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Notes on Anomalous, British Antarctic (Terra Nova) Expedition, Copepod Records in the Three Kings Islands (New Zealand) Region.

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Abstract

AMONGST the copepod records of the British Antarctic (Terra Nova) Expedition (Farran, 1929) in the Three Kings Islands area, north New Zealand, are instances of deep water species being caught at the surface. These anomalous records are shown to be the result of upwelling of deeper water layers.

INTRODUCTION

PLANKTON samples have been collected in the New Zealand region by three major expeditions and the copepods reported on: *Challenger* Expedition (Brady, 1883), British Antarctic (*Terra Nova*) Expedition (Farran, 1929), and British, Australian and New Zealand Antarctic Research Expedition (Vervoort, 1957). Kramer (1894), Brady (1899), and Thompson and Anderton (1921), have also reported on the copepods from coastal waters. Of the three major works on copepods those of Brady (1883) and Vervoort (1957) are concerned with that part of the New Zealand region nearer to Australia. Because Farran (1929) dealt with copepods from the north, east and south of New Zealand he is still the most important contribution to our knowledge of the New Zealand copepod fauna. The *Terra Nova* took a large number of surface plankton samples around Three Kings Islands off the north of New Zealand (Table I). A number of copepod species recorded by Farran (1929) at the surface are usually found at greater depth, e.g., *Scottocalanus securifrons* (T. Scott, 1894) (Vervoort, 1965).

Some authors have accepted many of Farran's records from north of New Zealand as indicating a difference in the behaviour of certain animal species, as Vervoort (1957) implied when he discussed vertical movements of *Euchaeta acuta* in the Bay of Biscay, and then wrote " that the condition in other areas may be different is demonstrated by the presence of considerable numbers of this form in surface waters off North Island, New Zealand (Farran, 1929) ". However, Garstang (1933) noticed the unusual vertical distribution of doliolids and postulated the presence of upwelling. Similarly the amphipod fauna is not typical of the surrounding northern waters, but has cold water affinities (Hurley, 1953).

The purpose of this paper is to show a relationship between the anomalous copepod results and unusual hydrological conditions of the Three Kings Islands region.

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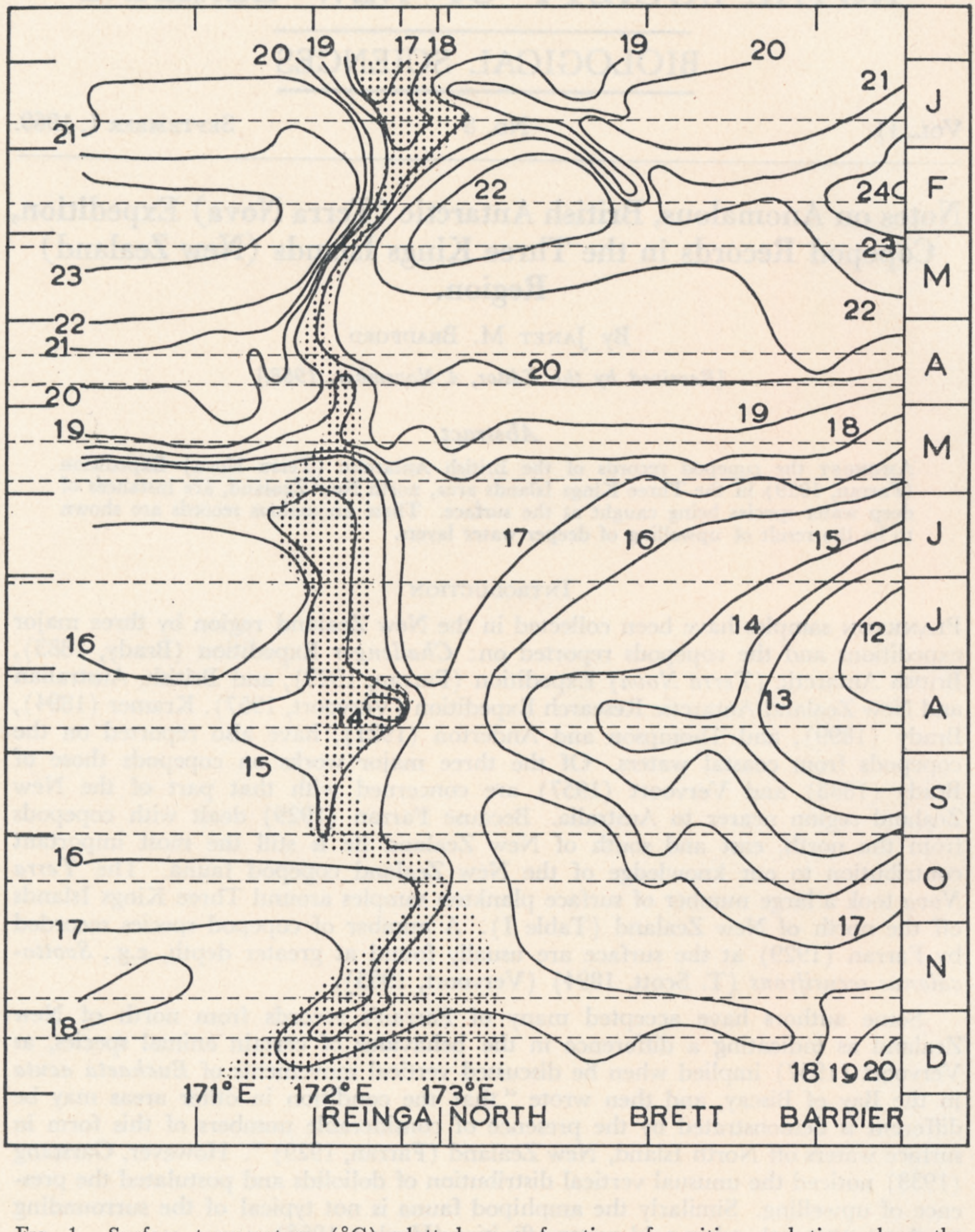

FIG. 1.—Surface temperature (°C) plotted as a function of position and time along the commercial coastal passage from Auckland northward through the Hauraki Gulf to North Cape, thence westwards to Sydney. Prominent geographical features are shown as abscissae and the months of the year as ordinates. Horizonal broken lines show the position of thermograph records used to construct this diagram (Garner, 1961).

HYDROLOGY OF THE THREE KINGS ISLANDS REGION

The general circulation well to the north of New Zealand is maintained by the warm westward flowing Trade Wind Drift. Part of the Trade Wind Drift is turned south on striking the Australian continent in the Coral Sea to form the East Australian Current flowing southwards down the east coast of Australia (Wyrtki, 1960). Part of this flow turns sharply eastwards at about the latitude of Sydney, 34° S, and leaves the Tasman region north of New Zealand (Hamon, 1961; Wyrtki, 1960).

Even though the general temperatures to the north of New Zealand are warm subtropical, anomalously low surface temperatures, 2–4°C less than surrounding water, have been recorded in the Three Kings Islands region and interpreted as upwelling by Garner (1954, 1961) and Stanton (1969).

The only occasion when the extent of upwelling at the surface has been recorded, was in September, 1966, when three ship's tracks crossed the area (Stanton, 1969). A minimum temperature of 14.8°C and salinity 34.41 parts per thousand was recorded. The low temperature and salinity area lay east of Three Kings Islands above the South Maria Ridge (van der Linden, 1968), which extended northwest from Cape Reinga.

The only repeated surface temperature records from the area are those from TSS *Monowai* that lie on an east-west track north of Cape Reinga. Surface tem-

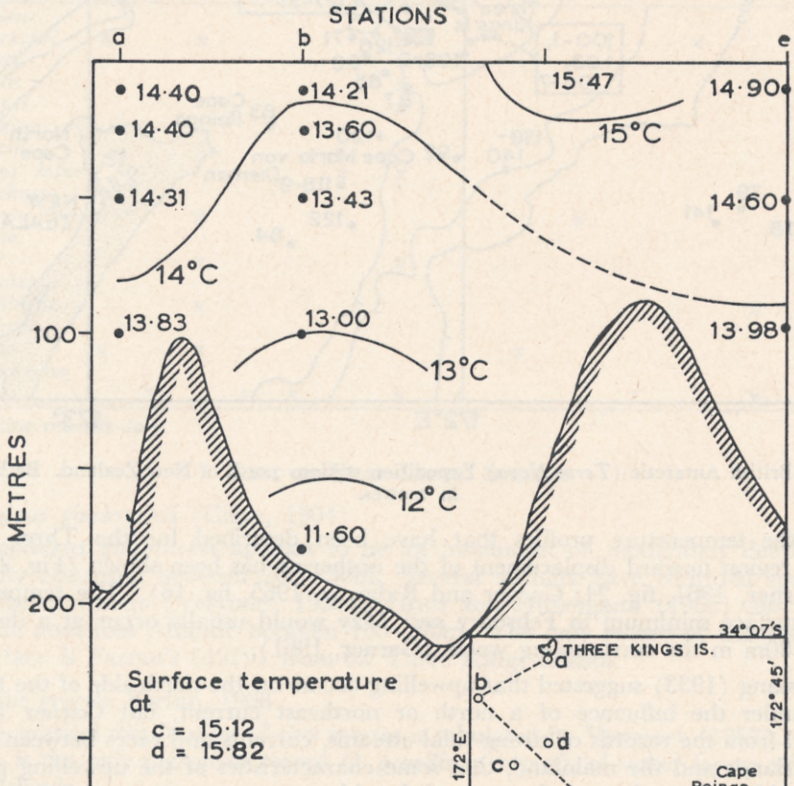

FIG. 2.—Temperature cross-section off Three Kings Islands in August from *Terra Nova* results (Garner, 1959).

peratures from this track recorded by thermograph in the engine room intake, have been plotted as a function of position and time (Fig. 1). Temperatures grading from below 14.5°C in August to below 19°C in February (hatched area in Fig. 1) are below "normal" for the area (Garner, 1954, fig. 1) north of Cape Reinga, representing upwelled water. Although it is not possible to say anything about general upwelling position and strength, considerable variation in location and properties of cold water has been recorded along one track past Cape Reinga (Fig. 1) (see also Garner, 1961, fig. 6).

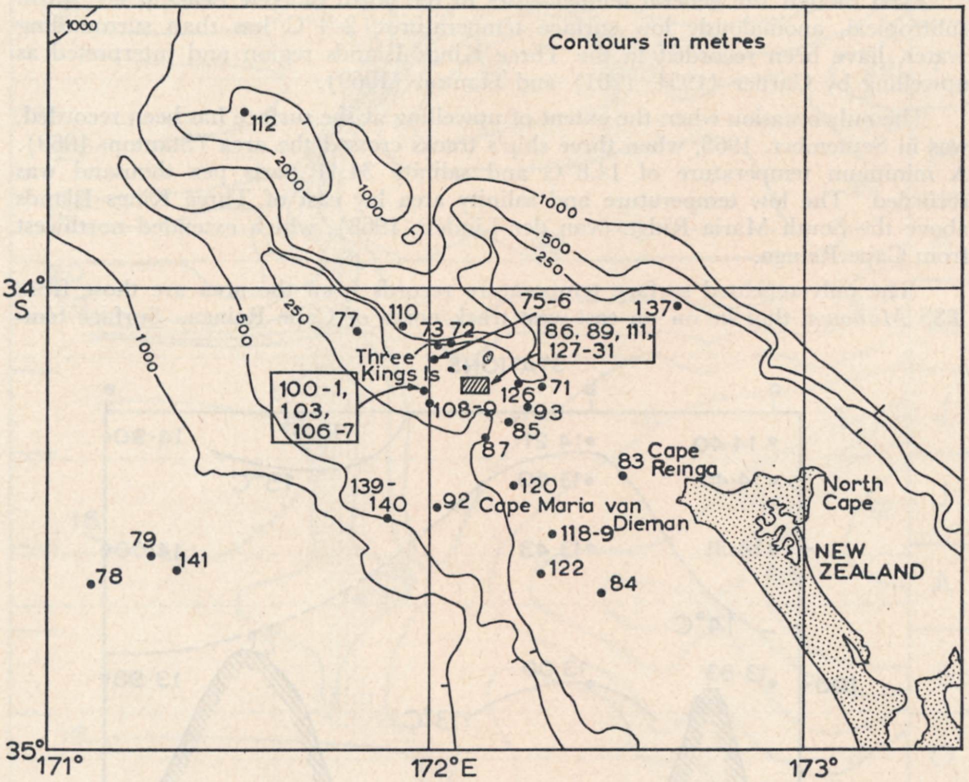

Fig. 3.—British Antarctic (*Terra Nova*) Expedition stations north of New Zealand. Bathymetry in metres.

In the temperature profiles that have been described for the Three Kings Islands region upward displacement of the isotherms has been shown (Fig. 2) (see also Garner, 1961, fig. 24; Garner and Ridgway, 1965, fig. 16). The temperature of the surface minimum in February and May would usually occur at a depth of about 100m in the surrounding water (Garner, 1961).

Garstang (1933) suggested that upwelling occurs on the north side of the Reinga ridge under the influence of a north or northeast current, but Garner (1959) deduced from the records of strong tidal streams, currents and races between Three Kings Islands and the mainland, that some characteristics of the upwelling pattern here would be dependent on the stage of the tide.

British Antarctic (Terra Nova) Expedition Copepod Records

As Farran (1929) gave neither a list of copepods found, nor a record of the kind of plankton hauls made at each station, both were prepared for the Three

Kings Islands area, north of New Zealand (from Farran, 1929; and Harmer and Lillie, 1914).

Amongst the copepods taken in surface hauls (Table I) were ten species usually restricted to deeper waters. These species with reference to evidence for them being confined to sub-surface layers are listed below.

The deep water species were caught collectively in surface hauls at stations 85–7, 89, 92–3, 100, 107, 118, 126–30, 139 (Table II).

TABLE I.—Type of Haul Taken at *Terra Nova* Stations north of New Zealand.

Surface Plankton Hauls
Stations occupied between 0900–1500 hours:
71–3, 83, 85, 87, 100, 108, 111, 119, 126, 131, 137, 140
Stations occupied between 1500–2100 hours:
75–7, 84–5, 89, 101, 103, 106
Stations occupied overnight:
86, 92–3, 107, 109–10, 118, 120, 122, 127–30, 139
Vertical Plankton Hauls
74, 80–2, 98–9, 104–5, 116–7

TABLE II.—Occurrence of Deep Water Species at *Terra Nova* Stations north of New Zealand.

Species Sta.	85	86	87	89	92	93	100	107	118	126	127	128	129	130	139
Euaetideus giesbrechti	x		x				x					x			
Chiridius gracilis							x								
C. poppei							x								
Chirundina streetsii						x									
Gaetanus minor						x	x								
*Undeuchaeta plumosa (minor)**			x							x					
*Euchaeta cuta**	x		x				x								
Scottocalanus securifrons			x										x		
Lothothrix latipes	x		x						x						x
Pleuromamma xiphias		x		x	x		x	x			x		x	x	

* Daytime records only.

LIST OF DEEP LIVING SPECIES

Euaetideus giesbrechti (Cleve, 1904)

Euaetideus giesbrechti appears to be an inhabitant of moderately deep water, generally occurring between 200–350m. Several authors have recorded specimens from deeper waters (Vervoort, 1957). Grice and Hulsemann (1965) also record it in the northeast Atlantic between 100–500m. The only record of this species at the surface is Farran's (1929) from off Three Kings Islands.

Chiridius gracilis Farran, 1908

The vertical distribution of this species is tabulated by Vervoort (1957). Farran (1929) is the only person to record *C. gracilis* in superficial water layers off Three Kings Islands.

Chiridius poppei Giesbrecht, 1892

Vervoort (1963) summarised the bathymetric distribution of *C. poppei.* Although he stated that Grice (1962) found *C. poppei* at the surface, in fact this species was recorded in two hauls one from 146–72m, the other an oblique haul from 169m to the surface. Grice and Hulsemann (1967) found *C. poppei* in the west Indian Ocean between 1,000–2,000m. Farran (1929) is the only author to find this species at the surface off Three Kings Islands.

Chirundina streetsii Giesbrecht, 1895

Vervoort (1963) tabulated the bathymetric distribution of *C. streetsii.* Grice and Hulsemann (1965, 1967) recorded *C. streetsii* in the northeast Atlantic at 450–1,000m and west Indian Ocean at 2,000–1,000, 0–3,820, 225–2,600, 350–2,500, 350–3,500, 350–1,479, 350–1,710, 0–3,140m. Farran (1929) is the only person to record it at the surface off Three Kings Islands.

Gaetanus minor Farran, 1905

Farran (1926) stated that during the day the optimum depth range lies between 150–250 fathoms, but at night a few specimens ascend to the lower 50 fathoms of the epiplankton. Grice and Hulsemann (1965, 1967) recorded *G. minor* from the northeast Atlantic at 450–100m and west Indian Ocean at 2,000–1,000m.

Undeuchaeta plumosa (Lubbuck, 1865)

Vervoort (1957) considered this species to be restricted to moderately deep waters and tabulated depths. It may come to the surface at night. Grice and Hulsemann (1965, 1967) recorded *U. plumosa* in the northeast Atlantic at 450–900m and in the west Indian Ocean at 2,000–1,000, 350–1,710, 1,980–1,010. Farran (1929) recorded this species as *U. minor* at the surface during the day north of New Zealand.

Euchaeta acuta Giesbrecht, 1892

Farran (1926) recorded *E. acuta* in the Bay of Biscay down to 1,000 fathoms although during the day its main distribution is between 100–200 fathoms. At night there is a distinct migration to the uppermost 75 fathoms. Farran (1929) found this species at the surface off New Zealand in quite large numbers during the day.

Scottocalanus securifrons (T. Scott, 1894)

Vervoort (1965) tabulated the bathymetric distribution which is in deep and intermediate water layers. Only Farran (1929) recorded *S. securifrons* from the surface off Three Kings Islands.

Lophothrix latipes (T. Scott, 1894)

Vervoort (1965) tabulated the vertical distribution of *L. latipes* which comes from deep and moderately deep waters. Farran (1929) is the only person to record it at the surface off Three Kings Islands.

Pleuromamma xiphias (Giesbrecht, 1889)

Vervoort (1965) considered this species to be very characteristic of intermediate and deep water masses of tropical, subtropical and temperate regions. Grice and Hulsemann (1965, 1967) record *P. xiphias* in the northeast Atlantic at 500–2,000m and the west Indian Ocean at 2,000–1,000, 275–2,868, 275–2,250, 0–3,820, 0–2,407, 0–3,140, 1,950–1,015m.

Discussion

All stations at which deep water copepod species were found at the surface were in a group centred on stations 87 and 100 (Fig. 3). These stations were near the southwest end of the Elingamite Channel which runs southwest-northeast at a depth of about 200m across the South Maria Ridge (van der Linden, 1968) extending from Cape Maria van Dieman in a northwesterly direction. The Elingamite Channel cuts off Three Kings Islands from the continental shelf. Stations exhibiting anomalous copepod records lie in the same position as upwelling detected in November, 1954, February, 1955 (Garner, 1961) and September, 1966 (Stanton, 1969).

As upwelling appears to be present all year round, surface occurrences of deep water species at *Terra Nova* stations 85–7, 89, 92–3, 100, 107, 118,126–30 and 139, in August are caused by upward movement of deeper water layers over the ridge that extends northwest from the north of New Zealand.

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