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Evidence of the South Tropical Counter-Current in the Coral Sea

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Abstract

In the Coral Sea, the mean dynamic topography of the sea surface indicates virtually zonal circulation with one westward flow and two eastward flows at 163°E. and two westward flows and one eastward flow at 158°E. One of the eastward flows may be defined as the South Tropical Counter-Current and its position suggests it originates in the western Coral Sea rather than north of New Guinea. However, the data of the abnormal years 1958 and 1972 point out only westward flow.

Introduction

The surface circulation at the 170°E. meridian, described by Merle *et al.* (1969), is virtually zonal. It is composed of two westward flows, the Equatorial Current near the Equator and the South Equatorial Current at 15°S., and two eastward flows, the South Equatorial Counter-Current at 10°S. and the South Tropical Counter-Current at 18°S. However, in spite of the work by Donguy *et al.* (1970), the continuity of these flows in the Coral Sea has not been ascertained. In 1971 and 1972 the Centre ORSTOM de Nouméa undertook some new cruises in the Coral Sea. Together with the earlier cruises, the number of cruises now seems great enough to determine accurately the main features of the surface circulation in the eastern part of the Coral Sea.

Data and Methods

The data of Fig. 1 comes from the cruises carried out since 1956 by the Centre ORSTOM de Nouméa, aboard the R/V Orsom III and Coriolis, and aboard the vessels Tiaré, La Dunkerquoise and Boussole in collaboration with the French Navy. Details are listed in the following tabulation.

Vessel	Cruise	Date	Reference
Orsom III	56·5	Nov. 1956	ORSTOM, I.F.O. Rapp. Sci. No. 5
Orsom III	Astrolabe	May 1958	ORSTOM, I.F.O. Rapp. Sci. No. 8
Orsom III	Boussole	Nov. 1958	ORSTOM, I.F.O. Rapp. Sci. No. 12
Orsom III	Dillon	May 1960	ORSTOM, I.F.O. Rapp. Sci. No. 18
Tiare	Entrecasteaux	Aug. 1960	ORSTOM, I.F.O. Rapp. Sci. No. 21
Orsom III	Epi	Sept. 1960	ORSTOM, I.F.O. Rapp. Sci. No. 22
La Dunkerquoise	Guadalcanal	Dec. 1962	*Cah. ORSTOM sér. Océanogr.* 1964, **2**, 49–54
Coriolis	Foc 1	Jan. 1971	Natn. Ocean. Data Centre No. 350058
Boussole	71–01	Feb. 1971	Unpublished data

Coriolis	Foc 2	July 1971	Natn. Ocean. Data Centre No. 350074
Boussole	71–02	Aug. 1971	Unpublished data
Boussole	71–03	Dec. 1971	Unpublished data
Coriolis	Gorgone	Dec. 1972	Natn. Ocean. Data Centre No. 350077

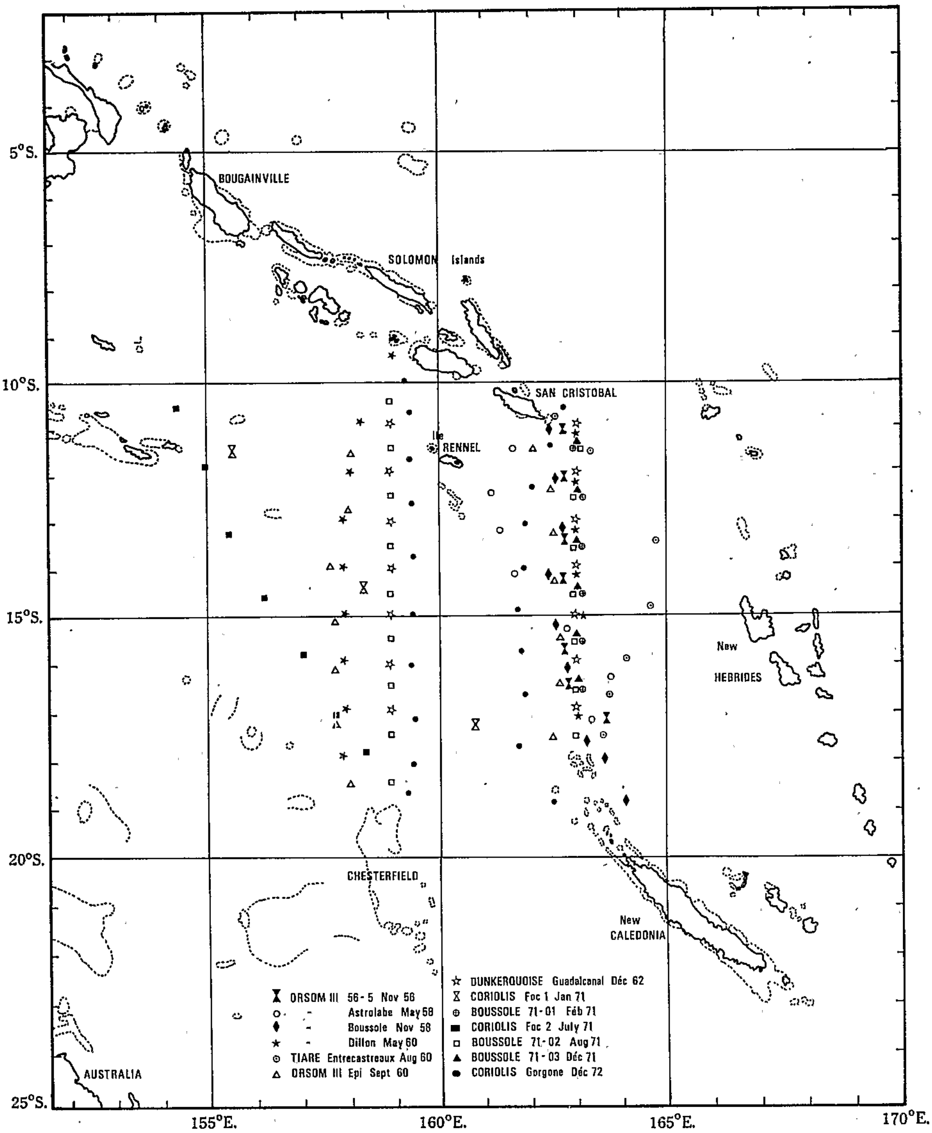

Fig. 1. Hydrographic stations occupied in the Coral Sea by the Centre ORSTOM de Nouméa since 1956.

Most of these cruises were carried out during the north-west monsoon and the seasonal coverage is not perfect.

The dynamic heights computed by usual methods from hydrographic casts are relative to the 1000 decibar surface, with an accuracy of $\pm 0 \cdot 5$ dynamic cm.

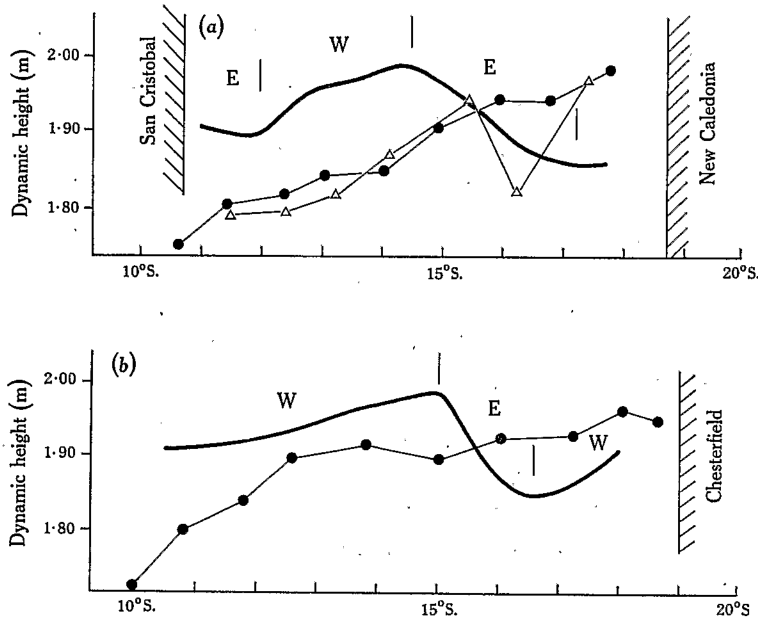

Fig. 2. Mean dynamic heights (heavy curves) in the Coral Sea relative to 1000 decibars at (*a*) 163°E. and (*b*) 158°E. and dynamic heights during the cruises Astrolabe (△, May 1958) and Gorgone (●, December 1972).

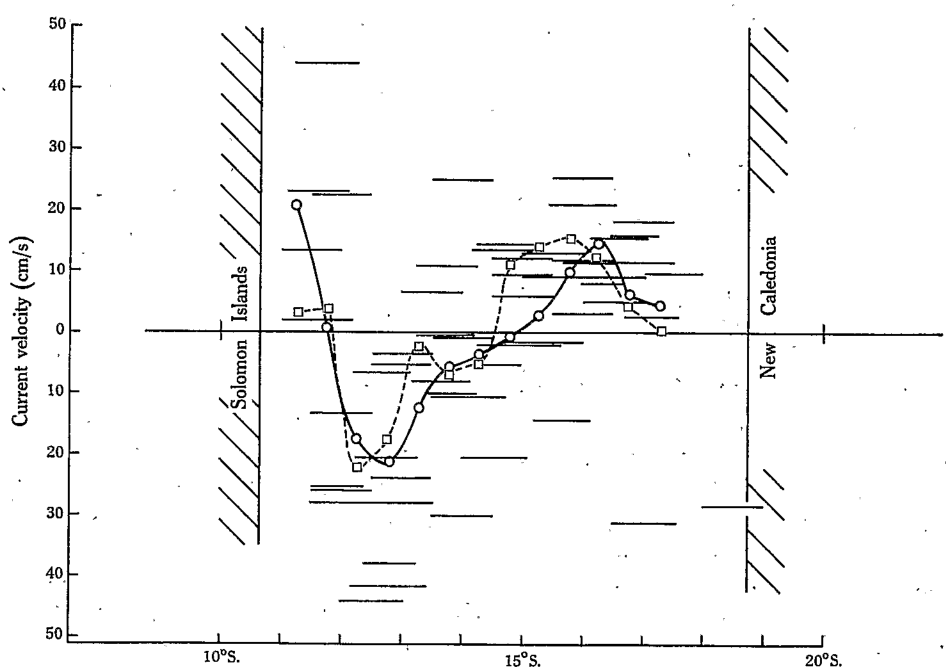

Fig. 3. Mean velocity of the current between New Caledonia and the Solomon Islands from the mean dynamic heights relative to 1000 decibars (□) and from the velocity averaged from the sea surface to a depth of 100 m relative to 1000 decibars (○). The horizontal lines represent the distance between two hydrographic casts.

Dynamic Heights at 158 and 163°E.

The hydrographic casts may be separated into two groups, one including the casts near the 163°E. meridian between New Caledonia and the eastern extremity of the Solomon Islands, and the other including the casts near the 158°E. meridian between the Chesterfield and Solomon Islands. The dynamic heights relative to 1000 decibars are averaged at 158 and 163°E. (Fig. 2) without the data of the cruises Astrolabe (May 1958) and Gorgone (Dec. 1972) which are recognized as abnormal.

At 163°E., from the north to the south, the eastward flow north of 12°S. is identified as the South Equatorial Counter-Current, the westward flow from 12 to 14°30'S. as the South Equatorial Current and the eastward flow from 14°30' to 18°S. as the South Tropical Counter-Current.

At 158°E., two westward flows and only one eastward flow are discernible: the South Equatorial Current from 10 to 15°S., the South Tropical Counter-Current from 15 to 17°S. and a westward flow south of 17°S.

The comparison of the dynamic features at 163 and 158°E. may be noted as follows.

(i) In the Coral Sea, the South Equatorial Counter-Current is observed only at 163°E.

(ii) The South Tropical Counter-Current exists both at 163 and 158°E.; it seems narrower but stronger at 158 than at 163°E. Its position at 158°E. suggests it originates in the western part of the Coral Sea rather than north of New Guinea like the South Equatorial Counter-Current (Jarrige 1968). This point is in accordance with the surface dynamic topography relative to 1500 decibars of the Diamantina cruise Dm4/68 (Scully-Power 1973*a*).

(iii) The existence of a westward flow north of the Chesterfield Islands may be connected with the presence of a northward flow west of New Caledonia (Scully-Power 1973*b*).

(iv) The dynamic heights of the cruise Astrolabe and Gorgone are smaller, which is an indication of unusual hydrographic conditions, and their slope, rising from the north to the south, is characteristic of a westward flow. At 159°E., the flow of the Gorgone cruise is stronger north of 12°S. than south of this latitude.

Velocity of the Surface Current at 163°E.

The mean velocity of the current between New Caledonia and the Solomon Islands is calculated (Fig. 3) through the 163°E. meridian by two different ways: one from the mean dynamic heights relative to 1000 decibars (Fig. 2) and the other from the velocity averaged from the sea surface to a depth of 100 m relative to 1000 decibars and calculated between the consecutive hydrographic casts of each cruise, except Astrolabe and Gorgone. Generally, the velocity maximum of all the tropical currents and countercurrents is in the sea surface. The South Tropical Counter-Current is shallow and its velocity at 100 m is very weak (Merle *et al.* 1969), unlike the South Equatorial Counter-Currrent which is much deeper (Jarrige 1968).

Though the two curves have almost the same shape, the discrepancy between them is due to their manner of construction. The northern boundary of the South

Equatorial Counter-Current is not determined but, in the Coral Sea, its maximum mean velocity is only 4 cm/s from the mean dynamic heights and reaches 20 cm/s at 11°S. by calculation between 0 and 100 m. From 12 to 15°S., the South Equatorial Current has a maximum mean velocity of 20 cm/s at 13°S. South of 15°S., the South Tropical Counter-Current has a maximum mean velocity of 15 cm/s at 16°S. but, from 14°30′ to 16°S., there is a difference of 10 cm/s between the two curves. However, the observed velocity during each cruise may be greater, up to 25 cm/s in the South Tropical Counter-Current and 45 cm/s in both the South Equatorial Counter-Current and the South Equatorial Current.

The mean transport deduced from the velocity in the upper layer (0–100 m) of the South Equatorial Current is $3 \cdot 5 \times 10^6$ m^3/s and the maximum is $6 \cdot 7 \times 10^6$ m^3/s which is in accordance with the inflow value of Scully-Power (1973*b*) (10×10^6 m^3/s between 0 and 250 m depth). The mean transport of the South Tropical Counter-Current is 2×10^6 m^3/s and the maximum is 5×10^6 m^3/s which is in accordance with Merle *et al.* (1969) for the 170°E. meridian.

Conclusion

The eastward flow observed between 15 and 20°S. at 170, 163 and 158°E. has been called the South Tropical Counter-Current. It seems to originate in the western Coral Sea and its transport is about 2×10^6 m^3/s.

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