Bull. Inst. Oceanogr. & Fish. ARE, 12, 1986: 127 - 134.

INVESTIGATION OF THE HIGH FREQUENCY OSCILLATIONS OF THE SEA LEVEL IN THE WESTERN HARBOUR OF ALEXANDRIA, EGYPT.

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ABSTRACT

The high frequency range of oscillations in the Western harbour are studied using sea level records for 20 day in each of the months June, 1980, October, 1980, January, 1981 April, 1981.

The spectral analysis is applied on different time series (each having 720 points), with an interval time of 10 minutes.

Three significant peaks have been shown. The first has a long period of about 12 hours due to astronomical tide. The second has half an hour period. This period agrees with the calculated seiche period in the basin as well as the estimated edge wave period. Finally, a one hour period oscillation was found and it agrees with period of the beat between half an hour period and the semidiurnal tidal period.

INTRODUCTION

The Western harbour of Alexandria is limited by (31° 10' - 31° 12') N and (29° 50' - 29° 53') E. It has an oblique shape relative to the geographic axes with a mean depth of about 9 - 10 meters and a surface area nearly 7.5 km^2. The mean length and width of the basin are 5 km and 1.5 kms respectively, Fig. (1).

The tide gauge is located in the inner part of the harbour. It is an old Hughes machine of the floating type with one day recording sheets erected in a double well an accuracy of 0.1 cm (Rady, 1979).

In this area, the sea level fluctuations due to astronomical and meteorological factors were investigated by different authors (Sharaf El Din and Rifaat, 1968, Sharaf El Din, 1975, Moursy, 1976, and Rady, 1979). These studies considered the hourly sea level heights after smoothing out the high frequency oscillations. The highest frequency to be detected by this analysis is 12 cycles/day. However, higher frequency oscillations, which affect the anchorage of ships in the harbours, were frequently observed in the Mediterranean gulfs and harbours (Lisitzin, 1974). These high frequency oscillations-even though they are fairly clear from the

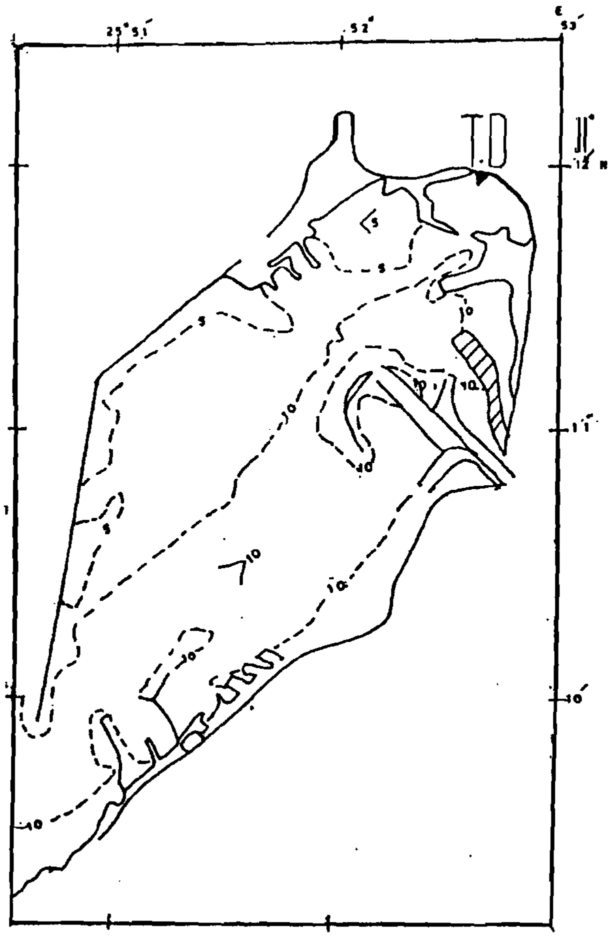

Fig. (1)
A map showing the position and topography of the Western Harbour of Alexandria and the situation of the tide gauge (T.D.).

sea level records of the Western harbour of Alexandria-have not yet been examined, and will therefore be dealt with in this paper.

Data and methods of analysis

To study the high frequency range in the sea level records, the records have been digitized at 10 minutes interval which is the minimum interval that can be followed from the daily charts. The periods of analysis are chosen to represent the different seasons; from 1st to 20th June, 1981, from 1st to 20th October, 1980, from 1st to 20th January, 1981, and from 1st to 20th April 1981. Each of these periods were devided into four samples, with five days record in each sample (i.e. 720 data points). The spectral analysis was applied on the different samples, with 72 lags, a nyquist frequency 3 cycles par hour, and 20 degrees of freedom.

As an attempt to explain the significant spectral peaks at 95% confidence limit, the periods of the seiche in the harbour and the period of the edge waves over the continental shelf were also estimated.

RESULTS

To do a preliminary examination of the sea level variations, some typical records are represented by Fig. (2). This figure shows variations of sea level at different seasons. It indicates that the apparent amplitudes and periods in the high frequencies are different, but in most of graphs, a one hour cycle can be observed. However, the complexities of the high range of frequencies is expected due to the variable meteorological conditions, e.g. the gust effect.

The results of the spectral analysis, which is a powerful tool to identify the energies of the different frequencies, are shown by figures (3 - a, b, c and d). In June and April, 1981, the spectrum manifests three significant peaks at theperiods of 12 hours, (0.96 to 1) hours, and at 29.4 minutes. In October, 1980, and January, 1981, the first two peaks are again shown, while the third peak, was not clear from all the spectral samples. The 12 hours period oscillation is expected to be due to the tidal sea level semi - diurnal variations by astronomical forces. This oscillation is known from previous studies of the hourly values and tidal analysis (Rady, 1979, and others).

However, since the main interest in this paper is to investigate the high frequency oscillations, an attempt to estimate the seiche period of the harbour and the period of the edge waves in front of Alexandria will be done and to compare them with the observed periods of the significant peaks.

a) Estimation of the Seiche Period in the Western Harbour of Alexandria:

If we consider the Western harbour of Alexandria, Fig. (1) as a narrow gulf, Marians formula can be applied to determine the resonance seiche period corresponding to the harbour length, where

$$T = 4\,L \text{ (for the nth mode)} / n\sqrt{gh} \quad \text{(Proudman, 1952)}$$

where

L = length of the gulf = 5km.
$g = 9.81\ m/sec^2$ = acceleratien of gravity.
h = mean depth of the basin = 10 m.

For the first mode, the Seiche period is about 33.65 minutes.

b) Estimation of the Edge Wave Period:

According to Eckart (1951) (See Inman et al, 1976). The longshore edge

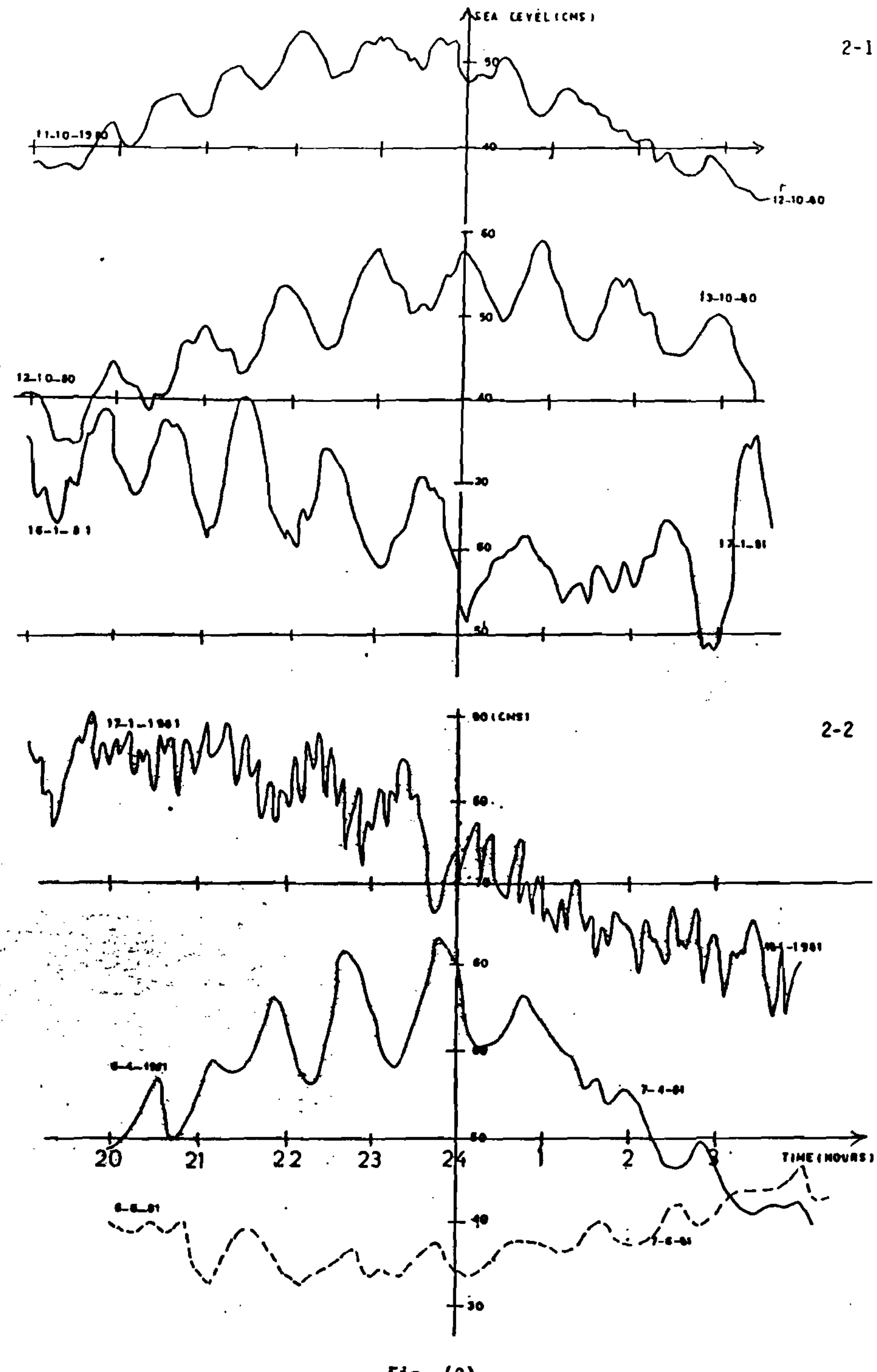

Fig. (2)
Sample records of sea level observations in the Western Harbour of Alexandria.

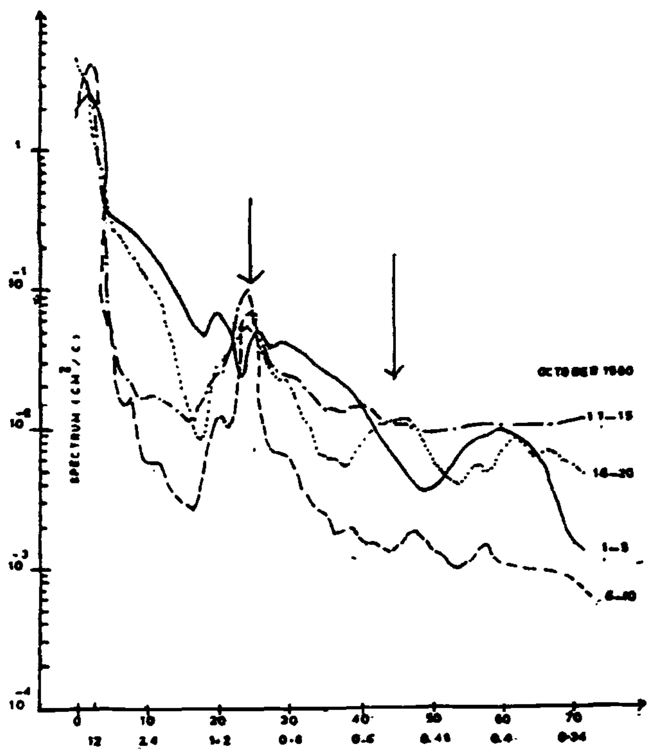

Fig. (3 - A)
Spectral analysis results of sea level data at
the Western Harbour of Alexandria. October, 1980.

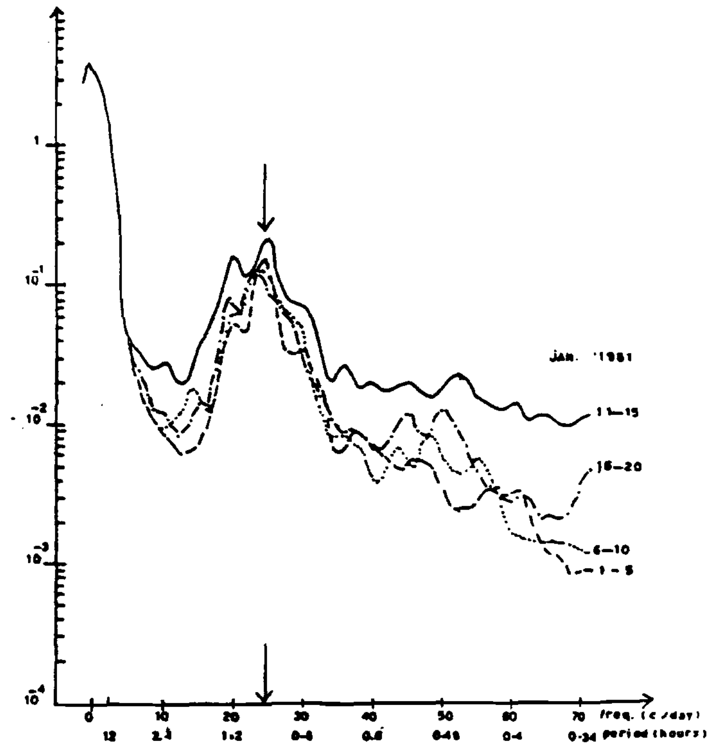

Fig. (3 - B)
Spectral analysis results of sea level data at
the Western Harbour of Alexandria. January, 1981.

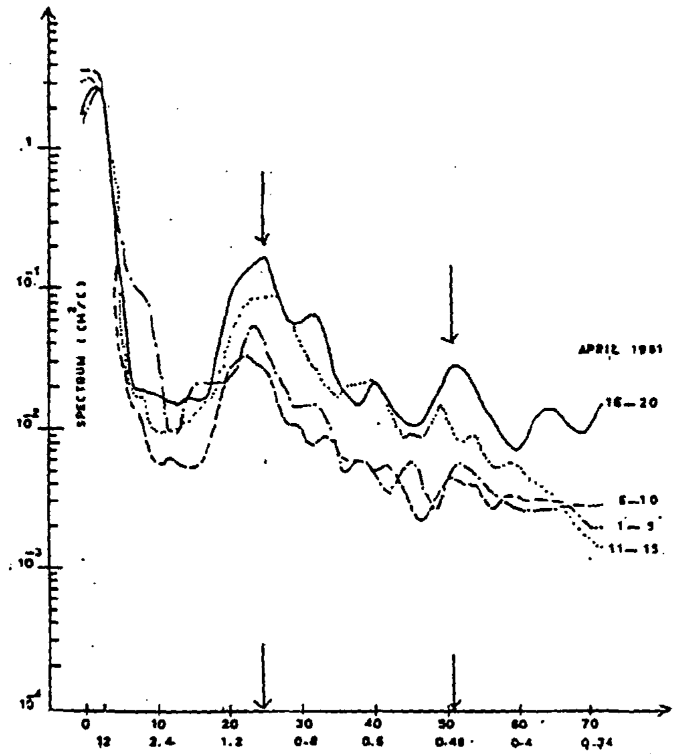

Fig. (3 - C)
Spectral analysis results of sea level data at the Western Harbour of Alexandria. April, 1981.

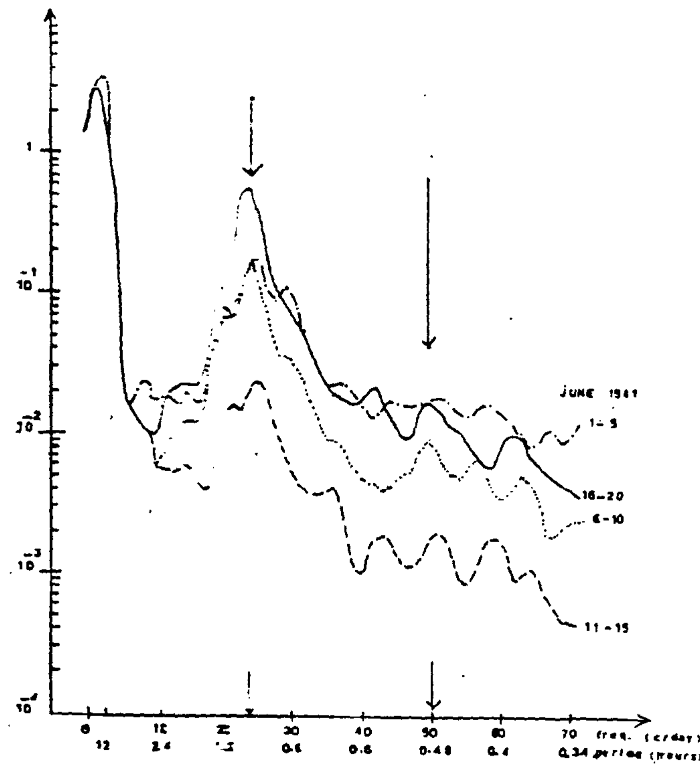

Fig. (3 - D)
Spectral analysis results of sea level data at the Western Harbour of Alexandria. June, 1981.

wave length (L_e) in shallow water can be expressed by

$$L_e = g \text{ (for the nth mode) } / 2\pi [T_e^2 (2n + 1) \tan B]$$

where
T_e = the edge wave period.
$\tan B$ = the slope of the bottom.

This equation is applied when $(2n + 1) \tan B \ll 1$. The slope of the coastal area up to 50 meters depth in front of Alexandria i.e. tan B equal to 4.7 x 10^{-3}. From evidences of large plumes extending offshore from Rosetta to Burullus promontories (east of Alexandria), given by a satellite immage, Inman et al (1976), speculated that if these plumes are due to large scale circulation analogous to nearshore circulation cells, they would require an edge wave with a longshore wavelength of about 30 kms. If this approximate figure is accepted, the period of the edge wave, for the zero mode comes to about 32.7 minutes.

DISCUSSION

The above estimates of the periods of the seiche of the basin and edge waves could explain the existence of the spectral peak at about 30 minutes. However, the one hour period can not be explained by these oscillations. If there is a beat between the seiche oscillation of the harbour with a period (T_1) and the dominant semidiurnal tidal oscillation (T_2 = 12.5 hours) another oscillation (T_3) will appear, so that

$$T_3 = 2\, T_1\, T_2 \,/\, (T_1 + T_2)$$

using T_1 = 0.55 hour, we get a beat period of about 1.05 hours which is of the same order as that observed in the spectral analysis.

CONCLUSION

The spectral analysis of sea level elevations digitized at 10 minutes interval indicated three spectral peaks; one of them is a long period oscillation (semidiural tide), and the other two are found at high frequency range with about one hour and half an hour periods. The oscillation with half an hour period could be explained by the seiche oscillation of the basin or the edge wave effect, while the one hour period oscillation is probably due to the beat effect between semidiurnal tide and the seiche inside the harbour.

AKNOWLEDGEMENT

The author would like to express his thanks to Mr. Magdy Farag for his assistance in the preparation of the data for the analysis.

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