ON THE SPECIAL CURRENT AND WATER LEVEL VARIATIONS IN THE CHANNEL OF SÃO SEBASTIÃO *

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SYNOPSIS

In this paper were discussed current measurements recorded at 5 meter depth in the São Sebastião Channel and its correlation with tidal currents and prevailing weather conditions.

It has been shown that the recorded current is dominated by long periodic variation with periods of about four days and is characterized by a net transport towards NE. Computations of the currents of tidal origin have shown that they are very small and of minor importance to the current conditions in the Channel, however there are evidences of the connection between the non tidal currents, the irregular sea level variation and the prevailing weather conditions.

INTRODUCTION

The island of São Sebastiãwo, located at 23°50'S, 45°20'W, or about 50 miles north-east of Santos, is a huge and rocky island, where the highest peaks reach altitudes of more than 1300 m. The neighbouring continent is also very high and the channel between the continent and the island therefore forms a well protected natural harbour: São Sebastião.

However, althought the channel and the port are well protected from the Atlantic Ocean, quite severe navigational difficulties may arise due to the strong currents frequently present in the channel.

In 1961, therefore, investigations were made in order to obtain more knowledge of the current conditions in the channel. Later on observations were supplemented by weather reports and tidal data.

Before discussing the observations and analysis it is of interest to consider the topography and surroundings of the channel.

SÃO SEBASTIÃO

The island of São Sebastião is of tectonic origin and the channel itself is considered to be due to a landslide (FRANÇA, 1954). The shelf is even and very shallow, extending 60-70 miles off the coast, nowhere deeper than 100 m. At the southern entrance the channel of São Sebastião runs in NE-direction, reaching its narrowest part at Pt. de Araçá. Further to the north-east the channel bends more to the north and becomes gradually wider until running into the open shallow bay of Caraguatatuba.

The bottom topography is unique: a relatively deep and narrow trench runs close to the island, the full length of the channel. At the southern entrance the bottom is even, and the trench only just perceptible. North of Pt. de Araçá the channel becomes narrower and the underwater trench deeper, forming the most important part of the channel.

The different profiles and their locations are illustrated on Figures 1 and 2.

The configuration of the shallow zone at the northern entrance is obviously closely related to the current conditions and to a counter-clockwise eddy in the bay of Caraguatatuba.

The material

The current measurements were performed by means of a NEYRPIC B.B.T. recording current meter at 5 meter depth. The instrument was suspended from surface float, anchored by a triple-anchor system and located at 23°49.47'S - 45°24.08'W, or near

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the middle of the channel between Pt. de Araçá and Ilha das Cabras (Section 2, Fig. 1.).

The current was observed during a period of 16 days from October 1st to October 16th 1961. This period was, however, interrupted for 5 hours on October 7th, and from October 12th to 15th, due to instrumental failure.

Sea level variations were observed during September and October 1961 by the maregraph at the port of São Sebastião.

Another series of sea level observations was made during 1964 and 1965, the data being put at our disposal by Laboratório de Hidráulica of the University of São Paulo.

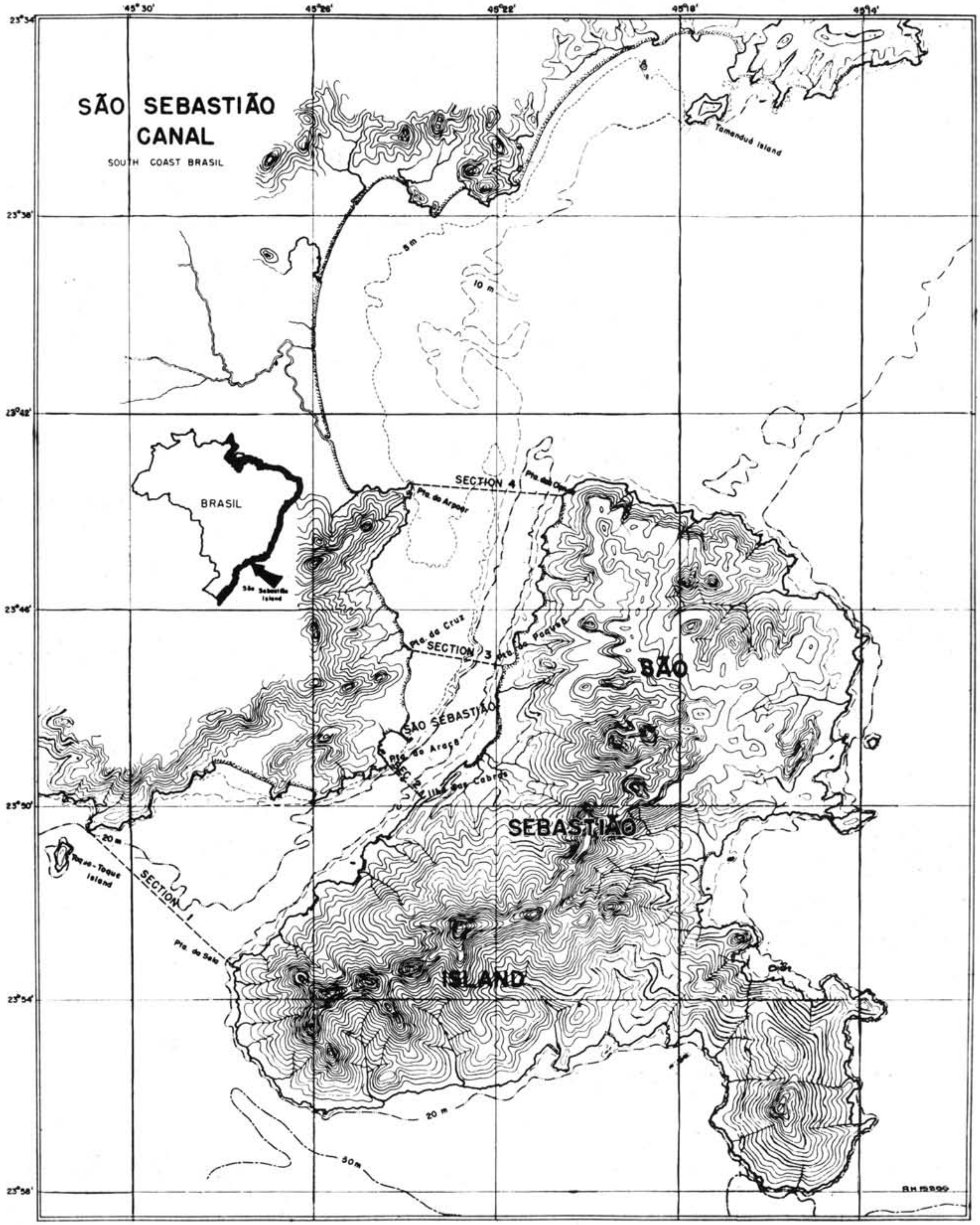

Fig. 1 — The channel of São Sebastião.

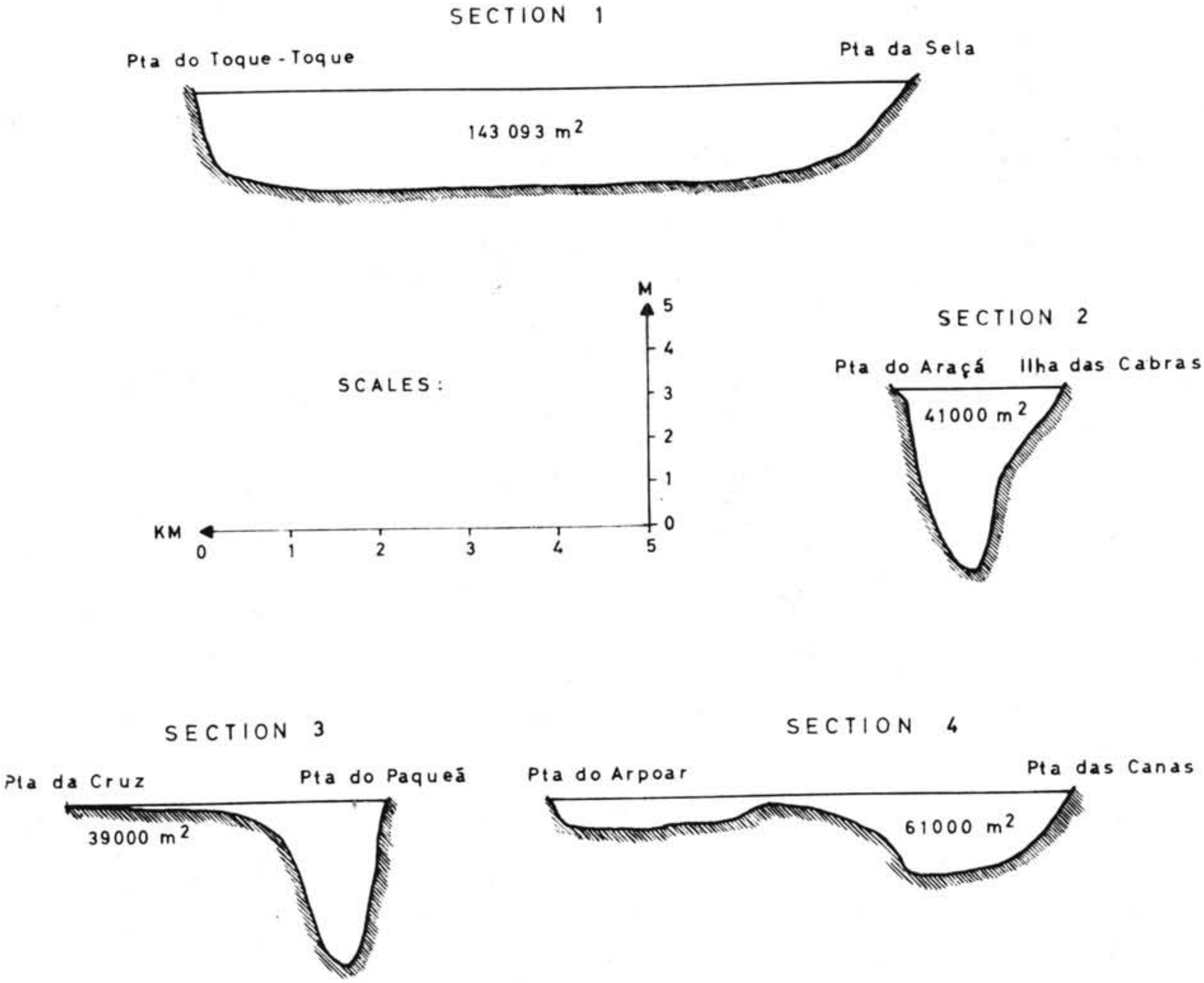

Fig. 2 — The channel of São Sebastião, bottom profiles.

The meteorological data are based upon daily weather maps issued by D.H.N. (Diretoria de Hidrografia e Navegação). Daily air pressure data for 1964 and 1965 from the Instituto Oceanográfico station in Ubatuba have also been included. The latter data are based on hourly values as registered by a barograph.

The current

It can be shown that the current-component in the transverse direction of the channel is negligible. Only the components parallel to the channel therefore will be dealt with, those towards 50° true being referred to as positive. Hourly current speed values are determined from the smoothed curve (Fig. 3). An even more smoothed curve is given in Figure 4, representing the residual current-component after the principal tidal and short periodic oscillations are eliminated by the process of 25 hours running mean.

Long periodic variations in the current

It can clearly be seen from the curves mentioned (Fig. 3 and 4) that the current is dominated by periods of about 4 days.

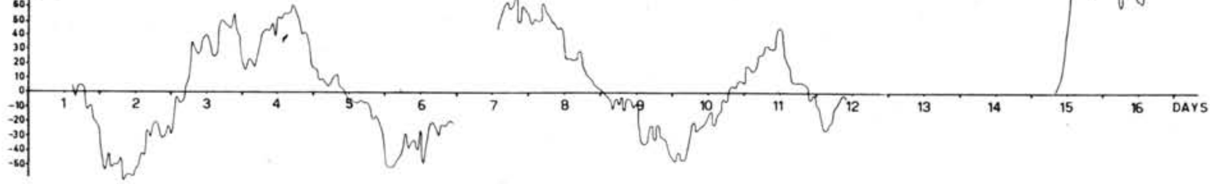

Fig. 3 — Current components, 4 hours running mean.

TABLE I — Long-period variations in current

N.º	Periods Date Hours		Duration hours	Max. ampl. cm/sec	Min.ampl. cm/sec	Range cm/sec
1.	From 2/10 | 11 to	6/10 | 10	94	42	—41	83
2.	From 6/10 | 09 to	10/10 | 00	87	52	—32	84
3.				20	—31	51
4.				76		

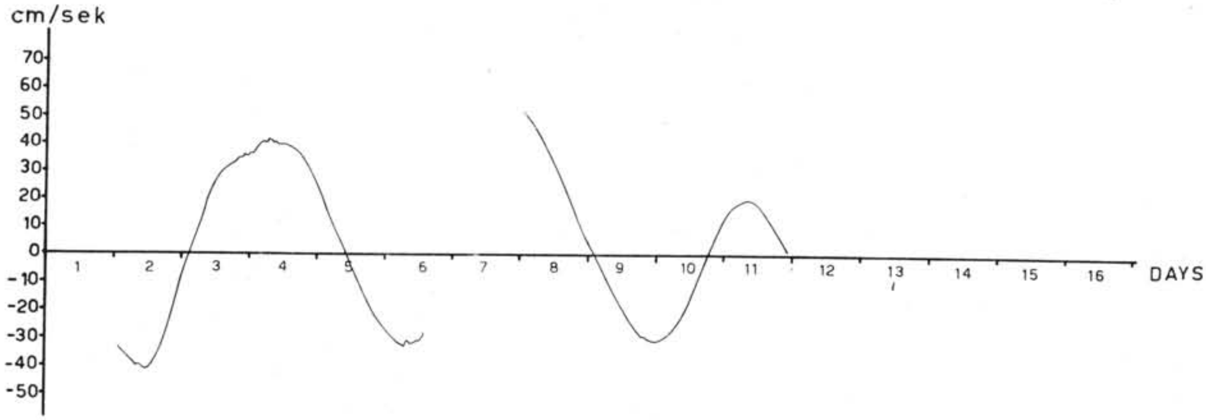

Fig. 4 — Current components, 25 hours running mean.

The figures given in Table I are taken from Figure 4, based on 25 hours running mean. Applied on a 94 hours period, this process will reduce the amplitude to about 91%.

Periods no. 3 and 4 are indicated on Figure 4, but their lengths can hardly be determined because of interruption in the observations. A possible explanation of the oscillations and the acting forces will be given in the section dealing with long-period terms.

The curve on Figure 4 also indicates that the NE component is greater than the SW one, and by integrating the curve (Fig. 4) it can further be shown that there is a net mass-transport towards NE. However, this may be connected with a long time variation which remains unrevealed because the observation period is too short.

The tidal current

Harmonic analyses with respect to diurnal and semidiurnal components have been performed, by applying the method given by Doodson. The results are given in Table II.

The harmonic constants given in Table II are more or less of the same order of magnitude, and remarkably small compared with the amplitudes of the long-period current. These conditions have been explained by I. Emilsson (unpublished manuscript 1962), who suggests that the observations are taken in a position very close to where the tidal wave from NE meets the wave from SW. The consequence is no tidal transport and no tidal current at this location. However, stronger tidal currents may occur at other locations in the channel.

TABLE II

Lunar days	Const. cm/sec	Diurnal cm/sec	phase	Semidiurnal cm/sec	phase
1	3.1	8.6	215	10.0	168
2	2.3	17.5	202	5.4	181
3	0.5	6.7	210	4.3	219
6	2.5	5.3	354	3.5	304
7	—1.8	4.3	307	5.6	288
8	—1.18	0.5	191	2.9	268

The curve on Figure 5 shows that the maximal tidal range coincides very closely with the moon-phase. The diurnal and semidiurnal current-components, however, decrease to a minimum when the moon is in the first quarter. An adequate explanation of these conditions can hardly be given from the available data. If one accepts that the tidal current-components are small because the observations were taken near the location where the two tidal waves meet, onde may also expect that this location may change with the moon-phase, and consequently that a chance in the current does not directly coincide with the actual tidal force. The author would, however, emphasize the fact that the tidal current-components are very small, and obviously only minor importance to the current conditions of this location.

The tidal conditions at São Sebastião

The tidal conditions at the port of São Sebastião have been analysed by Instituto Oceanográfico da

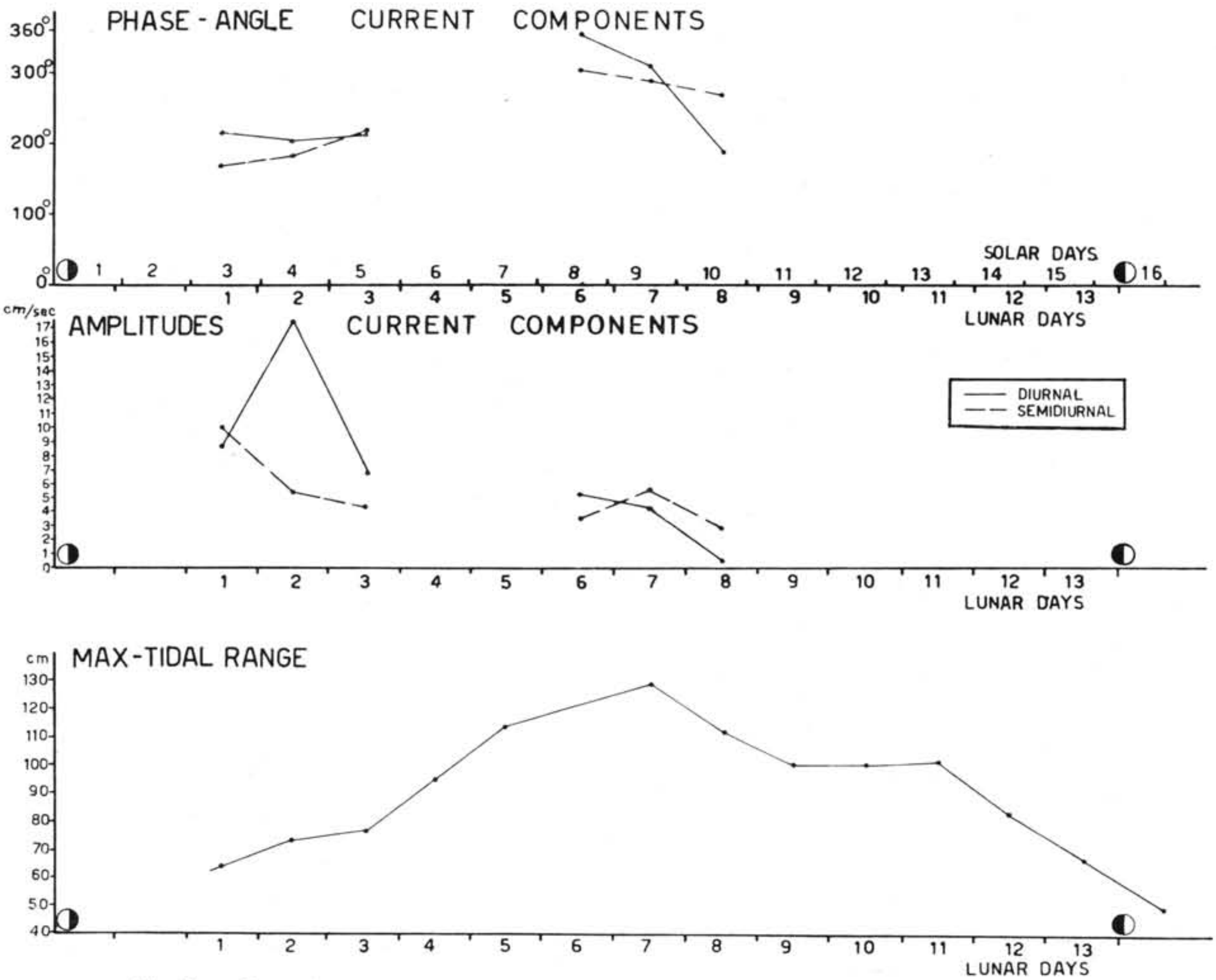

Fig. 5 — Comparison between the tidal current components and the maximal tidal range.

Universidade de São Paulo and the harmonic constants are given in Table III. The analysis is based on tidal observations, taken during a period of one month, from 18/8-18/9/1961, applying a method provided by the Tidal Institute in Liverpool.

The classification formula:

$$F = \frac{K_1 + O_1}{M_2 + S_2}$$

gives for São Sebastião: F = 0.385: hence a mixed, mainly semidiurnal tide (Defant, 1961). The process of 25 hours running means has also been applied to the tidal observations during the period 1st to 16th of October 1961, and it can be shown that there is a variation in the sea level with approximately the same period as found for the long period variation in the current (Fig. 10).

The maximal range of the variation for the period concerned amounts to about 40 cm, and the component should consequently be regarded as one of the most important contributions determining the sea level at this location.

To establish more knowledge of the existence and the length of this period, daily mean sea level values have been determined for a period of one year, September 1964 to September 1965, and perceptible and irregular variations in the daily mean sea level can be shown.

The number of equal periods has then been plotted as a function of period-lengths, and the periodgram (Fig. 6) shows a particularly high frequency on periods of 4-5 days' length.

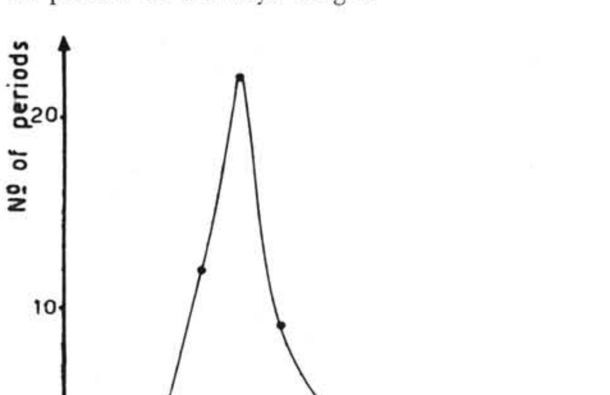

Fig. 6 — Periodgram, mean sea level periods.

There is a reason to believe that the frequencies of the different periods are unevenly distributed throughout the year, but an investigation of these conditions will require a longer observation period.

The long-period, non tidal current and the irregular sea level variations found in the channel of São Sebastião are probably due to, or connected with the meteorological conditions. It is therefore of interest to consider the prevailing weather system for the Brazilian coast.

The prevailing weather condition

The weather system of Brazil is very persistent, and a typical sequence may briefly be characterized as follows:

The South-Atlantic anticyclone will normally dominate the ocean and the coastal regions of the continent. The winds are generally weak and variable. At intervals cold airmasses accumulate along the south-western coast of Patagonia, followed by minor anticyclonic movements. A frontlike configuration travels northwards over the Argentine part of the continent, where the front becomes wider and more intense. The passage of the front is characterized by a pressure minimum, and a sudden drop in the air temperature. The winds generally blow from SE to SW in heavy gusts, even when the air pressure is minimal. Provided it is sufficiently strong, the front system may go as far as the north-eastern coast of Brazil, where it becomes more and more diffuse, and finally disappears altogether (Brasil. Ministério da Marinha).

Since the passage of a front is characterized by a pressure minimum, the period of a weather-cycles can be easily detected from a barogram, by measuring the time length between two consecutive pressure minima.

Daily mean air pressures for the period September 1964 to September 1965 for the station in Ubatuba have been determined by applying the process of 24 hours running mean, and the number of equal periods have been plotted as a function of period length (Fig. 7). The periodgram shows a configuration similar to that found for the daily mean sea level oscillation, with a most frequent period of 4-5 days. Periods of 7-8 days also apparently occur quite frequently. This phenomenon may, however, partly be due to the method, as a period of 7-8 days may be composed of two 3-4 days' periods.

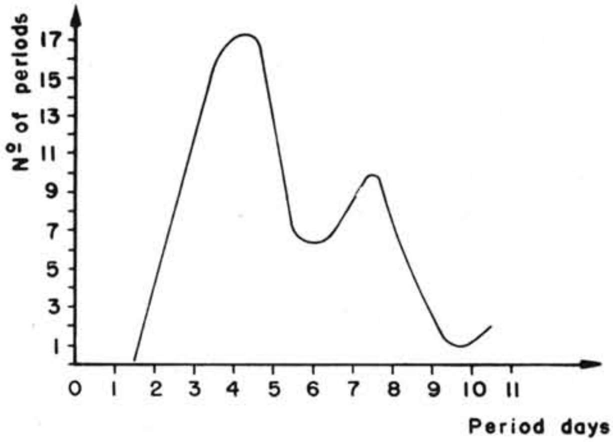

Fig. 7 — Periodgram, 24 hours mean air pressure.

The long term variations

It is shown that the current components, the mean sea level, and the weather system cycles are dominated by 4-5 days' periods. There is therefore reason to expect a close connection between these parameters. Hourly values of mean sea level have therefore been plotted as a function of the current-components (Fig. 8 and 9). The first period (Fig. 8) shows a remarkably close, nearly linear correlation, that by a careful examination will reveal a slightly different configuration for ascending and descending tide. The regression equation will therefore be different for ascending and descending sea level. In the diagram the sea level has been compared with simultaneous current components. There is, however, reason to expect a time lag, depending on the phase of the period. These conditions may very well explain the difference in regression curves for ascending and descending tide. An investigation, applying different time lags has been considered of little value, owing to the incomplete and short series of current observations.

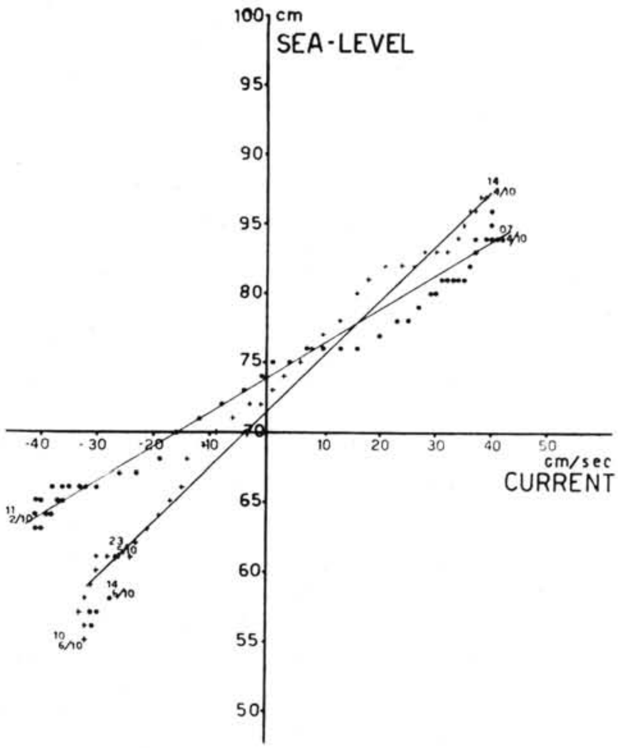

Fig. 8 — Relation between mean sea level and current components during the period October 2nd to October 6th.

The second period only comprises the decreasing part, but the curve (Fig. 9) shows a good correlation

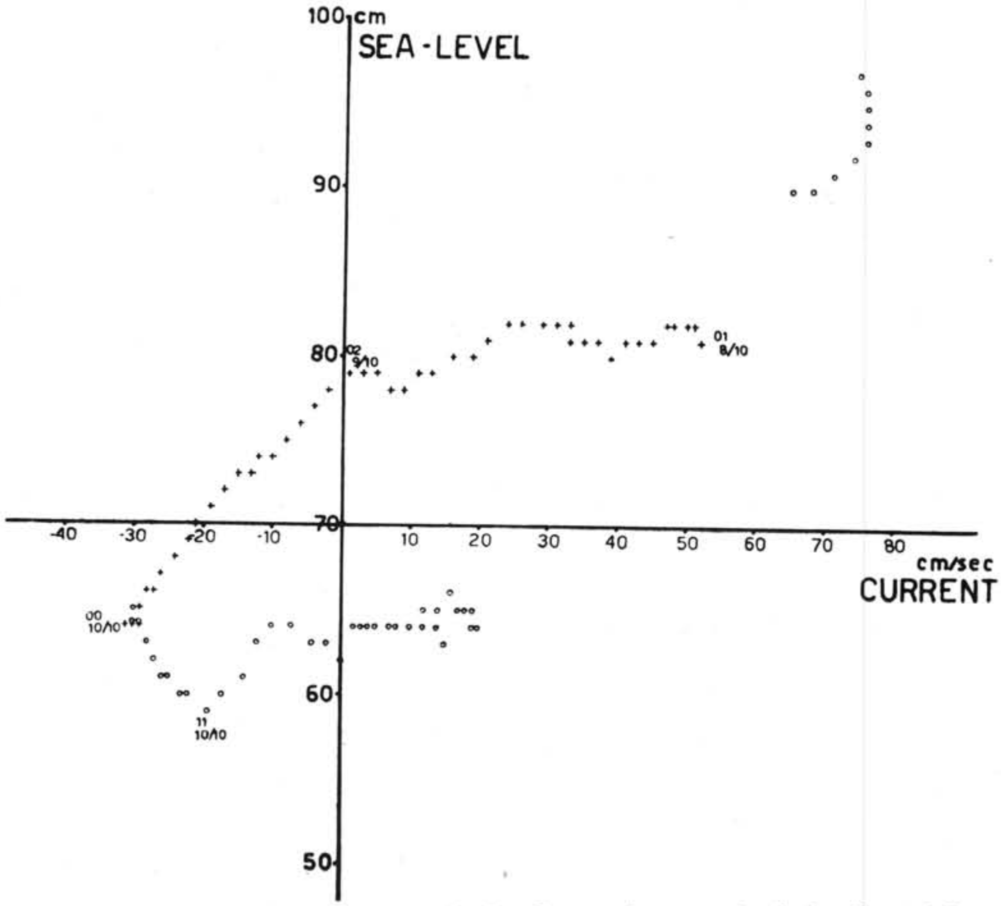

Fig. 9 — Relation between mean sea level and current components during the period October 8th to October 11th.

between mean sea level and current components, although not linear. During the second period the mean sea level keeps its value till the moment of no current, then it descends nearly proportionally with the current.

During the third period there are only small current components, and relatively low or medium mean sea level throughout the whole period. The current shows little or no significant correlation with the mean sea level.

The fourth period, of which only fragments can be presented, shows very strong current and extremely high mean sea level. We may therefore conclude: there is a close correlation between mean sea level and current towards NE along the channel, particularly in extreme situations. There is, however, reason to believe that the long-period current and the mean sea level oscillations are due to events or forces mainly acting off this particular locality. The acting forces will probably have a different effect on the two parameters, so that a differing time response is to be expected. Friction will have a nonlinear effect on the current, and the wind is also generally reckoned to have a nonlinear effect on surface currents.

One should therefore expect no direct and constant proportionality between current and mean sea level, although there seems to be a relatively strong connection.

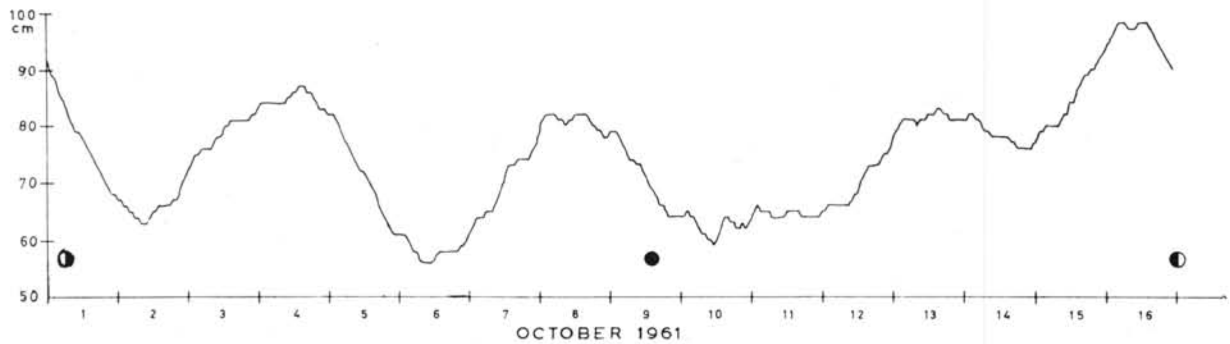

Fig. 10 — Mean sea level in the port of São Sebastião, based on 24 hours running mean.

FINAL REMARKS

The weather system of Brazil is considered very persistent, and it has been shown that the most frequent weather cycles has the same length as that of the most frequent mean sea level. The weather is therefore considered to be the cause, or one of the causes, of the unique sea level and current conditions in the channel of São Sebastião.

However, the author would emphasize the fact that the topographic conditions and the frictional forces will most certainly influence the final picture.

The cross-section of the channel decreases from south to north until the section Pt. da Cruz — Pt. do Paqueá. An inward waterflow passing the section at Pt. Toque-Toque will therefore either cause a more than 3 times as strong current, or an alternative piling up at Pt. da Cruz. Part of the mean sea level oscillation may be due to piling up caused by the current, but the current alone is not considered responsible for the total elevation.

The air pressure is not an adequate weather parameter, but since the weather conditions are very persistent it may still give a good indication. A more adequate parameter might probably be the air pressure gradient, because it is more representative of the great scale wind conditions.

The channel of São Sebastião is subjected to strong currents of which the tidal components play a nearly negligible part. The strongest non tidal component is estimated to be nearly 80 cm/sec, running along the channel in NE direction. For the interval dealt with, the dominating non tidal current has periods of about 4 days.

The most important components determining the sea level are thus irregular, the most frequent period is found to be about 4-5 days. There is a relatively strong correlation between currents towards NE and the mean sea level, particularly under extreme conditions.

It is indicated that the weather system propagation may be entirely or partly responsible for the conditions mentioned above. The 4-5 days periods are probably characteristic for the Brazilian shelf and are likely to be responsible for the most conspicuous and characteristic current and sea level conditions along the coast of Brazil.

The author would therefore strongly recommend further investigations on these conditions.

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TABLE III

Port: São Sebastião

State: São Paulo

Location of the maregraph:

Port of São Sebastião

Lat.: 23°48.7' S
Long.: 45°23.9' W

Time and duration of observations:

Year: 1961

Observation period: 18/8-18/9

Duration: 32 days

Method of observation: Maregraph

Authority: Instituto Oceanografico Universidade de São Paulo

Method of analysis: Tidal Institute, Liverpool

References:

Maregraph zero: 283.8 cm below reference level.

Mean sea level: 82.68 cm above maregraph zero.

Special information

Highest highwater observed relative to maregraph zero: 154 cm

Lowest low water observed relative to maregraph zero: 0 cm

Classification of the tide: Mixed, mainly semidiurnal.

Establishment: 2 hour 12 min.

	H	K	g
	cm	°	°
S_a			
S_{an}			
M_m	4,7		47,8
M_f			
MS_f	4,7		213,9
K_1	7,8		136,7
O_1	11,2		74,0
P_1	2,6		136,7
Q_1	3,3		49,1
J_1	1,3		95,5
M_1	0,8		42,3
OO_1	1,7		314,2
$\nu K_1 = \rho_1$			
$\nu J_1 = \sigma_1$	0,3		24,2
$TK_1 = \pi_1$	0,1		136,7
$NJ_1 = 2Q_1$	0,3		24,2
$KP_1 = \varphi_1$	0,1		136,7
$LP_1 = \chi_1$			
$\lambda O_1 = \theta_1$			
SO_1			
MP_1			
S_1			
$RP_1 = \psi_1$	0,1		136,7
KQ_1			
M_2	30,2		66,0
S_2	19,1		67,2
N_2	1,8		176,8
K_2	5,2		67,2
ν_2	0,3		176,8
$2MS_2 = \mu_2$	0,4		77,9
L_2	2,9		162,5
T_2	1,1		67,2
$2N_2$	0,2		287,7
MNS_2			
λ_2			
KJ_2			
R_2			
M_3	2,3		196,1

	H	K	g
	cm	°	°
$2SM_2$	1,8		44,4
MK_3	1,7		130,5
$MO_3 = 2MK_3$	1,7		316,9
SK_3			
SO_3			
S_3			
M_4	4,9		320,0
MS_4	2,1		49,1
MN_4	1,7		241,1
MK_4			
S_4			
SK_4			
SN_4	2,3		243,1
M_6	0,8		46,6
$2MS_6$	0,9		101,6
$2MN_6$	0,3		333,0
$2SM_6$	0,4		175,9
MSN_6	0,7		279,1
S_6			
$2MK_6$			
MSK_6			
M_8			
$3MS_8$			
$2(MS)_8$			
$2MSN_8$			
S_8			
OQ_2			
OP_2			
MKS_2			
MSN_2			

Instrument: NEYRPIC B.B.T. 187 837

Location: Canal de São Sebastião

Depth: 5 meters

Period: 1st to 16th October 1961

OCTOBER 1

Local hour	Direction	Speed	Local hour	Direction	Speed	Local hour	Direction	Speed
1500	20	5	1814	350	5	2114	165	8
15	295	5	29	35	5	29	160	14
30	220	7	44	30	5	44	165	10
45	220	5	59	50	5	59	170	20
1600	230	4	1914	165	5	2214	175	23
15	310	4	29	170	7	29	175	20
30	350	5	44	175	11	44	170	20
45	350	5	59	175	11	59	175	20
1700	0	5	2014	180	15	2314	170	23
14	10	5	29	175	11	28	170	23
29	10	5	44	170	11	43	175	26
44	30	5	59	165	11	58	185	26
59	15	5						

OCTOBER 2

Local hour	Direction	Speed	Local hour	Direction	Speed	Local hour	Direction	Speed
0013	175	32	0812	180	61	1611	190	27
28	180	39	27	175	62	26	190	27
43	180	41	42	175	48	41	185	29
58	180	42	57	175	58	56	190	33
0113	175	42	0912	175	58	1711	185	33
28	180	48	27	175	51	26	185	27
43	185	54	42	175	55	41	185	23
58	185	55	57	175	58	56	190	23
0213	180	45	1012	175	58	1810	190	26
28	180	42	27	175	58	25	185	23
43	190	42	42	175	61	40	185	17
58	185	42	57	180	58	55	185	20
0313	180	48	1112	185	58	1910	190	20
28	175	48	27	185	51	25	190	20
43	180	55	42	185	10	40	195	20
58	180	48	56	185	53	55	200	20
0413	180	51	1211	185	54	2010	195	26
28	180	54	26	185	55	25	190	29
43	180	48	41	180	52	40	185	29
58	180	48	56	180	48	55	185	26
0513	185	54	1311	180	51	2110	185	35
28	180	60	26	180	45	25	185	32
42	180	51	41	180	42	40	180	32
57	180	51	56	185	42	55	180	29
0612	180	48	1411	185	42	2210	180	29
27	180	42	26	185	45	25	175	23
42	180	42	41	185	42	40	175	27
57	180	45	56	185	45	55	175	23
0712	180	51	1511	185	42	2310	180	20
27	180	54	26	185	36	25	180	26
42	180	63	41	190	29	40	180	26
0757	180	61	1556	190	27	55	190	26

OCTOBER 3

Local hour	Direction	Speed	Local hour	Direction	Speed	Local hour	Direction	Speed
0010	190	29	0808	350	29	1607	0	50
24	195	23	23	350	32	22	355	45
39	190	17	38	355	26	37	0	50
54	185	20	53	350	29	52	0	50
0109	175	17	0908	350	26	1707	0	50
24	175	7	23	350	32	22	0	50
39	175	4	38	350	26	37	0	50
54	200	3	53	350	32	52	355	45
0209	225	4	1008	350	29	1807	0	50
24	240	4	23	350	32	22	0	50
39	205	10	38	350	35	37	355	45
54	195	7	53	350	38	52	0	50
0309	195	7	1108	355	40	1906	355	45
24	180	4	23	355	38	21	0	50
39	185	7	38	350	38	36	0	50
54	180	7	53	355	42	51	355	45
0409	195	4	1208	355	39	2006	355	45
24	295	4	23	355	42	21	355	45
39	340	4	38	355	39	36	0	50
54	330	7	52	355	32	51	5	55
0509	335	4	1307	0	35	2106	5	55
24	345	4	22	0	35	21	0	50
39	5	7	37	0	33	36	355	45
54	15	7	52	355	26	51	355	45
0609	0	13	1407	350	26	2206	350	40
24	10	17	22	350	23	21	355	45
38	0	29	37	355	26	36	0	50
53	0	29	52	0	26	51	340	30
0708	0	42	1507	0	30	2306	355	45
23	0	35	22	0	26	21	345	35
38	0	35	37	0	23	36	350	40
53	355	32	52	0	29	51	355	20

OCTOBER 4

Local hour	Direction	Speed	Local hour	Direction	Speed	Local hour	Direction	Speed
0006	355	20	0804	0	42	1603	355	55
21	350	20	19	0	45	18	0	58
36	350	17	34	0	42	33	0	58
51	345	13	49	0	42	48	0	64
0106	350	20	0904	0	45	1703	5	61
20	350	20	19	0	42	18	5	58
35	350	20	34	5	48	33	0	58
50	355	23	49	5	51	48	0	58
0205	355	26	1004	355	45	1803	0	55
20	355	23	19	355	45	18	0	51
35	355	23	34	355	45	33	0	52
50	355	23	49	355	42	48	0	51
0305	355	23	1104	355	39	1903	0	51
20	350	23	19	355	38	18	0	48
35	350	20	34	355	45	33	0	48
50	345	20	49	355	48	48	355	42
0405	345	17	1204	0	55	2002	355	38
20	350	20	19	5	55	17	0	38
35	355	20	34	0	55	32	355	42
50	355	23	49	0	51	47	0	42
0505	355	26	1304	5	51	2102	0	42
20	355	32	19	5	51	17	0	42
35	355	35	34	5	51	32	0	40
50	355	35	48	5	55	47	0	39
0605	355	32	1403	5	55	2202	5	35
20	355	39	18	5	55	17	5	32
35	355	42	33	5	55	32	5	26
50	355	42	48	5	51	47	5	26
0705	0	42	1503	10	58	2302	5	23
20	0	45	18	5	58	17	0	23
34	0	45	33	0	58	32	355	23
49	0	45	48	0	55	47	355	17

OCTOBER 5

Local hour	Direc- tion	Speed	Local hour	Direc- tion	Speed	Local hour	Direc- tion	Speed
0002	5	17	0801	345	14	1559	180	7
17	0	20	16	345	10	1614	170	3
32	5	23	30	340	7	29	180	3
47	5	20	45	335	7	44	180	4
0102	5	17	0900	345	4	59	180	10
17	10	7	15	330	4	1714	180	7
32	0	7	30	320	4	29	180	10
47	0	7	45	330	4	44	175	10
0202	350	10	1000	320	4	59	175	4
16	355	14	15	315	4	1814	170	7
31	350	10	30	300	0	29	175	7
46	350	7	45	290	4	44	175	7
0301	5	7	1100	265	7	59	180	10
16	5	10	15	255	7	1914	180	10
31	0	17	30	200	7	29	190	17
46	355	7	45	200	4	44	190	17
0401	5	7	1200	205	4	59	185	20
16	10	7	15	200	7	2014	190	13
31	20	4	30	195	4	29	190	14
46	25	4	45	175	7	44	185	14
0501	25	4	1300	195	4	58	180	20
16	20	4	13	215	4	2113	190	17
31	10	7	30	185	7	28	185	21
46	5	7	45	185	7	43	180	17
0601	0	10	1400	185	7	58	180	17
16	355	7	15	180	10	2213	190	20
31	350	10	30	180	10	28	190	20
46	345	14	44	185	7	43	190	23
0701	345	7	59	180	7	58	190	26
16	355	14	1514	185	7	2313	180	26
31	350	14	29	180	4	28	185	29
46	345	14	44	185	7	43	175	32
						58	180	35

OCTOBER 6

Local hour	Direc- tion	Speed	Local hour	Direc- tion	Speed	Local hour	Direc- tion	Speed
0013	185	35	0812	190	41	1610	185	23
28	185	36	27	185	39	25	195	23
43	185	51	42	180	32	40	200	23
58	185	54	57	180	35	55	200	23
0113	180	41	0912	180	32	1710	195	42
28	180	51	26	175	32	25	200	42
43	185	48	41	175	32	40	200	35
58	185	51	56	180	32	55	200	26
0213	180	51	1011	175	35	1810	200	29
28	185	58	26	175	38	25	195	23
43	180	51	41	180	42	40	190	17
58	180	51	56	180	42	55	190	23
0312	185	51	1111	180	32	1910	180	20
27	190	51	26	180	32	25	170	29
42	190	51	41	190	26	40	185	23
57	190	44	56	195	26	55	190	20
0412	190	45	1211	195	29	2010	185	7
27	190	48	26	190	29	25	180	26
42	190	45	41	185	45	40	190	23
57	180	41	56	180	51	55	190	20
0512	190	41	1311	175	48	2110	195	26
27	185	45	26	175	45	25	190	20
42	185	45	41	175	42	40	185	17
57	195	42	56	180	35	54	180	20
0612	190	38	1411	180	29	2209	170	20
27	190	29	26	190	29	24	180	20
42	195	29	41	195	26	39	175	23
57	190	29	56	195	23	54	180	20
0712	195	29	1511	195	23	2309	180	23
27	185	35	26	185	20	24	180	20
42	190	38	40	200	20	39	180	17
57	190	38	55	200	20	54	180	20

OCTOBER 7

Local hour	Direction	Speed	Local hour	Direction	Speed	Local hour	Direction	Speed
0009	185	20	1514	355	61	1944	0	67
24	180	23	29	355	58	59	0	67
39	180	26	44	355	58	2014	0	67
54	180	26	59	355	61	29	355	61
0109	185	29	1614	355	64	44	355	58
24	185	23	29	355	64	59	355	48
39	180	20	44	350	64	2114	355	51
54	180	17	59	355	67	28	0	58
0209	180	17	1714	355	64	43	0	51
24	175	4	29	355	61	58	0	64
			44	355	64	2213	0	64
			59	355	58	28	0	58
1330	350	42	1814	350	58	43	5	61
45	355	45	29	350	58	58	5	58
1400	355	42	44	350	61	2313	0	52
15	350	45	59	355	61	28	0	55
30	350	51	1914	350	64	43	0	55
45	355	51	29	0	70	58	0	58
1500	350	58						

OCTOBER 8

Local hour	Direction	Speed	Local hour	Direction	Speed	Local hour	Direction	Speed
0013	0	48	0812	5	48	1610	350	20
28	0	45	27	0	45	25	345	26
43	5	51	42	0	48	40	350	29
58	5	48	57	0	45	55	350	30
0113	355	51	0912	0	48	1710	350	30
28	0	51	27	5	45	25	350	26
43	5	51	42	0	45	40	350	26
58	0	51	56	0	42	55	350	23
0213	0	51	1011	0	45	1810	355	17
28	0	48	26	0	48	25	350	17
43	0	51	41	0	45	40	350	20
58	0	51	56	0	45	55	350	20
0313	0	51	1111	0	45	1910	350	17
28	0	42	26	0	45	25	345	14
42	0	42	41	0	39	40	350	7
57	355	48	56	0	35	55	345	14
0412	355	55	1211	355	33	2010	355	10
27	0	58	26	5	26	25	350	10
42	0	61	41	0	26	40	355	14
57	0	64	56	0	23	55	355	10
0512	0	58	1311	355	23	2110	355	10
27	0	58	26	355	30	25	5	7
42	0	55	41	355	26	40	5	7
57	0	55	56	355	23	55	5	7
0612	0	58	1411	355	23	2210	355	4
27	0	55	26	355	23	24	355	4
42	0	51	41	350	20	39	0	4
57	0	51	56	355	23	54	10	4
0712	0	55	1511	355	20	2309	0	4
27	0	51	26	350	23	24	350	4
42	5	48	41	355	26	39	345	4
57	5	48	56	355	23	54	325	4

OCTOBER 9

Local hour	Direc-tion	Speed	Local hour	Direc-tion	Speed	Local hour	Direc-tion	Speed
0009	320	0	0808	150	14	1607	180	26
24	315	4	23	155	7	22	185	23
39	205	4	38	140	4	37	185	23
54	190	4	53	145	4	52	190	20
0109	180	4	0908	145	4	1706	190	26
24	175	0	23	125	4	21	185	30
39	170	0	38	140	7	36	185	30
54	130	4	53	170	4	51	180	32
0209	125	4	1008	160	4	1806	185	32
24	150	4	23	160	10	21	185	26
39	170	4	38	170	10	36	185	26
54	180	4	52	170	10	51	185	23
0309	180	4	1107	180	10	1906	180	20
24	180	7	22	180	7	21	185	26
39	180	10	37	175	7	36	185	20
54	175	14	52	175	7	51	185	20
0409	180	7	1207	180	10	2006	180	32
24	180	10	22	185	14	21	175	33
38	170	7	37	185	20	36	180	35
53	170	4	52	185	26	51	180	30
0508	175	4	1307	185	26	2106	180	30
23	175	7	22	180	32	21	180	30
38	180	7	37	185	33	36	185	30
53	170	10	52	180	39	51	180	32
0608	165	7	1407	175	35	2206	180	32
23	165	4	22	175	35	21	180	39
38	160	0	37	175	39	36	180	39
53	145	4	52	180	32	51	180	39
0708	140	4	1507	180	35	2302	180	42
23	140	7	22	180	39	20	180	42
38	155	7	37	180	33	35	180	42
53	150	17	52	180	30	50	180	42

OCTOBER 10

Local hour	Direc-tion	Speed	Local hour	Direc-tion	Speed	Local hour	Direc-tion	Speed
0005	185	48	0804	190	26	1603	185	14
20	185	48	19	190	30	18	185	7
35	185	48	34	190	26	33	190	4
50	190	48	49	195	26	48	190	4
0105	190	48	0904	190	21	1703	195	4
20	190	48	19	190	20	18	200	7
35	190	45	34	190	23	33	190	10
50	190	39	49	180	26	48	220	4
0205	190	42	1004	175	23	1802	205	4
20	185	42	19	175	23	17	185	7
35	195	48	34	175	24	32	185	4
50	190	45	49	180	20	47	275	7
0305	185	48	1104	185	17	1902	320	4
20	185	45	19	185	17	17	345	4
35	185	45	34	185	17	32	340	4
50	190	48	48	190	21	47	355	7
0405	190	42	1203	195	17	2002	5	4
20	190	45	18	195	14	17	0	4
35	185	51	33	200	14	32	355	4
50	180	39	48	205	14	47	350	4
0505	185	39	1303	205	14	2102	350	4
20	190	35	18	210	14	17	340	7
34	200	29	33	210	17	32	355	4
49	195	30	48	210	20	47	355	10
0604	200	30	1403	200	26	2202	5	10
19	195	29	18	195	26	17	5	7
34	185	20	33	200	20	32	0	10
49	200	20	48	190	23	47	0	10
0704	195	23	1503	210	14	2302	355	10
19	195	20	18	195	14	17	355	4
34	195	23	33	200	14	32	345	7
49	185	26	48	190	14	47	350	7

OCTOBER 11

Local hour	Direction	Speed	Local hour	Direction	Speed	Local hour	Direction	Speed
0002	0	7	0800	350	32	1614	345	14
16	350	20	15	350	30	29	355	7
31	350	23	30	350	34	44	355	7
46	355	20	45	355	32	59	0	7
0101	350	20	0900	350	32	1714	355	7
16	350	17	15	350	29	29	5	7
31	350	20	30	350	29	44	10	7
46	350	20	45	350	26	59	10	7
0201	345	17	1000	345	32	1814	10	7
16	345	14	15	350	33	29	20	7
31	345	14	30	355	33	44	5	7
46	345	17	45	355	39	58	10	7
0301	350	17	1100	355	45	1913	10	7
16	355	17	15	0	45	28	5	7
31	350	14	30	0	45	43	0	7
46	350	17	45	0	51	58	0	4
0401	350	20	1200	0	42	2013	345	7
16	350	17	15	0	39	28	345	7
31	350	23	30	0	42	43	355	7
46	350	30	44	0	39	58	350	4
0501	350	26	59	355	39	2113	40	0
16	350	26	1314	355	32	28	30	0
31	350	26	29	350	29	43	115	4
46	350	23	44	355	26	58	170	7
0601	350	26	59	355	20	2213	160	7
16	355	26	1414	350	23	28	170	4
30	355	29	29	350	23	43	170	4
45	355	29	44	355	20	58	160	0
0700	350	32	59	350	20	2313	160	4
15	355	33	1514	355	17	28	170	4
30	355	32	29	355	14	43	165	7
45	350	32	44	345	10	58	180	7
			59	345	10			

OCTOBER 12

Local hour	Direction	Speed	Local hour	Direction	Speed	Local hour	Direction	Speed
0013	160	7	0342	175	26	0712	170	10
28	175	10	57	170	23	26	185	7
43	170	10	0412	170	20	41	170	7
58	165	10	27	175	20	56	170	3
0112	165	23	42	180	20	0811	170	0
27	175	20	57	180	20	26	155	4
42	175	17	0512	180	17	41	150	0
57	175	17	27	180	14	56	150	4
0212	170	20	42	180	14	0911	145	4
27	175	26	57	165	10	26	160	4
42	180	26	0612	165	10	41	160	4
57	180	26	27	170	7	56	160	7
0312	175	26	42	180	7	1011	170	7
27	175	26	57	175	7	26	170	4

OCTOBER 15

Local hour	Direction	Speed	Local hour	Direction	Speed	Local hour	Direction	Speed
0722	300	4	1306	0	70	1835	0	79
37	40	0	21	0	73	50	5	82
52	0	4	36	5	76	1905	0	82
0801	285	4	51	10	79	20	0	82
22	285	4	1406	10	85	35	5	79
31	310	4	21	10	95	50	0	73
52	325	7	36	5	95	2005	0	70
0907	355	26	51	0	97	20	0	73
22	340	7	1506	0	97	35	0	73
37	350	10	21	5	104	50	0	79
52	10	14	36	5	95	2105	0	82
1007	355	10	51	5	95	20	0	88
22	0	10	1606	5	85	35	355	85
36	350	13	21	10	85	50	0	85
51	355	23	36	10	85	2205	0	85
1106	355	29	50	5	88	20	0	82
21	350	17	1705	5	80	35	0	79
36	345	39	20	5	79	50	355	79
51	355	45	35	5	76	2304	355	77
1206	355	51	50	5	76	19	355	77
21	0	57	1805	0	76	34	355	73
36	0	64	20	0	76	49	355	73
51	0	73						

OCTOBER 16

Local hour	Direction	Speed	Local hour	Direction	Speed	Local hour	Direction	Speed
0004	350	77	0518	0	70	1018	0	67
19	350	73	33	355	73	33	0	64
34	355	79	48	355	60	48	0	70
49	355	76	0603	355	57	1103	0	70
0104	355	79	18	345	64	18	0	70
19	355	82	33	355	70	32	0	64
34	355	82	48	355	76	47	0	60
49	355	79	0703	355	70	1202	0	77
0204	355	76	18	5	73	17	355	60
19	355	76	33	0	73	32	0	58
34	0	76	48	355	70	47	0	61
49	0	80	0803	0	73	1302	5	64
0304	355	79	18	355	73	17	5	64
19	355	76	33	355	75	32	0	70
34	355	76	48	0	76	47	0	73
49	0	79	0903	0	73	1402	0	70
0404	5	79	18	0	79	17	0	70
19	0	79	33	0	76	32	0	73
34	5	76	48	0	70	47	355	73
49	0	76	1003	0	76	1502	0	79
0504	0	73						