On the Tides and Seiches of Osaki-Bay

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On the Tides and Seiches of Osaki-Bay

By

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1. Introduction

Osaki-Wan, immediately south of Wakanoura-Wan, is a small bay penetrating far into the land and measuring about 3 sq. kilometres in area; it is very deep—18 metres in the deepest part and 11.7 metres on an average. As it is, moreover, surrounded by hills, strong winds seldom, if ever, blow here. The range of tide attains more than 2 metres all over its coast.

Our tidal-station stands on the right shore of Osaki-ura in the north-west corner of the Bay (Fig. 1. O), and it is very favourable for tidal observation, having a depth of 8 metres only a few metres from the beach. The situation calculated from the trigonometrical survey bench mark shown in Charts[1] No. 59 and No. 98 is

$$34^\circ\ 7'\ 46''.7\ \text{N.} \qquad 135^\circ\ 7'\ 41''.1\ \text{E.}$$

We have here a self-recording tide-gauge (reduction 1/10) of the Kelvin type and have been carrying out observations since July 1st 1926.

For the correction of time we always compare it with a Rassel Co.'s chronometer, and determine the rate of the chronometer by the radio time-signal.

The standard level is taken as 180.9 cms. beneath a mark on the third step of the inner wall of the observation well.

As five years have elapsed since the commencement of our observations, I shall report here some results of our observations in that time.

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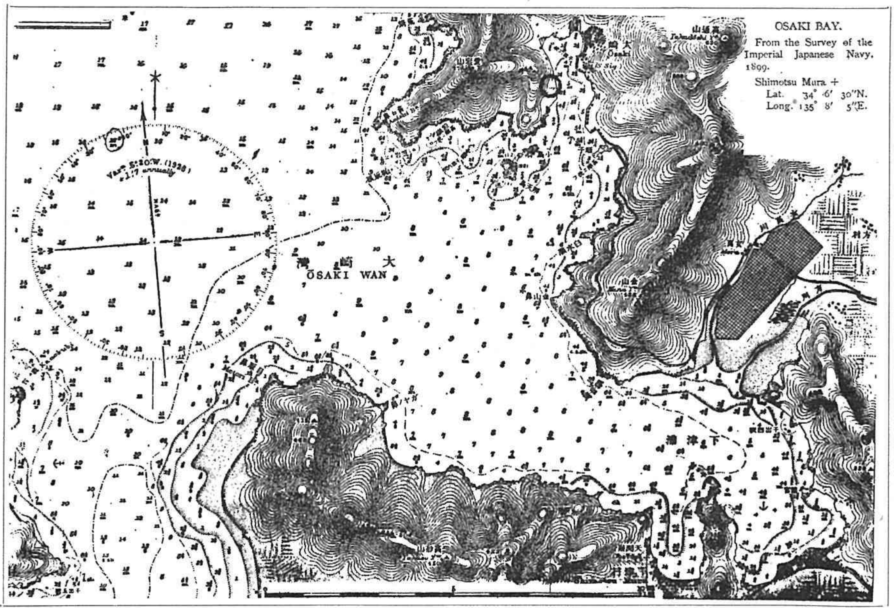
1. Chart published by the Hydrographic Department of Japan, No. 59. No. 98.

Fig. 1



2. Variations of the Monthly and Yearly Mean Sea-level

From the tidal-records for the five years we read off the hourly heights of sea-level, and calculated the monthly mean level, the result being as follows.

Monthly Means of Sea-level.

Month \ Year	1926	1927	1928	1929	1930	1931	Total	Mean
		cm.	cm.	cm.	cm.	cm.	cm.	cm.
Jan.		144.72	140.00	145.02	142.61	143.92	716.27	143.254
Feb.		144.12	135.07	134.00	141.71	140.10	695.00	139.000
Mar.		147.43	145.62	138.29	138.09	142 51	711.94	142.388
Apr.		149.44	154.47	148.44	152.96	142.71	748.02	149.604
May.		157.79	155.57	155.57	151.76	153.46	774.15	154.830
Jun.		161.40	171.35	158.09	160.40	158.99	810.23	162.046
Jul.	cm.	162.71	173.97	165.22	176.68	164.42	843.00	168.600
Aug.	171.65	170.55	188.44	178.59	176.58		885.81	177.162
Sep.	164.02	166.83	176.58	175.37	165.83		848.63	169.726
Oct.	169.95	170.05	170.35	173.46	170.85		854.66	170.932
Nov.	157.58	163.92	160.50	157.68	160.00		799.68	159.936
Dec.	157.58	151.65	158.99	152.56	148.94		769.72	153.944
Total	820.78	1890.61	1930.91	1882.29	1886.41	1046.11	9457.11	1891.422
Mean	(164.156)	157.551	160.909	156.858	157.201	(149.444)	788.093	157.619

The difference between the maximum and the minimum height every month is about 2 metres on an average, and that between the heighest (282.4 cms. on Aug. 18th 1928) and the lowest (10.1 cms. on Jan. 8th 1928) during the five years reaches 272.3 cms.

Fig. 2a, b, c show the variations of the monthly mean, the monthly maximum and the minimum and also the yearly mean of sea level.

Fig. 2

(a) Monthly Max., Mean and Min. Heights

(b) Mean of the Monthly Means.

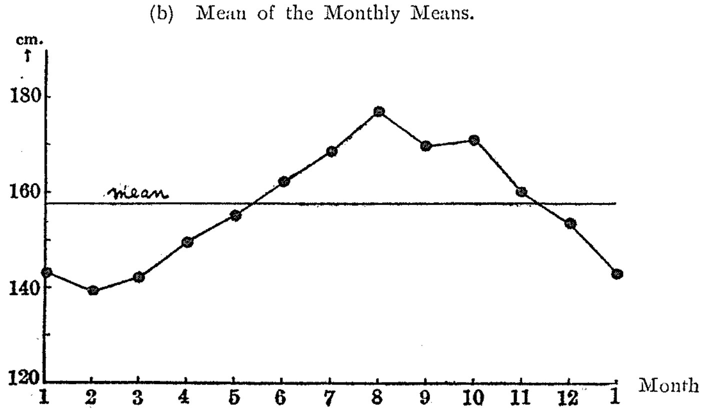
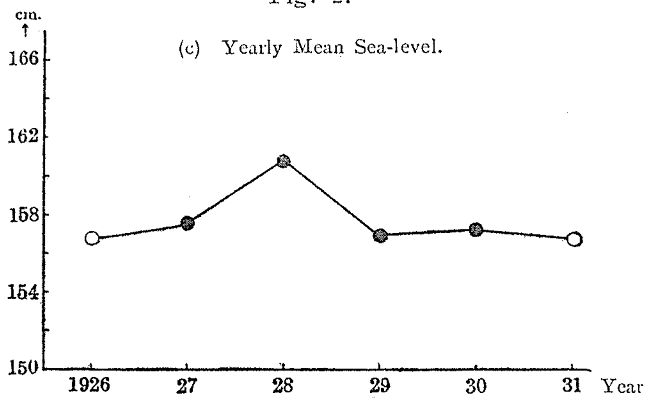


Fig. 2.



3. Tidal Constants at Osaki

The tidal constants determined from the data obtained in about one year from Oct. 1st 1929 by Darwin's Method[1] are as follows:

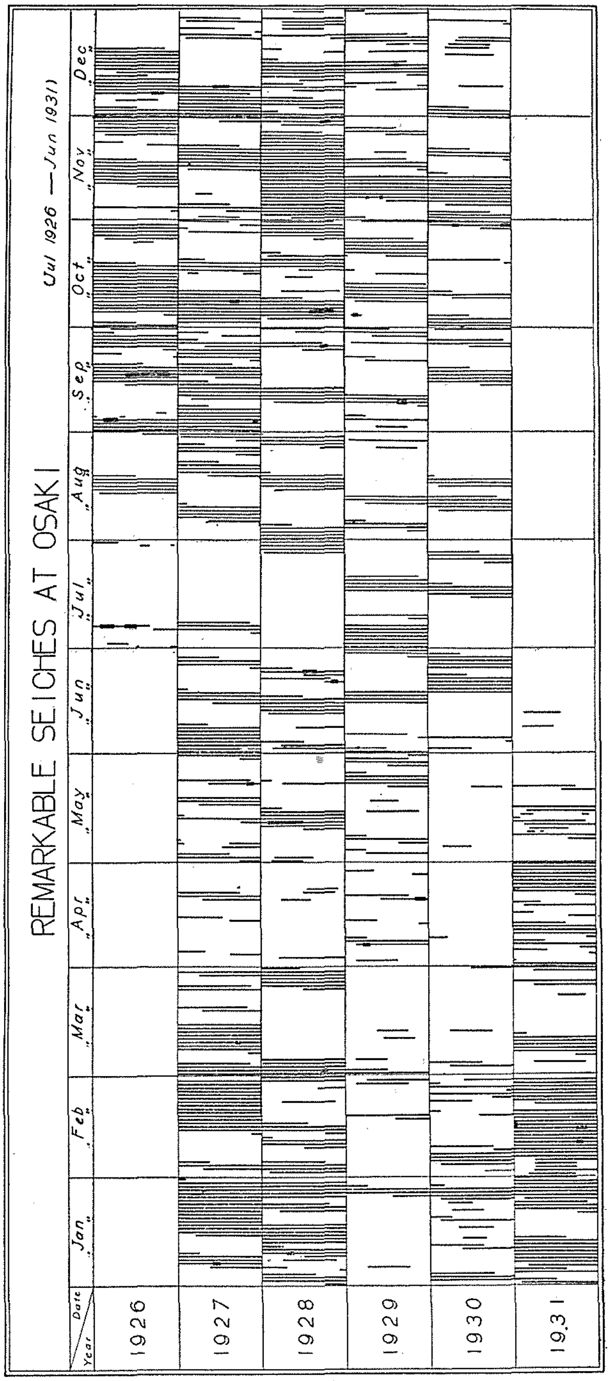
Harmonic Constants of Tides
Osaki, Japan.
34° 7′ 46″.7 N. 135° 7′ 41″.1 E.
(Epoch 1929 Oct. 1)

Tide	H	κ	Tide	H	κ
	cm.	°		cm.	°
Sa	17.405	151.33	K_2	5.762	197.90
Ssa	0.278	239.11	M_1	0.564	128.38
S_1	1.408	72.99	M_2	45.621	180.22
S_2	21.770	205.39	M_3	0.721	184.03
S_4	0.174	99.30	M_4	0.341	67.57
S_6	0.088	231.95	M_6	0.524	163.14
P	7.814	189.96	O	18.546	171.24
K_1	23.904	187.93	N	9.231	173.95
T	1.741	248.20	Q	3.811	161.38
R	0.346	152.15			

These values seem to be accord with the tidal constants of various ports about the Kii Channel which were determined some years ago by Dr. S. Hirayama[2] and by Dr. S. Ogura[3] and also with that of Port Shimotsu recently published by Mr. T. Hidaka.[4]

1. G. H. Darwin: Scientific Papers, Vol. I. Oceanic Tides. (1907).
2. S. Hirayama: Memoirs Coll. Science, Tokyo. **28**, No. 7 (1911).
3. S. Ogura: 日本近海ノ潮汐 (1914).
4. T. Hidaka: Jour. Oceanography, Kobe Marine-Meteo. Obs., **1**, 377 (1929).

Fig. 3


REMARKABLE SEICHES AT OSAKI
(Jul 1926 —Jun 1931)
Date
Year
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1926
1927
1928
1929
1930
1931

4. Seiches of Osaki-Bay

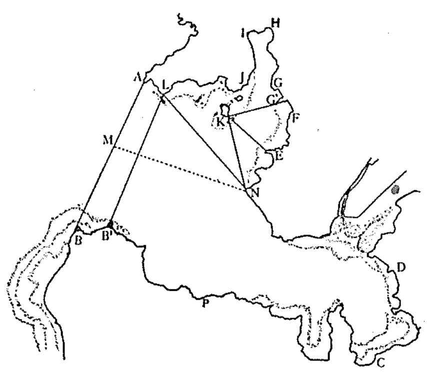
Owing to the complexity of shape and the great depth of the Bay, seiches of various periods frequently develop well.

On our marigram, remarkable seiches were recorded 247 times in five years and 29 of those indicate amplitudes of over 20 cms. It is usually between late autumn and winter that these seiches appear and some of them often last for more than ten days.

Fig. 3 shows the dates of occurrence and the time of duration of the chief seiches of the past five years, the thick lines in it corresponding to those which had amplitudes of over 20 cms.

In most cases seiches of various periods are superposed on one another, but if we choose only 170 records in which the periods can be easily read off, and classify the number of occurrences according to the period, we get eight groups as Fig. 5 shows.

Fig. 4



Looking over the shape and the depth of the bay, let us consider the following portions of sea (Fig. 4), as the oscillating areas that may produce the above eight kinds of seiche.

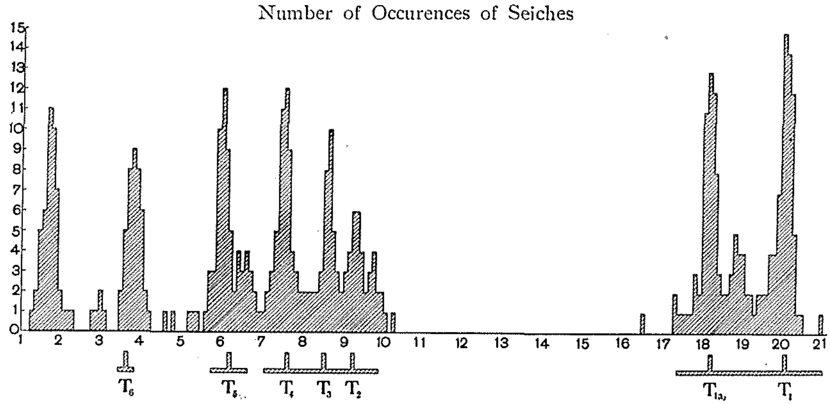
For each area we calculate the mean depth h and measure the length of the major axis L from the chart, and determine the corresponding period of free oscillation, using the well known formula $T=\frac{4L}{\sqrt{gh}}$ (for the transversal oscillation T_{VI} use $T=\frac{2L}{\sqrt{gh}}$) and performing on it a mouth correction after Rayleigh. The results are shown in the following table:—

	Area	Node	Length (L)	Breadth (B)	Mean depth (h)	Period
			km.	km.	min.	
1	ABCDNE″A	$\overline{AB}$	2.6	1.3	12.3	$T_I=19.9\pm0.9$
2	LB′CDNE″L	$\overline{LB}$	2.4	1.0	12.3	$T_{Ia}=18.1\pm0.8$
3	LNEGHIJL	$\overline{LN}$	1.0	0.9	9.2	$T_{II}=9.2\pm0.6$
4	KNEGHIJK	$\overline{KN}$	0.9	0.6	8.5	$T_{III}=8.5\pm0.4$
5	KEGHIJK	$\overline{KE}$	0.8	0.4	7.9	$T_{IV}=7.6\pm0.5$
6	KG′HIJK	$\overline{KG'}$	0.65	0.3	7.8	$T_V=6.2\pm0.4$
7	ABPE″A	$\overline{MN}$	1.3	1.2	14.4	$T_{VI}=3.65\pm0.15$

If we compare the calculated periods with those observed, we see that they are in good correspondence each other, as is shown in Fig. 5.

Fig. 5

Number of Occurences of Seiches



A short-period seiche of from 1.6 to 1.8 minutes always accompanies one of from 3.6 to 3.8 minutes, so it seems the former is to be considered the over undulations of the transversal oscillation T_{VI}.

5. Note on Some Types of Seiche

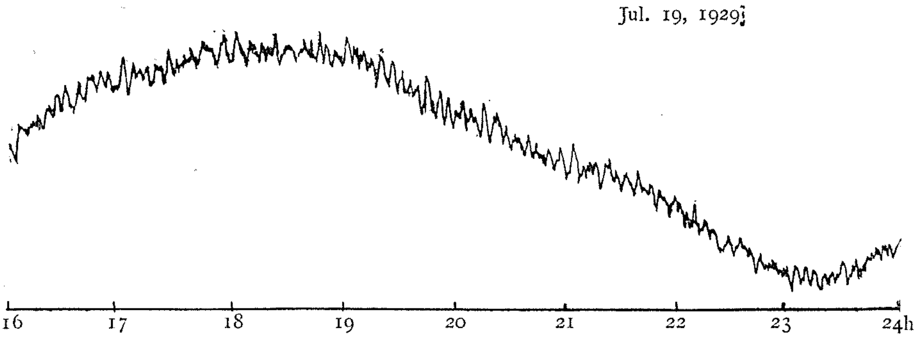
A type of conspicuous seiche is exemplified by an actual record in Fig. 6. Such seiches often occur continuously for several days, and show amplitudes within 10 cms. and periods from 1.6 to 1.8 minutes. They are always accompanied by typhoons.

If a typhoon appears far on the eastern sea of Formosa, our tide-guage immediately begins to record these seiches. When the typhoon has passed off Shiwono-misaki and gradually moved away northwards to the eastern sea of Sanriku or when it has gone over China or the Japan Sea, these seiches disappear.

Accordingly they occur mostly from Aug. till Nov. (see Fig. 3, light lines). Only two out of 46, the total number that have occurred in the past five years, are exceptional. These two cases were both when an unusual low-pressure of small area passed near Shiwono-misaki at a tolerable speed. The seiches of this type never occur with an ordinary low-pressure passing over the adjacent seas.

In this sense, we may say that such seiches forecast the visit of a typhoon.

Fig. 6



Next as to the seiches of very large amplitude, we usually meet them when a low-pressure passes over the adjacent seas and there can be distinguished two types among them. In one type, the amplitude increases gradually, and the other begins to oscillate suddenly with a large amplitude from the first.

Fig. 7 shows an example of the former, and Fig. 8 and Fig. 9 are examples of the latter.

According to the investigations of Mr. T. Namekawa and M. Takahashi, which will be published in the near future, the said kinds of seiches seem to be produced by minor fluctuations or kicks, but not the main depression of the atmospheric pressure and also not by wind.

Fig. 7

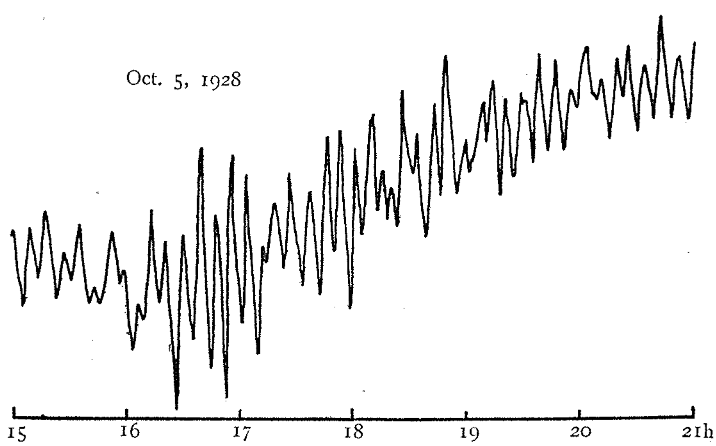


Fig. 8

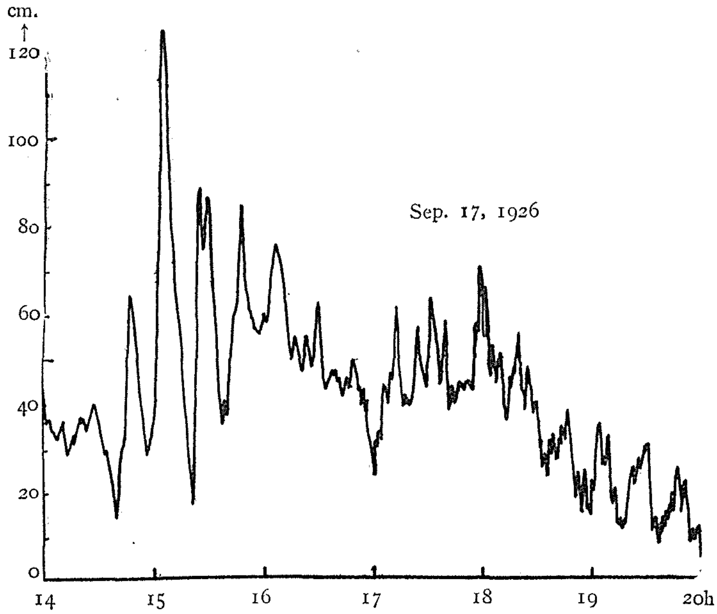
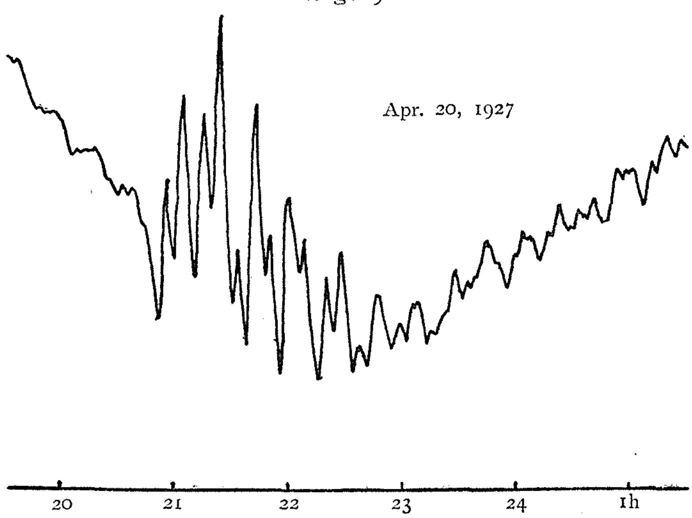

cm.
120
100
80
60
40
20
0
Sep. 17, 1926
14
15
16
17
18
19
20h

Fig. 9


Apr. 20, 1927
20
21
22
23
24
1h

We have had in recent years a great many earthquakes in the Kii Channel and its vicinity and can count more than one hundred perceptible earthquakes every year, but we have not yet detected any singularity in seiches that may be designated the effect of earthquakes.

In conclusion, the writer wishes to express his sincere thanks to Prof. T. Nomitsu for his kind guidance throughout the work, and also to the students for their laborious assistance in the numerical calculations.