CHAPTER VI
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SUMMARY AND CONCLUSIONS

This thesis is an outcome of the studies, carried out by the author on the Equatorial Undercurrent and the Equatorial Jet, an interesting and unique phenomenon discovered, recently, in the Indian Ocean (Wyrtki, 1973). The main objective of the thesis is to carry out a detailed investigation of the seasonal, latitudinal and longitudinal variation of the Equatorial Undercurrent in the Indian Ocean and also the Equatorial Jet, through mapping the vertical distribution of the oceanographic properties across the equator along various longitudes for all the months of a year, between $5^\circ$N and $5^\circ$S, utilising the oceanographic data collected during the International Indian Ocean Expedition and subsequently in the equatorial Indian Ocean.

As the distribution of the hydrographic properties give only a qualitative identification of the Undercurrent, a novel technique of computing the zonal flux through bivariate distribution of salinity and thermosteric anomaly, introduced by Montgomery and Stroup (1962), is adopted in order to have a quantitative variation of the Equatorial Undercurrent and the Equatorial Jet. Finally, an attempt
is made to give a plausible explanation of the features observed.

Transequatorial sections are chosen, as far as possible, in such a way that at least one section is included in each month, in the three regions namely western, central and eastern that fall within the longitudinal limits of west of $65^\circ$E, $65^\circ$ - $85^\circ$E and east of $85^\circ$E respectively so as to understand the longitudinal variation of the Undercurrent in each month. On the whole, 31 vertical sections are prepared, out of which 11 sections are selected for the computation of zonal flux. After mapping the distributions of temperature, salinity and oxyty along each vertical section, they are superimposed as a single section by presenting the isotherms, isohalines and oxyleths by different notations so as to enable an easy comparison of the distribution of one property with another.

The Equatorial Undercurrent is associated with specific characteristics of spreading of thermocline, high salinity core and the penetration of oxygen rich water to subsurface layers through vertical mixing. It is through such associated features in the distribution of hydrographic properties that the Equatorial Undercurrent in the Indian Ocean is identified monthwise and regionwise in the present study.
The details of the computation of zonal flux is presented in the materials and methods. The zonal flux, depicted on the bimodal distribution is demarcated into 50% and 75% of the total flux by thick and dashed lines in order to give an easy identification of different modes and their frequencies within the limits of 50% and 75% of the total flux. In general, higher number of frequencies indicate the heterogeneity while the lower number reveals the homogeneity. Further, when the Equatorial Undercurrent is present, it is normally represented by a primary mode of fewer frequencies either within the thermocline or associated with the high salinity core.

Unlike in the other major oceans of the world, namely the Pacific and Atlantic, where the Equatorial Undercurrent is present throughout the year, it appears only seasonally in the Indian Ocean because of the reversal of the atmospheric circulation over the North Indian Ocean, which reflects in turn in the surface and subsurface current pattern.

From the distribution of the hydrographic properties of the vertical sections along the various longitudes, it could be inferred that the Equatorial
Undercurrent is present all along the width of the Indian Ocean with the normal characteristic features of the Undercurrent, during February to April. But the commencement of the Undercurrent takes place in January in the western region, some times even in December, as the sections used for the present study shows some indications of the Undercurrent. Further, it is noticed that in the beginning it is located slightly north of the equator due to upwind shift of the northerlies prevailing in the western region. The Undercurrent is also found to be initially developed in the western region and extends to the east and shifts south to the equator with time. It is not very clear whether the commencement of the Undercurrent is permanent feature or only for the particular year of observation of the present study, as there is no indication of the Undercurrent in the eastern region in January.

During April and May, though the high salinity core is around $1^\circ N$, the weakening of the vertical thermal gradient is found around the equator. It is therefore difficult to distinguish the Undercurrent during these months in the western Indian Ocean. In the central and eastern Indian Ocean, the core is almost symmetrical about the equator, and it deepens in its course from west to east.
and also from February to May in the western region. Before the termination of the Undercurrent it is found to shift southward due to the wind shift of the southwesterlies that begin to blow by May at the equator.

At the peak of the southwest monsoon and subsequently, the surface flow is mainly easterly along the equator as the southwest Monsoon Current merges with the Equatorial Countercurrent, both being easterlies. During this period the South Equatorial Current which is a westerly, shifts to the northern most in an year. Although in the subsurface layers the easterly flow is, occasionally, noticed, it cannot be construed as the Equatorial Undercurrent as the characteristics are different from those associated with Undercurrent. It can, thus, be concluded that the Equatorial Undercurrent in the Indian Ocean is absent from late June to early December.

It is interesting to note that although the Equatorial Undercurrent is considered to be closely related with the spreading of the thermocline and high salinity core, in the Indian Ocean, seldom they coincide except in a few instances during February to April. Invariably, the Undercurrent appears to be identified below the high salinity core and at the bottom of the thermocline as is
evident from the zonal flux distribution also.

During May, October and November the hydrographic properties indicate the presence of strong easterly flow with intense gradients in temperature and salinity distribution. Thus, the presence of the Equatorial Jet in the central Indian Ocean is well depicted in the vertical sections, but, its intensity decreases on either side along the equator.

Flux distribution during February, March and May in the western Indian Ocean presents slightly higher value in March. In general, the transport increases from the western to the central Indian Ocean during the latter period of northeast monsoon while it remains almost unchanged in the eastern region. The transport during May and June, especially in the eastern region indicates a strong easterly flow at the surface within 3°N and 3°S with equally strong flow underneath it. Similar transport is observed in October with higher values indicating stronger flow in the surface layer. The transport does not indicate a westward flow during October in the subsurface layers as in the case of May.

The estimated geostrophic transport, within 200 and 400 cl/t, gives a total flux of $13.91 \times 10^6 \text{ m}^3 \text{ s}^{-1}$ at 59°E.
in March and it is in accordance with the value
$14 \times 10^6 \text{ m}^3 \text{ s}^{-1}$ computed by Swallow (1964) from direct
current observations. But, the transport at $92^\circ E$ in
April deviates much from the values of Taft and Knauss
(1967), as their volume transport is within the core
of the Undercurrent while the present estimate is within
the isanosteric limits of 200 and 400 cl/t but not within
the Undercurrent.

The Equatorial Undercurrent appears to be absent
during May and June in the eastern region of the Indian
Ocean while it is present in the western region. In the
place of the Undercurrent strong westerly flow is conspicuous
from the zonal flux distribution in the eastern sections.
Obviously, the Equatorial Undercurrent disappears in the
eastern region by these months.

The strong surface easterly flux present during
the two transition periods denotes the Equatorial Jet and
is symmetrical about the equator within $3^\circ N$ and $3^\circ S$. The
Jet in the October transition is intense with a total zonal
flux of $70.05 \times 10^6 \text{ m}^3 \text{ s}^{-1}$, particularly, in the upper
layers and it is stronger than its counter part in May.

In general, there are certain deviations in the
development and termination of the Equatorial Undercurrent
in the Indian Ocean, compared with that in the Pacific and Atlantic, while the salinity core gives a major indication in the Atlantic and thermocline spreading in the Pacific. In the Indian Ocean both features are noticed but they do not coincide.

As the development and termination of the Undercurrent could not be well established with the oceanographic data available at present, it is necessary to carry out the oceanographic measurements at closer intervals of stations along the various longitudes, particularly during December, January, May and June after which alone, the actual period and place of commencement and termination can clearly be confirmed.