Executive Summary

Background and Objectives: Although various authorities have stated that treating marine ballast water in municipal wastewater treatment plants (WWTPs) is impossible due to the impact of the chlorides in the ballast water on the biological processes of secondary wastewater treatment, preliminary investigations indicate that there exists a substantial capacity to treat ballast water in municipal WWTPs in the San Francisco Bay/Delta region without exceeding the target chloride levels for those plants.

This project will::

- investigate and report on the limiting factors that are likely to restrict the volume of ballast water that can be treated at municipal WWTPs.
- determine, for ports in the San Francisco Bay region and for selected other ports in North America, the portion of incoming ballast water that could be treated at the municipal WWTPs that serve the port region without exceeding those limiting factors.
- estimate the cost to treat that water at a representative set of ports, including treatment charges, cost of ship retrofitting and associated on-shore piping to offload ballast water and transport it into the sewer system, and the cost of any necessary buffer storage.
- test the effectiveness of standard municipal wastewater treatment to remove or kill ballast water organisms using benchtop wastewater treatment models.

Methods:
(1) Initial investigations indicate three types of potential limiting factors on the volume of ballast water that may be treated at existing municipal WWTPs: the plants flow volume may be exceeded at some times of the year; ballast water may raise the chloride levels to exceed the target operating levels for the plant's secondary treatment system; and in plants that reclaim wastewater for reuse, ballast water may raise the chloride levels to exceed the target levels for reclaimed water. Wastewater engineers at municipal WWTPs in the San Francisco Bay region and elsewhere will be interviewed to obtain information on the limiting conditions at their plants.

(2) Based on these limiting factors, on estimates of the volume of incoming ballast water at various San Francisco Bay region and selected North American ports (e. g. from Carlton et al. 1995, Cohen 1998, etc.), on information on the salinity of arriving ballast water, and on the flow volumes at plants that serve the areas of these ports, the portion of ballast water arriving at these ports that could be treated at existing municipal WWTPs will be estimated.

(3) Costs for such treatment will be made based on (1) treatment charges derived from interviews with staff at these WWTPs, (2) cost estimates for retrofitting ships and operating costs to discharge ballast water to shore, based on estimates made in several studies, and (3) estimates of the costs for on-shore piping and buffer storage needed to handle those volumes of ballast water.

(4) To test the effectiveness of treating ballast water in municipal WWTPs, dual benchtop models involving standard primary and secondary wastewater treatment will be constructed at the San Francisco's Southeast WWTP. Models will be run with a mix of influent and an appropriate percentage (not exceeding the limting factors) of "test ballast water" (explained below) and the effluent tested for the presence of viable organisms, by microscopic examination (for motile zooplankton and phytoplankton), and appropriate culturing techniques (for bacteria, dinoflagellate cysts, diatom spores, etc.). Test ballast water will consist of bay or ocean water, or of artificial seawater spiked with test organisms, for different tests. If organisms are found to survive the primary and secondary treatments, disinfection stages using chlorine or UV will be added to the models to test for survival through the disinfection process.
Location: The laboratory and analytical work will be conducted at SFSU's Romberg Tiburon Center in Marin County and the San Francisco Estuary Institute in Contra Costa County, with supplemental laboratory work at CDFG/IEP in San Joaquin County and USGS in San Mateo

County. Ships will be sampled at all Bay/Delta commercial ports, which are located in Sacramento, San Joaquin, Solano, Contra Costa, Alameda, San Mateo and San Francisco counties.

Cost: The request to CALFED is for $118,460 for this one-year project. In-kind contributions of staff time, laboratory space, some equipment and supplies, and some laboratory analyses will be provided by the City and County of San Francisco, and are estimated at about $23,000.

Applicant Qualifications: Project Leader **Andrew Cohen** has conducted extensive research on nonindigenous species and transport vectors in the Bay/Delta Estuary and other west coast estuaries, including research on the rate of invasions (published in Science) and ballast water in the Estuary. He has organized and led teams of taxonomists and ecologists in Rapid Assessment Surveys for nonindigenous species in the Bay/Delta Estuary and Puget Sound, and was recently awarded a Pew Fellowship in Marine Conservation to investigate biological invasions in tropical marine ecosystems. Project co-leader **Arleen Navarret** has 17 years experience with the San Francisco's wastewater treatment plants and processes and has also conducted research on ballast water biota.

Local Support/Coordination: The San Francisco and Contra Costa County Board of Supervisors and Planning Departments, the Delta Protection Commission and the Bay Conservation and Development Commision have been advised of the proposed project. The Center for Marine Conservation and the San Francisco BayKeeper are aware of the proposed project and strongly support it. The Director of the Southeast WWTP and the director of the water quality laboratory have reviewed the project and are enthusiatic about it. Staff at the Port of Oakland and the Port of Sacramento have been advised of the proposed project. Participants in other ballast water treatment studies in the Bay/Delta Region, including staff at the Central Contra Costa Sanitary District, Contra Costa Water District, Port of Oakland, SWRCB and San Francisco Bay RWQCB either have been or will be notified of this study, and will have an opportunity to review methods and results.

Compatibility with CALFED objectives: A programmatic action listed in the ERP (Vol. II, pp. 112, 151) is "Help fund ballast water treatment techniques that could eliminate non-native species before ballast water is released." More broadly, CALFED's Strategic Plan states that "in order to minimize the risk of potentially massive ecological and biological disruptions associated with non-native species disruptions that could threaten to negate the benefits of restoration efforts, it is important to initiate an early program that prevents or significantly reduces additional introductions of non-native species." Strategic objectives include preventing the "establishment of additional non-native species" and rehabilitating "the capacity of the Bay-Delta system to support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities, in ways that favor native members of those communities." The vision for non-native aquatic species is to "reduce their adverse effects on the foodweb and on native species resulting from competition for food and habitat and direct predation," including impacts on such important native and nonnative species as delta smelt, longfin smelt and striped bass whose recovery is among CalFED's objectives.

This project directly relates to the following ERP expectations, targets, actions and objectives:

- "Eliminate further introductions of new species in ballast water of ships" (Vol. I, p. 420; Vol. II, pp. 112, 151). "Eliminate the dumping of all organism-contaminated ballast water and ballast sediment into the estuary" (Vol. I, p. 464). "Develop and implement a ballast water management program to halt the introduction of introduced species into the estuary" (Vol. II, p. 151).

The ERP notes that the introduction of new species greatly increases the expense and difficulty of restoring the estuary, and that a new invasion can destroy the value of a restoration project (Vol. I, p. 464); and that the elimination of additional species introductions is crucial to the ultimate success of the ERP (Vol. I, p. 462, citing the Strategic Plan).