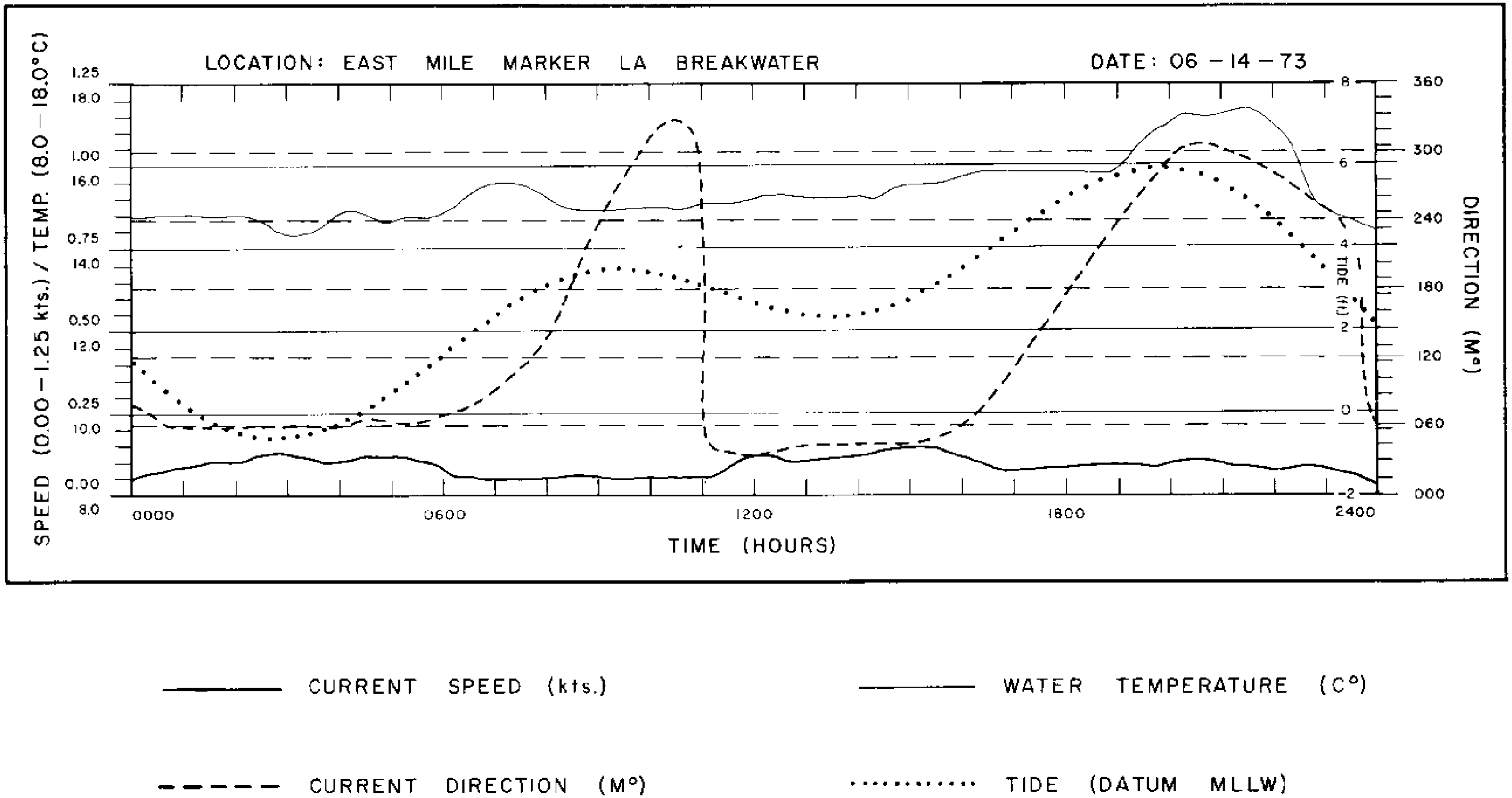

LOCATION: EAST MILE MARKER LA BREAKWATER
DATE: 06 - 14 - 73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
DIRECTION (M°)
360
300
240
180
120
060
000
TIDE (ft)
8
6
4
2
0
-2
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 36

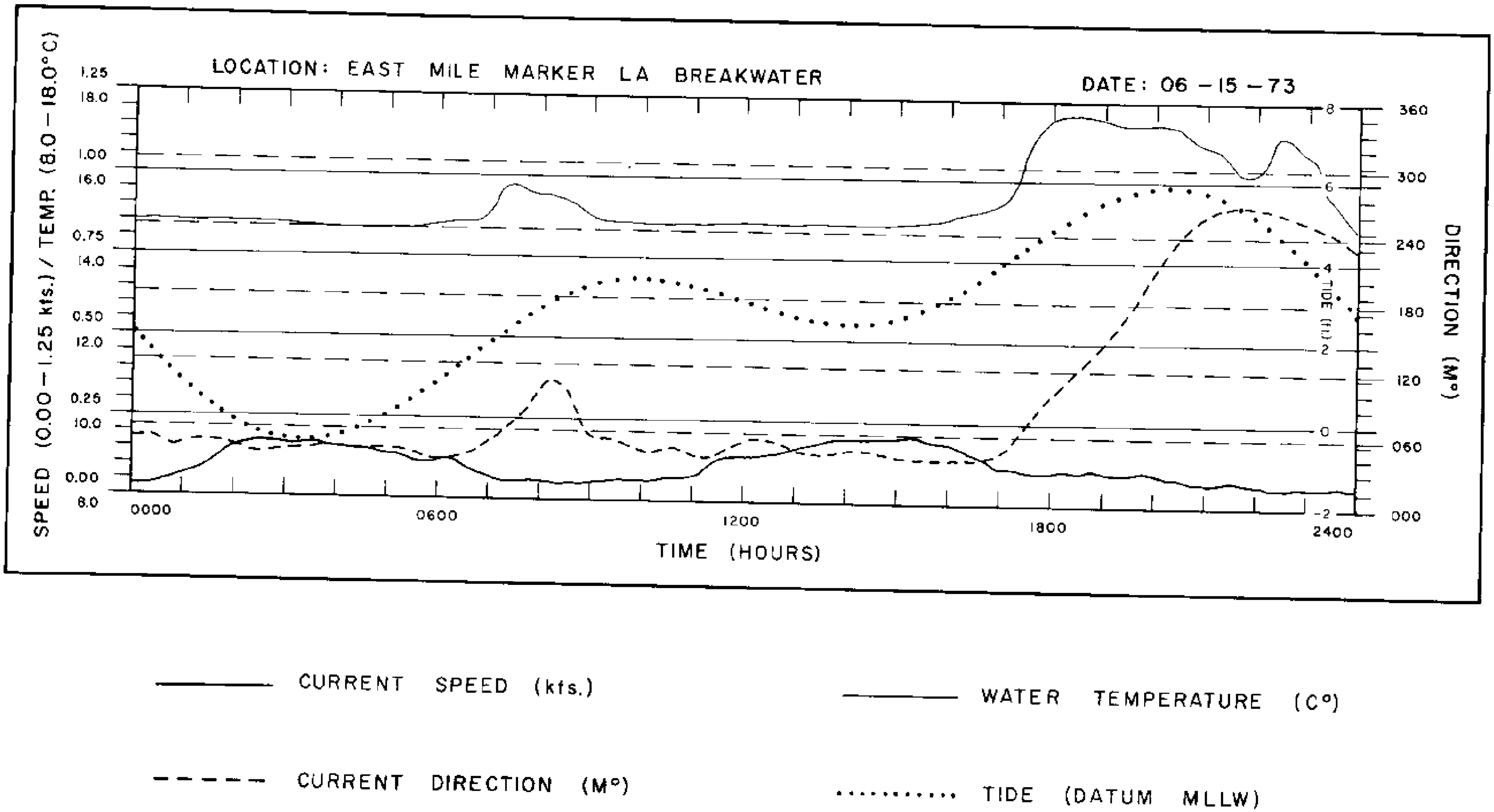
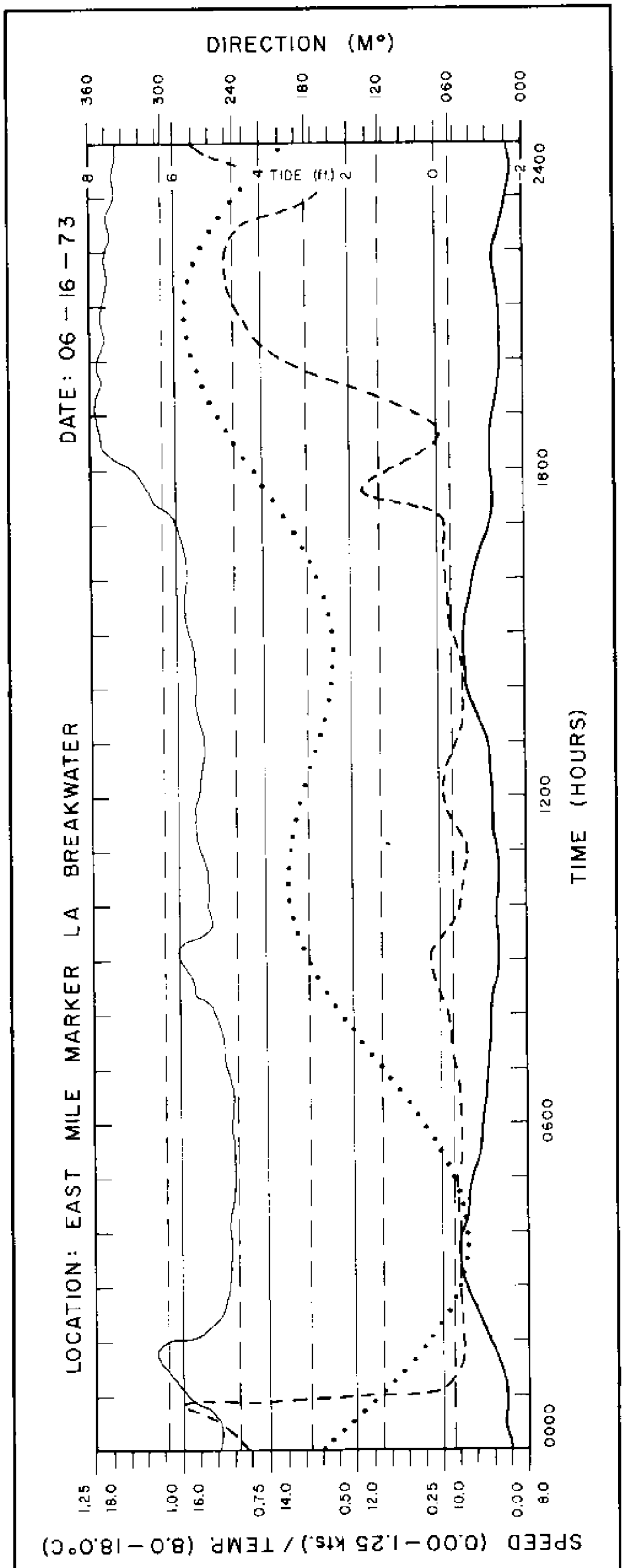

LOCATION: EAST MILE MARKER LA BREAKWATER
DATE: 06 - 15 - 73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
0000
0600
1200
1800
2400
TIME (HOURS)
DIRECTION (M°)
360
300
240
180
120
060
000
TIDE (ft.)
8
6
4
2
0
-2
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 37



——— CURRENT SPEED (kts.) ——— WATER TEMPERATURE (C°)

– – – – CURRENT DIRECTION (M°) ·········· TIDE (DATUM MLLW)

FIG. 38

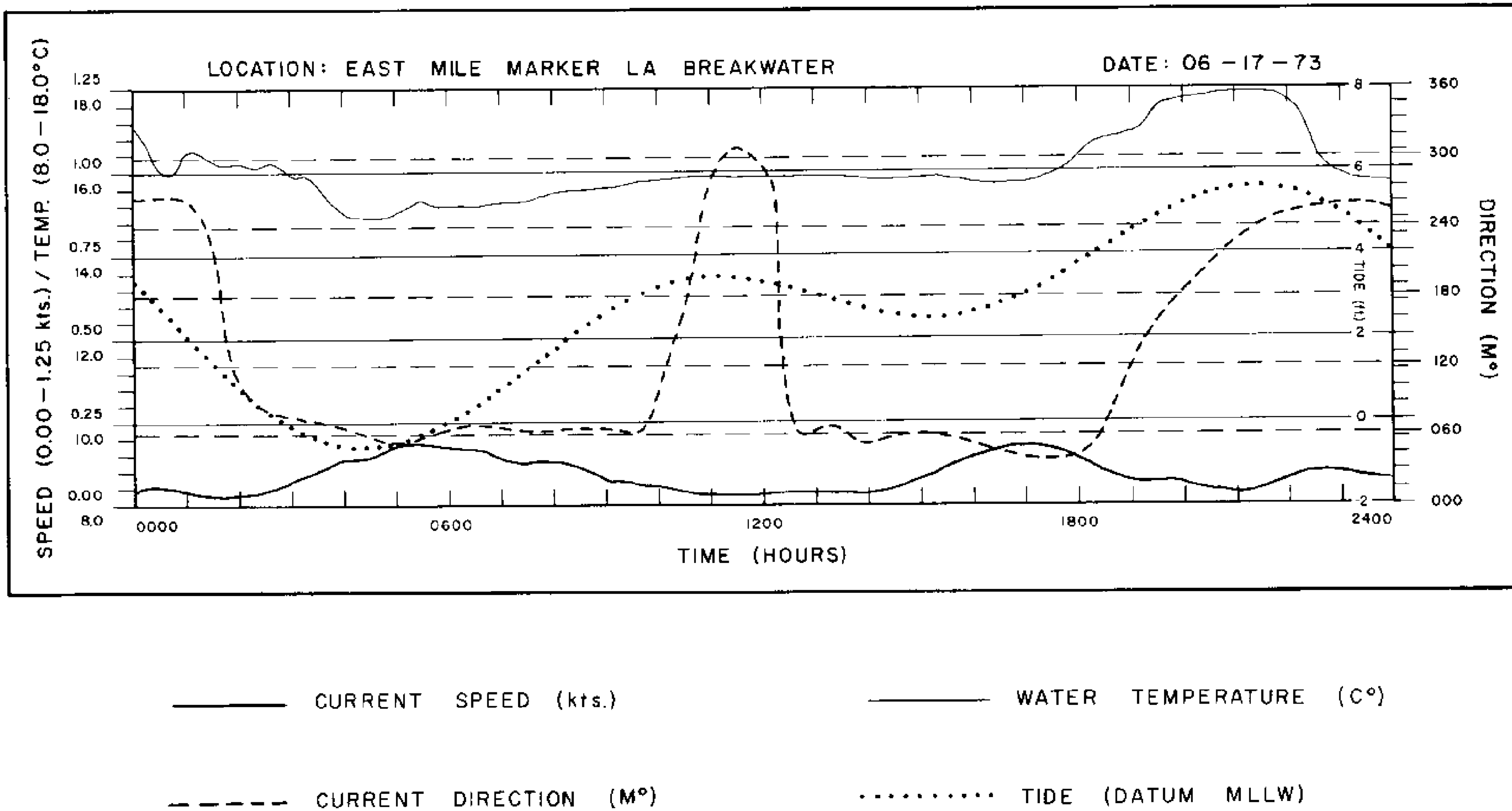
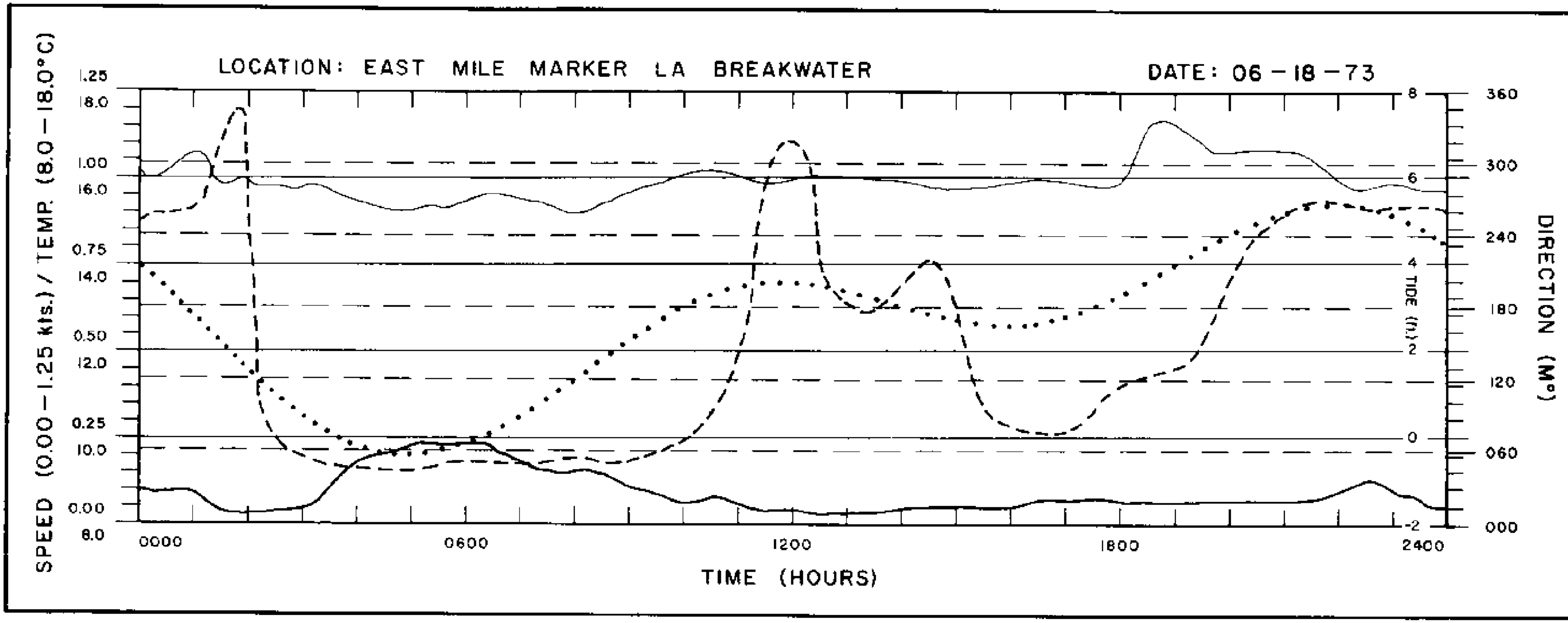

LOCATION: EAST MILE MARKER LA BREAKWATER
DATE: 06 - 17 - 73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
DIRECTION (M°)
360
300
240
180
120
060
000
TIDE (ft)
8
6
4
2
0
-2
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 39



CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 40

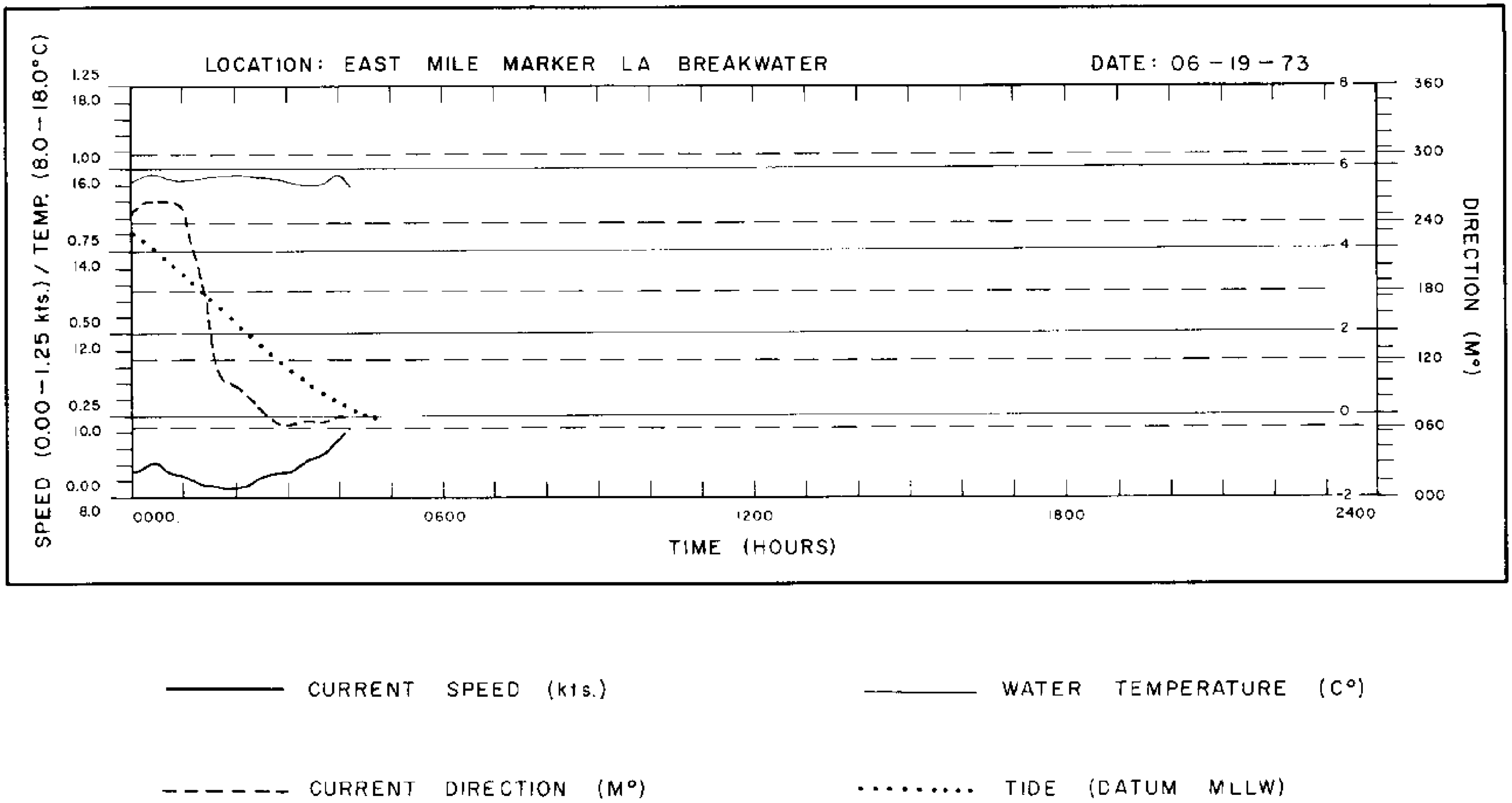
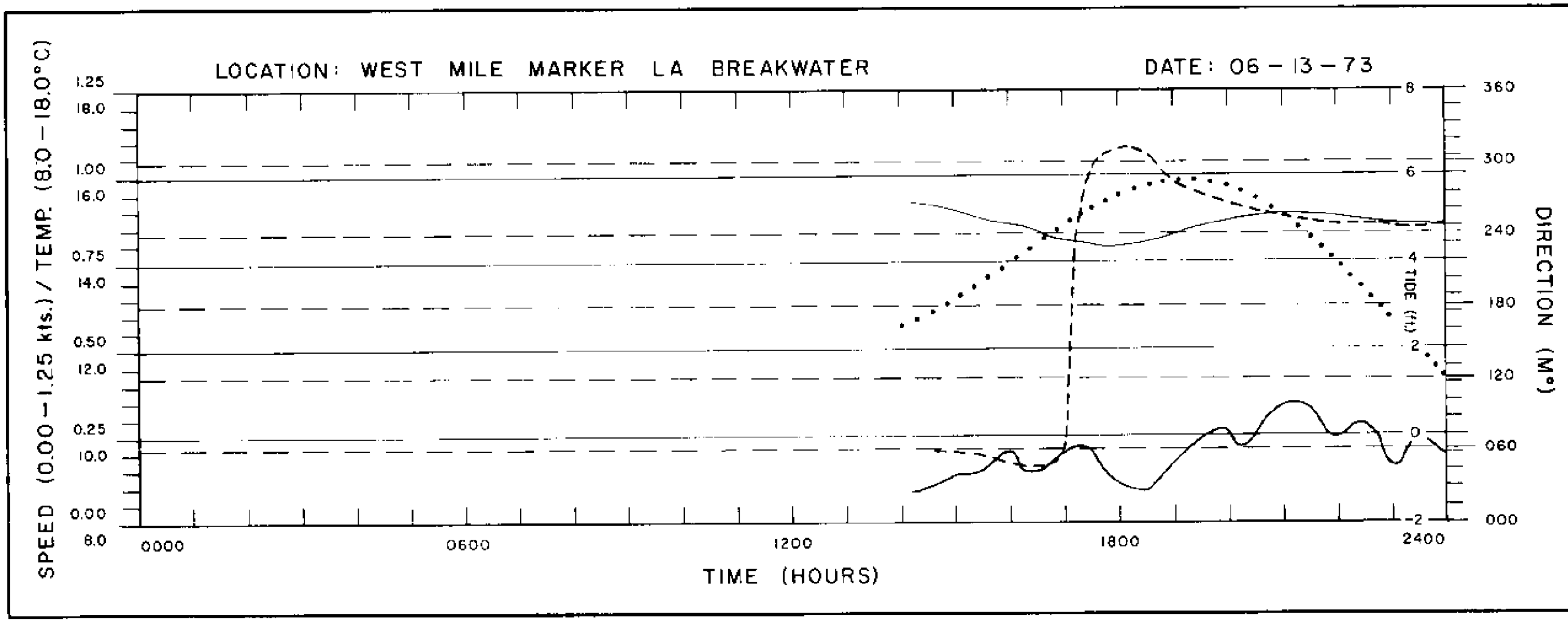

LOCATION: EAST MILE MARKER LA BREAKWATER
DATE: 06 – 19 – 73
SPEED (0.00 – 1.25 kts.) / TEMP. (8.0 – 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
8
6
4
2
0
-2
DIRECTION (M°)
360
300
240
180
120
060
000
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 41

13-19 JUNE 1973

WEST MILE MARKER OF LOS ANGELES BREAKWATER



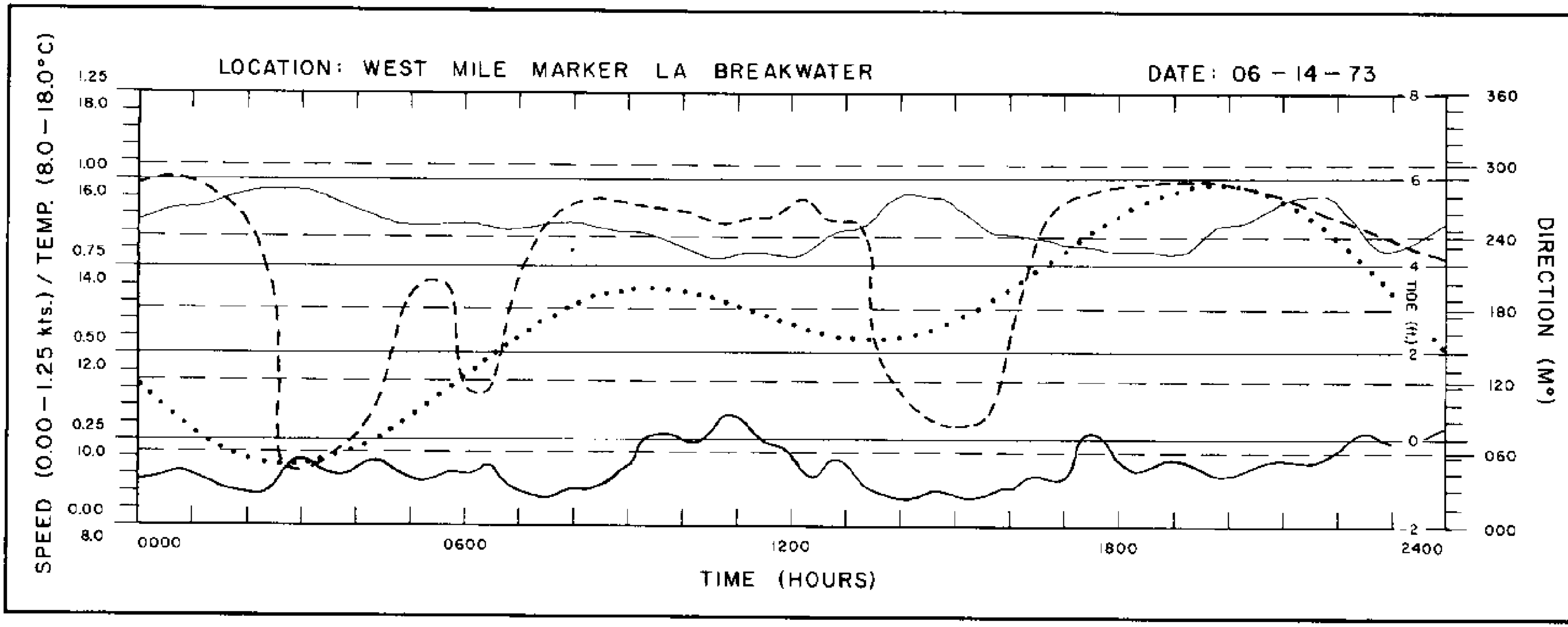
—— CURRENT SPEED (kts.)

—— WATER TEMPERATURE (C°)

– – – – CURRENT DIRECTION (M°)

········· TIDE (DATUM MLLW)

FIG. 42



CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 43

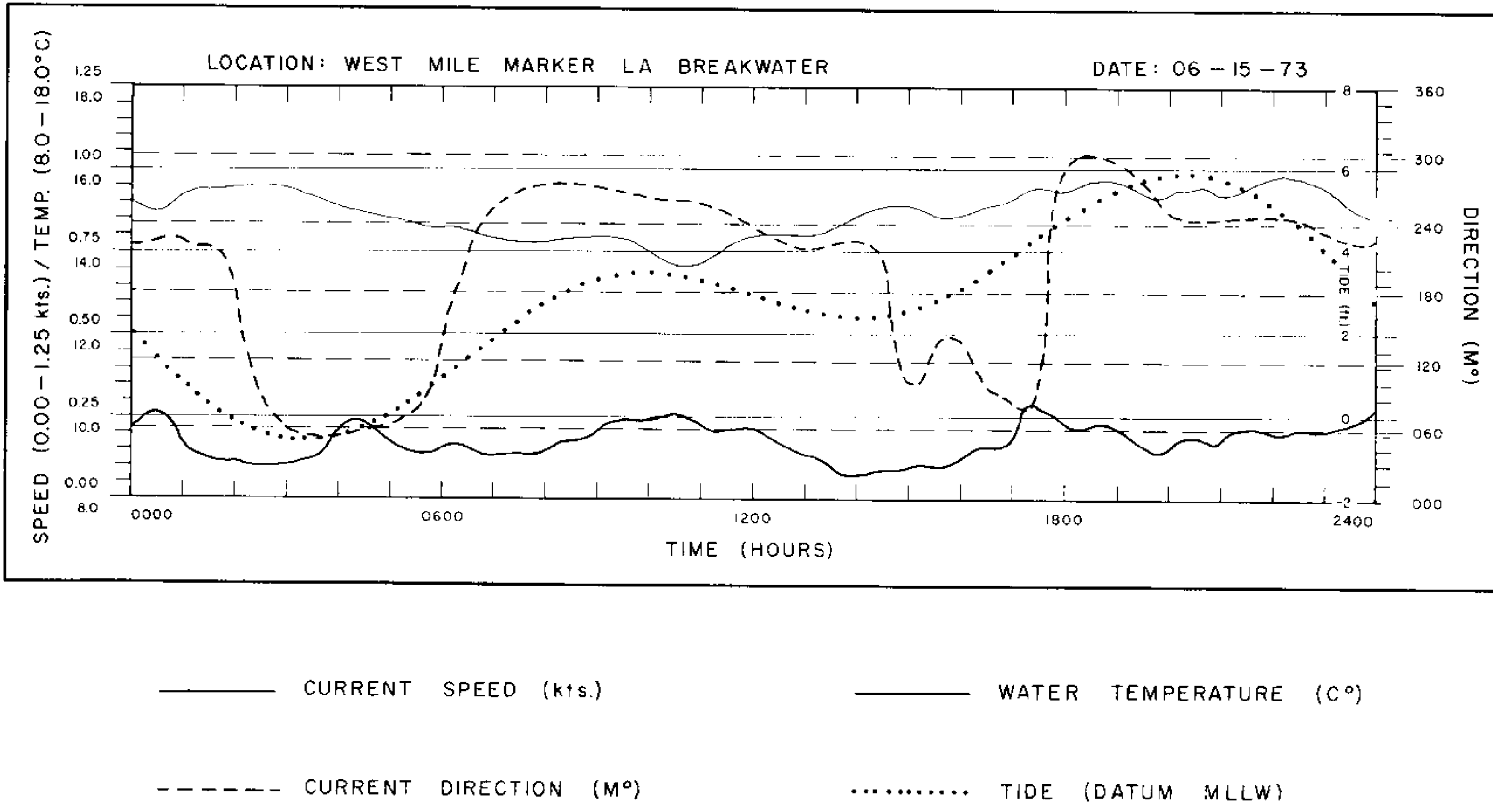
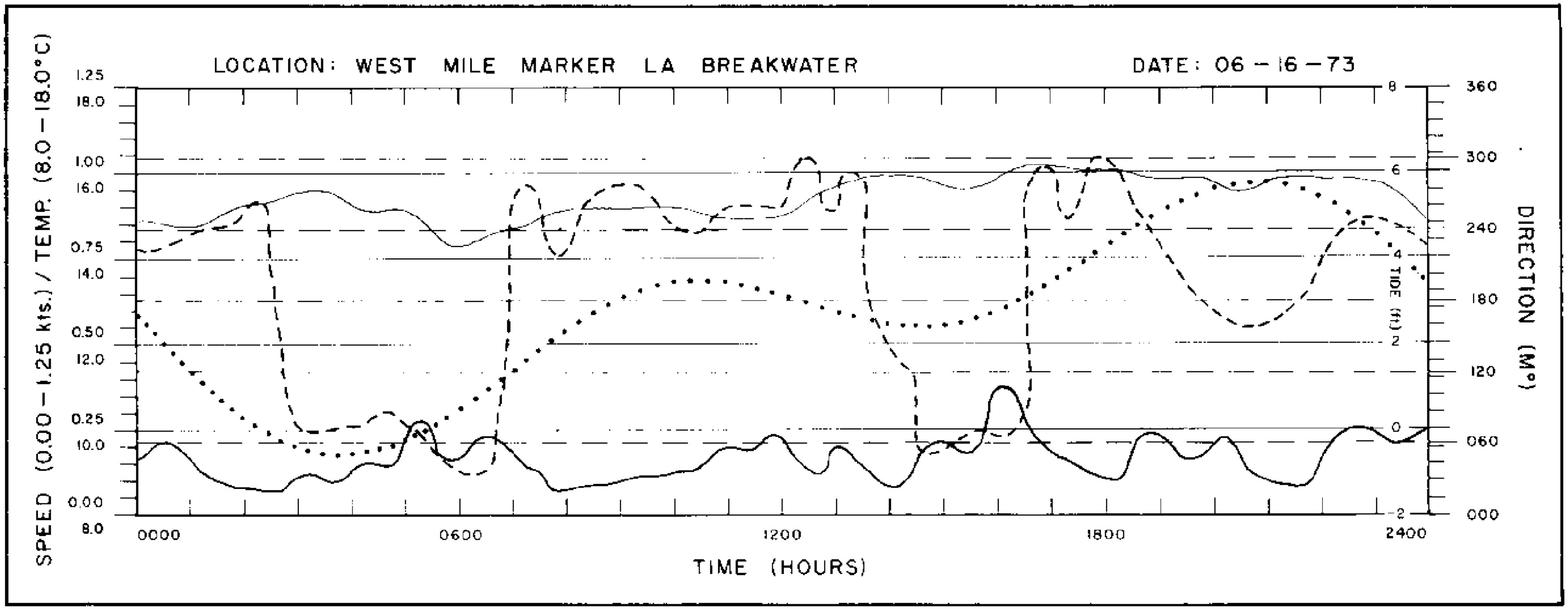

LOCATION: WEST MILE MARKER LA BREAKWATER
DATE: 06 - 15 - 73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
DIRECTION (M°)
360
300
240
180
120
060
000
TIDE (ft)
8
6
4
2
0
-2
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 44



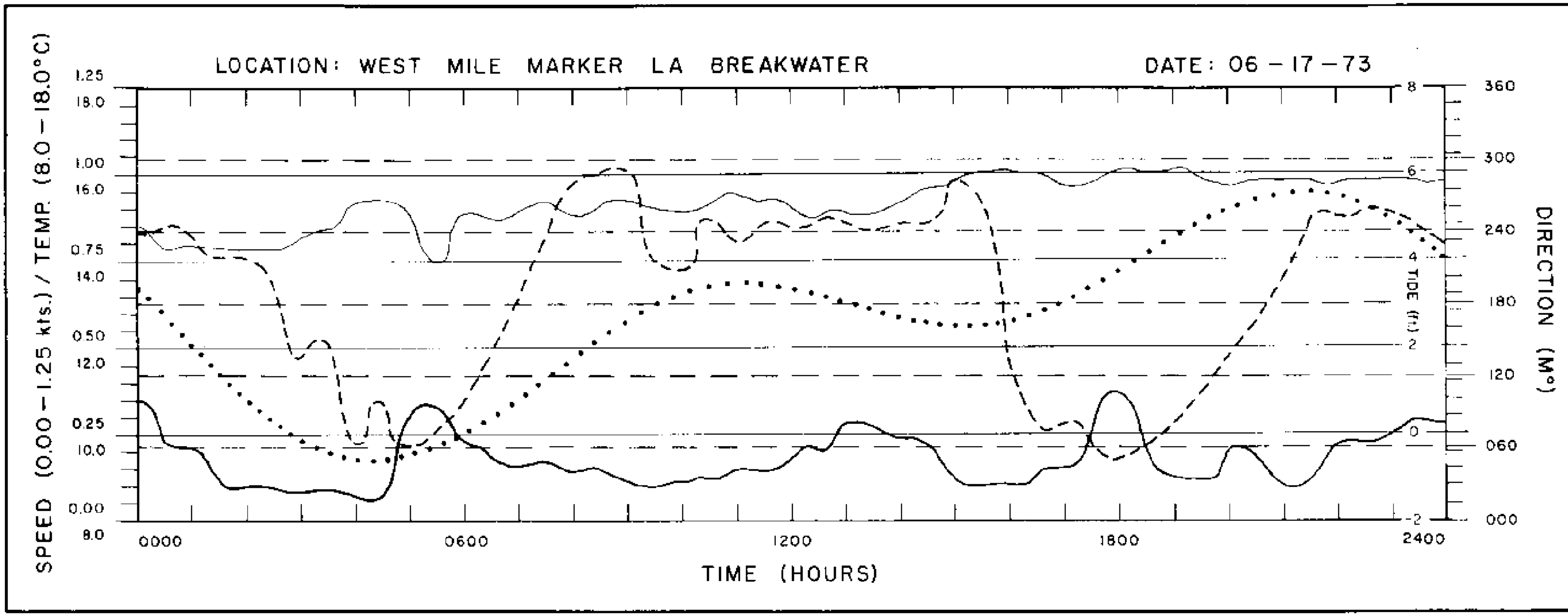
CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 45



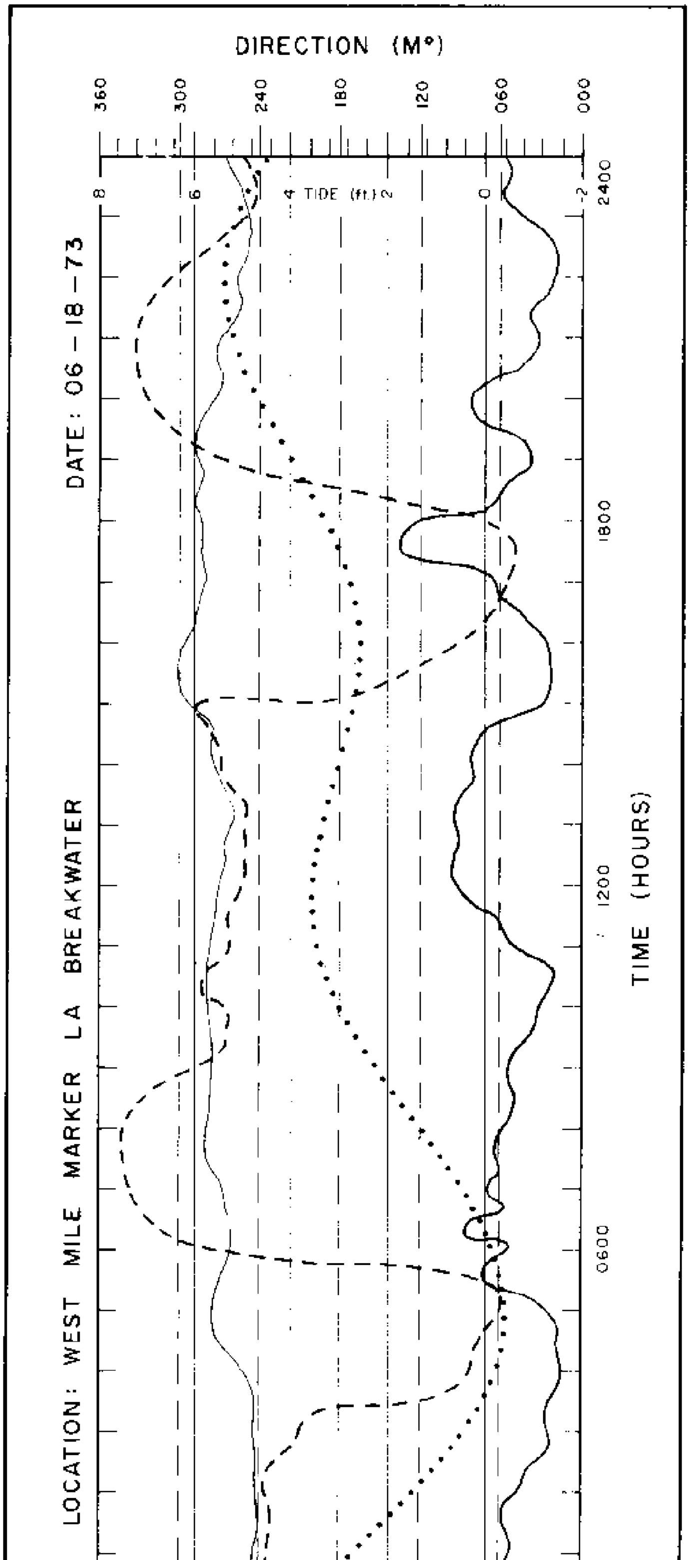
CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 46



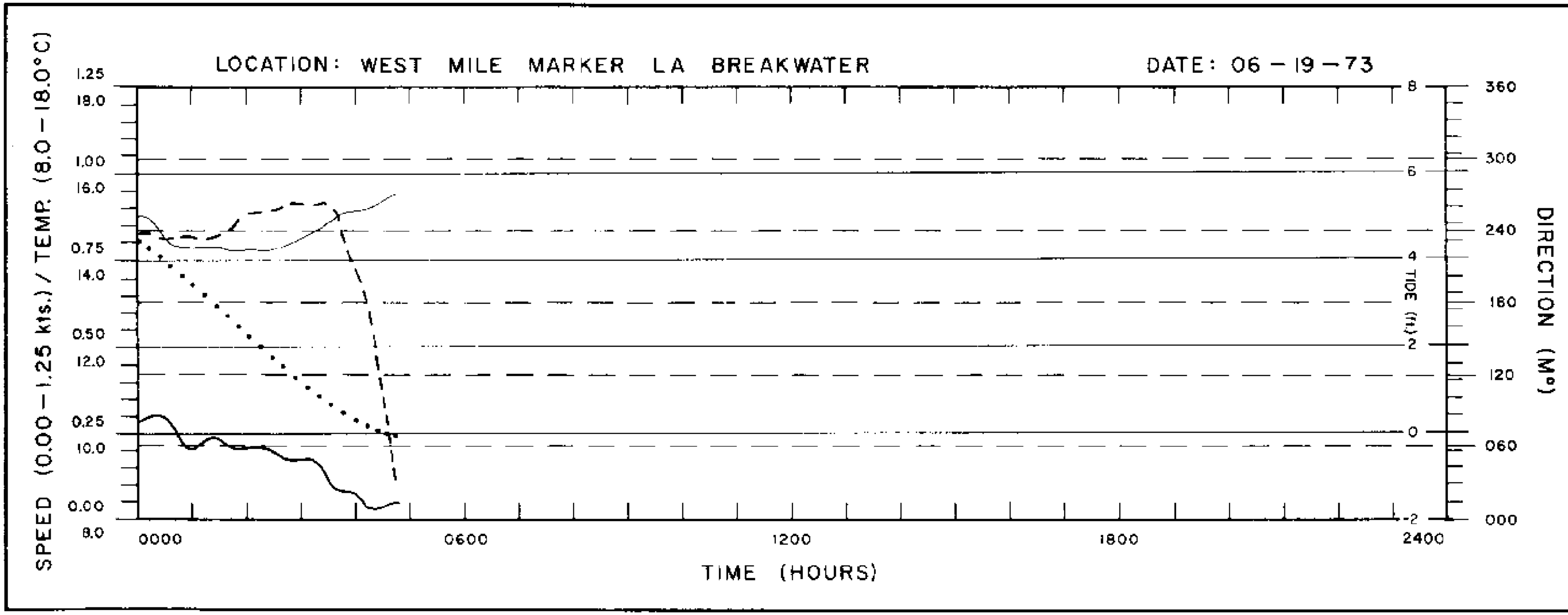
CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 47



CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 48

11-19 JULY 1973

BEND IN NAVY MOLE

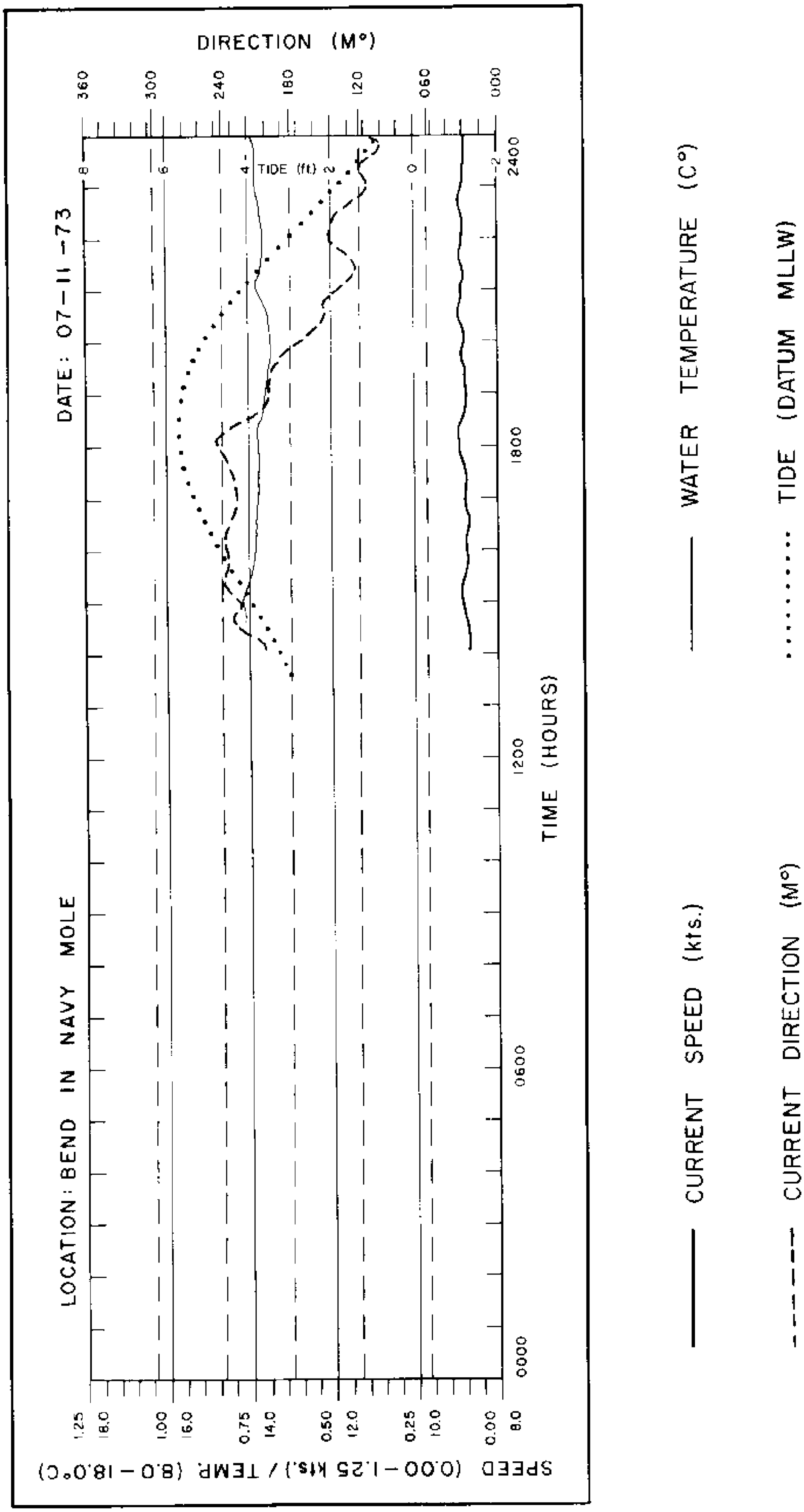
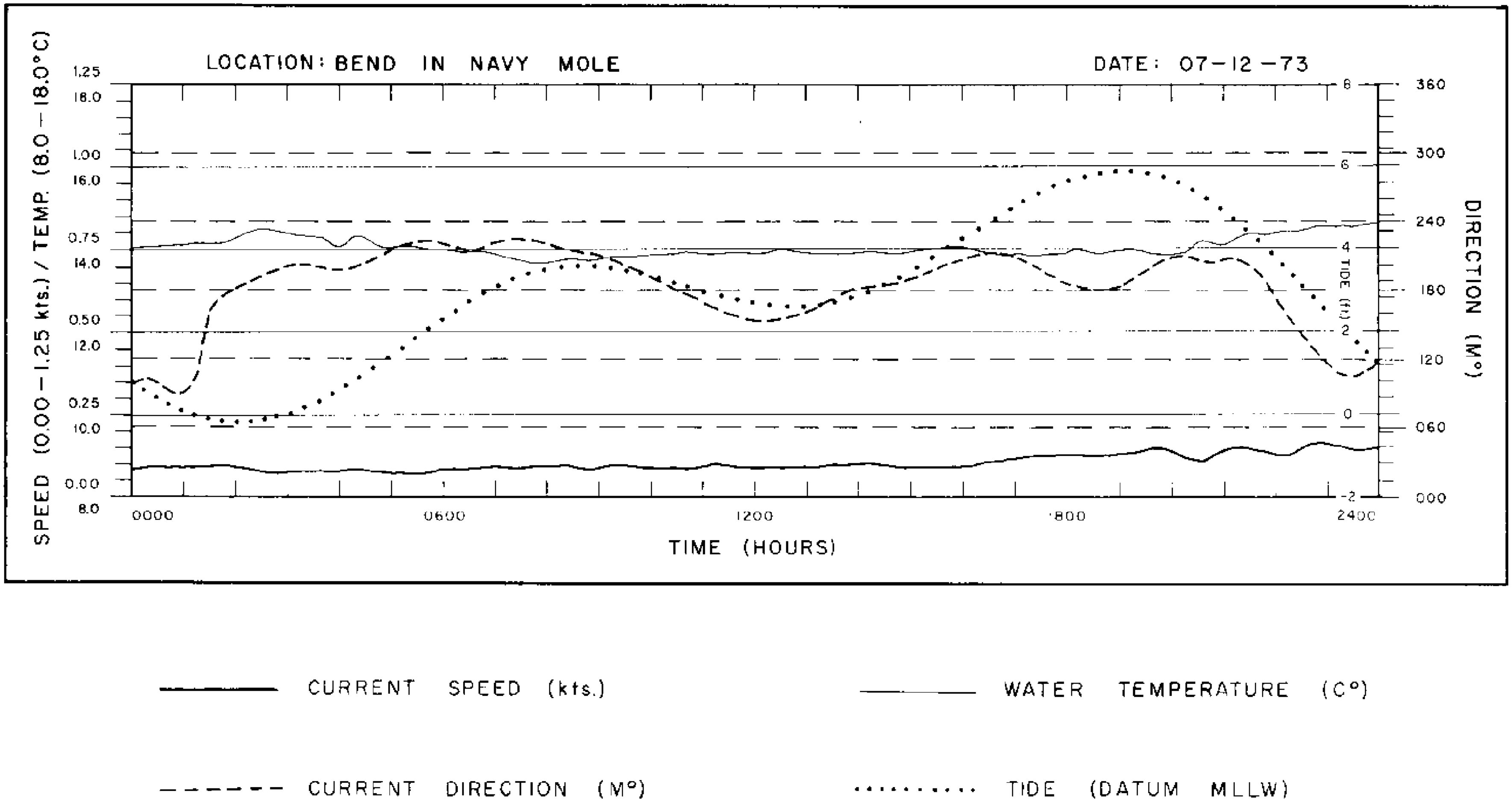
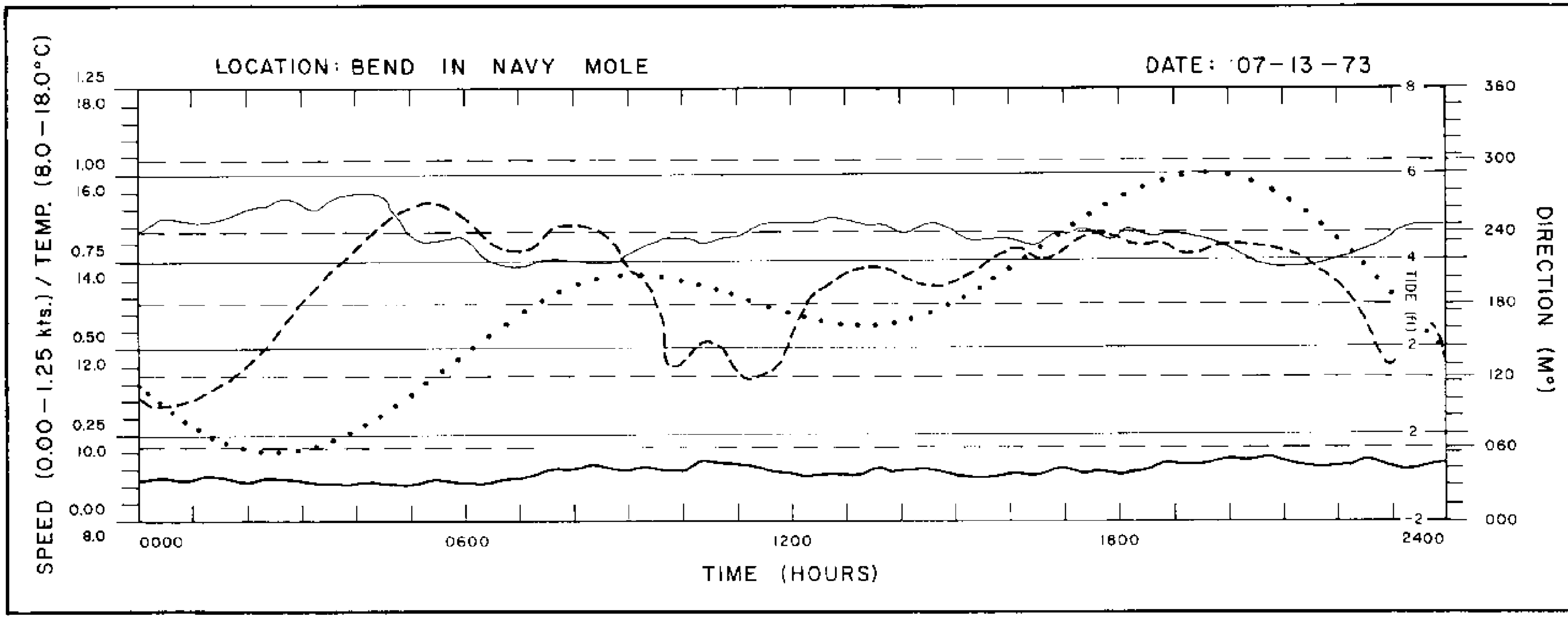

LOCATION: BEND IN NAVY MOLE
DATE: 07-11-73
DIRECTION (M°)
360
300
240
180
120
060
000
TIDE (ft)
8
6
4
2
0
-2
0000
0600
1200
1800
2400
TIME (HOURS)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
SPEED (0.00-1.25 kts.) / TEMP. (8.0-18.0°C)
CURRENT SPEED (kts.)
CURRENT DIRECTION (M°)
WATER TEMPERATURE (C°)
TIDE (DATUM MLLW)

FIG. 49



LOCATION: BEND IN NAVY MOLE
DATE: 07-12-73
SPEED (0.00 – 1.25 kts.) / TEMP. (8.0 – 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
DIRECTION (M°)
360
300
240
180
120
060
000
TIDE (ft)
8
6
4
2
0
-2
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 50



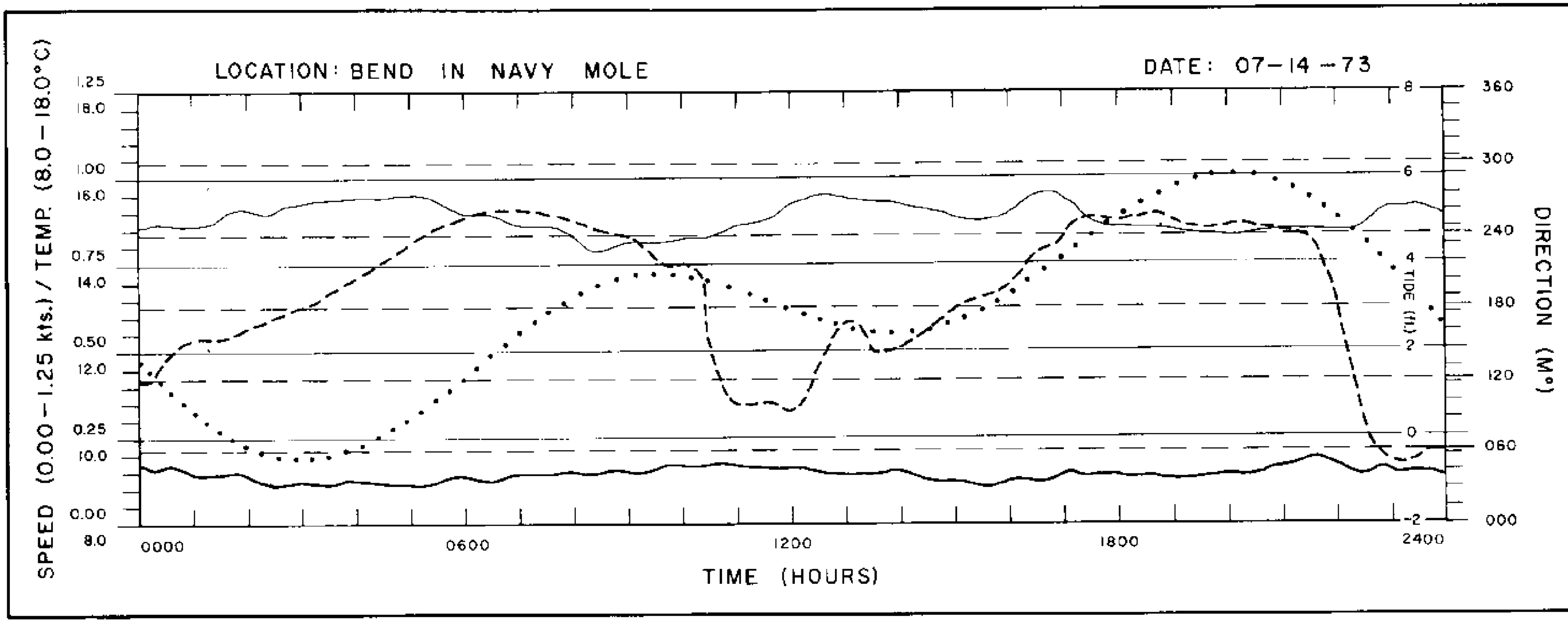
CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 51



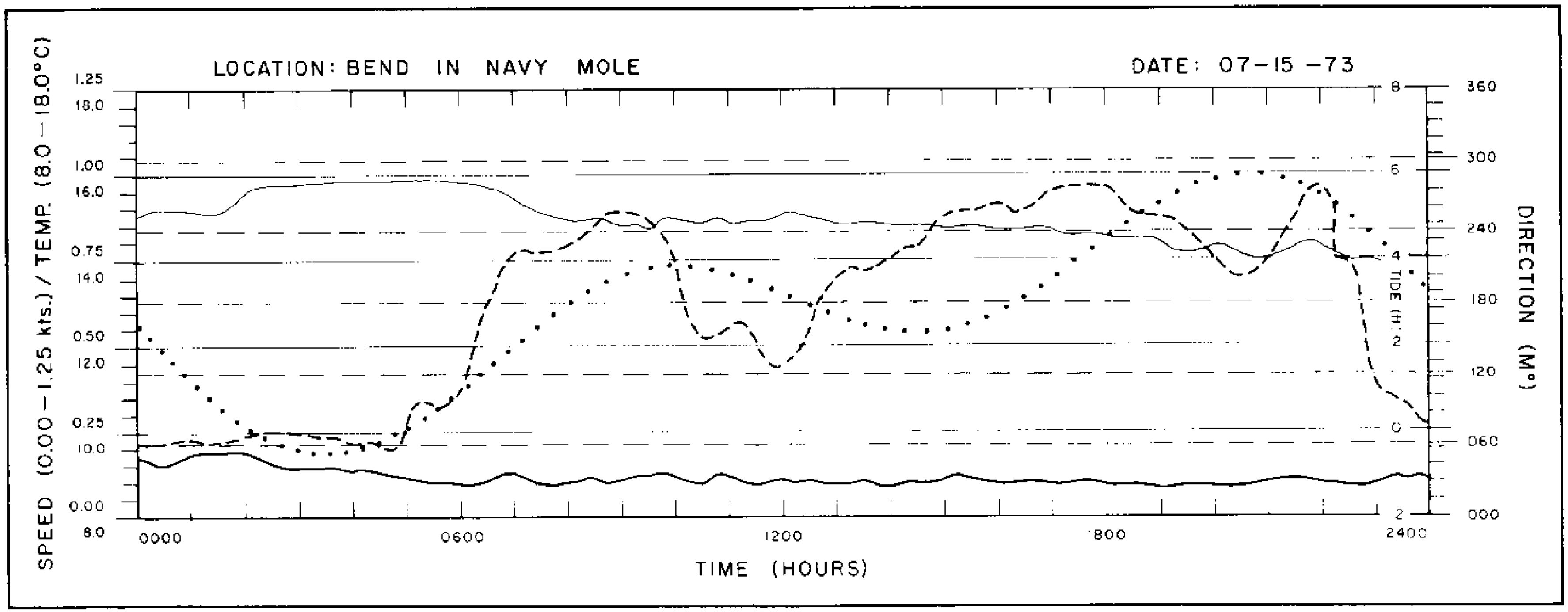
CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 52



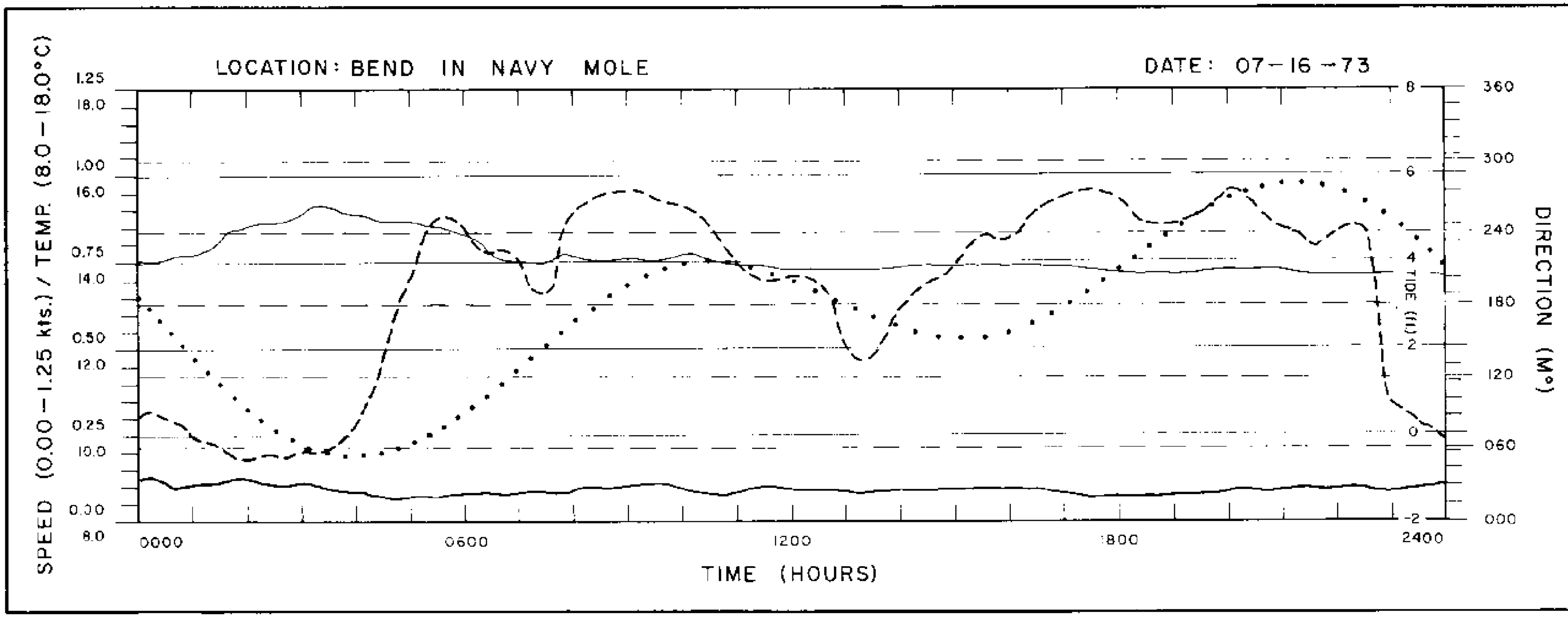
CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 53



———— CURRENT SPEED (kts.)

———— WATER TEMPERATURE (C°)

– – – – – – CURRENT DIRECTION (M°)

………… TIDE (DATUM MLLW)

FIG. 54

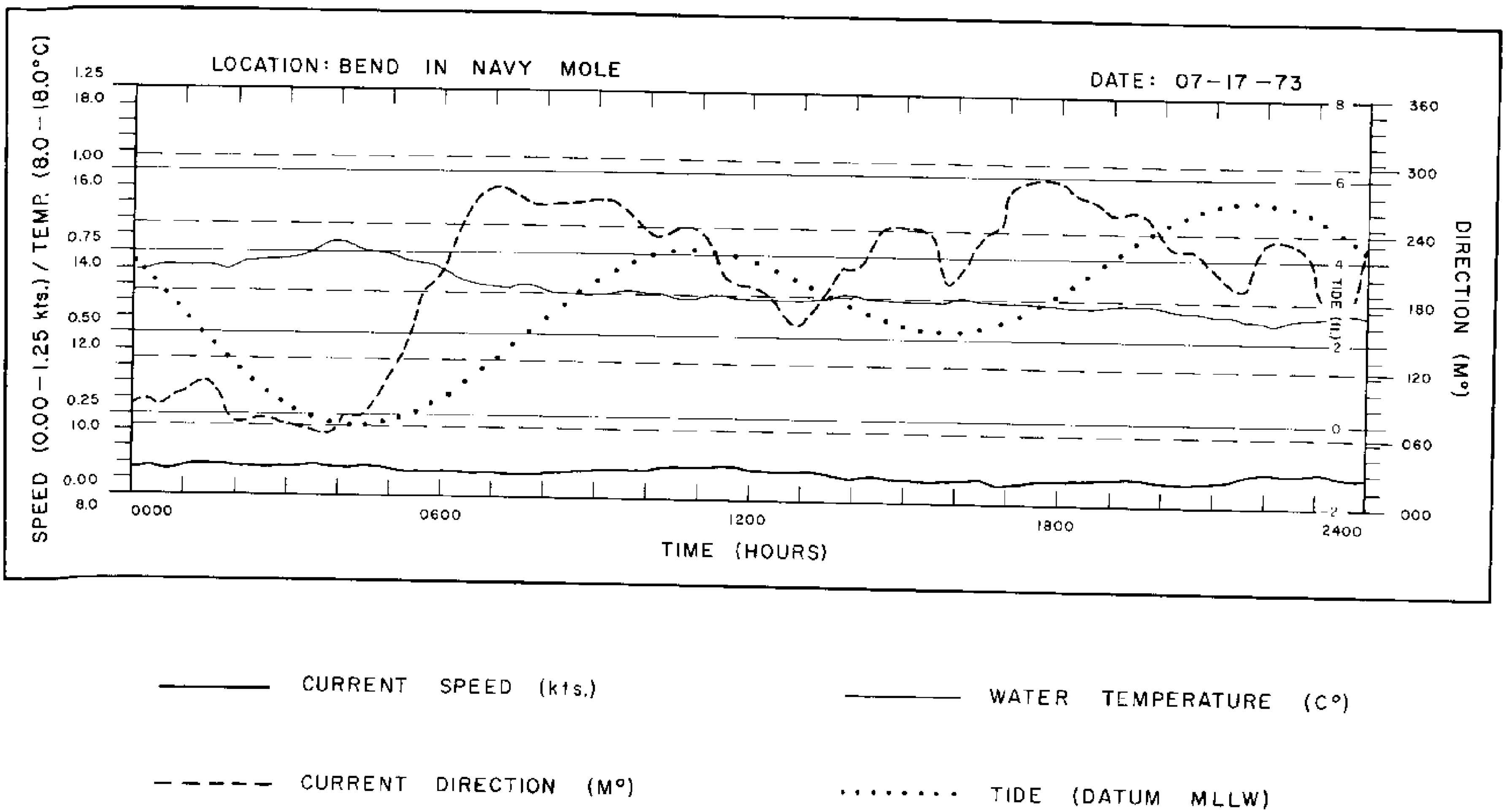

LOCATION: BEND IN NAVY MOLE
DATE: 07-17-73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
DIRECTION (M°)
360
300
240
180
120
060
000
TIDE (ft.)
8
6
4
2
0
-2
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 55

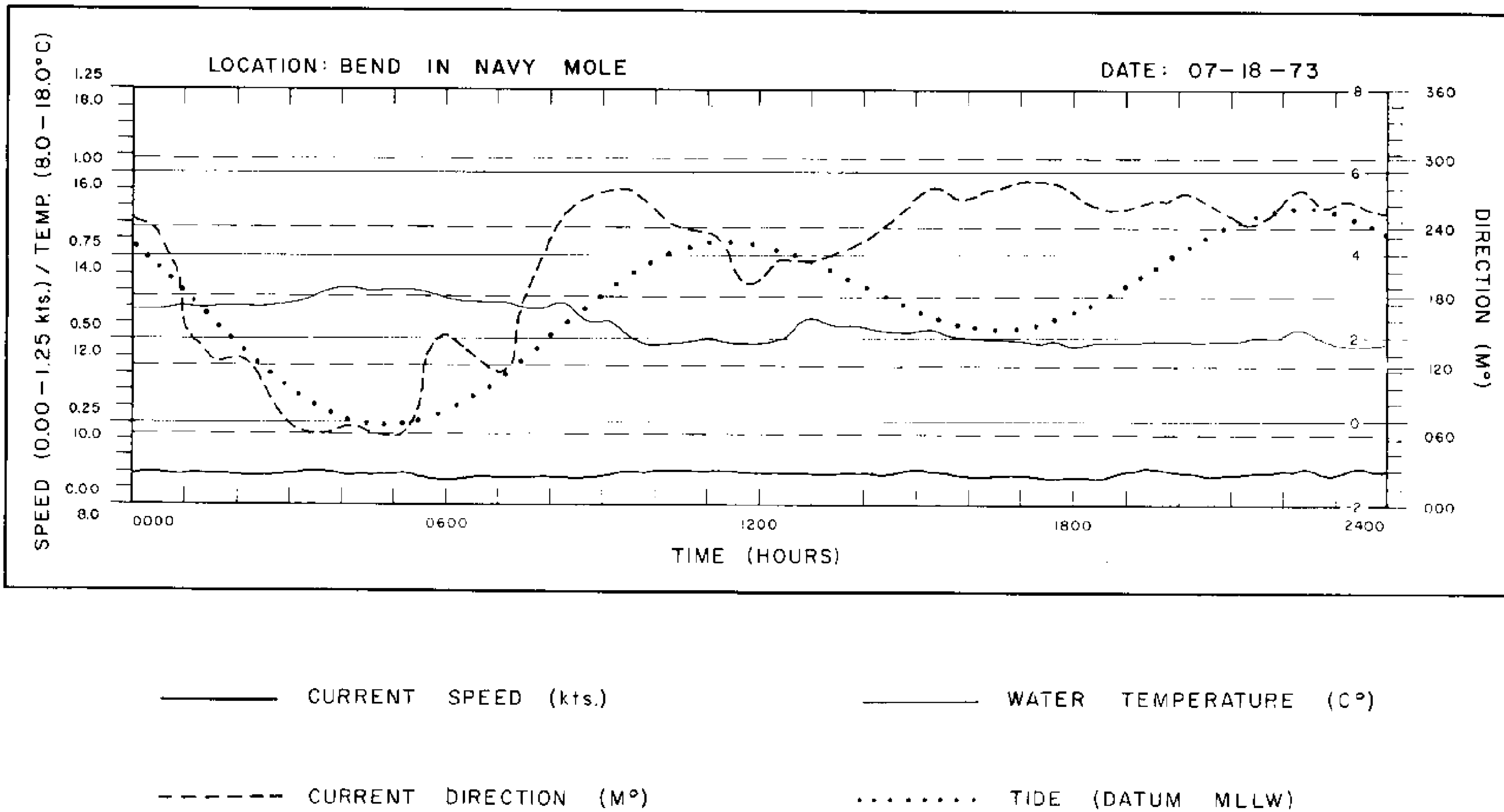
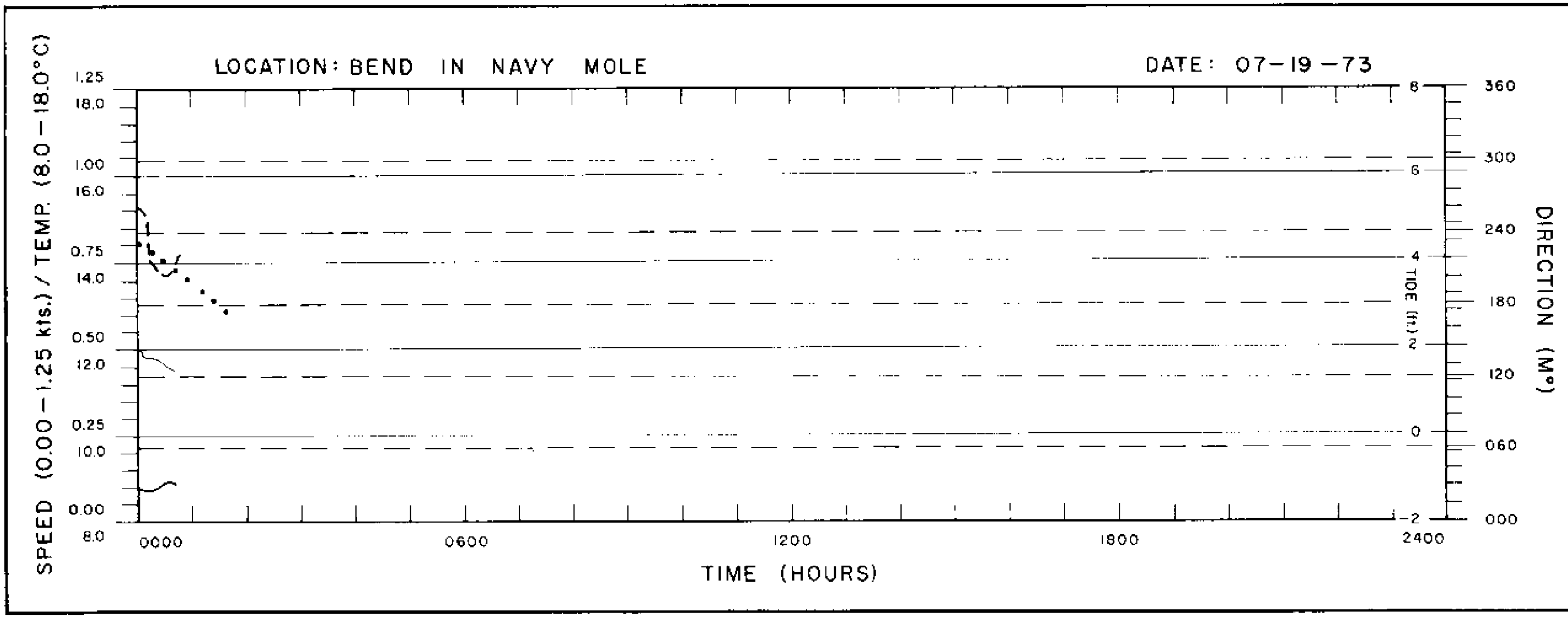

LOCATION: BEND IN NAVY MOLE
DATE: 07-18-73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
8
6
4
2
0
-2
360
300
240
180
120
060
000
DIRECTION (M°)
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 56



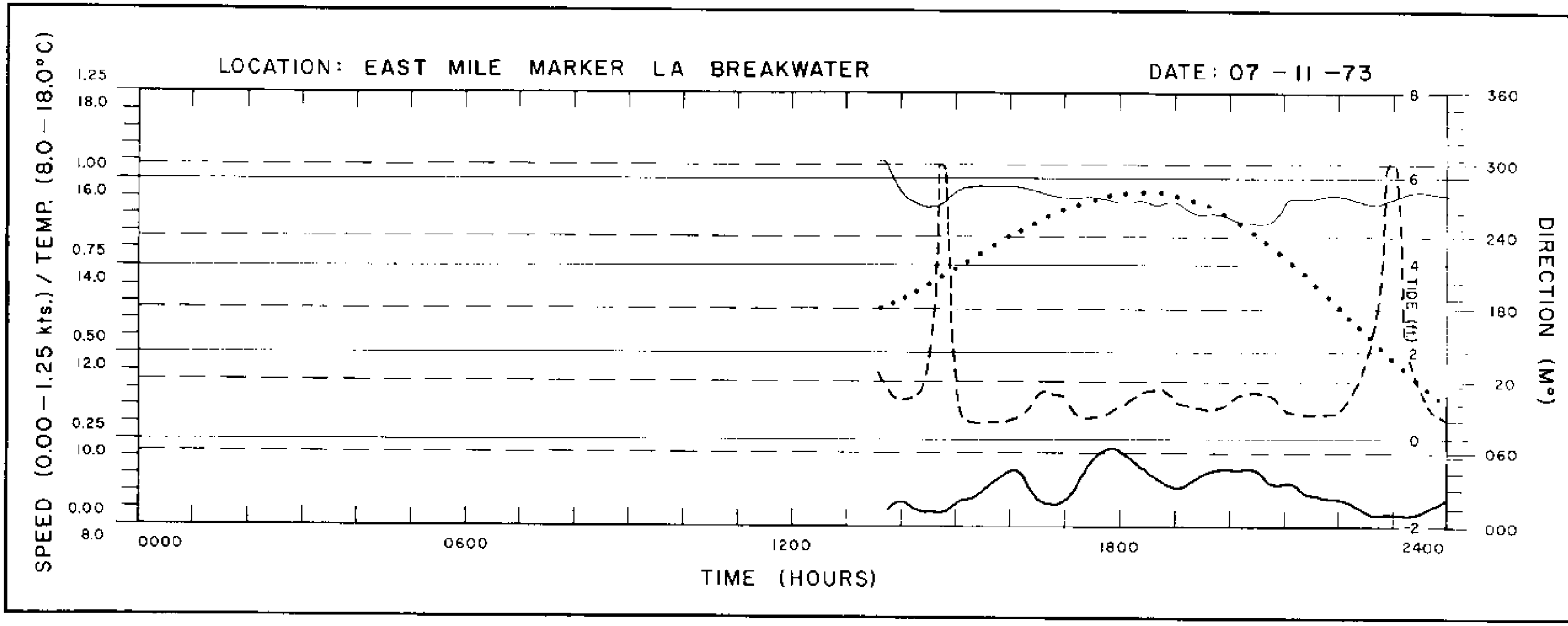
CURRENT SPEED (kts.) | WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°) | TIDE (DATUM MLLW)

FIG. 57

11-19 JULY 1973

EAST MILE MARKER OF LOS ANGELES BREAKWATER



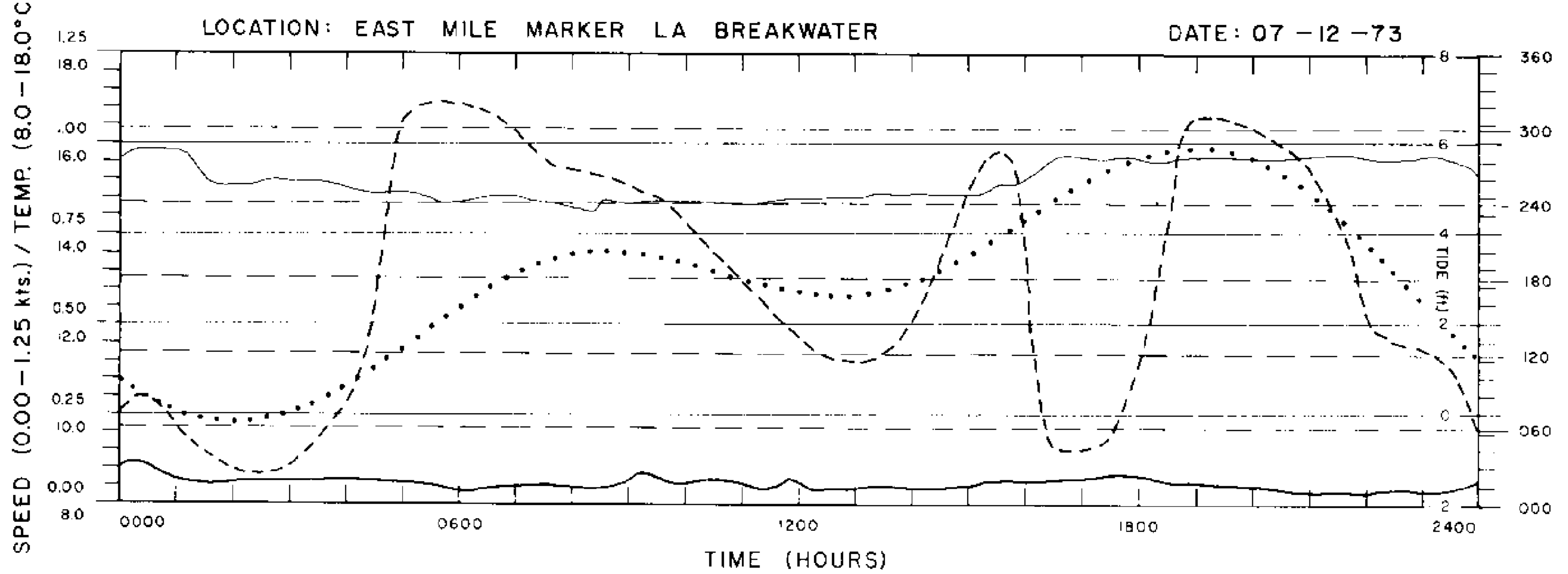
CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 58



CURRENT SPEED (kts.) — WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°) — TIDE (DATUM MLLW)

FIG. 59

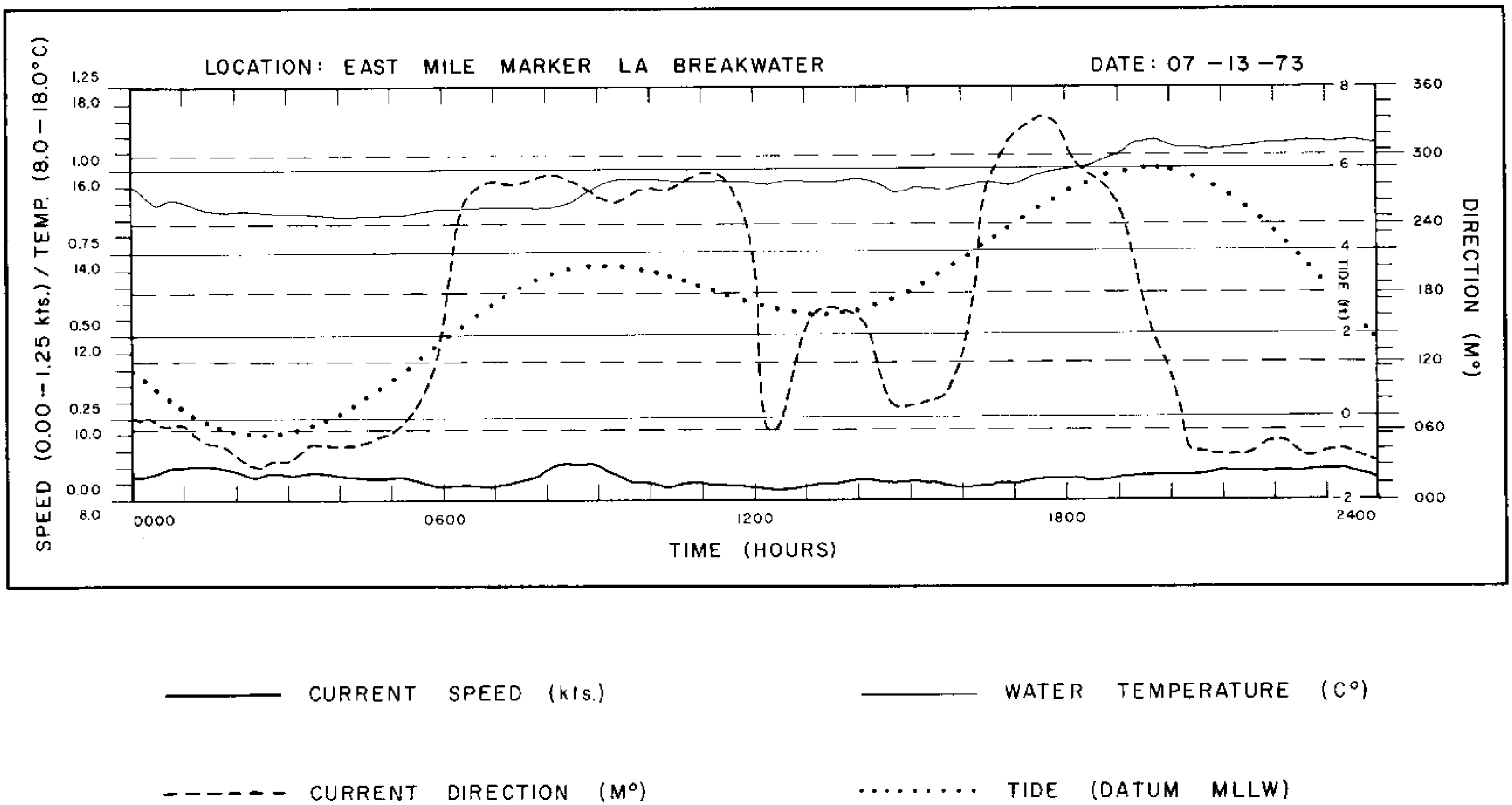

LOCATION: EAST MILE MARKER LA BREAKWATER
DATE: 07 -13 -73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
TIDE (ft)
8
6
4
2
0
-2
DIRECTION (M°)
360
300
240
180
120
060
000
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 60

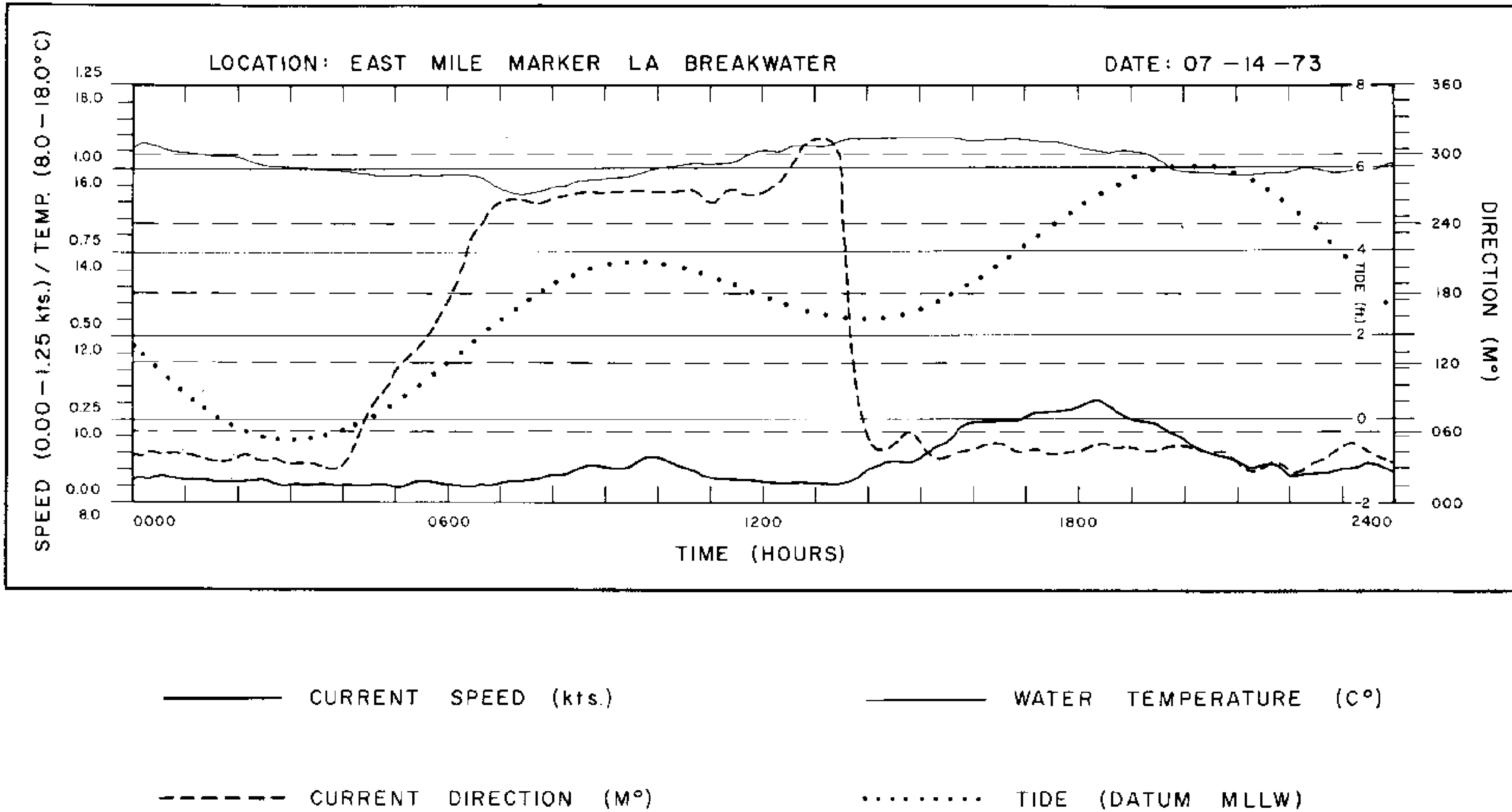
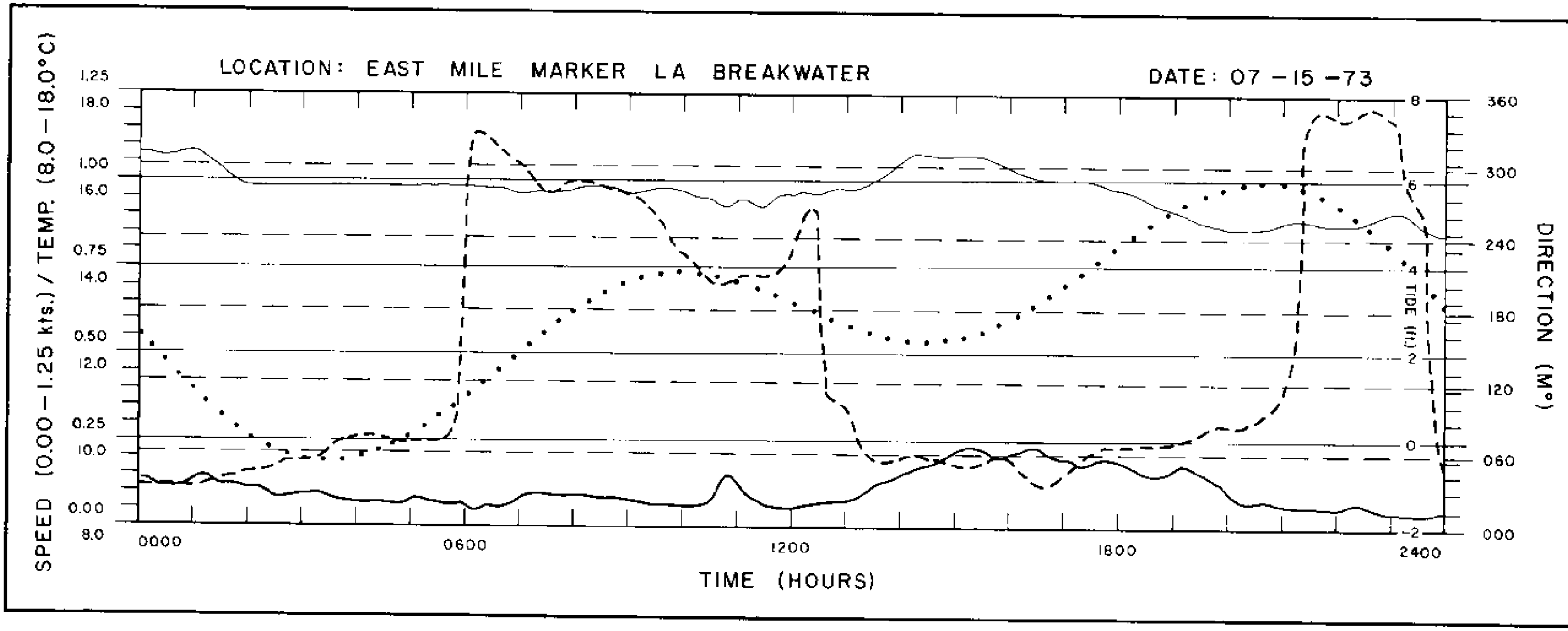

LOCATION: EAST MILE MARKER LA BREAKWATER
DATE: 07 -14 -73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
TIDE (ft.)
8
6
4
2
0
-2
DIRECTION (M°)
360
300
240
180
120
060
000
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 61



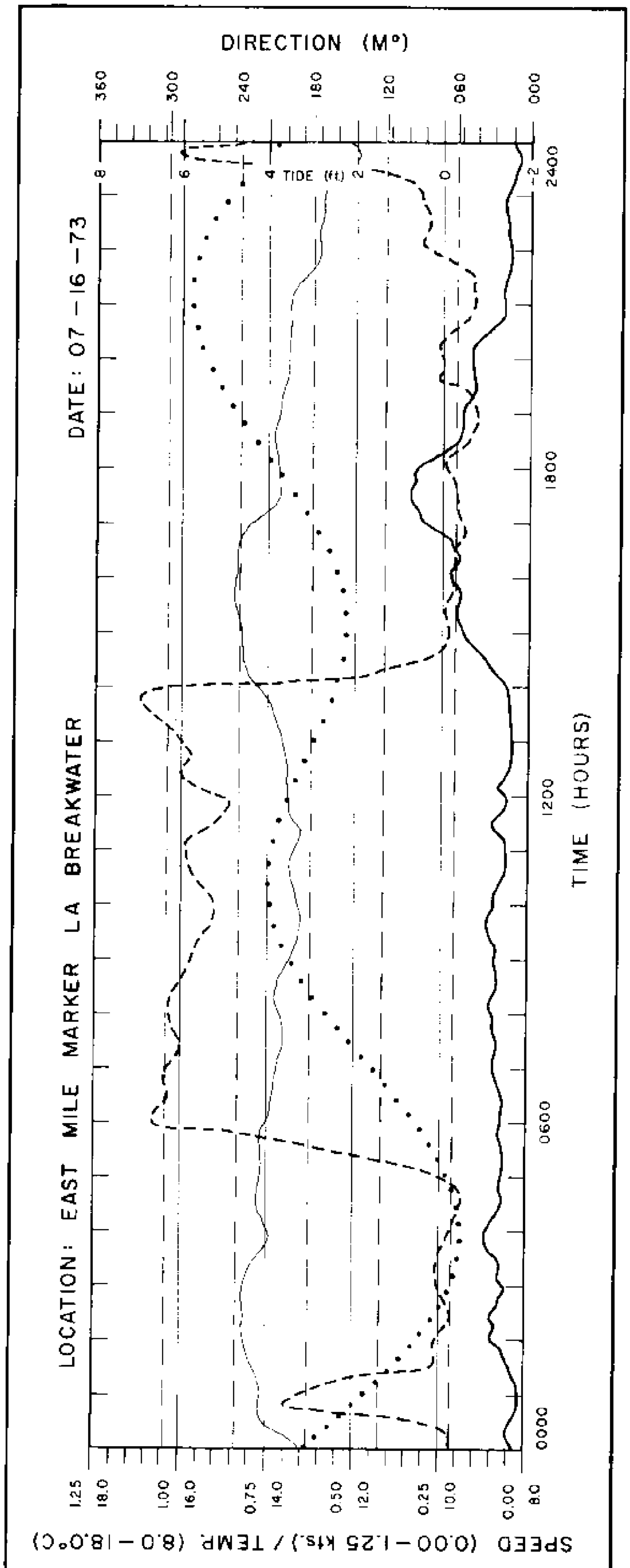
CURRENT SPEED (kts.)

WATER TEMPERATURE (C°)

CURRENT DIRECTION (M°)

TIDE (DATUM MLLW)

FIG. 62



——— CURRENT SPEED (kts.)

– – – – CURRENT DIRECTION (M°)

——— WATER TEMPERATURE (C°)

.... TIDE (DATUM MLLW)

FIG. 63

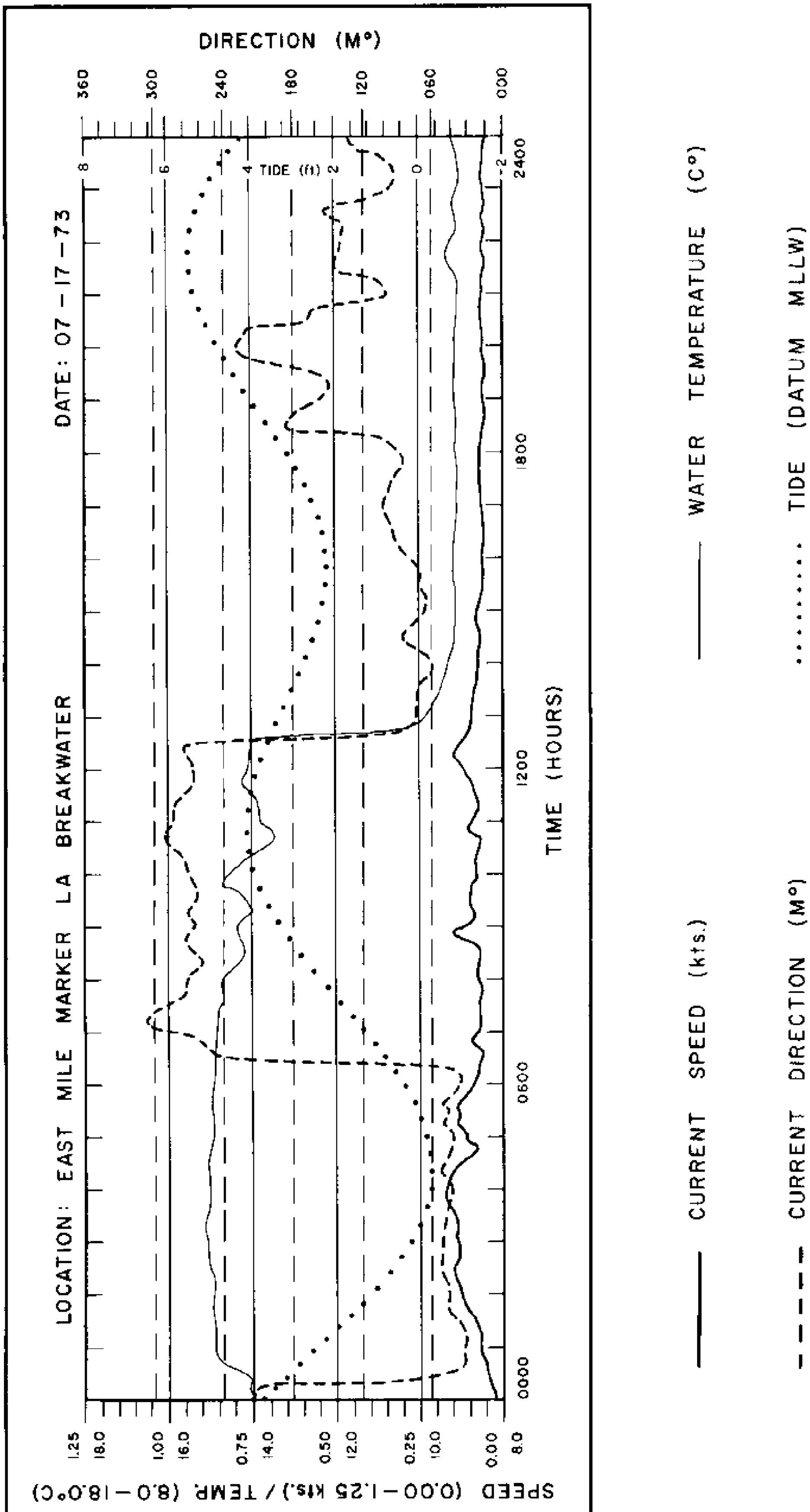
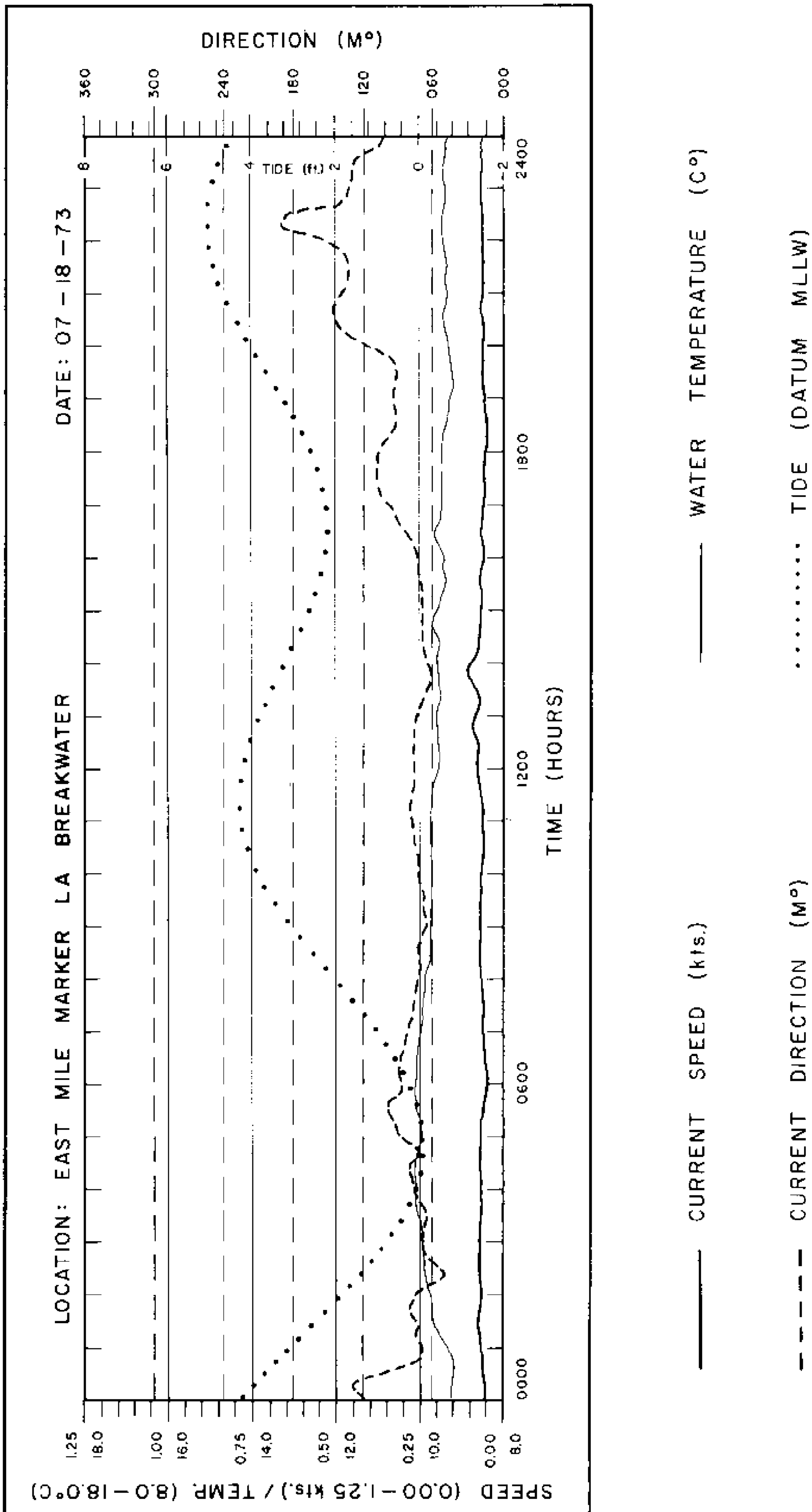

LOCATION: EAST MILE MARKER LA BREAKWATER
DATE: 07-17-73
DIRECTION (M°)
360 300 240 180 120 060 000
TIDE (ft)
8 6 4 2 0 -2
SPEED (0.00-1.25 kts.) / TEMP. (8.0-18.0°C)
1.25 18.0 1.00 16.0 0.75 14.0 0.50 12.0 0.25 10.0 0.00 8.0
TIME (HOURS)
0000 0600 1200 1800 2400
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 64



DIRECTION (M°)
360
300
240
180
120
060
000
LOCATION: EAST MILE MARKER LA BREAKWATER
DATE: 07 - 18 - 73
TIDE (ft)
8
6
4
2
0
-2
0000
0600
1200
1800
2400
TIME (HOURS)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
10.0
0.00
8.0
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 65

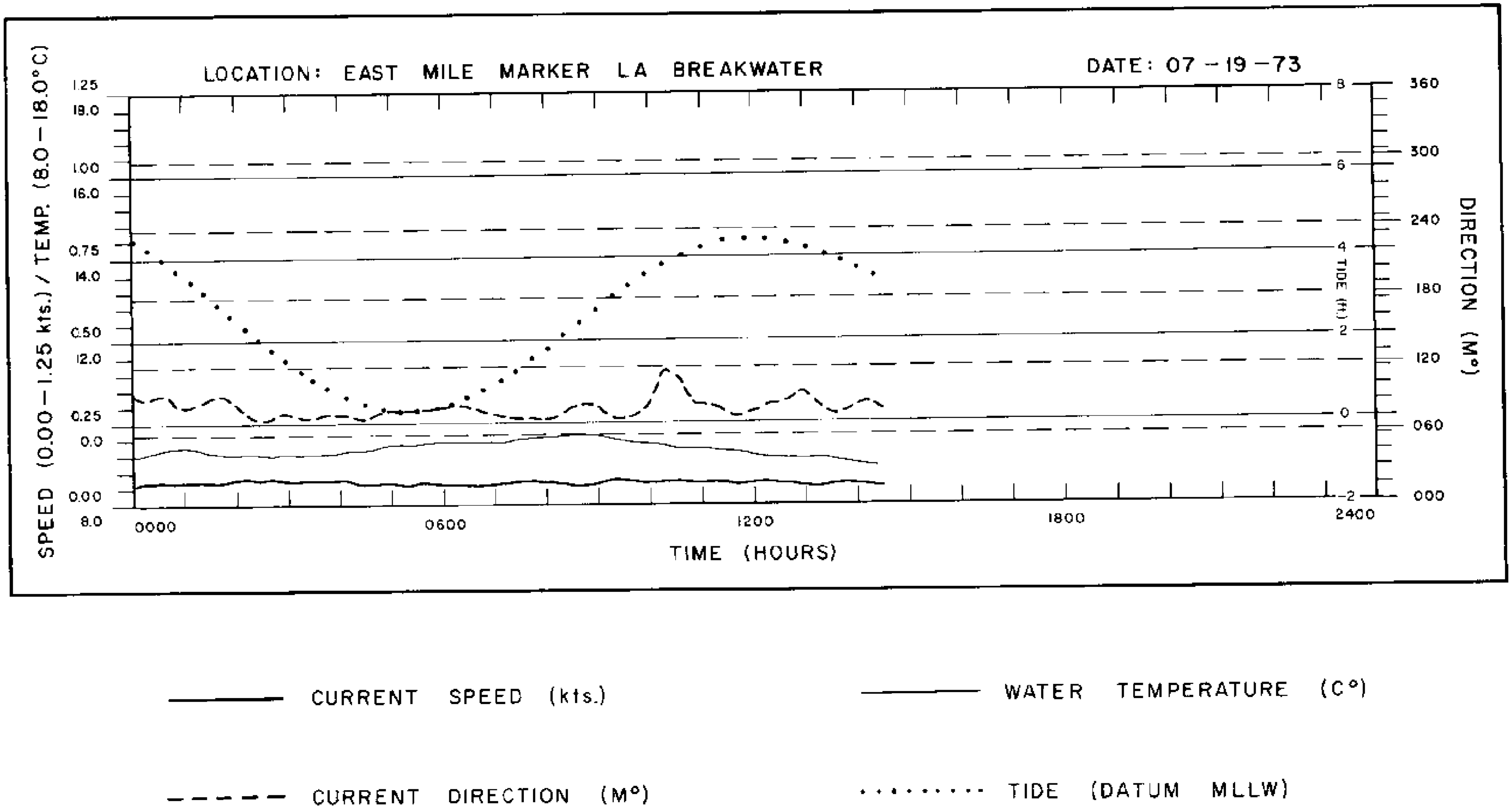

LOCATION: EAST MILE MARKER LA BREAKWATER
DATE: 07 - 19 - 73
SPEED (0.00 - 1.25 kts.) / TEMP. (8.0 - 18.0°C)
1.25
18.0
1.00
16.0
0.75
14.0
0.50
12.0
0.25
0.0
0.00
8.0
TIDE (ft.)
8
6
4
2
0
-2
DIRECTION (M°)
360
300
240
180
120
060
000
0000
0600
1200
1800
2400
TIME (HOURS)
CURRENT SPEED (kts.)
WATER TEMPERATURE (C°)
CURRENT DIRECTION (M°)
TIDE (DATUM MLLW)

FIG. 66