Our Ocean Backyard — *Santa Cruz Sentinel* columns by Gary Griggs, Director, Institute of Marine Sciences, UC Santa Cruz.

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Fertility, Food Chains and Fish

The waters off the coast of California are some of the most biologically productive on the planet because of the process of upwelling, which is most pronounced in the spring and early summer. During these months, winds from the northwest dominate along the California coast, and help drive the offshore California Current southward.

The surface waters of the ocean, however, are also influenced by the Earth's rotation. This process, known as the Coriolis effect, causes surface currents in the northern hemisphere to be deflected ninety degrees to the right of their direction of movement. As a result, the surface waters off California tend to move offshore in the spring and early summer, and are replaced by bottom waters through upwelling. This deeper water is typically rich in nutrients, such as nitrates and phosphates, from the decomposing organic matter that is constantly sinking to the seafloor.

The combination of the nutrients, which serve as fertilizer, and the exposure to the longer days and sunlight of spring and summer, lead to enhanced photosynthesis or blooms of the phytoplankton, which are the small floating algae. These microscopic plants, such as diatoms, are in turn fed on by the zooplankton, or the small floating animals like krill. The growth of the small plants and animals serve as the base of the food chain that provides for all of those marine animals higher up the food chain, the fish, sea birds, and marine mammals.

Coastal upwelling also influences weather patterns. Along the northern and central California coast, upwelling lowers sea surface temperatures and increases the frequency of summer fog. The cold surface waters chill the overlying humid air so that saturation occurs and fog forms, just like the condensation of moisture that occurs on a glass when you bring an ice cold drink outside on a warm day.

Globally, upwelling regions only constitute about 0.1% of the total surface area of the oceans, but these regions account for an astonishing 95% of the global production of marine biomass, and about 21% of the world's fishery landings. The major upwelling areas occur off the west coast of continents. In addition to

California, these include the rich fishing grounds off Ecuador, Peru and Chile, and off northwest Africa.

The fertile waters offshore California have been fished for as long as there have been humans occupying the coast. Native Americans stayed close to shore, fishing in the bays, estuaries and tide pools. The Chinese, Japanese, Italians, Azoreans, Portuguese, and others who came later, all discovered different resources they could harvest from the nearshore waters. At different times over the past 150 years these included abalone, albacore, anchovies, crabs, salmon, sardines, sea otters and sea urchins, shrimp, squid, rockfish, whales, and just about everything else that had any value to humans.

For a variety of reasons, however, many fisheries that flourished for years and supported entire industries and cultures have now been relegated to the history books. Each fishery or resource has its own history and reasons for decline, although in some cases it was overfishing, taking out more of the resource than could be sustained.

As we have continued to study and monitor the ocean, however, we have also discovered that there are major shifts in ocean climate that can have a significant influence on the abundance and distribution of marine life. In the Pacific these shifts or cycles have now been recognized as lasting several decades and are known as Pacific Decadal Oscillations or PDO cycles. The alternating dominance of sardine and anchovy populations was explained in my column from July 19, 2008, (and in case you don't keep a scrapbook of all the columns, you can find all three and a half years of them on the Seymour Marine Discovery Center website: http://seymourcenter.ucsc.edu/index.html).

So our offshore coastal waters are highly productive, but what is out there may change from decade to decade, with the best example being the cyclical alternating abundance of sardines and anchovies. The year 1977 marked the end of a 30-year long cool Pacific Decadal Oscillation. That year the commercial catch of anchovies was about 110,000 tons, while only five tons of sardines were caught.

In 1978 there was a pronounced shift to a warm phase of the PDO, which has lasted about 30 years. We now seem to be returning to a cool phase again. Looking at the commercial catch for California during the middle of this warm phase, from 1995 to 2005, about 45,000 tons of sardines were caught on average each year, and only about 7,000 tons of anchovies. These population shifts are believed to be due

to the types and sizes of plankton that thrive under these warmer and cooler regimes, and that are favored by either sardines or anchovies.