CHAPTER 5

WAVE CLIMATE IN SOME ZONES OFF THE BRAZILIAN COAST

Alberto Homsi[1]

INTRODUCTION

METEOROLOGICAL FEATURES - The Brazilian coast could be considered a calm area not affected by violent tropical storms. The major meteorological factor in Brazil is the South Atlantic anticyclone, almost permanent, which causes periodical northward heading of cold fronts. A slightly reduced energy and frequency of storms could be observed going up from South coast toward North and could reach the major part of Northeast region.
As a general condition the average monthly frequency of cold fronts passing along the Brazilian coast is higher during the winter - five per month with an average duration of 3 days, decreasing to 2 per month during summer with an average duration of 5 days. During winter high waves could occur between Santos and Macaé caused by a depression near the Rio de Janeiro as the cold front stays at North, before the cold front goes down to South. Fig.1 shows the average flow pattern across Brazil for summer and winter periods and a six days cold front advancing toward North, going into as far as to tropical latitudes during winter time. The daily tracks of the winter cyclones appear on this figure; they do not get beyond latitudes of 40° South.

WAVE MEASUREMENTS - CHARACTERISTICS AND CHRONOLOGY - Instrumental observations of waves in Brazil were initiated in 1962 with one year wave measurements and direction observations in Tramandaí, at the very South of the Brazilian coast. After the occasion thirteen other wave recording stations have seldom been installed simultaneously along the near-shore coastline (See Fig. 2), to collect wave data for some limited period on an ad-hoc basis. These limitations unfortunately occur because wave measurements are intrinsically difficult and normally expensive, restricting in quality the required data. As it could be observed from Fig. 4, only from 1973 the wave measurements have occasionally been taken on a simultaneous basis for two or few more locations. The information so obtained (See Fig. 3), could generally have application for the planning, design, construction and operation of local coastal engineering structures, but could not provide a reliable picture covering all the coast, and could not be used for the research of wave generation.

A NEED FOR A COMPREHENSIVE WAVE MEASUREMENT PROGRAM - Reliable information on waves along the Brazilian coast can only be obtained by installing, at suitable locations, and for sufficient time lenght (from three to five years, for example), wave recording stations being part of a system to carry out a comprehensive program of obser-

[1]Head of Scientific and Technical Support Division-INPH-PORTOBRÁS-MT

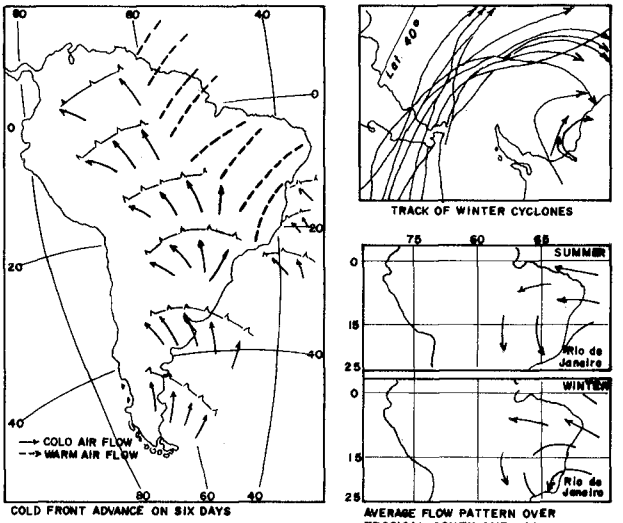


Fig. 1

REF. OHI ARACRUZ REPORT Nº 4

Fig. 2 ◯ Wave Measurement Stations in This Paper
⊕ Planned Wave Measurement Stations (BRAZWAVE)

Fig – 3	MEASUREMENT PERIOD	NUMBER OF RECORDS	LOCAL DEPTH	-15m CONTOUR DIRECTION	DAILY RECORDS	MEASUREMENT EFFICIENCY	TYPE OF WAVE RECORDS
NATAL	4/4/77 to 1/4/78	2288 (Measd) 1152 (Proc)	– 14	340° N	8	79 %	Pressure
RECIFE	22/7/76 to 19/10/77	585	– 10	4° N	2	65%	Ultrasonic
SUAPE	2/3/77 to 2/3/78	2628	– 17	12° N	8	90 %	Accelero. meter Buoy
MACEIÓ	29/8/72 to 31/6/73	—	– 10	41° N	8	—	Pressure
ARACAJU	9/65 to 8/66	388	– 20	35° N	2	53 %	Ultrasonic
RIO DOCE	13/10/72 to 31/5/73	189	P_1 – 22 P_2 – 53	65° N	2	40 %	Ultrasonic
PORTOCEL DHI	10/5/73 to 30/12/74	3080	– 16	36° N	8	85%	Pressure
PORTOCEL INPH	25/4/76 to 8/10/77	1929				56 %	
TUBARÃO	1/6/71 to 26/4/72	800 (Measd) 385 (Proc)	– 9	40° N	4	65%	Pressure
MACAÉ	1/6/77 to 31/7/78	499	– 17	84° N	2	68 %	Ultrasonic
ANGRA DOS REIS	14/4/76 to 17/3/78	3943	– 14,5	90° N	8	75 %	Pressure
P_1 SANTOS	11/72 to 11/73	540	– 10	65° N	3	49 %	Ultrasonic
P_2 SANTOS	7/73 to 11/73	108	– 15	65° N	3	37%	
PARANAGUÁ	4/72 to 3/73	553	– 10	38° N	3	50.5 %	Ultrasonic
SÃO FRANCISCO DO SUL	6/73 to 3/74	109	– 22	28° N	2	20 %	Pressure
TRAMANDAÍ	10/62 to 9/63	335	– 17,50	18° N	2	46 %	Ultrasonic

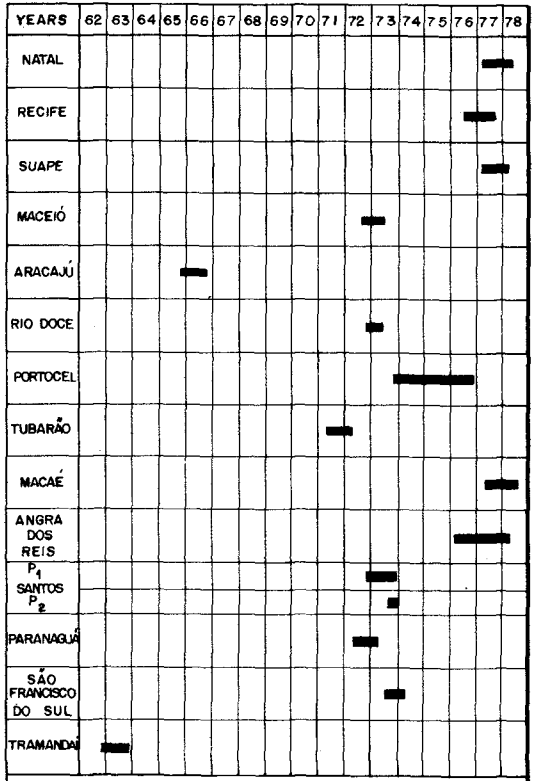


Fig-4 WAVE MEASUREMENTS CHRONOLOGY IN BRAZIL

vations of wave direction and also instrumental measurement of wave heights and periods, to detect annual and seasonal changes taking place in the characteristics parameters of the wave conditions. The more reliable the resulting information on waves, the better a coastal or an offshore structure could be properly and economically designed.

The increasing demand from 1975, for studies of coastal and offshore engineering problems, has led the INPH to undertake an evaluation of how the available wave record observations, specifically made for the design of a coastal engineeering work, could be of a possible and reasonable use in adjacent areas; and what kind of overall wave measurement and analysis program would be needed for the entire Brazilian coast, in order to get more accurate wave data to be mainly used in studies with simulation of random sea states, and in the rerearch of wave generation (four random wave generators are going to be installed in the INPH in the beginning of 79, with the cooperation of the Danish Hydraulic Institute).

With this evaluation it was possible to reach a diagnosis of the present state of understanding of the wave climate for the various wave recording locations, as well as an assessment of its usefulness. Experience gained with this evaluation formed the basis for the laying down of basic criteria, methodology and specifications(See Fig. 2) for the Brazilian Wave Measurement Project (BRAZWAVE) in order to derive the wave climatology by means of measurements and calculations. As waves information heavily affect the ultimate cost of a coastal or an offshore project, the cost of the wave information to be obtained with the BRAZWAVE are warranted by: the economy in capital cost of overdesigned structures, the economy in operational costs, major repair costs and costs of total reconstruction of underdesigned structures.

WAVE STATISTICS AND ANALYSIS METHODOLOGY

The wave statistics results presented in this paper are based in the analysis results of about seventeen thousands stripchart wave records of about fifteen minutes, obtained by means of fifteen wave record stations. With the exception of two or three stations where the significant wave heights were calculated by the average of the highest one-third wave, all records were processed according to Tucker-Draper's simplified method. In the case of Natal, the wave records have been processed also by spectral analysis.

WAVE CONDITIONS ALONG THE COAST

SHALLOW WATER WAVE HEIGHT TRENDS - Fig. 5 shows the general water wave height trends along the Brazilian coast for Hs max - the maximum significant wave height recorded during the observation period, for NE, E, SE and S directions, for the various seasons and for all seasons - all directions. The highest Hs max being 4,90m, occurred off Tramandaí for E and SE direction during the autumn. In Macaé the highest Hs max, also higher than 4,00m, occurred for S direction du

ring the spring.
As a general feature, from Rio Doce to Natal and for NE direction , the wave heights are less than 2,00m. For the other places,NE waves were not observed as a result of local shore configurations.
Because of the heavy local refraction the waves undergo (caused by the sea bottom topography) no E direction waves were recorded at Santos, Angra dos Reis, Macaé and Tubarão; for the other places,with the exception of Tramandaí and Natal where the waves are higher,the Hs max trend assumes values around 2,00m. SE direction waves have been observed all along the coast. At Tramandaí they range from 4,00 to 5,00m; at Tubarão and Maceió, they stay less than 2,00m,and for all the other places between 2,00 and 4,00m.
Only for Natal and Recife, S direction waves were not observed. For Tramandaí, S.F. Sul, Paranaguá, Portocel, Maceió and Suape the wave heights lie between 1,00 and 2,00m; for Aracaju, Rio Doce, Angra dos Reis and Santos between 3,00 and 4,00m; and for Macae they stay , between 4,00 and 5,00m.
During the spring at Macaé and Natal, the trends stays around 3,00 and 4,00m; for the other places around 2,00 and 3,00m.
During summer Hs max assumes values between 1,00 and 3,00m. In the autumm for all the places, exception made for Tramandaí,Hs max lies between 1,50 and 3,00m. In winter season all along the coast , the trend lies between 2,00 and 3,00m with the exception of Tubarão where it is about 3,50m. Considering all seasons all directions trend, Hs max values smaller than 2,00 were not observed.

DEEP WATER WAVE HEIGHT TRENDS - Fig. 6 shows the equivalent deep water wave height trends derived after the wave rays have been back tracked from shallow water waves directions. The trends show themselves more irregular than in shallow water. The highest Hs max deep water wave is found off Tramandaí with about 6,50m for E and SE direction during the autumn. Offshore Santos an Hs max of about 5,40m was found for SE direction. In the case of S direction, waves of about 5,50 to 6,00m could be found off Angra dos Reis, Macaé and Portocel, during winter and spring seasons.
As a general feature the Hs max waves become smaller the more northern the place is. An exeption is made to S direction waves which pass through a maximum at about Angra dos Reis and Portocel, to decrease towards the north. The shallow water wave trends and mainly the deep water wave trends results should be taken with precaution due to the restrictions imposed by the near-shore method of observation of wave directions (Visual).

WAVE CLIMATE ALONG THE COAST

The wave statistics presented herein for each location represent a seasonal and or annual reduction for publication, of the monthly results obtained in the whole analysis involved in this paper for the wave parameters: Hs, Hm (maximum wave height of the wave records),Tz, Tc, E (spectral width) and D (wave direction), of the joint-distribution of Tz x Hs, Hs x Tz and Hs x D, the Life-Time-Wave-Distri

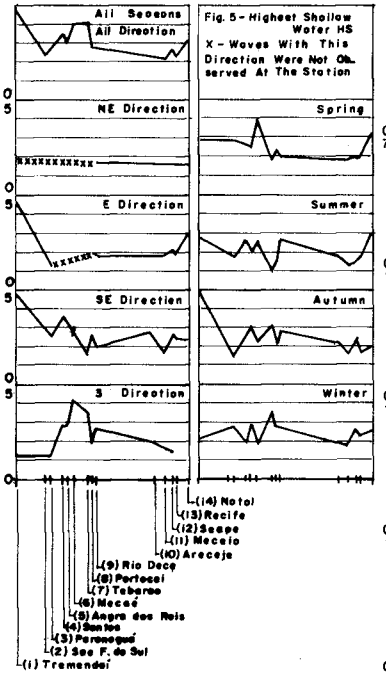


Fig. 5 – Highest Shallow Water HS
X – Waves With This Direction Were Not Observed At The Station

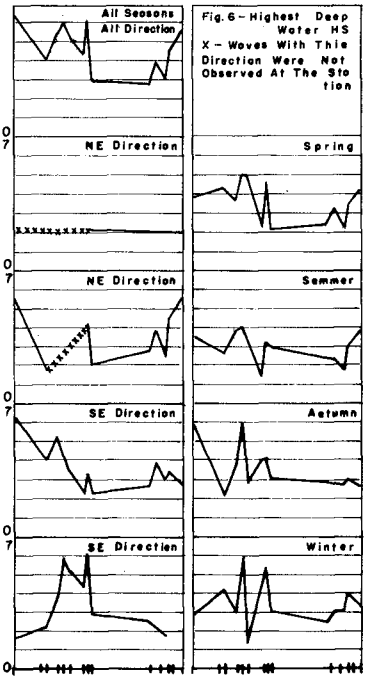


Fig. 6 – Highest Deep Water HS
X – Waves With This Direction Were Not Observed At The Station

bution of Hs and Hm and the excedance distributions of Hs.

TRAMANDAÍ - Fig. 7 presents some statistics information about the wave climate off Tramandaí coast. The field observations and a first simplified analysis were done by the "Instituto de Pesquisas Hidráulicas" of the Federal University of Rio Grande do Sul for PETROBRÁS (the Brazilian State Oil Company) for the purposes of the hydraulic model studies of the Tramandaí bar.
A range of Tz periods from 5 to 13,5 seconds, not varying for the various seasons were recorded, presenting a slightly asymetric distribution, with a maximum at about 7,5 seconds. The maximum occurence for Tz x D joint distribution is for 7,5 seconds and 105° N. For Tz x Hs it is 8,5 seconds and 1,5m. The Hs wave heights do show significant variations, tending to be higher in the autumn. Larger Hs wave heights of about 4 to 5m are associated with periods of about 13,5 seconds and larger, and with the SE direction. The Hs wave for a 30 year return period is 6,0m.

PARANAGUÁ - The wave measurements were done by the INPH to give support to the studies of disposal areas for the dredging materials of the new channel entrance of Paranaguá Port.
Fig. 8 shows information about the Paranaguá wave climate. The Hs x Tz distribution has a maximum percentage of occurence - 20%, for 1,00m and 5,5 seconds. For Hs x D the maximum is also 20% for 1,0m and 135° N. From Life-Time-Wave Log-Normal Distribution an Hs of 4,20m was predicted for a return period of 30 years. Tz periods do show a significant variation being longer in autumn with periods up to about 12 seconds.

SANTOS - For Santos the INPH made recordings of sea waves at two points simultaneously. P_2 point at -15,00m and P_1 Point at -10,00m, as a part of a large coastal measurements project for the hydraulic studies of the Port of Santos Expansion Program. The P_2 record station had been in operation only during the winter and spring, what restricts the comparisions which could be made between the wave characteristic parameters distributions of P_2 and P_1. During the winter the Hs distribution for P_1 and P_2 shows the same range while a larger frequency of occurence of low Hs could be noted in the case of P_1. In the case of spring the range of Hs for P_2 station is wider and with larger Hs wave heights.
A comparision between the Life-Time-Wave Log-Normal Distribution of HM for P_1 and of Hs for P_2 shows that they are almost coincident ; anyway, one must be aware that for P_2 Point the measurements of summer and autumn were not included and in the case they were, this coincidence should not occur.
The maximum value for Hs was 3,5m at P_2 and 2,40m at P_1.
The Tz period distribution ranges are about the same, at P_1 and P_2, during winter, spring and for all seasons.
In the case of P_1, the most common situation for Tz x D joint distribution is 12 seconds and 170° N; for Hs x Tz it is 1,0m and 12 seconds, and for Hs x D, 1,0m and 170° N. At P_2 there is a tendency to associate larger Tz period with 165° wave direction, and larger Hs

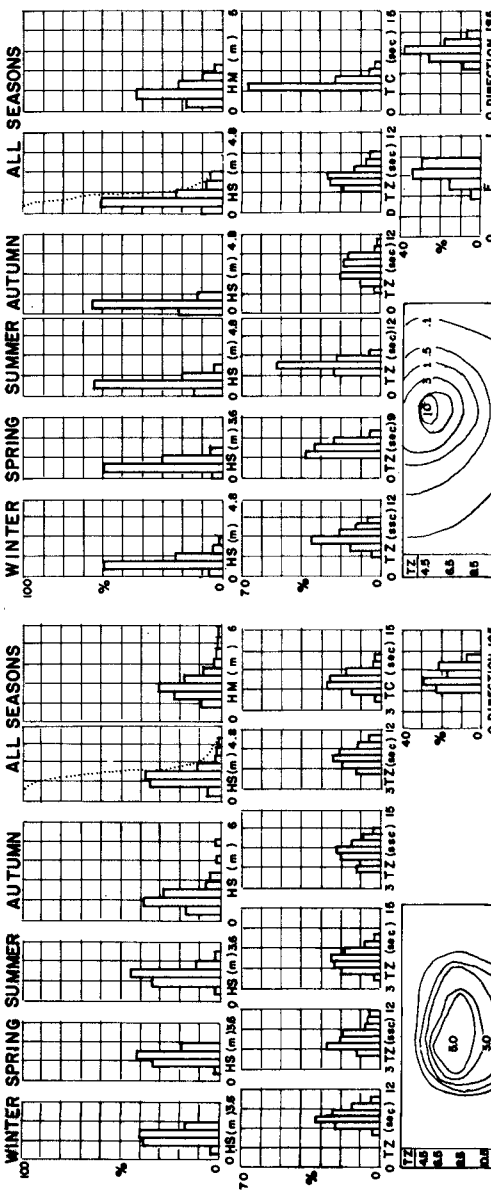

WINTER
SPRING
SUMMER
AUTUMN
ALL SEASONS
DIRECTION
Hs
Hmax
TRIANGULO
H(m) Life - Time Wave - Log Normal Distribution

FIG. 7

WINTER
SPRING
SUMMER
AUTUMN
ALL SEASONS
DIRECTION
Hs
Hmax
PARANAGUA
H(m) Life - Time Wave - Log Normal Distribution

FIG. 8

with southern wave direction and with 12 to 13 seconds Tz periods.

ANGRA DOS REIS - Two years of wave measurements have been made and processed by "FURNAS - Centrais Elétricas S/A" for the purposes of the hydraulics studies of the water intake protection works for the Angra dos Reis Nuclear Power Station. Fig. 10 presents the wave climate based on the first year of measurements.
During the winter and summer no Hs waves higher than 2,00 were observed, while in spring and autumn the waves respectively go up to 2,5 and 3,00m. A prediction of Hs = 4,00m could be observed for 30 years return period.
The range of the Tz distributions become wider going from spring to winter. The most common situation for Hs x D distribution is a frequency of 45% for the binary 0.5/1,0m and 165º N.

MACAÉ - The INPH was charged by PETROBRÁS (The Brazilian Oil State Company) to develop the hydraulics studies of the Maritime Terminal of Macaé. This terminal, now under construction, should provide 12 sheltered berths for the supply boats of the Campos Oil Field. As a part of the field measurements, wave have been recorded since June 1977. The first year of measurements has been analysed (See Fig. 11). The Hs distribution do show larger waves in the spring with heights of more than 4,00m. During the winter the Hs highest wave is less than 2,00m. Summer and autumn seasons show maximum Hs waves of about 3,00m. With the exception of the spring, when the Tz period distributions range from 4 to 10 seconds, for the other seasons the range is wider, going from 4 to about 14 seconds.
Due mainly to diffractions around nearby islands, the range of wave directions distribution obtained at the site is narrow going from 135° N to 170° N. Because of this, a second wave measurement station is now in operation to get information of waves coming from NE and E direction. The most common situation of the Tz x D joint distribution was for 8 seconds and 150° N; for the Hs x Tz it was 1,50m and 8 seconds, and for the Hs x D, 1,5m and 150°N. There is a strong association with higher waves heights and the direction 150° N.

TUBARÃO - CVRD (Tubarão Iron Ore Terminal) made a wave survey during 71/72 and the data were analysed by the CTH (Centro Tecnológico de Hidráulica). Fig. 12 shows the statistics obtained based on the processed CTH data. It is during winter and spring that occur the highest Hs waves being more severe during winter ranging from 0,0 to 4,00m and from 0,5 to less than 4,00m for the spring. Summer is the most calm season. The Tz period distributions range for the various seasons from 6 to 15 seconds. Higher wave heights are associated with 180º N direction and with 10,5 seconds periods.

PORTOCEL - The specialized Terminal of Portocel situated at about 65 Km north of CVRD Tubarão Iron Ore Terminal is now in operation. The wave observations carried out during the period 73/74 were analysed by the Danish Hydraulic Institute (DHI) and those of the period 76/77 by the INPH. Fig. 13 shows some statistics results obtain

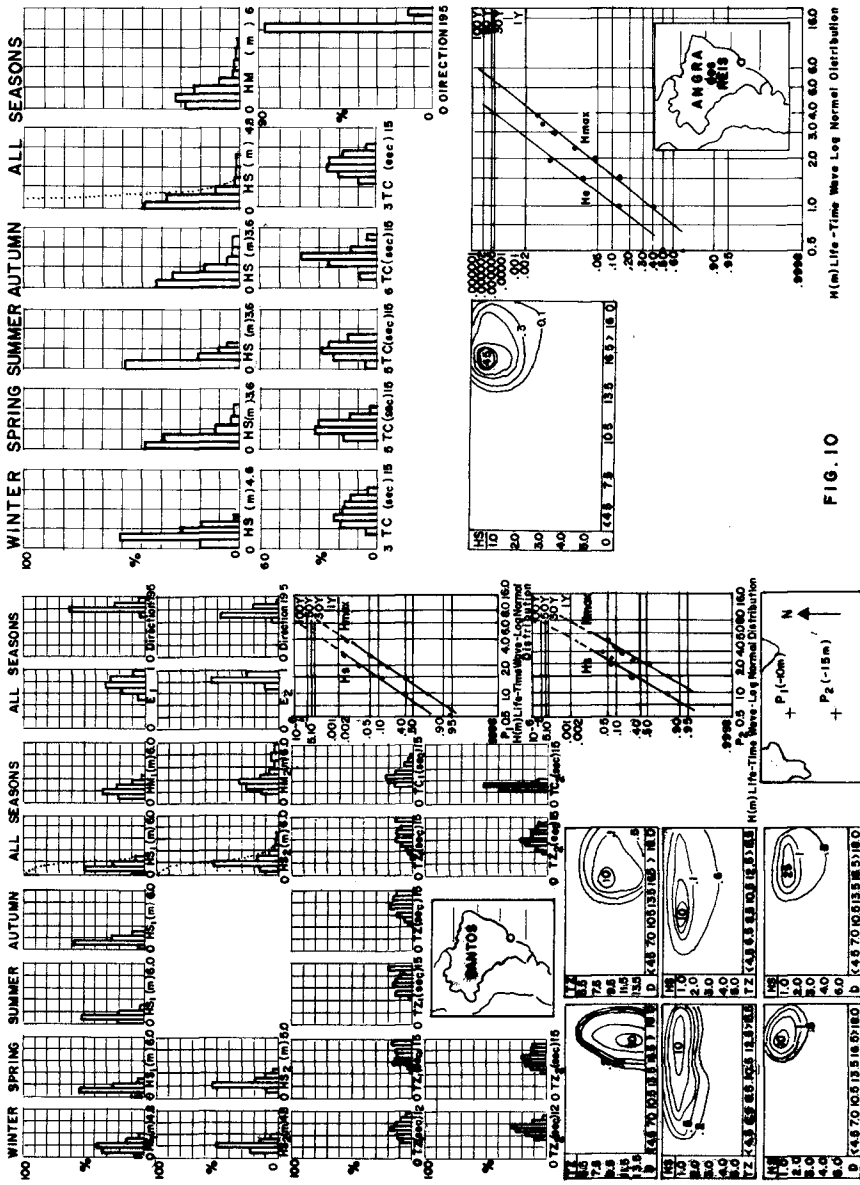

WINTER
SPRING
SUMMER
AUTUMN
ALL SEASONS
SANTOS
ANGRA DOS REIS
P1 – Depth – 10m
P2 – Depth – 15m
H(m) Life-Time Wave-Log Normal Distribution
N

FIG. 9

FIG. 10

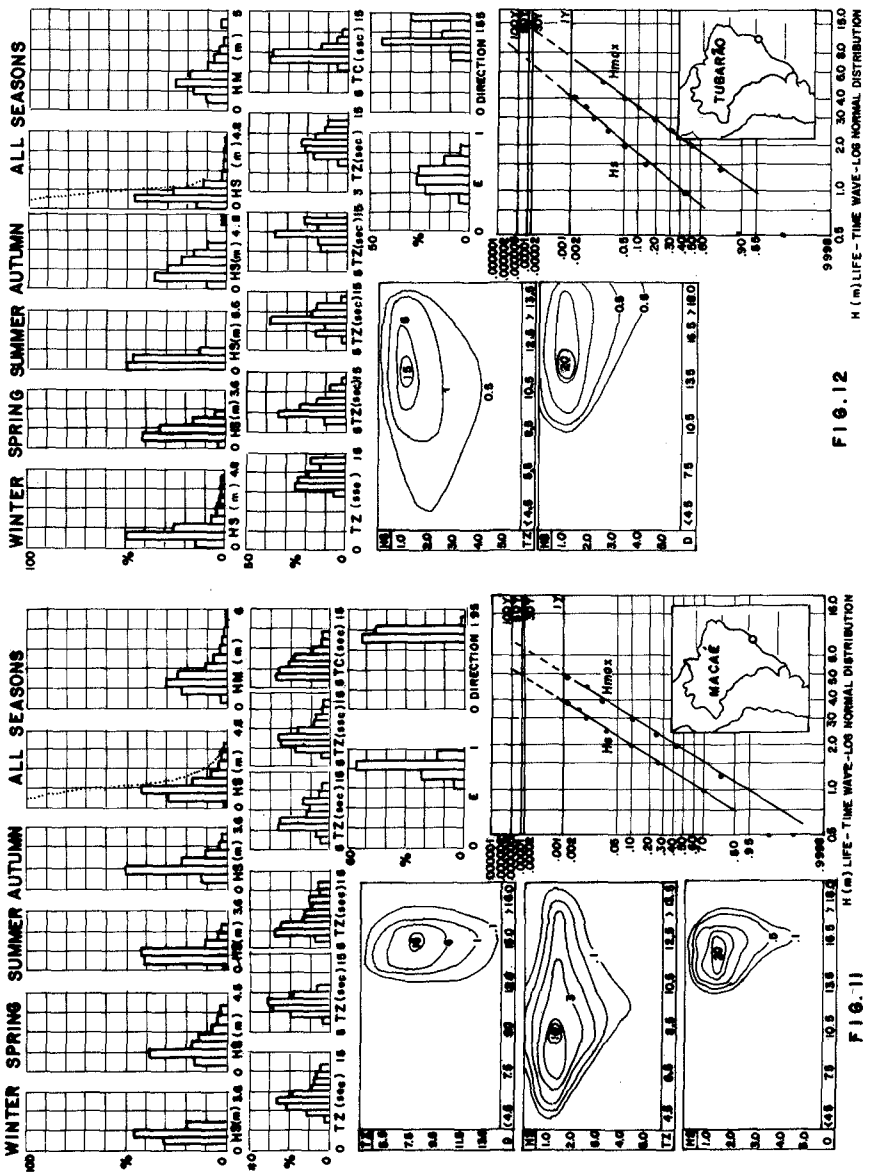

WINTER
SPRING
SUMMER
AUTUMN
ALL SEASONS
MACAÉ
TUBARÃO
Hmax
Hs
H (m) LIFE-TIME WAVE-LOG NORMAL DISTRIBUTION

FIG. 11

FIG. 12

ed for the period of 76/77, which did not include observation of wave directions.
During the spring and autumn the Hs wave distribution ranges from 0,00 to 2,50m. During the winter the conditions are a little more severe, ranging from 0,00 to 3,00m. In the summer, from 0,0 to 1,20m. With the exception of autumn when the Tz period distribution ranges from 5,5 to 10 seconds, for all the seasons it varies from 4,5 to about 12 seconds. The highest frequency (25%) is associated with the binary 1,0m and 7,5 seconds for the joint distribution Hs x Tz. According to Time-Life Log-Normal Distribution, a significant wave of about 4,40m is predicted for a return period of 50 years.

RIO DOCE - The CTH (Centro Tecnológico de Hidráulica) made wave recordings off Rio Doce at PETROBRÁS P_1 and P_3 oil survey platforms, in the period 72/73, and processed the resulted 189 strip-charts records. Fig. 14 presents some wave statistics information based on the CTH calculations. It is important to note that the observation period was less than one year and it did not include the winter.
The most severe conditions were found in the autumn with Hs waves going as high as 3,00m and HM as high as 4,50m. The Tz period distributions ranges from 3 to 8 seconds for the spring, 5 to 13 seconds for the summer, and 5 to 11 seconds for the autumn. The most common situation for the Hs x Tz joint distribution is 1,50m and 6,5 seconds with a frequency of 15%. The direction distribution show gaps due probably to an exagerated simplification on the wave direction method of observation.

ARACAJU - The wave measurements off Aracaju were made by the IPH of the Federal University of Rio Grande do Sul (Motta, V. F-1966), for the studies of the Off-Shore Terminal (TECARMO) of PETROBRÁS.
During the autumn (See Fig. 15) the significant waves went up to 2,50m while during spring, summer and winter less than 2,00m. A maximum wave height of 4,00m were observed during the autumn.
As regard of Ts (Significant Period) the range of the respective distributions become wider going from spring to summer and autumn, narrowing in the winter. Only during the autumn Ts values of about 14 seconds were found. A high frequency of 15% was found for the binary 8 seconds and 120° N; for Hs x Ts the most common binary was 1,50m and 7 seconds with a frequency of 20%. The 30 year return period Hs wave assume a value of about 3,50m.

MACEIÓ - The Danish Hydraulic Institute has carried out the hydraulic studies of the SALGEMA Terminal at Maceió. Fig. 16 presents some wave statistics based on the results of those studies.
The most severe conditions occur during the spring when Hs waves go up to about 2,20m. During autumn and winter the significant waves do not get nearer than 2,00m. In the summer the maximum waves lie at about 1,50m.
The most common situation for the joint distribution of Hs x D is 1,00m and 120° N, with a frequency of 20%.
The Life-TimeWave Log-Normal Distribution of Hs was constructed by

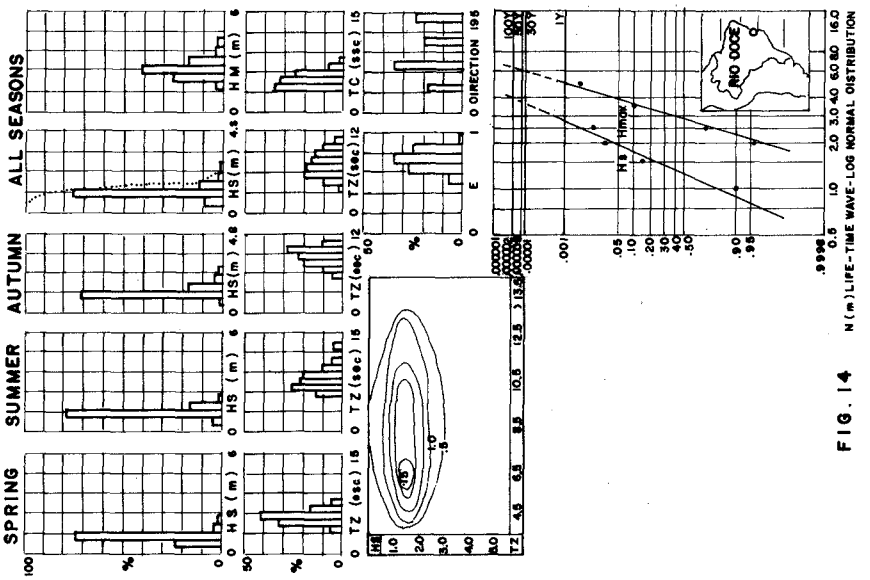

SPRING
SUMMER
AUTUMN
ALL SEASONS
HS (m)
TZ (sec)
TC (sec)
HM (m)
DIRECTION
E
%
Hs
Tz
Hmax
NO OCDE
N (m) LIFE-TIME WAVE-LOG NORMAL DISTRIBUTION

FIG. 14

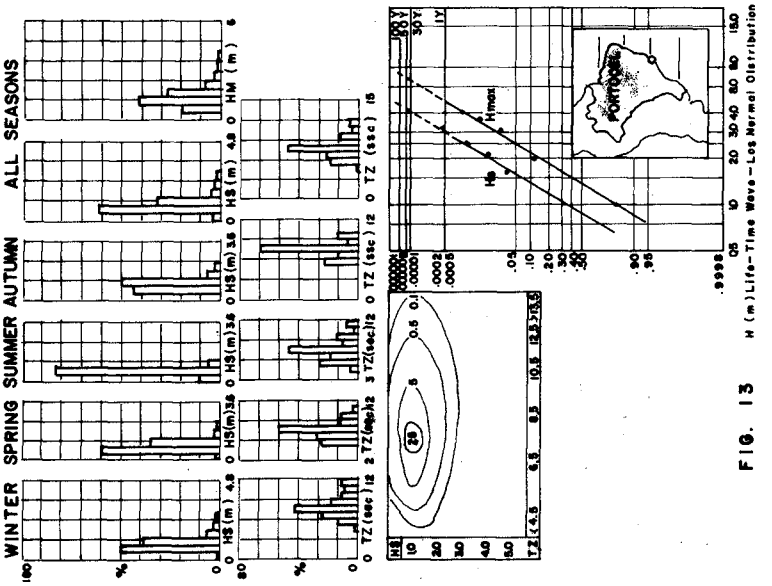

WINTER
SPRING
SUMMER
AUTUMN
ALL SEASONS
HS (m)
TZ (sec)
HM (m)
%
Hs
Tz
Hmax
PORTUGAL
N (m) Life-Time Wave-Log Normal Distribution

FIG. 13

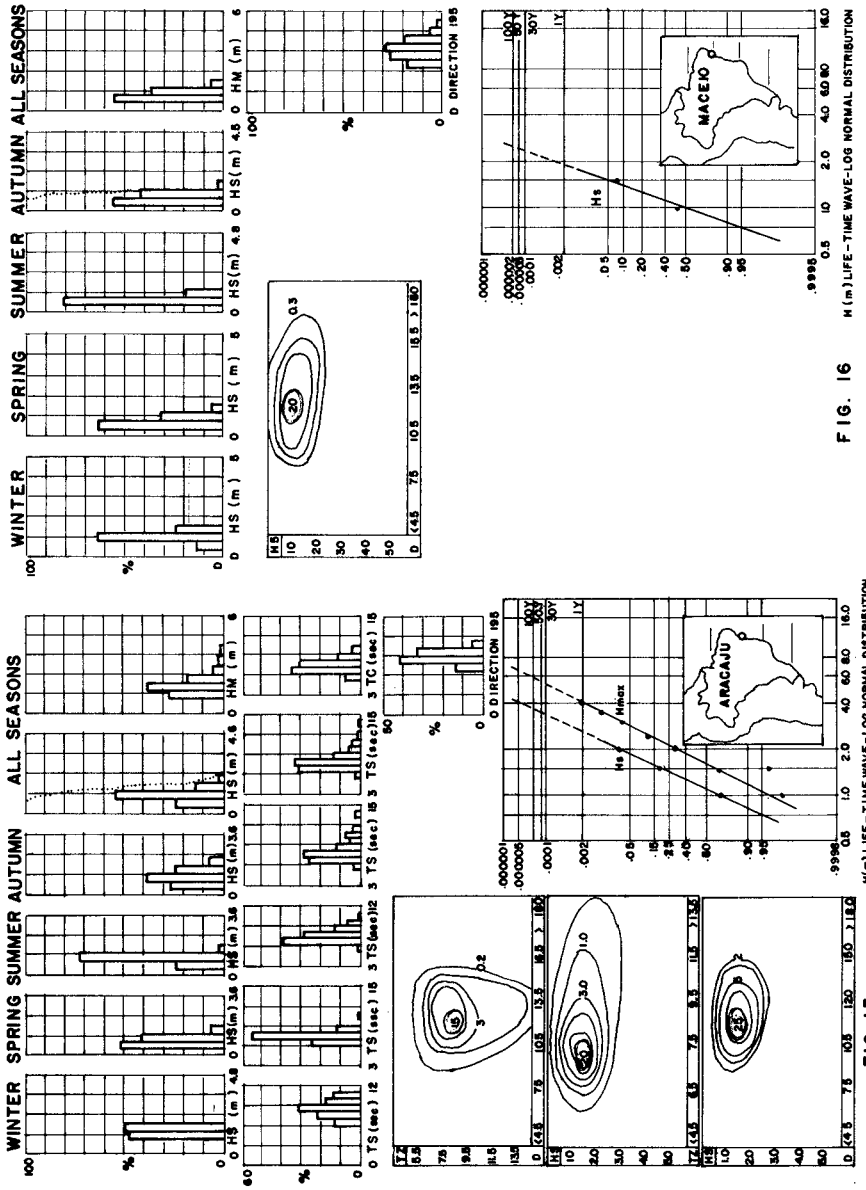

WINTER
SPRING
SUMMER
AUTUMN
ALL SEASONS
HS (m)
TS (sec)
TC (sec)
HM (m)
DIRECTION
ARACAJU
Hmax
Hs
H(m) LIFE-TIME WAVE-LOG NORMAL DISTRIBUTION
NACEIO
Hs
H(m) LIFE-TIME WAVE-LOG NORMAL DISTRIBUTION

FIG. 15

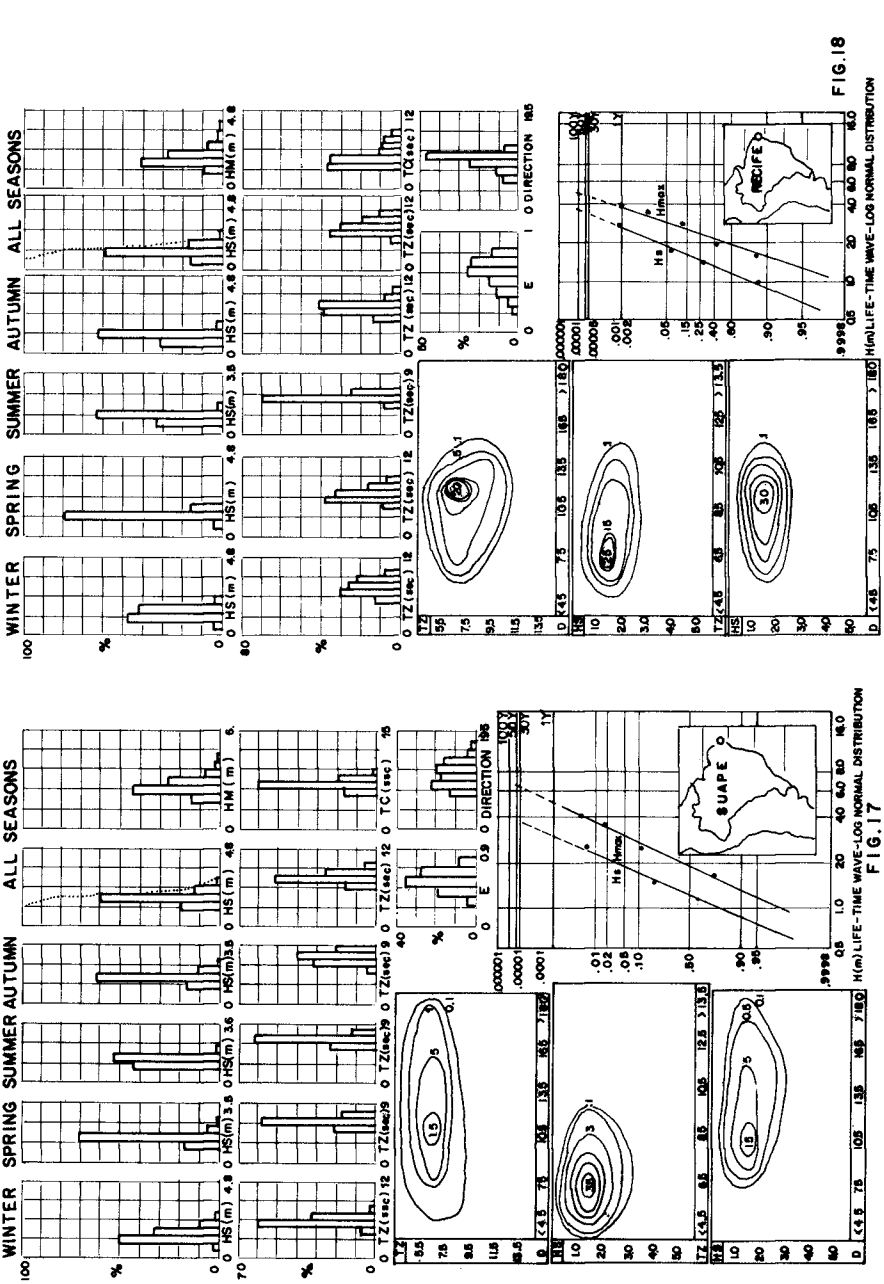
FIG. 16

using the daily Hs highest waves observed. For a return period of 30 years a prediction is made for an Hs = 2,40m. For 100 years, Hs= 2,70m.

SUAPE - The INPH was charged by the Government of the State of Pernambuco to develop extensive hydraulic studies comprising field measurements, stability and agitation models including mooring forces, by using irregular waves generators, and movable bed model including the coast and the estuary at Suape.
The wave measurements were made by the IPR (Radioactive Research Institute of NUCLEBRÁS) by means of an accelerometer buoy of Datawell. Fig. 167 shows the wave statictics analysis made by the INPH for the first year of measurements. During the autumn and winter the wave conditions are slightly more severe than during summer and spring. The highest Hs wave was about 3,00m and the highest maximum recorded wave about 4,50m.
A maximum Tz period of 10 seconds with a high concentration around 6,5 seconds was observed. The joint distribution show a concentration of 14% for the binary 6,5 seconds and 105° N; a slight tendency to associate large periods with northern wave directions could be observed. A high concentration of 35% for the binary 1,50m and 6,50 seconds occur, in the case of the Hs x Tz joint distribution. For the Hs x D distribution the most common frequency was for the binary 1,50m and 105° N. A slight association is observed between the highest waves and 135°/150° N wave direction. The Life-Time-wave Distribution provides a prediction of a significant wave of 3,90m which might occur over a return period of 30 years.

RECIFE - The INPH made recordings of sea waves at a point off Recife Port and used the Tucker-Draper's method of analysis. In Fig. 18 some wave statistics results obtained may be observed. The significant wave height exceeded 1,00m for 81% of the year. The variation in height for spring, summer and autumn is not significant; only during the winter the conditions are more severe with Hs waves up to 2,50m.
The scatter diagram Tz x D shows a tendency of wave with NE direction to be associated with periods of 6,5 seconds and waves of SE direction to be associated with periods from 10 to 12 seconds; the most frequent combination was when Tz period was about 6,5 seconds and the wave direction 120° N. For the Hs x Tz and Hs x D distributions the most frequent situations were respectively 1,5m and 6,5 seconds, and 1,50m 110° N.
The Life-Time-Wave Distribution predicts a significant wave of 3,40 m which might occur over a period of time of 30 years.

NATAL - The INPH is developing a comprehensive hydraulic study of the coast of Rio Grande do Norte around Natal and of the estuary of the Potengi river where the port of Natal is situated. The expansion plans include the increasing of the depth of the entrance channel to -12,00m. The wave measurements started at April/77 and is going to continue until April/79.
Fig. 19 include the statistic analysis made by the INPH by using the


WINTER
SPRING
SUMMER
AUTUMN
ALL SEASONS
SUAPE
H(m) LIFE-TIME WAVE-LOG NORMAL DISTRIBUTION
FIG.17
RECIFE
H(m) LIFE-TIME WAVE-LOG NORMAL DISTRIBUTION
FIG.18

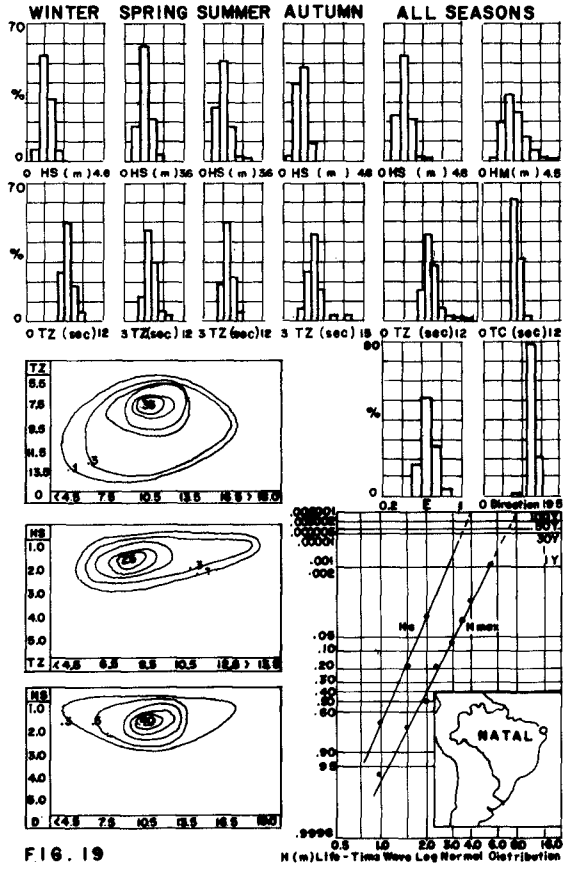
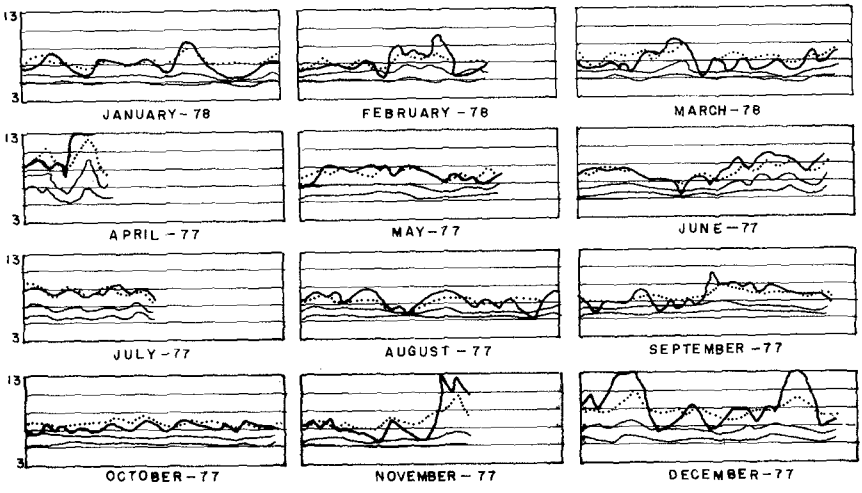

WINTER
SPRING
SUMMER
AUTUMN
ALL SEASONS
HS (m)
TZ (sec)
TC (sec)
HM(m)
Direction
NATAL
H(m) Life-Time Wave Log Normal Distribution

FIG. 19

NATAL FIG. 20



TP: —; TZ, TC (SPEC. ANAL.): —; TZ (TUCKER - DRAPER): •••••
COMPARISION OF PEAK PERIOD, ZERO CROSSING AND CREST PERIODS

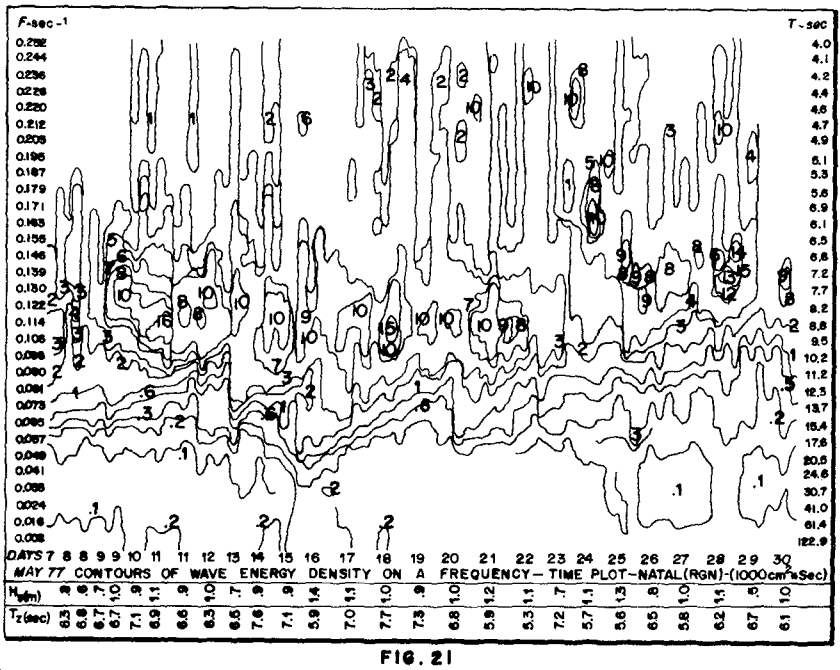


FIG. 21

Tucker-Draper's simplified method. The highest Hs wave was 3,00m and the highest maximum measured wave, 5,00m. During the autumn occur Tz periods of more than 13 seconds while in the other seasons the maximum is 9 seconds. The Hs x Tz distribution shows that there is a tendency to assiciate small wave heights with high periods;the highest frequency of occurence is 25% for the binary 1,50m and 7,5 seconds. In the case of Tz x D distribution the most common frequency (35%) is for 7,5 seconds and 105° N. For Hs x D the most common frequency has a very high percentage (40%) for the binary 1,50m and 105° N. An Hs wave of about 3,40m is probable to occur in a return period of 30 years. Fig. 20 presents a comparision of the periods obtained from the analysis of four daily strip-chart records by applying Spectral Analysis: Tp and Tc; and the Tz(.....) periods obtained by the Tucker-Draper method. In this figure the average of the four daily results were plotted. It could be observed that the zero-crossing period obtained by the simplified method has higher values than the obtained by spectral analysis. The trends of the peak period and the zero-crossing (Tucker-Draper) period compare well for the months of January, May, June, July and October, and reasonable well for August, September and November. The relation Tz/Tc for all seasons show values between 1,00 and 2,00 for the case of Tucker-Draper's analysis method,there being about 1% between 1,00/1,20 and 71% between 1,20/1,40. For the case of spectral analysis the relation Tz/Tc shows a range between 1,00/1,60 with 88% between 1,0/1,20 and 11% between 1,20/1,40m.
In the case of Tp/Tz (Tz of the S-A method) relation the values range from a little less than one (6.5%) to a little more than 2,00m (2%). The maximum occurence is for 1,0/1,20 (45%) and 1,20/1,40(40%). It is for the lowest value of the periods Tz and Tc that the relation Tz/Tc nearest to 1,00 are observed (due to filter effect of the pressure recorder). This characteristic is more accentuated in the case of the Tz/Tc Tucker-Draper's relation.
Fig. 21 shows the actual spectra for 24 days with significant wave height and zero-crossing period obtained from each strip-chart spectrum. The peak periods generally vary between 7,5 and 9,0 seconds.

THE PROBABLE WAVE INCOMING ENERGY

The wave action and the correspondent total energy at a location vary from season to season and, for each season from year to year. The actual situation is an irregular seasonal and yearly wave action. The information on this variability is important mainly for the cases of littoral process studies and work construction programs. The monthly, seasonal and annual wave energy could be obtained by considering the frequencies f_i of the distribution of the significant waves (Hs), calculating $\Sigma_i \; H_s^2 \times f_i$ for each month, each season, each year and for each location.

Fig. 22 shows the relative energy loads for the seasons, and for the year by taking as denominator the evarege of the annual expected wave energy of each location. The highest annual wave energy load occurred for Tramandaí (1.94) followed by Santos (1.53 for P_2 point) and Macaé (1.36).
In the case of the seasons, the highest seasonal wave energy load for each location occurred, for Tramandaí, in the spring(2.13) followed by Macaé also in the spring (1.98), Tubarão in the autumn (1.72); Suape in the winter (1.67) and Santos in the spring(1.60 for P_2 point).

	NATAL	RECIFE	SUAPE	MACEIO	ARACAJU	RIO DOCE	PORTOCEL	TUBARÃO	MACAE	A.DOS REIS	SANTOS P1	SANTOS P2	PARANAGUA	TRAMANDAI
YEAR	1.15	1.14	1.13	0.73	1.09	1.17	0.68	0.91	1.36	0.40	0.73	1.53	0.66	1.94
SPRING	1.15	1.16	0.99	0.67	0.74	0.94	0.68	1.02	1.98	0.43	0.64	1.60	0.74	2.13
WINTER	1.46	1.52	1.67	1.20	1.54	—	0.84	0.93	1.05	0.48	0.98	1.42	0.74	1.81
AUTUMN	0.85	0.86	1.10	0.69	1.28	1.41	0.84	1.72	1.59	0.54	0.76	—	0.42	1.94
SUMMER	1.09	0.84	0.80	0.50	0.90	1.20	0.39	0.38	1.00	0.27	0.59	—	0.53	1.89

ACKNOWLEDGEMENTS

The author would like to express his appreciation to the Management of PORTOBRÁS - Empresa de Portos do Brasil S/A, for making this study possible and to the various organizations involved in the wave measurements in Brazil.
Processing and organization of the data were possible with the help of : Miss B.M. Vargas, J. R. Cerdeira, M.F.C. Dourado, D. Accetta, L.C. Pucci and W.C. Scisinio. Thank for Mrs N.R. Veloso for the drawing and for Miss E.H. Jorge for the typing.

REFERENCES

Barcelõ , J. L. 1974 On the Portuguese Wave Regimen
Proc. 14th Conference Coastal Engineering, Kopenhagen.

Draper, L 1966 The Analysis and Presentation of wave Data a Plea for Uniformity.
Proc. 10th Conference Coastal Engineering, Tokyo.

Draper, L. 1976 Revisions in Wave Data Presentation.
Proc. 15th Conference Coastal Engineering, Hawaii

Dette, H. and Führbuter, A.1976 Wave Climate Analysis for Engineering Purpose.
Proc. 15th Conference Coastal Engineering, Hawaii