THE FEDERAL REPUBLIC OF NIGERIA

REPORT

ON

THE NEW OCEAN TERMINAL PROJECT, LAGOS (PHASE-II)

-NATURAL CONDITIONS SURVEY-

FEBRUARY 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

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1) General meteorology

The atmospheric temperature, atmospheric pressure and relative humidity observed at the project site were not much different from those observed in Lagos, but the amount of precipitation was largely different from that in Lagos.

The period in which observation was made is the season in which the atmospheric temperature is the lowest in the year, and the average was around 25°C. The daily maximum temperature occurs between noon and 3 o'clock in the afternoon, and the daily minimum temperature occurs between 6 o'clock and 8 o'clock in the morning.

As for the atmospheric pressure, surge phenomenon of the period of 6 hours in observed in its timewise trend, and the range is the maximum at noon and 6 o'clock in the evening.

The relative humidity increases between midnight and dawn, and becomes the lowest around 3 o'clock in the afternoon. The monthly mean relative humidity during the survey period was 87 ∿ 90%.

The amount of precipitation was as much as 2.5 times in July and 1.28 times in August of the values observed in Lagos in the same period, and the monthly ratio of number of rainy days to the month was 81% in July, 97% in August and 35% in September.

2) Wind

Because the survey period was the season in which ITC (Inter Tropical Convergence Zone) moves up north, the characteristics of distinguished Guinea monsoon were clearly seized. As for the frequency of occurrence of wind direction, the range of SSW - WSW occupies the ratio that is over 60% of all. Although the instantaneous maximum wind velocity of about 20 m/sec was recorded during the survey period, it is rare under normal arrangement of atmospheric pressure

that 10 m/sec is exceeded. The peak wind velocity often occurs in the afternoon toward the evening.

3) Waves

The main incoming waves are swell. As for their period, the range of 11 ∿ 13 seconds is distinguished, and the range of 13 ∿ 15 seconds follows. The waves of the ranges of 11 ∿ 15 seconds occupy the ratio that is over 80% of all. As for the frequency of occurrence of significant wave height, on the other hand, the range of 0.7 ∿ 1.8 m occupies the ratio that is about 90% of all. SSW is distinguished as for the wave direction.

4) Coastal current

The current direction inside of the breaker zone was from west to east, and the current velocity was 0.3 ∿ 0.4 m/sec. The current in this area is controlled by the wave conditions with wave direction as the main factor. The current outside of the breaker zone changes in both direction and velocity, but external factors for it are not known.

The main direction of current at an offshore point of 3 km from the shore was from west to east. The current velocity changes in the vertical (variation). That is, 0.4 m/sec (0.8 knot) at the depth of 5 m below the surface, and was 0.16 m/sec (0.3 knot) at the depth of 10 m from the surface. However, the current at an offshore point of 5 km from the shore was from east to west, and the current velocity did not involve vertical change, and was around 0.35 m/sec (0.7 knot).

5) Littoral drift

The beach drift at the shore is closely related to the wave conditions, and its variation is drastic. Although the sand disappears from the shore when the weather is rough, it is recovered when the weather is calm. Therefore, relatively stabilized shore topography is maintained in a long run. As for the longshore drift

phenomena at sea, the balance between incomings and outgoings has been maintained, and they have not yet reached the level that causes changes in the topography.

The grain size distribution at the bottom values by the deposit environment, and the grain size becomes relatively large at the water depth of 14 ∿ 15 m.

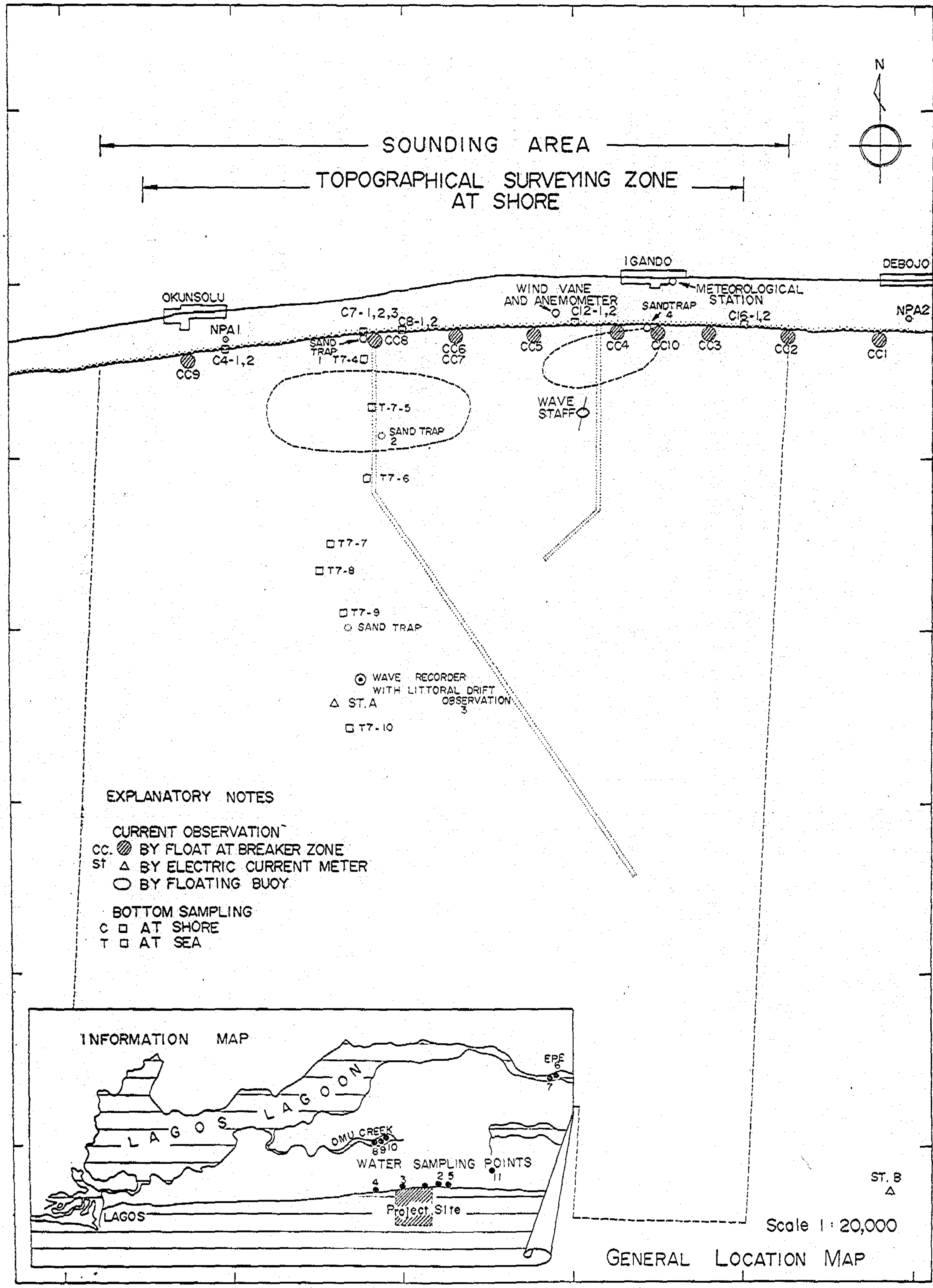
6) Topography

The coastline monotonously extends in east to west direction in general, and formation of cusps is observed at occasions in the places where the slope of foreshore is gentle.

The slope of foreshore is 1:5 ∿ 1:8 in general, but seasonal variation is observed in its cross sectional form, and the variation in the topography on the east side of the survey area was conspicuous. Development of sand bars was observed in the breaker zone. The depth contour in the offshore area indicate the topography of minor valley form at the center, but they are monotonous as a whole, and their slope is in the range of 2/1000 ∿ 3/1000.

7) Water quality

The water in the surface layers of the swamp and the lagoon was of brown color, and its pH value was inclined to acidity. But well water was colorless and neutrality.


SOUNDING AREA
TOPOGRAPHICAL SURVEYING ZONE AT SHORE
N
IGANDO
DEBOJO
OKUNSOLU
WIND VANE AND ANEMOMETER
METEOROLOGICAL STATION
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C8-1,2
C12-1,2
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CC6
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CURRENT OBSERVATION
CC. BY FLOAT AT BREAKER ZONE
ST BY ELECTRIC CURRENT METER
BY FLOATING BUOY
BOTTOM SAMPLING
C AT SHORE
T AT SEA
INFORMATION MAP
LAGOS LAGOON
EPE
OMU CREEK
WATER SAMPLING POINTS
Project Site
LAGOS
ST. B
Scale 1 : 20,000
GENERAL LOCATION MAP

1. OUTLINE OF THE SURVEY

1-1 Purpose of Survey

This survey was executed following the survey in fiscal 1977 (Phase-I) and fiscal 1978 (Phase-II, first year), for the purpose of obtaining fundamental data for establishment of the master plan related to the New Ocean Terminal Project in Lagos.

This survey was composed with seizure of natural conditions in the project area as the principal object, and was executed in rainy season in which meteorological and maritime conditions are particularly unstable.

1-2 Composition of Survey Team and Period of Field Survey

The field survey was executed by a team of the following five persons.

Hiroshi TAGUCHI, leader
Tatsuya YAMAUCHI
Mineo MASUDA
Hideaki HINATA
Seiji SASAKI

The survey was executed in the period of June 25, 1979 through October 5, 1979, and Yoshiyuki MUNAKATA joined the team for analysis of data in Japan.

1-3 Items and Quantity of Survey

The principal items of the survey of natural conditions are as follows.

a) General meteorological observation

Atmospheric pressure, atmospheric temperature, relative humidity, amount of precipitation:

July 15 ∿ September 27

b) Wind observation

Observation of wind conditions with wind vane and anemometer:

July 18 ∿ September 27

c) Wave observation

Wave observation with wave recorder and visual observation of wave direction:

July 12 ∿ September 29

d) Coastal current observation

Current observation at inshore and offshore with floating buoys and electric current meter:

Executed a number of times during survey period.

e) Drift sand observation

Collection of drift sand with sand traps, survey of topographical variation of shore by direct leveling, and grain size analysis of sand at shore and at bottom.

f) Topographical surveying

Off shore sounding: $4\ km \times 4.5\ km = 18\ km^2$

Topographical surveying of shoreline features by direct leveling.

g) Water examination

Measurement and analysis of surface water quality at swamps, logoon, etc. Twice at eleven points.

Items: Water temperature, pH, transparency, COD, Chlorine-ion, SS, etc.

2. METHOD OF SURVEY

2-1 Establishment of Survey Base

The base for various surveys and observations on the land was established in Igand area located in the site because of the geographical conditions. General meteorological observation equipment as well as a wind vane and anemometer were installed in this base and various surveys and observations were executed. However, the base port for the observation requiring vessels in the sea was Lagos Harbor.

2-2 Control Point Survey

Control points for clarifying the positions are required prior to execution of surveys.

NPA-1 and NPA-2, which are existing ground control points, were used as known points, and connection was made between these two points by traverse surveying, and in addition, stations were added and extended as required. For selection of stations, the stations provided for the last survey were recovered with priority, if they were remaining as they are.

At the same time, direct leveling using NPA-1 and NPA-2 as known points was executed, and was used as the reference for topographical surveying of the shore and for decision of altitude.

The induction points to become base points for sounding and shore surveying were newly established at 250 m intervals along the shore with said reference points used as references. The outline of arrangement of stations is indicated in Fig. 2-1.

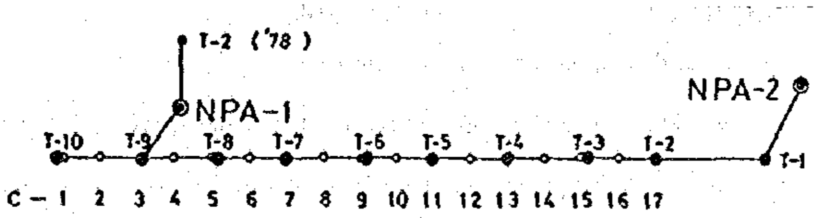

Fig. 2-1 Network of Traverse and Leveling

The coordinate and height of known points NPA-1 and NPA-2 are as shown in Table 2-1.

Table 2-1 Coordinate and Height of Control Points

		NPA-1	NPA-2
Coordinate	B	6° 26' 18.781"	6° 26' 22.342"
	L	3° 47' 44.575"	3° 49' 53.407"
	N	711 686.61	711 802.28
	E	587 992.82	591 950.31
Height		3.81m above M.S.L	4.09m above M.S.L
Location		In front of OKUNSOLU	In front of DEBOJO

Main equipment used for control point surveying are as follows.

Distance meter Type 3800-B
Theodolite Type TM-10
Auto level Type B-2

2-3 General Meteorological Observation

Meteorological observation was executed with the equipment mounted in the screen installed in Igando area.

The items of observation were atmospheric pressure, atmospheric temperature, relative humidity and amount of precipitation and the used equipment are as follows.

Atmospheric pressure: Aneroid barograph and aneroid indicating barometer

Atmospheric temperature and humidity:
Bimetal thermograph and hair hygrograph and Assmann ventilated psychrometer

Amount of precipitation: Rain gauge with reserving pot

Auto recording of atmospheric pressure, atmospheric temperature and of humidity was made using cylindrical clocks good for one week. Fixed-time observation at site was made at noon as a rule. Observation of

atmospheric pressure, atmospheric temperature and humidity was made with an aneroid indicating barometer and an Assmann ventilated psychrometer simultaneously with observation of weather, and comparison was made with auto records and correction values were obtained.

The ground height of the place of installation of the screen was 4.52 m above mean sea level and the instrument height was 5.8 m.

The results of observations are recorded in daily registers and monthly registers.

2-4 Wind Observation

Wind observation was executed at the project site using a wind vane and anemometer.

A place on the shore where no palm trees obstruct observation was selected for observation, trees in the vicinity were cut off, a post was erected, and the sensor was fixed on top of the post at the height of 10 m above the ground. The recorder was fixed in the shed on the ground, and connection with the sensor was made with a private cable.

The ground height of this point is 4.4 m above mean sea level.

2-5 Wave Observation

The wave height and its period in the project area were calculated from the records obtained by the hydraulic direct wave recorder (wave recorder; Type DW-III) anchored at the seabottom. These records are what were obtained by operation of the recorder for 10 minutes once every two hours under the control of a clock. The wave direction in the observation period was observed on the land by using a magnet compass.

A wave staff was installed in the sea front of the metrorological station on the land for making a comparison with the result of observation made with the wave recorder, but it became unserviceable in the middle of the observation period due to damage caused by waves.

The amplitude and period were measured based on zero up crossing method from the records on the recording paper obtained with the wave recorder,

and the data were processed with a computer. The results are indicated in daily registers and monthly registers together with records of meteorogical observation.

Situations of establishment of the wave recorder and the wave staff are indicated in Fig. 2-2.

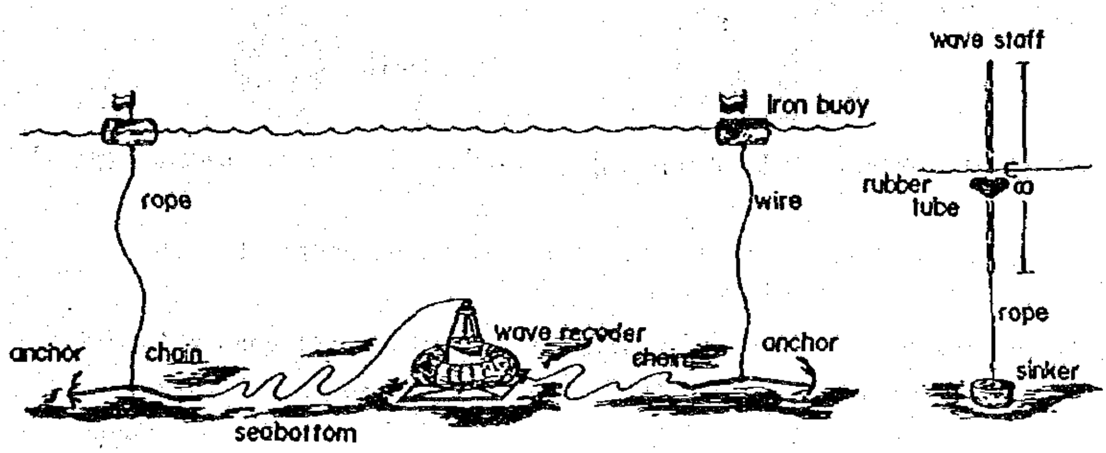

Fig. 2-2 Establishment of Wave Recorder and Wave Staff

2-6 Coastal Current Observation

Coastal current observation was executed for the purpose of seizing the outline of flow of the coastal current in the project area at inside and outside of the breaker zone and also at an offshore point of 5 km from the shore with local flow characteristics taken into consideration. Observation at inside and outside of the breaker zone was made by floating buoys, and measurement in vertical station at the fixed point was made with an electric current meter at the offshore point.

The shape of floating buoys used for observation at inside and outside of the breaker zone is indicated in Fig. 2-3.

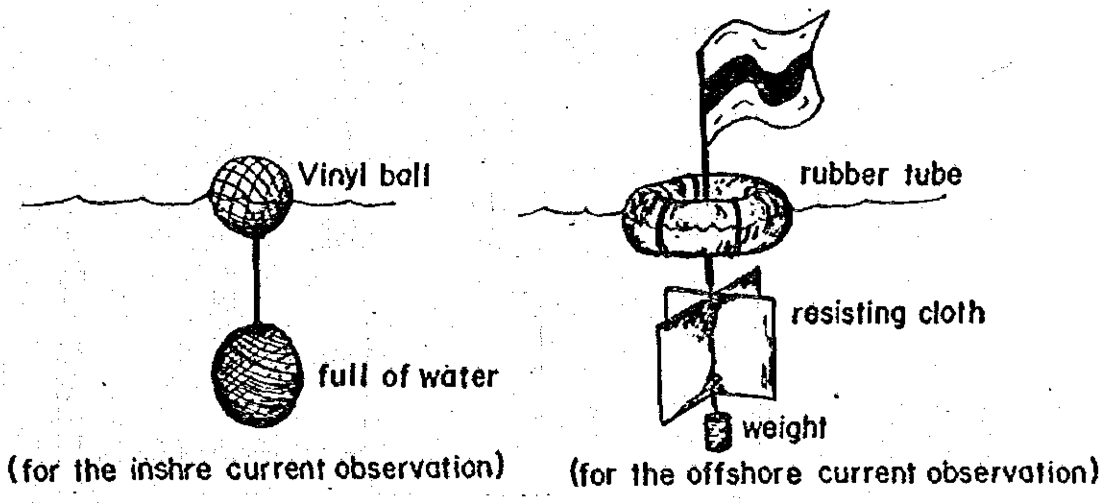

Fig. 2-3 Floating Buoys for Surface Current Observation

The floating buoy track chart is indicated in Fig. 2-4 and current observation points at the breaker zone are indicated in Fig. 2-5 in the following pages.

Fig. 2-4 TRACK CHART OF COASTAL CURRENT OBSERVATION BY FLOATING BUOY

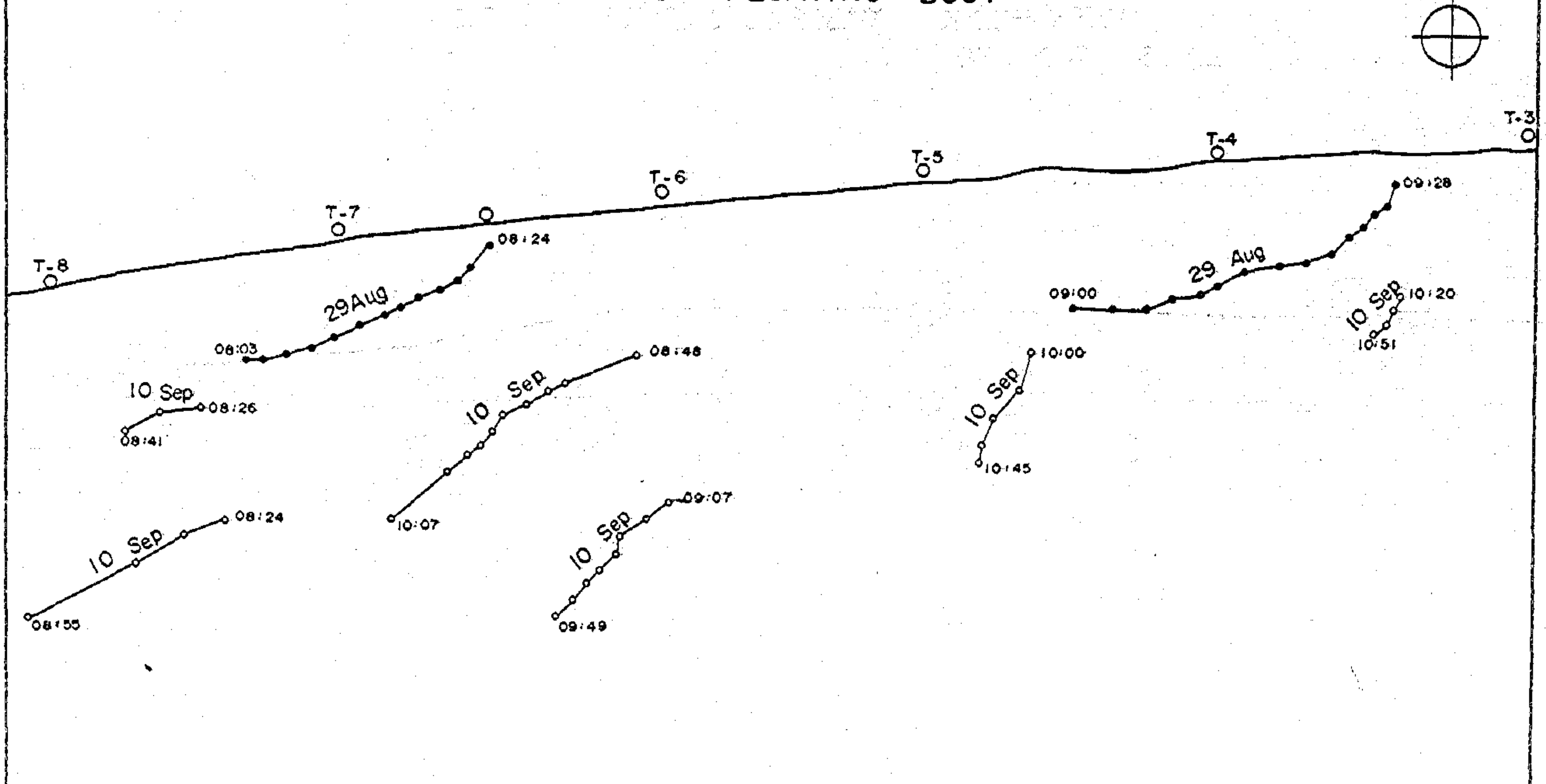

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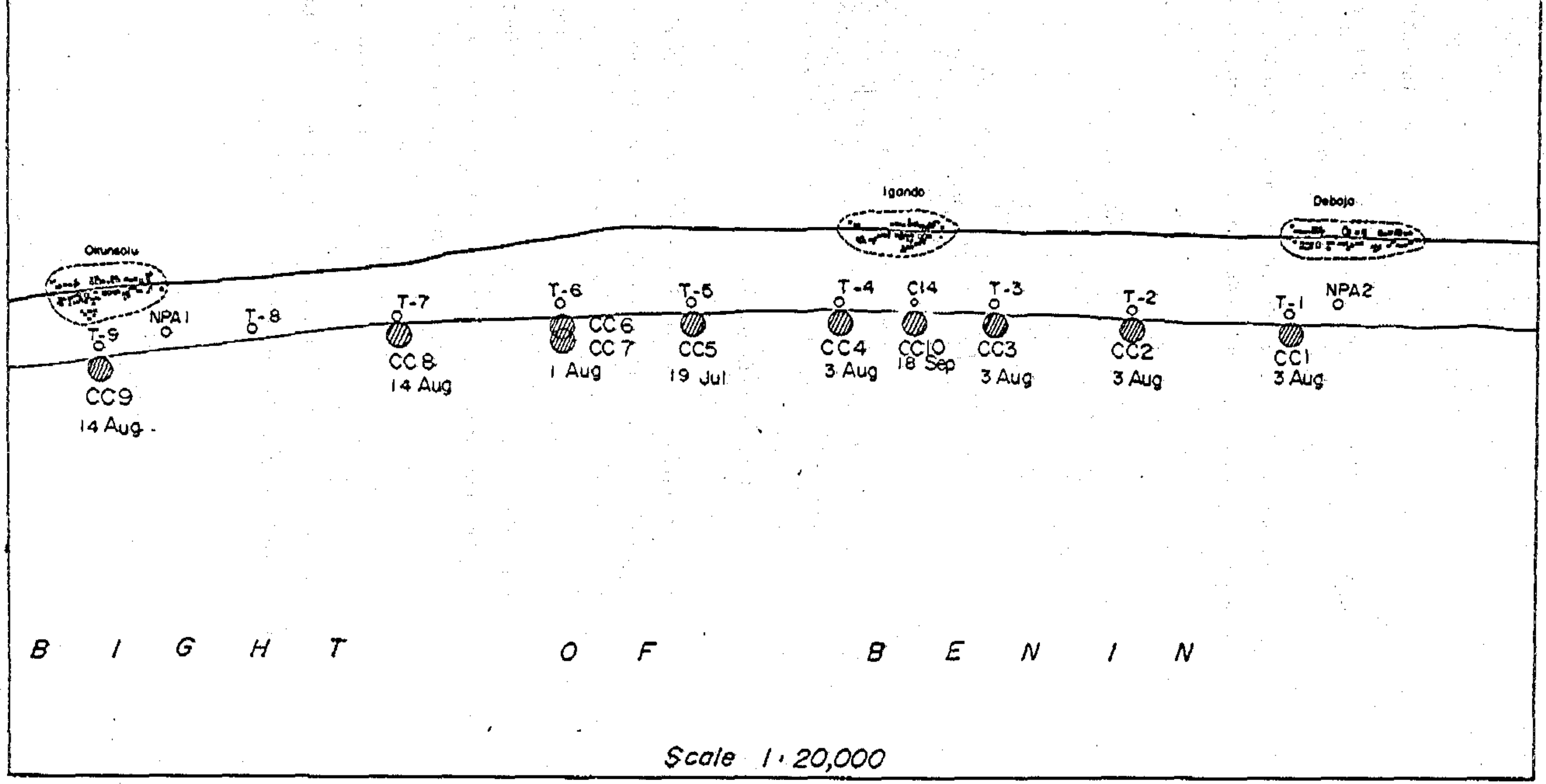
Fig. 2-5 INDEX MAP FOR LITTORAL CURRENT OBSERVATION AT BREAKER ZONE



2-7 Drift Sand Observation

Direct observation with sand traps was executed for the purpose of seizing the trend of drift sand.

Traps of two kinds, that is, one for beach drift and another for longshore drift, were prepared and established by the method indicated in Fig. 2-6.

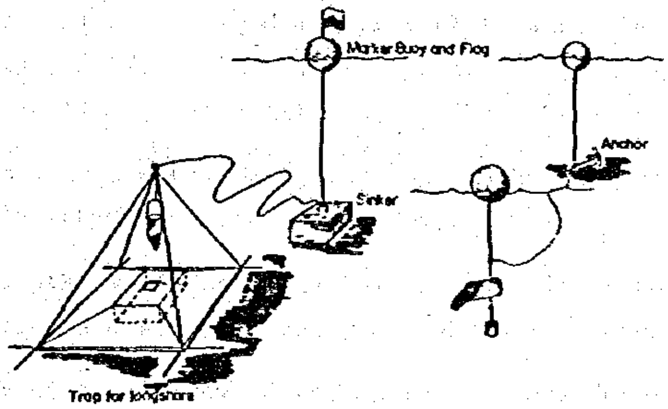


Fig. 2-6 Traps for Beach and Longshore Drift

With the trap for longshore, the marker buoy became missing after establishment, and this trap could not be found as a result. Therefore, a simple substitute was made and mounted to the wave recorder, and observation was continued with it.

Dry weight was measured with the samples collected with these traps, and in addition, specific gravity test and grain size analysis were carried out with a part of the samples.

2-8 Topographical Surveying

Sounding was executed in the sea and direct leveling was executed at the shore for the purpose of seizing the outline of the topography of the project area.

2-8-1 Sounding

The subject of sounding was the range that covers the area for which establishment of break water is planned, that is, about 4 km along the shore and about 4.5 km toward offshore.

17 sounding lines were arranged in parallel in 250 m intervals in south to north direction. The total extension of 19 sounding lines including the cross line and its auxiliary line was about 92 km.

Of the sounding lines arranged in parallel in south to north direction, lines of courses 5, 7, 9, 11, 13, 15 and 17 matched with the positions of the sounding lines of the last survey (December, 1978).

Continuous records of the underwater topography were obtained by using an echo sounder (Type RS-61) for sounding.

Final water depths were determined by applying draft correction, tidal level correction and sound velocity correction to these records.

The positions of the survey vessel on the sea was determined by simultaneous observation using theodolites from an induction point and a control point provided on the land.

2-8-2 Shore surveying

Seizure of topography of the shore was made by direct leveling at the shore along the extension of the course of traverse of each induction point used as a base point. The measuring interval was 5 m as a rule, and the points at which topography changes were also added. These lines are illustrated in the drawing "Cross Section of Beach", and as for the lines which are common with those established last time (December, 1978), their data are also indicated in said drawing.

2-9 Water Examination

Water examination was executed twice in the survey period for the surface layer in the project area.

A canoe or a rubber boat was used in swamps and Omu Creek (Gbogije), and a coastal jetty or the like was used in the lagoon (Epe) for water sampling and observation. Sampling of sample water for indoor analysis was made by using a Kitahara type water sampler.

The sampling points and dates of sampling are indicated in Table 2-2.

Table 2-2 Details of Water Sampling

Position No.	Location		Date of Sampling	
			1st	2nd
1	Igando	(Swamp)	Aug. 2	Sep. 5
2	Debojo	(")	" 5	" 6
3	Okunsolu	(")	" 5	" 6
4	Iwesolu	(")	" 7	" 6
5	Idado	(")	" 7	" 6
6	Epe	(Lagoon)	" 27	" 23
7	"		" 27	" 23
8	Gbogije	(Omu Creek)	" 31	" 22
9	"	(")	" 31	" 22
10	"	(")	" 31	" 22
11	Orimedu	(Swamp)	" 7	" 7
ADD. 1	Igando	(Well)	-	" 6
ADD. 2	Debojo	(")	-	" 6

See the information map indicated in General Location Map attached to the beginning of this report for the relationship between sampling positions and the project area.

The methods of measurement and analysis of water examintion items are as follows.

a) Water temperature

A mercury bar thermometer and a water quality checker (aquameter Type WQC-1A; herein after called aquameter) were used.

b) pH

Antimony electrode method using aquameter was mainly used and pH test papers were used as auxiliary means.

c) Transparency

A secchi plate of the diameter of 30 cm was used.

d) COD

Colorimetric measurement (Scheltz method) was made. Using refined glucose standard solution.

e) Chlorine-ion

Mercury (II) nitrate titration method was used.

f) SS

Filter filtration method was used with millipore filters of HA type, hole diameter 0.45 μm.

Measurement of DO by diaphragm type measuring method and measurement of turbidity by light transmission system were executed by using an aquameter in addition to the above items.

The results of these measurements are summarized in Table 3-12, 13 (Water Examination Sheets).

3. RESULTS OF SURVEY

3-1 General Situation of Project Site

The project site is located in the position of about 40 km (25 miles) in the east of Lagos. Private houses constitute villages along the shoreline in dotty form with intervals of several kilometers.

The center of the planned Ocean Terminal is located between Igando area and Okunsolu area. The number of private houses in these two areas is 20 to 30 each.

The front side of each village faces sand beach via coconut forest, and the back side of each village faces swamp zone.

The altitude of these villages is around 4 m in general, and the entire surface soil in these areas is sand.

The coconut forest, which is distributed along the shoreline in linear form, plays the role of a windbreak that breaks sea-wind in the monsoon season. On the other hand, the swamp with abundant vegetation expands in belt form along the shoreline, and its width is as wide as about 1 km to 2 km. Comings and goings from and to the inland area in the rainy season are made by canoes by making use of the watercourse of this swamp.

3-2 General Meteorology

The monthly mean values of observation items are indicated in Table 3-1 based on the results of meteorological observations made in the project area.

Table 3-1 Results of Meteorological Observations

Item	Month	July	August	September
Atmospheric Temperature (°C)	Min.	23.5 (23.7)	23.6 (23.7)	23.3
	Max.	27.6 (28.0)	27.9 (27.9)	29.0
	Mean	25.2	25.5	25.6
Atmospheric Pressure (mb)	Min.	11.1	9.2	9.5
	Mean	12.3 (12.7)	10.6 (10.9)	11.0
Relative Humidity (%)	Min.	80	77	75
	Mean	90 (88)	87 (89)	87
Total Amount of Precipitation (mm)		[685.2](493.2)	345.1 (268.7)	509.1

Note: The figures in parentheses are the results of observations obtained at Lagos Station by Nigerian Meteorological Service in the same period.

1) Atmospheric temperature

Variations of atmospheric temperature in Lagos in a year are shown in Fig. 3-1.

The atmospheric temperature is relatively low in the period of July through September and is high in the period of December through April in general.

The periods of May and June and also October and November are transient periods.

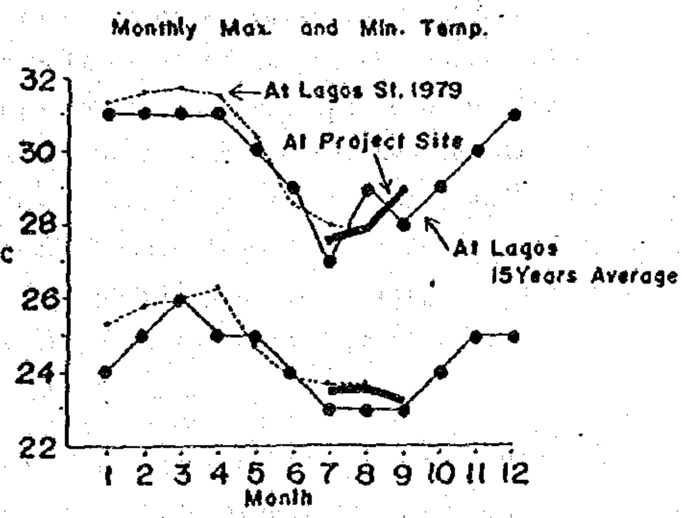


Fig. 3-1 Monthly Change of Max. and Min. Temperature

The period in which observations of this survey were made is the period in which the atomospheric temperature is the lowest in a year.

Fig. 3-2 indicates the result of plotting of variation in time of mean atmospheric temperature and daily maximum and minimum temperature.

The time of occurrence of maximum temperature is concentrated to the band of noon through 3 o'clock p.m., and its minimum temperature is concentrated to the band of 6 o'clock in the dawn through 8 o'clock a.m. This trend is more conspicuous in September in which daily difference increases, and this trend suggests that transition to dry season is in progress.

The dispersion of maximum temperature in a day and the time of its occurrence is mainly caused by the influence of rainfall, and decrease of maximum temperature alone is caused by the reduction of duration of sunshine due to cloud of stratus series.

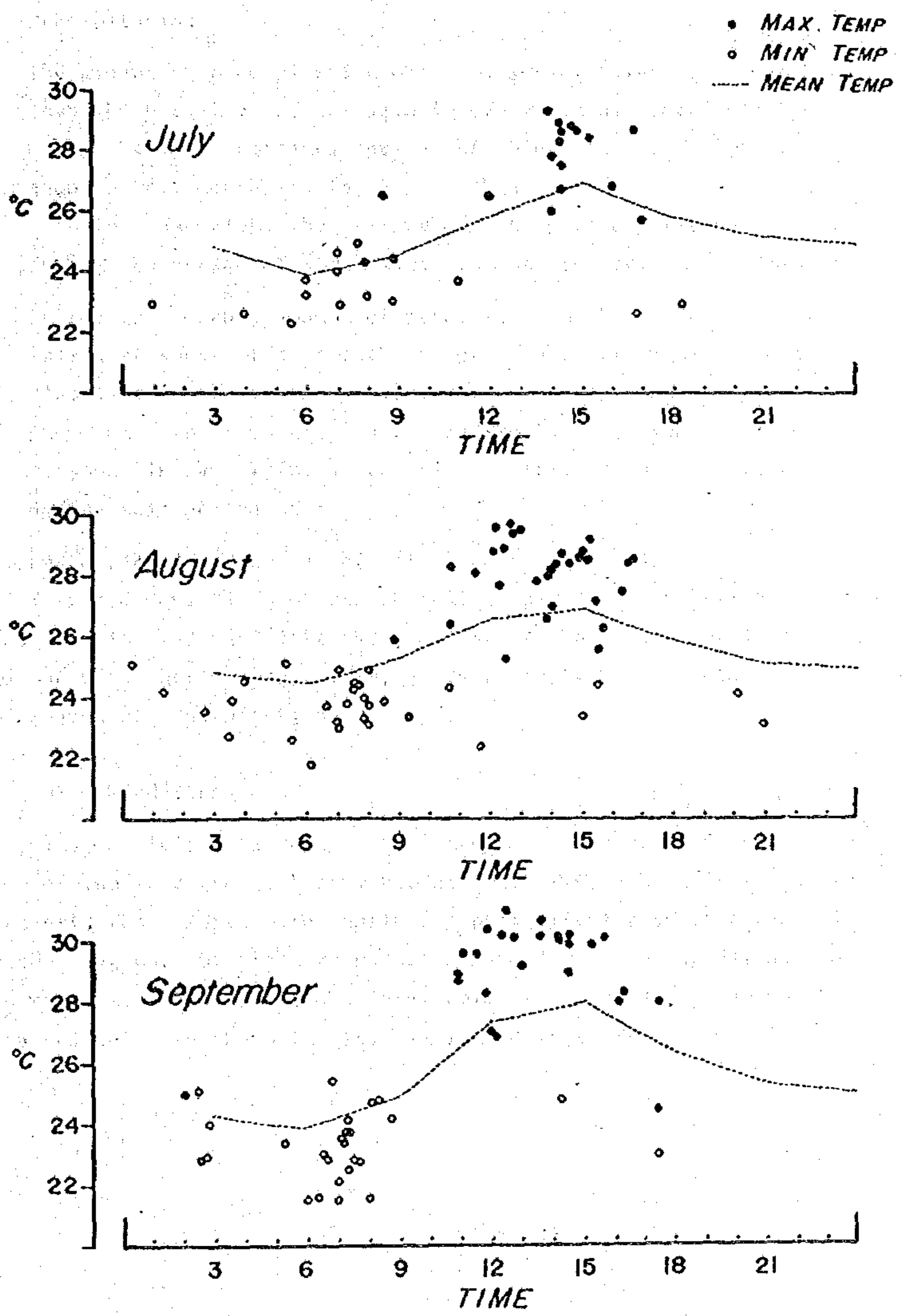
2) Atmospheric pressure

The monthly variation of mean atmospheric pressure is around 2 mb, and low atmospheric pressure was observed in the latter half of August through the first half of September in the observation period. When the variation of atmospheric pressure in time is observed, it is low at midnight in each month, and the difference is the maximum at noon and 6 o'clock in the evening, and the difference increases as the month changes from July to August and then to September. The minimum atmospheric pressure during the observation period was 1,004.5 mb recorded at 18:20 on September 2.

3) Relative humidity

The monthly average value of relative humidity is 87 ∿ 90%, and this condition is inherent to tropic areas. High humidity in a day is recorded in the period of midnight through dawn, and humidity becomes the lowest at around 3 o'clock (15:00) in the afternoon. This pattern is in good contrast with distribution in time of mean

Fig. 3-2 *Time Distribution of Occurrence of Max. and Min. Temperature*



atmospheric temperature. The monthly average of the daily minimum humidity changed as 80% in July 77% in August and 75% in September.

4) Precipitation

The amount of precipitation obtained during this survey was higher than the normal value in Lagos in every month. Particularly in July, the value obtained during the observation in a period of 1 about a half month was far higher than the normal value in Lagos. In this connection, the maximum amount of precipitation per day during the period of the survey was 154 mm recorded on September 1.

As for the monthly amount of precipitation the value in August is less than those of the months before and after August, and it is also true in the result of observation in Lagos in the past. This phenomenon is presumably caused by the layer of the southwest monsoon air mass lying in the higher altitude, which gets thinner during this period of the year.

Figures attached to the end of this report indicates variations in time and standard deviations of atmospheric temperature, relative humidity, wind velocity and wind direction, and after that indicates daily variation of atmospheric temperature, atmospheric pressure, relative humidity and amount of precipitation in graphs.

3-3 Wind Conditions

The wind conditions in West Central Africa are controlled by the migration of the intertropical convergence zone (ITC), which is a low pressure belt that exerts major influence over circulation of the atmosphere in this region. Distinct rainy season and dry season appear accordingly. The variations in January and July, which are representative months with this respect, are shown in Fig. 3-3 in modelized form.

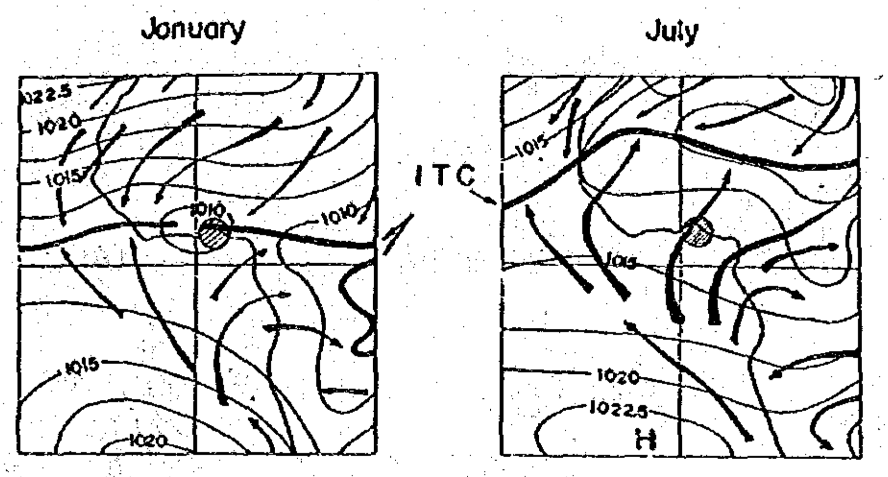


Fig. 3-3 Significant Wind and Distribution of Pressure

In January (dry season), when the ITC stays in the neighborhood of the survey area, wind from northern direction is prominent as shown in Fig. 3-4 (Wind roses), and in July, the wind from southern directions is prominent because the ITC reaches the northernmost point. These phenomena are controlled over relatively broad areas.

In the result of observation made during this survey, SW is prominent in the wind direction, and its frequency is the highest as shown by the figures of 32.8% in July, 47.6% in August and 28.8% in September, and the range of SSW through WSW covers as much as 60% or higher in the frequency of occurrence. Fig. 3-5 indicates wind roses in Lagos and the project site. It is characteristic that frequency of occurrence of SW wind is extremely low in the former. It is considered to be caused of the topographical difference in the places of observation. The wind of SSW ∿ WSW to the project site is the wind from the sea side, and the frequency of occurrence of the wind from the inland side is extremely small.

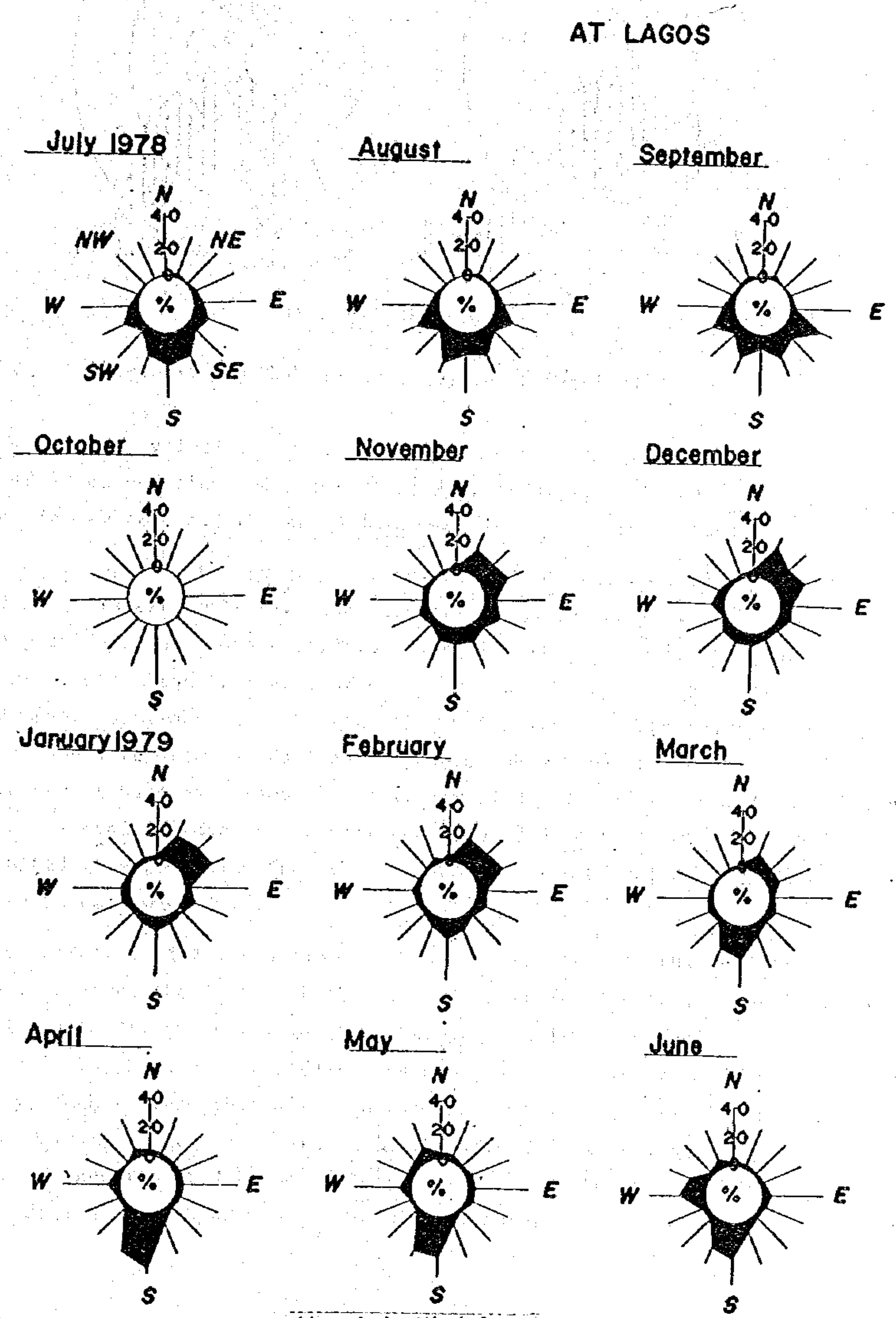


Fig. 3-4 Wind Roses

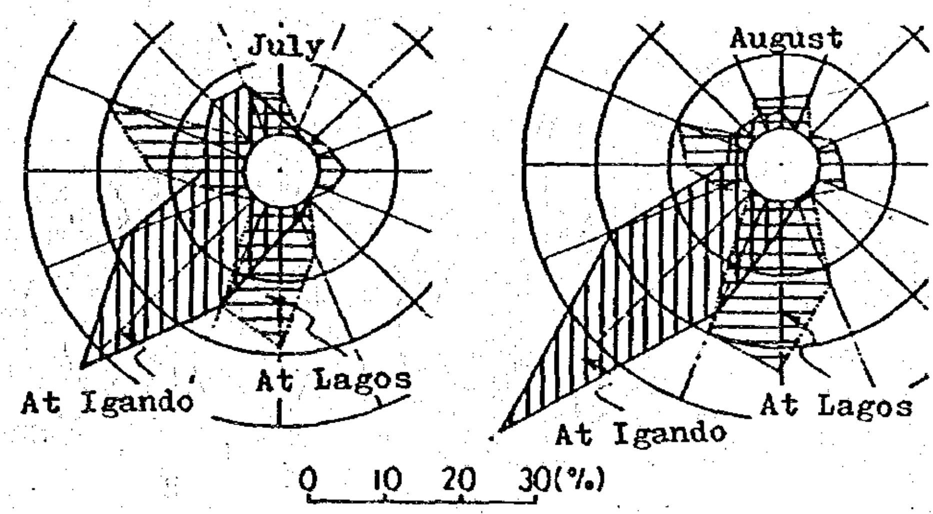


Fig. 3-5 Wind Roses in Lagos and Project Site

As for the wind velocity, the frequency of occurrence of wind of less than 10 m/sec occupies the majority as 99.7% (July), 99.0% (August) and 99.9% (September), and the trend is common in these three months.

In August, however, the frequency of occurrence of the wind of 5.0 m/sec ∿ 9.9 m/sec is extremely high and occupies about 80% of all. It is quite peculiar and is quite different from the trend of July and September, in which the frequency of occurrence of the wind of 5.0 m/sec ∿ 9.9 m/sec is almost equal to that of 0 ∿ 4.9 m/sec. Wind roses shown in Fig. 3-6 were drawn up for the purpose of observing the frequency of occurrence of wind direction classified by wind velocity class. It is apparent in this figure that appearance of wind directions of SSW ∿ WSW is limited to strong wind from the sea and that the wind from the inland appears in calm wind only.

As the characteristic variation of the wind conditions in the subject region, the fact that although the conditions are gentle in the morning, the wind velocity gradually increases and the maximum wind velocity appears in the afternoon toward the evening can be indicated. Consequently, such a trend that although land-wind = is frequently observed in the morning as for wind direction, the wind direction changes in the afternoon when the wind velocity increases and settling is made in the direction of SW ∿ WSW in the evening is observed.

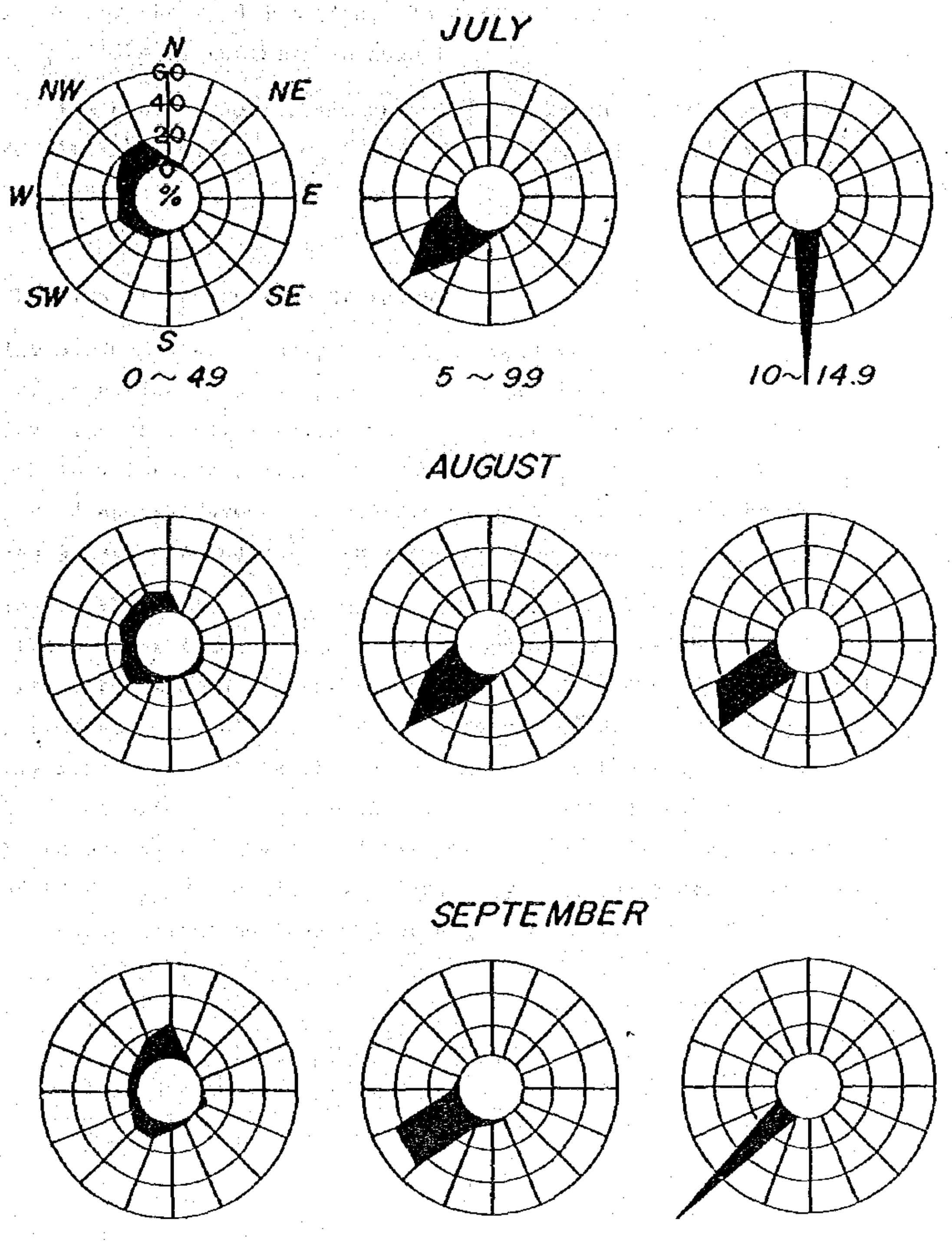


Fig. 3-6 Frequency of Occurrence of Wind Direction Classified by Wind Velocity Class

The wind velocity at the time when the wind direction is thus stabilized is normally 6 ∿ 7 m/sec in July and August, and is 5 ∿ 6 m/sec in September. As for the wind duration, there is such a trend that continuousness of wind = is the best in August.

A list of frequency of occurrence of wind direction and wind velocity in Lagos and in the project site is attached to the end of this report.

3-4 Waves

3-4-1 Results of observation of waves

The daily maximum wave (H max, T max), as well as mean daily height and period of significant waves (H 1/3 , T 1/3) are indicated in Table 3-2 as the results of observation of waves obtained during this survey. Out of these values, the average frequency distribution of significant waves period and the average frequency of occurrence of wave height-direction groups are indicated in Table 3-3 and 3-4.

According to these results, occurrence of wave height of 0.7 ∿ 1.2 m was of the highest frequency, and occurrence of wave height of 1.3 ∿ 1.8 m was of the second highest frequency. It should be described with special remarks that calm state of wave height of 0.6 m or less is extremely rare as a feature of this area. As for the period, on the other hand, occurrence of waves of 11.1 ∿ 13.0 seconds was of the highest frequency, and the second highest frequency is occurrence of waves of 13.1 ∿ 15.0 seconds. The frequency of occurrence of waves of these two ranges is as much as 80% or higher of all.

Table 3-2 Mean Daily Height and Period of Waves

JULY

Date	H max	T max	H 1/3	T 1/3	Date	H max	T max	H 1/3	T 1/3
18	1.6	11.6	1.1	12.6	25	2.3	8.4	1.3	9.7
19	1.5	13.4	1.1	13.3	26	1.4	11.3	1.1	12.8
20	1.6	11.2	1.2	12.2	27	1.6	12.8	1.2	12.3
21	1.7	13.4	1.3	13.9	28	2.0	12.1	1.4	12.0
22	1.8	11.5	1.3	12.7	29	1.7	11.2	1.2	12.3
23	1.7	12.0	1.3	12.3	30	1.8	11.6	1.3	12.4
24	2.0	11.1	1.3	12.0	31	1.8	10.6	1.2	11.9
							MEAN	1.2	12.3

AUGUST

Date	H max	T max	H 1/3	T 1/3	Date	H max	T max	H 1/3	T 1/3
1	2.0	13.9	1.4	13.6	17	-	-	-	-
2	3.1	16.4	2.2	16.2	18	1.8	12.0	1.3	13.2
3	3.3	14.7	2.4	14.6	19	1.8	12.6	1.3	12.0
4	2.3	12.7	1.8	12.9	20	1.9	13.9	1.4	12.2
5	2.2	10.8	1.5	12.4	21	2.3	12.4	1.6	12.4
6	3.0	15.2	2.4	16.7	22	2.4	7.7	1.6	10.2
7	2.8	14.9	2.1	15.1	23	2.3	8.0	1.5	9.2
8	3.1	12.1	2.1	13.1	24	1.8	8.8	1.1	11.2
9	3.4	13.6	2.5	14.3	25	1.3	9.9	0.9	11.3
10	2.9	14.6	2.3	14.4	26	1.2	13.2	0.8	13.0
11	-	-	-	-	27	1.7	9.3	1.2	13.0
12	-	-	-	-	28	1.8	13.2	1.3	13.3
13	-	-	-	-	29	1.7	13.2	1.2	13.0
14	-	-	-	-	30	1.8	13.4	1.2	13.4
15	-	-	-	-	31	1.7	11.9	1.2	13.0
16	-	-	-	-					
							MEAN	1.6	13.1

SEPTEMBER

Date	H max	T max	H 1/3	T 1/3	Date	H max	T max	H 1/3	T 1/3
1	1.4	12.9	1.0	13.3	16	1.5	12.4	1.1	12.5
2	1.4	12.1	0.9	13.2	17	1.4	12.1	1.0	11.9
3	1.4	12.6	1.0	12.9	18	1.7	10.3	1.1	10.4
4	1.5	12.5	1.1	13.3	19	1.5	10.5	1.0	11.0
5	1.6	12.9	1.1	13.7	20	1.3	11.2	0.9	11.9
6	1.6	13.8	1.2	13.7	21	1.6	11.0	1.2	12.2
7	1.6	13.8	1.1	13.6	22	1.9	11.0	1.3	11.9
8	1.5	12.4	1.2	13.2	23	1.6	12.2	1.1	12.5
9	1.4	12.7	1.1	12.7	24	1.6	11.7	1.1	12.7
10	1.4	11.0	1.0	12.4	25	1.5	11.9	1.0	12.6
11	1.3	11.8	0.9	12.4	26	1.5	11.6	1.0	12.5
12	1.3	13.4	0.9	12.8	27	1.5	12.1	1.1	12.6
13	1.4	12.9	1.0	13.5	28	1.4	12.4	1.0	12.6
14	1.4	12.5	1.0	13.2	29	1.3	12.2	1.0	12.7
15	1.5	12.9	1.1	13.1					
							MEAN	1.1	12.6

Table 3-3 Average Frequency Distribution of Significant Wave Period

Period (Sec)	Significant Wave Height (m)							Total
	0~0.6	0.7~1.2	1.3~1.8	1.9~2.4	2.5~3.0	3.1~3.6	3.6 plus	
0 ~3								
3.1~5								
5.1~7								
7.1~9		0.4 (3)	1.2 (9)	0.1 (1)				1.7% (13)
9.1~11		6.3 (48)	4.4 (33)	0.1 (1)				10.8% (82)
11.1~13	0.3 (2)	33.9 (256)	11.6 (88)	0.5 (4)				46.3% (350)
13.1~15		23.0 (174)	6.3 (48)	4.4 (33)	0.7 (5)			34.4% (260)
15.1~17		0.1 (1)	1.7 (13)	2.1 (16)	1.3 (10)	0.1 (1)		5.4% (41)
17.1~19			0.4 (3)	0.5 (4)	0.3 (2)	0.1 (1)		1.3% (10)
TOTAL	0.3 (2)	63.7 (482)	25.7 (194)	7.8 (59)	2.3 (17)	0.2 (2)		100% (756)

Table 3-4 Average Frequency of Occurrence of Wave Height-Direction Groups

Dir.	Significant Wave Height (m)							Total
	0~0.6	0.6~1.2	1.2~1.8	1.8~2.4	2.4~3.0	3.0~3.6	3.6 plus	
ESE								
SE								
SSE								
S		8.2	4.1					12.3%
SSW		20.4	14.3	6.1				40.8%
SW		18.4	12.2	2.0	4.1			36.7%
WSW		4.1	6.1					10.2%
TOTAL		51.0	36.7	8.2	4.1			100%

From these tables it can be understood that the waves in this area are of very long period. In this connection, the wave lengths are as long as 190 ∿ 350 m as converted into deep sea waves. Fig. 3-7 indicates a frequency distribution of appearance of period corresponding to wave height groups. Such a trend that the period becomes long when the wave height increases is observed in this figure as a general trend, together with the fact that the kurtosis of the frequency distribution curves in particular is extremely good.

As for the wave direction, waves of SSW - SW occupy the majority as shown in Fig. 3-8, and the frequency of occurrence of waves of S and WSW is only a little over 10% respectively. This trend is almost fixed regardless of the wave height, but with waves of the height of 1.8 m or higher, the directions are limited to SSW - SW.

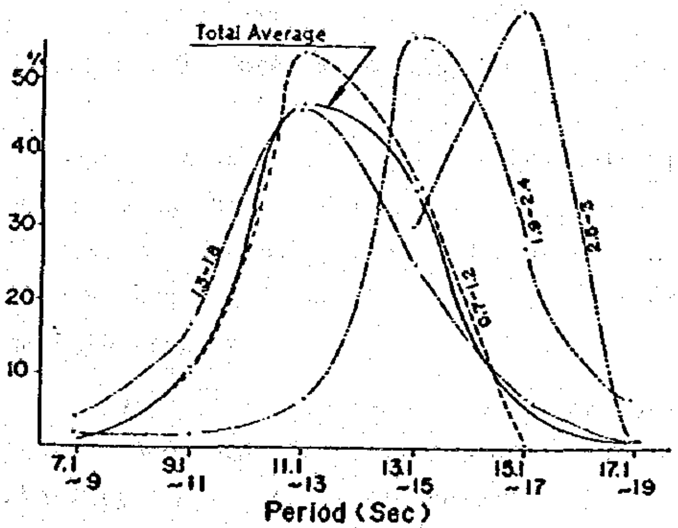


Fig. 3-7 Frequency Distribution of Wave Height-Period Groups

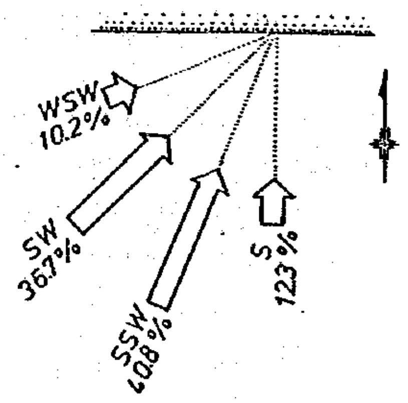


Fig. 3-8 Frequency of Occurrence of Wave Directions

When the distribution of mean height of significant waves is observed as classified by the month of observation, it is 1.2 m in July, 1.6 m in August and 1.1 m in September, and the condition is the roughest is August. It corresponds to the length of wind duration, wind of the velocity of 5 m/sec or faster in particular as described earlier, and this situation can also be observed in Fig. 3-9.

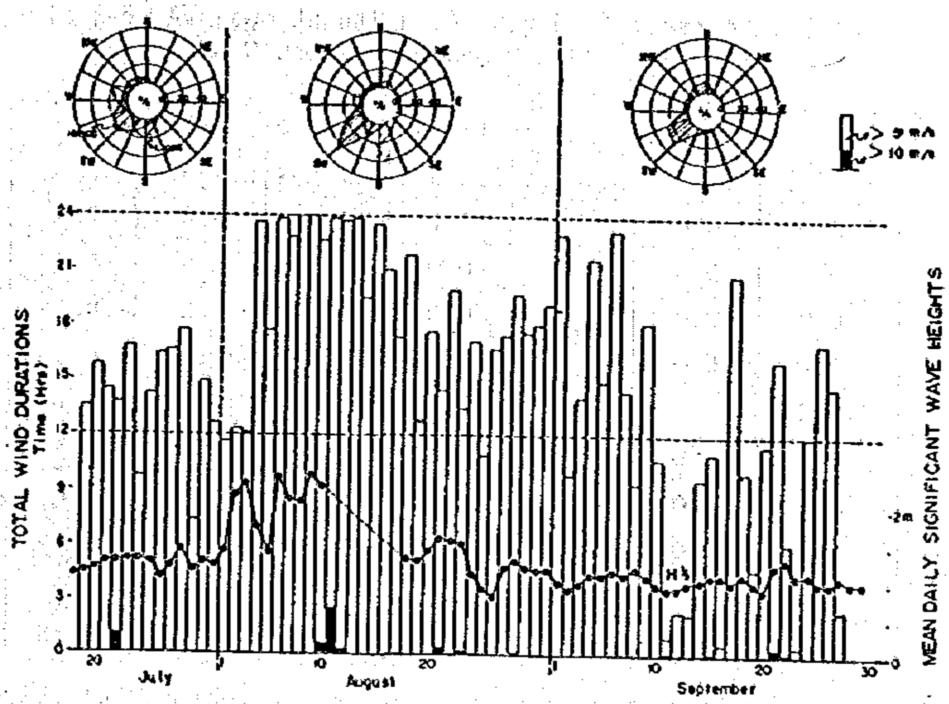


Fig. 3-9 Total Wind Durations and Mean Significant Wave Heights

Although the wave conditions immediately after the time when the longest duration was recorded are not known because observation was not made at this time, it can be estimated that the maximum value of the entire survey period did probably occur at this time and that attenuation was made thereafter.

The results of observation obtained at Forcados are indicated in Table 3-5 and 3-6, and the variation of mean height of significant waves as classified by month are indicated in Fig. 3-10 for the purpose of examining general trend of wave conditions in the subject sea. As for the wave height, the range of 0.6 ∿ 1.8 m occupies about 65% of all, but occurrence of calm waves occupies the majority in a whole year. As for the period, the range of 9 ∿ 15 seconds is large, but there also is such a trend that the period becomes short as a whole. As for the wave direction, occurrence of directions of S - W occupies the majority, but waves of direction from west also appear frequently, and it can be said that the difference in geographical conditions is indicated. When the mean monthly values of mean significant wave height are observed,

Table 3-5 Average Annual Frequency Distribution of Significant Wave Period at Forcados

Period (sec)	Significant Wave Height (H 1/3) (m)							Total
	0~0.6	0.6~1.2	1.2~1.8	1.8~2.4	2.4~3.0	3.0~3.6	3.6 plus	
0~3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
3~5	0.8	0.5	0.0	0.0	0.0	0.0	0.0	1.3
5~7	1.8	2.3	0.2	0.0	0.0	0.0	0.0	4.3
7~9	3.2	4.5	1.4	0.3	0.0	0.0	0.0	9.4
9~11	7.2	12.2	4.9	1.5	0.3	0.1	0.0	26.2
11~13	6.2	11.8	7.0	3.0	0.8	0.3	0.1	29.2
13~15	3.9	7.7	3.9	1.9	0.4	0.1	0.0	17.9
15~17	1.8	5.0	1.6	0.5	0.0	0.0	0.0	8.9
17~19	0.5	1.4	0.6	0.1	0.0	0.0	0.0	2.6
Total	25.8	45.3	19.4	7.3	1.6	0.5	0.1	100.00

Source: A.H. Glenn and Associate: Meteorological-Oceanographic factors affecting design and planning of petroleum operations in Nigerian oil company offshore leases.

Table 3-6 Average Frequency of Occurrence of Wave Height-Direction Groups at Forcados

Direction	Significant Wave Height (m)							Total
	0~0.6	0.6~1.2	1.2~1.8	1.8~2.4	2.4~3.0	3.0~3.6	3.6 plus	
N	1.1	0.8	0.2	0.0	0.0	0.0	0.0	2.1
NE	1.3	0.7	0.0	0.1	0.0	0.0	0.0	2.1
E	1.9	0.6	0.1	0.0	0.0	0.0	0.0	2.6
SE	2.5	2.4	0.7	0.2	0.1	0.0	0.0	5.9
S	6.3	9.9	3.6	1.1	0.3	0.1	0.0	21.3
SW	7.9	22.6	11.2	4.6	0.9	0.3	0.1	47.6
W	3.0	7.2	3.2	1.2	0.3	0.1	0.0	15.0
NW	1.8	1.1	0.4	0.1	0.0	0.0	0.0	3.4
Total	25.8	45.3	19.4	7.3	1.6	0.5	0.1	100.00

although the peak appears in June - July period in Forcados, it appears in August in the project area. This difference is a subject to be examined in the future for finding out if, for example, it is due to a difference in locality, due to peculiarity of the year of observation or due to a difference in the observing conditions.

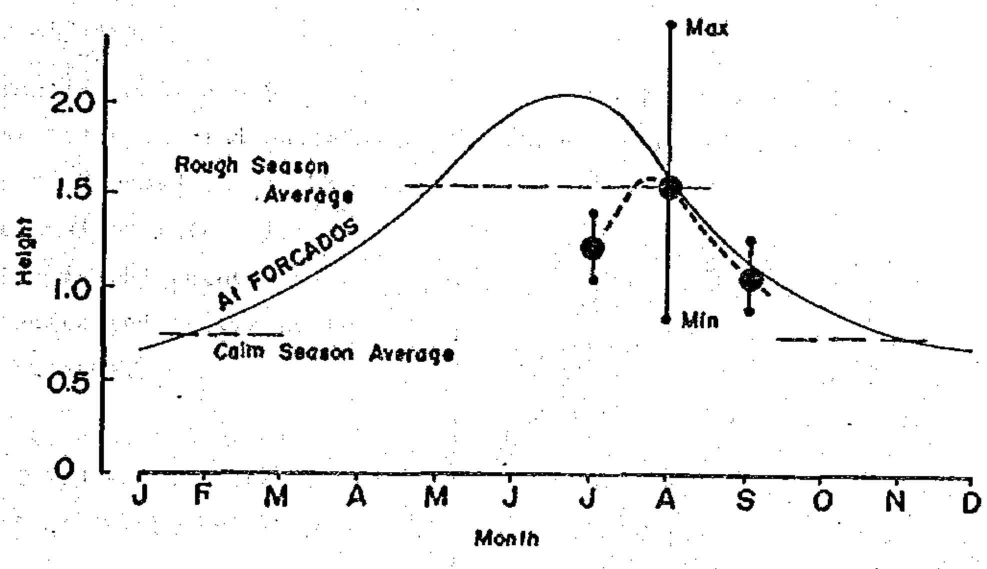


Fig. 3-10 Comparison of Monthly Significant Waves with Forcados

3-4-2 Wave estimation

It was found out that waves of extremely long periods are distinguished in the survey area. When expression is made by wave steepness, waves of the order of 10^{-3} are the main, and the majority of the waves are of swelling nature.

An attempt was made to estimate waves based on the average arrangement of atmospheric pressure in Africa in July shown in Fig. 3-11 for the purpose of examining under what conditions these characteristic waves make attacks.

Estimation was made by S.M.B. method with waves which made sufficient development as wind waves assumed as deepwater waves and estimation was also made based on Bretchneider method for the period in which these waves attenuate and arrive at the object area.

As a result, H 1/3 = 1.2 m and T 1/3 = 14.7 seconds were obtained in the survey area.

As the results described above indicate, it is apparent that attack of waves of long periods is universally provided by the average arrangement of atmospheric pressure on the Atlantic Ocean.

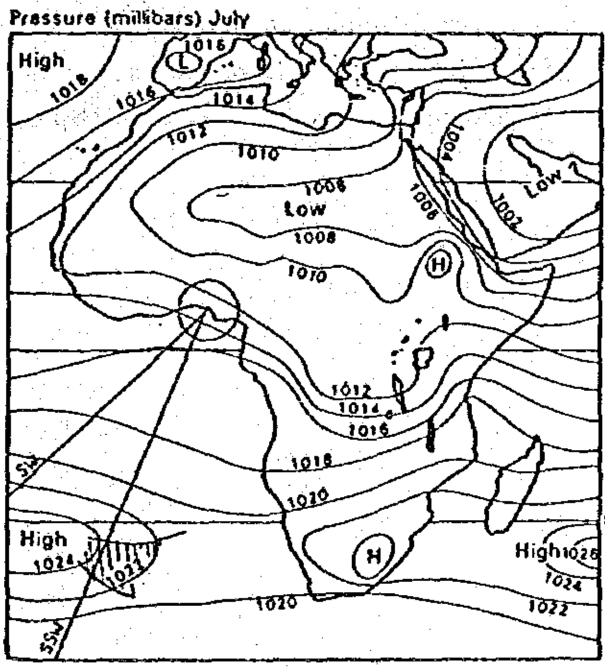


Fig. 3-11 Mean Atmospheric Pressure over Africa in July

3-4-3 Wave refraction diagrams

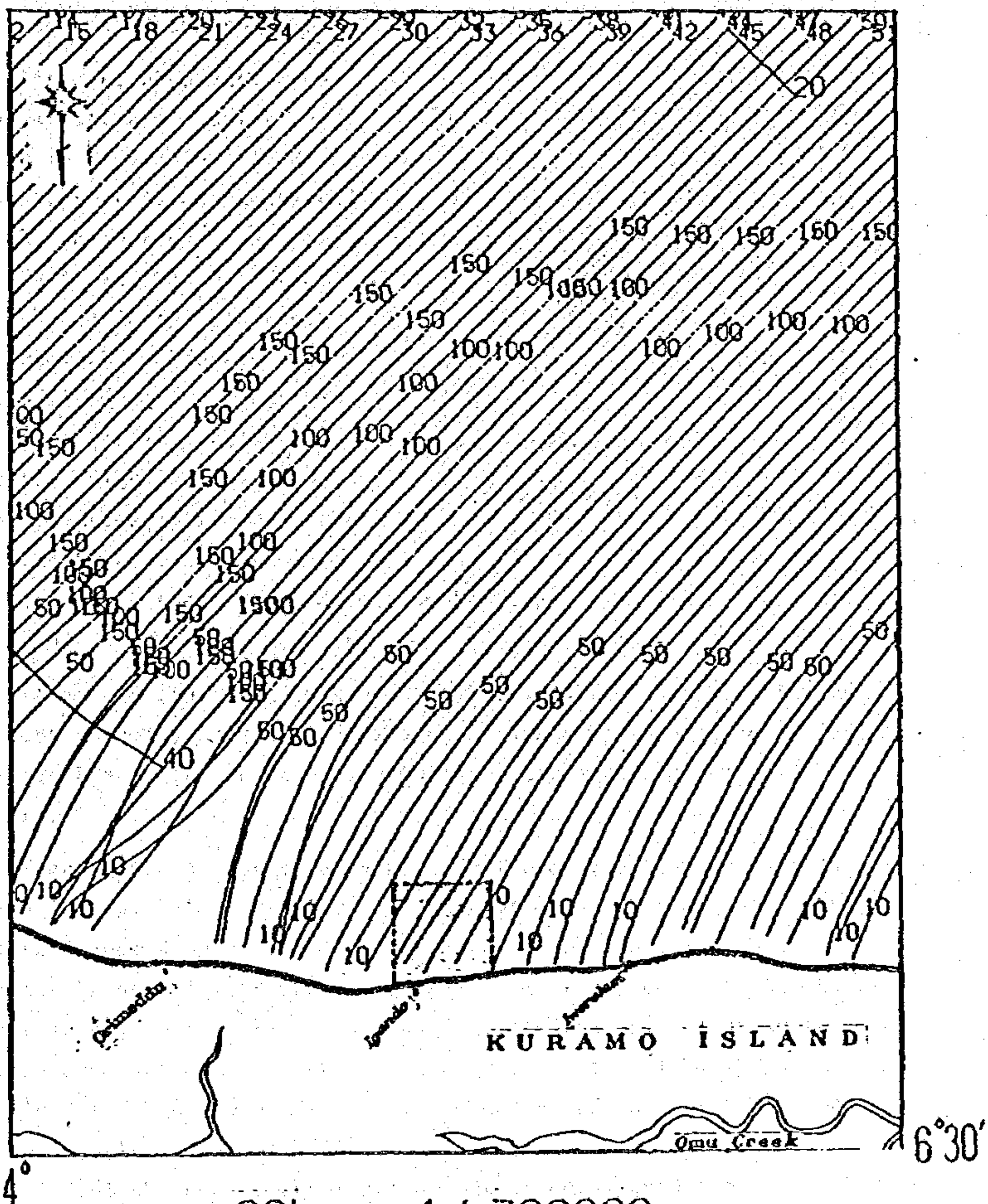
Refraction diagrams of nine cases were drawn up with SW, WSW and SSW applied to the range of 11 ∿ 13 seconds, which is of high frequency of occurrence in both period and height of attacking waves which became apparent as a result of wave observation. (See Fig. 3-12 and appended figures.)

The fact that wave direction lines spread in fan-shape in the east of the project area in each case is caused by the valley-wise topography which is subsequent to Avon Canyon located in the offshore area. Therefore, the wave direction lines make convergence on both sides of this valley, and a heavy breaker zone is formed as a result. However, it does not exert direct influence over the project area.

In the project area, it appears that the extent of convergence and dispersion of local wave direction lines due to the influence of the bottom topography becomes more conspicuous as the period increases.

REFRACTION DIAGRAM

PLOT NO. 1 T = 12.0 SW



SCL = 1/ 300000

Fig. 3-12 Refraction Diagram

3-5 Current in Survey Area

Current observation was carried out in three zones, that is, offshore, outside of the breaker zone and inside of the breaker zone, for the purpose of seizing the current in the survey area.

At offshore, observation was made at St. A and St. B as shown in Fig. 3-13. At St. A, east current is distinguished as the whole trend, and its mean velocity was 0.4 m/sec (0.8 knot) in the depth of 5m below the surface, and was 0.16 m/sec (0.3 knot) in the depth of 10 m below the surface. The current direction is not stabilized in the lowermost layer, and the difference in the current direction between the top layer and the lowermost layer is as much as around 90° at maximum.

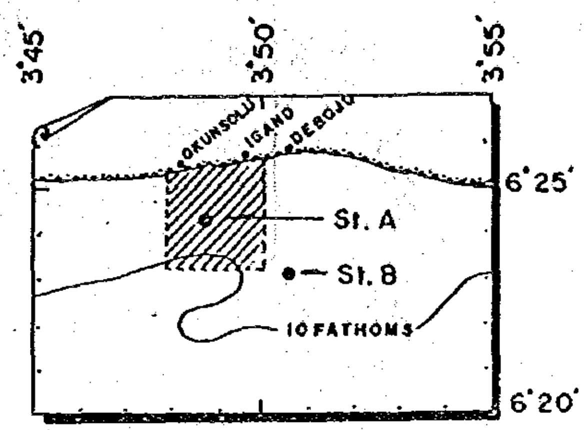


Fig. 3-13 Location Map

At offshore St. B, west current is distinguished, and variation of current velocity in vertical direction is far less than that at St. A. The results stated above are shown in a diagram in the end of this report.

The result of observation obtained outside of the breaker zone is shown in Fig. 3-14 and 3-15. The current directions are entirely reversed depending on the date of observation. That is, while east current or northeast current was indicated at the occasion of the first observation, southwest current was indicated at the occasion of the second observation. As for the current velocity, although it was a little faster than 0.3 m/sec at the occasion of the first observation, it was as slow as about a quarter of the above stated figure at the occasion of the second observation. It is considered that it is because the first observation was made while the waves are in slack state and

Fig. 3-14 DIRECTION AND VELOCITY

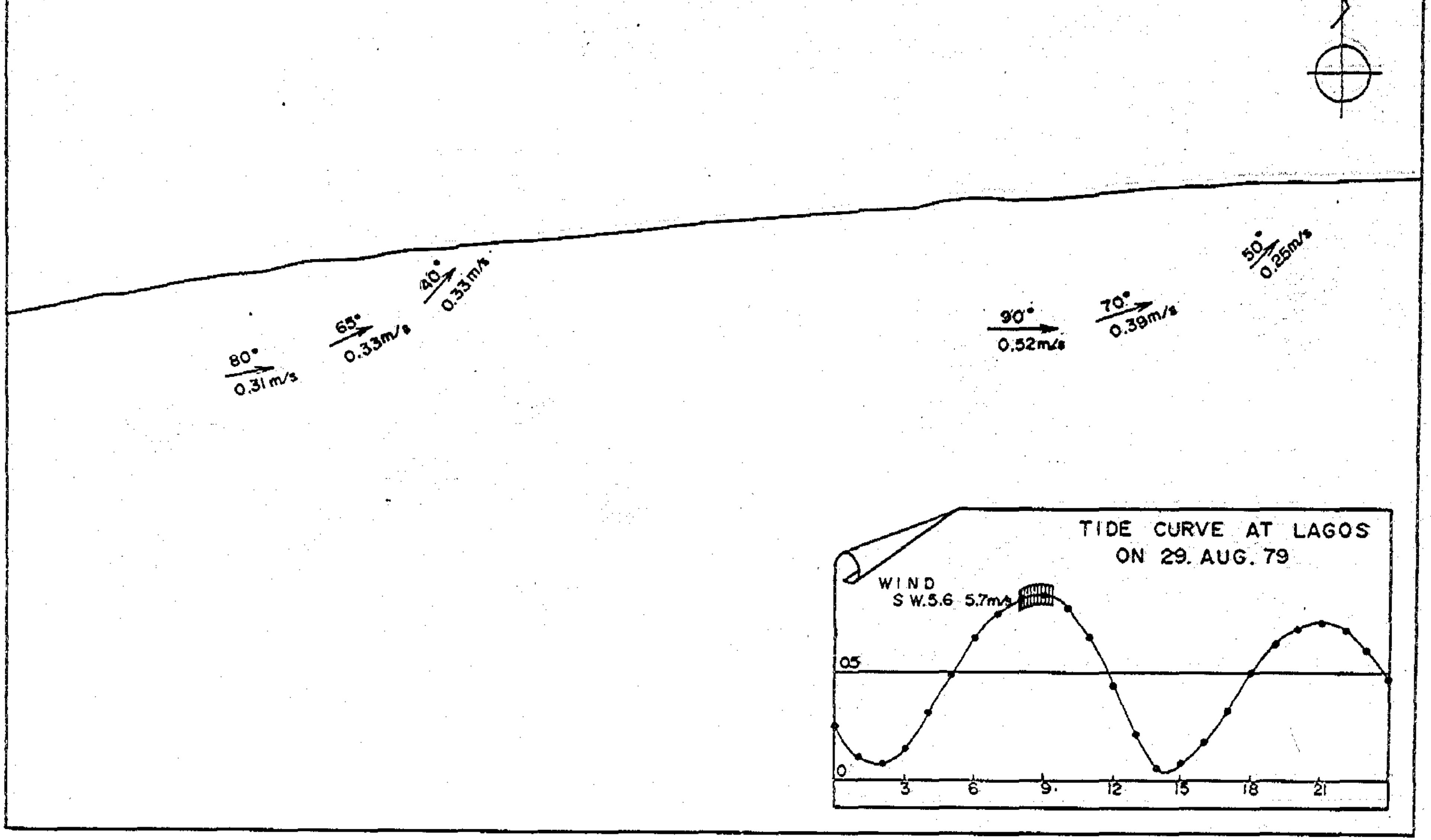
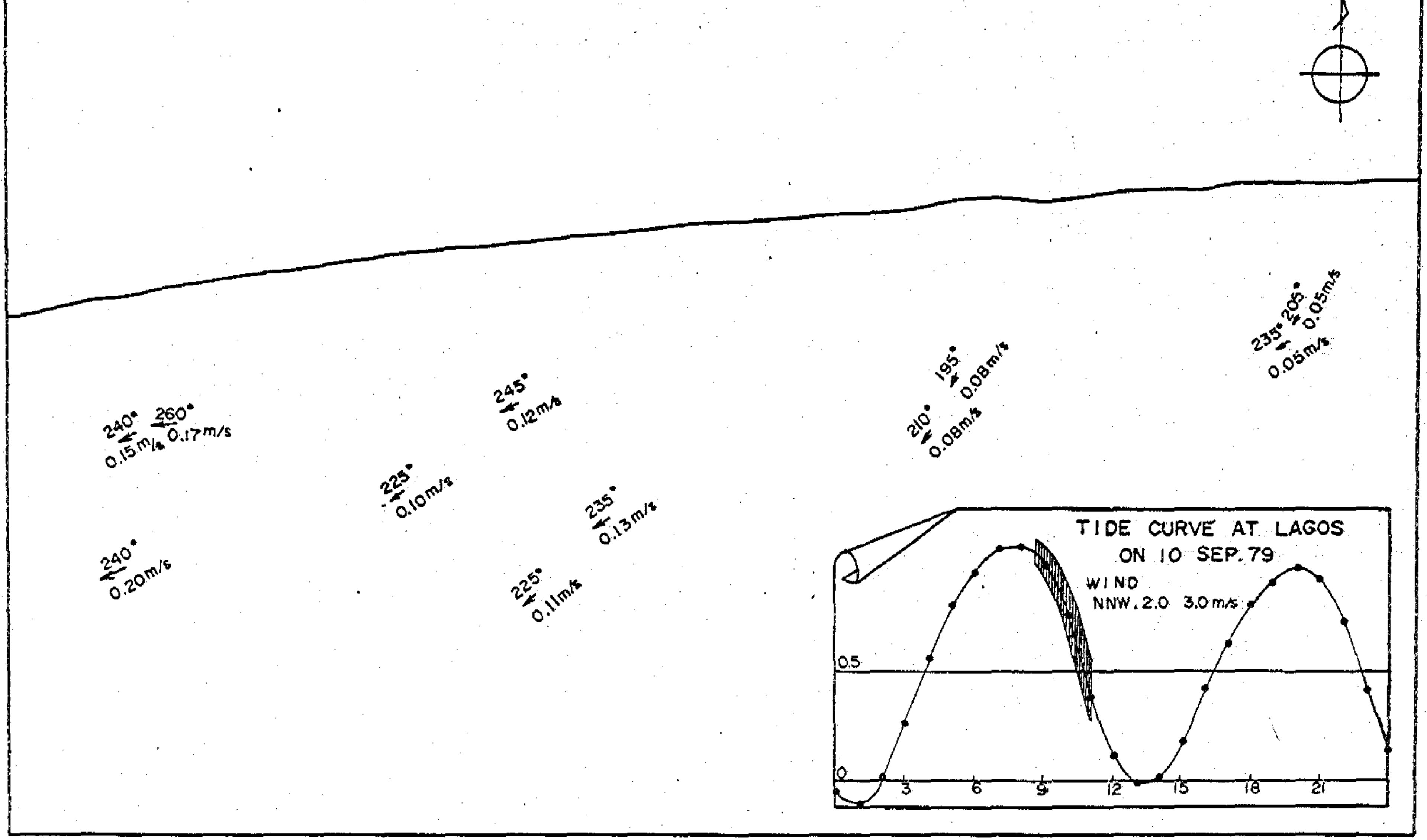


Fig. 3-15 DIRECTION AND VELOCITY



the second observation was made during ebb-tide, but it can be considered that it is more affected by the difference in the wind conditions. This matter should be clarified in the future through more systematized survey.

The result of current observation inside of the breaker zone is indicated in the current diagram and the current velocity table attached to the end of this report.

The current is from west to east with the trough as the center at every point. The current velocity is 0.3 ∿ 0.4 m/sec at average, and it is not of an extremely fast level.

The current inside of the breaker zone is controlled by the direction and strength of the incident waves, and it is also convincing from the distinguished wind direction of SW - SSW in the subject area. Although a part of the result of observation indicates the current which appears to be rip current, it is pushed back by the attacking waves, and its clear configuration could not be seized.

3-6 Littoral Drift

3-6-1 At shore

The place of installation of the trap was a trough on the shore side of the breaker zone, and the method of its installation was suspension system using a float. The sectional area of the collecting face was 27 cm^2, the height from the seabottom surface varied by the flow of attacking waves, but was generally in the range of 0.5 ∿ 1.0 m.

The volume of sand collected with this trap per unit time was 0 ∿ 28.7 g (dry weight), as shown in Table 3-7.

It was not possible to sufficiently find out the relationship between the volume of collected sand and waves, but it is apparent that the height and volume of sand suspension vary to a considerable extent.

Fig. 3-16 CROSS SECTIONS OF SHORELINE

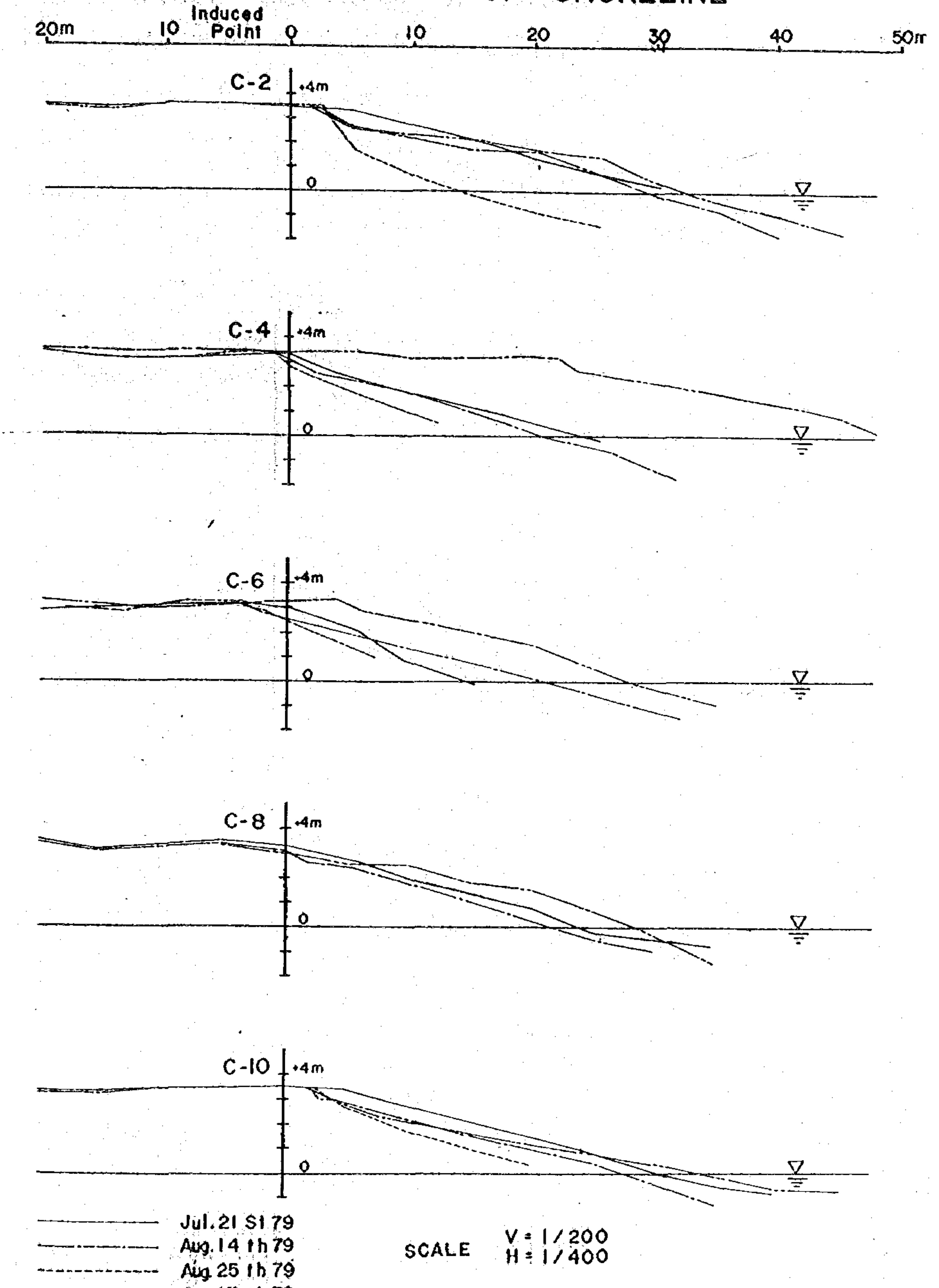
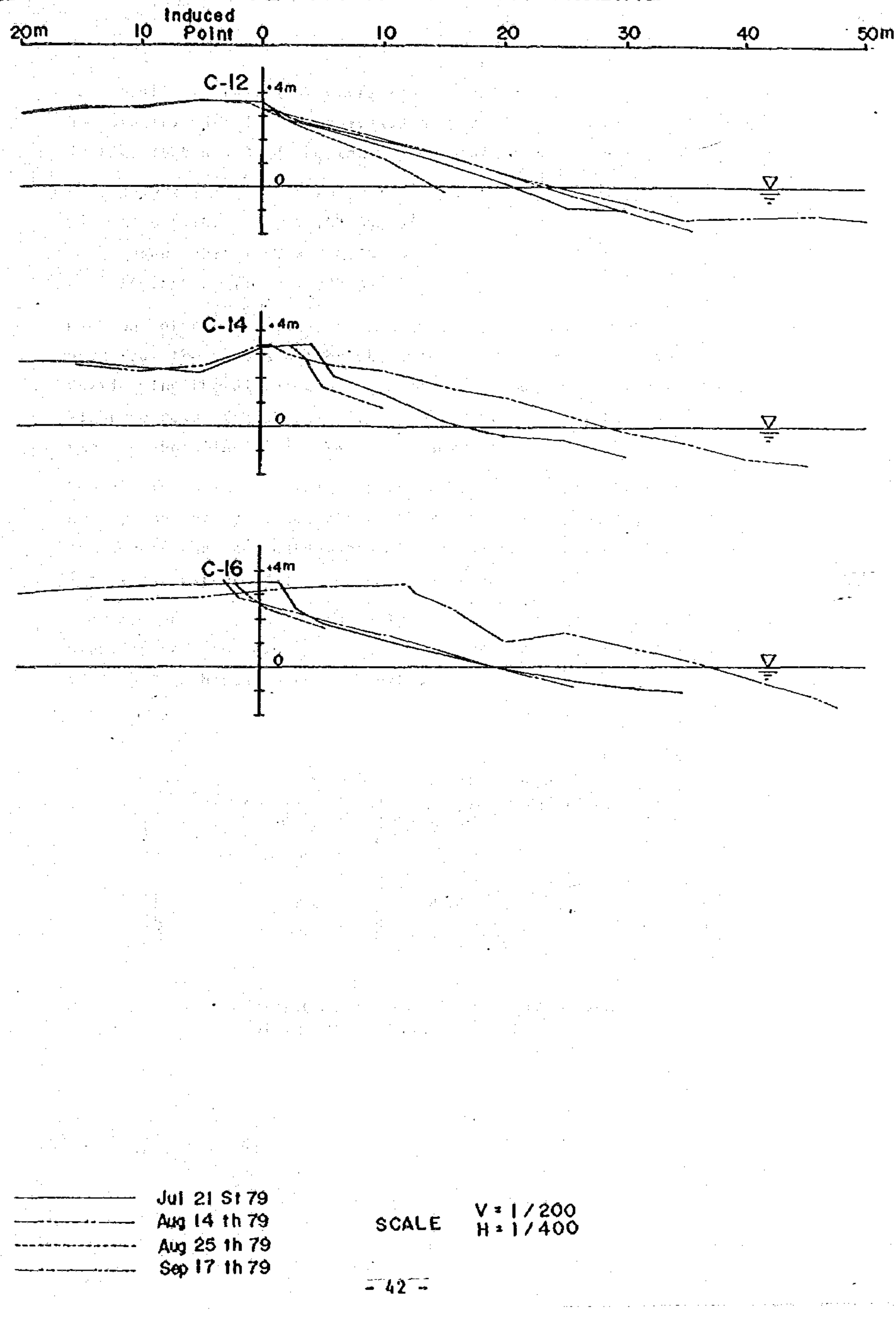


Fig. 3-17 CROSS SECTIONS OF SHORELINE



The result of tracing of variation of sand volume at shore carried out in parallel with direct observation by means of a sand trap is indicated in Fig. 3-16 and 3-17 and the representative values are as shown below.

July 22: V = 281,283 m^3
August 14: V = 197,586 m^3
August 25: V = 254,507 m^3
September 17: V = 277,038 m^3

Each one of these volumes was calculated by obtaining the crosssectional area from the ground height obtained through direct leveling and by multiplying the distance between adjacent courses of traverse, with eight cources of traverse, i.e., C-2, C-4, ... C-16, and the extention of shoreline of 3.5 km as the subject.

The variation in the shore topography is mainly brought about by waves and by the energy of current that is generated by waves, and it is considered that the extent of topographyical variation is also controlled by the extent of changes of waves and current.

Increase and decrease of the volume of sand at shore and variation of significant wave height caused by the topographical variation are shown in Fig. 3-18 based on this thought.

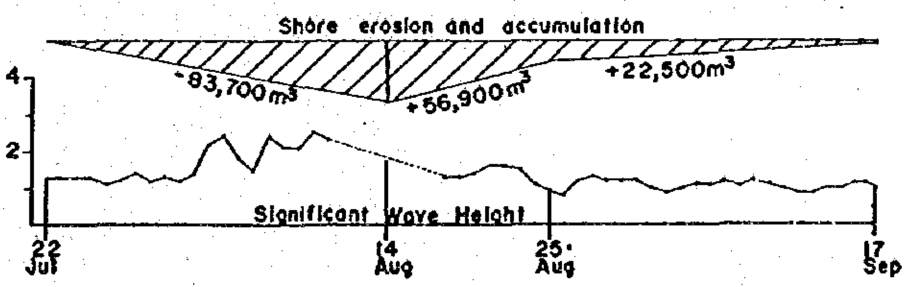


Fig. 3-18 Relation with Significant Wave Height and Volume Fluctuation at Shore

As is seen in this figure, the volume of sand at shore made a decrease of about 84,000 m^3 due to rough weather in the early half of August, and recovery was almost made by the middle of September when the significant wave height became about 1 m.

The distinguished direction of current along the coastline of the subject area is also largely related to the wave direction, and it was found out the current is directed to east from west. This direction of current can be considered to suggest the distinguished direction of drift sand in the subject area.

Table 3-7 Results of Littoral Drift Observations at Breaker Zone

Item \ Point	St-1				
Date	22 July	1 Aug.	8 Aug.	15 Aug.	25 Aug.
Observed Depth	1 meter below sea surface				
Time of Initial Setting	10:00	09:30	12:20	10:00	10:30
Time of Final Setting	17:00	16:00	17:10	13:00	15:00
Total Hrs	7	6h-30m	4h-50m	3	4h-30m
Amount of Sediment Sample (g)	No. sample	No. sample	31.7	7.5	No. sample
Wind Direction	S~WSW	SW~NW	SSW	SW~WSW	SW~WSW
Wind Velocity (m/s)	2.4~11.5	2.1~6.9	6.8~8.0	5.6~7.6	2.5~5.3
Wave Direction	SW	SSW	SSW	SSW	SSW
Significant Wave Height (m)	1~1.4	1.2~1.4	2.1~2.3	-	0.8~1.0
Period of above	10~16	12~15	14	-	10~11
Note			6.6g/h	2.5g/h	

Item \ Point	St-1		St-4		
Date	1 Sep.	8 Sep.	16 Sep.	18 Sep.	23 Sep.
Observed Depth	1 meter below sea surface				
Time of Initial Setting	09:30	09:30	14:00	09:00	09:00
Time of Final Setting	12:30	11:30	17:00	11:30	13:30
Total Hrs	3	2	3	2h-30m	4
Amount of Sediment Sample (g)	86.0	19.5	11.1	46.7	No. sample
Wind Direction	SW~WSW	SSW~NNW	SW~SSW	N~NW	SSE~SSW
Wind Velocity (m/s)	6.5~8.5	2.2~3.0	4.2~5.2	1.1~3.4	2.4~3.9
Wave Direction	SW	S	-	SSW	SSW
Significant Wave Height (m)	0.8~1.0	1.1~1.2	0.9~1.1	1.0	0.9~1.2
Period of above (sec)	13	13	12	10	12~13
Note	28.7g/h	9.8g/h	3.7g/h	18.7g/h	

3-6-2 At sea

The result of collection of sand by the trap installed at sea is as shown in Table 3-8. The area of the collecting hole for the bottom surface is 16 cm^2, and the area of collection hole for the level of 0.5 m above the bottom is 27 cm^2. Both traps were installed with the collecting holes facing upward.

Table 3-8 Results of Littoral Drift Observations at Sea

Item \ Point		St-3			
Date and Time of Initial Setting		10 Aug. 13:00	28 Aug. 14:30	9 Sep. 14:30	14 Sep. 15:00
Date and Time of Final Setting		22 Aug. 14:30	9 Sep. 14:00	14 Sep. 14:00	21 Sep. 13:00
Period (days)		12	12	5	8
Amount of Sedimental Sample (g)	Upp.	82.6	No Sample	No Sample	No Sample
	Bot.	528.1	157.4	174.8	No Sample
Note		1.8g/h	0.5g/h	1.5g/h	

The volume of sand collected at the height of 0.5 m above the bottom was significant only during the period in which wave height was high, and was minor to unweighable level during other periods. The volume of collected sample per unit time was 0.3 g, but the result of grain size distribution is similar between this sample and the sample collected with the trap installed at the bottom, and measured values of specific gravity of samples were also as close as 2.638 with sand in the higher layer and 2.650 with sand at the bottom.

On the other hand, the volume of sand collected at the bottom per unit time was 0.5 ∿ 1.8 g.

A comparison of earth volume was made with last year from the result of sounding, by using the technique identical to that of calculation of variation of earth volume at the shoreline with the area of 3 km square of the water depth of 12 m and deeper, in which the bottom slope becomes gentle.

As a result, the volume was increased by about 910,000 m^3 from the level obtained in December, 1978. When this figure is converted into the increased volume per unit area from the acreage of the area of comparison, it is 0.1 m^3, and when conversion is made into the difference in the mean depth, it is 0.1 m. The local topographic variation in this area was accumulation in the west half and was erosion in the east half as a general trend. However, the figure of 0.1 m obtained as the difference in the mean depth is almost matched with the sounding accuracy obtained with an echo sounder, and it is not possible to unqualifiedly determine this difference as what was brought about by drift sand phenomena.

At any rate, the topography at sea is stabilized, which is in good contrast with that at shore, and the bottom material balance brought about by drift sand phenomena is almost maintained.

3-6-3 Grain size distribution

The result of grain size analysis carried out for the purpose of seizing the characteristics of bottom materials which have important relationship with littoral drift phenomena together with waves and current is indicated as grain size accumulation curves attached to the end of this report. The median diameter, sorting coefficient and skewness were obtained from this curve, and are indicated in Table 3-9.

Table 3-9 Median Diameter, Sorting Coefficient and Skewness

Element / Place	Median diameter Md	Sorting coefficient So	Skewness Sk	Element / Place	Median diameter Md	Sorting coefficient So	Skewness Sk
C4-1	0.42	1.13	0.99	C4-2	0.86	1.17	0.95
C8-1	0.42	1.11	1.03	C8-2	0.63	1.32	0.96
C-12-1	0.45	1.13	0.98	C12-2	0.56	1.25	1.03
C-16-1	0.45	1.19	1.01	C16-2	0.61	1.28	1.03
T7-1	0.43	1.16	1.10	T7-2	1.40	1.43	1.02
T7-3	0.13	1.78	1.17	T7-4	0.30	1.38	0.97
T7-5	0.14	1.60	1.03	T7-6	0.50	2.07	1.16
T7-7	0.65	1.52	1.07	T7-8	0.56	1.71	1.10
T7-9	0.55	1.58	1.04	T7-10	0.23	1.31	0.80
No.3 Above	0.17	1.64	0.97	No.3 Bottom	0.17	1.38	0.98

The sampling point at shore were just before the beach scrap (C4-1 ∿ C16-1 and T7-1), beach (C4-2 ∿ C16-2) and trough (T7-2), and bar top (T7-3) in addition. The sampling points including those at sea are shown in General Location Map inserted at the beginning of this report. Sample No. St. 3 is sand collected with a sand trap. As a general trend, the diameter is larger and grain size distribution is more complicated at the beach where the sand is always washed by waves. It is considered that there is no essential difference in the grain size distribution in the direction that is parallel with the shore.

On the other hand, mean grain size distribution in the direction from the shore to the sea is indicated in Fig. 3-19 for the purpose of observing the grain size distribution in the direction that is square to the beach.

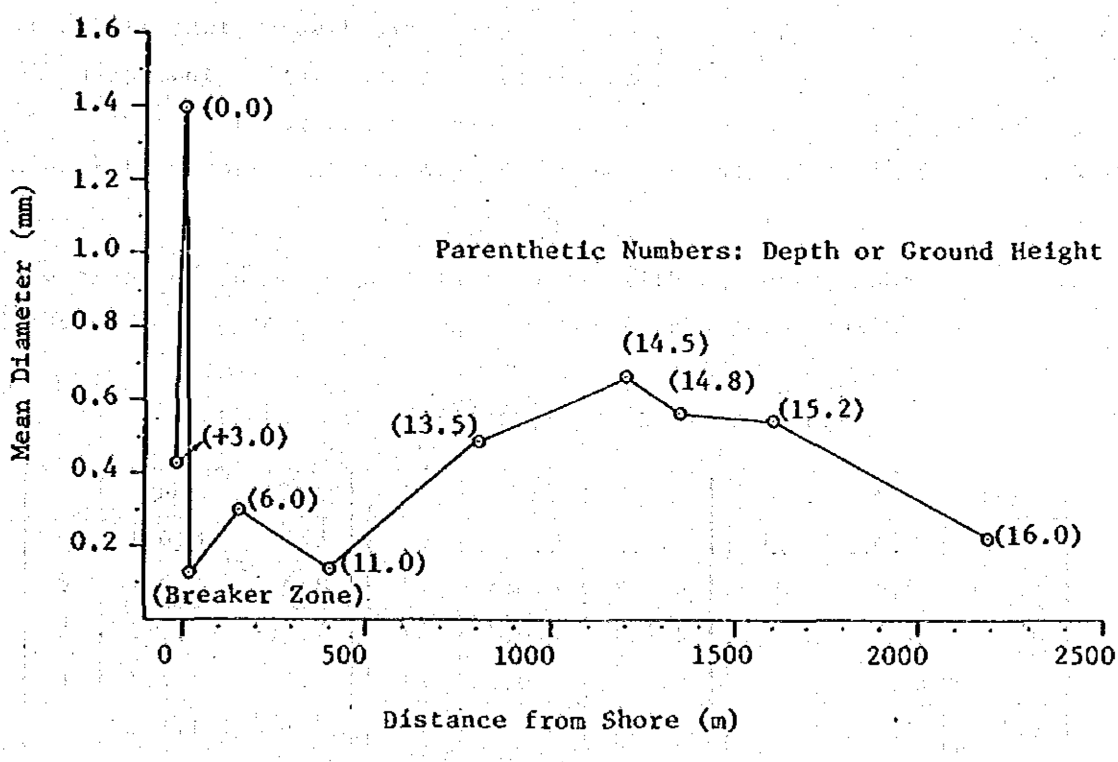


Fig. 3-19 Grain Size Distribution of Right Angle Direction toward Shore Line

The grain size is the maximum in the trough of the breaker zone, and is the minimum at the top of the bar. The grain size at sea generally decreases as the water depth increases, but this trend is not indicated by the grain size distribution in the subject area, but the grain size is the largest at the point of water depth of 14 ∿ 15 m located at the distance of 1 ∿ 1.5 km from the shore. It is probably the result controlled by the distinguished wave conditions of this area.

It is also characteristic that the bottom materials which constitute the seabottom of this area are sand of the grain size which are hydraulically most easily moved.

3-7 Shore Topography and Bottom Topography

3-7-1 Shore topography

The coastline of this area is rather monotonous, as it linearly stretches in almost east to west direction. A cross section of the beach is shown in an appended figure attached to the end of this report, but the slope of the foreshore is almost held in the range of 1:5 ∿ 1:8, and its sectional form varies in correspondence to the variation of the sea conditions.

The slope of the foreshore is compared with the values obtained last time at common cources of traverse and is shown in Table 3-10.

Table 3-10 Comparison of Foreshore Slopes

	1978	1979		1978	1979		1978	1979
5	1:6.8	1:7.8	10	1:6.9	1:7.4	15	1:6.2	1:5.7
6	1:6.7	1:4.8	11	1:6.8	1:6.0	16	1:5.0	1:7.8
7	1:7.5	1:7.7	12	1:6.2	1:6.6	17	1:7.2	1:5.6
8	1:5.6	1:7.2	13	1:6.2	1:5.9		Mean	
9	1:7.1	1:7.1	14	1:5.0	1:5.0		1:6.4	1:6.5

Although such local variation that the slope becomes gentle at some places and steep at other places is observed, the mean slope is almost matched between the last survey and this survey.

As for the sectional form, while it is relatively stabilized in the west section of the survey area, erosion is conspicuous before Igando area in the east section.

Beach scarp is formed in general at this shore, but when its cross section is observed, thin layers of rejected oil, which indicate that there were periods in which topography was temporarily stabilized, can be seen in stripe form.

Eight rejected oil layers are observed in the beach scarp of the head of about 1 m before Debojo area.

3-7-2 Bottom topography

When the bottom topography of the subject area is generally observed, the contour line is almost parallel with the shoreline to the depth of about 10 m, but the gap makes expansion as the depth further increases, and topography of minor valley shape is indicated at offshore at the center of the survey area. This topography of valley shape, however, is of small scale of the depth difference of less than 1 m.

A comparision of bottom topography with the result of the surveying made last time is attached to the end of this report, but large variation is not observed in this result, either. The depth reaches the level of 20 m at offshore of about 5 km in this area. The bottom topography in the section of up to this depth indicates an extremely gentle slope. The bottom slope as classified by the depth is indicated in Table 3-11 in this connection. The highest slope is observed in the depth of 10 m or less and the density of contour lines is high in the range of depth of 2 ∿ 5 m.

Table 3-11 Bottom Slope Classified by Depth

Depth (m)	Slope
5 ~ 10	25/1000 ~ 33/1000
10 ~ 12	6/1000 ~ 12/1000
12 ~ 14	3/1000 ~ 4/1000
14 ~ 16	1.3/1000 ~ 2/1000
16 ~ 18	1.3/1000 ~ 1.6/1000
18 ~ 20	1.6/1000 ~ 2.2/1000

3-8 Water Quality in Swamp and Lagoon

Water area environment of water sampling points:

The subject water area includes the swamp located in the project area and also on its east and west sides as the essential part, a part of the lagoon that surrounds its external peripheries and the OMU Creek branched from the lagoon.

The swamp zone distributed along the shore is covered by abundant trees, and its width is about 1 km near the project site.

Extremely conspicuous differences are observed in the water depth (water volume) between dry season and wet season, but flow of water mass is not conspicuous, and withered woods and grasses are sedimented and accumulated at the bottom, and distribution of floating-leaved plants is observed in the shrub areas. At the present time it is considered that influence over the water quality by artificial factors is almost none.

On the other hand, the role as the inland water way is also important for the Lagos Lagoon which occupies a large area. Epe, which is one of the observation points, is the terminal for the surrounding area, although it is of a small scale, and influence over the water quality by artificial factors cannot be ignored.

The OMU Creek, which is branched from the Lagos Lagoon and extends to the east in meandering form, is also a communication water way for reaching Lagos, and transportation of goods by powered ships is made in small scale.

The results of water examination are indicated in Table 3-12 and 3-13 in the following pages.

Table 3-12 Results of Water Examination

Item	Unit	① ICANDO		② DEBOJO	
Date	-	2 Aug.	5 Sep.	5 Aug.	6 Sep.
Weather	-	Rain	Fine	Rain	Cloudy
Air Temp.	°C	24.8	28.5	25.8	28.2
Depth	m	2.0	1.1	2.5	1.1
Turbidity	ppm	45	40	70	70~80
Chromaticity	-	>21	>21	>21	>21
Water Temp.	°C	24.1	24.9	24.3	25.2
pH	-	5.1	4.4	4.6	4.7
Transparency	m	1.0	1.0	1.0	0.9
Cl	ppm	<4.2	<4.2	<4.2	<4.2
COD	"	20	20	20	20
SS	"	4.3	3.7	1.9	2.4
DO	"	0.8	1.0	3.5	0.8

Item	Unit	③ OKUNSOLU		④ IWESOLU	
Date	-	5 Aug.	6 Sep.	7 Aug.	6 Sep.
Weather	-	Cloudy	Fine	Rain	Fine
Air Temp.	°C	24.9	27.2	28.3	26.5
Depth	m	1.7	1.0	1.0	0.9
Turbidity	ppm	40	20	20	25
Chromaticity	-	>21	>21	>21	>21
Water Temp.	°C	24.2	24.8	24.9	25.5
pH	-	5.1	4.7	4.5	4.7
Transparency	m	1.5	1.2	0.6	0.7
Cl	ppm	<4.2	<4.2	<4.2	<4.2
COD	"	10	10	50	10~100
SS	"	2.4	2.8	3.2	4.0
DO	"	2.0	1.0	0.4	0.3

Item	Unit	⑤ IDADO		⑥ EPE (1)	
Date	-	7 Aug.	6 Sep.	27 Aug.	23 Sep.
Weather	-	Cloudy	Cloudy	Cloudy	Fine
Air Temp.	°C	25.8	26.5	27.9	31.9
Depth	m	1.3	1.3	2.2	2.5
Turbidity	ppm	45	20	100	50
Chromaticity	-	>21	>21	>21	>21
Water Temp.	°C	24.2	25.4	25.8	27.9
pH	-	4.4	4.4	5.6	5.7
Transparency	m	0.8	0.9	1.1	1.0
Cl	ppm	<4.2	<4.2	<4.2	<4.2
COD	"	30	20	10	10
SS	"	1.1	1.0	21.9	15.2
DO	"	1.0	0.9	3.8	5.6

Table 3-13 Results of Water Examination

Item	Unit	⑦ EPE (2)		⑧ GBOGIJE (1)	
Date	-	27 Aug.	23 Sep.	31 Aug.	26 Sep.
Weather	-	Cloudy	Fine	Cloudy	Rain
Air Temp.	°C	28.1	32.0	27.0	26.2
Depth	m	1.8	2.0	2.5	2.4
Turbidity	ppm	80	50	40	50
Chromaticity	-	>21	>21	>21	>21
Water Temp.	°C	26.0	28.0	Bot. Sur. 27.0 26.5	25.1
pH	-	5.7	5.6	4.2	4.5
Transparency	m	1.0	0.9	0.9	0.8
Cl	ppm	<4.2	<4.2	<4.2	<4.2
COD	"	10	20	10	10
SS	"	18.1	17.3	3.3	2.7
DO	"	4.2	5.2	5.1	5.5

Item	Unit	⑨ GBOGIJE (2)		⑩ GBOGIJE (3)	
Date	-	31 Aug.	26 Sep.	31 Aug.	26 Sep.
Weather	-	Cloudy	Rain	Cloudy	Rain
Air Temp.	°C	27.4	25.8	27.3	25.9
Depth	m	2.4	2.3	2.1	2.4
Turbidity	ppm	50	60~70	45	50
Chromaticity	-	>21	>21	>21	>21
Water Temp.	°C	26.4	25.0	26.5	25.1
pH	-	4.4	4.4	4.2	4.1
Transparency	m	0.8	0.9	0.9	0.8
Cl	ppm	<4.2	<4.2	<4.2	<4.2
COD	"	10	20	20	10
SS	"	2.4	3.9	3.3	3.7
DO	"	4.6	5.1	3.8	5.1

Item	Unit	⑪ ORIMEDU		ADD 1 IGANDO	ADD 2 DEBOJO
Date	-	7 Aug.	7 Sep.	6 Sep.	6 Sep.
Weather	-	Cloudy	Rain	Cloudy	Cloudy
Air Temp.	°C	25.5	24.5		
Depth	m	2.0	2.1		
Turbidity	ppm	70	40~50		
Chromaticity	-	>21	>21		
Water Temp.	°C	24.8	26.2		
pH	-	4.6	4.5	6.5~7.0	6.0
Transparency	m	0.8	0.6		
Cl	ppm	<4.2	<4.2		
COD	"	20	10~20		
SS	"	4.2	3.5		
DO	"	4.3	3.8		

4. CONCLUSION

The seasons of the survey area are composed of rainy season and dry season which appear repeatedly, and the result of the survey carried out this time seized the characteristics of natural conditions in the rainy season.

Various phenomena in the sea occur as the results of interaction of waves, current and so forth. Examination is made below regarding the littoral drift phenomena, which are important for construction of structures on the sandy beach, from the standpoint of elucidation of its mechanism, with the interaction of the factors stated above taken into consideration.

The distinguished direction of movement of littoral drift sand near the shore in this area is from west to east, and it is considered that its main force is intensified in the wave conditions. The direction of swelling waves which attack this area makes convergence in one direction (mainly SW), and the angle of incident waves is matched with about 40° which is assumed to the angle at which the volume of littoral drift sand becomes about the largest.

Consequently, it is considered that the littoral direction component of energy is stabilized and that migration of bottom materials is occurring continuously (Fig. 3-20).

As it was clarified through this survey, the topographical variation inside of the breaker zone is primarily controlled by waves.

From the phases of said topographic variation, the situations that although erosion is made by waves of wave height and period which are larger than those of ordinary waves,

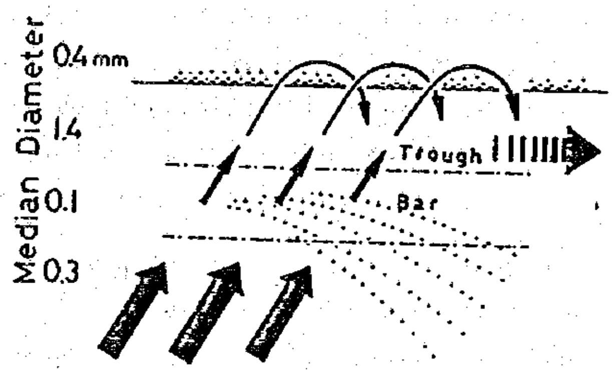


Fig. 4-1 Direction of Waves and Beach Drift

recovery is gradually made were observed. When judgement is made from such a result, it can be considered that, out of drift littoral phenomena which are occurring at all times, such cyclic changes that accumulation is made in relatively calm period and that erosion occurs in rough period are involved.

This cycle is seasonal variation for instance or the variation in a short period such as that obtained this time, and the phenomena probably are very much complicated.

Sand beach is continued in the neighborhood of the shore of the survey area, and therefore, drift is not obstructed at all by artificial structures. The current situation, therefore, is such that infinite supply can be expected. When a breakwater is constructed for such a beach, what have been originally located in single open system are split into two systems with the breakwater as the boundary. Therefore, when the breakwater is extended, accumulation is accelerated starting at the base on the west side of the breakwater, supply of sand is obstructed in its east side, erosion advances, and back-off of the shore occurs as a result. Such cases are observed in large number in the scales of both small and large, and it considered that it can be used as the result of qualitative forecast of topographical variation.

It is considered, on the other hand, that the longshore drift is not as active as that of beach drift, but incoming waves are of long periods as clarified in the wave characteristics, and the wave lengths are kept at 100 m or longer. These waves, therefore, exert influence over the bottom materials starting at offshore of considerable distances from the shore, and they are more than sufficient as the force applied to the bottom materials in the survey area of the depth of 20 m or less.

However, no large difference is observed in the bottom topography of this area compared to that in dry season surveyed six months prior to this survey, and the bottom topography is relatively stabilized. When the current of the lowermost layer in the subject area is observed on the other hand, the direction of the current is unstable and the current velocity was as small as 0.1 m/sec (0.2 knot). When migration limit

current velocity (U) is calculated by substituting representative values of the median diameter in this area in expression of relation (by Sato et al.) between median diameter of bottom materials and threshold velocity, it is obtained as follows. At sea side of breaker zone and at an offshore point of 2 km from the shore:

Median diameter Md = 0.2 mm

$$U = 6.3 \times 10^{-1} \sqrt{0.2} = 0.28 \text{ (m/s)}$$

At an offshore point of 1 ∿ 1.5 km from the shore:

Median diameter Md = 0.6 mm

$$U = 6.3 \times 10^{-1} \sqrt{0.6} = 0.49 \text{ (m/s)}$$

The mean grain size of the bottom at the points of observation does not reach the threshold velocity.

The current on the sea side of the breaker zone is considered to be such that the onshore current and the return flow, which accompany mass transport of waves, but opposite surface current directions were observed in the observations carried out twice. It is probably because of the difference in the observing conditions, that is, total of the differences in the point of provision of floating buoys, wind, waves, permanent current tide and so forth. But the correlation among these factors is not known.

The Guinea current of the nature of warm current flows to east through the offshore of the survey area. Because the main direction of the current at the center of the survey area is east flow, it was considered at the beginning that it is influenced by this Guinea Current.

However, when observation was made at a point of further offshore, the main direction of the current at this point is west flow, and thus it was found out that the current situation in this area is not monotonous. These main directions of current at different points did not make large changes even under the conditions where tide is different, and the only change observed was in the current in the lower layers. If expression of the reason for reversing of the current direction is pressed with importance attached to this fact, it cannot help determining that it is

caused by topographical influence of the Avon Canyon (Avon's deep) located in southeast direction of this area. But the current velocity of 0.7 knot is excessive even in such a case.

ATTACHED DATA

METEOROLOGICAL AND MARINE PHENOMENAL RECORDS OF MONTH
AT PROJECT AREA
6° 26' N, 3° 49' E

July, 1979

Element / Day	Pressure (mb) Mean	Pressure (mb) Min.	Temperature (°C) Mean	Temperature (°C) Max.	Temperature (°C) Min.	Humidity (%) Mean	Humidity (%) Min.	Wind Velocity and Direction: Mean for 24	Prev. Wind Dir.	Max. Dir.	Max. Vel.	Max. Time	Instantaneous Dir.	Instantaneous Vel.	Instantaneous Time	Total Amount of Precip.	Prev. Wave Dir.	Wave Height and Period: H Max	T Max	H 1/10	T 1/10	H 1/3	T 1/3	H Mean	T Mean	Note
1																										
2																										
3																										
4																										
5																										
6																										
7																										
8																										
9																										
10																										
11																										
12																										
13																										
14																										
15																	ssw									
16	11.9	10.7	26.0	28.8	24.0	87	76									103.0	ssw									
17	12.2	11.6	24.6	25.0	24.8	95	87									44.1	ssw									
18	13.3	12.0	23.8	25.7	23.2	96	94			wsw	3.8	1725	wsw	4.7	2243	11.5	s	1.6	11.6	1.1	12.3	1.1	12.6	0.8	12.9	
19	12.8	10.7	24.6	27.5	23.0	91	79	4.6	wsw	sw	7.7	1813	sw	8.2	1807	50.0	sw	1.5	13.4	1.4	13.6	1.1	13.3	0.7	13.2	
20	12.7	11.6	25.5	28.6	22.6	90	78	6.0	wsw	wsw	9.3	1846	wsw	10.0	1838	72.1	sw	1.6	11.2	1.4	12.0	1.2	12.2	0.8	11.7	
21	12.4	10.7	24.8	27.8	23.0	91	79	5.5	wsw	wsw	9.0	1450	wsw	10.3	1447	2.1	ssw	1.7	13.4	1.5	13.6	1.3	13.9	0.9	12.6	
22	12.6	11.6	24.1	26.5	23.0	93	81	5.7	ssw	SE	14.3	1551	SE	19.9	1548	78.0	sw	1.8	11.5	1.6	11.5	1.3	12.7	0.9	13.5	
23	13.5	12.1	24.1	26.7	22.6	92	85	5.7	sw	ssw	9.6	1548	s	17.8	1543	146.0	sw	1.7	12.0	1.6	11.8	1.3	12.3	0.9	12.8	
24	12.7	11.4	24.8	26.8	22.9	92	80	4.2	sw	sw	6.9	1353	ssw	8.0	0451	—	s	2.0	11.1	1.6	11.6	1.3	12.0	0.9	12.1	
25	11.5	10.3	26.0	29.3	22.9	85	72	5.0	sw	sw	7.9	1546	sw	8.2	1542	0.0	s	2.3	8.4	1.6	9.1	1.3	9.7	0.9	10.9	
26	11.5	10.8	26.0	28.6	23.7	87	75	5.3	sw	sw	7.7	1251	sw	8.3	1611	16.0	ssw	1.4	11.3	1.3	11.5	1.1	12.8	0.8	13.1	
27	12.2	11.2	25.8	28.4	24.4	90	77	5.1	ssw	sw	7.6	0648	wsw	8.4	0746	0.0	sw	1.6	12.8	1.4	11.9	1.2	12.3	0.9	12.5	
28	12.3	10.9	26.3	28.3	23.8	90	80	5.4	sw	sw	7.9	0555	sw	9.0	0550	8.6	ssw	2.0	12.1	1.7	11.8	1.4	12.0	1.0	12.3	
29	11.9	10.9	26.1	28.6	24.9	89	77	4.5	ssw	s	7.9	1241	s	9.0	1232	90.3	ssw	1.7	11.2	1.5	11.6	1.2	12.3	0.8	12.4	
30	12.3	10.9	26.3	28.9	24.9	87	77	5.5	sw	sw	9.2	1949	sw	10.3	1930	30.1	sw	1.8	11.6	1.6	12.2	1.3	12.4	0.9	12.0	
31	11.6	10.3	24.5	26.0	22.3	92	87	4.8	sw	sw	8.0	1434	s	10.2	2316	33.1	ssw	1.8	10.6	1.5	11.5	1.2	11.9	0.9	13.5	
T	197.4	177.7	403.3	441.5	376.0	1447	1284	67.3								685.2		24.5	162.2	21.1	166.0	17.3	172.4	12.1	175.5	Total
M	12.3	11.1	25.2	27.6	23.5	90	80	5.2	sw									1.8	11.6	1.5	11.9	1.2	12.3	0.7	12.5	Mean
		10.3		29.3	22.3		72			SE	14.3	1551	SE	19.9	1548	146.0										Max or
Day		25		25	31		25				22			22		23										Min.

KOKUSAI AERIAL SURVEYS CO., LTD.

METEOROLOGICAL AND MARINE PHENOMENAL RECORDS OF MONTH
AT PROJECT AREA

6° 26′ N, 3° 49′ E

Aug., 1979

Element	Pressure (mb)		Temperature (°C)			Humidity (%)		Wind Velocity and Direction								Total Amount of Precip	Prev. Wave	Wave Height and Period								Note
								Mean	Prev. Wind	Max.			Instantaneous					H	T	H	T	H	T	H	T	
Day	Mean	Min	Mean	Max	Min	Mean	Min.	for24	Dir.	Dir.	Vel.	Time	Dir.	Vel.	Time		Dir.	Max.	Max.	1/10	1/10	1/3	1/3	Mean	Mean	
1	13.3	11.7	240	26.2	22.3	93	84	4.5	sw	wsw	9.0	1045	wsw	11.2	1029	1.7	ssw	2.0	13.9	1.7	12.8	1.4	13.6	1.0	13.5	
2	12.9	11.6	24.6	27.8	23.1	92	79	4.4	sw	ssw	8.9	1535	sw	14.6	1528	10.0	ssw	3.1	16.4	2.8	16.5	2.2	16.2	1.5	15.7	
3	12.3	11.6	24.8	27.9	22.8	91	78	4.5	sw	sw	7.9	1851	sw	9.0	1849	64.5	ssw	3.3	14.7	2.9	14.6	2.4	14.6	1.5	14.5	
4	12.7	11.6	25.5	28.0	23.2	92	78	6.0	ssw	ssw	7.6	0957	ssw	8.8	0957	9.1		2.3	12.7	2.1	12.6	1.8	12.9	1.2	13.2	
5	×	×	25.9	28.1	24.4	92	82	5.6	sw	sw	9.2	0720	sw	11.0	0713	0.3	ssw	2.2	10.8	1.8	11.8	1.5	12.4	1.0	12.7	
6	×	×	26.3	28.9	24.6	87	77	6.1	ssw	ssw	7.8	2227	ssw	8.8	2322	18.6		3.0	15.2	2.8	16.1	2.4	16.7	1.7	16.8	
7	×	×	25.3	25.7	24.4	90	82	6.2	sw	sw	7.7	1053	ssw	9.0	1020	0.6	sw	2.8	14.9	2.6	15.0	2.1	15.1	1.5	14.8	
8	13.3	11.7	26.5	29.7	24.3	87	74	7.4	ssw	ssw	8.5	2245	sw	10.0	2240	0.6	ssw	3.1	12.1	2.7	14.1	2.1	13.1	1.5	13.3	
9	13.1	11.7	26.2	28.4	25.1	86	79	7.6	sw	sw	9.5	1420	sw	11.9	1418	35.1	sw	3.4	13.6	3.0	14.4	2.5	14.3	1.7	14.2	
10	11.7	9.7	25.9	28.4	23.9	88	78	8.1	sw	sw	10.3	2255	sw	12.5	1855	19.9	sw	2.9	14.6	2.7	14.5	2.3	14.4	1.6	14.1	
11	10.7	9.3	25.6	27.2	24.0	87	81	9.4	sw	sw	11.4	1308	sw	13.3	1308	1.1	sw									
12	11.4	10.4	26.0	28.1	24.2	86	77	8.3	sw	sw	10.4	0237	wsw	13.9	1559	8.9	sw									
13	12.3	10.9	25.8	28.3	23.9	86	74	7.9	sw	wsw	9.4	0258	wsw	11.0	0255	2.0	ssw									
14	11.3	10.0	25.7	28.7	23.3	85	73	6.2	sw	sw	8.5	0347	sw	10.3	0343	7.1	sw									
15	10.6	9.4	26.5	28.8	24.5	83	72	6.6	sw	sw	7.7	0436	wsw	9.1	1220	14.1	ssw									
16	11.1	10.0	25.2	28.3	23.5	86	74	6.8	sw	sw	8.0	0216	sw	9.3	0210	5.8	ssw									
17	9.0	6.6	26.1	28.4	23.7	84	77	5.2	wsw	wsw	7.8	0020	wsw	8.4	0020	7.8	sw									
18	7.1	5.7	25.3	26.3	25.2	90	81	6.7	sw	sw	8.9	1915	sw	10.0	2251	3.7	sw	1.8	12.0	1.6	13.0	1.3	13.2	0.9	13.3	
19	10.8	8.7	25.8	29.1	23.1	90	(81)	7.2	sw	sw	9.5	1510	sw	11.4	1507	2.8	ssw	1.8	12.6	1.6	12.4	1.3	12.0	0.9	12.5	
20	11.3	9.7	25.8	27.5	24.4	87	81	5.5	sw	sw	7.8	0207	sw	8.8	0156	2.2	ssw	1.9	13.9	1.7	12.1	1.4	12.2	1.0	12.5	
21	10.1	9.9	24.4	25.9	24.5	90	74	5.3	wsw	wsw	11.5	1353	wsw	14.4	1330	3.0	ssw	2.3	12.4	1.9	12.4	1.6	12.4	1.0	12.9	
22	10.0	8.6	24.4	26.4	22.5	90	83	7.8	wsw	wsw	11.2	2203	wsw	13.2	1655	2.5	ssw	2.4	7.7	2.0	9.6	1.6	10.2	1.0	11.6	
23	10.1	9.2	25.6	28.5	22.6	84	73	7.4	sw	wsw	10.2	0411	wsw	12.8	0400	21.5	sw	2.3	8.0	2.4	8.1	1.5	9.2	1.0	10.8	
24	10.7	9.5	25.9	28.8	23.1	81	68	5.3	wsw	sw	7.3	0030	sw	7.3	1800	25.4	sw	1.8	8.8	1.3	9.8	1.1	11.2	0.7	12.1	
25	10.2	8.5	25.4	28.5	21.8	84	71	4.9	sw	sw	7.9	2240	NNW	9.0	0404	—	ssw	1.3	9.9	1.1	10.9	0.9	11.3	0.7	12.0	
26	9.5	7.4	25.7	28.6	24.0	83	69	5.2	wsw	wsw	7.8	1600	wsw	8.9	1548	6.0	wsw	1.2	13.2	1.1	12.7	0.8	13.0	0.6	13.4	
27	6.2	4.5	24.2	25.9	22.9	87	82	5.5	wsw	sw	8.0	1712	sw	8.7	1610	50.4		1.7	9.3	1.5	12.4	1.2	13.0	0.8	13.2	
28	6.4	5.3	24.5	26.0	23.0	88	81	6.3	sw	sw	10.0	1712	sw	12.5	1708	7.1	sw	1.8	13.2	1.6	13.0	1.3	13.3	0.9	13.1	
29	9.6	8.5	25.9	29.6	22.4	85	71	5.3	ssw	sw	8.0	0645	sw	8.1	0318	8.2	sw	1.7	13.2	1.5	12.9	1.2	13.0	0.8	13.2	
30	9.5	8.5	25.7	27.7	23.7	85	76	5.5	wsw	sw	7.4	1850	w	8.5	1300	3.5	wsw	1.8	13.4	1.5	13.3	1.2	13.4	0.8	13.5	
31	8.7	6.7	26.1	29.2	23.7	86	75	6.6	wsw	sw	9.5	2009	sw	11.5	2005	1.6	wsw	1.7	11.9	1.4	12.8	1.2	13.0	0.8	13.3	
T	295.9	256.9	790.6	865.5	732.4	2705	2388	195.3								345.1		53.6	298.4	47.3	307.8	38.3	313.7	26.1	320.2	Total
M	10.6	9.2	25.5	27.9	23.6	87	77	6.3	sw									2.2	12.4	2.0	12.8	1.6	13.1	1.1	13.3	Mean
		5.7		29.6	21.8		68			wsw	11.5	1353	sw	14.6	1528	64.5										Max. or
Day		18		29	25		24				11			2		3										Min.

KOKUSAI AERIAL SURVEYS CO., LTD.

METEOROLOGICAL AND MARINE PHENOMENAL RECORDS OF MONTH
AT PROJECT AREA
6° 26′ N, 3° 49′ E

Sep., 1979

Element / Day	Pressure (mb) Mean	Pressure (mb) Min.	Temperature (°C) Mean	Temperature (°C) Max.	Temperature (°C) Min.	Humidity (%) Mean	Humidity (%) Min.	Wind Velocity and Direction: Mean for 24	Prev. Wind Dir.	Max. Dir.	Max. Vel.	Max. Time	Instantaneous Dir.	Instantaneous Vel.	Instantaneous Time	Total Amount of Precip.	Prev. Wave Dir.	Wave Height and Period: H Max.	T Max	H 1/10	T 1/10	H 1/3	T 1/3	H Mean	T Mean	Note
1	7.9	6.5	25.5	28.0	24.8	89	77	7.7	sw	sw	9.6	1643	sw	11.2	1642	6.0	sw	1.4	12.9	1.2	13.1	1.0	13.3	0.6	13.6	
2	7.9	4.5	26.1	28.9	23.5	89	75	4.2	wsw	ssw	9.6	1833	wsw	11.3	1915	10.0	wsw	1.4	12.1	1.2	12.7	0.9	13.2	0.7	13.8	
3	7.3	5.7	26.1	29.2	22.8	86	73	5.7	wsw	wsw	8.5	1538	wsw	10.6	1515	4.0	sw	1.4	12.6	1.2	12.5	1.0	12.9	0.7	13.7	
4	11.4	9.7	26.1	28.3	24.2	90	82	7.0	sw	sw	8.0	1600	sw	10.2	2443	5.1	ssw	1.5	12.5	1.3	13.1	1.1	13.3	0.7	13.7	
5	11.2	9.3	26.6	29.9	24.1	87	76	5.1	wsw	sw	8.0	2100	wsw	9.3	0300	0.0	sw	1.6	12.9	1.4	13.4	1.1.	13.7	0.7	13.8	
6	10.5	8.9	26.2	28.8	25.1	86	75	6.8	wsw	sw	8.2	1118	sw	9.9	1607	9.0	wsw	1.6	13.8	1.4	13.5	1.2	13.7	0.8	14.0	
7	11.1	9.4	24.3	26.9	24.1	90	83	5.2	wsw	sw	9.4	1507	sw	10.8	1505	2.2	sw	1.6	13.8	1.4	13.3	1.1	13.6	0.8	14.0	
8	11.7	9.8	24.7	30.1	21.0	87	69	4.0	sw	sw	6.7	2220	sw	7.3	2216	0.0	s	1.5	12.4	1.3	13.3	1.2	13.2	0.8	13.6	
9	11.7	10.6	26.9	30.1	23.1	84	71	5.2	sw	sw	7.8	1726	sw	8.5	1725	11.1	ssw	1.4	12.7	1.3	12.7	1.1	12.7	0.7	13.0	
10	11.6	9.7	26.2	29.6	23.4	84	68	4.5	wsw	wsw	8.3	1718				11.0	ssw	1.4	11.0	1.2	12.0	1.0	12.4	0.7	12.5	
11	10.7	9.1	23.0	23.8	21.5	90	88	2.1	N	E	11.3	0505				17.0	s	1.3	11.8	1.2	12.1	0.9	12.4	0.6	12.7	
12	11.6	10.5	24.1	27.0	22.5	89	82	2.8	N	SSE	8.0	1230	sw	7.6	1603	66.5	s	1.3	13.4	1.2	12.9	0.9	12.8	0.6	13.1	
13	12.0	10.8	24.6	28.4	22.8	88	76	3.2	sw	sw	6.9	1250	sw	8.1	1244	0.0		1.4	12.9	1.2	13.2	1.0	13.5	0.6	13.4	
14	12.1	10.4	26.3	30.2	23.0	86	74	4.3	sw	sw	6.8	1715	sw	7.5	1710	135.5		1.4	12.5	1.3	12.9	1.0	13.2	0.7	13.6	
15	12.6	10.6	25.4	28.0	21.6	87	80	4.9	ssw	E	11.0	0640	E	17.1	0638	—		1.5	12.9	1.3	13.0	1.1	13.1	0.7	13.1	
16	12.3	10.6	26.6	30.0	23.7	86	71	3.4	ssw	ssw	5.3	1652	ssw	6.0	1638	—		1.5	12.4	1.3	12.5	1.1	12.5	0.7	12.5	
17	11.2	10.0	27.1	31.0	24.0	84	71	5.8	sw	sw	8.4	1942	sw	9.5	1948	11.1	sw	1.4	12.1	1.2	12.2	1.0	11.9	0.7	12.3	
18	10.8	9.1	25.6	29.0	22.8	86	69	4.5	sw	sw	8.3	1610	sw	9.7	1557	--	ssw	1.7	10.3	1.4	9.9	1.1	10.4	0.7	11.3	
19	10.9	10.1	25.8	30.2	23.0	86	70	3.3	ssw	sw	6.6	0040	sw	7.2	0040	--		1.5	10.5	1.2	10.1	1.0	11.0	0.7	11.6	
20	11.6	10.4	26.6	30.7	23.8	85	73	4.5	sw	sw	7.8	1717	sw	8.3	1715	30.5		1.3	11.2	1.1	12.0	0.9	11.9	0.6	12.1	
21	10.9	9.3	26.1	29.6	24.8	90	76	5.4	sw	sw	11.4	2205	sw	14.1	2155	154.5		1.6	11.0	1.4	11.6	1.2	12.2	0.8	12.7	
22	11.7	9.6	23.1	24.5	23.4	91	79	3.3	N	×	10.2	1047	×	11.9	1040	0.0	ssw	1.9	11.0	1.7	11.6	1.3	11.9	0.9	12.6	
23	12.0	11.2	24.2	29.9	21.5	85	72	2.9	N	sw	5.3	1535	sw	5.9	1203	4.5	ssw	1.6	12.2	1.4	12.5	1.1	12.5	0.7	13.0	
24	12.2	9.8	25.5	30.1	22.1	86	70	5.0	sw	wsw	8.8	1605	sw	9.9	1601	29.5		1.6	11.7	1.4	12.4	1.1	12.7	0.8	13.1	
25	12.0	10.6	26.7	30.2	24.7	87	73	5.4	sw	sw	8.1	0415	sw	9.4	0412	—		1.5	11.9	1.3	12.3	1.0	12.6	0.7	12.9	
26	11.4	9.6	26.8	30.4	23.7	83	69	4.9	sw	sw	8.0	1850	sw	8.7	1848	1.6		1.5	11.6	1.3	12.0	1.0	12.5	0.6	13.0	
27																		1.5	12.1	1.3	12.4	1.1	12.6	0.7	12.9	
28																		1.4	12.4	1.2	12.8	1.0	12.6	0.6	12.6	
29																		1.3	12.2	1.2	12.6	1.0	12.7	0.7	13.2	
30																										
31																										
T	287.2	246.1	666.4	752.8	605.0	2261	1942	121.1								509.1		43.0	352.8	37.5	360.9	30.5	367.0	20.3	377.4	Total
M	11.0	9.5	25.6	29.0	23.3	87	75	4.7	sw									1.5	12.2	1.3	12.5	1.1	12.7	0.7	13.0	Mean
		4.5		31.0	21.0		68			sw	11.4	2205	E	17.1	0638	154.5										Max or
Day				17	8		10				21			15		21										Min

KOKUSAI AERIAL SURVEYS CO., LTD.

METEOROLOGICAL RECORDS OF MONTH

AT LAGOS STATION

6° 27′N, 3° 24′′ E   Jan. 1979

Element / Day	Mean Pressure.	Temperature Max.	Temperature Min.	Mean Humid.	Wind Vel. and Dir. Mean V.	Wind Vel. and Dir. Prev. Dir.	Total Amount of Precip.
	mb	℃		%	m/s	—	mm
1	07.3	31	24	84	1.5	ENE	
2	07.4	31	24	86	1.5	E	
3	07.8	31	25	85	2.1	END~ESE	
4	07.8	30	24	88	1.5	ENE	
5	07.4	31	25	86	1.5	ENE	
6	07.4	30	24	85	2.1	ENE	
7	08.9	30	25	87	2.1	SE	
8	08.2	30	25	85	2.1	E	
9	07.9	31	26	87	2.1	SE	0.2
10	07.6	32	26	83	2.1	E	
11	06.9	32	26	83	2.1	ENE	
12	07.5	32	26	84	2.1	E	TR※
13	07.1	32	25	82	2.1	ENE	
14	07.7	31	26	85	2.1	E	
15	07.2	31	26	86	2.6	SE	
16	06.1	31	26	84	2.6	ESE	
17	05.7	31	25	84	2.1	ESE	
18	06.2	32	26	85	2.1	E	
19	07.6	32	26	87	1.5	ENE	
20	07.4	32	24	84	2.1	E	
21	07.3	31	25	84	1.5	ENE~E	
22	07.2	32	26	84	2.1	E	
23	08.3	31	26	82	2.1	ESE	
24	08.9	32	26	82	2.1	E	
25	08.2	32	26	83	2.1	ESE~SE	
26	08.3	31	25	83	2.6	E	
27	07.9	31	25	83	2.1	ENE	
28	07.7	32	26	83	2.1	E~ESE	
29	07.5	32	26	58	2.1	ESE	TR
30	07.7	32	26	83	2.1	E~ESE	2.7
31	08.1	32	25	81	2.1	E	
Total	233.9	971	786	2586	62.3		2.9
Mean	07.5	31.3	25.3	83	2.1		

※ TR : TRACE

METEOROLOGICAL RECORDS OF MONTH

AT LAGOS STATION

6°27'N, 3°24'E   Feb., 1979

Element / Day	Mean Pressure	Temperature Max.	Temperature Min.	Mean Humid	Wind Vel. and Dir. Mean V.	Wind Vel. and Dir. Prev. Dir.	Total Amount of Precip.
	mb	℃		%	m/s	−	mm
1	08.5	32	26	83	2.1	E	3.5
2	08.3	31	25	80	2.1	E	
3	08.1	32	26	82	2.6	E	TR
4	08.1	29	25	83	2.6	E	
5	08.5	31	24	81	1.5	NE	TR
6	08.3	32	26	84	2.1	ESE	TR
7	08.5	32	26	85	1.5	NE~E	
8	08.3	32	26	83	2.1	E~ESE	
9	09.1	32	25	82	1.5	NE	
10	09.1	32	25	82	2.1	ESE	
11	08.4	32	25	82	2.1	ENE	
12	08.5	32	26	81	1.5	ENE	
13	09.1	32	26	81	2.1	ESE	
14	08.6	32	26	83	1.5	NE~E	
15	07.6	33	26	82	1.5	ENE~ESE	
16	08.0	32	27	82	1.5	ENE~E	
17	07.7	32	27	81	2.1	ENE	
18	09.0	32	26	93	1.5	NE	10.5
19	08.4	29	23	81	2.1	E	
20	08.1	31	25	85	2.1	E~ESE	
21	08.3	31	26	80	2.1	ESE	
22	08.3	31	26	81	2.1	E	
23	08.5	32	27	81	1.5	NE	
24	08.3	32	27	83	2.1	E	
25	07.6	31	26	84	1.5	NE	3.3
26	07.2	33	26	82	2.1	ESE	
27	07.1	31	26	83	2.1	E	
28		32	27	80	2.1	ENE	1.8
29							
30							
31							
Total	223.5	885	722	2310	53.4		19.1
Mean	08.0	31.6	25.8	83	2.1		

METEOROLOGICAL RECORDS OF MONTH

AT LAGOS STATION

6°27′ N, 3°24′ E   March, 1979

Element / Day	Mean Pressure	Temperature Max.	Temperature Min.	Mean Humid.	Wind Vel. and Dir. Mean V.	Wind Vel. and Dir. Prev. Dir.	Total Amount of Precip.
	mb	℃		%	m/s	—	mm
1	08.2	32	26	82	2.1	E	2.9
2	09.0	30	26	79	2.1	SE	
3	09.1	31	26	86	1.5	ENE	
4	08.7	31	24	82	2.6	S	2.5
5	08.7	31	25	78	2.6	E~ESE	
6	08.2	31	26	80	2.1	ESE	
7	08.3	31	26	82	2.1	SE	
8	08.2	31	25	82	2.1	SE	
9	07.8	32	26	79	2.6	SE	
10	07.2	32	27	79	2.6	ESE	
11	06.6	32	27	79	2.6	ESE	3.9
12	06.9	32	27	81	2.1	ESE	
13	06.6	32	27	81	2.1	E	
14	07.0	33	28	79	2.6	SE	
15	07.7	32	27	78	2.1	ESE	
16	07.4	32	28	80	2.6	SE	24.0
17	07.1	31	23	83	2.6	SE	
18	06.3	32	27	82	2.1	SE	
19	06.3	33	27	82	3.1	SE~SSE	
20	05.8	33	27	81	2.6	SE	
21	06.3	32	26	79	3.1	ESE	16.0
22	07.0	31	22	76	2.6	ESE	TR
23	07.2	32	26	78	3.6	S	11.0
24	08.4	30	24	80	2.1	SE	TR
25	08.7	33	24	71	2.1	ENE	0.1
26	08.7	33	25	72	1.0	NNE	
27	07.9	32	26	78	2.6	SE	
28	09.3	32	27	76	2.6	S	
29	08.7	32	28	80	2.6	S~SW	
30	07.8	31	27	82	3.6	SE~W	TR
31	07.3	31	27	79	3.1	ESE	
Total	229.7	983	807	2387	75.2		60.4
Mean	07.1	31.7	26.0	77	2.6		

METEOROLOGICAL RECORDS OF MONTH

AT LAGOS STATION

6 ° 27 ′ N 3 ° 24′ E

April, 1979

Element / Day	Mean Pressure.	Temperature Max.	Temperature Min.	Mean Humid	Wind Vel. and Dir. Mean V.	Wind Vel. and Dir. Prev. Dir.	Total Amount of Precip.
	mb	℃		%	m/s	—	mm
1	07.3	32	27	78	3.6		4.0
2	08.3	32	25	78	2.6		
3	07.4	31	24	77	2.6		
4	06.9	31	24	77	1.5		20.6
5	07.4	31	27	79	2.6		
6	08.3	31	27	78	3.1		3.2
7	08.2	32	27	76	2.6		
8	09.2	32	28	75	2.6		0.7
9	09.6	31	28	79	2.6		
10	09.4	32	25	77	3.1		44.4
11	08.4	32	28	77	3.6		TR
12	08.1	33	28	76	3.1		7.2
13	08.2	32	28	79	3.6		56.2
14	07.5	31	28	78	4.1		9.9
15	07.4	32	28	78	2.6		
16	07.6	33	27	79	3.1		10.4
17	07.0	33	28	78	2.6		
18	07.5	32	25	79	2.1		3.0
19	07.2	31	27	79	2.6		
20	07.6	32	29	81	2.6		17.0
21	08.1	30	21	82	2.6		
22	08.3	31	26	78	4.1		70.2
23	08.4	31	23	79	2.6		17.0
24	07.8	32	27	78	3.1		11.0
25	07.4	32	28	82	2.1		13.0
26	07.3	32	27	81	1.5		
27	07.0	30	24	80	2.1		13.1
28	08.1	31	25	82	2.1		
29	07.1	32	26	76	3.6		
30	08.8	28	23	92	2.6		17.3
31							
Total	2368	945	788	2358	829		3083
Mean	07.9	31.5	26.3	79	2.6		

METEOROLOGICAL RECORDS OF MONTH

AT LAGOS STATION

6°27'N 3°24'E May, 1979

Element / Day	Mean Pressure	Temperature Max.	Temperature Min.	Mean Humid.	Wind Vel. and Dir. Mean V.	Wind Vel. and Dir. Prev. Dir.	Total Amount of Precip.
	mb	℃		%	m/s	—	mm
1	09.8	31	24	88	1.5	NE	
2	09.2	31	25	80	2.6	SE	
3	09.0	31	27	81	2.6	ESE	
4	09.1	30	26	81	3.1	SE	42.4
5	10.1	30	26	82	3.1	E	14.7
6	09.6	31	22	79	3.1	E	
7	09.1	31	24	84	3.6	E	
8	08.8	31	25	87	3.1	S	TR
9	09.4	32	22	76	3.1	SE	3.8
10	09.4	31	26	78	3.6	S	
11	09.0	31	26	79	3.6	ESE	15.5
12	09.3	28	26	93	3.1	S	TR
13	08.4	30	23	82	2.6	NNE~S	
14	07.5	31	25	77	3.1	NNE	
15	07.5	33	26	86	2.6	ESE	
16	08.1	31	24	81	3.1	E~SE, SSW	
17	09.4	28	22	87	3.1	E~SE	
18	10.1	27	23	92	2.6	ESE	
19	09.3	30	23	81	2.6	E	
20	09.7	31	23	81	2.1	Calm	
21	09.7	31	26	82	3.1	SE	7.3
22	09.4	30	22	83	2.6	ESE	
23	07.7	31	26	81	3.6	S	
24	08.2	32	27	80	2.6	SE	
25	09.0	30	28	80	3.6	S	
26	10.6	30	23	83	2.6	ESE~SE	TR
27	10.6	30	25	80	2.6	ESE	TR
28	10.3	30	26	84	2.6	SE	
29	09.7	31	26	81	3.1	ESE	TR
30	09.2	29	22	88	2.1		17.1
31	09.5	31	24	76	3.1		
Total	285.7	944	763	2553	89.1		100.8
Mean	09.2	30.5	24.6	82	3.1		

METEOROLOGICAL RECORDS OF MONTH

AT LAGOS STATION
6° 27′ N, 3° 24′ E

June, 1979

Element / Day	Mean Pressure	Temperature Max.	Temperature Min.	Mean Humid.	Wind Vel. and Dir. Mean V.	Wind Vel. and Dir. Prev. Dir.	Total Amount of Precip.
	mb	℃		%	m/s	—	mm
1	09.8	30	24		3.1	SE	10.4
2	09.9	30	25		3.6	SSE・SW	18.3
3	09.8	30	24		2.6	SE	5.5
4	09.1	29	25		3.1	SE	15.0
5	09.5	29	22		3.6	E, S	0.2
6	10.9	28	23		3.6	E	26.8
7	10.2	31	23		2.6	E, S	20.9
8	09.5	30	26		3.1	SE	
9	10.1	28	25		2.1	E	15.6
10	11.1	30	23		2.6	ESE	10.1
11	11.8	25	24		3.1	ESE	2.3
12	12.4	28	22		2.6	ESE~SSE	0.8
13	11.6	29	23		3.6	SW	12.8
14	11.5	29	25		3.1	S	14.5
15	11.5	30	24		3.1	NE, ESE, SW	14.2
16	11.7	29	22		2.6	E, SW	6.4
17	12.8	30	25		2.1	E, ESE, SSE	
18	12.6	29	25		3.1	SE	
19	11.7	27	24		3.6	E	0.7
20	13.5	27	23		2.6	ESE~SE	6.4
21	12.9	27	23		3.1	E	
22	12.9	27	24		2.6	ENE~E	4.9
23	13.0	27	23		3.1	ESE	0.5
24	13.0	27	24		2.6	ESE	TR
25	13.2	27	23		3.1	SE	TR
26	12.7	30	24		3.6	S	0.6
27	12.1	29	25		2.6	ESE	2.5
28	12.3	29	25		2.6	ESE~SE	
29	13.1	29	25		3.1	ESE	
30	13.9	27	25		3.1	SE, S	
31							
Total	350.1	857	718		86.0		189.4
Mean	11.7	28.6	23.9		3.1		

METEOROLOGICAL RECORDS OF MONTH

AT LAGOS STATION

6° 27′N, 3°24′ E

July, 1979

Element / Day	Mean Pressure.	Temperature Max.	Temperature Min.	Mean Humid.	Wind Vel. and Dir. Mean V.	Wind Vel. and Dir. Prev. Dir.	Total Amount of Precip.
	mb	℃		%	m/s	—	mm
1	13.5	29	24	86	4.1	SE	
2	12.3	28	25	89	3.6	ESE	2.2
3	12.2	30	24	82	3.1	E~ESE	2.0
4	13.6	28	24	88	4.1	S	25.5
5	13.6	29	23	86	2.6	SE	0.5
6	14.4	28	25	85	3.1	ESE	11.9
7	16.2	26	22	92	3.6	ESE~SW	87.2
8	14.2	26	22	93	2.1	E	11.6
9	14.0	29	23	81	3.1	E~S	0.4
10	13.6	29	24	78	3.6	ESE~SE	
11	13.1	28	25	88	4.1	WSW	19.2
12	13.1	27	23	82	2.6	SE	TR
13	12.9	29	24	84	4.1	SSE~S	13.6
14	12.1	29	23	83	3.1	ESE	13.8
15	12.4	29	23	85	3.1	SSE	
16	11.8	29	24	84	4.6	SSW	TR
17	12.0	27	25	97	3.1	SE~S	56.1
18	12.5	25	23	98	2.1	NE, ENE, E	97.9
19	12.6	27	23	93	3.1	E	11.3
20	12.0	29	25	88	2.6	E	0.3
21	12.1	27	23	91	2.1	Calm	0.5
22	12.3	28	23	90	2.6	E	33.3
23	13.5	25	23	95	1.5	ESE	28.8
24	12.8	28	23	89	1.0	Calm	0.7
25	11.5	29	23	80	2.1	E~SE	
26	11.0	29	24	78	2.1	E	
27	12.2	29	24	86	2.1	E	TR
28	12.0	29	24	87	2.6	ESE	TR
29	12.0	29	24	87	1.5	NE	
30	11.4	29	25	87	1.5	NNE, ESE	2.6
31	11.4	25	24	98	2.1	ESE	38.1
Total	394.3	868	734	2727	86.5		493.2
Mean	12.7	28.0	23.7	88	2.6		

METEOROLOGICAL RECORDS OF MONTH

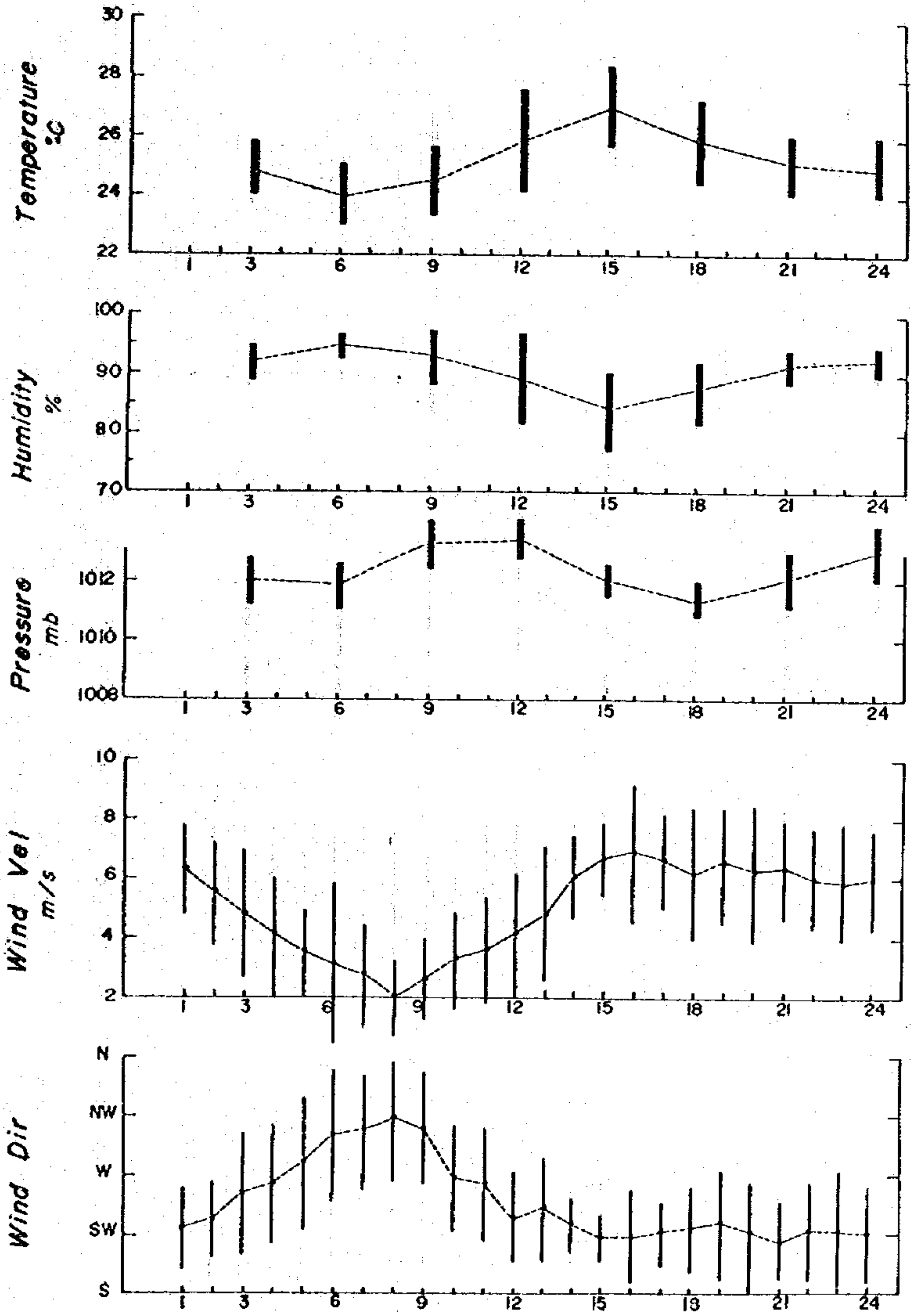
AT LAGOS STATION

6° 27′ N, 3° 24′ E   Aug., 1979

Element / Day	Mean Pressure.	Temperature		Mean Humid.	Wind Vel. and Dir.		Total Amount of Precip.
		Max.	Min.		Mean V.	Prev. Dir.	
	mb	℃		%	m/s	–	mm
1	12.6	26	22	100	1.0	Calm	63.7
2	12.8	28	23	94	1.0	Calm	6.5
3	11.7	28	23	88	1.5	ENE	TR
4	12.1	27	24	92	2.1	Calm	2.5
5	12.9	27	24	94	2.1	E	8.0
6	12.8	29	24	80	2.1	Calm	
7	11.7	28	24	85	1.5	E	
8	12.6	29	25	86	2.6	ESE	1.0
9	12.5	28	25	84	2.6	ENE	13.3
10	11.7	29	25	88	2.6	E	21.3
11	10.3	28	24	88	2.6	E	1.2
12	11.6	28	24	88	2.6	NE	1.2
13	11.8	28	24	87	2.6	ESE~SE	5.0
14	11.9	28	24	87	1.5	Calm	1.5
15	10.5	28	23	91	2.1	Calm	16.7
16	11.5	28	24	92	1.5	NE	3.4
17	11.1	29	23	86	1.5	E	1.2
18	10.3	27	24	95	1.0	Calm	5.7
19	10.4	27	24	88	2.1	ENE	6.4
20	11.5	29	24	86	1.0	Calm	TR
21	10.2	28	25	89	1.5	ENE	37.5
22	9.0	26	22	95	1.5	NE	31.3
23	9.9	27	23	86	2.6	ENE	0.7
24	10.5	29	24	81	1.5	ENE~E	24.2
25	10.1	27	22	87	1.0	Calm	TR
26	9.0	29	24	87	1.5	Calm	
27	9.2	27	24	90	1.0	Calm	2.6
28	9.2	29	24	87	1.5	SE	3.6
29	9.2	27	23	86	3.1	SE	1.7
30	10.1	28	24	85	1.5	NE	1.8
31	7.8	29	24	89	1.5	Calm	10.7
Total	338.5	865	736	2741	56.1		268.7
Mean	10.9	27.9	23.7	89	2.1		

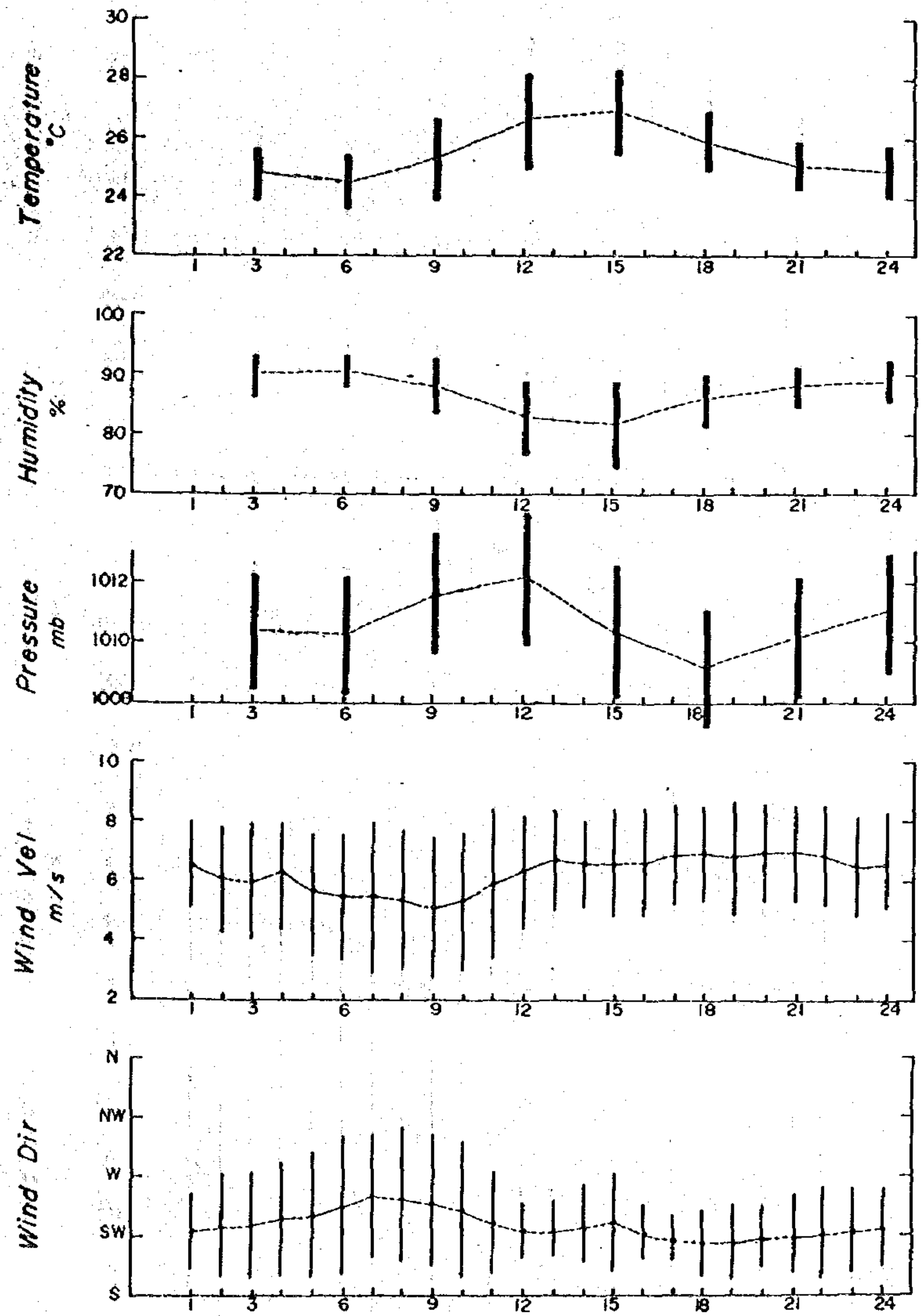
TIME DISTRIBUTION OF AVERAGE AND STANDARD DEVIATION

July



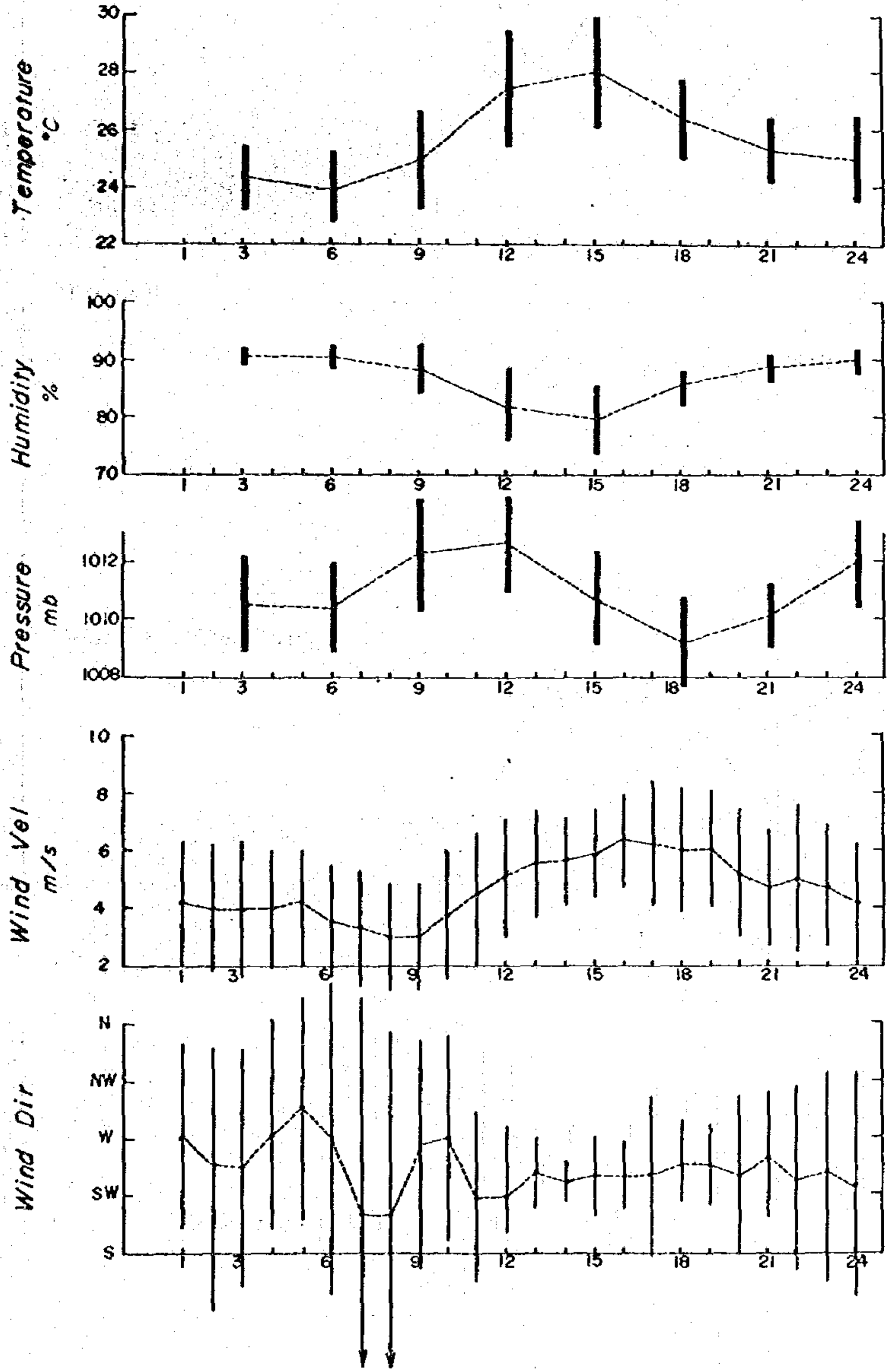
TIME DISTRIBUTION OF AVERAGE AND STANDARD DEVIATION

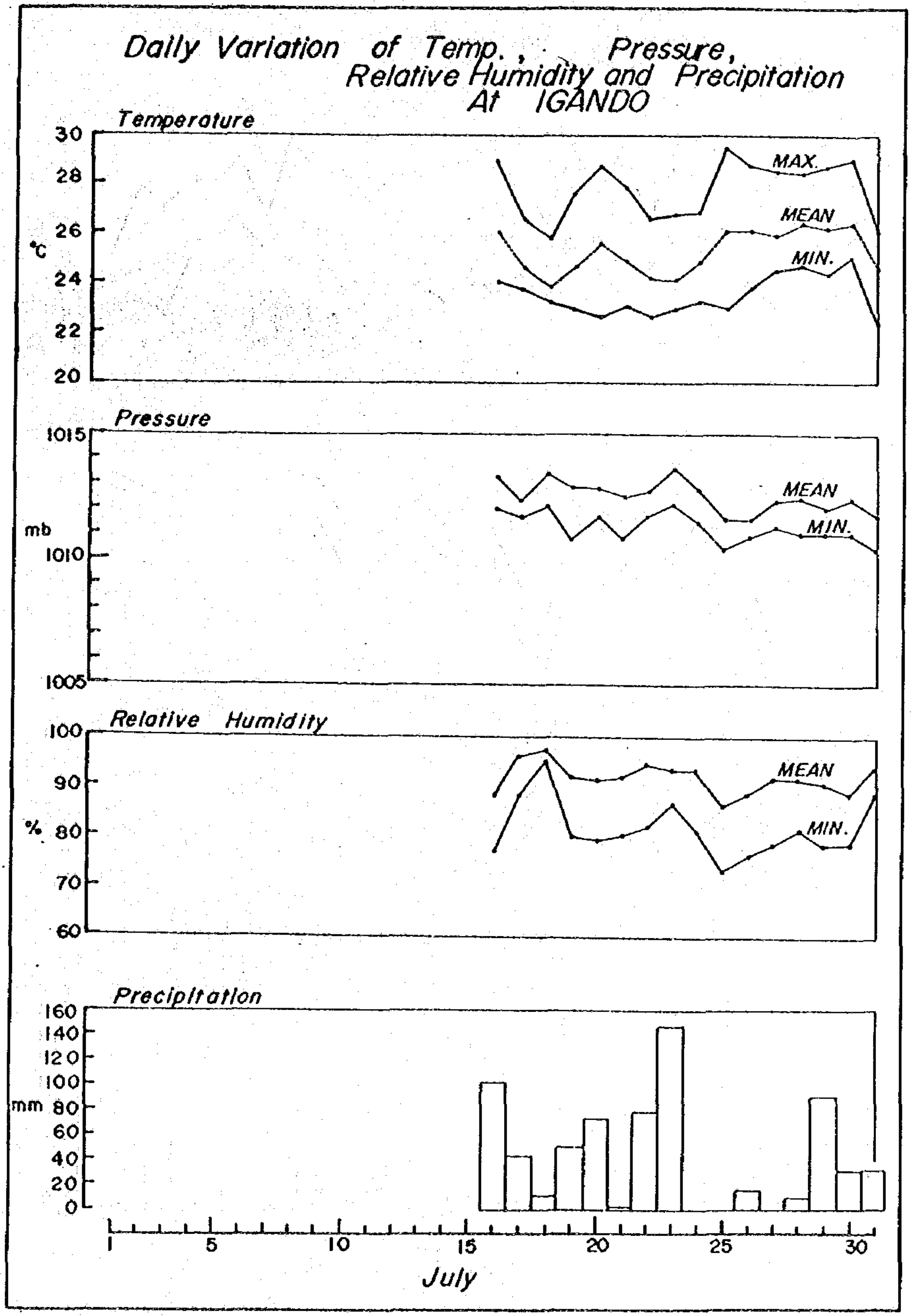
August

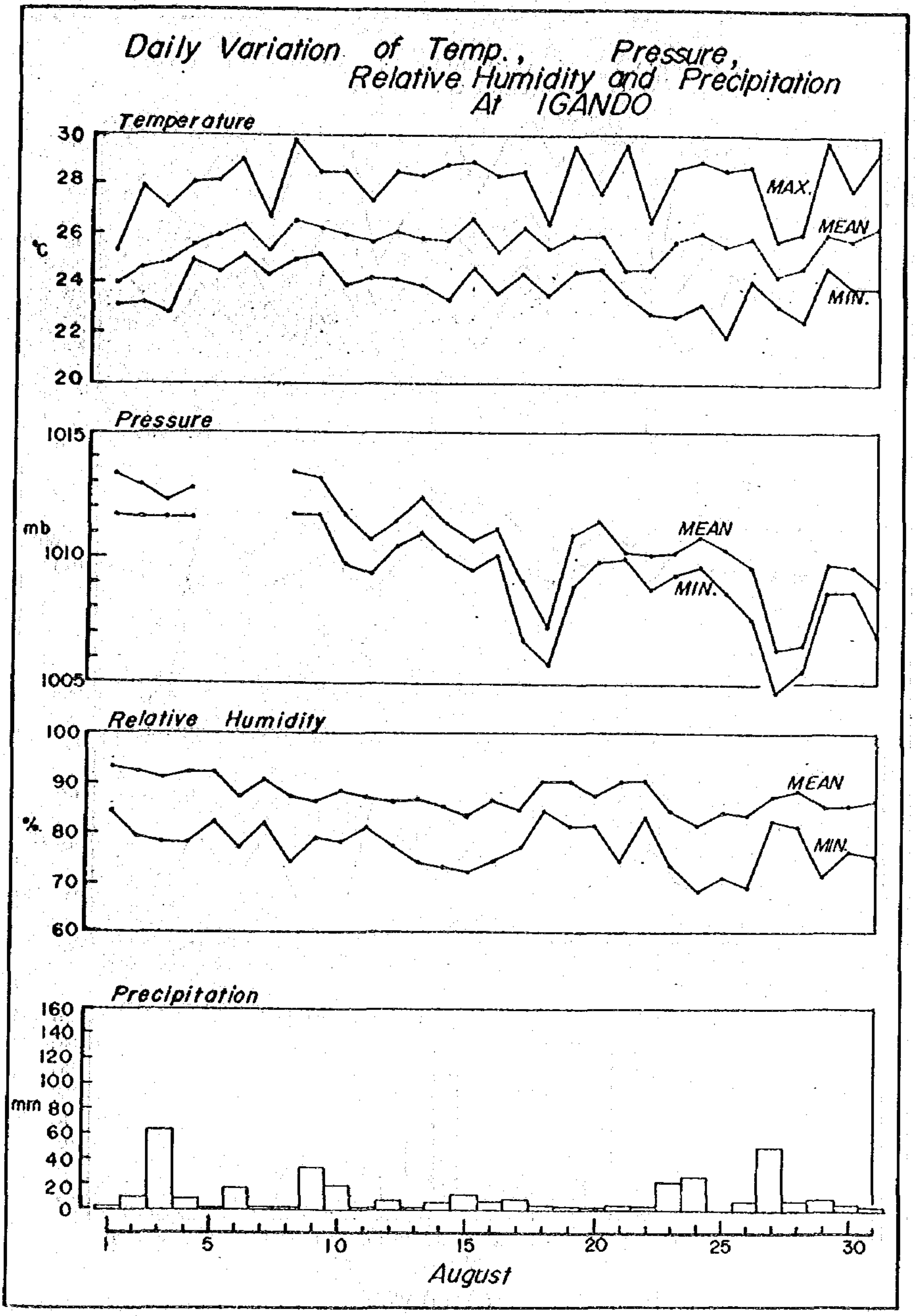


TIME DISTRIBUTION OF AVERAGE AND STANDARD DEVIATION

September




Daily Variation of Temp., Pressure, Relative Humidity and Precipitation At IGANDO
Temperature
30
28
26
24
22
20
°C
MAX.
MEAN
MIN.
Pressure
1015
1010
1005
mb
MEAN
MIN.
Relative Humidity
100
90
80
70
60
%
MEAN
MIN.
Precipitation
160
140
120
100
80
60
40
20
0
mm
1
5
10
15
20
25
30
July



Daily Variation of Temp., Pressure, Relative Humidity and Precipitation At IGANDO
Temperature
°C
30
28
26
24
22
20
MAX.
MEAN
MIN.
Pressure
mb
1015
1010
1005
MEAN
MIN.
Relative Humidity
%
100
90
80
70
60
MEAN
MIN.
Precipitation
mm
160
140
120
100
80
60
40
20
0
1
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25
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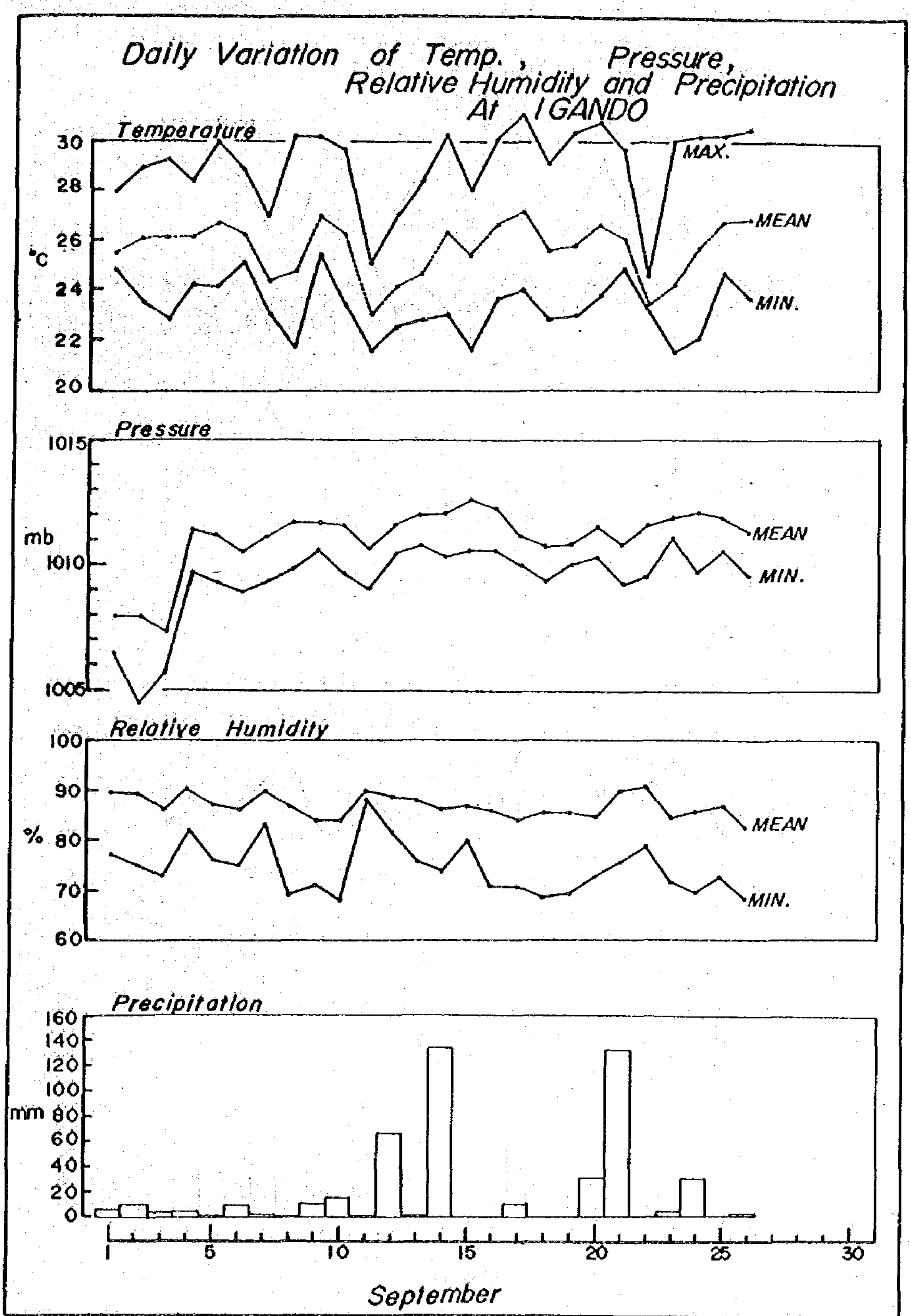
August


Daily Variation of Temp., Pressure, Relative Humidity and Precipitation At IGANDO
Temperature
°C
30
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MAX.
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Pressure
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MIN.
Relative Humidity
%
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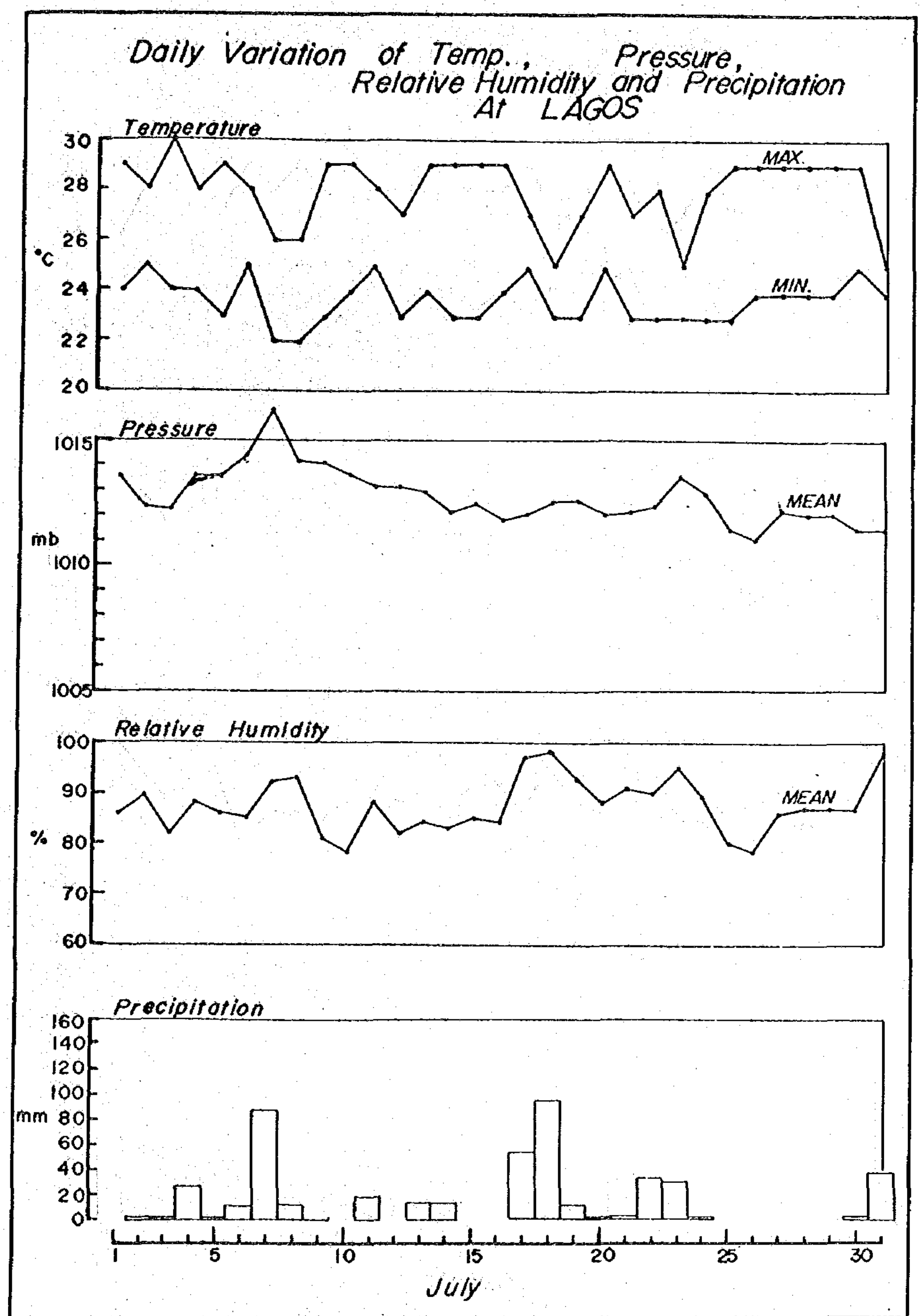
September



compiled from Records of NIGERIAN METEOROLOGICAL SERVICE