Overview of the Life History, Distribution, Abundance, and Impacts of the Chinese mitten crab, *Eriocheir sinensis*.

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Juvenile and adult Chinese mitten crabs can also survive long periods out of water. Crabs can survive up to 38 days in a wet meadow (Nepszy and Leach 1973) and at least 10 days in a burrow in a dessicating field (CDFG and CDWR unpublished data). Air temperature in the burrow was significantly lower than the ambient air temperature. Thus, the Chinese mitten crab can survive in areas with *fluctuating* water levels.

IMPACTS OF THE CHINESE MITTEN CRAB IN CALIFORNIA

Based on the impacts of the mitten crab in its native range and in Europe, a large mitten crab population poses several threats to California. These impacts have both ecological and economic consequences. The impacts of the increasing crab population are already evident.

Impacts on Levees

In Germany, the numerous burrows constructed by mitten crabs accelerated bank erosion rates and caused reduced levee stability (Peters and Panning 1933, Panning 1939). In some locations, burrows were reported to be up to 50 cm (20 inches) deep (Peters and Panning 1933). In south San Francisco Bay creeks, mitten crab burrow densities of nearly 30 burrows/m^2 (3 burrows/ft^2) have been reported with most burrows no more than 20 to 30 cm (8 to 12 inches) deep (Halat 1996). Densities in the Sacramento-San Joaquin Delta and Suisun Marsh are currently much lower ($\leq$ 5 crabs/m^2) (Veldhuizen 1997, Holmes and Osmondson 1998), but are expected to increase to levels comparable to south San Francisco Bay creeks within several years.

Based on currently available data, any damage to banks or levees in the estuary should be confined to tidally influenced areas and will be dependent on crab density, levee structure, and suitability of the bank for burrowing. Due to

the extensive levee system protecting agricultural fields and communities in the delta, deterioration of levees due to mitten crab burrows is of great concern.

Impacts on Fisheries

The most widely reported economic impact of mitten crabs in Europe was damage to commercial fishing nets and the catch when high numbers of crabs were caught (Panning 1939). The crabs ate the abdomens of the fish and caused increased wear on the nets. Crabs also filled eel-basket pots and hoop nets, preventing eels from entering the traps, thus reducing catch (Panning 1939). In 1981, the mitten crab population in the Netherlands increased substantially, resulting in serious damage to fishing nets (Ingle 1986). However, with the currently low population level in most areas of Europe and a demand for crabs by Chinese restaurants, mitten crabs are no longer a problematic by-catch (C. Schubart, email comm. with K. Hieb, November 17, 1997).

In the San Francisco Estuary, the crab has been a nuisance to commercial bay shrimp trawlers and sport anglers for several years. In south San Francisco Bay, commercial shrimp trawlers find it time consuming to remove crabs from their nets (one fisherman twice caught over 200 crabs in a single tow during fall 1996). They are also concerned that a large catch of mitten crabs will damage their nets and the shrimp. Damaged shrimp are unsuitable for the bait market. Currently, shrimp trawlers are able to move to other areas in south San Francisco Bay with fewer crabs, but this option will diminish as the mitten crab population grows.

A commercial fishery for the introduced signal crayfish (*Pacifastacus leniusculus*) is located in the Sacramento-San Joaquin Delta. During fall 1998, when large numbers of adult mitten crabs migrated downstream, mitten crabs were caught in crayfish traps. If the mitten crab population continues to increase, the crab will become a serious pest by filling the traps and, thus, reducing the crayfish catch. In addition, the mitten crab overlaps in dietary and

habitat preferences with the signal crayfish which may reduce crayfish abundance and growth rate.

The sport fishery in the Sacramento-San Joaquin Delta is also impacted by the increasing mitten crab population through loss of bait. The majority of complaints received by CDFG concerning the mitten crab are from recreational anglers.

Water Diversion Impacts

Currently, the most conspicuous impact of the crab in California is on the fish salvage operations at the Federal and State water pumping plants and fish collection facilities in the south delta. These facilities pump and divert several million acre-feet of water from the Sacramento-San Joaquin Delta annually. The fish collection facilities screen all water heading toward the pumping plants and salvage millions of fish.

At the fish facilities, out-migrating adult crabs are entrained along with fish. Only 25 crabs were counted at both the federal Tracy Fish Collection Facility (TFCF) and the State Skinner Fish Facility (SFF) in 1996. In 1997, an estimated 16,000 to 20,000 crabs were captured in the holding tanks at TFCF (USBR unpublished data). In 1998, nearly 1 million crabs were entrained into the federal facility alone (USBR unpublished data). The fish salvage operations at TFCF and SFF were severely hindered by the large numbers of mitten crabs in the holding tanks and fish transport trucks. Initially, crabs were entrained seasonally, mainly during the fall downstream migration period. In 1998, due to the large population size, mitten crabs were entrained year-round with approximately 100 crabs captured per week during the non-migratory periods and 5,000 to 40,000 crabs captured per day during the peak fall migratory period (USBR unpublished data).

In Europe, reports were made of crabs entering water intake pipes or trapped on the screens (Ingle 1986, Attrill and Thomas 1996, Vincent 1996, J. Mares, Strandwerkgroep, email comm. to K. Webb, USFWS, November 1998).

In California, Pacific Gas and Electric Company (PG&E) reported the Pittsburg Power Plant, located on the southern shore of Suisun Bay, was affected by high numbers of adults in fall 1997 and 1998, and the Contra Costa Plant, located near Antioch, was affected in fall 1998 (K. Hieb, CDFG, pers. comm. 1998). Workers noticed reduced flows in the cooling water system. Upon back-flushing, they found the internal piping system had been partially blocked by hundreds of crabs.

Agricultural Impacts and Concerns

In its native range in China and Korea, juvenile mitten crabs were reported to damage rice crops by consuming the young rice shoots and burrowing in the rice field levees (Ng 1988, as cited in Halat 1996). Rice fields in tidally influenced areas apparently are most subject to damage. However, no control measures have been reported. In some rice fields, the crab is even cultured with fish. Apparently, the mitten crab is stocked at a rate that does not damage the rice crop.

Ecological Concerns

The ecological impact of a large mitten crab population is the least understood of all the potential impacts. A large population of mitten crabs could change the structure of the estuary's fresh and brackish water benthic invertebrate communities through direct predation and effect the abundance and growth rates of other species through competition. In tributaries to south San Francisco Bay, the mitten crab and the introduced red swamp crayfish (*Procambarus clarkii*) co-occur, overlapping in dietary and habitat preferences. A 1996 survey found no negative correlation between the presence of the mitten crab and presence of the red swamp crayfish in tributaries to south San Francisco Bay; the crayfish was always present in areas with the mitten crab (Halat 1996). However, at almost all sites mitten crabs were visually more abundant, active, and aggressive than crayfish (Halat 1996). If competition does

occur, the mitten crab may reduce abundance and growth rates of the red swamp crayfish and the introduced signal crayfish (*Pacifasticus leniusculus*), which supports a commercial fishery in the Sacramento-San Joaquin Delta.

Fish species which produce demersal or adhesive eggs may also be impacted. Chinese mitten crabs may prey on the eggs of nest building species, such as centrarchids. Some fish species spawn in submergent vegetation, a known habitat of mitten crabs, and thus expose their eggs to mitten crab predation. Mitten crabs have the ability to reach salmonid spawning grounds. However, with the cold water temperatures in these areas supressing the crabs' metabolic activity, the predation rate may be low.

Public Health Concerns

The presence of the mitten crab is also a human health concern, as it is a secondary host to the Oriental lung fluke (*Paragonimus westermani*), with mammals, including humans, as the final host. The fluke causes tuberculosis-like or influenza-like symptoms in humans. Humans risk infestation through the consumption of raw or partially cooked infected mitten crabs or the transfer of the crab's bodily fluids through nonsterile cooking practices (USFWS 1989, Marquardt and Demaree 1985, as cited in Halat 1996). Neither the lung fluke nor any of the freshwater snail species that serve as the primary intermediate host for the fluke in Asia have been found in the estuary. It has been noted that several species of freshwater snails currently present in the watershed could possibly serve as an intermediate host or that the correct snail species is present but yet undetected (USFWS 1989).

Mitten crabs are known to inhabitat agricultural ditches and other areas that may contain high levels of contaminants. The crabs potentially could bioaccumulate contaminants, which then would be transferred to predators, such as sturgeon, and to humans.