



Golden Mussel

LIMNOPERNA FORTUNEI



Figure 1: Golden Mussels provided by USGS



Figure 2: Golden Mussels colonizing a water pipe at a hydroelectric plant in Brazil (Mountinho, 2021).

Invasive Non-Native Golden Mussel Discovered in California

- ▶ Discovered in the Sacramento - San Joaquin Delta in October 2024
 - ▶ Discovered at Rough and Ready Island, just west of the Port of Stockton and further downstream at a location known as Turner Cut in October 2024
- ▶ First known occurrence of golden mussels in North America.
- ▶ Native Range: Rivers and creeks of China and Southeast Asia
- ▶ Non-Native Range: Hong Kong, Japan, Taiwan, Brazil, Uruguay, Paraguay, and Argentina



Figure 3: Golden Mussels affecting aquaculture in Brazil



Figure 4: Golden Mussel Detection in Burns Cutoff CA on 12/7/2025 reported to CDFW

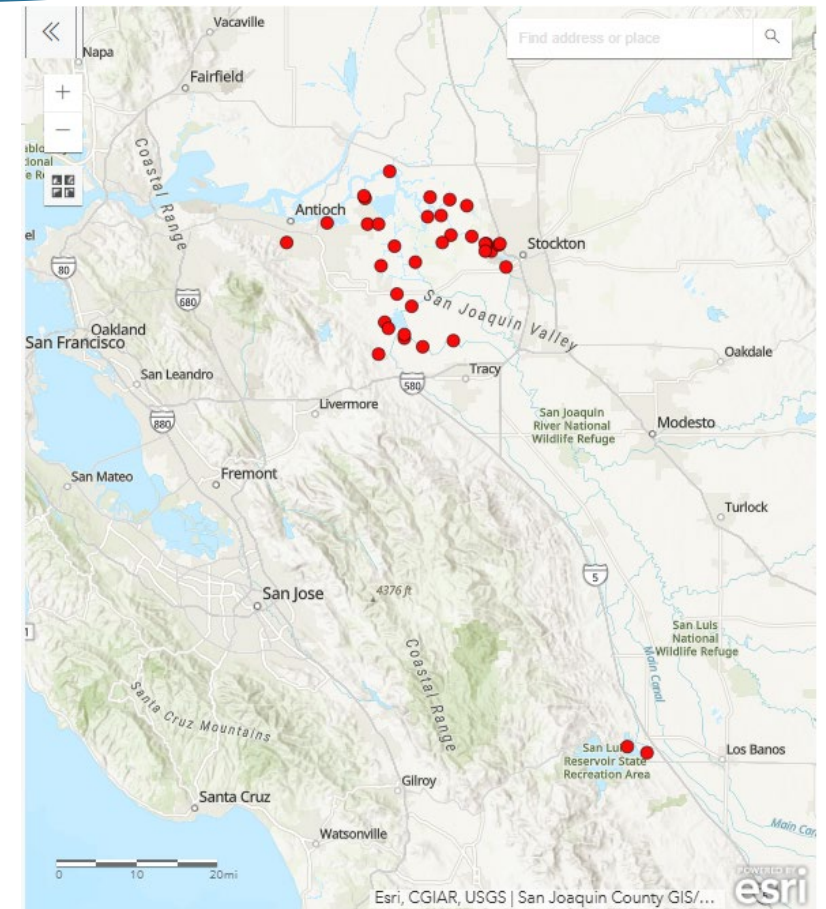


Figure 5: CDFW Map of California Golden Mussel Detections 2/3/2025

Life Cycle and Exponential Growth

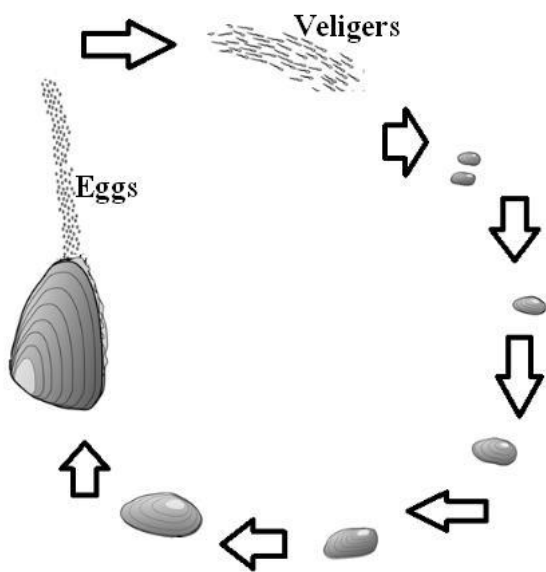
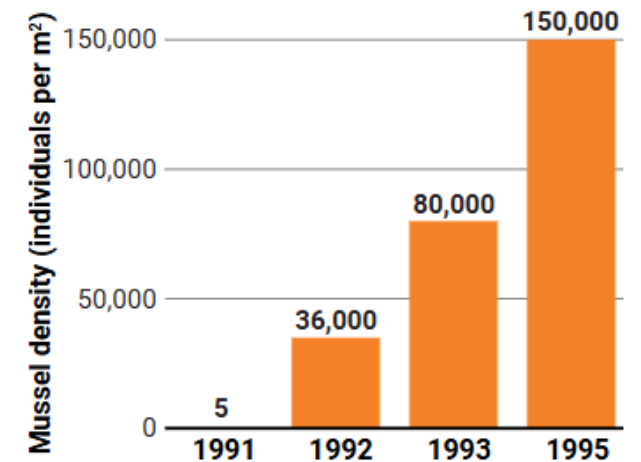


Figure 6: Golden Mussel Life Cycle

- ▶ Veliger – Microscopic, planktonic larval stage
- ▶ Settlers – newly settled juvenile mussels, feel like sandpaper
- ▶ Adults – larger individuals, seen with naked eye
- ▶ Settlers avoid light, but prefer to settle higher in the water column
- ▶ Larval densities during the reproductive period are very variable
 - ▶ Normally average around **6,000 larvae per cubic meter of water**, although values in excess of **20,000 larvae per cubic meter** of water have been reported.
- ▶ Maturity is reached when the mussel attains a length of approximately 5.5 mm (almost ¼ inch) which occurs within the first year of its lifespan.
- ▶ Golden mussels can grow in dense clumps or colonies containing as many as 80,000 -200,000 organisms per square meter.

Exponential invasion

After arriving in Argentina, golden mussels quickly multiplied on rocks at the La Plata River. The population there is now stable at 85,000 per square meter.



(GRAPHIC) K. FRANKLIN/SCIENCE; (DATA) GUSTAVO DARRIGRAN/NATIONAL UNIVERSITY OF LA PLATA

Figure 7: Graph of the Golden Mussel Exponential Growth

Identification & Morphology

- ▶ Small, typically under 1.5 inches in length
- ▶ Firmly attached to hard/semi-hard surfaces by byssal threads
- ▶ Upright, shell margins opposite of attached side
- ▶ Shell color is light golden to darker yellowish-brown to brown color
- ▶ Rounder subterminal umbo, smooth shiny exterior, rounded triangle shape
- ▶ Freshwater and brackish water



Figure 7: Golden Mussel Shells collected in October 2024 at Rough and Ready Island



Figure 10: Shells of the invasive Golden Mussel (*Limnoperna fortunei*) showing general morphology (Boltovskoy, 2017).



Figure 9: *Limnoperna fortunei* (Golden Mussel) with Scale Bar



Figure 11: *Limnoperna fortunei* (Golden Mussel) at different life stages

Golden Mussel Habitat Suitability

Parameters for Survival/Reproduction

Golden Mussels	Survive		Reproduce	
	Lowest	Highest	Lowest	Highest
Reported Values				
Calcium (mg/L)	< 3	-	5	-
Salinity (ppt)	0	> 15	0	5
Temperature (°F)	41	95	61	82

Table 1: Golden Mussel Parameters for Survival/Reproduction Provided by CDFW.

Species Comparison

Parameter	Numeric Value		References
	Q/Z mussels	Golden mussel	
Calcium	10-25 mg/L	1-50 mg/L	Mackie and Brinsmead 2017
Salinity	≤4 ppt	0-3 ppt; up to 23 ppt w/ FW pulses	Sylvester et al. 2013
Temperature (adult survival)	1-32 °C (34-90°F)	5-35 °C (41-95°F)	Oliveira et al. 2010
Temperature (spawning)	12-18 °C (54-64°F)	16-28 °C (61- 82°F)	Darrigran et al. 2003
Temperature (larval devel)	20-22 °C (68-72°F)	16- 28 °C (61- 82°F)	Ricciardi 1998
pH	7.4-8.4	5-10	Yang et al. 2023
DO	0.1-13.3 mg/L	3.7-11.2 mg/L	Mackie and Brinsmead 2017
Depth	≤ 50m (164 ft)	0.5 - 40m (1.5-131ft) , 10m* (33 ft)	Darrigran 2022
Sexual Maturity (shell size)	8-9 mm (~½ in)	6-8 mm (~¼ to ½ in)	Xu et al. 2013

Table 2: Golden Mussel and Quagga/Zebra Mussel Species Comparison Provided by SCWA.

Golden mussel Habitat Suitability				
CDFW	Calcium (mg/l)	pH	Temperature	
High	10	>7 - <10	26-32°C	<ul style="list-style-type: none"> • Adult mussels survive long-term • Reproduction and full life-cycle completion occurs • Calcium is not a limiting factor
Moderate	5	>7 - <10	16-26°C or 32-35°C	<ul style="list-style-type: none"> • Adult mussels survive long-term • Reproduction can occur, but survivorship is reduced due to inadequate calcium for veliger development • Survivorship increases as calcium increases up to 10 mg/L
Low	3	>7 - <10	5-15°C or 35-40°C	<ul style="list-style-type: none"> • Adult mussels survive long-term • Reproduction may occur, but veligers cannot survive • Introduced late-stage veligers may survive and settle
Very Low	<3	>7 - <10	<5°C or >40°C	<ul style="list-style-type: none"> • Adult mussels can't survive long-term • Adult mussels are more resistant to gradual changes in salinity, like those seen in estuaries and can survive at higher salinities for several hours

Table 3: Golden Mussel Habitat Suitability Provided by CDFW.

Reservoir Risk Rating

Upper Reservoir Risk Rating				
Reservoir	Calcium (mg/l)	Temp (°C)	pH	Risk
Bowman - Dam	4.11	17.87	7.46	Low / Moderate
Bowman - Boat Launch	4.27	17.74	7.44	Low / Moderate
Bowman - Campground	4.16	16.98	7.36	Low / Moderate
Bowman - MB Tunnel Outlet	4.76	8.12	7.42	Low
Bowman - Jackson Creek	4.27	16.45	7.41	Low / Moderate
Sawmill - Dam	0.96	17.02	7.15	Very Low
Faucherie - Boat Launch	0.80	15.56	7.43	Very Low
Jackson Meadows - Pass Creek	4.09	17.48	7.27	Low / Moderate
Jackson Meadows - Dam	4.03	17.86	7.56	Low / Moderate
Jackson Meadows - Wood Camp	4.03	17.06	7.49	Low / Moderate
Milton - East Side	4.25	10.74	6.97	Low
Milton - Middle	4.30	12.02	7.12	Low
Milton - Dam	4.29	8.43	7.30	Low
Jackson - Dam	1.15	17.14	7.37	Very Low
French - Dam	0.80	16.05	7.34	Very Low

Table 4: Upper Reservoir Water Chemistry collected in October 2024.

Reservoir Risk Rating				
Reservoir	Calcium (mg/l)	Temp (°C)	pH	Risk
Combie - Bear River Inlet	5.15	29.443	7.38	Moderate / High
Combie - Dam	6.09	27.084	7.7	Moderate / High
Deer Creek - North Shore Boat Launch	3.39	11.604	7.08	Low
Scotts Flat - Rec Gate 2	3.27	29.923	7.06	Low
Scotts Flat - Cascade Shores	3.39	28.946	7.27	Low
Rollins - Greenhorn	6.91	28.744	7.39	Moderate / High
Rollins - Orchard Springs	6.43	27.974	7.95	Moderate / High
Rollins - Long Ravine	6.09	27.144	7.8	Moderate / High
Dutch Flat Forebay - Dam	7.85	23.76	7.68	Moderate / High
Dutch Flat Afterbay - Boat Launch	7.47	25.101	7.87	Moderate / High

Table 5: Lower Reservoir Water Chemistry collected in July and October 2024.

Environmental and Economic Impacts

- ▶ Mussels may impede water distribution clogging water intakes, fish screens, impede distribution of municipal water supplies, agricultural irrigation, and power plant operation.
- ▶ The Golden Mussel has been identified as one of the **highest-risk** invasive species globally
- ▶ Filter feeders that can consume large quantities of the microscopic plants and animals that other species depend on.
- ▶ A single adult filters, on average, half a liter of water per hour—about **10 times more than the zebra mussels** infesting the U.S. Great Lakes.

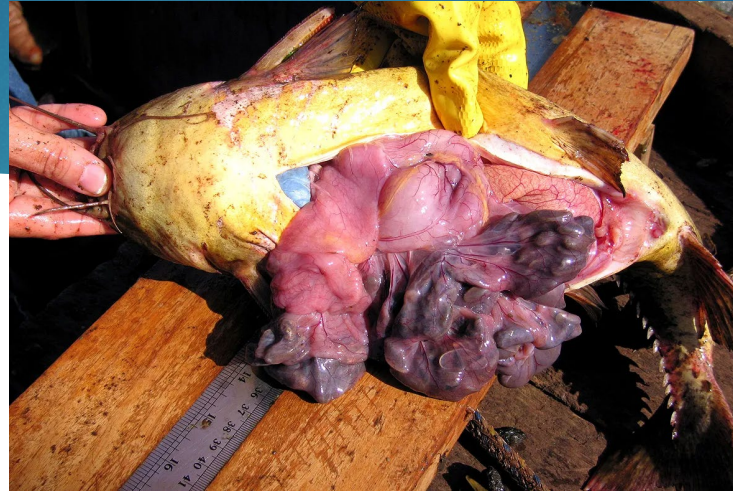


Figure 12: Golden Mussels shown surviving inside native fish in Brazil.



Figure 13: Golden Mussels fouling on an iron pipe.



Figure 14: Golden Mussels shown as newborns on top of an adult, grow in reeflike structures that cover underwater surfaces

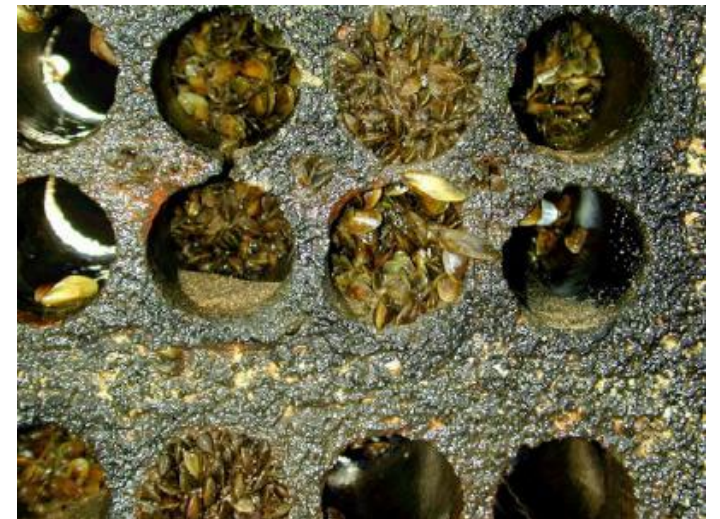


Figure 15: Golden Mussels provided by USGS

Hydroelectric Power Effects

- ▶ Impacts in South American Hydroelectric Power Plants
- ▶ 40% of Hydropower plants in Brazil have a Golden Mussel problem.
- ▶ In 2016 São Francisco Hydroelectric Company spent approximately **USD 510,000 annually** on chemicals for cleaning pipes at the Sobradinho power plant.
- ▶ CTG Brazil (the second largest private HPP operator in the country) estimates that the cost of monitoring and maintenance due to golden mussel fouling in Brazilian HPPs ranges from **USD 6.9 to 8 million annually**.
- ▶ The opportunity cost (lost revenue) due to halts from fouling is around **USD 120 million per year**.

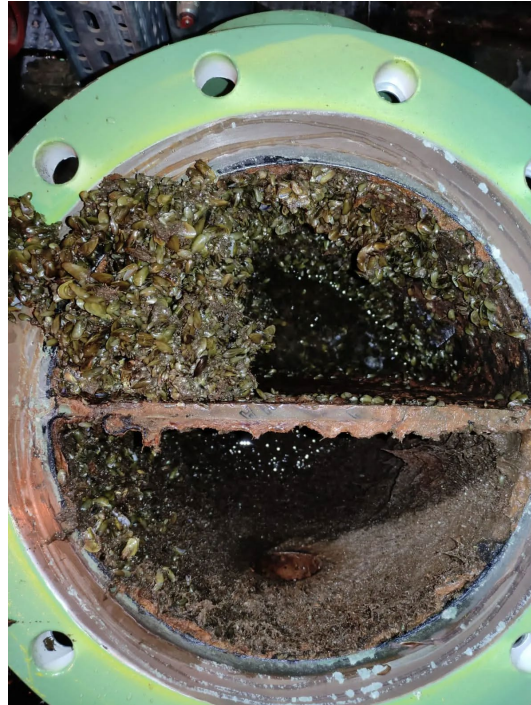


Figure 16: Golden Mussels colonizing a pipe at a hydroelectric plant in Brazil.



Figure 17: A colony of golden mussels (*Limnoperna fortunei*) in a hydroelectric powerhouse turbine room, Brazil.



Figure 18: A colony of golden mussels (*Limnoperna fortunei*) on a hydroelectric powerhouse intake rack, Brazil.

Actions Taken

- ▶ Scotts Flat and Rollins boat launches temporarily closed on December 10th, 2024.
- ▶ Berryessa (Solano County Water Agency) has the 30-day quarantine requirement with staff onsite to conduct inspections and full decon work
- ▶ Other Closed Reservoirs:
 - ▶ Camanche Reservoir
 - ▶ New Melones
 - ▶ Lake Hennessey
 - ▶ Woodward Reservoir
- ▶ PG&E (Spaulding): No action yet. Awaiting further direction/guidance/Updated F&W Codes (for enforcement) from CDFW. Not currently planning restrictions.

Boater Seal Program

- ▶ All motorized boats must pass a 30-day quarantine (boat type dependent) or be decontaminated by an approved entity prior to entry.
- ▶ Boat will be inspected and must be **CLEAN DRAIN DRY** in order to get a red quarantine seal and receipt.
- ▶ Seals have unique serial numbers and will be tracked using the Watercraft inspection and decontamination (WID) web database.
 - ▶ Free online database created by Colorado Parks and Wildlife.
 - ▶ Cannot be accessed by the public, need credentials to access and use.
- ▶ When exiting Rollins or Scotts Flat, the boater is offered a green (soon to be blue) re-entry seal and receipt.
 - ▶ Re-entry seal allows boat access to Rollins or Scotts Flat without 30-day quarantine.
 - ▶ Seal **CANNOT** be tampered with in anyway

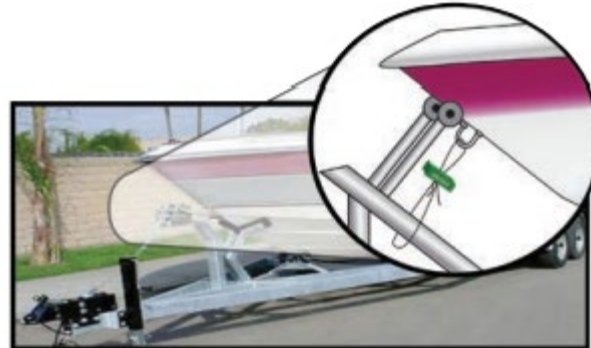


Figure 19: Example of a properly installed boat seal.



Figure 20: Example of a tampered seal in comparison to an untampered seal

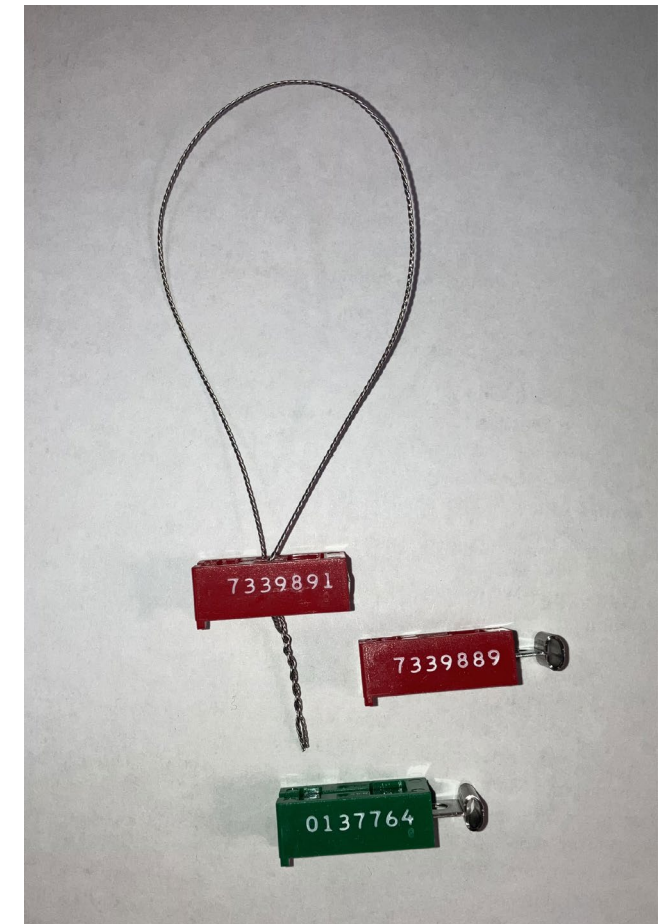


Figure 21: Red and green seals with wire.

What Does This Mean For Recreation?

- ▶ Entry Gates will need to be staffed year-round.
 - ▶ Boat launches will be gated when entry gates are not staffed.
- ▶ Long Ravine and Orchard Springs Park Rangers will need to increase to 40 hrs/week year round
- ▶ Staffing increases for summer and winter.
 - ▶ Temp staffing increase by 10
 - ▶ Staff needed for winter gate coverage 3.5 and 6.5 for summer, gaps will be filled with Park Rangers and camp hosts.
- ▶ Motorized boating hours:
 - ▶ Summer 5/1-9/30: 7:30AM-6:30PM
 - ▶ Winter Options:
 - ▶ Winter 10/1-4/30: 7:30AM-4:30PM
 - ▶ Close all launches during winter months (10/1-4/30)
 - ▶ Close Long Ravine and Cascade Shores during winter months.
 - ▶ Launches will be closed during bad weather, rain and snow.

Decontamination Unit Options

▶ Pressure Washer

- ▶ Quotes from Steam Cleaners: \$17,834 and \$28,482
 - Reached out to other vendors
- ▶ High and low pressure
- ▶ Trailered units/Mobile
- ▶ Gas and Diesel powered
- ▶ No water and power hook ups needed



Figure22: Pressure washer decontamination unit

▶ On-Demand Hot Water

- ▶ ~\$8,000
- ▶ Easier, safer, cheaper to operate and maintain
- ▶ Needs shelter, power and water supply
- ▶ Maintains hot water temps for long times



Figure23: On-Demand hot water decontamination unit

▶ Dip Tank

- ▶ \$800,000+ and getting more expensive
- ▶ Faster
- ▶ Ballast tanks, and engines get flashed at same time.
- ▶ No full decontamination option



Figure24: Dip Tank decontamination unit



Questions?