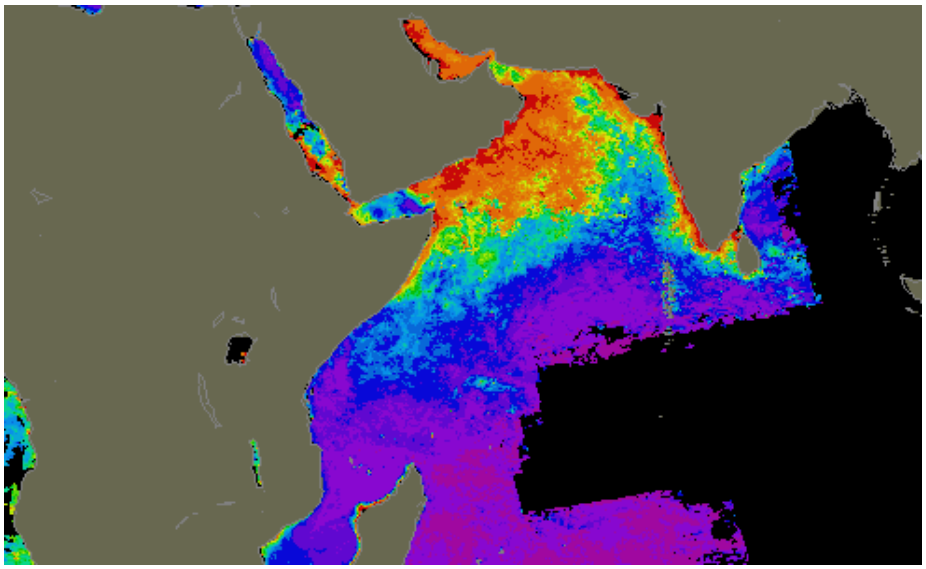
Chapter 4: The Arabian Sea (seasonal changes in upwelling and productivity)

In the previous chapters, CZCS images have illustrated interactions of ocean currents and ocean biology, and how the process of upwelling induces areas of high primary productivity. In this chapter, composite seasonal images of one of the most dramatic changes in the entire ocean will demonstrate how different conditions during different seasons of the year can affect the productivity in a large oceanic region.

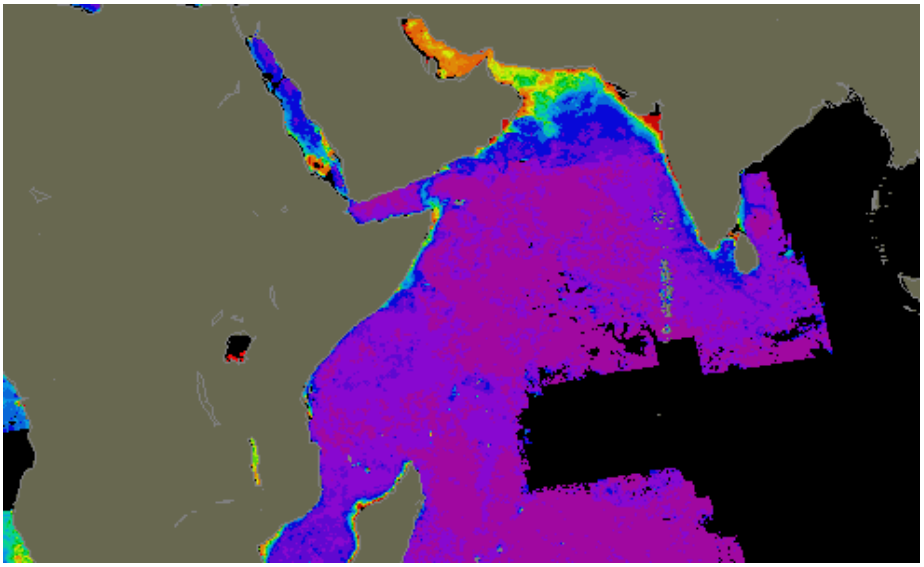
The area of the images is the Arabian Sea, on the northwest side of the Indian Ocean. This area is roughly bounded to the east by India, to the north by Pakistan, Iran, and Saudi Arabia, and to the east by Oman and Somalia. This is the area of the *monsoon*. For half the year (July-December), the winds in this region are from the southwest, inducing a great deal of evaporation from the warm waters of the Arabian Sea, and heavy rainfall along the coast of India. In the other half of the year, the winds blow in the opposite direction, and not as strongly as the southwest monsoon.



CZCS composite image of the Arabian Sea for July-September 1979, showing the large area of high productivity waters that develops under the influence of the southwest monsoon.

During the southwest monsoon, a low-level atmospheric feature called the Findlater Jet forms over the ocean, near the coasts of Somalia, Yemen, and Oman. The northeastward flow of the surface current induced by the Findlater Jet causes strong upwelling near the coast, inducing a period of high productivity that is easily observable in composite images of the Arabian Sea for these months.

As the winds diminish and switch direction at the end of the southwest monsoon season, the Findlater Jet ceases to blow. The weaker southward flowing currents do not induce upwelling near the coast, so that during the months of January to June, the Arabian Sea is an area of low productivity. This marked change in conditions is one of the most distinct seasonal alterations observed anywhere in the world.



CZCS composite image of the Arabian Sea for April-June 1979, the latter half of the annual period of low productivity preceding the development of the southwest monsoon. Outflow features from the Persian Gulf are also visible.

The peak of the monsoon season in the Arabian Sea occurs in July, resulting in heavy cloud cover that obscured most of the area from view. Also, because of the experimental nature of CZCS, it was not continuously operational, leaving noticeable gaps in the coverage.

This distinct change in conditions made the Arabian Sea the subject of a recent process study in the Joint Global Ocean Flux Study (JGOFS) program. JGOFS seeks to determine the rates of primary productivity in various ocean regions, to better understand how carbon is cycled through the atmosphere and the oceans. One reason that the Arabian Sea is of particular interest is that some models of the Earth's future climate, as global warming influences the oceans and atmosphere, indicate that many patterns of productivity in the ocean will become more "monsoonal"; that is, more like the seasonal patterns observed in the Arabian Sea. This possibility makes the Arabian Sea an important region for intense study.