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Tracing L.A.'s Marine Topographies: Climate, Currents, and Calamari

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The greater Los Angeles region is home to an estimated 13 million people. The region's climate and culture is intimately tied to its coastal proximity. Famous for many things, the region is world-renowned for its envious climate, characterized by golden rays of sunshine and mild winters. The capacity of the ocean to store heat results in warmer winters and cooler summers, creating the area's Mediterranean microclimate, which is much more temperate than the desert conditions further inland. The California current, one of only five major ocean currents globally to be associated with an upwelling zone, also regulates the coastal conditions in this area. The California current is an eastern boundary current of the North Pacific Gyre, a clockwise circulation, transporting cool waters from the northern Bering Sea south along the California coast. Upwelling generated by this circulation transports nutrient-rich sediments from the deep ocean to the surface, stimulating abundant primary production and in turn thriving fisheries. This allows Southern California to profit from the abundance of sardine, anchovy, hake, and mackerel fish species, which help to support their thriving ocean economy, the largest in the United States (Kidow and Colgan 2005).

Seasonal Ocean Temperatures: The California and Davidson Currents

This movement of northern Pacific water southward along the California coast results in cooler waters than otherwise might be expected at similar latitudes. The articulation of the California current with the prevailing northeasterly winds induces an additional transport of cold water from the deep, to the surface. This Ekman transport occurs when winds blow parallel to the coast, moving surface water away from the shore, which is then replaced by water from below. As this deep water replaces the surface water, the upwelling results in a nutrient-rich, sub-surface flow, replenishing the nutrient depleted surface water. This upwelling further reduces the temperature of these coastal waters as well as provides a supply of nutrients necessary for phytoplankton to flourish. The chlorophyll concentrations, shown in Figure 1, as measured by the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) aboard the SeaStar satellite, shows the abundance of phytoplankton blooming amongst the upwelling waters. These primary producers are the basis for a healthy aquatic ecosystem food chain, which, in turn, support marine mammals and bird populations, such as whales and pelicans, as well as highly productive fisheries.

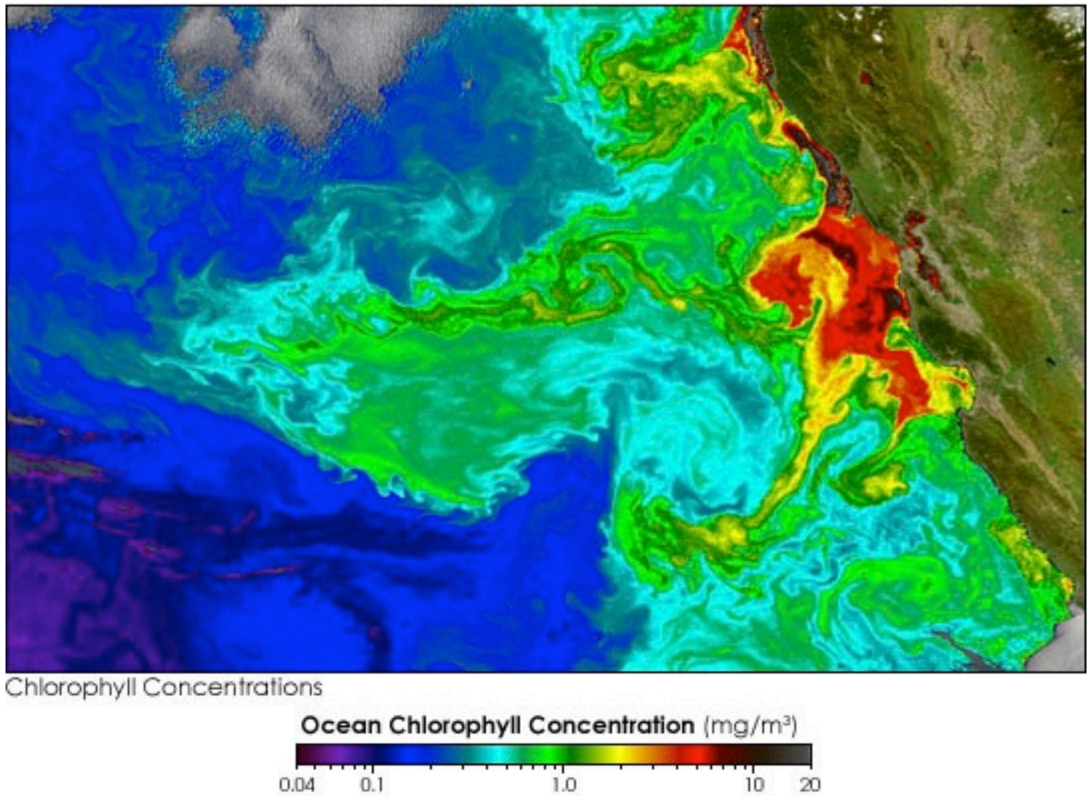

Figure 1: This image from March 16, 2004 shows phytoplankton blooming in the upwelling off the California coast. Image courtesy the SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE

In contrast to the cool ocean surface temperatures of summer, the Davidson current, a narrower, weaker countercurrent to the California current, moves warmer water northwards to the southern California coast during the winter months, increasing ocean surface temperatures in winter. The Davidson current results from seasonal changes in Pacific Ocean atmospheric pressure conditions. This brings southwesterly winds to the California coast, resulting in this northward Davidson current inland of the California current. Also important for surface water temperature and marine production in this region is the ability of the El Niño phase of the El Nino Southern Oscillation (ENSO) to disrupt the California current. This disruption results in decreased phytoplankton levels producing a potentially devastating effect on the food chain as the impacts move up the trophic levels, affecting fish, marine mammals, and seabirds (Schwing et al. 2003).

Scripps Institution of Oceanography has detected a disturbing long-term trend in water temperatures at their monitoring site Scripps Pier in La Jolla. Since 1950 scientists reported an increase of almost 3 degrees Celsius, or about 5 Fahrenheit. This seemingly more permanent shift in the temperature regime of these coastal waters has important implications for changing the spatial distributions of local marine species as well as invasions of exotic species, such as the Humboldt squid.

Invasions of Humboldt Squid

In September 2011, hundreds of Humboldt squid washed up mysteriously on beaches along the southern California coast, carried in on high tides. Occurrences of Humboldt squid washing up on California shores were once a rare event. However, the growing range of habitat of the squid, which were previously confined to east Pacific tropical and subtropical waters, has resulted in an increase in "squid incidents" since the early 2000s. Theories accounting for the increase in numbers of squid off the California coast include: warming sea temperatures; reductions in predator populations; and low oxygen zones in subsurface currents that the squid are following. Although these same oceanic climate, current, and hypoxia phenomena threaten the health and existence of populations of many of the diverse species that inhabit the unique California current, for the highly adaptable Humboldt squid they present a perfect opportunity for habitat expansion.

Figure 2: Three to four hundred Humboldt squid washed ashore at Blacks Beach, California in September 2011. Photo BD Outdoors
http://www.grindtv.com/outdoor/blog/30360/rare+squid+invasion+off+southern+california+sparks+fishing+frenzy/

Changes in climate, water stratification, wind patterns, and currents are hypothetical determinants of expanding hypoxia zones in the Pacific Ocean. In contrast to river-mouth dead zones, such as that from the Mississippi delta in the Gulf of Mexico, primarily from agricultural runoff, deep ocean hypoxia zones occur naturally. These low oxygen zones are crucial decomposition zones, where anaerobic bacteria break down organic matter, emitting carbon dioxide in the process. Unlike many aquatic species that cannot tolerate low oxygen zones, marine biologists believe that the Humboldt squid actually has an affinity for these regions.

The implications of the growing abundance of the Humboldt squid in the waters off the southern California coast remain unclear, but evidence from Chile's longer experience with the species is cause for concern. Although the squid can grow to over 6 feet long and often tip the scales at 100 pounds, at birth they emerge from an egg measuring only 1 millimeter in diameter. During their short life span of only 1 to 2 years, the squid must eat almost continuously to maintain their rapid growth. Chile's coast is also an area that experiences upwelling, and is considered one of the most productive fisheries in the world. The ravenous behavior of the squid is blamed for significant declines in hake fishery populations that constitute an important sector of the Chilean fishing economy. Pacific hake supports one of the largest commercial fisheries in southern California. The impacts of the increasing squid population here could also prove devastating for California's fishery economy.

Literature Cited:

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