

nitrogen and irrigation water were higher. It was of interest to find that the average transit time (surface to 50-foot depth) for all sites was the same as the cropping history period chosen for the project—10 years.

### NO<sub>3</sub>-N and agricultural practices

Relationships between agricultural practices and the movement of NO<sub>3</sub>-N past the root zone obviously are a func-

tion of many complex variables. Even in non-agricultural locations sampled during this investigation, NO<sub>3</sub>-N concentrations in the soil water of the unsaturated zone ranged from 4 to 53 ppm, with an average of 22 ppm. In fact, at three sites in western Fresno County (not included in the table), it was necessary to postulate the presence of geologic salt beds to account for the NO<sub>3</sub>-N concentrations of over 2,000 ppm found in the unsaturated zones.

*John M. Rible, Area Soils and Water Specialist, Cooperative Extension, and Parker F. Pratt, Professor of Soil Science, Department of Soil Science and Agricultural Engineering, are both at University of California, Riverside.*

## Hydrobiological studies in the Sacramento-San Joaquin Delta

Clifford A. Siegfried ■ Allen W. Knight

**T**he Sacramento-San Joaquin Delta carries about 42 percent of the natural runoff of the state. It is high in biological productivity, receiving nutrient-laden waters from municipal and industrial activities and from intensively cultivated agricultural land surrounding the basin. The Delta supports important freshwater fisheries and serves both as a nursery ground for marine species and as an access route and habitat for young and adult anadromous species important in the state's sport fishery.

Saline water enters the Delta from San Francisco Bay and the Pacific Ocean during periods when freshwater inflow is reduced. Releases from man-made reservoirs generally confine salinity intrusion to the area west of Rio Vista, preventing it from intruding into the interior of the Delta. Without summertime releases from these reservoirs, the waters of the Delta would, on occasion, probably become too saline for agricultural, industrial, and municipal users within the Delta and for diversion of irrigation waters to the San Joaquin Valley, and would harm the fisheries and wildlife resources of the Delta. Because of the importance of salinity intrusion to water quality in the Delta, much of our attention has been focused on the effects of salinity on the invertebrate fauna there.

The dominant invertebrate organisms of the Delta estuary include the opossum shrimp, *Neomysis mercedis*, the grass shrimp, *Crangon franciscorum*, and amphipods, *Corophium* spp. They are food organisms for such fish as the striped bass (*Morone saxatilis*), the American shad (*Alosa sapidissima*), the white sturgeon (*Acipenser transmontanus*), and the white catfish (*Ictalurus catus*). Any changes in water quality that affect *Neomysis*, *Crangon*, and *Corophium* populations also affect the fish that feed on them.

*Neomysis* has received considerable attention in prior work at our laboratory, and we are continuing to focus efforts on the physiology and population dynamics of this highly important component of the Delta community. Intensive studies on the metabolism of *Neomysis*, now completed, indicate that its metabolic rate is related to body size, temperature, salinity, sex, and season.

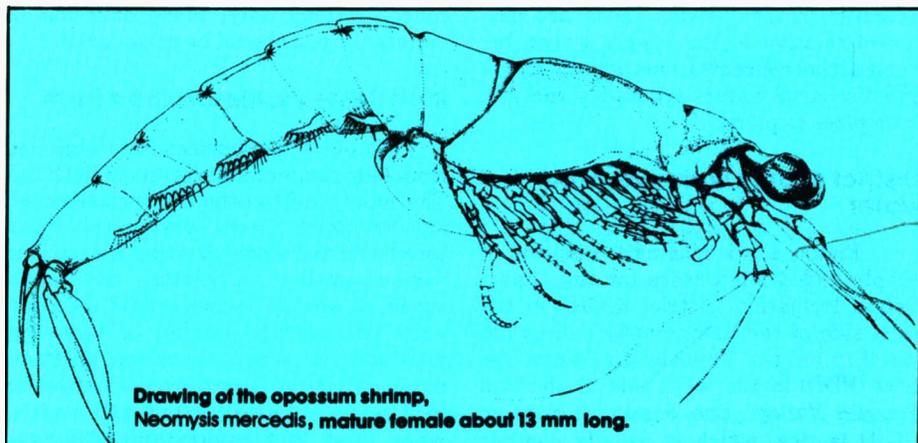
Results of bioassays suggest that *Neomysis* is relatively tolerant of a wide range of temperatures and salinities, with salinity tolerance affected by temperature. Juvenile *Neomysis* appear more tolerant of high temperatures than do mature ones. We have also evaluated the tolerance of *Crangon franciscorum* to variations in temperature and salinity and to the pesticide Kelthane.

One of the most important aspects of circulation in the western Delta is a two-layered flow generated by the intrusion of saline water, resulting in the establishment of an area in which circulation patterns create an "entrapment zone" where suspended materials are concentrated. Phytoplankton, zooplankton, *Neomysis*, and juvenile striped bass

are also concentrated there in response to the concentration of food materials. The entrapment zone may be critical to the population dynamics of the fish and invertebrate fauna of the Delta estuary.

Cooperatively with the U.S. Bureau of Reclamation and the California Department of Fish and Game, we are currently engaged in a detailed determination of the distribution of *Neomysis*, *Crangon*, and *Corophium* in relation to the entrapment zone. Our studies will assist development of a preliminary model to describe the distribution and abundance of these organisms in the western Delta. Continued work on the basic estuarine dynamics of the Delta is designed to contribute to a more intelligent assessment of impacts resulting from man's manipulation (peripheral canal, industrial discharges, etc.) of the Delta water resources.

*Clifford A. Siegfried is Post-doctoral Researcher, and Allen W. Knight is Associate Professor of Water Science, Department of Land, Air, and Water Resources (Water Science and Engineering), U.C., Davis.*



Drawing of the opossum shrimp, *Neomysis mercedis*, mature female about 13 mm long.