

Surviving invasion

"You never see a frog so modest and straightfor'ard as he was, for all he was so gifted. And when it come to fair-and-square jumping on a dead level, he could get over more ground at one straddle than any animal of his breed you ever see. Jumping on a dead level was his strong suit, you understand, and when it come to that, Smiley would ante up money on him as long as he had a red. Smiley was monstrous proud of his frog, and well he might be, for fellers that had traveled and ben everywhere, all said he laid over any frog that ever they see."

From Mark Twain's "The Celebrated Jumpin' Frog of Calaveras County"

In one ongoing struggle to preserve California's native fauna from invasive species, a tiny northern California county's jumping frog competition each spring leaps into the glare of the spotlight.

Launched, at least in the literary sense, by Mark Twain's 2,700-word short story, the promoters of the annual Calaveras County's Jumping Frog Jubilee have enjoyed 75 years of reliving the mythical time depicted in Twain's story and the jumping prowess of the California red-legged frog. Still, along with the throngs of people, the event draws criticism from many directions. While some groups claim the competition is abusive for the frogs, state biologists' anxiety has centered on the negative impact to the resource when the non-native bullfrogs are used for the contest and then released into the wild.

For the first time, the California Department of Fish and Game (DFG) developed a proactive approach with jubilee promoters that addressed the issue of spreading non-native bullfrogs across the state.

The DFG, led by Fisheries Program Branch Chief Ed Pert, worked several months with organizers of the jubilee to develop a workable solution that curbs potential adverse effects caused by the inevitable release of hundreds of frogs immediately after the annual event. Fair organizers and the DFG will now ask participants to hand over the non-native bullfrogs once the competition is finished. Event organizers will release the frogs in



The bull frog has affected native frogs through competition for food sources and predation.

Photo © Elvira Lavell



The red-legged frog used to be abundant in California but numbers have dwindled from harvesting in the early 20th century, habitat loss and the introduction of species like the bullfrog.

Photo © Karen McClymonds

DFG-designated area ponds and reservoirs that will minimize the negative impact to native fauna.

Pert acknowledges it's not a perfect solution, but one that allows the tradition to continue and still offers some protection from the potential for disease to be introduced by the amphibian competitors. "With the support of the jubilee planners, and the cooperation of those who bring frogs to the fair, we have the mechanism in place to help curtail future infestation to native amphibian populations which guards against the continued decline of the California red-legged frog," Pert said.

The California red-legged frog is the largest native frog west of the Continental Divide. The species' numbers have plummeted dramatically in recent decades. According to herpetologists Mark Jennings and Marc Hayes, the frog was once so common it was a staple cuisine in San Francisco and the Central Valley. As the population declined, bullfrogs (not native west of the Rocky Mountains) were imported to keep the "froggery" going. Bullfrogs, however, are voracious predators. They, along with a number of other factors such as water diversion, dams, introduced non-native predatory fishes, and urban expansion, helped drive the numbers of the red-legged frog (and many other species) lower yet.

The Calaveras County jumping frog competition illustrates the peril involved in the indiscriminate transfer of a species into an unfamiliar and ecologically unsuitable territory. The problems of invasive species — and the disruption they cause to California's sensitive natural habitat — are hardly limited to frogs.

The problem of invasive species

The sudden introduction of a non-native species into a new habitat—a species with no natural competitors in the new environment — can trigger ecological chaos. *Invasive* animals and plants sometimes spread unchecked, disrupting natural cycles, crowding out native species and amassing huge costs in property damage and lost economic productivity.

A 1999 study by the College of Agriculture and Life Sciences, Cornell University estimates that costs associated with invasive species in the United States ran to \$138 billion. Invasive species have an impact on 42 percent of the species currently listed as threatened or endangered under the Federal Endangered Species Act, the study pointed out.

According to the National Invasive Species Council, one invasive plant, the purple loosestrife, produces up to 2.7 million seeds per plant yearly and spreads across approximately a million additional acres of wetlands each year. The Council is an inter-departmental association that helps coordinate federal activities regarding invasive species.

The Council also states that the glassy-winged sharpshooter — an invasive insect recently detected in California — carries with it the plant bacterium *Xylella fastidiosa*, a disease that has caused nearly \$40 million in losses of California grapes. The disease poses a collective \$35 billion threat, according to some estimates, to the state's grape, raisin, and wine industries, and the tourism associated with them.

Clearly, the costs of invasive species are high.



Photo © UC Regents

Vineyard. Glassy-winged sharp shooters infect grapevines with a bacteria that eventually kills the vines.



The glassy-winged sharpshooter. Photo © UC Regents



Photo © Jay Van Rein

Grapes are not the only crop affected by non-native insects. The olive industry faces a similar threat from another insect.

Taking its own bite: Northern pike



Photo © Eric Engbretson

The finding of northern pike at a Plumas County reservoir remains one of the better-known cases of invasive species. Anglers at Lake Davis discovered the first northern pike in 1994, possibly transplanted from nearby Frenchman Reservoir — where pike had also been illegally introduced and later eradicated by chemical treatment. Portions of Lake Davis, particularly at the northern part of the lake, provide ideal habitat for the survival and reproduction of the northern pike. The reservoir's rainbow trout fishery made easy prey for the aggressive and insatiable pike. Fisheries managers have been working to contain the pike within the lake, fearing they may eventually escape down the Middle Fork Feather River, then the lower Feather River and, eventually, into the Sacramento-San Joaquin Delta. According to DFG's *Managing Northern Pike at Lake Davis: A Plan for Y2000*, "Sensitive fish species such as the endangered winter-run Chinook salmon, threatened spring-run Chinook salmon, threatened delta smelt, and Sacramento splittail could be adversely impacted by the further spread of the northern pike. If pike were to invade the Delta this could lead to future listings of threatened and endangered species and increase the possibility of extinctions." 🐟

The costs and risks of doing nothing remain higher.

California contains nearly 158,000 square miles with an estimated 82 percent, or 131,000 square miles, considered wild land. Part of DFG's trustee responsibility is conserving and managing the habitats upon which wildlife depends. It places the responsibility of stemming the spread of invasive plant and animals species squarely on the DFG.

In 2002, Gov. Gray Davis signed into law SB 1573, a bill that establishes an Interagency Aquatic Invasive Species Council and provides for the development of a State Aquatic Invasive Species Plan. The plan, prepared by DFG's Habitat Conservation Planning Branch, will follow federal guidance and fall under the direction of the state invasive species coordinator.

The responsibility has never been easy. Over the last several years, DFG has seen a growing number of invasive species — some have been widely publicized while others have slipped in and received attention from only the biologists forced to deal with the damage.

A few key issues have received widespread attention.

The lesser-known invasions

California's San Francisco Estuary has been bombarded with the introduction of at least 260 species since the Gold Rush. Most of these introductions were accidental, and the unintended introduction rate has increased as trade between the United States and Pacific Rim nations increases. Many species travel in the ballast water of ocean-crossing vessels and today's large and fast ships carry more ballast water and spend less time in transit, which enhances survival of

hitchhiking organisms.

Over the past four decades, DFG biologists and other scientists have observed the establishment of many new species of zooplankton, clams, worms, shrimp, crabs, and fish in the estuary, many from Asia. Although most of these species have had a minor impact, others have proved to be more significant.

The small Asian clam, *Potamocorbula amurensis*, rapidly colonized the brackish water areas of the estuary since its introduction in the mid-1980s. It has affected the base of the food web by removing much of the algae, which is food for zooplankton, from the water column. This clam is so abundant in Suisun Bay that scientists estimate it can filter the entire amount of water above the clam bed in 24 hours. The clam has also reduced the abundance of *Eurytemora*, the once dominant copepod (a small free-swimming crustacean) that provides food for larval striped bass and delta smelt. The number of the native mysid shrimp *Neomysis mercedis* appears to have been greatly reduced through competition for food with the clam.

However, in a strange twist, other introduced species have partially filled the void. *Pseudodiaptomus forbesi*, another copepod, arrived in 1987 and became the dominant copepod in the upper estuary, replacing *Eurytemora* in the diets of larval striped bass and delta smelt. A small mysid shrimp, *Acanthomysis bowmani*, arrived in 1993 and has supplanted the native *Neomysis mercedis* in the diet of young striped bass, although it is not as abundant as *Neomysis* once was. In recent years, the native mysid *Neomysis kadiakensis* has extended its range from San Francisco

Battling toxic a



Bays, lagoons, and estuaries are besieged by invaders from vessels and from the urban population like Agua Hedionda Lagoon which was infected with *Caulerpa*.

Photos © Mike Brock



Caulerpa was believed to have been dumped into a storm drain from a private aquarium, and traveled to the outlet (right) that fed into the water.

In 2000, the state faced yet another infestation of an invasive species, this time not from a single source — such as a lone angler looking to stock an isolated fishing haven — but from unsuspecting individuals who enjoy saltwater aquariums as a hobby. In the summer of 2000, the marine (saltwater) algae, *Caulerpa taxifolia*, was discovered in two separate Southern California coastal embayments: Agua Hedionda Lagoon in San Diego County, and Huntington Harbour in Orange County.

The Agua Hedionda infestation was first identified by biologists from the consulting firm of Merkel and Associates during routine monitoring of an eelgrass mitigation site. Those tracking the infestation believe the problems likely occurred when people disposed of the contents of their aquaria by dumping them into these saltwater lagoons. Even a small fragment of the plant can become established and become a new infestation.

Caulerpa taxifolia grows as a dense smothering blanket. When introduced into a non-native marine habitat, it covers and kills all native aquatic vegetation in its path. Fish, invertebrates, marine mammals, and sea birds that are dependent on native marine vegetation are displaced or die off from the areas where they once thrived.

The invasive strain of *Caulerpa taxifolia* was first discovered in the Mediterranean Sea in 1984. Immediate eradication was not attempted and, as a consequence, within a few years government officials determined the infestation to be uncontrollable. Today, marine scientists in the Mediterranean are largely resigned to monitoring the seaweed's expansion over thousands of acres of sea floor. Biologists blame *Caulerpa* for devastating marine ecosystems in the Mediterranean Sea and along the coast of Australia. The *Caulerpa* has transformed vast areas of the Mediterranean into watery wastelands.

As with any invasive species, complete eradication of *Caulerpa* is expensive and often elusive. Since first discovering



Algae: Caulerpa

the infestations in Southern California, state, federal, and local authorities as well as private entities have spent more than \$4 million on eradication efforts. A coalition of federal, state, and local agencies, as well as private parties, formed the Southern California Caulerpa Action Team with the purpose of eradicating the algae. Biologists are cautiously optimistic that complete eradication can be achieved. There is still much work to be done, however, before complete eradication can be declared.

Invasive species, almost universally viewed as an environmental evil, will continue as an ongoing, worldwide problem. Whether the unwanted species travel in the ballast water of ocean crossing vessels, are illegally spread by anglers wishing to establish a fishery in other areas, or are a plant variety transported unknowingly, the incursion moves forward. Any success of curbing the influx depends on people understanding the consequences of introductions, their knowledge and understanding of the law, and their willingness to comply with what is best for the state's natural environment.

Under State law (Fish & Game Code Section 2300), the sale, possession, and transport of *Caulerpa taxifolia* was prohibited throughout California in September 2001. California also bans nine species of *Caulerpa* that look similar to *C. taxifolia* or are believed to have the capability to become invasive. The nine species are *C. cupressoides*, *C. mexicana*, *C. sertularioides*, *C. floridana*, *C. ashmeadii*, *C. racemosa*, *C. verticillata*, and *C. scapelliformis*. The importation of the Mediterranean strain of *Caulerpa taxifolia* into the United States and interstate trade, including via the Internet, is a federal offense under the Federal Noxious Weed Act of 1999 and the Plant Protection Act of 2000.



It only takes part of a frond to establish Caulerpa which thrives: frond and creeping stolon pictured lower right. Beginning stages of a dense bed middle right.



Visitors are informed of the work and made aware of locations where the Caulerpa is being eradicated.

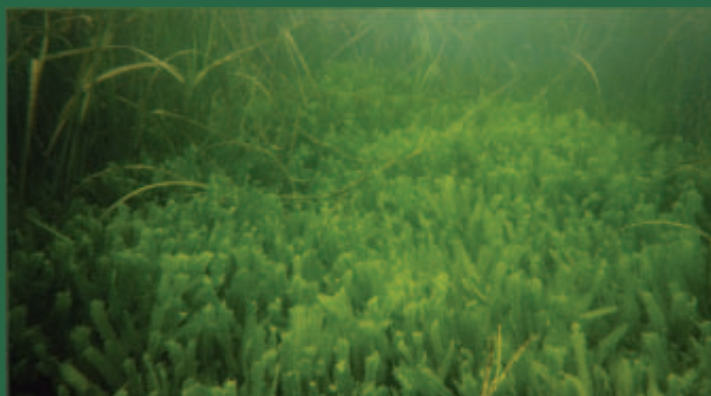


Photo © Rachel Woodfield, Merkel & Associates



Photo © Rachel Woodfield, Merkel & Associates

Feeling the pinch

Chinese mitten crab

The Chinese mitten crab, *Eriocheir sinensis*, spread rapidly in the San Francisco Estuary and its watershed since it was discovered in South San Francisco Bay in 1992. By 1998, distribution of the mitten crab extended north to Colusa and Yuba counties, east to the Sierra Nevada foothills, and south to Merced County. But from 1999 to 2002, the numbers and distribution of the crab decreased and numbers appear to again be low in 2003. Although biologists do not understand what factors control the crab's population, they expect that numbers will again increase.



Chinese mitten crab.

DFG photo by Lee Mecum

Green Crab

The green crab, *Carcinus maenas*, was first found in San Francisco Bay in the late 1980s and spread rapidly north along the Pacific coast. It reached

Coos Bay, Ore., by 1997, Willapa Bay, Wash., by 1998, and Vancouver Island, British Columbia in 1999. It lives in a variety of shallow subtidal and intertidal habitats and is a voracious predator that

consumes bivalves, snails, and other crustaceans. Because of its food habits, the green crab may compete with shorebirds and other crabs for food and prey upon juvenile Dungeness crabs, which use

West Coast estuaries as a nursery. It has been blamed for the collapse of the soft-shell clam industry in Maine and is a threat to the oyster and clam fisheries in the Pacific Northwest. 🐞

Bay into San Pablo and Suisun bays, possibly in response to the greatly reduced numbers of *Neomysis mercedis*.

Two very recent lesser-known introductions from Asia are the shokihaze goby, *Tridentiger barbatus*, and the freshwater shrimp, *Exopalaemon modestus*. It is likely that both species were introduced via ballast water. The shokihaze goby, a small bottom-dwelling species, was first collected in 1997 from the lower Sacramento River and is now common in

Suisun Bay and the western delta, an area that is dominated by introduced fishes. The freshwater shrimp, which was first collected in 1999 from the lower San Joaquin River, is much more widespread, as it has been found from Suisun Bay to above Sacramento and Merced County. This is the only shrimp in the estuary that can complete its life cycle in freshwater. It is now so common in some areas that sport anglers are collecting it for bait; it has been observed in stomachs of

several fishes, including many of the introduced sunfishes that are common in the warmer areas of rivers and sloughs.

There are also many examples of nonnative fish introductions gone awry. The presence of the golden shiner, *Notemigonus crysoleucas*, has had major consequences for put-and-grow trout fisheries in cold-water lakes. Trout biomass has dropped up to 90 percent in some lakes following golden shiner introduction. The golden shiner, a native to the eastern

United States, became widely distributed in California after 1950, following its introduction in 1891.

The brown bullhead, *Ameiurus nebulosus*, was introduced to California from the eastern United States in 1874. It is now the most numerous and widely distributed of the three species of bullhead present here. As a sought-after sport species, anglers wishing to establish a fishery in other areas illegally spread it. However, because of its prolific capabilities, it often

results in stunted populations that compete with other desirable species, such as trout.

It may come as a surprise that the legal and illegal movement of trout, deemed by many as desirable sport species, has nearly wiped out some native aquatic species. In the Sierra Nevada, native trout species such as the California golden trout, *Onocorhynchus mykiss aguabonita*, Little Kern golden trout, *Onocorhynchus mykiss whitei*, Lahontan cutthroat trout, *Onocorhynchus clarki henshawi*, and Paiute cutthroat trout, *Onocorhynchus clarki seleniris*, are threatened by other trout species that are not indigenous to the area. Brown trout, *Salmo trutta*, native to Scotland and Europe, have invaded the upper drainage of the South Fork Kern River, where they are predators on California golden trout—designated as California's official state fish.

Not everything has legs or swims

Still, the issue of invasive species does not rest solely with animals. Through a conscious act or by accident, according to DFG's Habitat Conservation Planning Branch, California has become home to scores of plant varieties that are not native to the state. Many of these organisms have thrived in one or many of California's vast variety of habitats. In the process, they have invariably had a detrimental effect on the native



Brown trout, a non-native fish.



Invasive plants: parrot feather (above) and pampas grass (below).



species, either by out-competing them for the existing resources, or preying upon them.

In their book "Invasive Plants of California Wildlands," authors John M. Randall and Marc C. Hoshovsky address how widespread the state's invasive plant problems have become. Hoshovsky is a biological conservation planner with the DFG, and Randall is with the University of California, Davis. They write:

"The state's varied topography, geology, and climates have helped to give rise to the state's extraordinary native biological diversity and high levels of endemism. However, these varied conditions also provide suitable habitat for a wide variety of non-native plant species, many of which have readily established and rapidly spread in the state. Fewer than 10 percent of the 1,045 non-native plant species that have established in California are recognized as serious threats, but these have dramatically changed

California's ecological landscape. They alter ecosystem functions such as nutrient cycles, hydrology, and wildfire frequency, out compete and exclude native plants and animals, harbor dangerous animal invaders, and hybridize with native species. Some spread into national parks, preserves, and other wildlands and reduce or eliminate the

species and communities these sites were set aside to protect. Rare species appear to be particularly vulnerable to the changes wrought by non-native invaders. For example, the California Natural Diversity Database indicates that 181 of the state's rare plant species are experiencing threats from invasive weeds. Habitats for rare animals such as the San Clemente sage sparrow and the Palos Verde blue butterfly are also being invaded. Even more common species could be driven to rarity or near extinction by particularly disruptive invaders, as evidenced by the fate of the American chestnut (*Castanea dentata*) in the eastern hardwood forest following introduction of chestnut blight, (*Cryphonectria parasitica*)."

Penalties for Spreading Aquatic Nuisance Species

Under Fish and Game Code Sections 12023-12026, California courts may impose a fine of up to \$50,000 and a year in jail for spreading aquatic nuisance species. In addition, violators are liable to pay for damages caused to property, commercial and sport fisheries, and local communities that depend on those fisheries. Violators are also responsible for all public and private response, treatment, and remediation efforts to eradicate the introduced aquatic species. Costs commonly run in the millions of dollars. 🐼

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Scotch broom. Non-native plants compete with natives for resources like water and nutrients. In some cases, non-natives will crowd out native plants, affecting the entire ecological system.



Non-native star thistle infests about 10 million acres of land in California (the state of Vermont would easily fit within that space). A native of Europe, it is one of the common weeds found along roadsides.