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Division of Fisheries and Oceanography

REPORT 24

Scientific Reports of a Cruise on

H.M.A. Ships "QUEENBOROUGH" and "QUICKMATCH"

March 24 - April 26, 1958

Marine Biological Laboratory
Cronulla, Sydney
1959

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H.M.A. SHIPS "QUEENBOROUGH" AND "QUICKMATCH"

The Department of the Navy gave permission for scientists from this Laboratory to accompany H.M.A. Ships "Queenborough" and "Quickmatch" to carry out an oceanographical survey of the Coral and Tasman Seas as an International Geophysical Year project. The ships left Sydney March 24, Brisbane March 31, arrived Noumea April 3, departed Wellington April 22, and returned Sydney April 26. The ships travelled together and each carried two scientists. H.M.A.S. "Queenborough" did a regular hydrology cast to 1000 m and a 900 ft bathythermograph lowering, and H.M.A.S. "Quickmatch" did a phytoplankton net tow and carbon fixation determination with $^{14}CO_2$, at the same stations. The stations were located at approximately 100 mile intervals (Fig. 1).

The co-operation of the Department of the Navy is gratefully acknowledged. The interest and assistance of the officers and men of the ships are greatly appreciated.

When citing this Report abbreviate as follows:-
C.S.I.R.O. Aust. Div. Fish. Oceanogr. Rep. No. 24.

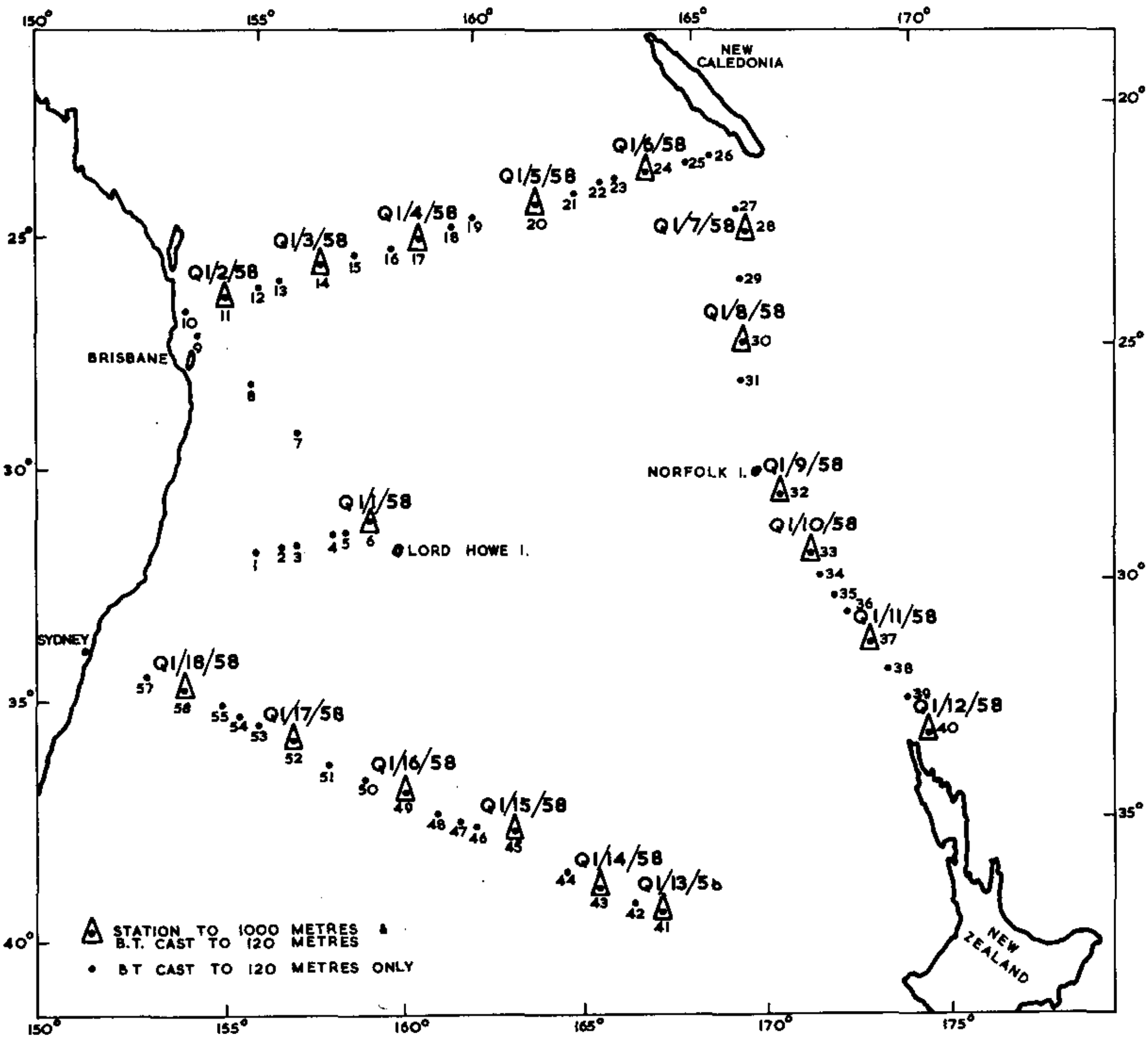

Fig. 1. Cruise Q1/58. Track chart showing stations and positions of bathythermograph casts.

H.M.A. SHIPS "QUEENBOROUGH" AND "QUICKMATCH"

SCIENTIFIC REPORT OF CRUISE Q1/58

March 24 - April 26, 1958

SCIENTIFIC PERSONNEL

H.M.A.S. "Queenborough" - D.J. Rochford (in charge)
F.N. Davies
H.M.A.S. "Quickmatch" - E.J.F. Wood
H. Jitts

ITINERARY

Figure 1 shows the track chart of this cruise with the positions of the Stations Q1/1-18/58, and the positions at which bathythermograph casts to 120 m were made.

SCIENTIFIC REPORTS

(a) HYDROLOGY - D.J. ROCHFORD

At each station samples for chlorinity, dissolved oxygen, inorganic and total phosphate were taken at 0, 25, 50, 75, 100, 150, 200, 300, 500, 750, and 1000 m. Unprotected thermometers were used at all depths below 150 m. During this cruise, sea temperatures were recorded by the use of deep sea reversing thermometers, bathythermographs, and a direct reading thermometer mounted in the sea-water supply to the engine room. The deep sea reversing thermometers had been checked by the manufacturers in Japan prior to use and are accepted as correct to within ± 0.01 °C. All readings at sea were done through a thermometer lens viewer and the reading accuracy was probably well within the performance limits of the thermometer. The temperatures taken by the reversing thermometers were used to check the accuracy of the other method for recording sea temperatures. Figure 2 shows that temperatures registered on the bathythermographs agreed well with the reversing thermometers but those read from the engine room intake thermometer were about 1.5°F too high (Fig. 3). All temperatures have been adjusted to the reversing thermometer equivalent.

Chlorinities were measured on board ship with an electric meter (Hamon 1956). These readings were found subject to a non-systematic error and were repeated later in this laboratory. Their accuracy is probably within the limits of ±0.015°/oo.

Dissolved oxygen was determined by the Winkler method (C.S.I.R.O. 1951). The percentage oxygen saturation values were computed by the method used by Richards and Corwin (1956). The accuracy of the oxygen and percentage saturation values is within the limits of ± 0.05 ml/l. and ± 1.00 per cent. respectively.

Inorganic phosphate was determined on board ship within one hour of collection. An automatic reagent dispenser designed and made at this laboratory (Fig. 4) was found most reliable for the introduction of the molybdate and stannous chloride solution of the Atkins (1923) method. The intensity of the phosphate blue was measured in a Lange photo-electric colorimeter with a cell path of 35 mm. The accuracy of this determination is probably ± 10-15 per cent. for phosphate values below 10 μgP/l., ± 5-10 per cent. in the 10-30 μgP/l. range, and ± 2-5 per cent. in the 30-60 μgP/l. range. Total phosphorus was determined at this laboratory by the method described by Rochford (1951). The accuracy of this determination is equal to and probably higher than that for inorganic phosphate. The value of the difference between total phosphorus and inorganic phosphate has been arbitrarily termed "organic" phosphate in this report.

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Hamon, B.V. (1956).- A portable temperature-chlorinity bridge for estuarine investigations and sea water analysis. J. Sci. Instr. 33: 329-333.

Richards, F.A., and Corwin, N. (1956).- Some oceanographic applications of recent determinations of the solubility of oxygen in sea water. Limn. Oceanogr. 1: 263-7.

Rochford, D.J. (1951).- Studies in Australian estuarine hydrology. I. Introductory and comparative features. Aust. J. Mar. Freshw. Res. 2: 1-116.

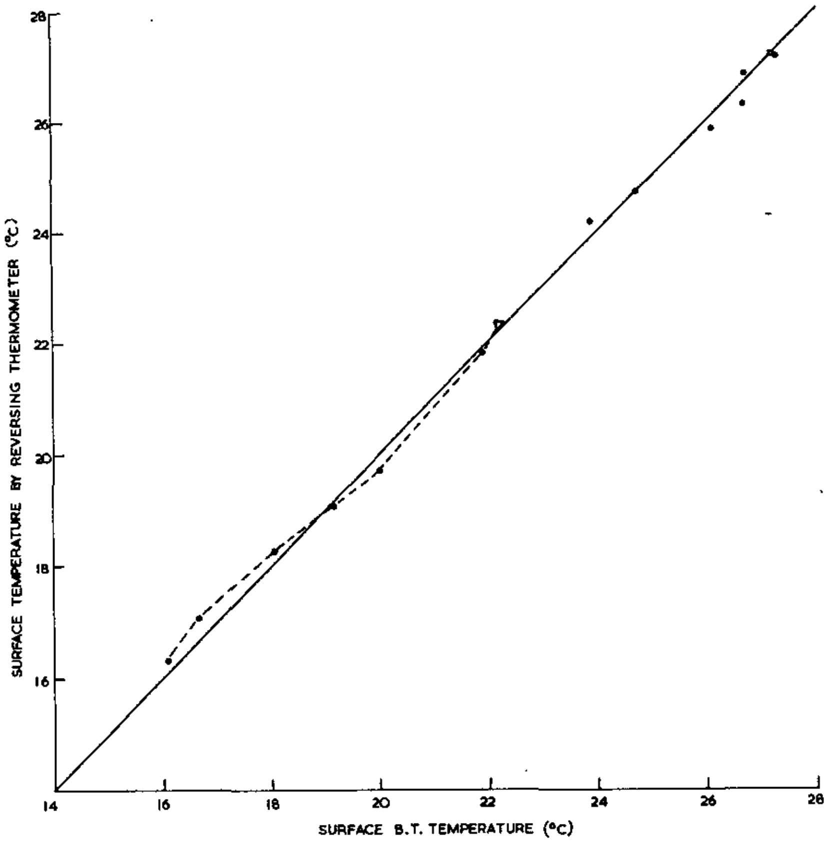

Fig. 2. Comparison of surface bathythermograph and reversing thermometer temperatures.

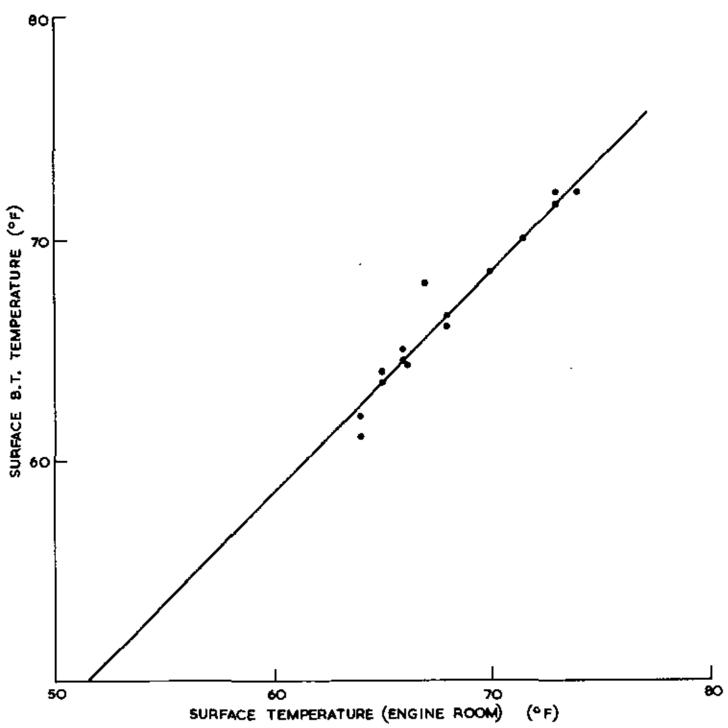

Fig. 3. Comparison of surface bathythermograph and engine room sea-water temperatures.

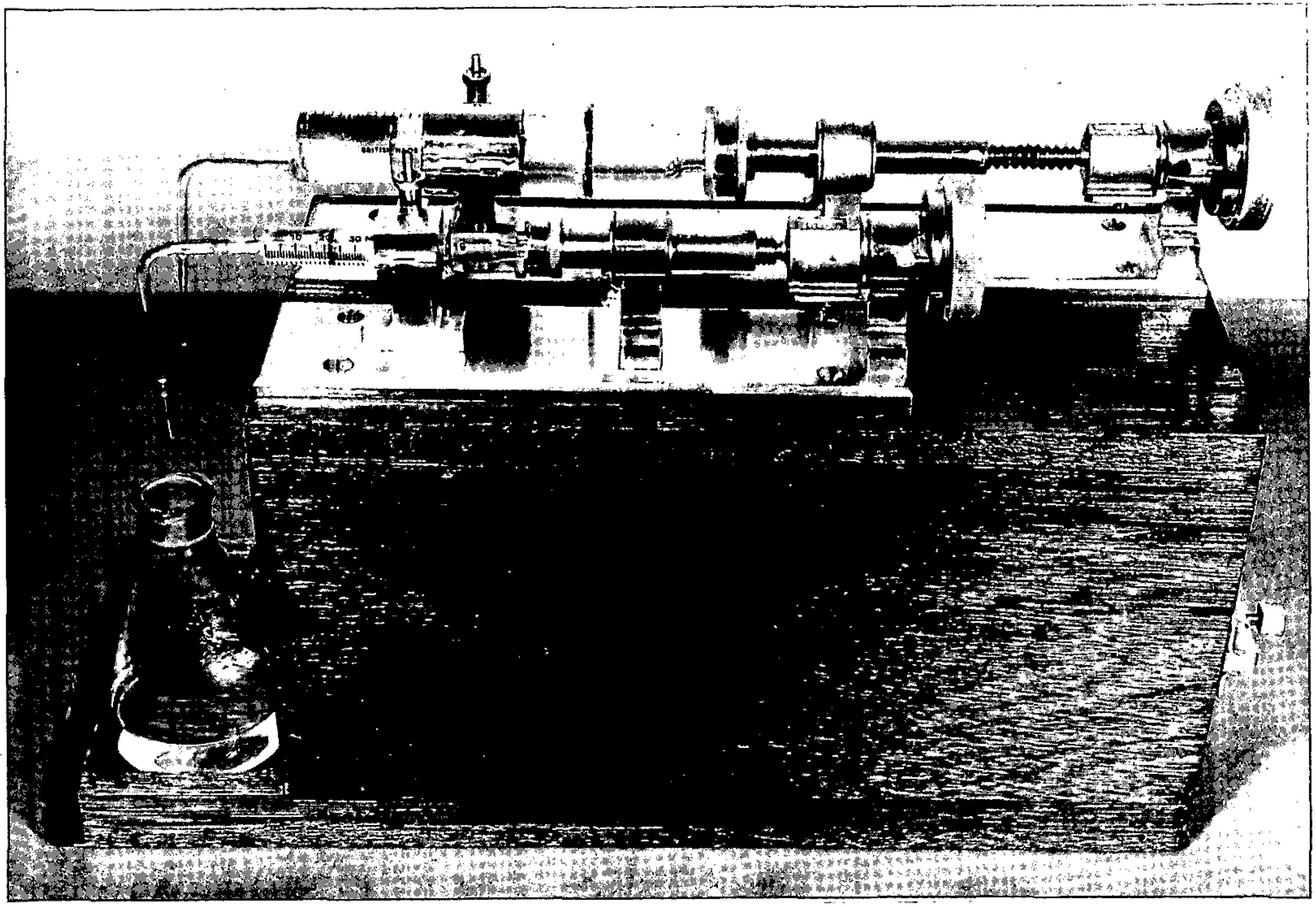

Fig. 4 Automatic reagent dispenser.

I. VERTICAL DISTRIBUTION OF PROPERTIES

A. TEMPERATURE

(1) Bathythermograms (120 m)

(a) Sydney - Lord Howe Island (Fig. 5).- Bathythermograph casts commenced about midway from Sydney and showed an increase in the temperature of the upper 80-90 m to a maximum of 26.11°C in longitude 157°30'E. The lower 90-120 m stratum in general decreased in temperature in the same direction.

(b) Lord Howe Island - Brisbane (Fig. 6).- North-east of Lord Howe I. the 26°C water was not found until near the Australian coast off Moreton Island. Colder waters in general were found nearer the surface at the eastern end of this section.

(c) Brisbane - Noumea (Fig. 7).- On this section the upper 50 m had temperatures higher than 25°C with maximum values of 27.2° in longitude 154° 30'E. and 27.5° in longitude 165-166°E. A thermocline was found between 50-60 m at the majority of stations east of 156°E. Colder waters (20-22°C) were found nearer the surface in the middle region of the section (longitude 157-161°E.).

(d) Noumea - Auckland (Fig. 8).- The temperature of the upper 40-50 m decreased regularly with latitude to about 27°S., but after that almost uniform temperatures were found in this layer until north of New Zealand in latitude 33°S. where a surface decrease from 22 to 19°C occurred within 30 miles. This boundary extended to depths of at least 120 m and separated much colder water on the south from the northern side. A thermocline was found at depths of 45-95 m at most stations north of 32°S. In the layer below 90 m there was a tendency for temperatures to decrease with distance from Noumea.

(e) Wellington - Sydney (Fig. 9).- In the upper 60 m the temperature structure consisted of narrow bands of warm water (Fig. 9) separated by much wider regions of relatively uniform intermediate temperatures. The temperature of these warm bands increased with distance from Wellington. The circulation was almost zonal from west to east in this region (Section (b) of this report) and the surface temperatures were developed by zonal flow and eddies of warm water. West of 158°E. the influence of this warm water extended to deeper levels than further east.

(2) Temperature (°C) to 1000 m

(a) Brisbane - Noumea (Fig. 10).- The 18° isoline occurred at the same depth and separated an upper (0-200 m) and deeper layer (200-1000 m) in which the horizontal variation of temperature progressively increased to the surface in the former, and to about 900 m in the latter.

(b) Noumea - Auckland (Fig. 11).- The 18° isoline rose in a very regular fashion from a depth of 300 m in the north to about 50 m in the south of the section. Above and below the depth of this isotherm the horizontal distribution of temperature was less regular, with maximum deep temperatures at Station Q1/9/58, some 250 miles to the south of the maximum surface temperature at Station Q1/7/58. The coldest waters at all depths occurred at Station Q1/12/58, to the south of the marked surface thermal boundary (Fig. 8).

(c) Wellington - Sydney (Fig. 12).- Along this section there was a progressive deepening of the isotherms from east to west, in accordance with the rise in surface temperatures previously noted (Fig. 9).

B. CHLORINITY ($^{\circ}/_{oo}$) TO 1000 M

(a) Brisbane - Noumea (Fig. 13).- At the surface there were alternating bands of high (19.75-19.80$^{\circ}/_{oo}$) and low (19.55-19.70$^{\circ}/_{oo}$) chlorinity water. The deeper chlorinity structure was not related to these surface features, and exhibited big changes in horizontal distribution in the 200 m level where the temperature structure was very uniform (Fig. 10). In the 800-1000 m layer the chlorinity and temperature structure (Fig. 10) was very similar.

(b) Noumea - Auckland (Fig. 14).- At the surface the chlorinity decreased from north to south, in a similar position to temperature (Fig. 11). In the 0-500 m layer the chlorinity structure was almost uniform south to latitude 30°S. but from that latitude onwards there was a considerable decrease in the depth of the isochlors. Below 500 m the chlorinity structure was not uniform with latitude and had no direct relation to temperature (Fig. 11).

(c) Wellington - Sydney (Fig. 15).- At the surface, chlorinities were 19.66$^{\circ}/_{oo}$ near Wellington with a maximum of 19.71$^{\circ}/_{oo}$ at Station Q1/14/58 and decreasing to a value as low as 19.30$^{\circ}/_{oo}$ at the Sydney end of the section. In the deeper layers there was a marked decrease in the depths of all isochlors to the west of Station Q1/15/58, although no similar variation in temperature structure occurred (Fig. 12).

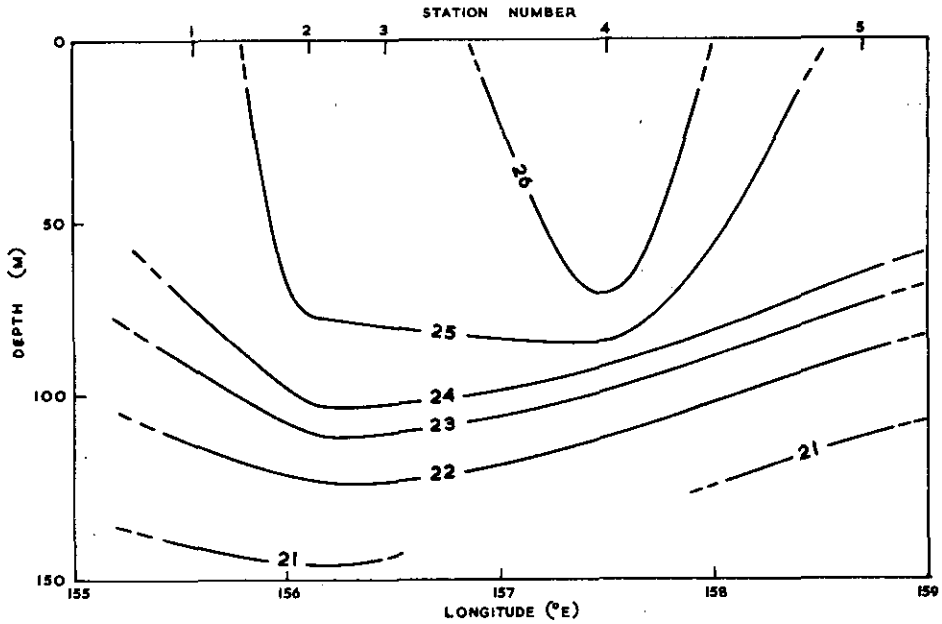

Fig. 5. Sydney - Lord Howe I.

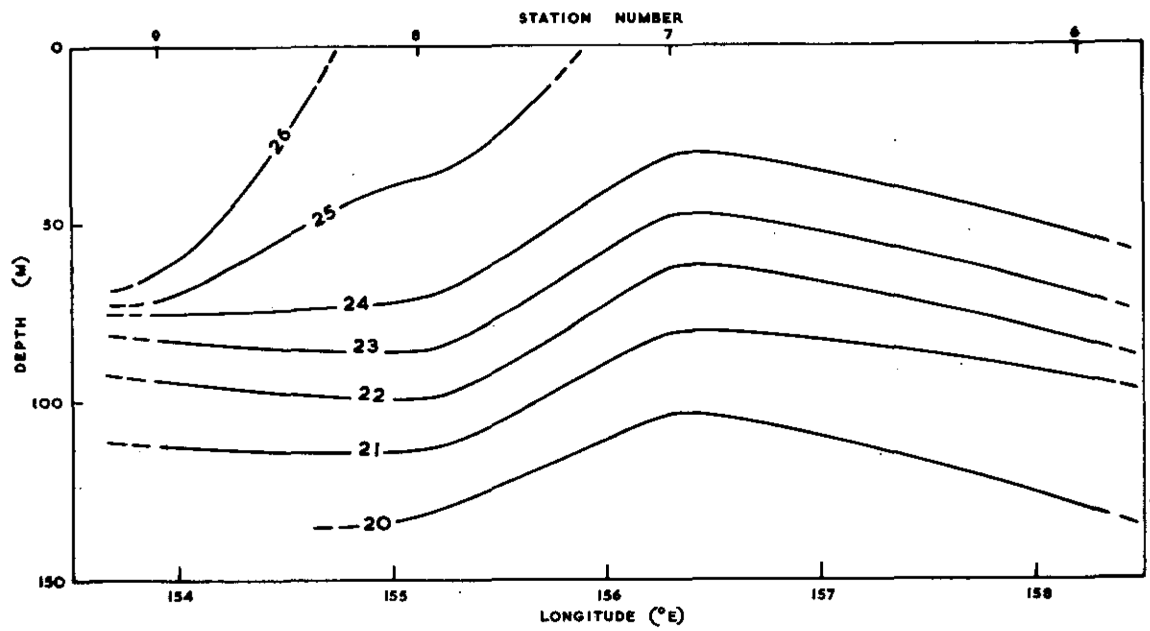

Fig. 6. Lord Howe I. - Brisbane.

Temperature (°C) distribution to 120 m from bathythermograph casts.

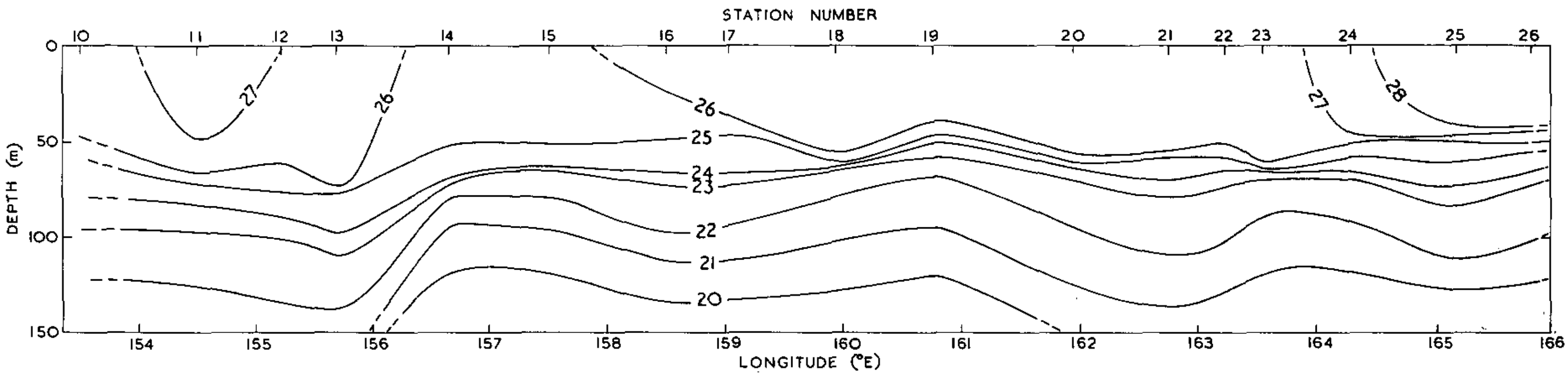

Fig. 7. Brisbane - Noumea

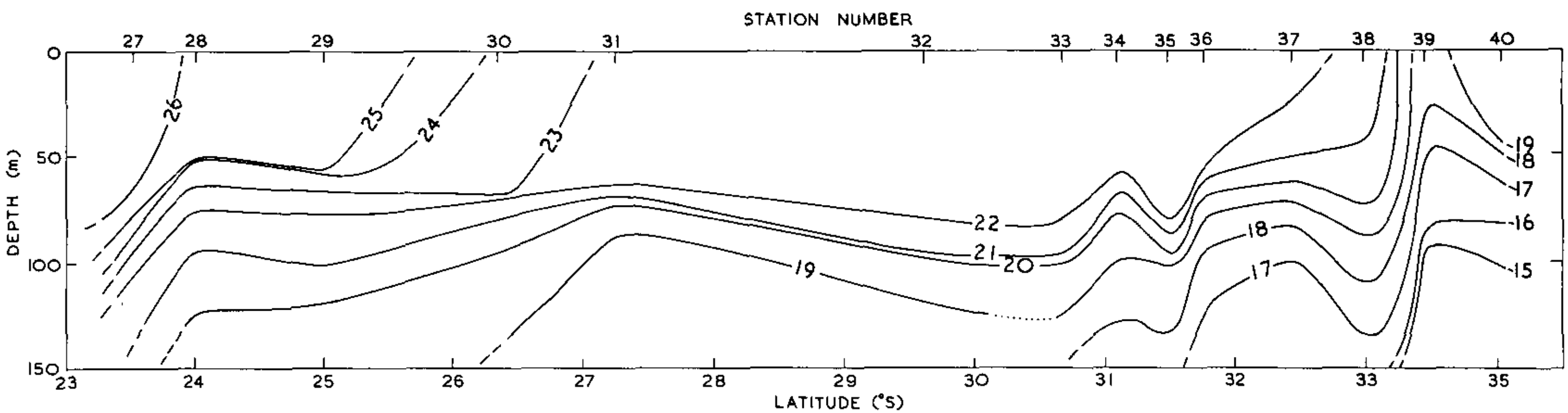

Fig. 8. Noumea - Auckland

Temperature (°C) distribution to 120 m from bathythermograph casts.

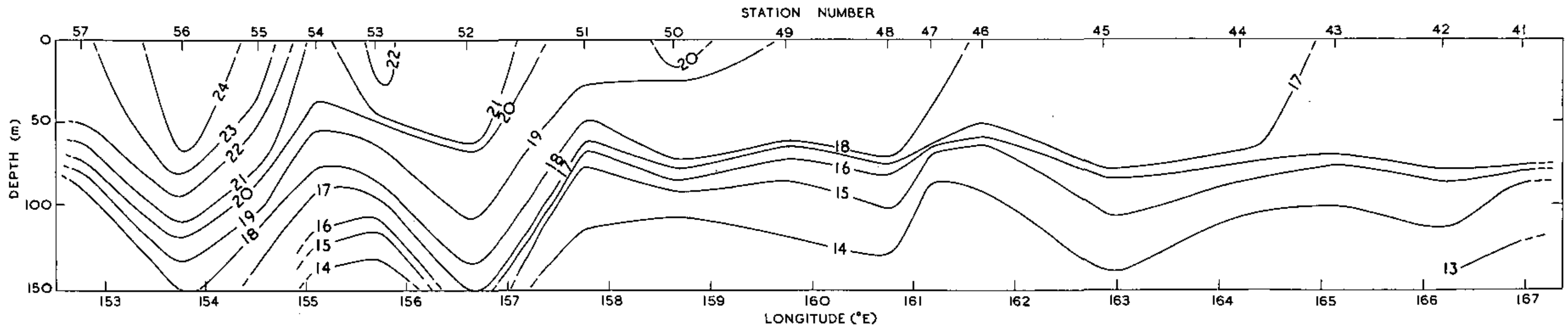

Fig. 9a. Station Q1/13/58 - Sydney

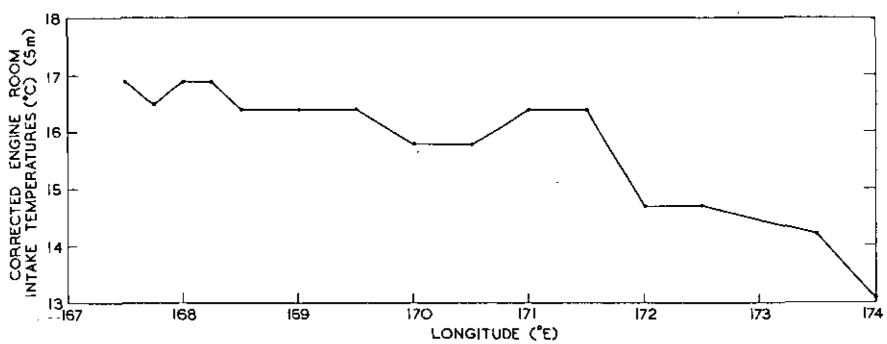

Fig. 9b. Cook Strait - Station Q1/13/58.

Temperature (°C) distribution to 120 m from bathythermograph casts.

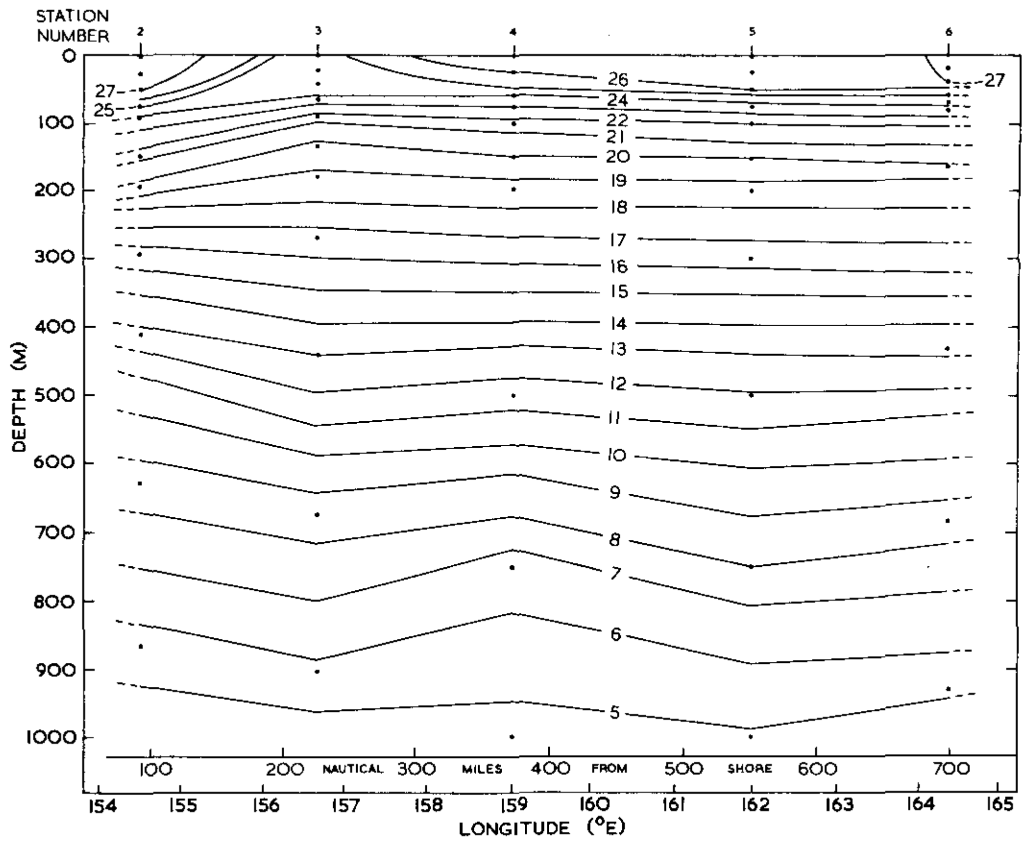

Fig. 10. Brisbane - Noumea

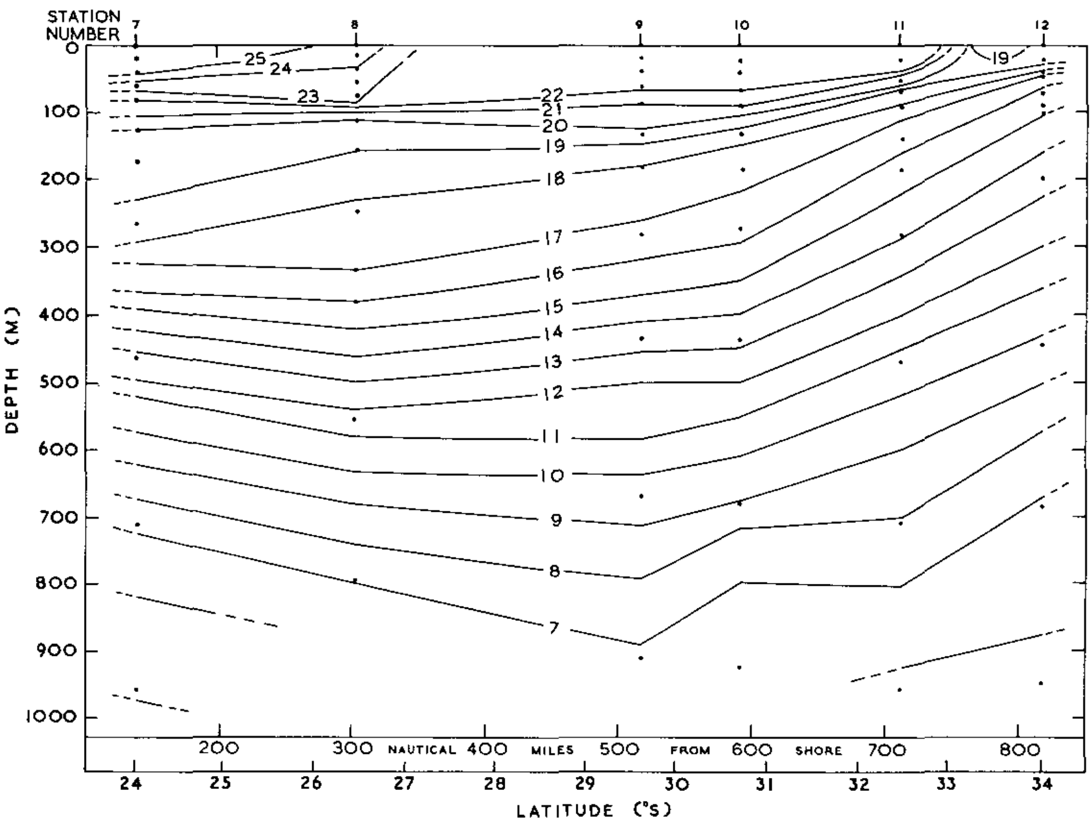

Fig. 11. Noumea - Auckland

Temperature (°C) distribution to 1000 m

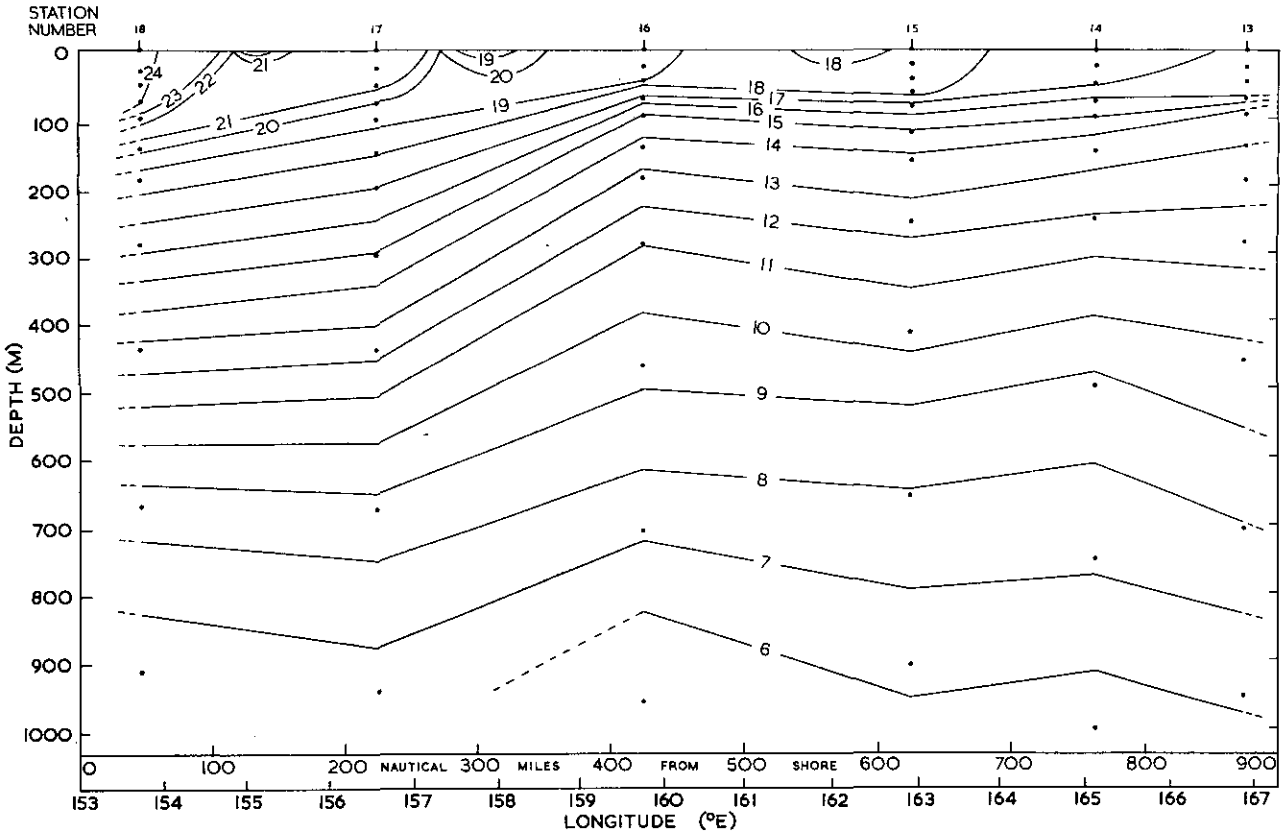

Fig. 12. Wellington - Sydney

Temperature (°C) distribution to 1000 m

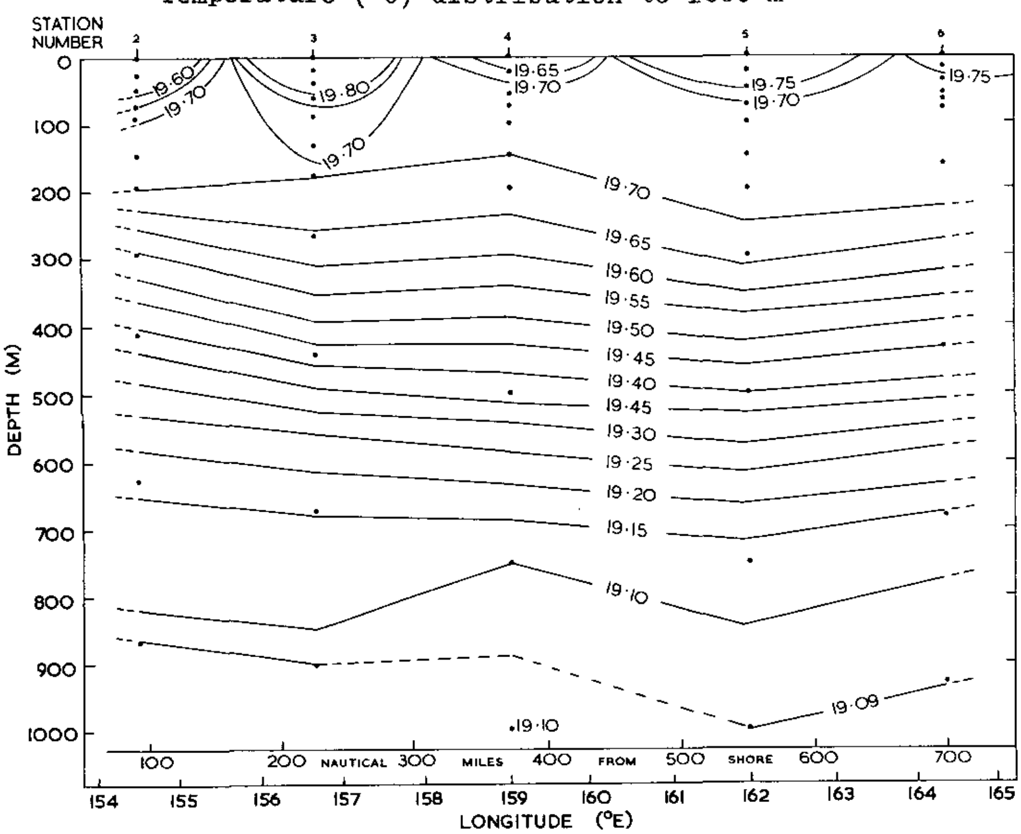

Fig. 13. Brisbane - Noumea

Chlorinity (°/oo) distribution to 1000 m

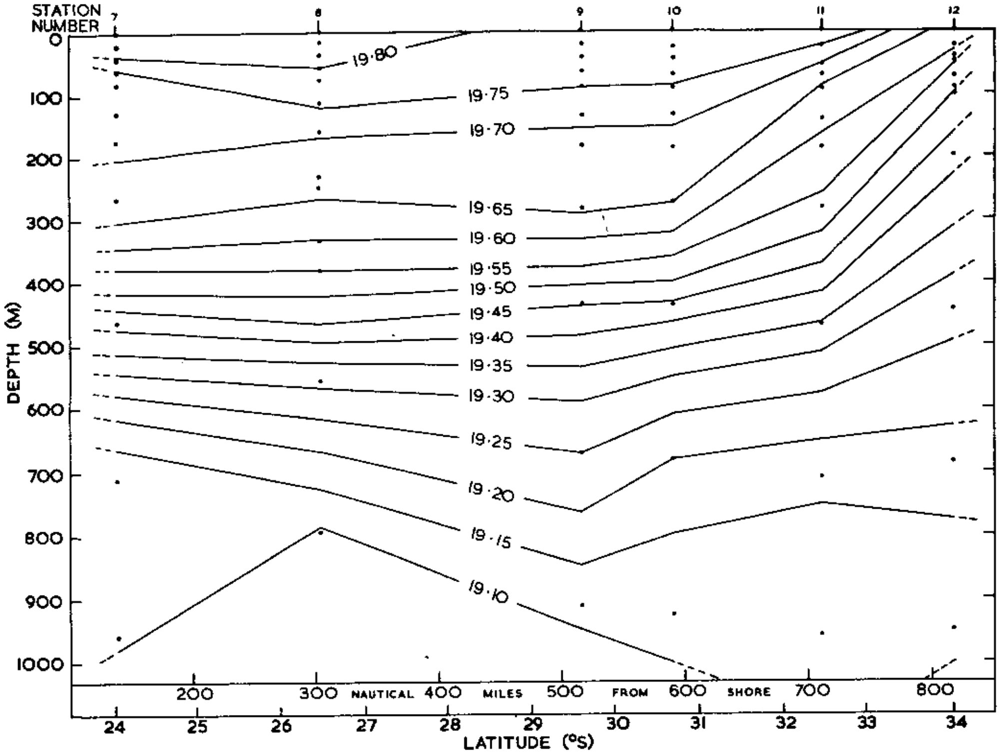

Fig. 14. Noumea - Auckland

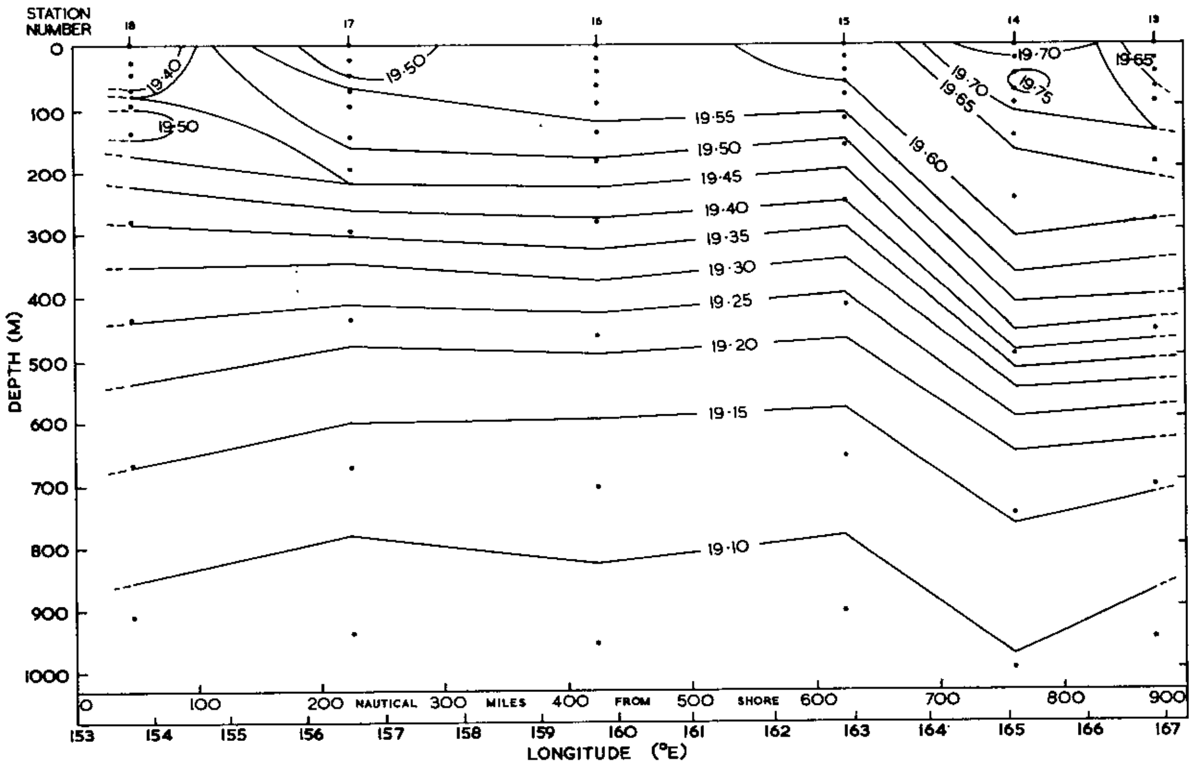

Fig. 15. Wellington - Sydney

Chlorinity (°/oo) distribution to 1000 m

C. DENSITY (σ_t) TO 1000 M

(a) Brisbane - Noumea (Fig. 16).- In the upper 100 m the lightest waters were concentrated at the western end of the section, where a pycnocline (0.022 σ_t/m) had developed. The greatest change in density structure below 100 m occurred in the 800-1000 m layer.

(b) Noumea - Auckland (Fig. 17).- The lighest waters, in the 0-100 m layer, were found at the northern end of the section. A pycnocline (average 0.02σ_t/m) extended throughout the section at depths of 100 (north end) to 50 m (south end).

(c) Wellington - Sydney (Fig. 18).- The lightest waters were found at the western end of this section but no well developed pycnocline was found until Station Q1/16/58, much further to the east. This pycnocline (0.020σ_t/m) extended at depths of 60-100 m from Station Q1/16/58, to the eastern limit of the section. The variability in density structure of the 100-1000 m layer decreased with depth to about 900 m where minimum horizontal changes occurred.

D. PERCENTAGE OXYGEN SATURATION TO 1000 M

(a) Brisbane - Noumea (Fig. 19).- At the surface, values ranging from 95-99 per cent. saturation were found, these had no direct relation to temperature (Fig. 10), or chlorinity (Fig. 13). In the mid depth layers much greater quantities of water with 60-70 per cent. oxygen saturation occurred at the western than at the eastern end.

(b) Noumea - Auckland (Fig. 20).- Values ranging from 97-99 per cent. saturation were found south of Station Q1/33/58, at the surface only, but these bore no relation to other structural features (Figs. 11, 14, 17). In the north, at Station Q1/7/58, saturated waters were found at depths of 50-75 m, and undersaturated (90 per cent.) waters occurred at the surface. Waters within the 60-70 per cent. range in oxygen saturation occupied a greater extent of the vertical column in the south than in the north.

(c) Wellington - Sydney (Fig. 21).- The oxygen content of the upper 50 m varied from 95 to 100 per cent. saturation with minimum values at Stations Q1/17 and 18/58 associated with the low density water at the western end of the section (Fig. 18). East of Station Q1/16/58 the oxygen saturation values decreased most rapidly with depth through the pycnocline (Fig. 18). To the west of this station, where *the pycnocline was not found* (Fig. 18), the decrease in oxygen saturation with depth was much less. Below about 500 m there was general agreement between the oxygen saturation and density structure (Fig. 18).

E. INORGANIC PHOSPHATE (μgP/l.) TO 1000 M

(a) Brisbane - Noumea (Fig. 22).- At the surface, there was a small decrease of phosphate concentration from each end of the section to a minimum of 5μgP/l. at Station Q1/5/58. The phosphate distribution below 200 m was comparable with that of chlorinity (Fig. 13) rather than with any other property.

(b) Noumea - Auckland (Fig. 23).- Phosphate values of 4μgP/l. were found at the surface at Stations Q1/8 and 10/58. Elsewhere values were higher (5-6μgP/l.). Below 100 m the phosphate and density structure (Fig. 17) were in agreement except at either end of the section. Phosphate values at the northern end were lower, values at the southern end were higher, than those at equivalent densities in the middle position of this section.

(c) Wellington - Sydney (Fig. 24).- Surface phosphate concentrations in this section were higher than in the other sections. The density (Fig. 18) and phosphate structure were similar below about 100 m except for the two end stations where the phosphate values were lower at the western end and higher at the eastern end than the values at equivalent densities in the middle of the section.

F. TOTAL PHOSPHORUS TO 1000 M

(a) Brisbane - Noumea (Fig. 25).- At the surface the highest total phosphorus value (19μgP/l.) was found at Station Q1/4/58, where a value of 16μgP/l. was found but elsewhere the total phosphorus ranged from 9-12μgP/l. Below about 200 m the total phosphorus was entirely in the inorganic form (Fig. 22), except at Station Q1/3/58 where below about 600 m 75-80 per cent. only of the total phosphorus was inorganic. At the 500 m level, the distribution of total phosphorus followed that of density (Fig. 16). Above and below this level however the two fields did not agree.

(b) Noumea - Auckland (Fig. 26).- Surface values ranged from 7-11μgP/l. with minimum values at the northern, and maximum values at Stations Q1/8 and 11/58. Below about 400 m the total phosphorus was entirely inorganic (Fig. 23), except for Station Q1/12/58, where 75-80 per cent. only was in the inorganic form. Below 300 m the total phosphorus and density fields (Fig. 17) were similar except for Station Q1/7/58 where higher total phosphorus values were found than for similar densities elsewhere.

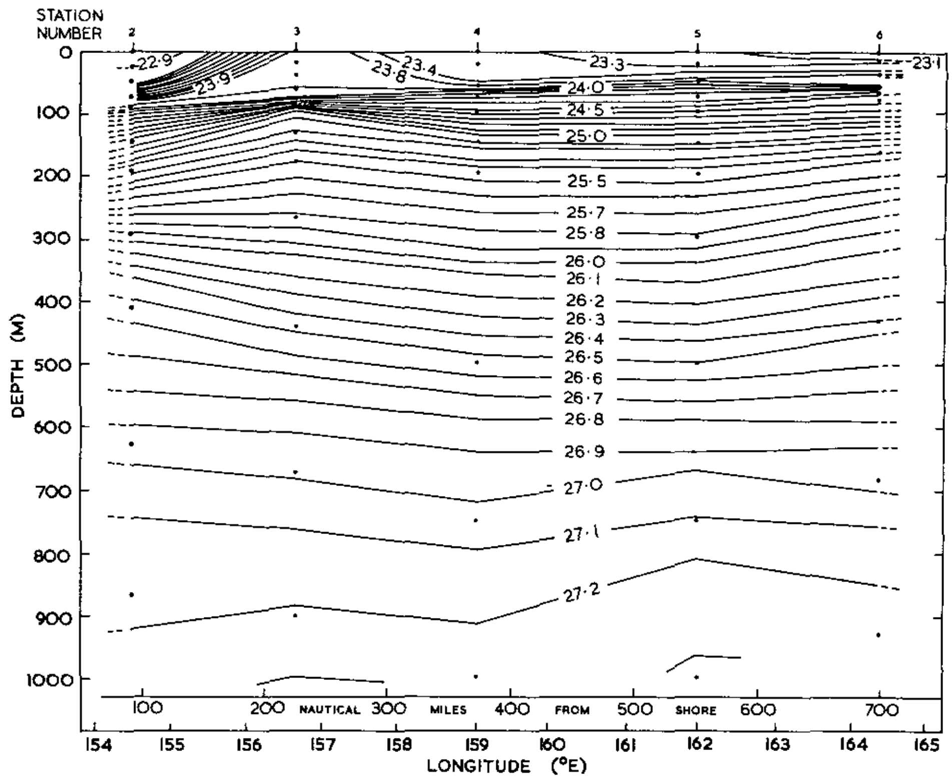

Fig. 16. Brisbane - Noumea

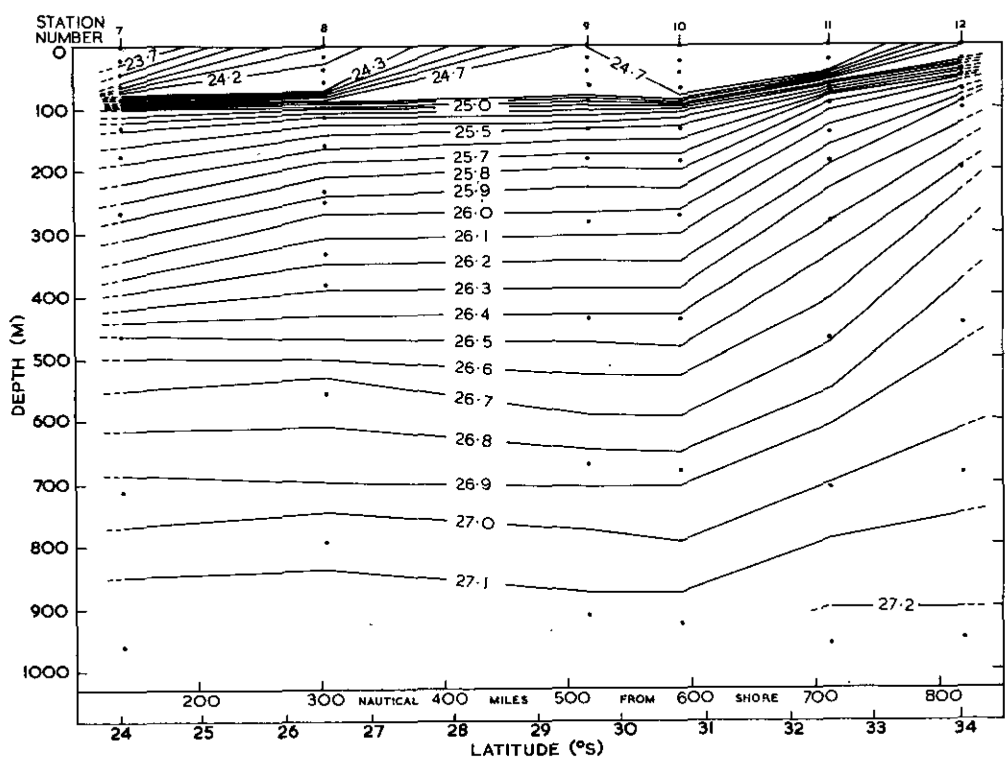

Fig. 17. Noumea - Auckland

Density (σ_t) distribution to 1000 m

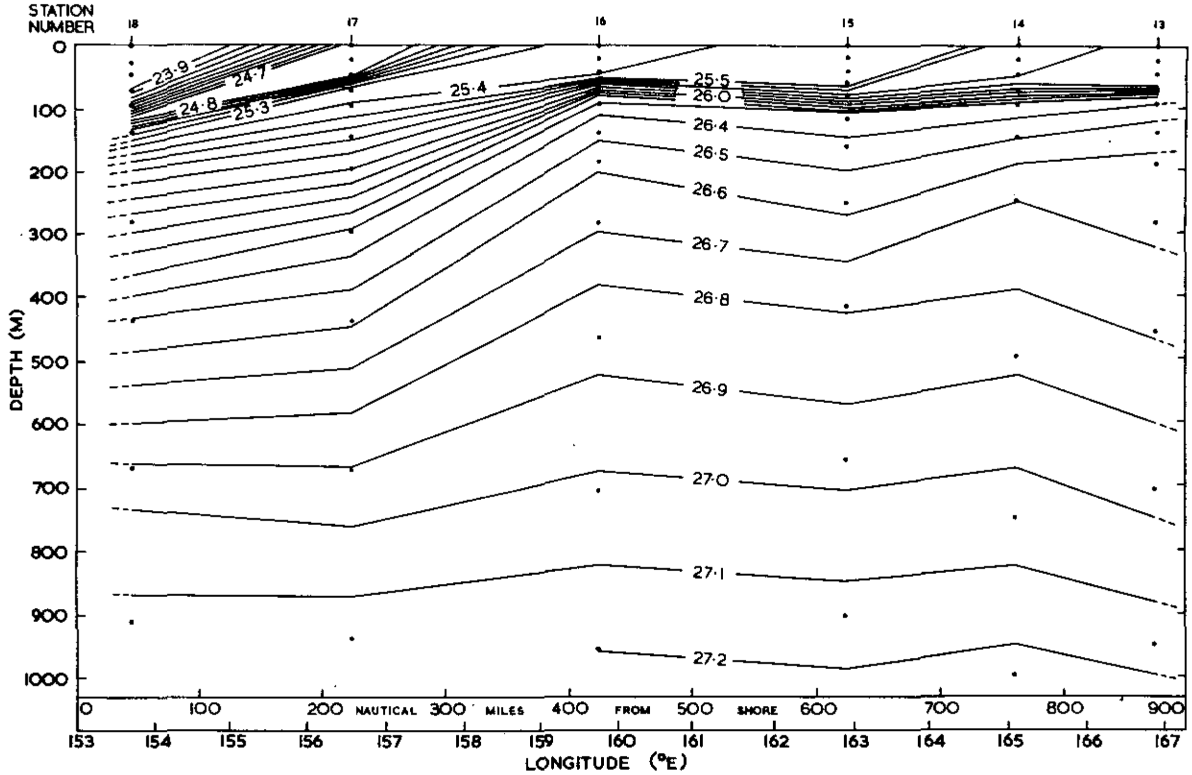

Fig. 18. Wellington - Sydney

Density (σ_t) distribution to 1000 m

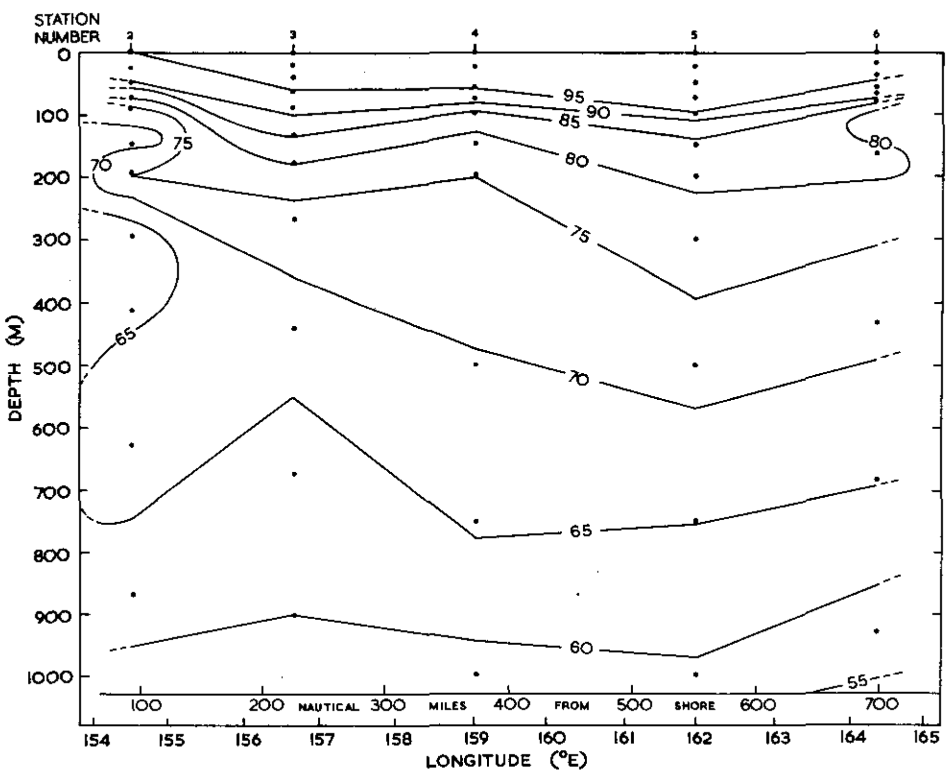

Fig. 19. Brisbane - Noumea

Percentage oxygen saturation distribution to 1000 m

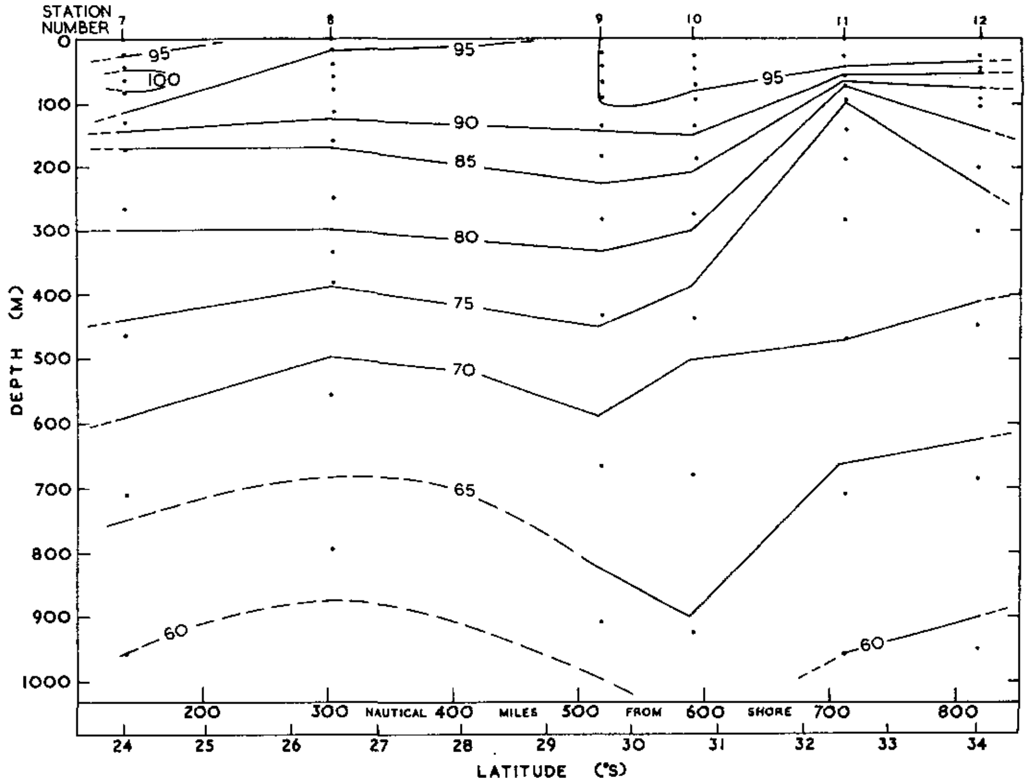

Fig. 20. Noumea - Auckland

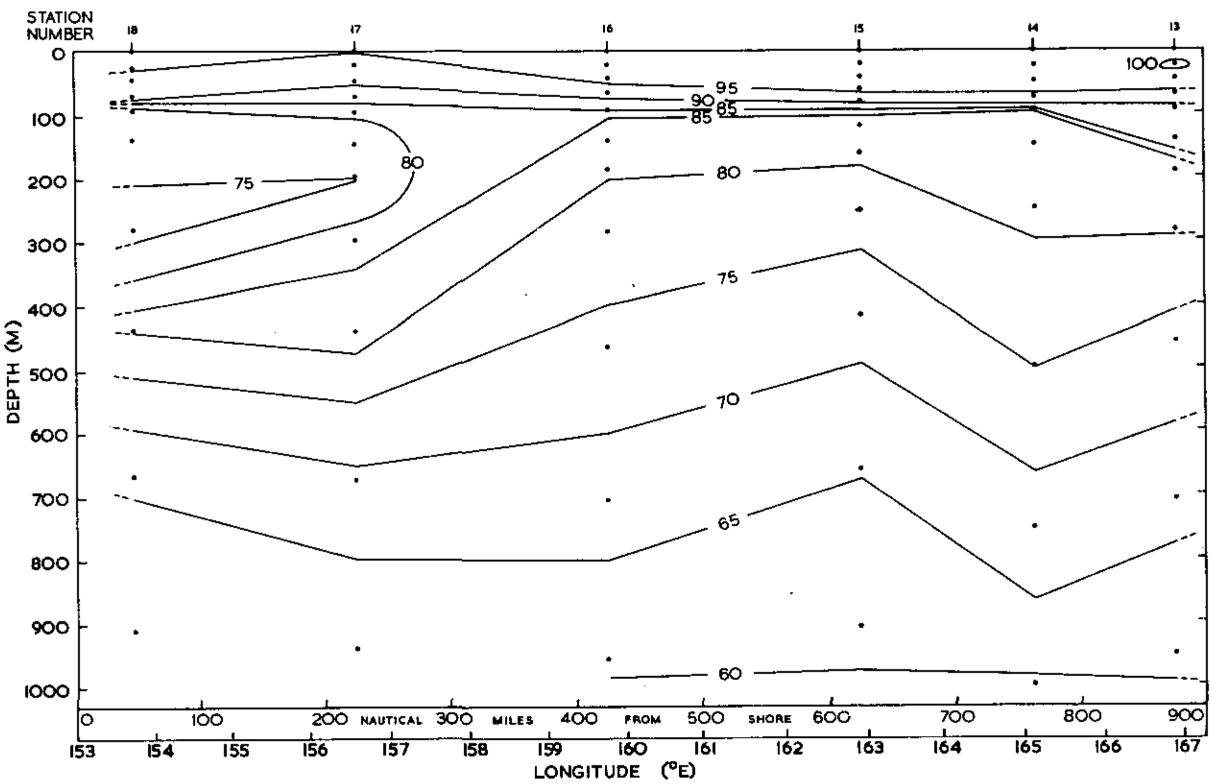

Fig. 21. Wellington - Sydney

Percentage oxygen saturation distribution to 1000 m

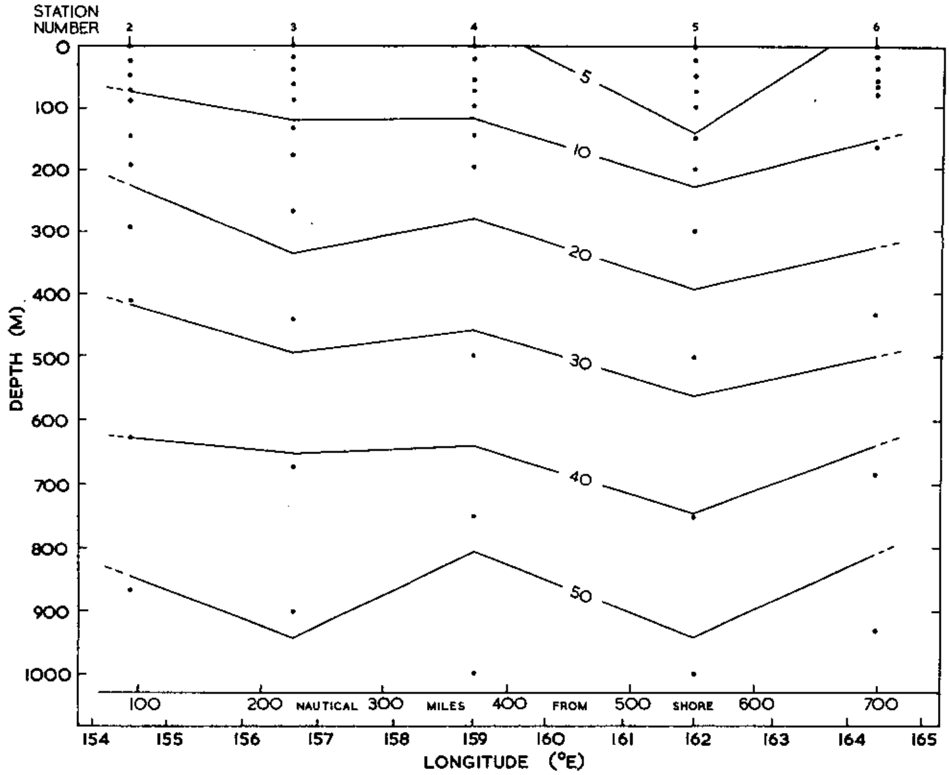

Fig. 22. Brisbane - Noumea

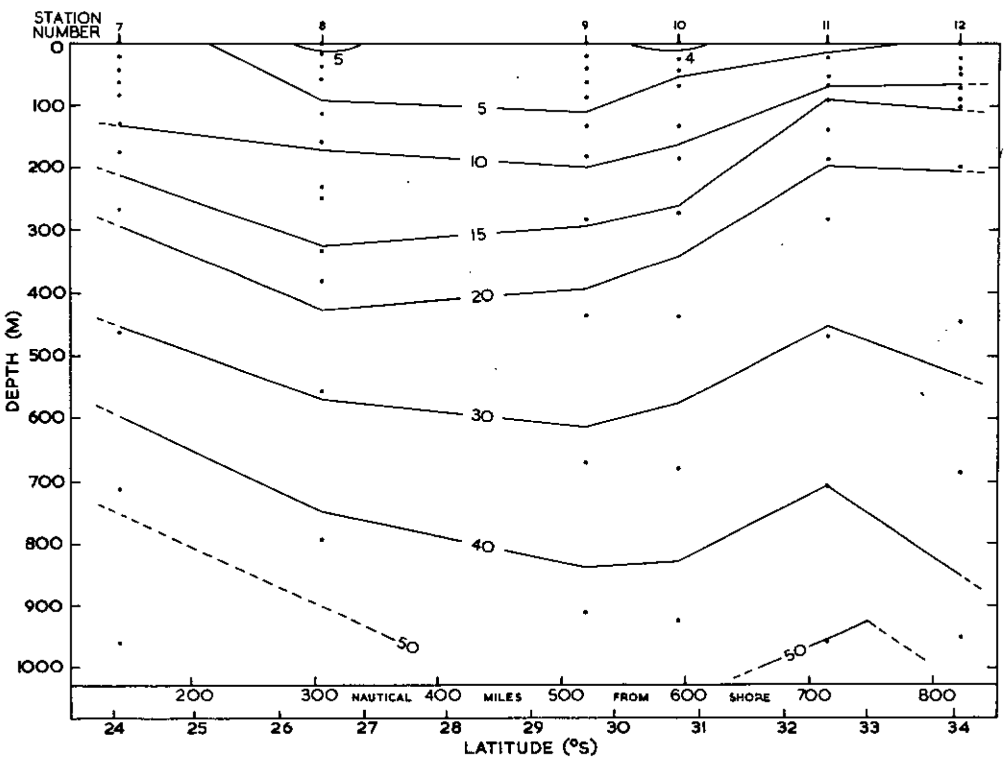

Fig. 23. Noumea - Auckland

Inorganic phosphorus (μgP/l.) distribution to 1000 m

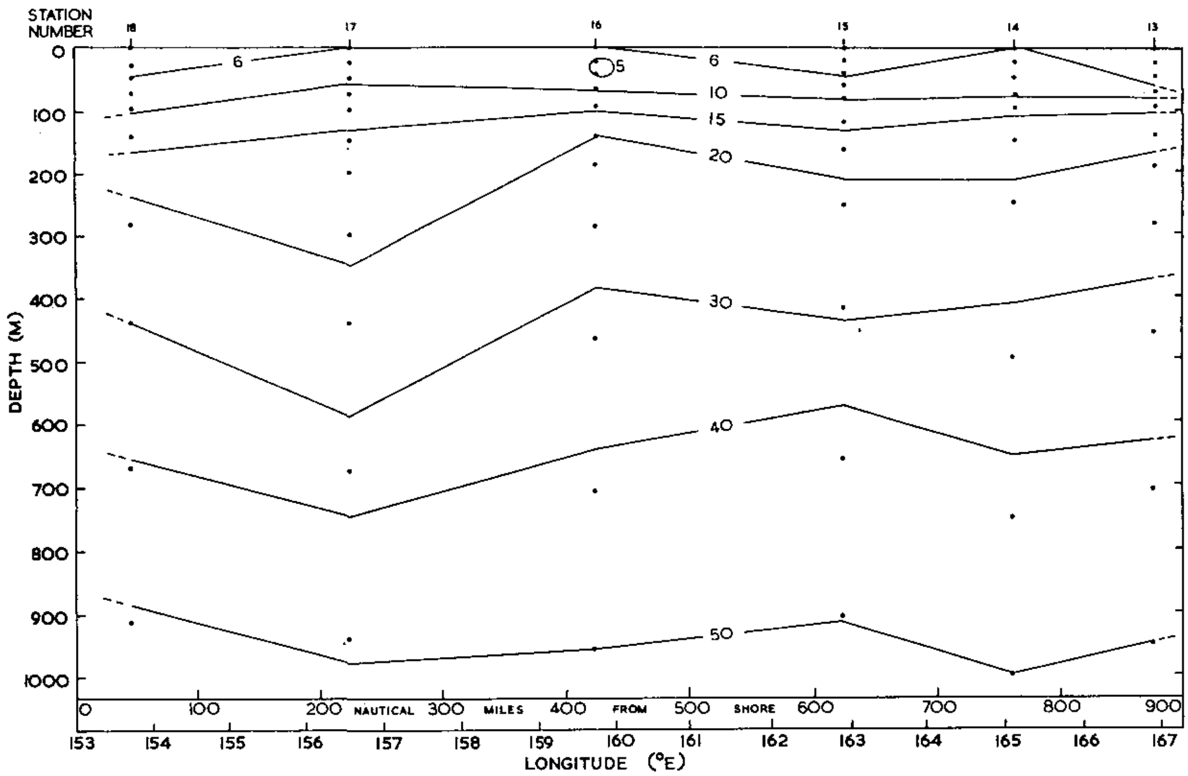

Fig. 24. Wellington - Sydney

Inorganic phosphorus (μgP/l.) distribution to 1000 m

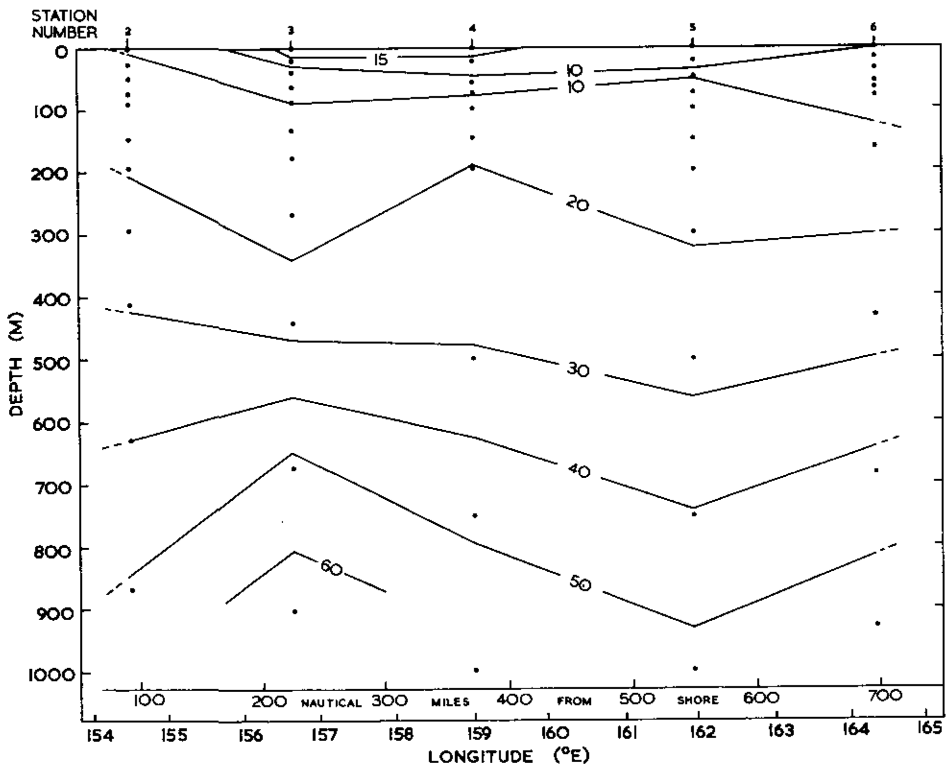

Fig. 25. Brisbane - Noumea

Total phosphorus (μgP/l.) distribution to 1000 m

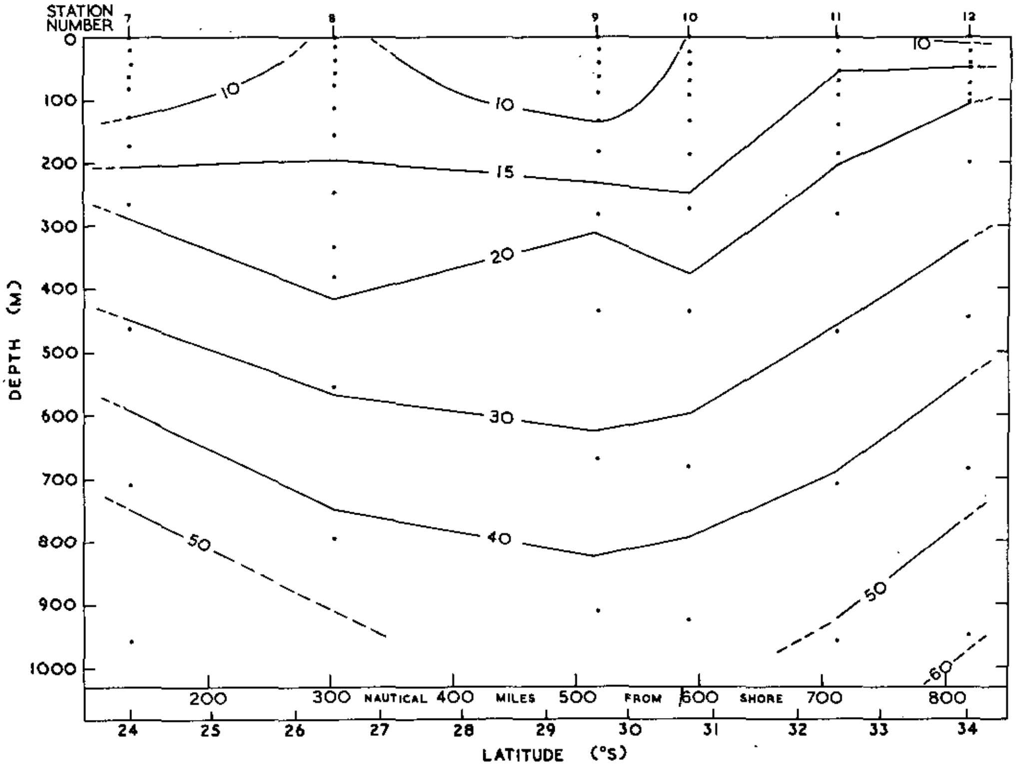

Fig. 26. Noumea - Auckland

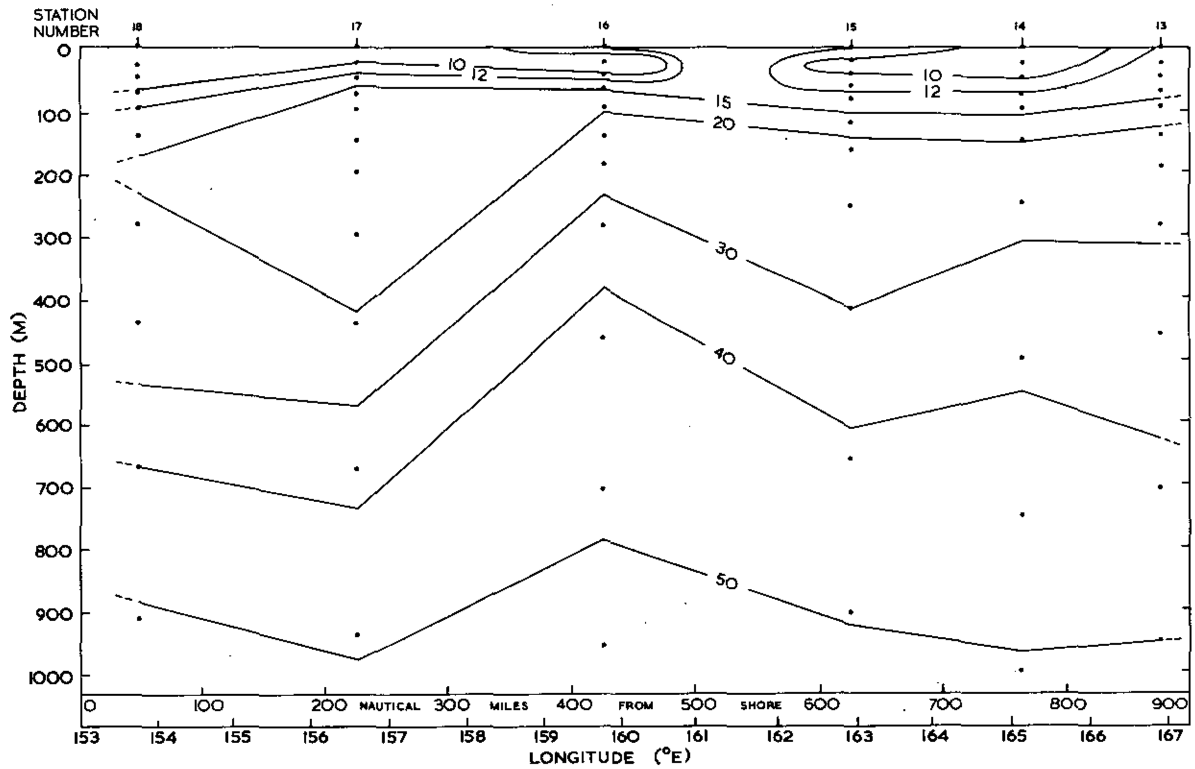

Fig. 27. Wellington - Sydney

Total phosphorus (μgP/l.) distribution to 1000 m

(c) Wellington - Sydney (Fig. 27).- Surface values ranged from 8-13μgP/1. with maximum values at Station Q1/13/58 and between Stations Q1/15 and 16/58 and minimum values between these two regions at Station Q1/14/58. Below about 500 m the total phosphorus was entirely inorganic (Fig. 24) except for Station Q1/16/58 where only 80-90 per cent. was in this form. The distribution of total phosphorus below 500 m was closely related to that of density (Fig. 18), except that total phosphorus values were higher at Station Q1/16/58 and lower at Station Q1/17/58 than normally associated with particular values of density elsewhere.

II. HORIZONTAL DISTRIBUTION OF PROPERTIES

(1) Surface

(a) Temperature (Fig. 28).- South of latitude about 34°S. the isotherms were distributed zonally, but north of this latitude meridional distortion occurred in the western half of the region. This was brought about by the transfer of 25°C waters north and south, and to a lesser extent by the more southward transport of 27°C waters in the extreme western side.

(b) Chlorinity (Fig. 29).- The maximum chlorinity (19.80°/oo) was found in a zone extending west from the area south of New Caledonia. The high temperature waters along the western side of the region (Fig. 28) had chlorinities less than 19.60°/oo. South of latitude 35°S. chlorinities decreased rapidly towards the south-east corner of the region.

(c) Percentage Oxygen Saturation (Fig. 30).- The area as a whole was undersaturated with oxygen. The region of maximum chlorinity (Fig. 29) had values of oxygen saturation varying from 90-97 per cent.

(d) Inorganic Phosphate (Fig. 31).- Minimum values (4μg P/1.) were found between New Caledonia and New Zealand. The highest value, 9μgP/1., was found midway between New Zealand and Australia. This value was associated with a near saturation value of oxygen (Fig. 30), but this relation was not consistent throughout the region.

(e) Total Phosphorus (Fig. 32).- The minimum values were found in the region of high chlorinity (Fig. 29), 25°C (Fig. 28) waters. The maximum values at Stations Q1/3/58 and Q1/16/58 were associated with eddies (see Section (b) of this Report).

(f) Organic Phosphorus (Fig. 33).- Maximum values were found associated with the eddies at Stations Q1/3/58 and Q1/16/58. In general the organic phosphorus levels decreased evenly in all directions from these two stations. Minimum values were found off east Australia, New Caledonia, and northern New Zealand.

(2) 100 m

(a) Temperature (Fig. 34).- At this level there was a general tendency for the isotherms to run in a north-east to south-west direction except along the east Australian coast where meridional distribution occurred.

(b) Chlorinity (Fig. 35).- The isochlors at this level were only slightly distorted from a zonal distribution pattern, with a wedge of high chlorinity ($19.75 - 19.78\,^{o}/_{oo}$) waters at Stations Q1/8/58 and Q1/9/58 (Fig. 35) separating lower chlorinity waters to the north and south.

(c) Percentage Oxygen Saturation (Fig. 36).- The wedge of high chlorinity water (Fig. 35) had the highest percentage oxygen saturation, with minimum values in the vicinity of east Australia, New Caledonia, and northern New Zealand.

(d) Inorganic Phosphate (Fig. 37).- At this level minimum inorganic phosphate was found along the path of maximum oxygen saturation (Fig. 36) and to some extent of maximum chlorinity (Fig. 35). On either side of this region of lowest values, phosphate increased particularly sharply south of Norfolk Island to a maximum value of $17 \mu gP/l$. This region had a low oxygen saturation (Fig. 36).

(e) Total Phosphorus (Fig. 38).- The region of minimum total phosphorus at this level lay on the northern limit of the high chlorinity waters (Fig. 35) and extended south-west to Australia. South of this region the total phosphorus increased at this level in relation to decreases in chlorinity (Fig. 35) and temperature (Fig. 34). North of this region total phosphorus increased only slightly except at Station Q1/4/58 which lies to the east of the high surface values (Fig. 39) associated with an eddy.

(f) Organic Phosphorus (Fig. 39).- At the northern end of the region of minimum inorganic phosphates (Fig. 37) the organic phosphorus was at a maximum, but it decreased to its minimum value along a wedge extending through Station Q1/11/58, where the maximum inorganic phosphate was found (Fig. 37). In general there seemed to be an inverse relationship between inorganic and organic phosphorus at this level.

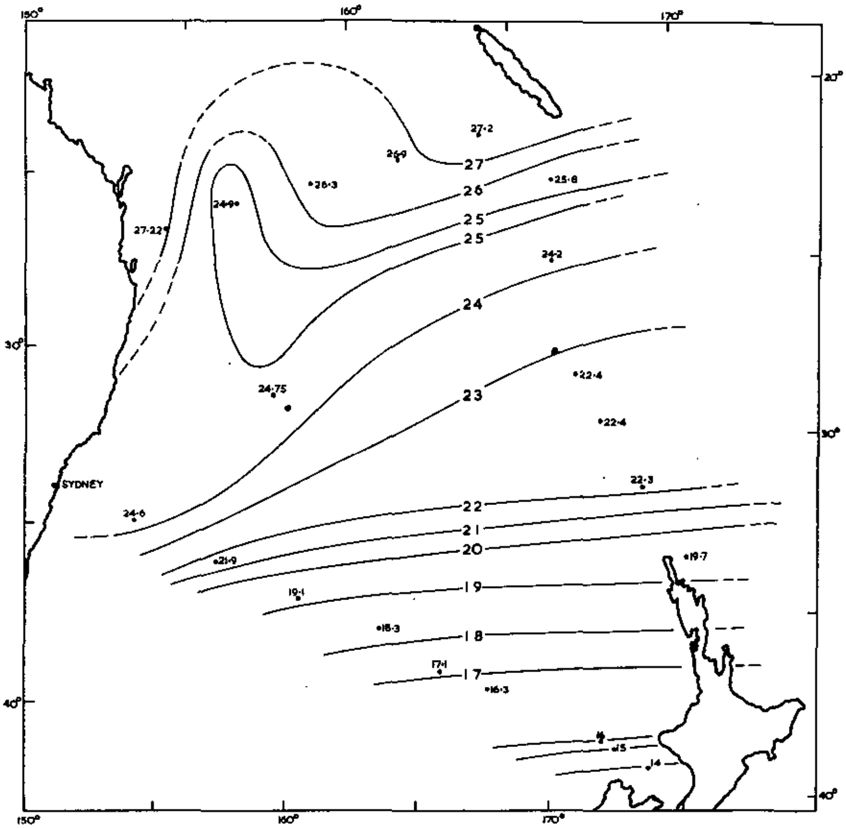

Fig. 28. Temperature (°C)

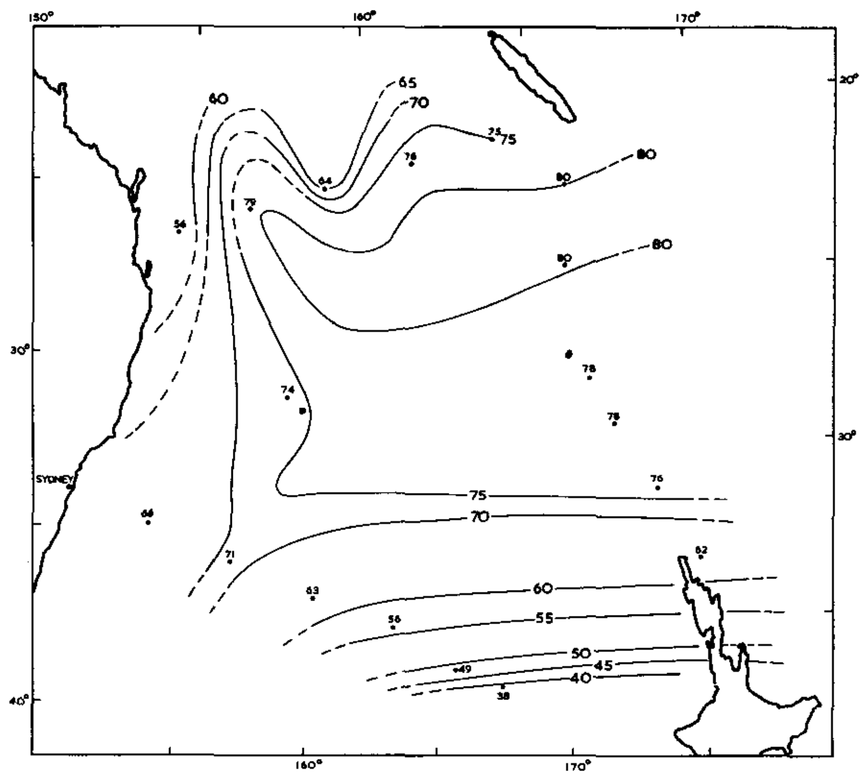

Fig. 29. Chlorinity (°/oo)

Horizontal distribution of properties at the surface

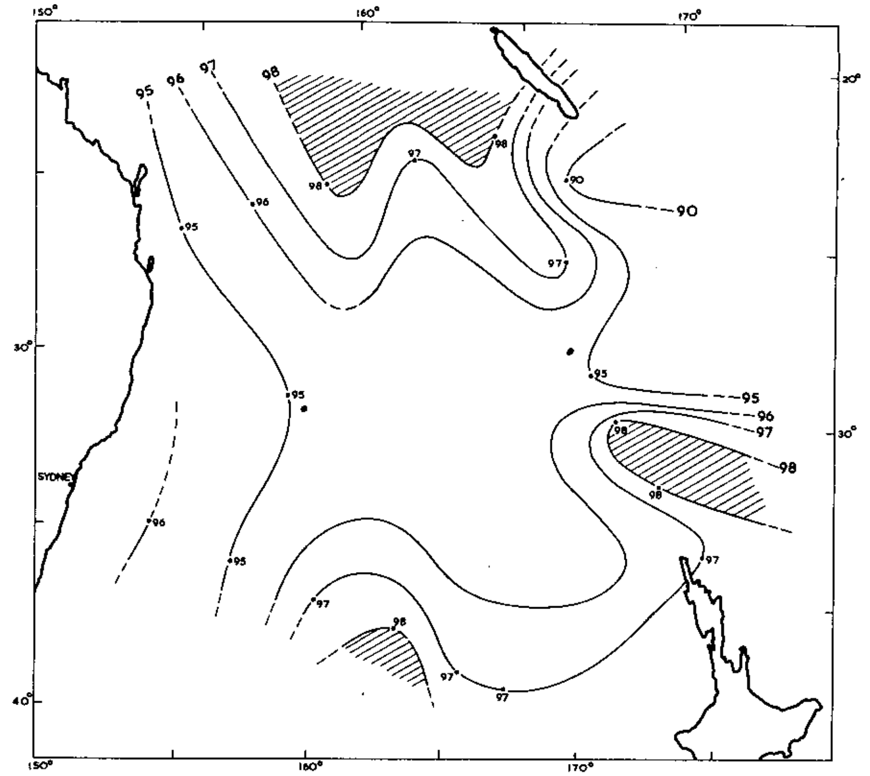

Fig. 30. Percentage oxygen saturation

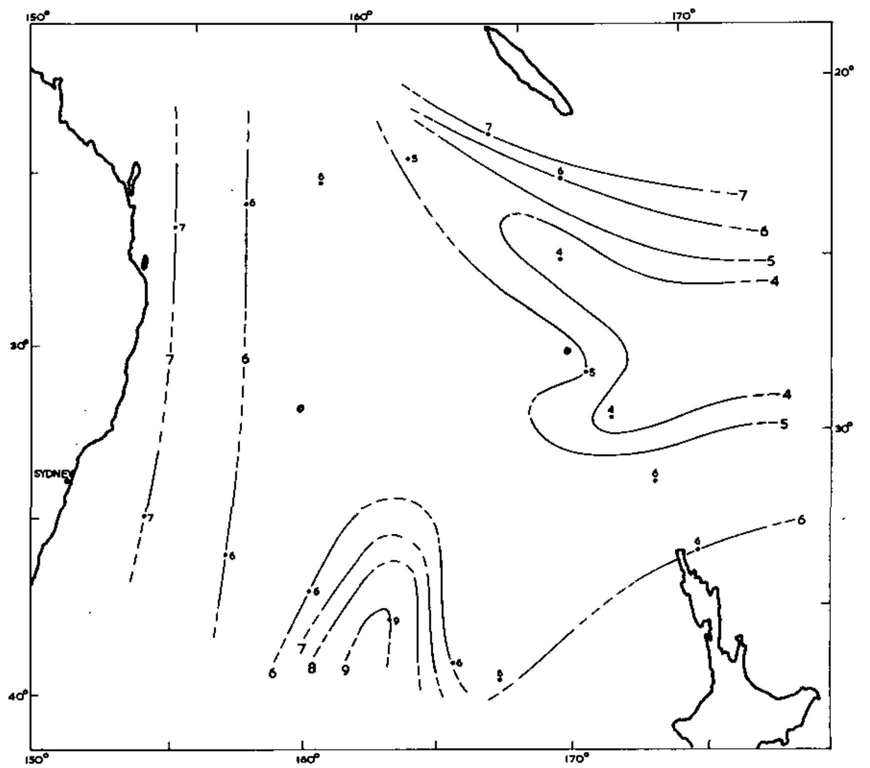

Fig. 31. Inorganic phosphate ($\mu gP/l.$)

Horizontal distribution of properties at the surface

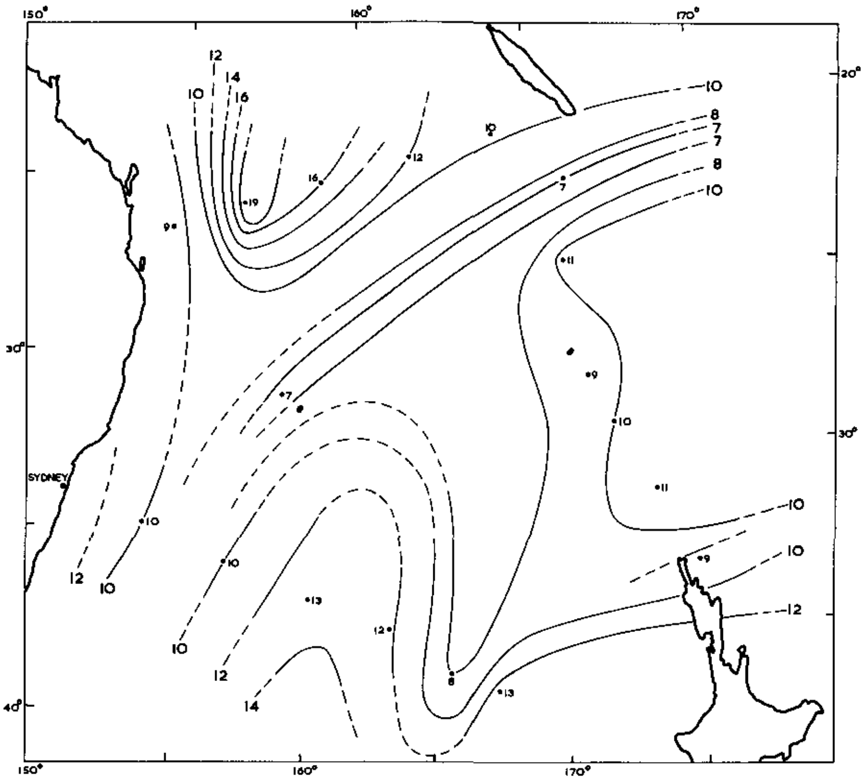

Fig. 32. Total phosphorus (μgP/l.)

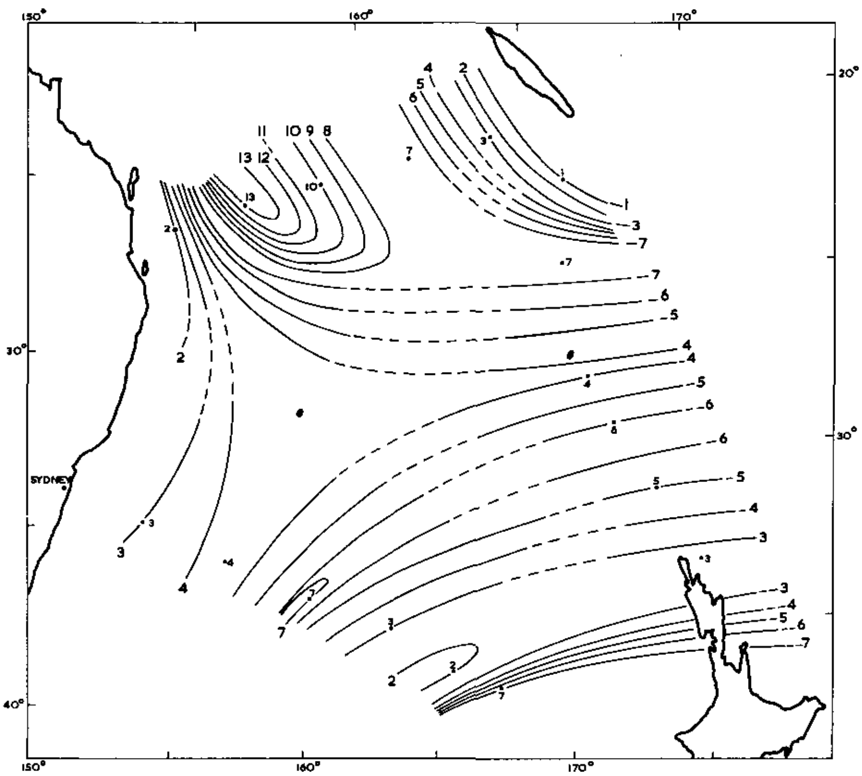

Fig. 33. Organic phosphorus (μgP/l.)

Horizontal distribution of properties at the surface

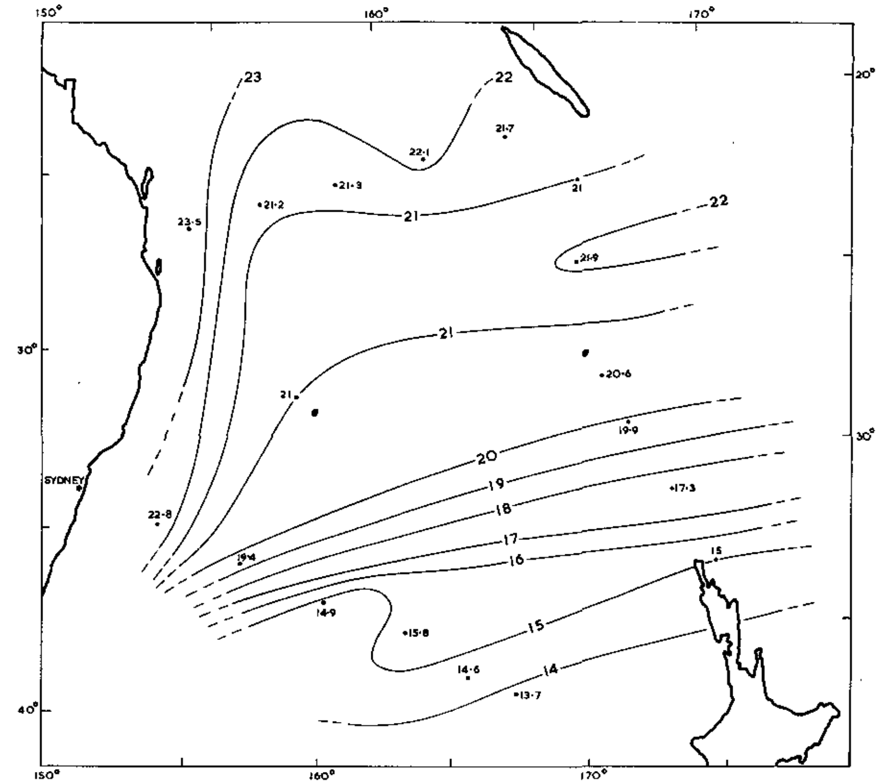

Fig. 34. Temperature (°C)

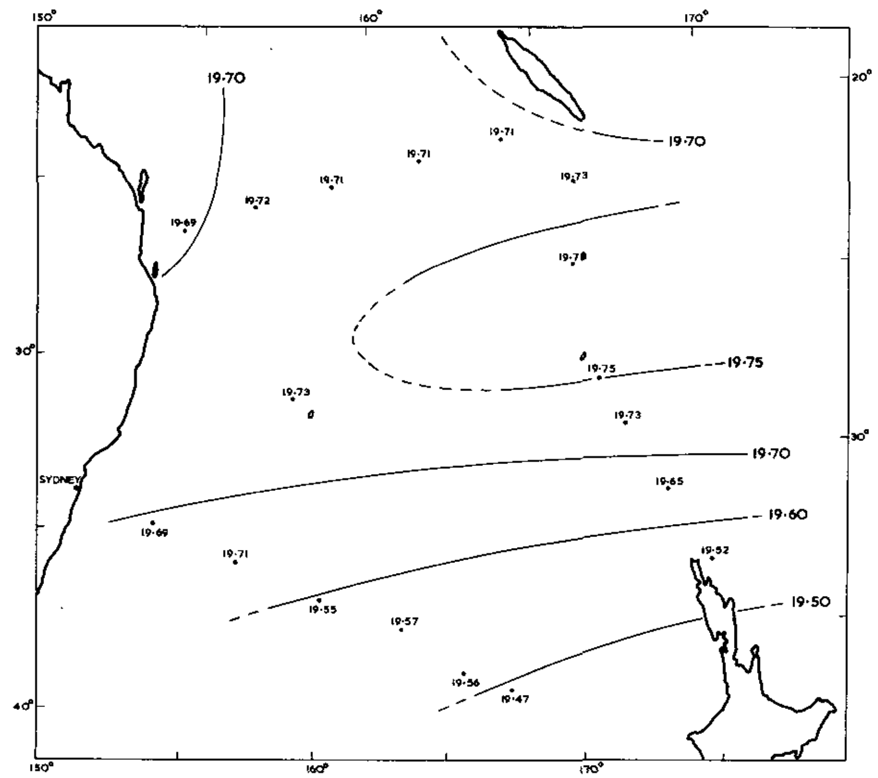

Fig. 35. Chlorinity (°/oo)

Horizontal distribution of properties at 100 m

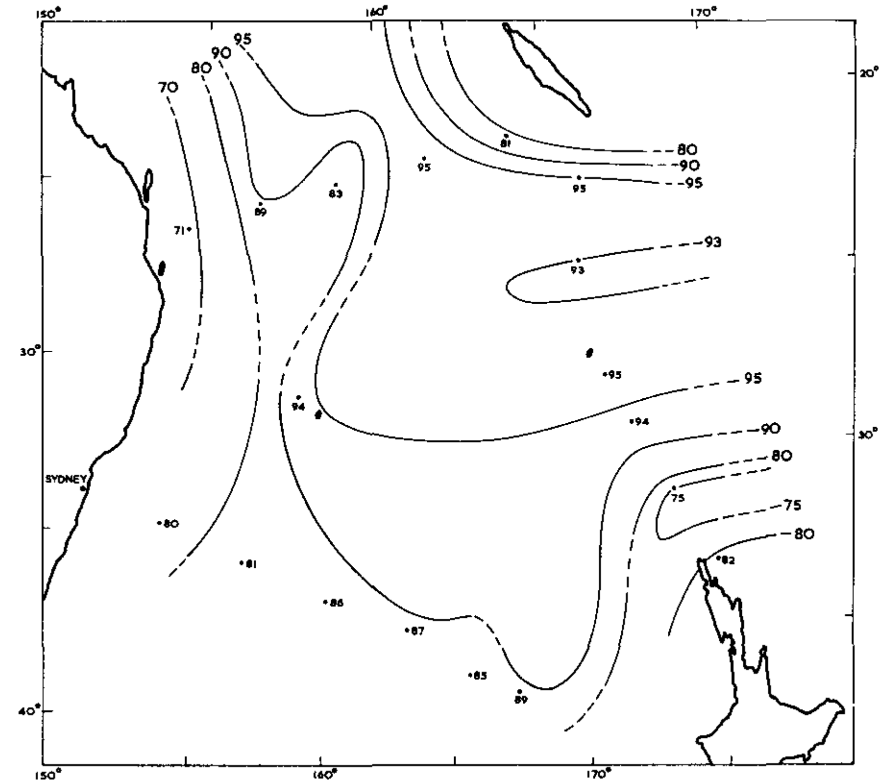

Fig. 36. Percentage oxygen saturation

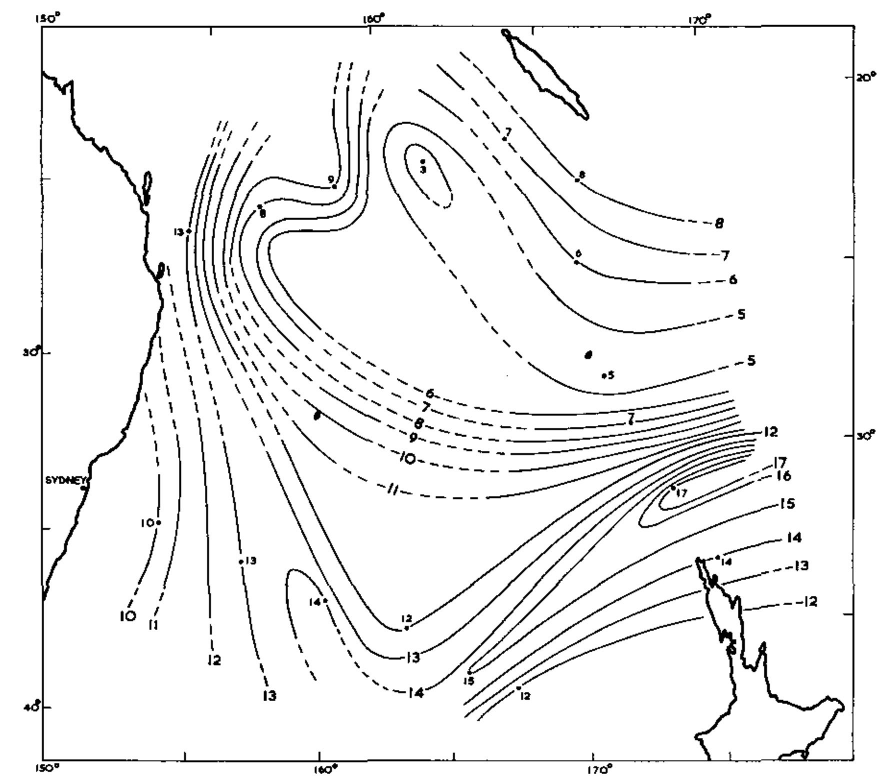

Fig. 37. Inorganic phosphate (µgP/1.)

Horizontal distribution of properties at 100 m

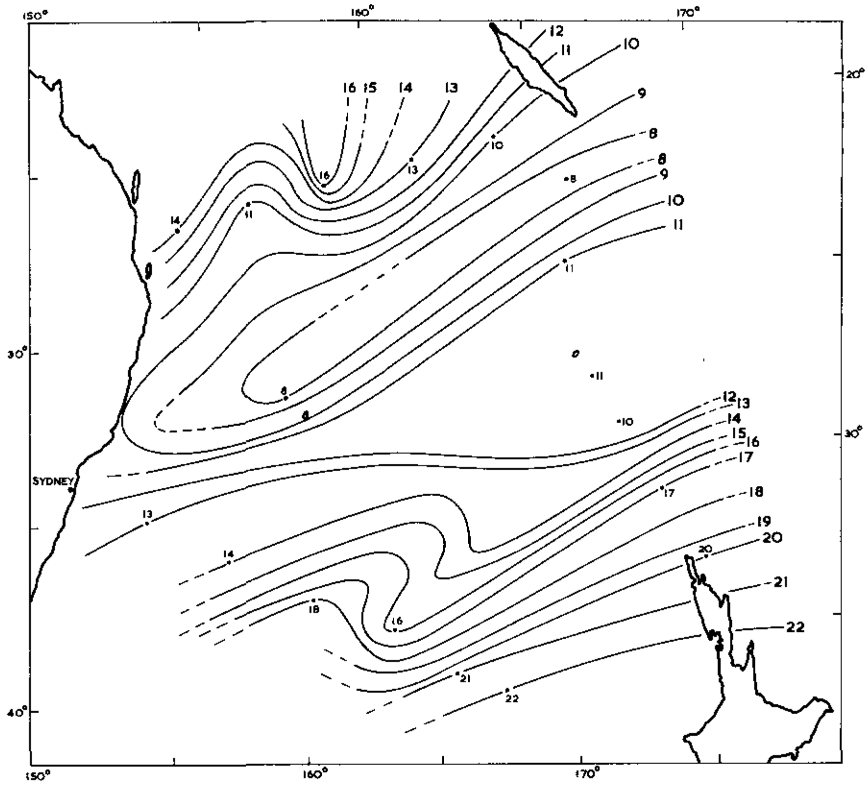

Fig. 38. Total phosphorus (µgP/l.)

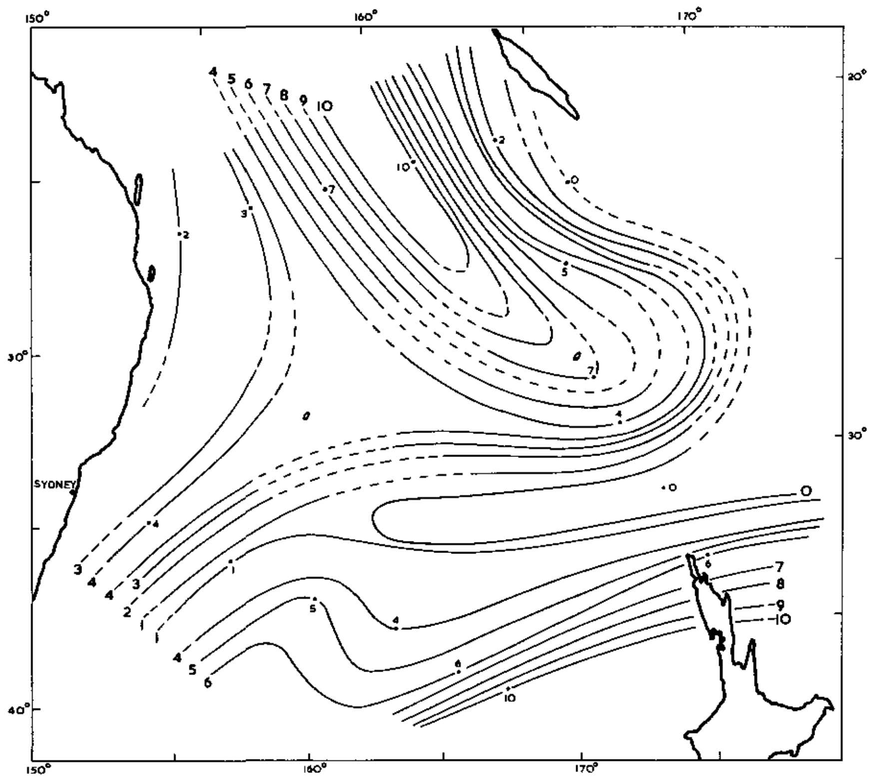

Fig. 39. Organic phosphorus (µgP/l.)

Horizontal distribution of properties at 100 m

(3) 300 m

(a) Temperature (Fig. 40).- The zonal distribution of the isotherms south of about 30°S. was again found at this level. North of this latitude however the isotherms were distributed meridionally.

(b) Chlorinity (Fig. 41).- Except for the region off Australia the isochlors were almost zonal in their distribution. As at higher levels the maximum chlorinities were found in a middle zone extending east to the limit of the stations.

(c) Percentage Oxygen Saturation (Fig. 42).- The highest value (86 per cent.) was found south of Norfolk Island, and appeared restricted to this region. Values greater than 80 per cent. were found elsewhere except in the vicinity of Australia, New Caledonia, and New Zealand, and in the region south of about 37°S.

(d) Inorganic Phosphate (Fig. 43).- The minimum values were found in the northern central portion of the area but at this level had no consistent relation with oxygen saturation (Fig. 42) and only partially with maximum chlorinity (Fig. 41).

(e) Total Phosphorus (Fig. 44).- The minimum values were found in the central region, the highest values in the shallow waters near land masses (Stations Q1/2,11,12,13/58) or in the region of the eddies previously referred to at Stations Q1/3,15,16/58.

(f) Organic Phosphorus (Fig. 45).- At this depth the organic phosphorus was less than $2 \mu g$P/l. except for a zone with values between 4 and $5 \mu g$P/l. extending south-east from Station Q1/5/58, a region to the north and west of New Zealand ($4 - 5 \mu g$P/l.), and an area around Station Q1/16/58 where values as high as $10 \mu g$P/l. were encountered. The first two regions coincided with regions of high organic phosphorus at the 100 m level (Fig. 39). The organic phosphorus values at Station Q1/16/58 at 300 m were much higher than at the same stations at 100 m (Fig. 39).

(4) 750 m

(a) Temperature (Fig. 46).- The temperature distribution at this depth, unlike that at the upper levels (Figs. 28, 34, and 40), did not have the zonal character of the south nor the meridional of the north. A zone of waters between 8 and 8.5°C extended south-west from the eastern section line to Australia. Temperatures decreased on either side of the level but more rapidly on the northern.

(b) Chlorinity (Fig. 47).- Corresponding in position to the zone of maximum temperatures (Fig. 46) an area of maximum chlorinities ($19.16 - 19.21\,^{\circ}/_{oo}$) was found. North and south of this area, chlorinities decreased.

(c) Percentage Oxygen Saturation (Fig. 48).- A zone of maximum values (67-68 per cent.) was situated in the same region as maximum temperature (Fig. 46) and to a lesser extent maximum chlorinities (Fig. 47). Elsewhere values decreased but no appreciable gradients were found.

(d) Inorganic Phosphates (Fig. 49).- Minimum values of inorganic phosphates were found in the same region as maximum temperatures (Fig. 46), chlorinities (Fig. 47), and oxygen saturation (Fig. 48). Off Noumea the maximum inorganic phosphate was found at this level without a corresponding decrease in the values of other properties.

(e) Total Phosphorus (Fig. 50).- Minimum values were found on the northern limit of the region of maximum temperature (Fig. 46), and oxygen saturation (Fig. 48), but beyond the region of maximum chlorinity (Fig. 47) and minimum inorganic phosphate (Fig. 49). The highest values (45μgP/l.) were found at Station Q1/3,7,12,16/58. Of these, Stations Q1/3,16/58 were probably still influenced by the eddies in their vicinity and Station Q1/12/58 by bottom sediments. Station Q1/7/58 was in deep water and it does not seem likely that either of these effects could have contributed to the high total phosphorus at the 750 m level.

(f) Organic Phosphorus (Fig. 51).- At Stations Q1/3 and 16/56 appreciable quantities of organic phosphorus were found in the region of high total phosphorus values (Fig. 50). At Station Q1/12/58 the high organic phosphorus was indicative of sediment effects. However, the absence of organic phosphorus at Station Q1/7/58 indicates that sediment effects could not have been responsible for the high total phosphorus at this station (Fig. 50).

III. REGIONAL WATER MASSES

Figure 52 shows the chlorinity-temperature relationship, and the properties of the regional water masses in the area; their distribution is given in Figure 53, and their characteristics in Table 1.

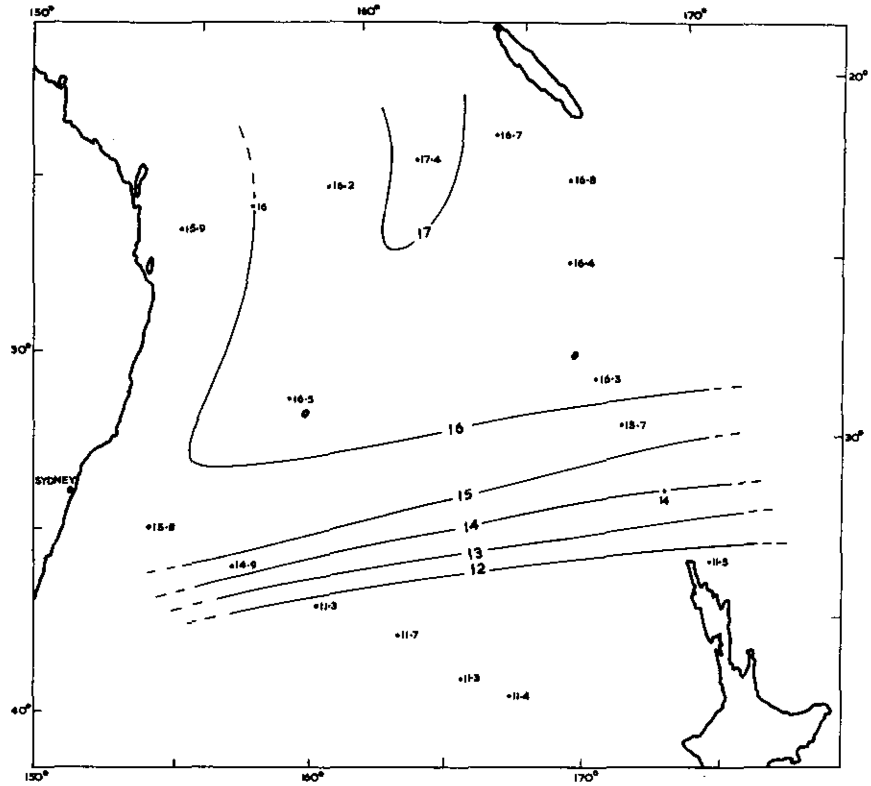

Fig. 40. Temperature (°C)

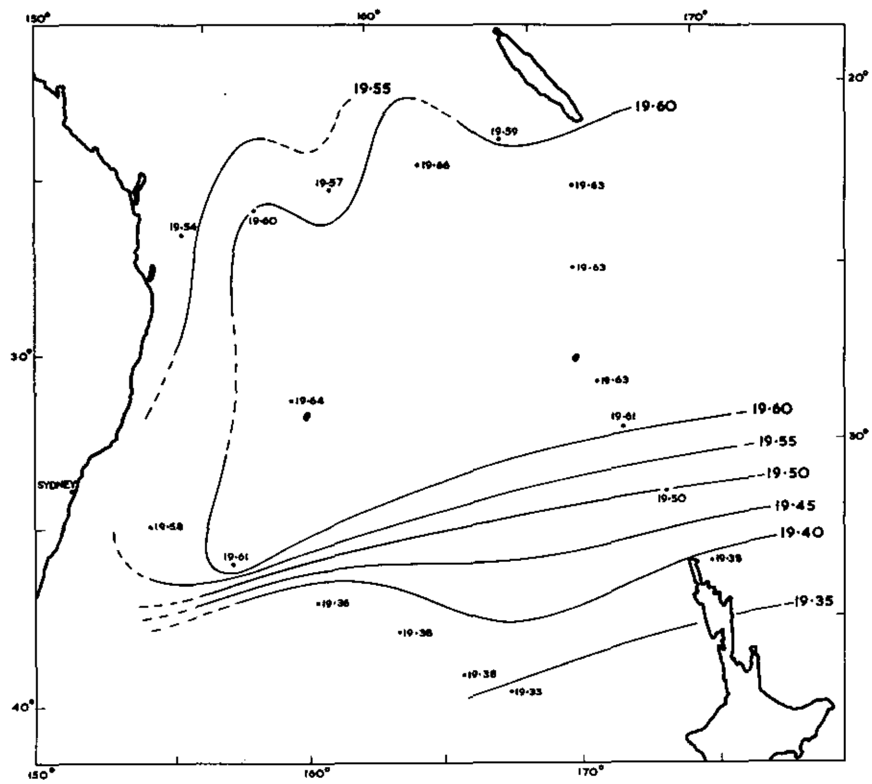

Fig. 41. Chlorinity (°/oo)

Horizontal distribution of properties at 300 m

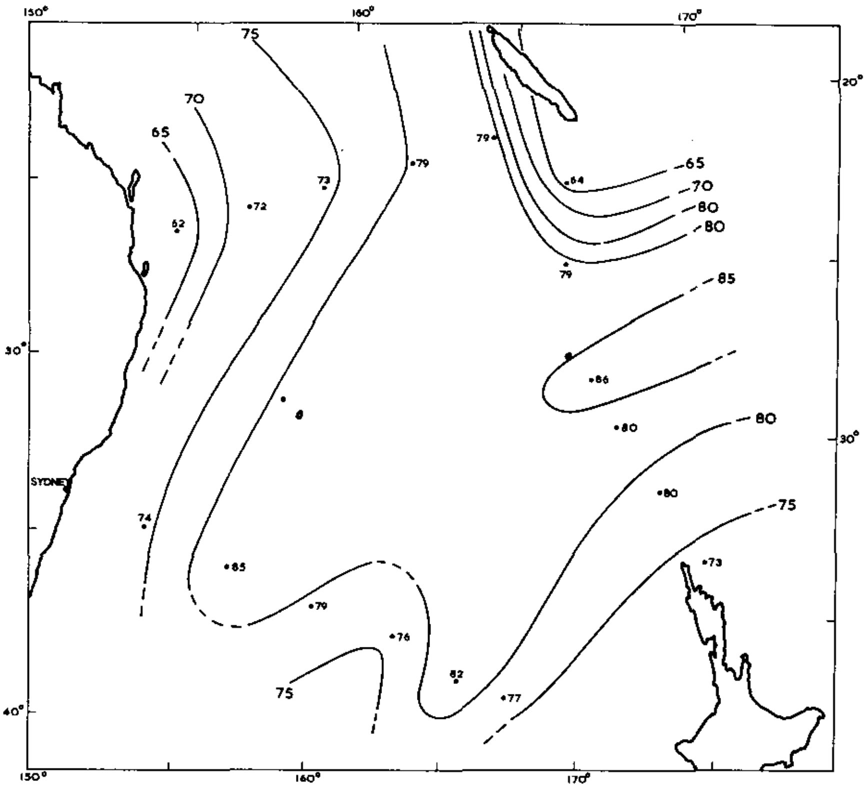

Fig. 42. Percentage oxygen saturation

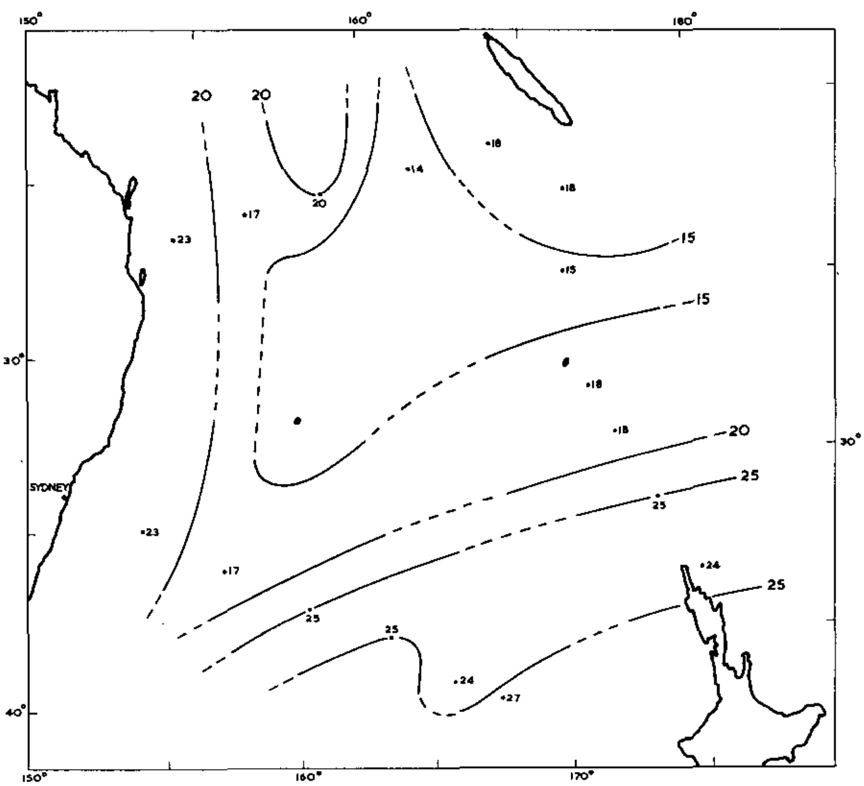

Fig. 43. Inorganic phosphate (μgP/l.)

Horizontal distribution of properties at 300 m

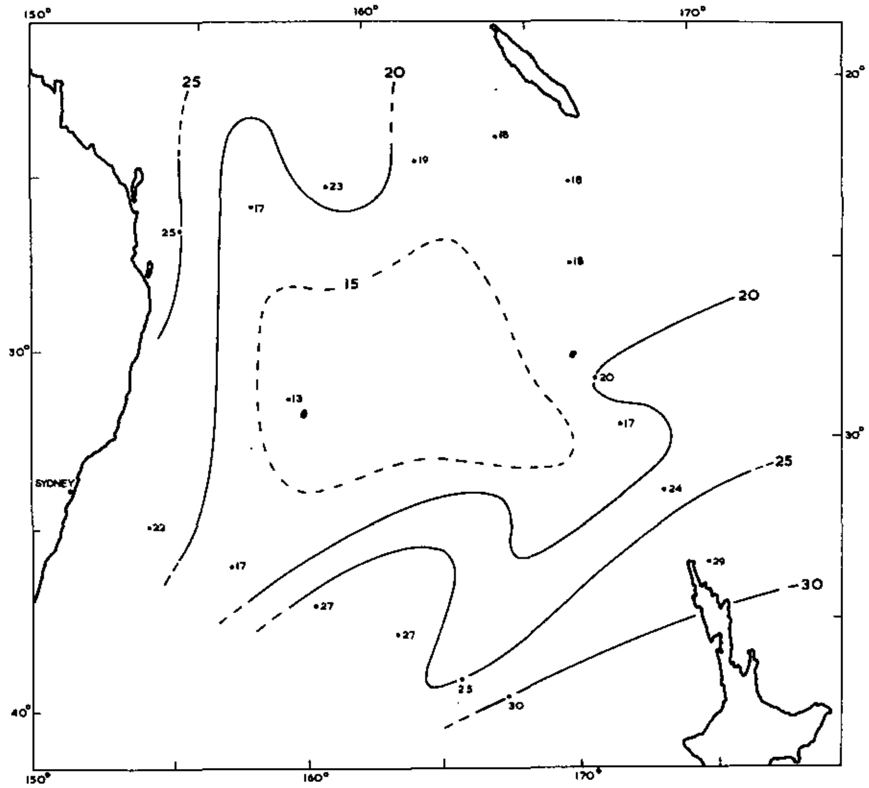

Fig. 44. Total phosphorus (μgP/l.)

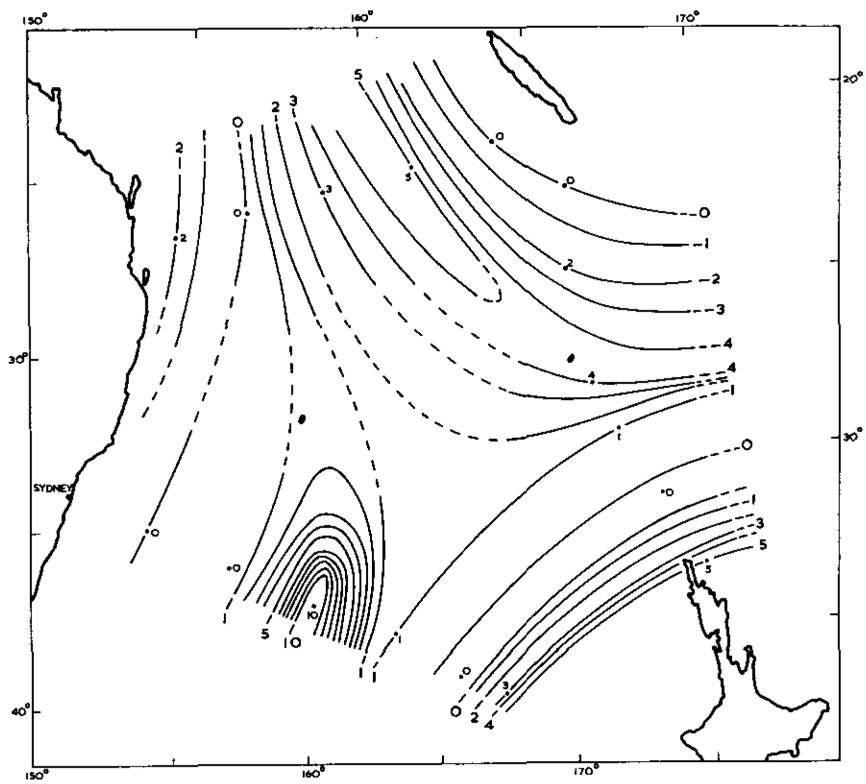

Fig. 45. Organic phosphorus (μgP/l.)

Horizontal distribution of properties at 300 m

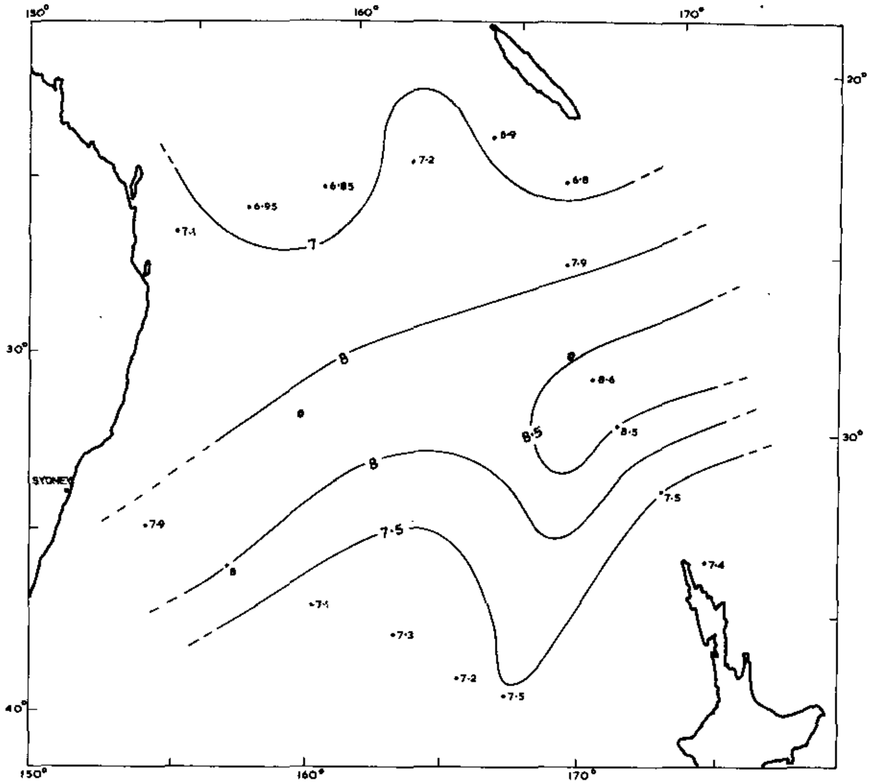

Fig. 46. Temperature (°C)

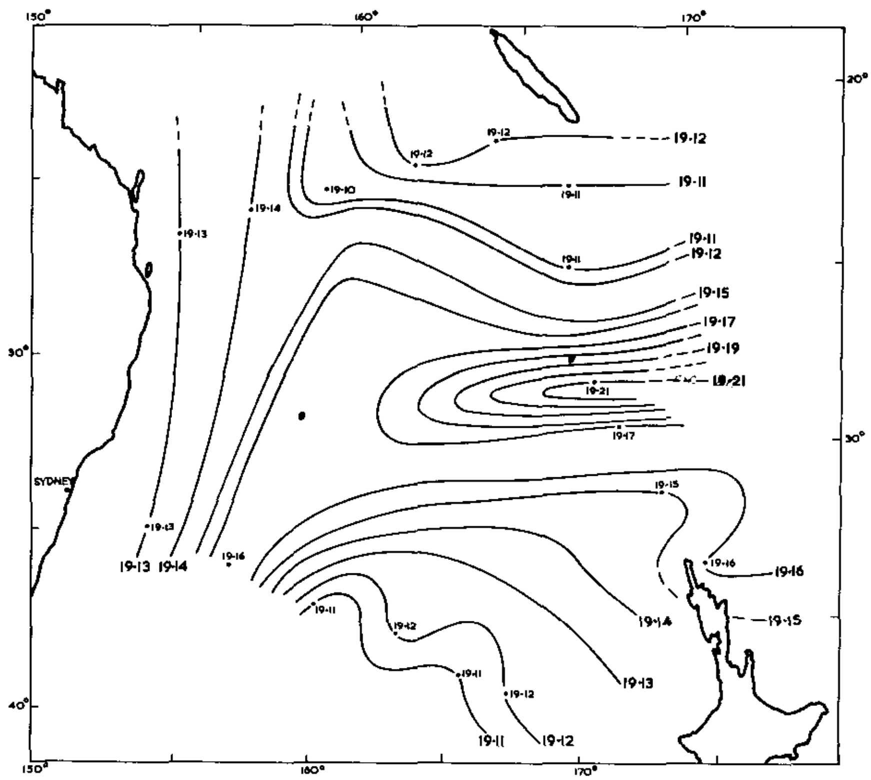

Fig. 47. Chlorinity (°/oo)

Horizontal distribution of properties at 750 m

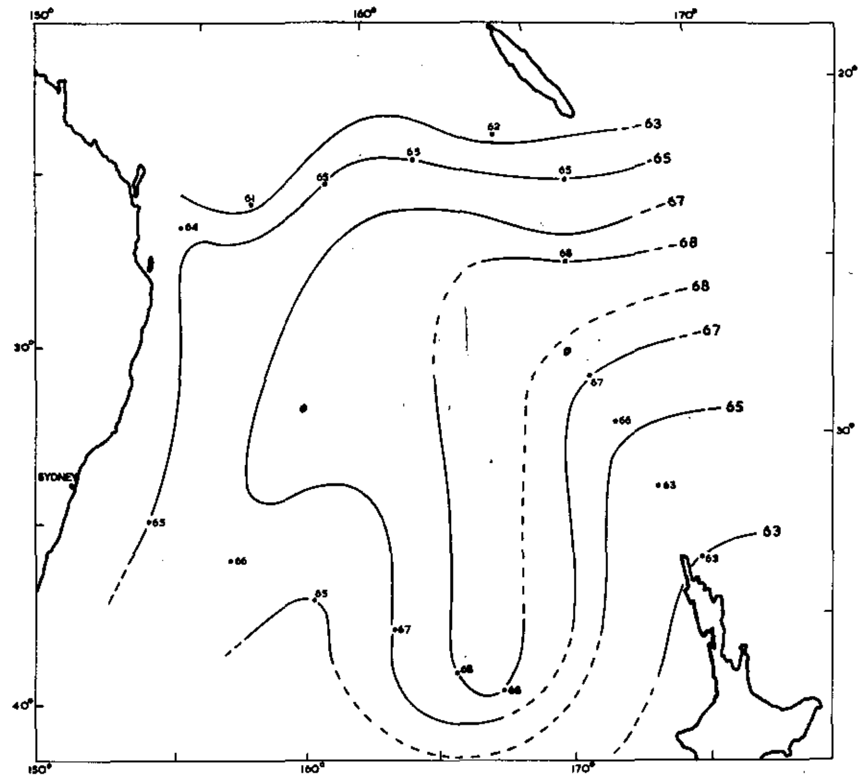

Fig. 48. Percentage oxygen saturation

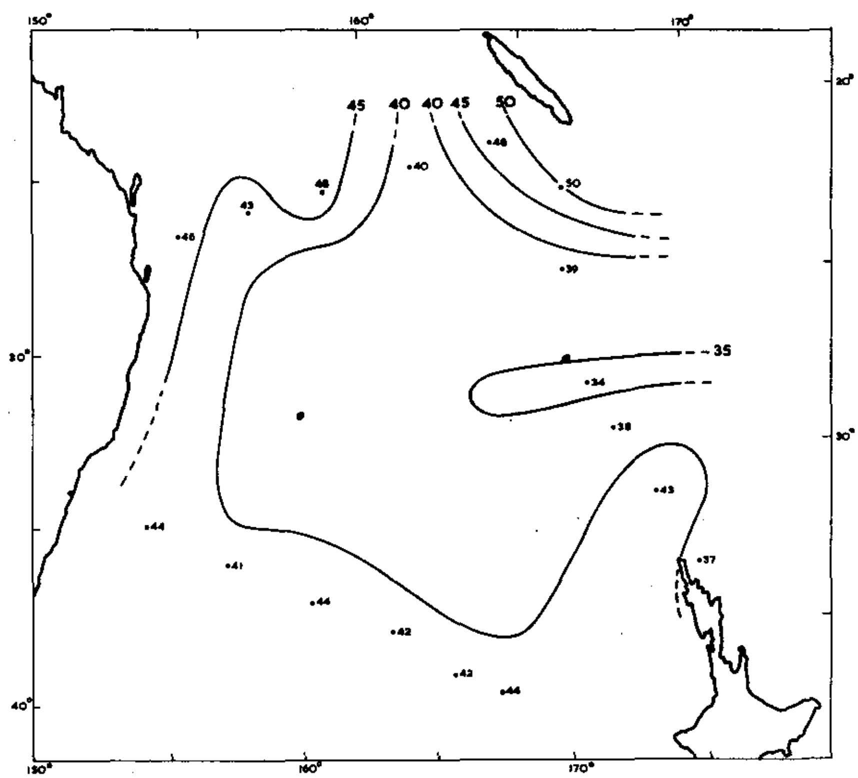

Fig. 49. Inorganic phosphate (μgP/l.)

Horizontal distribution of properties at 750 m

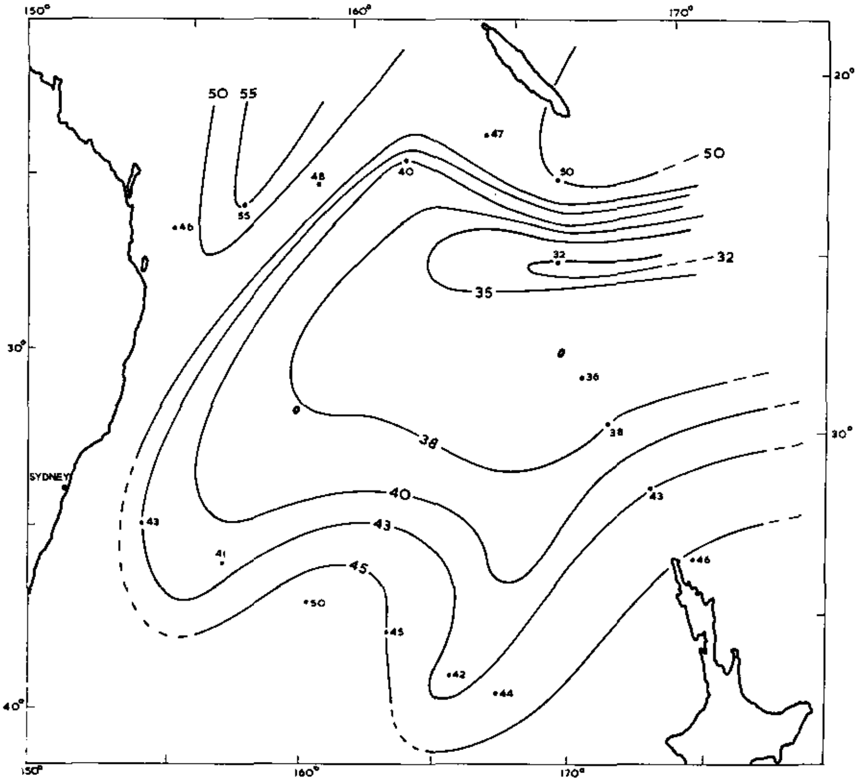

Fig. 50. Total phosphorus (μgP/l.)

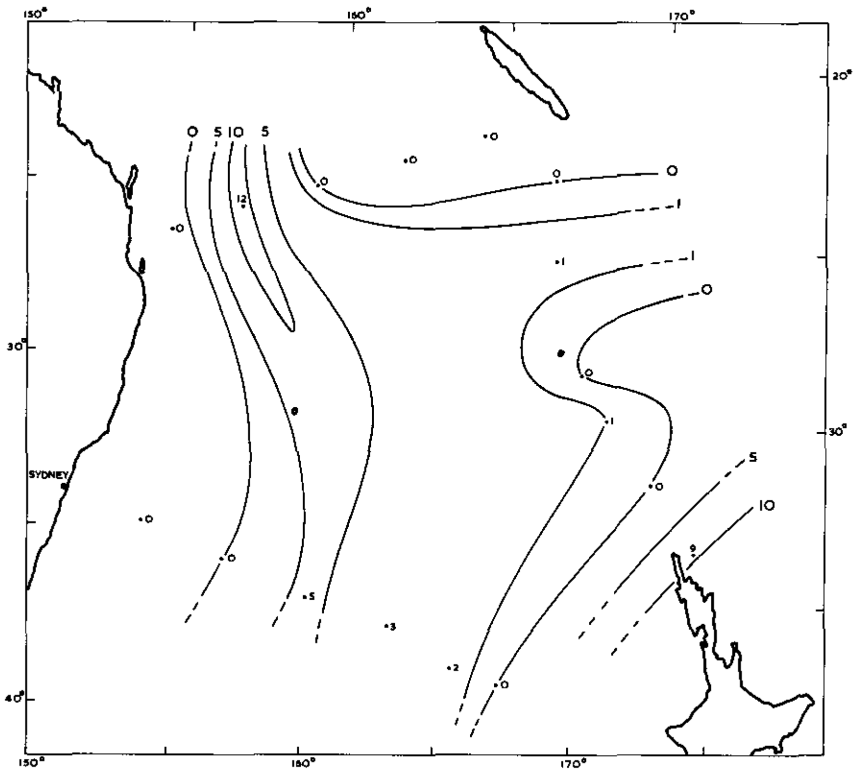

Fig. 51. Organic phosphorus (μgP/l.)

Horizontal distribution of properties at 750 m

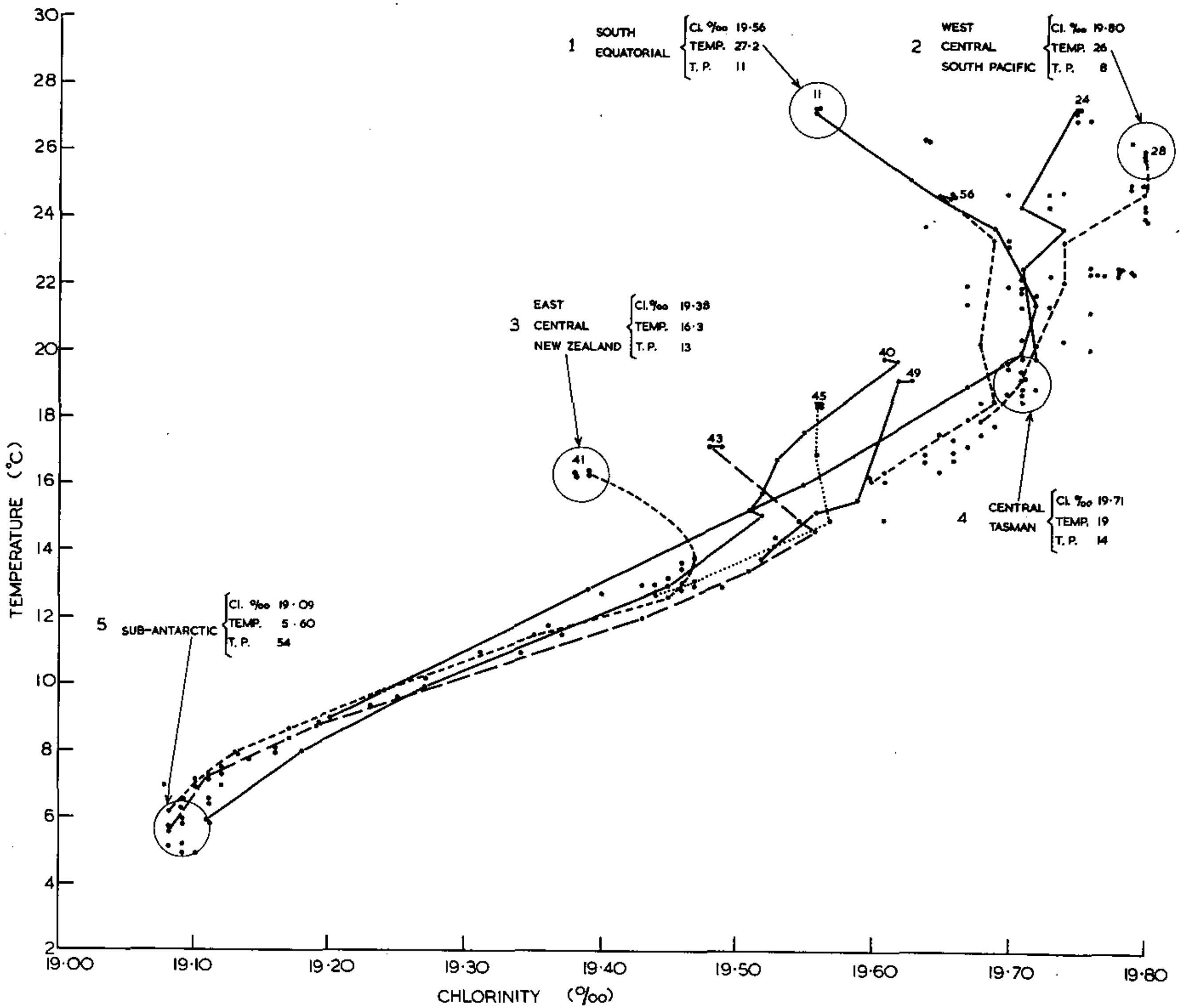

Fig. 52. Temperature-chlorinity relationships and properties of the regional water masses.

TABLE 1

REGIONAL WATER MASSES

No.	Water Mass Identity	Chlorinity ($^\circ/_{oo}$)	Temperature $^\circ$C	Total P. $\mu g/l$
1	South Equatorial	19.56	27.20	11
2	West Central South Pacific	19.80	26.00	8
3	East Central New Zealand	19.38	16.30	13
4	Central Tasman	19.71	19.00	14
5	Sub-Antarctic	19.09	5.60	54

The Central Tasman water mass was not found at the surface in the area traversed and its exact boundaries cannot be precisely determined. However, from the distribution of its mixtures with adjoining water masses it was possible to show its approximate position at the surface.

(b) PHYSICS - B.V. HAMON

The surface dynamic heights, in dynamic centimetres, are shown in Figure 54.

The following volume transports, above 1000 metres, have been calculated:

Stations	Volume Transport ($10^6 m^3/sec$)	Direction
Q1/2-3/58	6	N
Q1/3-6/58	6	S
Q1/6-9/58	5	W
Q1/9-12/58	16	E
Q1/12-16/58	2	N
Q1/16-18/58	14	N

(c) PHYTOPLANKTON - E.J.F. WOOD

Table 2 shows the occurrence of all species of diatoms and dinoflagellates in the collections taken at eighteen stations of this cruise. Table 3 gives the numbers of phytoplankton organisms for twelve stations. The phytoplankton was sparse over most of the area covered in this cruise except for the cryptomonads which reached relatively high numbers and at Station Q1/12/58 where there were relatively large numbers of diatoms. This change in composition of the flora is probably due to the influence of water from the Kermadec trench.

At Station Q1/6/58 much microplankton was collected, particularly at the 20 m level. At this station *Ceratium contrarium* was the dominant dinoflagellate; this and *Amphisolenia bidentata* are the indicator species for the water mass extending south-west from Lord Howe I. and frequently reaching the edge of the continental shelf between Sydney and Jervis Bay. These two species also occurred at Station Q1/8/58 indicating that part of this water mass extended to, and west of, Station Q1/1/58.

At Stations Q1/2,3,5/58 the dinoflagellates *Podolampas palmipes* was present but was absent from Q1/4/58. This species appears to be a useful indicator suggesting that the flora at these stations was derived from further east since *P. palmipes* occurred also at Station Q1/10/58.

The diatom *Coscinodiscus lineatus* occurred at Stations Q1/4,6, 7/58 and *Mastogloia rostrata* at Stations Q1/4,7/58 but not at Q1/6/58.

The collections at Stations Q1/9-12/58 contained the dinoflagellate *Oxytoxum scolopax*, numerous coccolithophores occurred at Stations Q1/9,11/58 and a *Pyramidomonas* at Station Q1/10/58.

At Station Q1/12/58 abundant *Rhizosolenia*, mainly *R. alata* and *R. styliformis*, occurred. This is similar to the *Rhizosolenia* flora which often occurs off east Australia and may represent an extension of the south-east Australian community across the Tasman. The presence of *Oxytoxum* and *Ceratium schmidtii* at this station suggests at least a fairly strong mixing with tropical water, if indeed this water is not directly derived from the tropics.

An examination of collections of diatoms made on the east coast of New Zealand shows that once the north-east corner of New Zealand is passed an entirely different diatom flora is encountered, with *Biddulphia chinensis* as the dominant, and this flora extends south into Hauraki Gulf and to Wellington and Port Lyttleton.

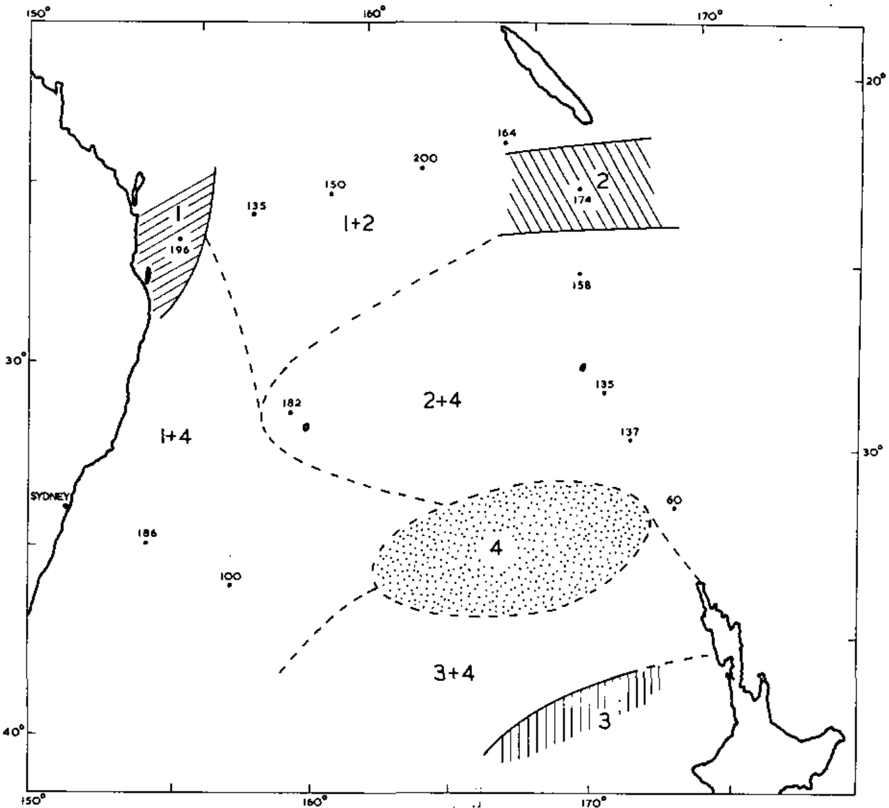

Fig. 53. Surface distribution of water masses listed in Table 1.

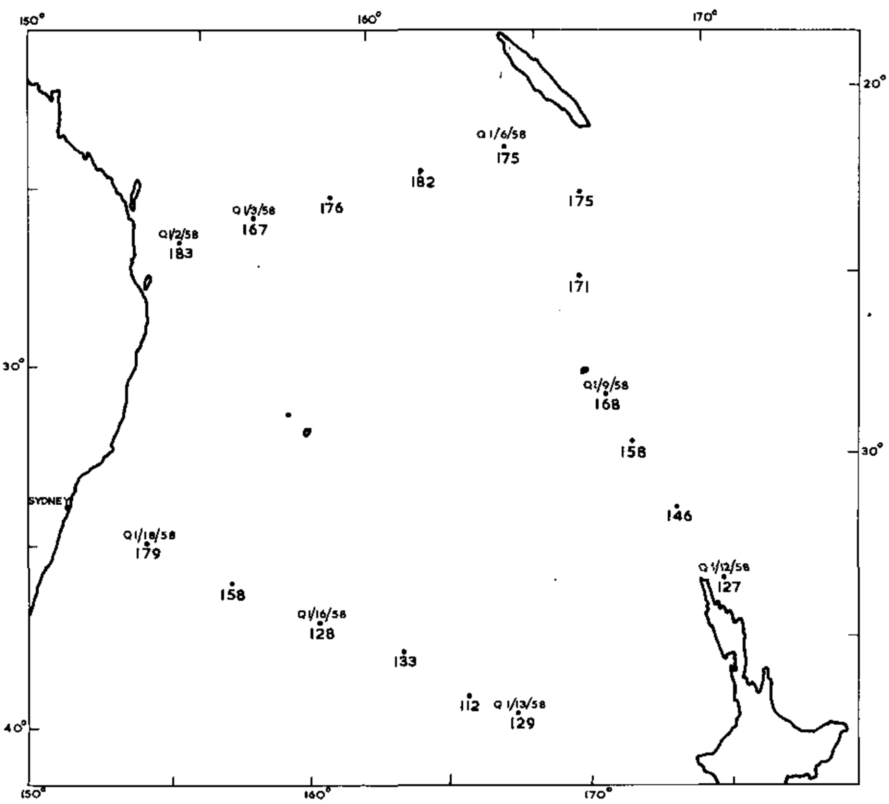

Fig. 54. Dynamic heights (dyn. cm) of the surface relative to 1000 decibars.

As B. chinensis is a warm water form, its presence indicates a sharp division between Station Q1/12/58 and the Bay of Islands.

Between Wellington and Sydney a barren area occurred between Stations Q1/13/58 and Q1/16/58, but Stations Q1/17,18/58 had a relatively rich diatom flora containing species associated with the Coral Sea flora, Rhizosolenia stolterforthii, R. cleveii, and R. bergonii, but no dinoflagellates.

TABLE 2

H.M.A.S. "QUEENBOROUGH" - "QUICKMATCH"

OCCURRENCE OF DIATOMS AND DINOFLAGELLATES

DIATOMS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Climacodium frauenfeldianum	+			+						+							+	
Hemiaulus sinensis	+				+	+		+									+	
Thalassiosira decipiens									+		+	+						
Planktoniella sol		+										+						
Rhizosolenia styliformis	+				+			+				+					+	
R. alata		+			+			+	+			+					+	+
f. gracillima					+							+						+
R. calcar-avis												+						+
R. setigera											+	+						
R. hebetata																		
f. semispina					+													+
R. stolterforthii																	+	+
R. fragilissima																	+	
R. clevei																	+	
R. bergonii																	+	
Chaetoceros coarctatum	+																	
Ch. eibenii																		
Ch. concavicorne																	+	
Ch. decipiens																	+	
Ch. laciniosus																	+	
Guinardia flaccida																	+	
Achnanthes longipes																+	+	
Coscinodiscus lineatus				+		+	+											
C. oculus-iridis							+		+									
Skeletonema costatum					+													
Eucampia zoodiacus				+							+							
Thalassiothrix nitzschioides							+		+			+						
T. frauenfeldii											+							
T. longissima					+												+	
Hantzschia amphioxys									+									
Nitzschia seriata											+						+	+
Mastogloia rostrata				+			+											

TABLE 2 (contd.)

DINOFLAGELLATES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Amphisolenia bidentata	+							+										
Prorocentrum micans									+			+						
Dinophysis tripos												+						
Ornithocerous steinii				+				+										
O. magnificus								+		+								
Peridinium depressum	+																	
P. globulus								+										
Oxytoxum scolopax	+								+	+	+	+						
O. globosum									+									
O. elegans									+									
Ceratium fusus						+		+	+	+	+	+						
C. contrarium	++	+		+				+		+								
C. concilians								+										
C. arietinum	+																	
C. euarcuatum								+										
C. massiliense	+							+					+					
C. carriense	+						+											
C. incisum					+							+						
C. karsteni									+	+								
C. schmidti									+			+						
C. setaceum										+								
C. kofoidi											+	+						
C. gallicum		+						+		+	+							
C. trichoceros			+		+													
C. porrectum												+						
C. minutum												+						
C. extensum																		
Podolampas palmipes	+	+		+						+								
Gymnodinium sp.	+								+		+							
Diplopsalis lenticula												+						
Dinophysis sacculus												+						

TABLE 3

NUMBER OF PHYTOPLANKTON

(Figures are log. number per l.)

STATION	0m			20m			50m			DOMINANT SPECIES
	1-5	5-15	15 +	1-5	5-15	15 +	1-5	5-15	15 +	
Q1/1/58	6.78		0.70	7.8.70	*	0.70	5.30	*	0.70	
Q1/2/58	5.71	*	2.04	5.08	*	*	*	2.30	2.20	
Q1/3/58	4.30	*	*	4.70	*	2.30	4.30	*	*	
Q1/4/58	6.80	*	*	6.31	4.00	*	6.70	*	*	
Q1/5/58	5.34	*	*	4.70	*	*	6.52	*	*	
Q1/6/58	4.47	4.30	*	5.00	4.90	*	5.48	4.30	*	
Q1/7/58	5.30	4.00	*	6.00	5.06	*	6.04	5.70	*	
Q1/8/58	5.90	*	*	5.78	4.90	*	5.60	5.30	*	
Q1/9/58	5.60	5.34	2.10	5.91	4.00	1.69	5.30	5.30	*	Coccolithophores
Q1/10/58	5.25	5.78	*	5.28	5.47	*	5.30	5.36	*	Pyramidomonas
Q1/11/58	5.31	*	*	5.40	3.60	2.30	5.57	4.00	3.79	Coccolithophores
Q1/12/58	5.32	*	4.90	5.48	*	4.84	5.75	*	4.48	(Gymnodinium sp.; (Rhizosolenia alata; (R. styliformis.

+ Phytoplankton collections at Stations Q1/13-18/53 were for qualitative study only

* Numbers too small to count.

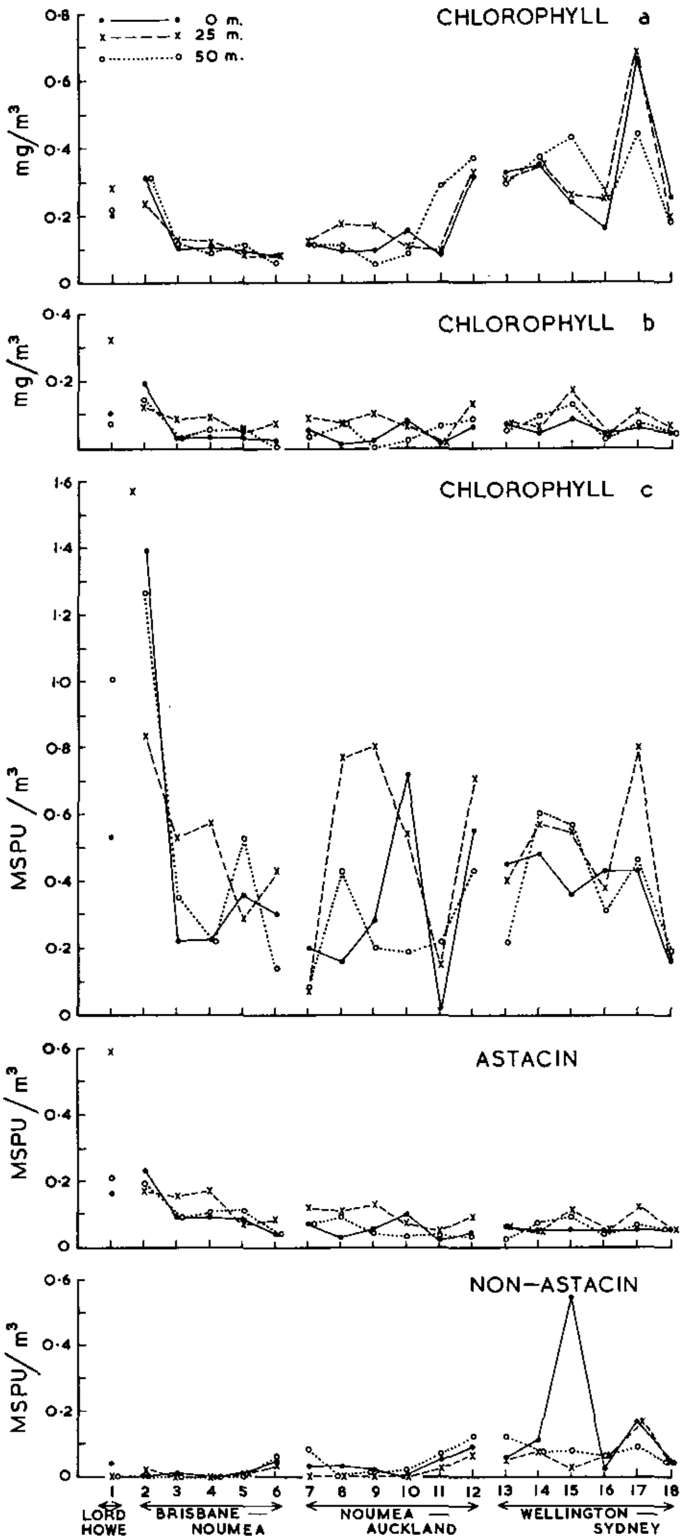

Fig. 55. Variations in pigment concentration.

(d) BIOCHEMISTRY - G.F. HUMPHREY

Water samples were taken with a plastic sampler and filtered at once through millipore filters. The filters were placed in envelopes and stored in metal vacuum desiccators over silica gel. The analyses were carried out within one month of collection using the method of Richards with Thompson (1952). The details and justification of the method used are given in Humphrey (1959).

The results of the analyses are given in Table 4 and Figure 55. It can be seen that, except for chlorophyll c, the distribution of the pigments is usually the same for all depths. Again except for chlorophyll c, the richest areas are generally those near the Australian coast.

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TABLE 4

CONCENTRATION OF PIGMENTS

DATE	TIME	STATION	DEPTH (m)	CHLOROPHYLL a mg/m^3	CHLOROPHYLL b mg/m^3	CHLOROPHYLL c MSPU/m^3	ASTACIN MSPU/m^3	NON-ASTACIN MSPU/m^3
26.3.58	1425	Q1/1/58	0	0.20	0.10	0.53	0.16	0.04
			25	0.28	0.32	2.28	0.59	*
			50	0.21	0.07	1.01	0.21	*
31.3.58	1710	Q1/2/58	0	0.31	0.19	1.39	0.23	*
			25	0.23	0.12	0.83	0.17	0.02
			50	0.31	0.14	1.27	0.19	*
1.4.58	0510	Q1/3/58	0	0.10	0.03	0.22	0.09	0.01
			25	0.13	0.08	0.53	0.15	*
			50	0.11	0.03	0.35	0.09	*
1.4.58	1710	Q1/4/58	0	0.10	0.03	0.22	0.09	*
			25	0.12	0.09	0.57	0.17	*
			50	0.09	0.05	0.22	0.10	*
2.4.58	0510	Q1/5/58	0	0.09	0.03	0.36	0.08	0.01
			25	0.08	0.04	0.29	0.07	0.01
			50	0.11	0.05	0.53	0.11	0.00
2.4.58	1715	Q1/6/58	0	0.08	0.02	0.30	0.04	0.05
			25	0.08	0.07	0.43	0.08	0.04
			50	0.06	*	0.14	0.04	0.06
8.4.58	1710	Q1/7/58	0	0.11	0.05	0.20	0.07	0.03
			25	0.12	0.09	0.07	0.12	*
			50	0.10	0.03	0.08	0.07	0.08
9.4.58	0505	Q1/8/58	0	0.09	0.01	0.14	0.03	0.03
			25	0.17	0.07	0.77	0.11	*
			50	0.10	0.07	0.43	0.09	*
9.4.58	2315	Q1/9/58	0	0.09	0.02	0.28	0.05	0.02
			25	0.16	0.10	0.80	0.13	*
			50	0.05	0.00	0.20	0.04	0.01

* Indicates negative values

TABLE 4 (contd.)

DATE	TIME	STATION	DEPTH (m)	CHLOROPHYLL a mg/m^3	CHLOROPHYLL b mg/m^3	CHLOROPHYLL c $MSPU/m^3$	ASTACIN $MSPU/m^3$	NON-ASTACIN $MSPU/m^3$
10.4.58	0635	Q1/10/58	0	0.15	0.08	0.72	0.10	*
			25	0.10	0.06	0.54	0.07	*
			50	0.08	0.02	0.19	0.03	0.02
10.4.58	1715	Q1/11/58	0	0.08	0.01	0.02	0.02	0.05
			25	0.09	0.01	0.14	0.03	0.02
			50	0.28	0.06	0.22	0.04	0.07
11.4.58	0505	Q1/12/58	0	0.31	0.06	0.55	0.04	0.09
			25	0.32	0.13	0.71	0.09	0.06
			50	0.36	0.08	0.43	0.03	0.12
23.4.58	1315	Q1/13/58	0	0.32	0.07	0.45	0.06	0.06
			25	0.30	0.07	0.40	0.06	0.05
			50	0.29	0.05	0.22	0.02	0.12
23.4.58	2030	Q1/14/58	0	0.34	0.04	0.48	0.05	0.10
			25	0.34	0.06	0.57	0.05	0.07
			50	0.36	0.09	0.60	0.07	0.07
24.4.58	0510	Q1/15/58	0	0.23	0.08	0.36	0.05	0.54
			25	0.25	0.17	0.55	0.11	0.02
			50	0.42	0.13	0.57	0.09	0.08
24.4.58	1700	Q1/16/58	0	0.15	0.04	0.43	0.05	0.02
			25	0.24	0.04	0.38	0.05	0.06
			50	0.24	0.02	0.31	0.04	0.06
25.4.58	0500	Q1/17/58	0	0.65	0.05	0.43	0.05	0.16
			25	0.67	0.10	0.90	0.12	0.16
			50	0.43	0.06	0.47	0.06	0.09
25.4.58	1700	Q1/18/58	0	0.24	0.04	0.16	0.03	0.05
			25	0.18	0.06	0.18	0.03	0.04
			50	0.17	0.04	0.19	0.03	0.04

* Indicates negative values

(e) PRIMARY PRODUCTION OF ORGANIC MATTER - H.R. JITTS

Measurements were made of the relative rates of production of organic matter at each station, using the ^{14}C method described by Jitts (1957). Light and dark bottle samples were taken from 0, 25, 50, and 100 m, $Na_2{}^{14}CO_3$ added, and the samples incubated in a light bath for four hours. The rate of photosynthetic uptake of CO_2 was thus measured at each depth and expressed as $mgC/hr/m^3$. The results are given in Figure 56 a, b, and c.

In order to compare the rates of production at the various stations, the rate of CO_2 uptake per day per column of water under 1 metre square at each station was calculated by the formula:-

$$\text{Daily Rate} = \frac{10}{1000}\left[\frac{25}{2}(a+b) + \frac{25}{2}(b+c) + \frac{50}{2}(c+d)\right] gC/day/m^2$$

where a, b, c, and d are the rates of CO_2 uptake in $mgC/hr/m^3$ at 0, 25, 50, and 100 m respectively. Multiplication by the factor 10 in the above formula assumes the daily rate to be ten times that of the hourly one. These results are given in Figure 57.

On five occasions during the cruise the depth of penetration of 1 per cent. of the surface light was determined (Jitts 1959). These results are also given in Figure 57. Apart from Station Q1/1/58, it was not possible to make these measurements in conjunction with the full stations as these were carried out either too early in the morning or too late in the evening. The measurements were made during special stations at as close to noon as possible.

(1) Lord Howe Island Station Q1/1/58

A very low rate of production was found at this station; the rate of 0.05 $gC/day/m^2$ was the lowest found on the cruise. The vertical column showed an almost uniform uptake of 0.05 to 0.06 $mgC/hr/m^3$ down to 50 m, then fell to 0.01 $mgC/hr/m^3$ at 100 m. The estimated depth of penetration of penetration of 1 per cent. of the surface was 122 m.

(2) Brisbane - Noumea Q1/2/58 to Q1/6/58

A moderate rate of production was found on this section, averaging 0.13 $gC/day/m^2$ for the five stations. These values are of the same order of magnitude as those found by SteemannNielsen (1954) and Jitts and Rotschi (1957) for the South West Pacific water mass.

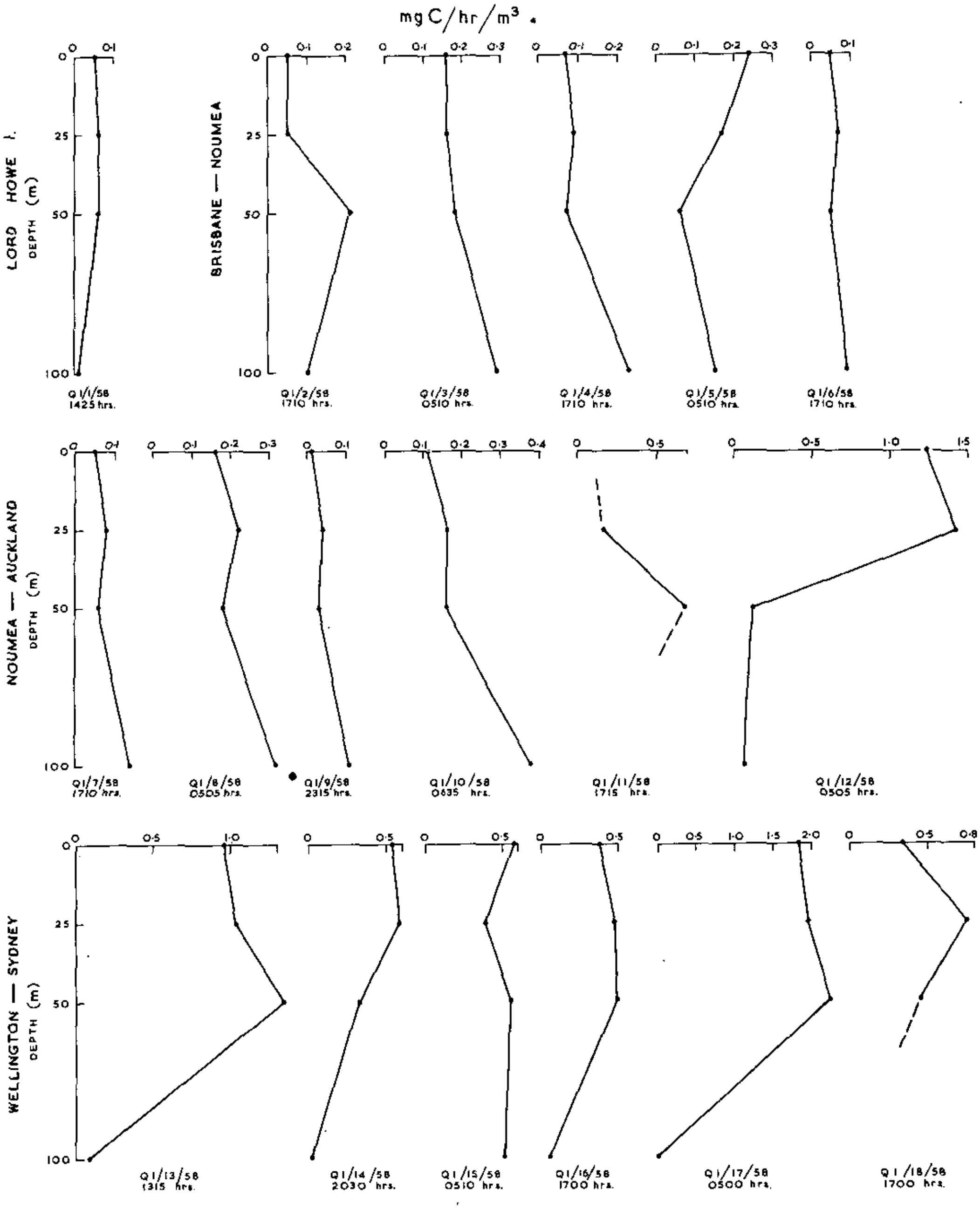

Fig. 56. Vertical profiles of hourly rates of CO_2 uptake at each ^{14}C station. Sampling times are given below the station numbers.

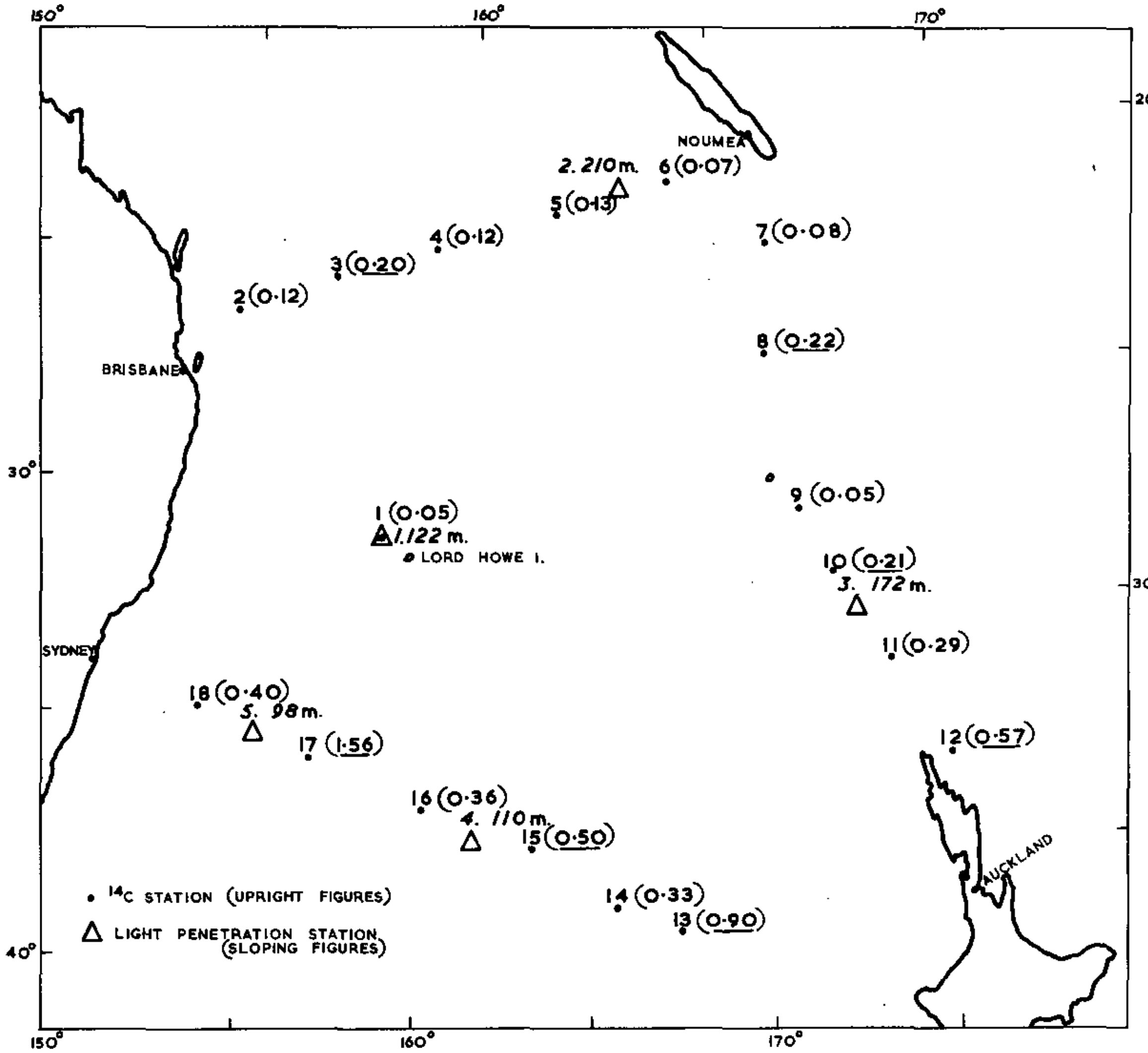

Fig. 57. Daily rates of CO_2 uptake, calculated for the columns under 1 metre square from 0 to 100 metres depth, are given at each ^{14}C station in $gC/day/m^2$ (in brackets). Those underlined are morning stations.
The depths of penetration of 1 per cent. surface light are given at each light station.

There was some evidence of the diurnal periodicity effect described by Doty and Oguri (1957). Morning stations gave values of 0.13 and 0.20, whilst the evening stations gave values of 0.07, 0.12, and 0.12 gC/day/m^2.

The vertical columns were characterized by relatively high values at 100 m. This was in keeping with the estimated depth of 1 per cent. light penetration.

(3) Noumea - Auckland Q1/7/58 to Q1/12/58

Again, moderate values of rates of production were found down to latitude 31°S., (mean, 0.14 gC/day/m^2). The vertical columns had much the same characteristics, and diurnal periodicity was again in evidence. At latitude 31°29'S. the depth of the euphotic layer was 172 m.

South of latitude 32°S. there was an abrupt rise in the rates of production to 0.29 (evenings) and 0.57 (morning) gC/day/m^2. The characters of the vertical columns also changed markedly, with large surface values rising to maxima between 25 and 50 m and falling to very low values at 100 m.

(4) Wellington - Sydney Q1/13/58 to Q1/18/58

High values of production were found throughout this section, even higher than those found by Steemann Nielsen and Aabye Jensen (1957) in a section further to the south. The average value was 0.68 gC/day/m^2. Diurnal periodicity was very marked, the average morning value being 0.99 and the evening 0.36 gC/day/m^2. As in the stations south of latitude 32°S. in the previous section, the vertical columns showed high maxima between 25 and 50 m and very low values at 100 m, except at Station Q1/15/58. At two positions along the section the depth of penetration of 1 per cent. of the surface light was found to be 110 and 98 m.

In Section (a) E., paragraph (c), of this Report it was shown that nutrient levels on this section were higher than on the others. This suggests that the high values found for the rates of production may be due to intrusions of richer Sub-Antarctic waters into this region.

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