Biological Invasions in the Estuary

Andy Cohen, San Francisco Estuary Institute

We recently reported on over 200 exotic species that have become established in the San Francisco estuary and noted studies showing that the biomass and number of organisms are dominated by exotic species in several habitats (Cohen and Carlton 1995). The rate of invasion also appears to be increasing, due at least in part to expanding international travel and trade, which have increased the diversity and scale of mechanisms by which coastal and freshwater organisms may be transported across oceans and continents. Halting the acceleration in invasions will require managing these transport mechanisms, chief among which are the discharge of ships' ballast water, aquaculture activities, and the global trade in aquarium organisms (more significant for southern California than for the estuary), ornamental plants, live seafood, and live bait.

Since 1986, the year in which the Asian clam *Potamocorbula amurensis* was first collected in the estuary, an astonishing number of additional exotic species have been reported (Table 1). Some of these have made front-page headlines, which has helped to focus public and political attention on this issue.

In 1996 the National Invasive Species Act passed Congress. Although the Act failed to regulate any of the mechanisms bringing exotic species into the estuary, it was amended to authorize research funding of up to $750,000/year on exotic species in the estuary (thanks to pressure from some California organizations and politicians). However, no funds have been included in the President's budget this year, and they are unlikely to be appropriated — in this or future years — unless California's political influence is again brought into play.

This year, the National Sea Grant College Program is awarding $1.7 million in grants for research on nonindigenous aquatic species. However, it appears this program will be cut substantially by next year.

The San Francisco Estuary Institute has established a program to pursue scientific and policy research on biological invasions in marine and aquatic ecosystems, focusing on the estuary and its watershed, with initial funding provided by CALFED and USFWS. Projects include:

- Research into the introduction of organisms in the marine baitworm trade.
- Research into exotic parasites of freshwater fish.

Table 1
FIRST RECORDS OF EXOTIC SPECIES IN THE ESTUARY SINCE 1986 (1)

1986	Asian clam *Potamocorbula amurensis*
	Japanese foraminifer *Trochammina hadai* (2)
	Asian copepod *Pseudodiaptomus marinus* (3)
	Asian amphipod *Corophium heteroceratum*
	Asian cumacean *Nippoleucon hinumensis* (4)
1987	Asian copepod *Pseudodiaptomus forbesi*
1988	Japanese Moon Jelly *Aurelia "aurita"*
	African/Asian freshwater snail *Melanoides tuberculata* (5)
1989	Oligochaete *Monopylephorus evertus* (6)
	A polychaete in the genus *Potamilla*
	An isopod in the genus *Munna* (7)
	European Green Crab *Carcinus maenas* (8)
1991	Northwestern Atlantic polychaete *Marenzelleria Viridis*
	Alligator Gar *Lepisosteus spatula* (9)
1992	Black Sea jellyfish *Maeotias inexspectata*
	New Zealand sea slug *Philine auriformis*
	A nebaliid in the genus *Epinebalia*
	Asian mysid shrimp *Acanthomysis aspera*
	A mysid shrimp in the genus *Acanthomysis*
	Chinese mitten crab *Eriocheir sinensis*
	Bryozoan *Watersipora subtorquata* (10)
1993	North Atlantic periwinkle *Littorina saxatilis*
	Asian copepod *Acartiella sinensis*
	Asian copepod *Limnoithona tetraspina*
	A copepod in the genus *Tortanus*
	Indian Ocean isopod *Sphaeroma walkeri* (11)
	A second isopod in the genus *Munna* (12)
	An isopod in the genus *Paranthura*
	An amphipod *Listriella goleta* (13)
	An amphipod *Synchelidium miraculum* (13)
	An amphipod in the genus *Ampithoe* (12)
	An amphipod in the genus *Caliopiella* (12)
	An amphipod in the genus *Melita*
	An amphipod in the genus *Paradexamine*
	Asian shrimp *Exopalaemon carinicauda* (14)
	Northwestern Atlantic cordgrass bug *Trigonotylus uhleri*
	North Atlantic bryozoan *Anguinella palmata* (15)
	Bryozoan *Zoobotryon verticillatum* (16)
	Asian tunicate *Ciona savignyi* (17)
	Tunicate in the genus *Ascidia*
1994	Japanese pond smelt *Hypomesus nipponensis* (18)
1995	A polychaete in the genus *Typosyllis* (19)
	A shrimp in the family *Pandalidae* (9)

Notes

1 References and records are given in Cohen and Carlton (1995) unless otherwise indicated.
2 D. Sloan, M. McGann, pers. comm.
3 Also collected from southern California in 1986.
4 Known from Oregon since 1979.
5 Known from southern California since 1972.
6 W. Fields, pers. comm. Not known if established.
7 W. Fields, pers. comm.
8 First observed in the estuary in 1989 or 1990. A crab collected in Estero Americano in 1988 may represent an inoculation that did not "take". A report of this crab in Willapa Bay in 1961 could not be corroborated.
9 Apparently not established.
10 Known from southern California since 1963.
11 Unpublished records. Known from southern California since 1973.
12 Not known if established.
13 Reported from southern California in the late 1980s.
14 A second specimen was collected in 1995 (K. Hieb, pers. comm.), but it is unclear whether it is established.
15 Collected in southern California by 1942.
16 Apparently not established. Known from southern California since 1905.
17 Reported from Alaska in 1903 and southern California since 1966.
18 Introduced to California waters in 1959.
19 M. Kellogg, pers. comm. Not known if established.

- Development and application of a method for prioritizing potential control of exotic marsh plants.
- Assessment of the potential range and abundance of zebra mussels in California.
- Preparing a report on the status and potential for management of ballast water invasions.
- Organizing a workshop on the control of exotic species.
- Research into the diet and trophic impact of exotic crabs.
- Comparative studies of invasions into other estuaries.
- Assessment of the economic impacts of exotic species.

Literature

Cohen, A.N., and J. T. Carlton. 1995. Biological Study. *Nonindigenous Aquatic Species in a United States Estuary: A Case Study of the Biological Invasions of the San Francisco Bay and Delta*. A Report for the United States Fish and Wildlife Service, Washington, DC, and The National Sea Grant College Program, Connecticut Sea Grant, 246 pp. + Appendices.

Green Crab and Chinese Mitten Crab

Kathy Hieb, DFG

Surveys to determine the relative abundance and distribution of the introduced green crab (*Carcinus maenas*) in San Francisco Bay were conducted in the fall of 1995 and 1996. Distribution was very similar both years, with crabs distributed from South Bay to mid-San Pablo Bay. In 1996, catch-per-unit-effort increased at the San Pablo Bay stations and decreased at the South Bay stations (Table 1). Sampling in 1996 was inadequate to determine if the green crab population was increasing or decreasing. Green crab distribution in the bay appears to be limited by salinity; we have collected crabs from 7.5-31.0‰, with few from less than 10‰.

The Chinese mitten crab (*Eriocheir sinensis*) was first collected in South San Francisco Bay in 1992 and has steadily increased in abundance and expanded its distribution throughout the bay area. The first mitten crabs were collected in San Pablo Bay in the fall of 1994, Suisun Marsh in February 1996, and the delta in August 1996. Their distribution in South Bay creeks also continued to expand in 1996, with reports of mitten crabs about 30 miles upstream from the mouth of Coyote Creek and in the Niles Canyon section of Alameda Creek.

Table 1
GREEN CRAB CATCH PER UNIT EFFORT AT SELECTED STATIONS SAMPLED WITH BAITED TRAPS, 1995 AND 1996
Catch per Hour

Station	1995	1996
South Bay		
Candlestick Point Pier	1.3	0.4
Hayward (Sulfur Creek)	1.4	0
Hayward (Triangle Marsh)	4.0	2.7
Redwood Shores Lagoon	2.3	0
Central Bay		
Berkeley Fishing Pier	0.2	1.2
Paradise Park Pier	0	0.5
San Pablo Bay		
McNears Beach Pier	0.4	1.2
Point Pinole Pier	1.1	2.3

Density of juvenile mitten crab was determined by Halat (in prep) at several South Bay locations in 1995 and 1996. The most comparable data are from four sites in July and August 1995 and July 1996 (Table 2). Immigration of crabs from downstream areas and emigration to upstream areas probably contributed to the highly variable densities in 1995. Because of this variation, one should cautiously interpret the differences between 1995 and 1996 densities.

Anecdotal information from bay shrimp fishermen indicate that mitten crab abundance increased significantly in 1995 and 1996. Fishermen reported as many as 200 mitten crabs per trawl in South San Francisco Bay (B. Laine, personnel communication) and an increasing number of crabs collected in the Petaluma River channel (K. Martin, personnel communication) in 1995 and 1996.

Mitten crab distribution information from South San Francisco and San Pablo bays was supplied by Andy Cohen (SFEI), Kathleen Halat (UC Berkeley), Margaret Roper (DFG), and Richard Wetzig (Alameda County).

Literature

Halat, K.M. in prep. The distribution and abundance of the Chinese mitten crab (*Eriocheir sinensis*) in southern San Francisco Bay, 1995-1996. M.S. Thesis, University of California, Berkeley, 80 pp.

Table 2
JUVENILE CHINESE MITTEN CRAB DENSITY (number/m2) AND ONE STANDARD DEVIATION ( ) FROM SELECTED SOUTH BAY LOCATIONS
From Halat (in prep)

	July 1995	August 1995	July 1996
Alviso Slough at 237	6.8 (3.6)	18.1 (7.2)	4.0 (1.2)
Alviso Slough at Tasman Road	7.3 (0)	4.4 (1.3)	6.3 (1.4)
Guadalupe Slough at 237	1.6 (0)	3.5 (1.9)	4.1 (3.0)
Alameda Creek at Ardenwood Road	13.7 (4.3)	2.6 (0.8)	No Data

Interagency Ecological Program for the Sacramento-San Joaquin Estuary

Newsletter

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For information on the Interagency Ecological Program, visit our home page on the World Wide Web (*www.iep.water.ca.gov*).

Readers are encouraged to submit brief articles or ideas for articles. Correspondence, including requests for changes in the mailing list, should be addressed to Randy Brown, California Department of Water Resources, 3251 S Street, Sacramento, CA 95816-7017.

Interagency Program Quarterly Highlights

These quarterly highlights summarize significant activities and findings of the Interagency Program during the past 3 months.

Delta Flow Measurement

Rick Oltmann

The floods of January disabled three UVM sites: Sacramento River at Rio Vista, Threemile Slough, and San Joaquin River at Stockton. A destroyed transducer pile has been replaced at the Threemile Slough site, and the site is again operational. The Rio Vista UVM recorded a velocity of just under 7 feet per second right before it failed — probably due to damage to the across-channel transducer cable. We are awaiting the arrival of a more robust transducer cable. A transducer pile was destroyed at Stockton also and has not been repairable because of the high San Joaquin River flows. The site was operational again by early April.

The USGS obtained an indirect measurement of delta outflow by combining daily flow data for four UVM sites: Sacramento River at Rio Vista, Threemile Slough, San Joaquin River

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