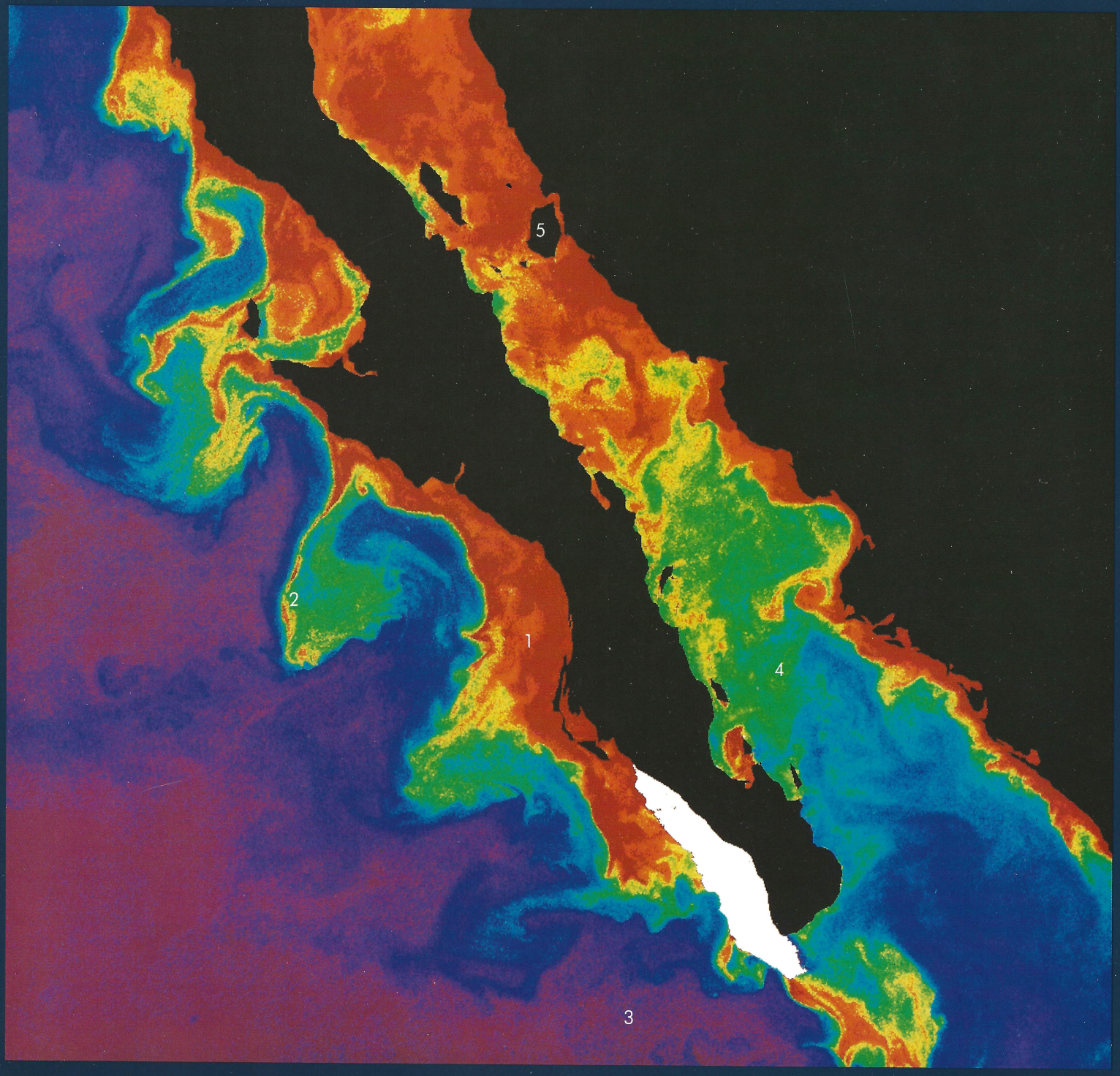
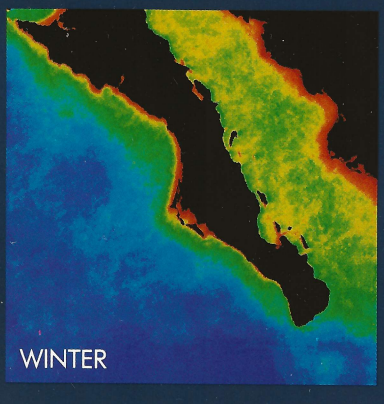
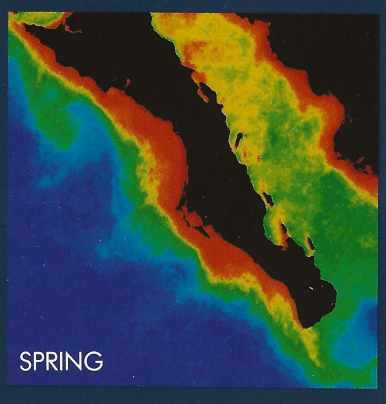
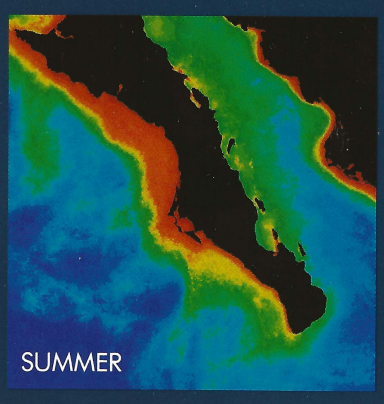
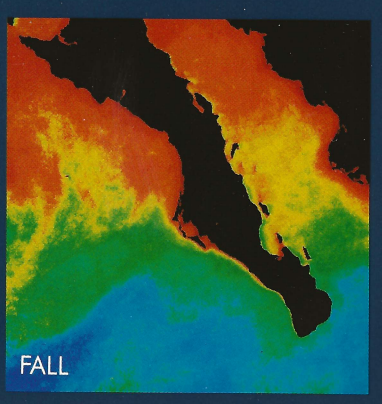
Seasonal Baja Ocean Color











Seasonal Baja Ocean Color

In 1539, a Spanish captain exploring Baja was so impressed by the strange reddish color of the water separating the peninsula from the mainland of Mexico that he called it the Vermilion Sea. Today biological oceanographers understand that the often observed red color of the Gulf of California is the result of the very high productivity of the phytoplankton. These intense phytoplankton blooms are called "red tides." What factors control levels of marine life in this region? How do conditions differ in the Gulf versus the Pacific Ocean? How do conditions change seasonally and annually? Oceanographers have been asking these questions for decades, and now satellites are providing a capability to observe such phytoplankton blooms and to study their distribution in time and space.

Phytoplankton, the single-celled plants that color the water and represent the base of the marine food chain, require light and nutrients to grow. The usually cloud-free atmosphere over this region assures sufficient light in the surface layers of the ocean for phytoplankton growth, so the limiting factor is the supply of nutrients. This can be provided by mixing nutrient-rich deep water up into the lighted surface layers. Two processes are responsible for the high productivity in this area: wind-driven upwelling and, within the Gulf, tidal mixing. The combination of these two processes results in complex and varying patterns of productivity. Traditional shipboard studies have defined the processes, but satellites are required to give the broad, synoptic view necessary to evaluate the extent and variability of the productivity of this area.

The large image shows phytoplankton abundance, measured as chlorophyll pigment concentration, calculated from ocean color data collected by the Coastal Zone Color Scanner (CZCS) on NASA's Nimbus-7 satellite during a single pass on May 12, 1979. (See: Western North Atlantic Color.) This image measures 1600 km (1000 mi) on a side, and the spatial resolution (pixel size) is 800 m (0.5 mi). These data were collected at the Goddard Space Flight Center; processing and analysis were performed by Dennis Clark at NOAA using software developed at the University of Miami. The color scale represents chlorophyll pigment concentrations as follows: purples and blues are low levels (0.05 to 0.35 mg/m^3), greens and yellows are intermediate levels (0.35 to 1.0 mg/m^3), and oranges and reds indicate high levels (1.0 to 30.0 mg/m^3).

Adjacent to the Pacific coast of Baja California there is a stretch of high-phytoplankton concentration (1) caused by wind-driven upwelling. (See: West Coast Upwelling.) In places, long filaments of this phytoplankton-rich water extend hundreds of kilometers offshore, mixing with the meandering California Current (2). Farther south, the Costa Rica Current (3) flows north bringing warm water from equatorial regions to meet the cooler southward-flowing California Current. Near the southern tip of Baja, a cloud/fog bank (the white area) has formed over the cold water at an upwelling site. The high-phytoplankton abundance of the cold nutrient-rich coastal waters contrasts sharply with the low-phytoplankton waters of the California and Costa Rica Currents offshore; these two currents are not easily distinguished in this image because they are both relatively low in phytoplankton.

Conditions in the Gulf are quite different from those in the Pacific. The southern part of the Gulf is a deep basin. Low-nutrient surface water flowing into this area from the south results in generally low levels of phytoplankton (4), except for a narrow area of upwelling along the coast of mainland Mexico. North of the Midriff Islands (5) there is a shallow basin; strong tidal currents cause intense mixing as they pass over the shallow subsurface ridges near these islands, bringing deeper nutrient-rich waters to the surface. The result is high-phytoplankton abundance indicated by reds in the image.

The four smaller CZCS images illustrate the marked seasonal variations in the distribution and abundance of phytoplankton in this region. They were derived from a total of 115 satellite passes, with each image combining appropriate data to depict the mean pigment concentration for a given season. From left to right they are: winter (December 1978 to March 1979), spring (April to May 1979), summer (June to September 1979), and fall (October to November 1979). Transient features, such as the filaments seen in the upper image, have been smeared out in the averaging process and are not apparent in the seasonal means.

Except for the summer, the southern half of the Gulf has a reasonably high concentration of phytoplankton throughout the year. The most striking seasonal change in the Gulf is from low-phytoplankton abundance in the summer to high-phytoplankton abundance in the fall. This increase is due to upwelling induced by favorable northwest winds in the fall; this also results in high abundance on the Pacific side of Baja. These patterns, very difficult – if not impossible – to measure from scattered ship observations, represent the first statistically valid analysis of the seasonal variation of phytoplankton distributions. The data upon which this one-year time series is based far exceeds all at-sea measurements of phytoplankton ever made in this area.

Satellite data from 1980 to 1985 are also being analyzed. The winter pattern for 1979-80 shows much lower productivity than either the previous or the following two winters, indicating strong inter-annual as well as seasonal variations. To understand the long-term variability of ocean productivity requires continuing satellite ocean-color observations and complementary at-sea measurements. Unfortunately, the CZCS is over seven years old (six years beyond its design lifetime) and shows signs of failing. An improved version of the CZCS, the Ocean Color Imager (OCI) has been proposed for flight in the early 1990's. Beyond that, a new instrument, the Moderate Resolution Imaging Spectroradiometer (MODIS) is planned for the mid-1990's. These instruments are needed to further our understanding of the magnitude and long-term variability of regional and global ocean productivity.

NASA
National Aeronautics and Space Administration