SOUVENIR

20th Anniversary

Central Marine Fisheries Research Institute

(Government of India)

★

ISSUED BY

THE ORGANISING COMMITTEE C. M. F. R. I. RECREATION CLUB

MANDAPAM CAMP

Ocean Currents

By A. V. Suryanarayana Murty
Central Marine Fisheries Research Institute

Looking at the sea one sees the ripples on the surface and the rolling waves, but a more keen observant sees that more portions on the shore are submerged at times and exposed at other times owing to the rise and fall of sea surface, the tidal influence brought about by the gravitational pull of the sun and moon on the oceans. What one fails to notice is that the body of water is in constant flowing motion; this becomes obvious when one watches some debris floating on the surface. This movement of water is known as current. Some of these currents are so enormous in extent that the Amazon could be found a rivulet. The speed of movement varies from a few meters per hour to several knots.

The three-dimensional motions lead to and ensure a thorough mixing and circulation of the ocean waters which is of significance; they ensure a constancy of temperature, despite the heating and cooling processes at the surface; ensure transport of oxygen to the depths of the oceans and maintain the constancy of the salinity of the waters and ensure the distribution of nutrient salts. These lead to the sustenance of the tremendous organic production and supply of food to the millions of organisms in the water including fish on which we are dependent. The currents are not only at the surface but in deep waters also. These can be studied by measuring the temperature and salinity at all depths at several geographical positions and studying their distribution across the length and breadth of the oceans. The density gradients and wind force and so on cause this horizontal movement of water. The vertical and horizontal distribution of dissolved oxygen and nutrients, the similarity of plant and animal populations are also used to trace the origin and movements of water masses. We have several well-established currents in the oceans, the Gulf Stream, Kuroshio, California, Benguela and Peru currents to mention a few. The Gulf Stream of the North Atlantic carries larvae of the eel from the Sargasso Sea to the coasts of Europe. The Kuroshio Current of the North Pacific supports vast pelagic fisheries of Japan. The California Current flownig along the west coast of the United States is important for the California sardine fishery. The Benguela Current of the west coast of South Africa has a tremendous impact on the pilchard industry of the Southwest Africa. The Peru Current off the coast of South America is one of the highly productive waters and accounts for the vast shoals of anchovies and the guano deposits which are the faecal deposits of birds which feed on these fishes. Guano deposits are a rich source of fertilizers.

We owe our knowledge of the currents in the Indian Ocean and adjacent seas to the data gathered by the British Admiralty and the pioneering work of the late Col. R. B. S. Sewell (the '*INVESTIGATOR*' cruises) and the *JOHN MURRAY EXPEDITION* and quite recently of the work carried out in the Central Marine Fisheries Research Institute and the International Indian Ocean Expedition.

In the North Indian Ocean the main water mass is the Equatorial Water (Tropical Water) which covers the central part of the Indian Ocean and extends into the Arabian Sea and the Bay of Bengal. This water mass is present at depths 100-200 m. The Bay of Bengal Water is subdivided into the North Dilute Water and the Southern Bay of Bengal Water. The Southern Bay of Bengal Water which is relatively productive is the most predominent surface water mass in the Bay. The North Dilute Water of the Bay is formed during the fall due to the influx of water from the rivers emptying into the northern region of the Bay. The highly saline surface water in the Arabian Sea area sinks and forms the so called North Indian Deep Water (Arabian Sea Water). This water mass penetrates to the south and could be traced up to Java in the East. Its exact limit to the south is yet to be established. It is characterized by high salinity and very low oxygen content. The warm and highly saline Red Sea Water flows along the bottom of the Strait of Bab-el-Mandeb into the Indian Ocean where it mixes with other water masses and spreads. The transform ed Red Sea Water was observed up to 68°E longitude only. Recent investigations of R. V. *VITYAZ* revealed that the role of the Red Sea Water in the formation of the Arabian Sea Water is not as considerable as it was believed earlier. Apart from the Indian Ocean Tropical water which extends from the Equator to the Tropical Convergence (24°S), the Subtropical Surface Water and the Subantarctic Surface Water are the main surface water masses in the South Indian Ocean. The Subtropical Surface Water extens from the Tropical Convergence to the Subtropical Convergence (42°S). The subantarctic Surface Water extends from the Antarctic Convergence (50°S) to the Subtropical Convergence. The mixed Subtropical and Subantarctic Water masses in the Subtropical Convergence region give rise to the formation of the Central water Mass which sinks and spreads northward from the Subtropics at depths 200-600 m This water mass bridges the poorly saline Antarctic Intermediate Water and highly saline Surface and Subsurface waters. It is known for its moderate temperature and salinity, and high oxygen content. The Antarctic Intermediate Water forms in mid-depths by mixing up of Antarctic and Subantarctic Water just north of the Antarctic Convergence. This water sinks and spreads northwards at about 1000 m, depth. This water mass may spread even into the Northwest Indian Ocean. The Deep Water which is of Atlantic origin is also present in the South Indian Ocean, apart from the North Indian Deep Water. This water usually lies between 1600 and 3000 m. The Antarctic Bottom Water exists below 3000 m. It is a very stable layer. Very little change occurs within this layer. Temperature of this watermass in the Indian Ocean is usually less than 2°C and the salinity about 34 7 parts per thousand.

A very wide belt of of the equatorial region (from about 20°S) of the South Indian Ocean is occupied by westerly drifts at the surface. The current is called the South Equatorial Current. It starts from the north-west corner of Australia, branches into two off the east coast of Madagascar. The southern branch of the current partly joins the south flowing Agulhas current and partly mixes with the east flowing Antarctic West-Wind drift. The northern branch of it feeds the Somali current during the Northern Hemisphere summer and the Equatorial Counter-Current during the Northern Hemisphere winter. The Equatorial Counter Current is an eastward flow. The width of this current which is very narrow depends upon the season. But it however, lies south of the equator unlike its sister currents in the other oceans. North of this counter current, there is again a west-bound flow spreading upto about 5°N which is known as the North Equatorial Current. There is a relative seasonal spread of the respective bands of these currents which may be associated with the shift of the doldrums. The South Equatorial Current and the Equatorial Counter Current are steady throughout the year whereas the North Equatorial Current reverses its direction during the Northern Hemisphere summer during which season the southwest monsoon is active. Apart from the east-bound strong drift currents, the monsoon circulation develops drift currents in the North Indian Ocean which vary from region to region. The drift currents developed in the Bay of Bengal, which flow northeastward, lead to an extremely high piling up of water along the eastern side of the Bay. As a result of these drift currents, the coastal currents in the southern part of the east coast of India will have northeasterly components flowing away from the coast and the coastal currents in the northern part of the east coast will be parallel to the coast.

The drifts in the Arabian Sea during this season (Northern Hemisphere summer) are relatively strong. They take a clockwise deviation (anticyclonic shear) as a result of the continental effect. In view of this, the drift currents in the Arabian Sea assume more southerly components on the western side of the Indian peninsula. Therefore, the currents off the west coast of India, during this season, flow southwards parallel to the coast. Beyond the Indian peninsula, the drifts regain their eastward components and are finally reinforced with the eastbound Equatorial Counter Current. As a result of this reinforcement, the easterly currents south of Ceylon get strengthened.

During the Northern Hemisphere winter the drifts in the Arabian Sea are south to southwesterly. The drifts in the Bay of Bengal, during this season, present with an interesting feature. The entire Bay region is occupied by a single cell constituted by clockwise drift currents. As a result of this, the waters of the central part of the Bay are almost at a standstill and the waters of its southern region experience a reversal of the currents of the previous season.

As the current from the southern rim of the clockwise cell joins with the Equatorial Current, there would be a concentrated westward flow south of Ceylon. Due to the boundary effects, it is possible that this strong current may take a northerly deviation from its general westward flow. It flows close to the Indian sub-continent or even northward to some extent on the western side of the sub-continent. Such deviations of the flow during this season (Northern Hemisphere winter) may be important from the view-point of the commercially important pelagic fisheries like the sardines and the mackerels which are supposed to enter the Indian fishery from the latitudes south of India and which show marked differential regional changes in their fisheries along the Southwest Indian Coast In fact, the northward movements from the surface to at least down to 200 m depth, in the southeastern Arabian Sea area (off the southwest coast of India), were revealed from the hydrographic observations of R. V. *VARUNA* during the same season.

From the fishery view-point, the important upwelling regions, namely the Somali Coast, the Java Coast and the North West Australian Coast, are all associated, directly or indirectly, with these wind drifts. The fishing grounds of the tunas in the Indian Ocean are located within the broad belt of the Equatorial Currents. The tuna fishing is more intense in the South Equatorial Current region rather than the region of the other two counterparts of this current.

Apart from the wind drifts which occupy a wide suface area of the Indian Ocean, there are some major currents in the ocean. It may be interesting to deal with them in detail.

In the Southwestern Indian Ocean (south of Madagascar) there is a rapidly flowing southward current along the east coastline of South Africa. This is known as the Agulhas Current. It is strongly developed during the Northern Hemisphere winter. It varies from 50 to 100 miles in width with surface velocities of about 2 to 4 knots. It extends to much greater depths (about 3500 m) unlike the other currents in the Indian Ocean, The current is bounded offshore by a weak couter current at the surface. There is also a counter but weak flow at great depths under the current. In the view-point of extending to great depths, the Agulhas Current is comparable with the Gulf Stream.

There is a strong northward flow parallel to the Coast of Somalia. This is known as the Somali Current. This current was studied in great detail by R. R. S. '*DISCOVERY* III' during the International Indian Ocean Expedition in the recent years. Surface currents of the order of 6 knots are present in the core of the current. The current takes a deviation from the coast in the northern part of its course (8°N). The current is bordered, on its oceanic side, by a weak counter current at the surface. A weak opposite flow is also present underneath.

As it is driven by the stress of the monsoon airflow, the Somali Current is present only during the Northern Hemisphere summer. This is the reason why it runs across the equator, unlike the other "western-boundary" currents such as the Gulf Stream and the Kuroshio. During the other season, a reversal of this current takes place, but it is feeble when compared with the north-bound Somali Current.

In the Northern region of the Somali Current upwelled cold waters have been recorded. In this region plankton growth is poor, though the upwelled waters are found rich in nutrients. Further, fish mortality is observed in the colder waters. The very low temperatures recorded possibly explain the paucity of life in this area. Further north of the current (10°N) warm water from the Gulf of Aden is found spreading at the surface. The biological activity in this northern area is found to be good with abundant plankton and large number of larval fish.

The Equatorial Undercurrent was recently discovered by R. V. *ARGO* in the Indian Ocean. The current is about 4° wide flowing from west to east. The high velocity core of it is situated in the region of thermocline (at a depth of about 100 m from the surface) along the Equator. The Equatorial Undercurrent in the Indian Ocean, unlike its sister currents in the other oceans, is not steady with time. It is more unsteady and less pronounced during the southwest monsoon period. Its flow is faster in the eastern part of the Indian Ocean than in the western part.

Spreading of the thermocline is an interesting feature which is associated with the Equatorial Undercurrent. As this feature is an indication of upwelling, the equatorial regions, where the influence of this undercurrent is more, would be important from the biological point of view.

It may be mentioned finally that we have hardly touched the fringe of the problem and a great deal remains to be known before the picture of circulation during the seasons becomes clear. Intensive work on these aspects is being pursued at the Central Marine Fisheries Research Institute.