Non-Seasonal Variations in the Hydrological Environment off Port Hacking, Sydney

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NON-SEASONAL VARIATIONS IN THE HYDROLOGICAL ENVIRONMENT OFF PORT HACKING, SYDNEY

By F. F. DE CASTILLEJO*

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Summary

Non-seasonal variations of temperature, chlorinity, nitrate, and dissolved oxygen at 10, 50, and 100 m were obtained from an analysis of data collected weekly at Port Hacking 100-m station (34°05′30″S., 151°15′30″E.) over 10 yr.

The mean monthly seasonal variation has been eliminated by taking differences between the weekly observations and the long-term mean for the same month.

Graphs of non-seasonal anomalies are presented and standard deviations of these anomalies and long-term means are given in tables.

I. Introduction

In a recent paper, Newell (1966) described a seasonal cycle in the hydrological regime at the Port Hacking 100-m station (34°05′15″S., 151°15′30″E.). This cycle, however, was based upon a study of 10-yr means in four properties, namely, temperature, salinity, dissolved oxygen, and nitrate. In any individual year there are significant departures from this mean cycle. These departures, or anomalies, reflect an interplay between the various influences on the coastal regime such as riverine dilution or oceanic advection and are a useful measure of change in these influences.

To facilitate future studies, these anomalies have been calculated for the four properties at the three depths (10, 50, and 100 m) and the 10 yr (1953–62) used by Newell. The anomalies have been presented in graphical form. Their standard deviations, and the 10-yr means are also presented, in tabular form.

II. Data and Methods

The data were obtained from CSIRO station lists (CSIRO Aust. 1954, 1956, 1957*a*, 1957*b*, 1959, 1960, 1961, and CSIRO Aust., unpublished data). Approximately weekly observations for 10 yr (1953–62) were considered but only data from 10, 50, and 100 m depths were used, to simplify analysis and avoid short-term (especially diurnal) effects at the surface.

The long-term mean for the pth month, M_p, is given by

$$M_p = \frac{1}{N_p} \sum_{i=1}^{M_p} X_{i,p},$$

where $X_{i,p}$ is the value of the ith observation during the pth month of any year; N_p is the total number of readings taken during all the pth months.

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The anomaly is given by

$$\delta = X_{t,p} - M_p.$$

The standard deviation of the individual anomalies for the pth month is given by

$$\sigma_p = (\Sigma\delta^2/N_p)^{\frac{1}{2}}.$$

Data from the oceanographical station lists were entered on punch cards and a Fortran programme was designed to produce the above operations.

Long-term averages based on records for the period 1953–62 are presented in Table 1. Non-seasonal anomalies are plotted against time for the years 1955–62 (Figs. 1–6), 1953 and 1954 being excluded because of insufficient data.

TABLE 1

LONG-TERM AVERAGES AT PORT HACKING 100-m STATION PERIOD 1953–62

Month	Temperature (°C) at Depths (m):			Chlorinity (‰) at Depths (m):			Nitrate (μg-atom/l) at Depths (m):			Oxygen (ml/l) at Depths (m):		
	10	50	100	10	50	100	10	50	100	10	50	100
January	21·25	17·53	15·13	19·67	19·64	19·58	1·3	3·1	6·0	5·18	4·66	4·45
February	21·91	18·07	14·40	19·62	19·62	19·53	1·0	3·5	8·4	5·08	4·45	4·35
March	22·24	18·17	14·83	19·55	19·60	19·53	1·8	4·6	7·5	4·96	4·41	4·27
April	21·57	19·39	16·32	19·62	19·64	19·59	1·4	2·9	5·8	5·02	4·69	4·28
May	19·72	19·25	17·78	19·70	19·70	19·67	0·3	0·9	3·0	5·04	4·96	4·67
June	18·18	17·77	16·65	19·68	19·69	19·65	1·3	1·9	3·5	5·20	5·04	4·77
July	17·48	17·12	15·95	19·69	19·68	19·63	1·2	2·1	4·2	5·26	5·03	4·83
August	16·62	16·15	15·10	19·69	19·67	19·62	1·3	3·2	5·0	5·43	5·25	5·02
September	16·71	15·63	14·16	19·64	19·61	19·55	0·8	3·2	5·3	5·58	5·08	4·80
October	17·80	15·90	14·27	19·65	19·60	19·54	0·6	4·0	7·6	5·58	4·86	4·53
November	19·10	16·56	14·56	19·63	19·61	19·55	0·8	4·4	6·8	5·32	4·64	4·40
December	19·98	16·81	14·46	19·64	19·61	19·55	0·8	3·7	5·9	5·25	4·55	4·39

Temperature anomalies are expressed in degC, chlorinities in parts per thousand, nitrates in μg-atom of NO_3N/l and the dissolved oxygen as ml/l.

Nitrate anomalies are plotted positive downwards for simplicity because high nitrate content is associated with low temperature, low chlorinity, and low dissolved oxygen content.

Since the correlation between non-seasonal anomalies for different properties at each depth was considered more interesting than the correlation of a particular property at different depths, the anomalies are arranged in three groups, each covering 8 yr of temperature, chlorinity, nitrate, and dissolved oxygen, for a particular depth.

The probability distribution of temperature, chlorinity, nitrate, and dissolved oxygen anomalies was computed and found to be approximately normal. Standard deviations of the anomalies are given in Table 2.

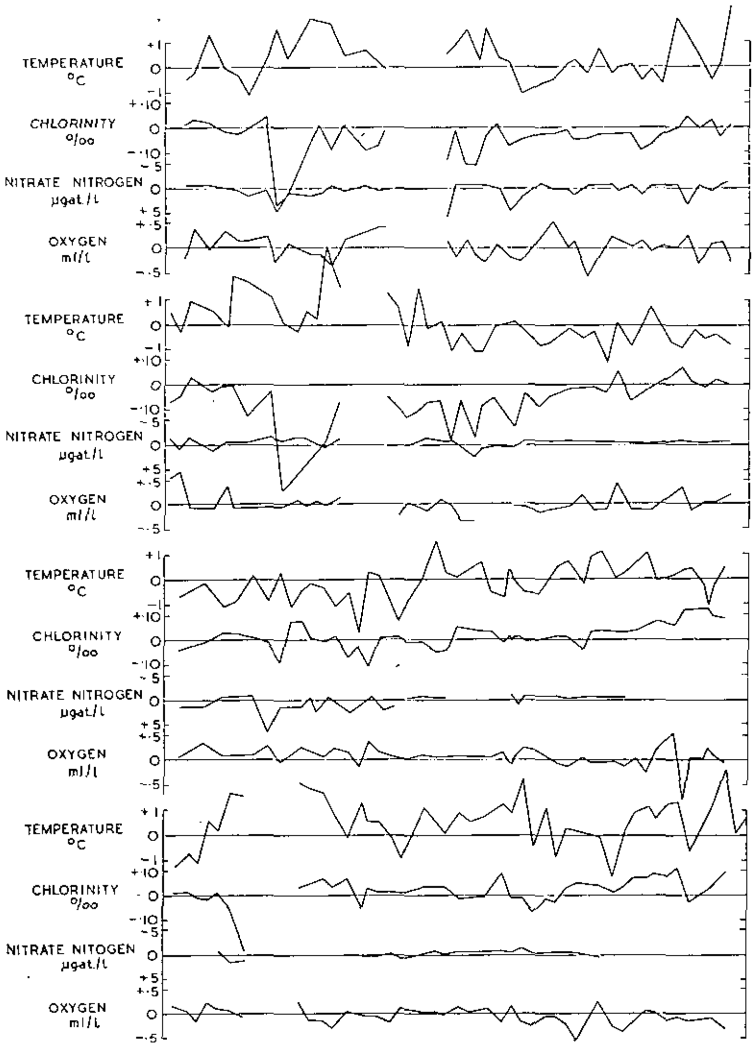

Fig. 1.—Non-seasonal anomalies of temperature, chlorinity, nitrate, and oxygen at 10 m for the period 1955–58.

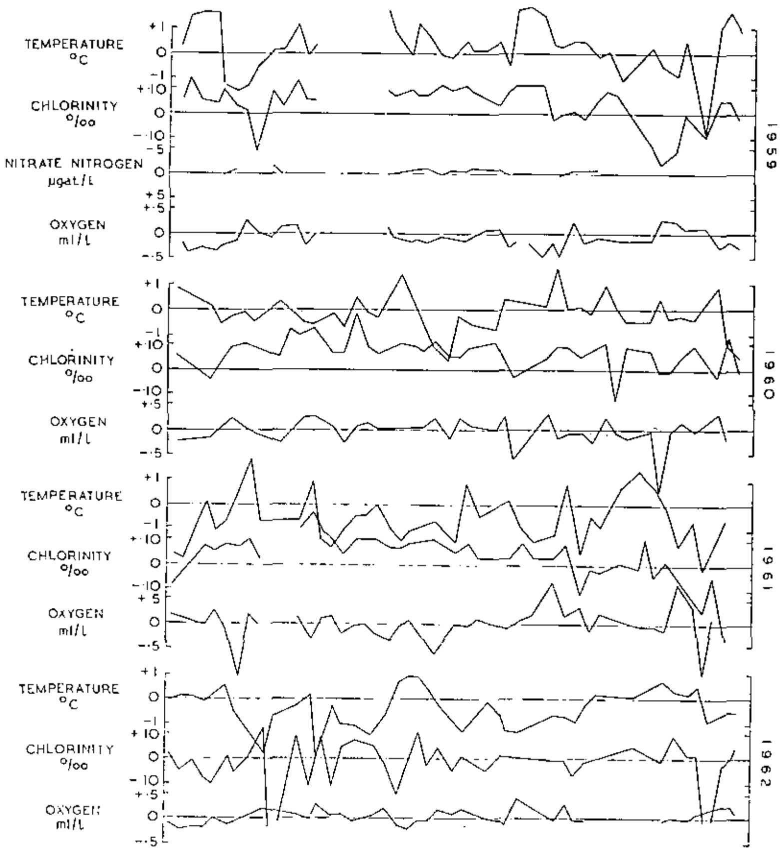

Fig. 2.—Non-seasonal anomalies of temperature, chlorinity, nitrate, and oxygen at 10 m for the period 1959–62.

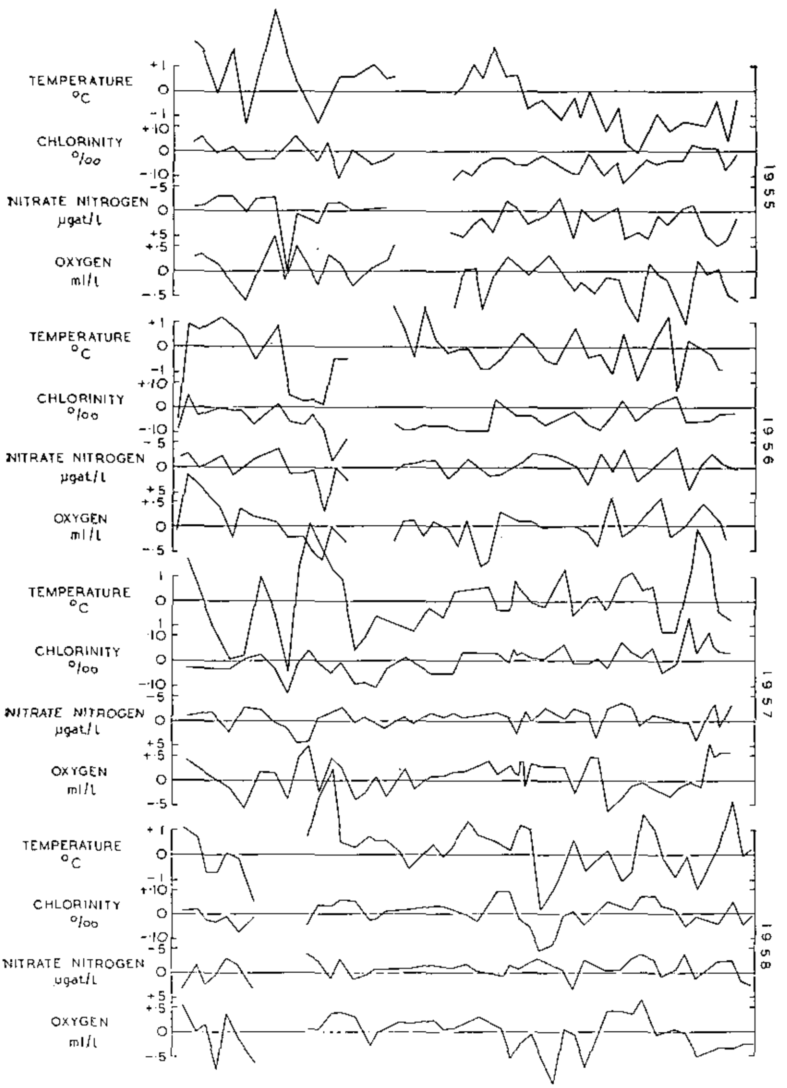

Fig. 3.—Non-seasonal anomalies of temperature, chlorinity, nitrate, and oxygen at 50 m for the period 1955–58.

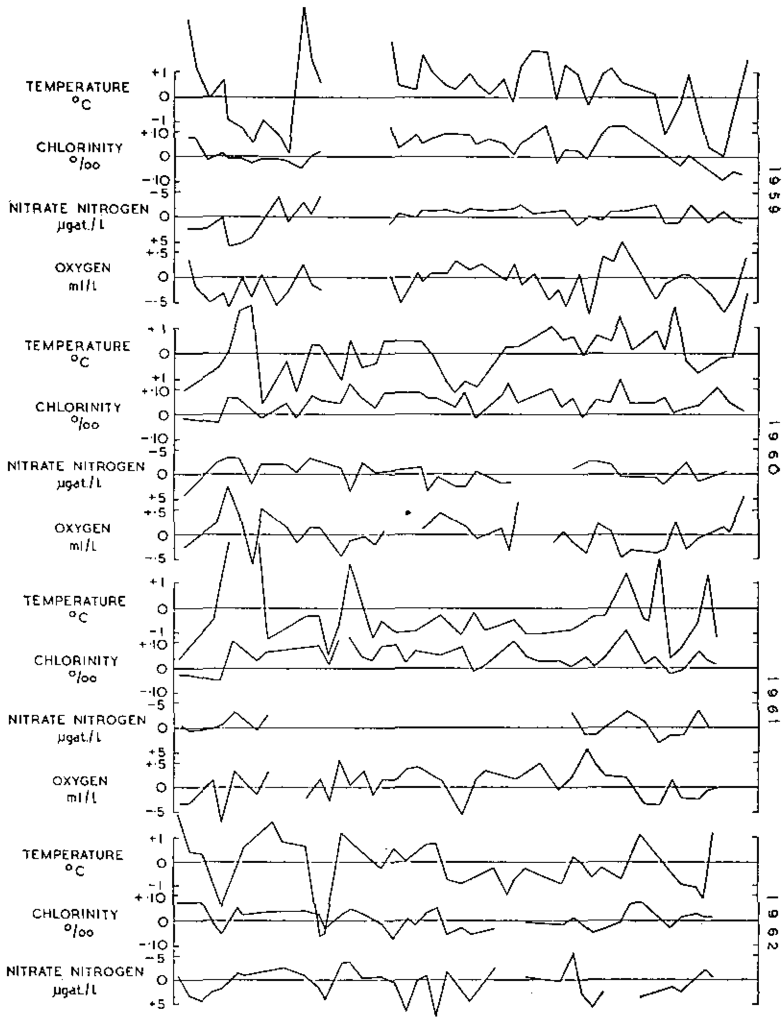

Fig. 4.—Non-seasonal anomalies of temperature, chlorinity, nitrate, and oxygen at 50 m for the period 1959–62.

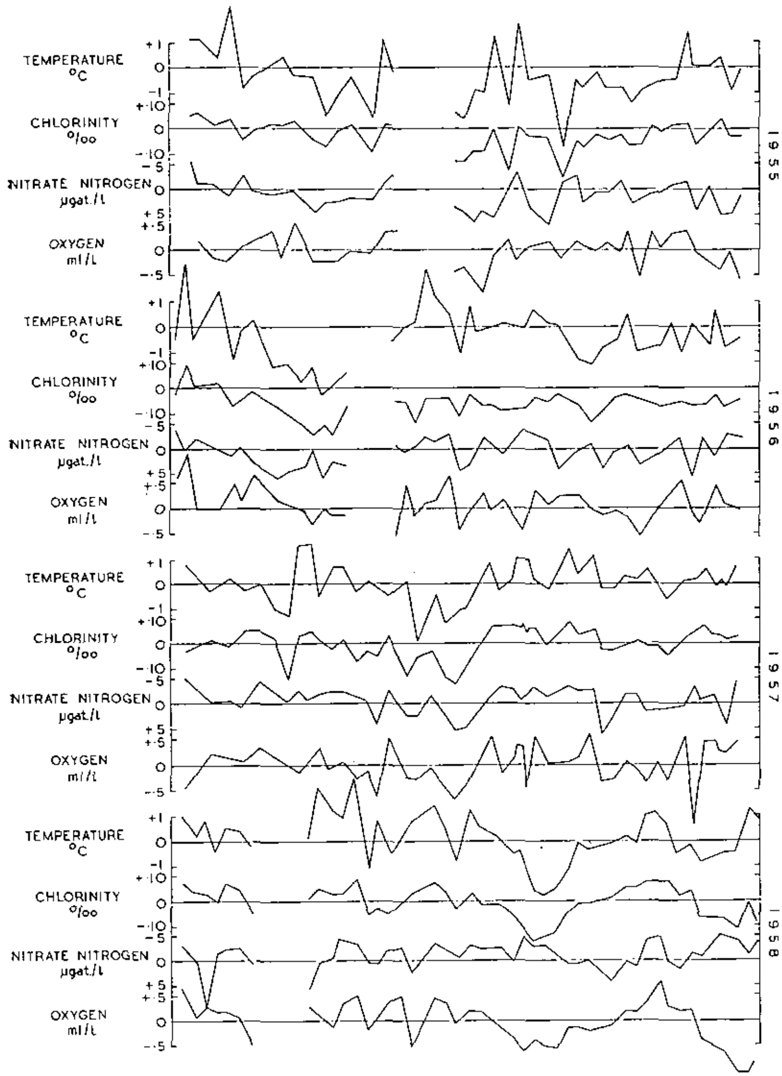

Fig. 5.—Non-seasonal anomalies of temperature, chlorinity, nitrate, and oxygen at 100 m for the period 1955–58.

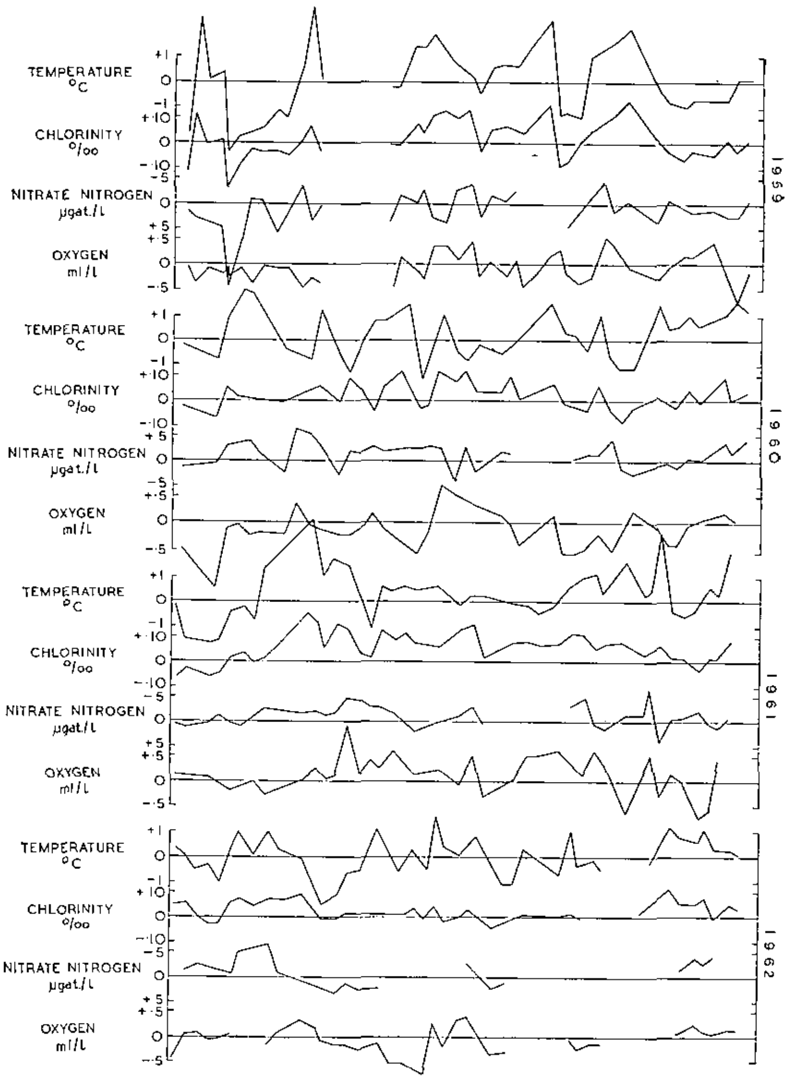

Fig. 6.—Non-seasonal anomalies of temperature, chlorinity, nitrate, and oxygen at 100 m for the period 1959–62.

III. Discussion

Figures 1–6 indicate that in each year deviations from the long-term mean of all four properties at all three depths are irregular in magnitude, timing, and duration, though in general, deviations are least in the period May–July. The magnitude of the deviations is emphasized by Tables 1 and 2, in which it can be seen that the annual range of means in chlorinity, nitrate, and oxygen is only of the order of one standard deviation about the respective monthly means. (Temperature is an exception to this, probably because of the more rapid exchange of heat between depths and between the sea and the atmosphere, compared to dissolved properties.)

Table 2

STANDARD DEVIATIONS OF NON-SEASONAL ANOMALIES AT PORT HACKING 100-m STATION

Month	Temperature (°C) at Depths (m):			Chlorinity (‰) at Depths (m):			Nitrate (μg-atom/l) at Depths (m):			Oxygen (ml/l) at Depths (m):		
	10	50	100	10	50	100	10	50	100	10	50	100
January	0·96	1·49	1·08	0·05	0·04	0·05	1·0	2·1	3·2	0·25	0·43	0·44
February	1·05	1·94	1·07	0·06	0·05	0·06	0·9	2·9	4·2	0·28	0·44	0·25
March	1·14	1·78	1·47	0·05	0·05	0·09	2·4	3·6	3·5	0·19	0·33	0·24
April	1·35	1·50	1·39	0·13	0·08	0·07	0·6	2·8	2·8	0·16	0·34	0·30
May	0·89	0·85	0·88	0·07	0·06	0·07	0·2	0·8	2·2	0·21	0·26	0·38
June	0·84	0·77	1·08	0·08	0·07	0·08	1·6	2·0	2·9	0·18	0·31	0·43
July	0·77	0·74	0·71	0·08	0·06	0·07	1·1	1·7	2·8	0·23	0·36	0·35
August	0·95	0·90	1·14	0·06	0·06	0·08	1·4	4·3	3·8	0·27	0·34	0·37
September	0·65	0·69	0·84	0·05	0·05	0·06	0·6	2·3	2·8	0·25	0·44	0·40
October	0·79	1·29	1·07	0·06	0·09	0·05	0·5	2·9	2·9	0·18	0·47	0·32
November	0·96	1·30	0·67	0·06	0·06	0·05	1·2	2·5	2·0	0·41	0·40	0·38
December	1·26	1·23	0·68	0·11	0·05	0·05	0·5	2·6	3·1	0·21	0·40	0·45

Newell (1966) explained the long-term annual cycle in hydrological properties at Port Hacking in terms of riverine dilution, seasonal climatic change, and oceanic advection. All three influences are basically climatic. The irregularity and magnitude of deviations from the long-term mean at Port Hacking suggest either that this climatic influence is highly variable and exerts its effects rapidly and profoundly, or that the effects of local small scale climatic changes are being superimposed upon the mean seasonal cycle.

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