Introduction

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The San Francisco Estuary is the largest estuary on the west coast of North America. Located somewhat more than halfway up the California coast from the Mexican border, it is the natural exit point of 40% of California's freshwater outflow. This water is a prized commodity in California, sought after by farmers for food production, municipalities for people and industries, and environmentalists for the rich, but in some cases threatened, fish and invertebrate resources of the estuary. To capture the water for human needs, dams, aqueducts, canals, and pumping plants have been constructed to pump water out of the estuary and transport it to the San Francisco Bay area, the San Joaquin Valley, and southern California.

These human alterations affect the life of the estuary by reducing the freshwater flow that creates the estuary. Freshwater flowing seaward, mixing with ocean water, creates habitats that attract coastal fish to spawn, while providing low salinity habitat for the rearing of their young. Other fish, such as salmon, detect the scents of their home rivers in the freshwater outflow and enter the estuary on their spawning migrations. Still other fish and many open water and bottom crustaceans and shellfish reside in the brackish water regions all their lives.

California's 2 largest rivers, the Sacramento and the San Joaquin, merge to form the estuary (Figure 1). They drain part of the Sierra Nevada and Cascade mountains and form a large and convoluted delta in the Central Valley. The delta consists of about 1,100 km of river channels and sloughs that cover an area of about 3,000 km^2 and drain into Suisun Bay on the edge of the low mountains of the Coast Range. A 100-m deep ship channel runs along the south side of Suisun Bay. To its north are extensive shoals. West of Suisun Bay the deep trough of Carquinez Strait breaches the Coast Range and connects Suisun Bay with the much larger San Pablo Bay. Most of San Pablo Bay is a broad shoal, only the ship channel on its southeastern side provides deep water. San Francisco Bay is the last of the bays and empties into the Pacific Ocean through the Golden Gate. Its small northern quarter is termed Central Bay. Although small, it is the deepest of the bays with shoals confined mainly to its eastern side. The long southeast leg of San Francisco Bay is called South Bay. It has a central channel that narrows southwards and broad shoals on either side of the channel.

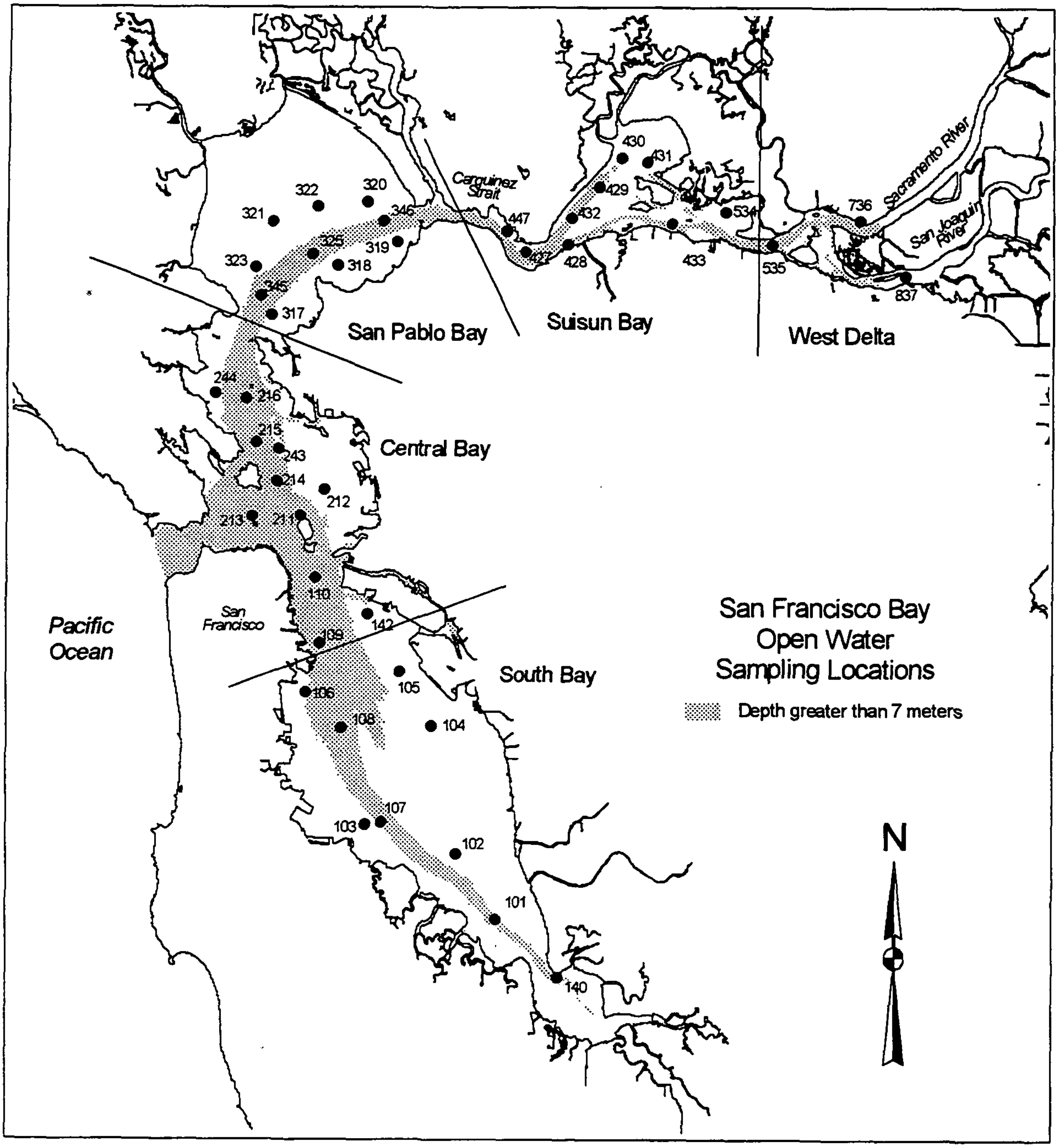

Figure 1 Map of the San Francisco Estuary showing the 7 m depth contour

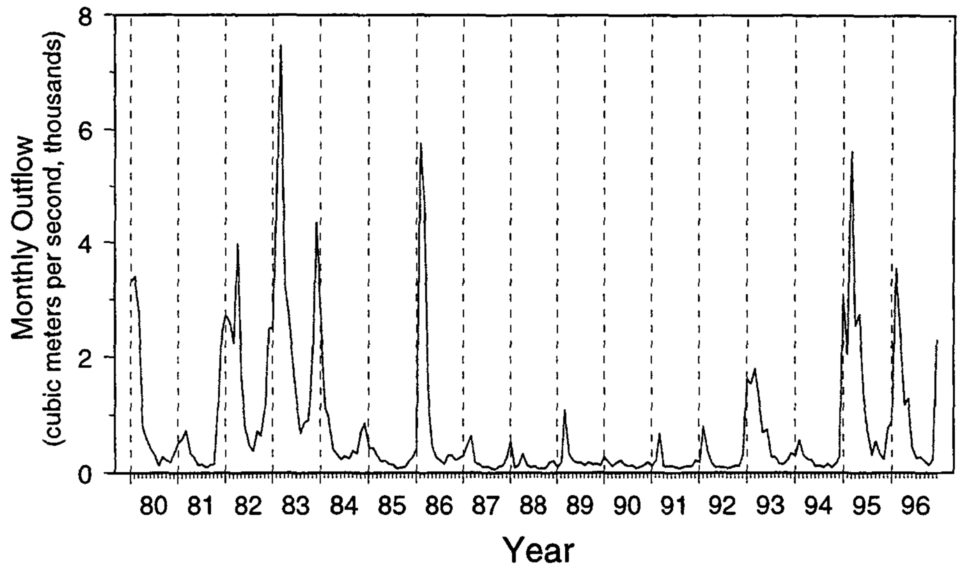

Figure 2 Mean monthly delta outflow in cubic meters per second at Chipps Island from 1980 to 1996

The climate is Mediterranean; most precipitation falls in winter and spring as rain throughout the Central Valley and as snow in the Sierra Nevada and Cascades. The freshwater outflow pattern is seasonal; highest outflow occurs in winter and spring. In summer, inflow to the Sacramento–San Joaquin Delta is controlled mainly by water released from Shasta Reservoir on the Sacramento River and Oroville Reservoir on the Feather River. A portion of this inflow is diverted to the San Joaquin Valley and southern California by the state and federal export pumping plants in the south delta. A smaller diversion in Suisun Bay diverts water into the Contra Costa Canal. Additionally, numerous small diversions on the delta islands remove water for local farming operations. The volume of water flowing seaward from Suisun Bay varies greatly both annually and seasonally due to variations in precipitation and export pumping (Figure 2).

Ocean conditions affect the estuary. The California Current system dominates California's nearshore ocean environment. Off northern and central California, surface waters are driven south by northeasterly winds in spring and summer and, as a result of Ekman transport of surface water, cold, nutrient-rich water is upwelled to the surface and transported offshore. This creates one of the most productive ocean regions in the world. Off central California, upwelling is strongest in June and July, when winds are strongest. When winds and upwelling subside in August or September, sea surface temperature increases to an annual maximum in October. With the advent of winter storms and southerly winds in November or December, the nearshore surface current becomes northerly. This current is called the Davidson Current and is associated with downwelling and onshore Ekman transport of surface water.

Ocean temperature is a major factor determining the distribution of fish and invertebrates along the coast and consequently, the marine fauna of the estuary. There are major faunal breaks at Point Conception (subtropical fauna to the south) and Cape Blanco (cold water fauna to the north). The coast in between, including the San Francisco Estuary, is a transitional zone containing species from both faunas (Parrish and others 1981). In addition to the longitudinal temperature gradient and seasonal variation due to upwelling, there are large interannual temperature differences during El Niño events.

Before 1980, little scientific information was available to set water quality standards for the protection of the fish and invertebrates of San Francisco and San Pablo bays. In 1979, the Interagency Ecological Program (IEP) designed a plan to collect biological and physical data from South San Francisco Bay to the west delta. The State Water Resources Control Board (SWCRB) approved this plan and the Bay-Delta Division of the California Department of Fish and Game (CDFG), operating as part of the IEP, set the plan in action. The objective of the study was to determine the effects of freshwater outflow from the delta on the abundance and distribution of marine and estuarine fishes, shrimps, and crabs and use this knowledge to understand the volume and timing of freshwater outflow that is necessary for their well-being. In 1984, the U.S. Geological Survey started a hydrodynamic study of currents and salinity fluxes in the estuary (Smith and others 1995). The hydrodynamic data will eventually be useful in understanding the distribution and movements of fish and invertebrates.

This report presents data collected by the study on the abundance and distribution of selected organisms from 1980 to 1995 (shrimp and crab data extend to 1996). It is restricted mainly to presentation and description of the data. More detailed analyses will appear in subsequent reports and papers, although some have already been done for SWRCB Water Rights Hearings (CDFG 1987, 1992).

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