SJC-411

DFG Exhibit 28

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Exhibit 28, entered by the California Department of Fish and Game for the State Water Resources Control Board 1987 Water Quality/ Water Rights Proceeding on the San Francisco Bay/Sacramento-San Joaquin Delta

LONG-TERM TRENDS IN ZOOPLANKTON DISTRIBUTION AND ABUNDANCE IN THE SACRAMENTO-SAN JOAQUIN ESTUARY

long-term trend was sharply downward from 1973 to 1976 with a partial recovery in 1977 when Synchaeta entered the Delta along with the entrapment zone. The recovery lasted until 1979 only to be followed by another decline continuing until 1983.

Summary

Of the native species only Acartia and Neomysis did not undergo a long-term decline. Yet, Neomysis was abundant only in two years after the drought, 1980 and 1982. Both of these years were characterized by high outflows in the spring. Rotifers and Diaptomus were the taxa most reduced in abundance. The introduction of Sinocalanus, Limnoithona and Oithona helped maintain the total abundance of calanoid and cyclopoid copepods. Sinocalanus. However, is a possible cause of the reduction of Diaptomus and may have affected Eurytemora as well. The evidence is circumstantial because our data is not of the proper kind to show just how these species interact. Some of the annual fluctuations in abundance and shifts of population between Suisun Bay and the Delta can be attributed to variations in Delta outflow which regulate water residence times, the position of the entrapment zone and salinity gradient, and hence the distribution of all zooplankton species.

Regression Results

Stepwise multiple regressions were run for the important zooplankton taxa in their areas of greatest abundance against from a variety of channels in the interior Delta. Judging from the much greater zooplankton abundance in the south Delta as compared to the Sacramento River at Hood (Orsi and Mecum 1986), much of the zooplankton in Old River must originate within the Delta as shown by the reduced zooplankton abundance in the San Joaquin River at the mouth of Old River.

The sharp reduction in Sinocalanus abundance in the San Joaquin River at the mouth of Old River suggests that this copepod is drawn into Old River by the cross-delta flow (Figure 21). Other zooplankton taxa are likely to be pulled into the cross-delta flow but since the other freshwater zooplankton species are most abundant in the San Joaquin upstream from Old River it is not possible to demonstrate this as easily as for Sinocalanus.

Increased salinity in the drier years reduces the habitat available to Neomysis. This shrimp can be regarded as being in a box, the sides of which expand and contract with the volume of river outflow. The location of the box also moves, oscillating up and downstream with the tides and with river outflow. Tides cause minor daily displacements; changes in river outflow bring about major movements.

Basically, Neomysis tends to be most abundant in the entrapment zone and immediately upstream from there (Knutson and Orsi 1983)). This appears to be due to the diel vertical migration of the mysids interacting with two-layered estuarine flow (Orsi 1986). The high outflows of wet and normal winters and springs push the entrapment zone and Neomysis seawards into Carquinez Strait and even San Pablo Bay. Shrimp located in the main Delta channels are scoured out by these flows. By late spring, outflow has diminished and the entrapment zone has been pushed into Suisun Bay by intruding marine water. Once again, the mysids move with the zone and begin to appear in increasing numbers in the Delta.

Their upstream extent in the Delta and in the rivers that feed it is limited by high net velocities, light penetration to the bottom, high temperature, especially in combination with low dissolved oxygen (Heubach 1969, Orsi and Knutson 1979) and cross-delta flow to the export pumps in the south Delta.

In general, mysids are not abundant in the Sacramento River upstream from its junction with Steamboat Slough, in the Mokelumne River, and in the San Joaquin River upstream from the mouth of Old River. In the first two streams high net velocities and flow direction that may not reverse on the flood tide plus light penetration to the bottom are inhibiting factors (Heubach 1969, Delta Study, unpublished). In the San Joaquin the cross-delta flow appears to divert mysids into the south Delta, and in addition, high temperature in combination with low dissolved oxygen during late summer and fall depresses mysid abundance in the Stockton area of the San Joaquin River (Heubach 1969, Orsi and Knutson 1979).

Movement of the entrapment zone into the Delta not only reduces the area of suitable habitat but also cause a reduction in the phytoplankton concentration in this productive zone (Arthur