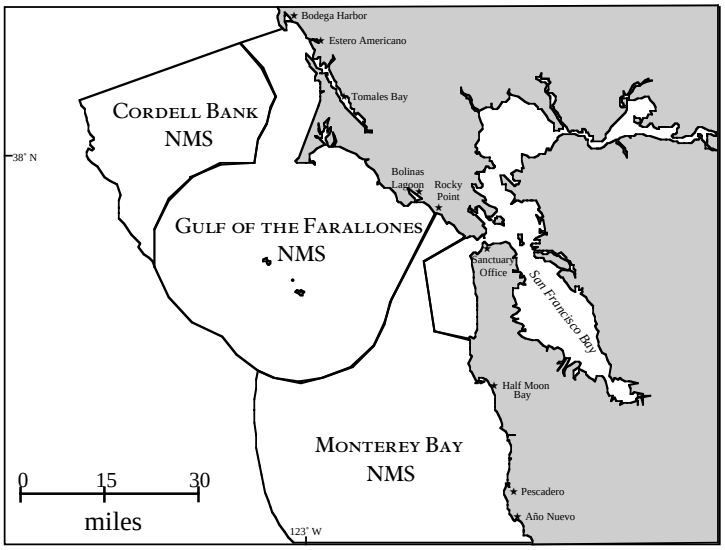
Oceanography of the Gulf of the Farallones

The Gulf of the Farallones is a unique oceanographic area. Just outside of San Francisco Bay, strong spring winds bring nutrient-rich water to the surface and create a rich biological community. The geological landscape under the water sets the scene and impacts the flow of water. Waves and surface currents are primarily wind-driven and result in three oceanographic seasons over this interesting region: winter storms, upwelling, and relaxation. The Gulf of the Farallones National Marine Sanctuary encompasses 948 square nautical miles (3,251 km^2) of the offshore region of the Gulf of the Farallones.



Geology

Located just west of the Golden Gate Bridge, the Gulf of the Farallones covers the continental shelf and slope. From the shoreline to about 100 - 150 m deep, the shelf is nearly horizontal with rocky outcrops, gravel, sand, clay, and deposits of broken shells. Sand and silt cover much of the continental shelf. About 25 miles from the coast, the seafloor drops off, creating the continental slope with a grade of about 3°. The slope is from 100 - 150 m to about 3200 m and is covered with a more uniform sandy sediment. The Farallon Islands, located a few miles east of the slope, rise up from the continental shelf to the sea surface.

Winter Storms

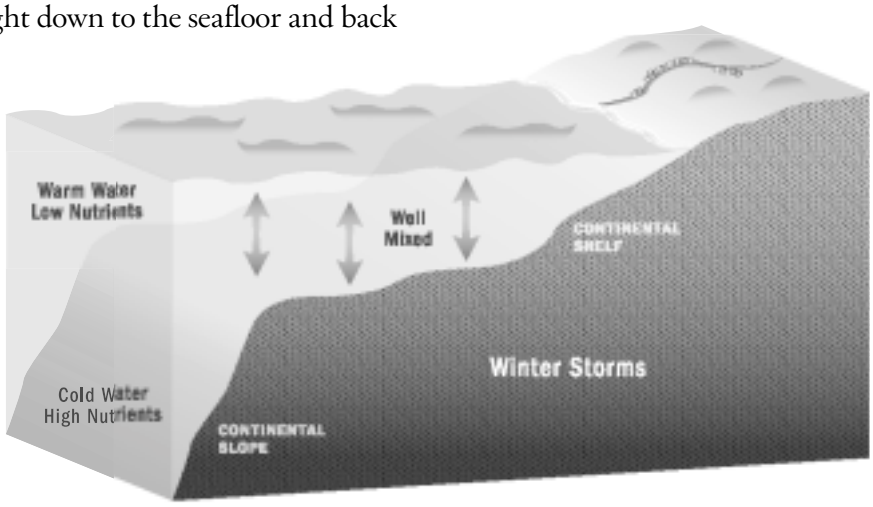
During winter months (mid November through early spring), atmospheric storms cause rough seas and, in turn, cause deep mixing of the ocean. Water on the shelf is brought down to the seafloor and back up again.

The water becomes well mixed, with the temperature, salinity, and concentration of nutrients the same at the surface as at depth.

Upwelling

In the spring and early summer, coastal winds blow from the north to the south driving the offshore California Current and the process of upwelling. The California Current is part of the clockwise-flowing North Pacific subtropical gyre. Upwelling is the result of coastal winds and the Coriolis effect on the water above the shelf.

Water traveling over a large distance appears to be deflected from its original direction of motion. Called the Coriolis effect, this phenomenon is due to



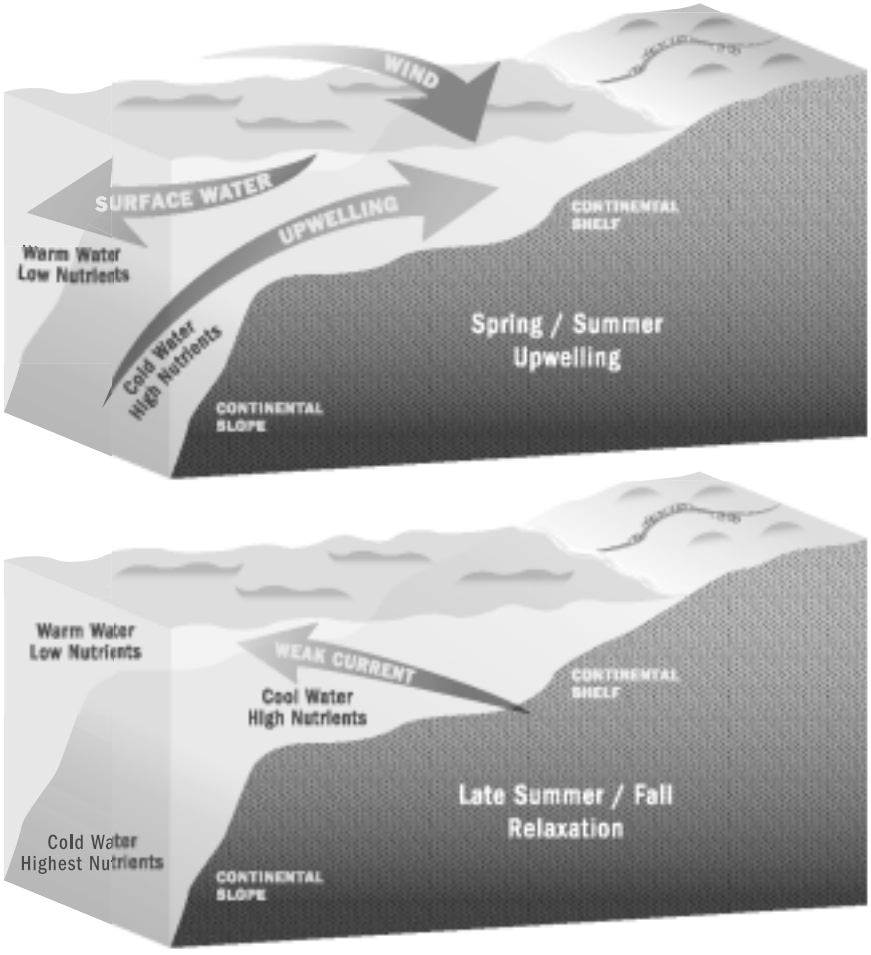
the fact that Earth is a rotating sphere. In the Northern Hemisphere, ocean water is deflected to the right of the wind that is pushing it. Along the California coast, northerly winds cause the surface water to move offshore to the west. As the spring wind blows, shelf water moves away from the shore, and deeper water from above the slope is brought to the surface. This deep water is cold and nutrient rich.

Sunlight warms the ocean water and provides energy for photosynthesis by algae. Algae require nutrients for growth and use the nutrients from upwelling. Deeper water is not warmed by sunlight nor do algae survive without sunlight. Thus, nutrient concentrations are higher in the deep water than in surface water. Upwelling brings this cold, nutrient-rich water to the surface. Algae, especially diatoms, increase in abundance dramatically during the upwelling season.

Upwelling comes in pulses of a week or so, with a relaxation period when the winds weaken. During the relaxation of upwelling, the offshore water flows back towards shore, carrying a soup of nutrients, algae, and zooplankton. Now, the diatoms can bloom in the sunlit water, and pelagic larvae of benthic animals are able to settle on the continental shelf. During upwelling, most plankton are carried offshore and are not as productive.

Relaxation

During the late summer and fall, coastal winds die down, and the sea surface calms. The northward-flowing Davidson Current replaces wind-driven upwelling in the Gulf of the Farallones. Warm water from the south moves into the Gulf bringing nutrient-poor waters. Without strong winds, the water is not mixed, and a layer of warm, nutrient-poor water forms at the surface. Dinoflagellates become the dominant algae during the late summer months, because they survive well in lower nutrient waters, unlike diatoms. The cycle of the oceanographic seasons begins again in November with increased winds and storms.



For more information contact:

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