

Causes and Consequences of Aquatic Invasions

Dr. Ted Grosholz

**Department of Environmental
Science and Policy**

University of California, Davis



Biological Invasions

- **Biological invasions are “non-native species” moved beyond their normal range limits due to human activities**
- **Non-native = alien = non-indigenous = exotic = introduced**

Invasive Species

- **Invasive species are those that cause measurable economic or ecological damage**
- **Federal Executive Order 13112 defines “invasive species” as: “A species that is (1) non-native (or alien) to the ecosystem under consideration and (2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health”.**

Economic Consequences of Biological Invasions

- Invasive species cost the world's economy hundreds of billions per year (IUCN)
- In the U.S., invasive species cost \$128 billion per year (Pimentel et al. 2000)
- Zebra mussels cost >\$100 million per year in U.S. for removal from water pipes, drains, screens, intakes from electric plants
- Invasive species cost CA (agriculture) \$120 million in 2003 (Sumner et al. 2006)

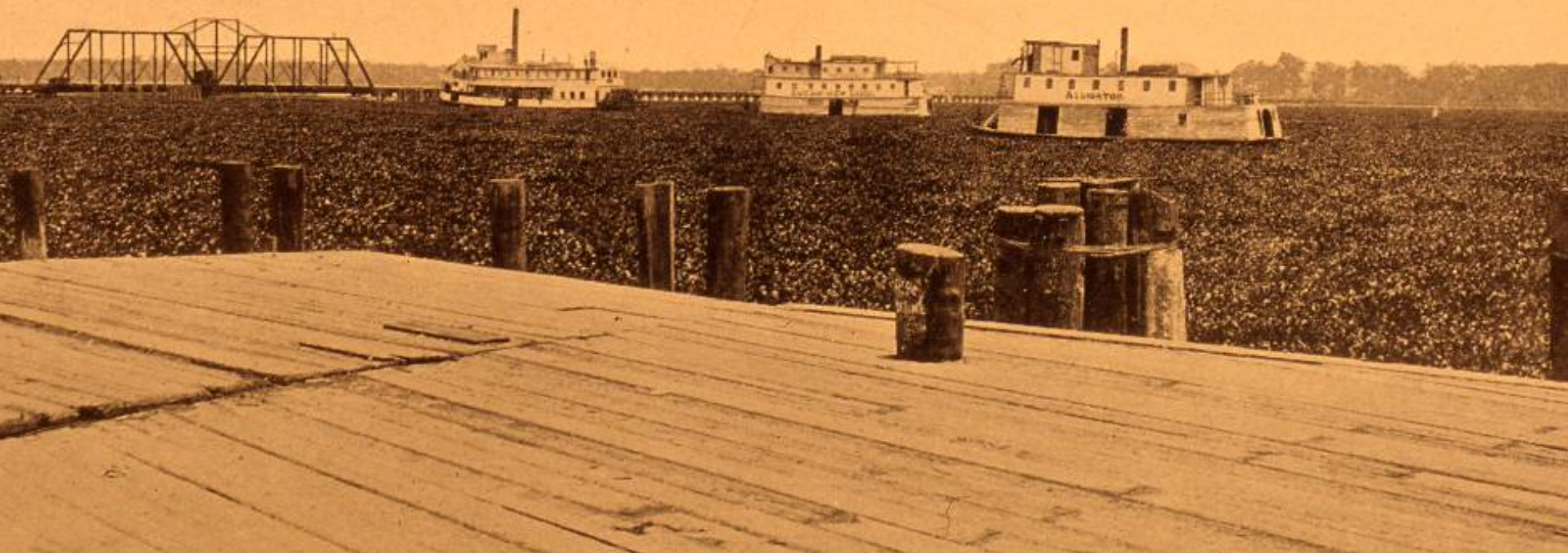
Ecological Consequences of Biological Invasions

- **Biological invasions are the second most important threat to global biodiversity, behind habitat loss (Chapin 2000, Sala 2000)**
- **In the U.S., 10% of all plants and animals are introduced (OTA 1993)**
- **Introduced species are a significant risk factor for more than 40% of listed threatened and endangered species in the U.S. (Wilcove et al. 1998)**

able Alien Species



Water hyacinth
St. Johns River, FL
1898



Historic Damage from Invasive Ship “Worm”



Undesirable Alien Species



Zebra Mussel



Diseases and vectors

West Nile Virus



Chinese Mitten Crab



**Sudden Oak Death
Pierce's Disease
Chestnut Blight
Dutch Elm Disease**

Really Undesirable Alien Species



Extent of Invasions in Coastal Systems

- Few coastal systems remain without introduced species
- In U.S. waters, 500 spp. of introduced species
 - Great Lakes >140 spp.
 - Chesapeake Bay >200 spp.
 - San Francisco Bay >240 spp.
 - In San Francisco Bay, new species every 14 weeks (Cohen and Carlton 1997)

Non-native Aquatic Species in California Harbors

- 199 San Francisco Bay
- 73 Los Angeles-Long Beach
- 62 San Diego Harbor
- 53 Humboldt Bay
- 21 Tomales Bay
- 56 Elkhorn Slough
- 18 Santa Barbara
- 11 Avalon Harbor
- 15 Dana Point

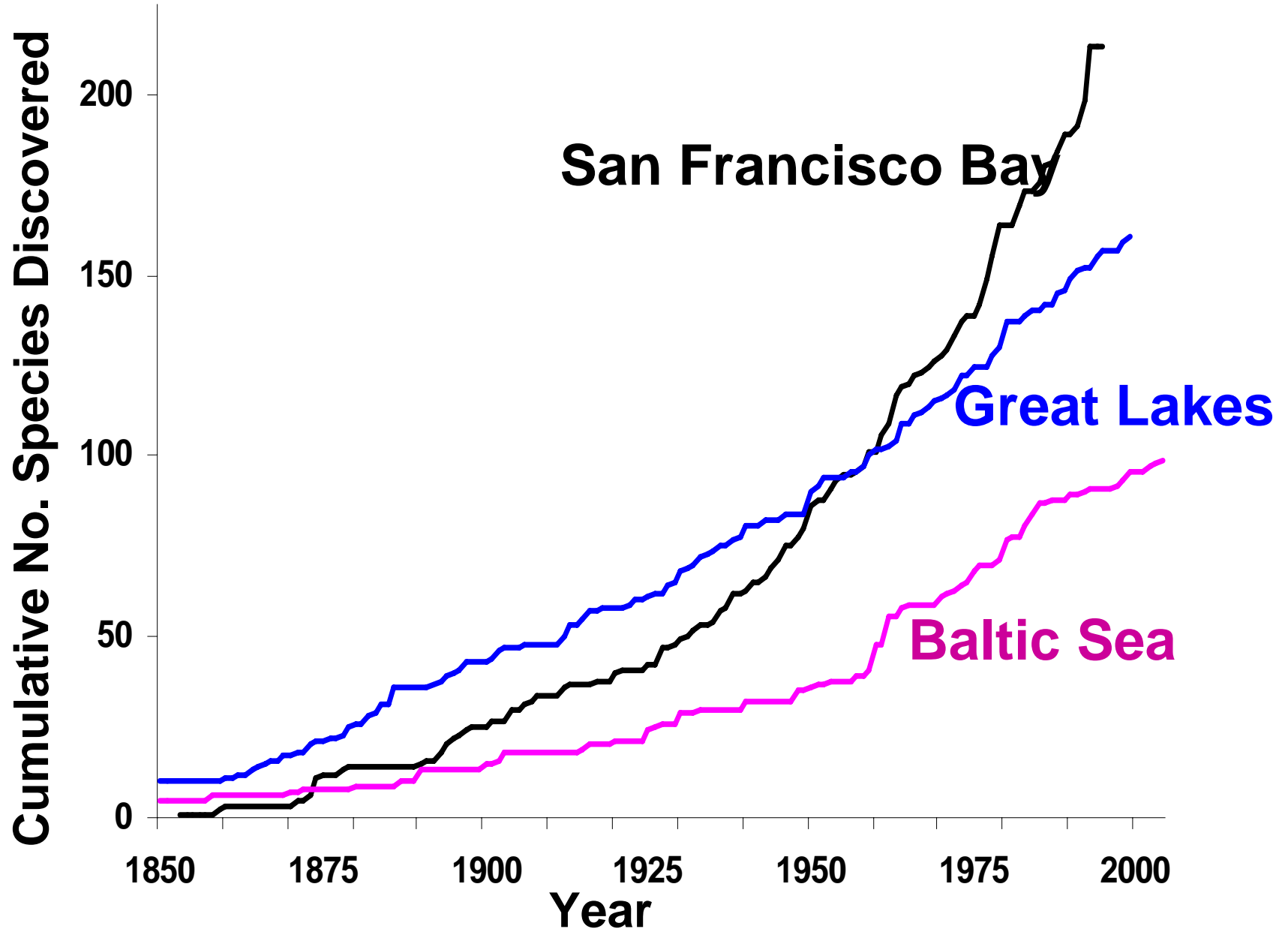
CDF&G 2002; Wasson et al. 1999; Ruiz et al., unpublished data

Cost of Aquatic Invaders in California

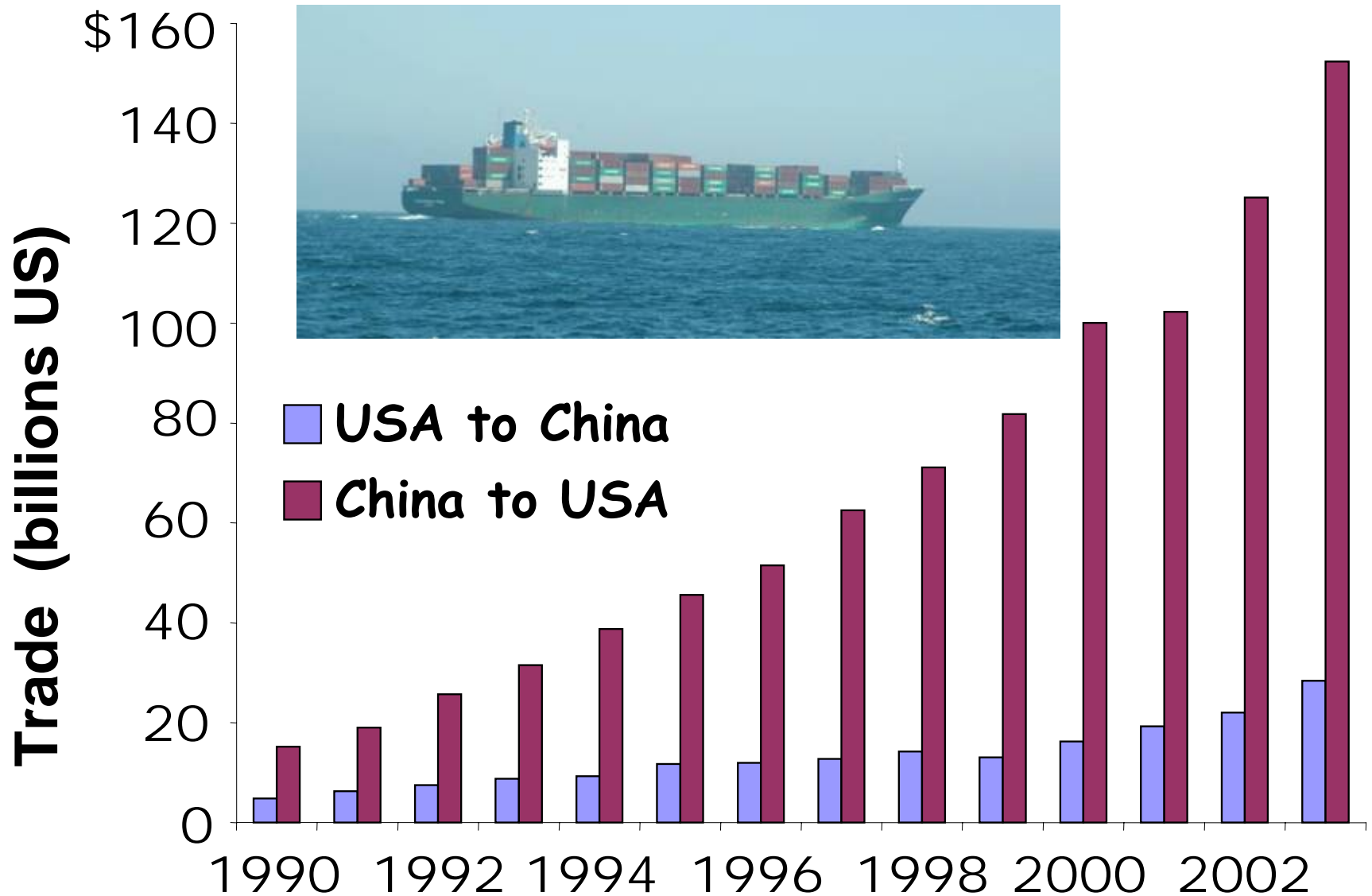


- In CA, aquatic plants (*Hydrilla*, *Egeria*, Water Hyacinth) clog waterways and cost CA \$ millions per year to control (CA Dept. of Boating and Waterways)
- Seaweed invasions (*Caulerpa* in So. CA) cost \$ six million to eradicate (CA Dept. of Fish and Game)
- Chinese mitten crabs, European green crabs and other have also resulted in substantial costs to fisheries, aquaculture and natural habitats (CA Dept. of Fish and Game)

Increasing Invasion Rates



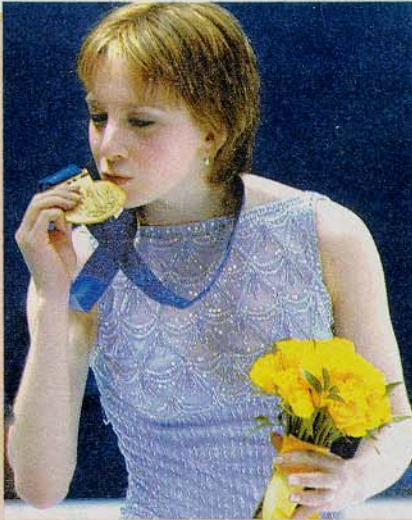
Increasing Globalization



High Profile Invasions (from Parade Magazine 2002)

JUST PERFECT

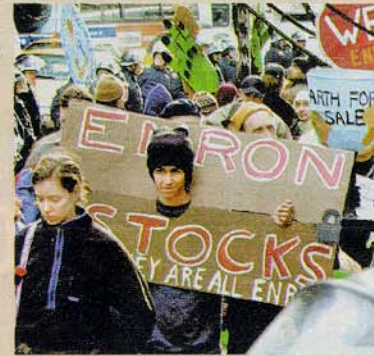
As corruption marred the pairs skating event, Sarah Hughes—a 16-year-old from Great Neck, N.Y.—won the Olympic gold medal for figure-skating with a flawless program that included two triple-triple combinations.



A CHILLING MURDER IN PAKISTAN
Daniel Pearl, a reporter for *The Wall Street Journal*, was abducted and killed by Islamic fundamentalists.

CORPORATE GREED EXPOSED

First came Enron's collapse, with revelations that executives and accountants knowingly had cost shareholders billions of dollars.



ANOTHER ZANY TV FAMILY

The Osbournes, MTV's hit "reality sitcom," gave viewers a window into the domestic life of a heavy-metal rock star.

CRISIS OF TRUST

The Catholic Church came under attack for hiding sexual abuse by priests such as John Geoghan, who was convicted.



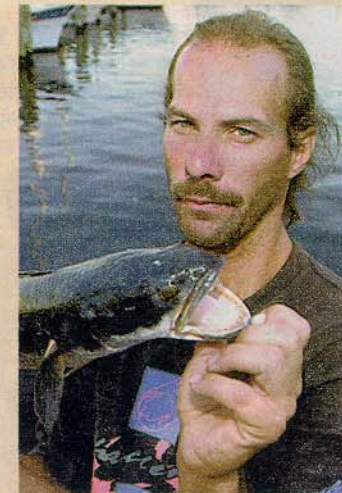
A NEW START IN AFGHANISTAN

Hamid Karzai (r, with Tony Blair) was voted his country's president in a traditional council election—the first in more than 20 years in which all of Afghanistan's people were represented.



A HISTORIC OSCAR

Halle Berry became the first black actress to earn an Academy Award in a lead role, for *Monster's Ball*.



VICTORY DECLARED

State biologists in Maryland announced that the northern snakehead—the most notorious of all invasive fish—had been eradicated.

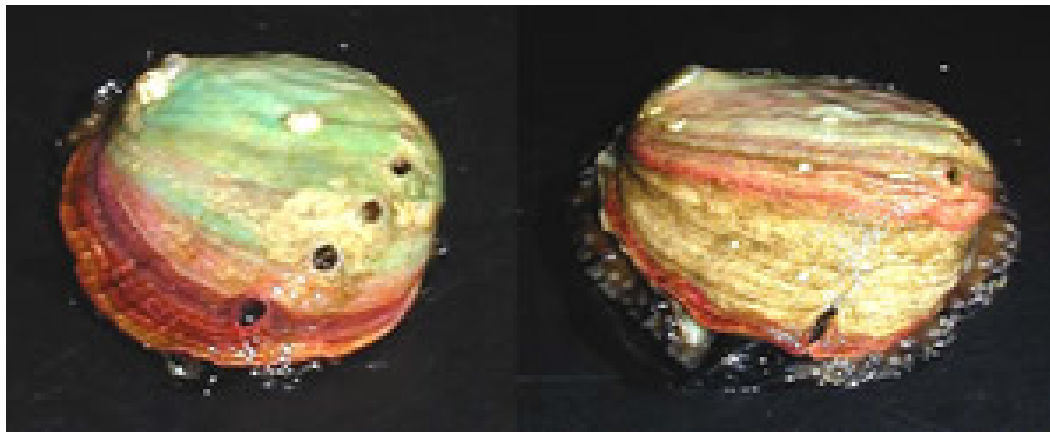
Invasive Seaweed *Caulerpa taxifolia*



- Invaded four continents and eight countries since 1986
- Grows 3 inches per day and overgrows nearly all other species
- Invaded Orange and San Diego Counties
- Required \$6 million to eradicate

Parasite of Cultured Abalone

- Movement of abalone stocks introduced a parasitic worm from South Africa
- Resulted in deformed shells (not viable)
- Shut down CA production facilities for several years costing \$ millions



Invasive Plankton



© S. Wickham

- Invasive planktonic species (copepods, microalgae) have replaced native plankton and are implicated in the declines of key fish species
- Declining fishes include endangered Delta smelt, a key indicator of the health of SF Bay-Delta
- Recently, highly publicized fish declines forced shut-downs of Delta pumping facilities which may entrain and kill fish
- Continuing declines in indicator fish species will exacerbate conflicts among water uses (farmers vs. endangered species)

Delta Water Weeds

- Invasive aquatic plants can clog waterways, prevent boat access, impact commercial and sport fishing
- Control programs for *Hydrilla*, water hyacinth (*Eichhornia crassipes*) and *Egeria densa* have cost CA \$ millions annually



Chinese Mitten Crab



- Clogged fish salvage facilities associated with Delta pumps
- Nearly shut down Tracy pumping facility
- Thwarted sport fishing and clogged commercial shrimp trawls in SF Bay
- Potential vector for human pathogens

Prevention of New Invasions

- **Most cost-effective strategy is the prevention of new invasions**
- **Invasive species become introduced through several pathways**
 - Shipping (ballast water, hull fouling)
 - Live bait, seafood, aquarium products, etc.
- **Many species introduced elsewhere are “repeat offenders”**
- **Key is identifying the high priority pathways and species**

Early Detection of New Invasions

- **Prevention will never be complete, so early detection of new invasions is critical**
- **Most cost-effective investment is fund a regular survey of high priority introduction sites**
- **Early detection of a recently established invasion can permit successful and cost effective eradication**
- **An annual survey of high priority sites in CA (major ports and harbors) could be accomplished for a few hundred thousand \$\$**

Rapid Response Planning

- **Eradication success is increased by responding rapidly to a new introduction**
- **A comprehensive rapid response plan for priority species is required for effectively dealing with a new invasion**
- **Prior agreements/MOUs outlining authorities and means of coordination must be in place**
- **An adequate rapid response fund (similar to oil spill response funds) to support eradication**
- **Public education to raise awareness about the the risks and costs of invasions**

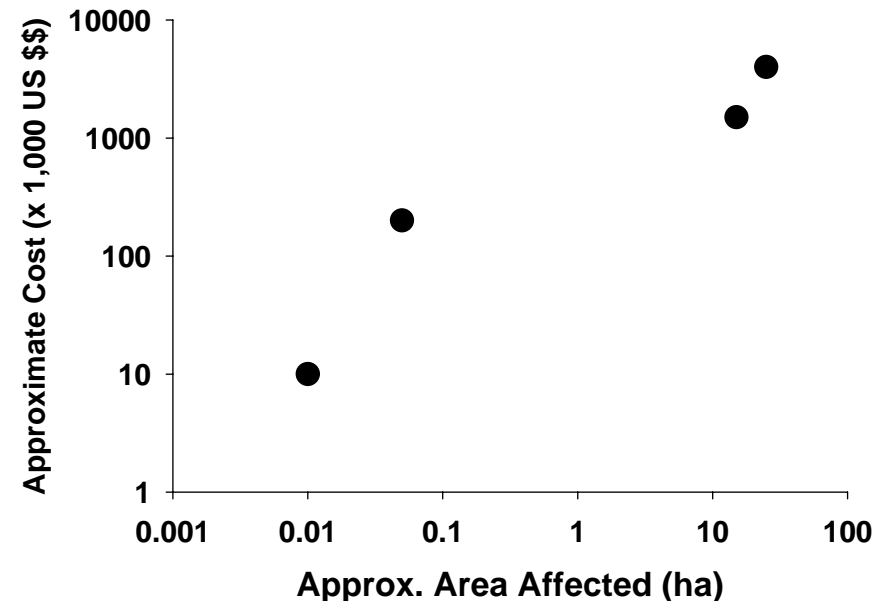
Eradication is Difficult Not Impossible

- **Successful eradication of four invasive species has already been conducted in coastal systems**
- **Three of these have been conducted on California shores**
- **The success of these efforts have made clear the importance of early detection and rapid response**
- **The cost of eradication is directly related to the area of infestation**

Costs of Successful Eradication

Examples of successful eradication in coastal systems

Species	Site
Black Striped Mussel	Australia (NT)
Caulerpa	California (SD, OR)
Abalone parasite	California (MB)
NE seaweed	California (SF)



Cost of Inaction

- Invasive species are likely contributing to the decline of threatened and endangered fishes in the SF Bay-Delta region
- Mitten crabs have highlighted the susceptibility of the water distribution system to invasions
- Likely invaders like Zebra and Golden mussels could potentially shut down the water distribution system in the Delta
- The Delta supplies irrigation water for the \$32 billion California agriculture industry and drinking water for 22 million people
- What do you tell the voters if the water distribution system is compromised?

What We Need to Do Now

- **Prevent Further Introductions**
 - Identify the most important pathways and species for new introductions
- **Early Detect of New Introductions**
 - Initiate a program of annual monitoring of new introductions in targeted ports and harbors
- **Rapidly Respond to New Introductions**
 - Establish rapid response plans and sufficient funding to eradicate new high priority introductions