Golden Mussel

Limnoperna fortunei

Golden Mussels colonizing water quality monitoring equipment in the Sacramento Delta (DWR).

Juvenile Golden Mussels growing on an adult golden mussel (Mountinho, 2021).

Presented by: Drew Gantner
Solano County Water Agency

APRIL 4TH, 2025

For: North Bay Watershed Association

Golden mussels colonizing a water pipe at a hydroelectric plant in Brazil (Mountinho, 2021).

Today's Presentation

- GLOBAL AND REGIONAL DISTRIBUTION
- BIOLOGY
- EFFECTS
- LAKE BERRYESSA PREVENTION PROGRAM


Photo: Google

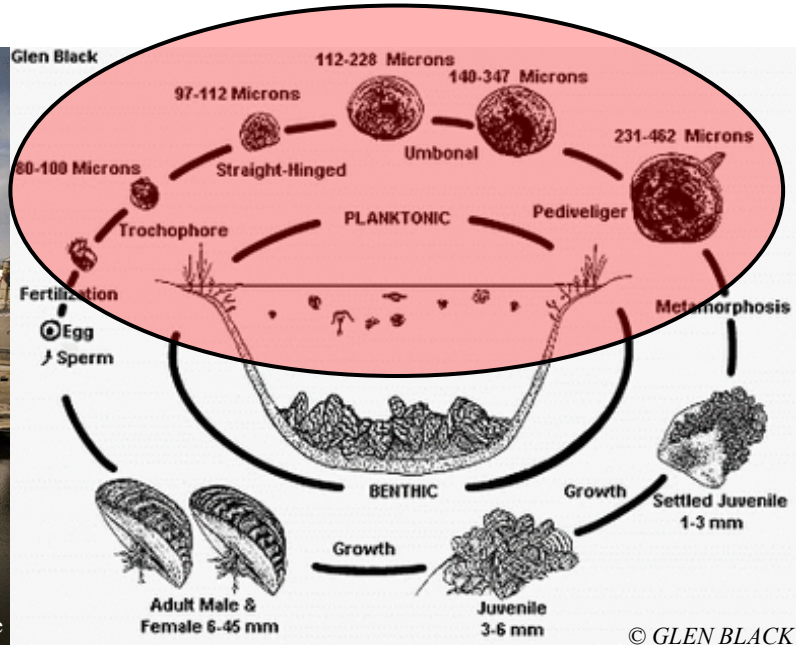

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Photo: Google

Global Distribution & Transport

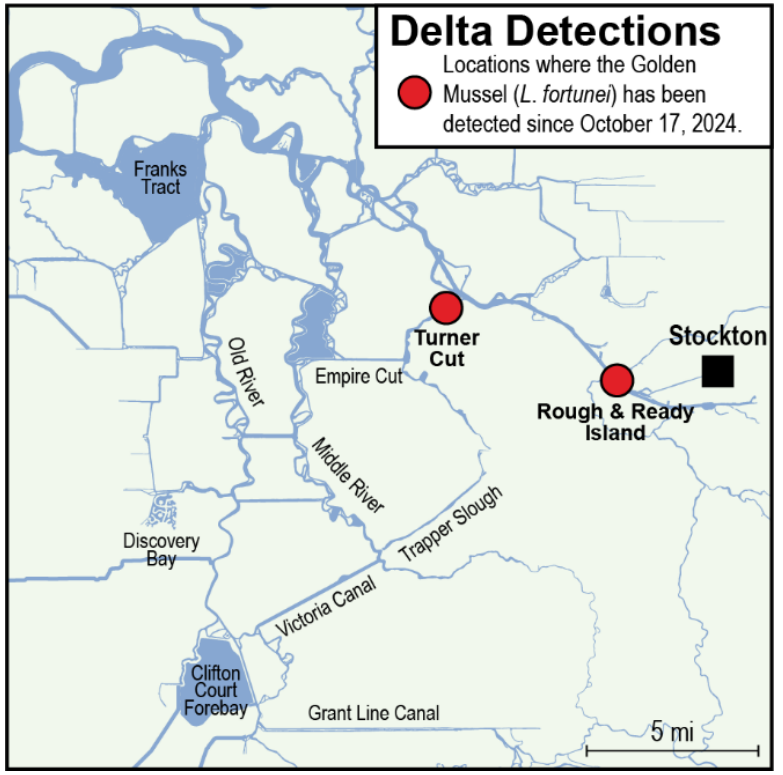
- First North American observation discovered on October 17th 2024 near Stockton.
- Likely introduced by international shipping into the Port of Stockton.
- Detections of these mussels in the Delta and region are increasing at a rapid rate now that people are looking for them.

Golden Mussel (*Limnoperna fortunei*)

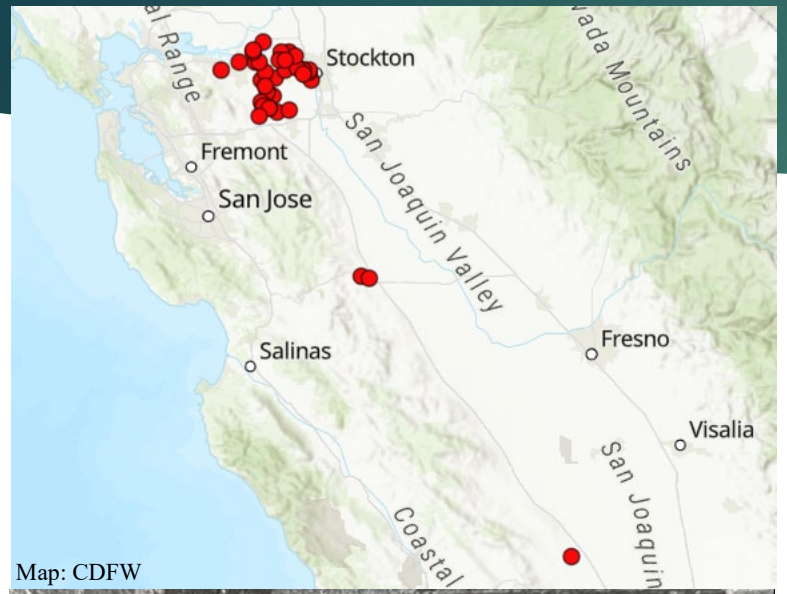
A new invasive mollusk was discovered in the Delta on October 17, 2024.

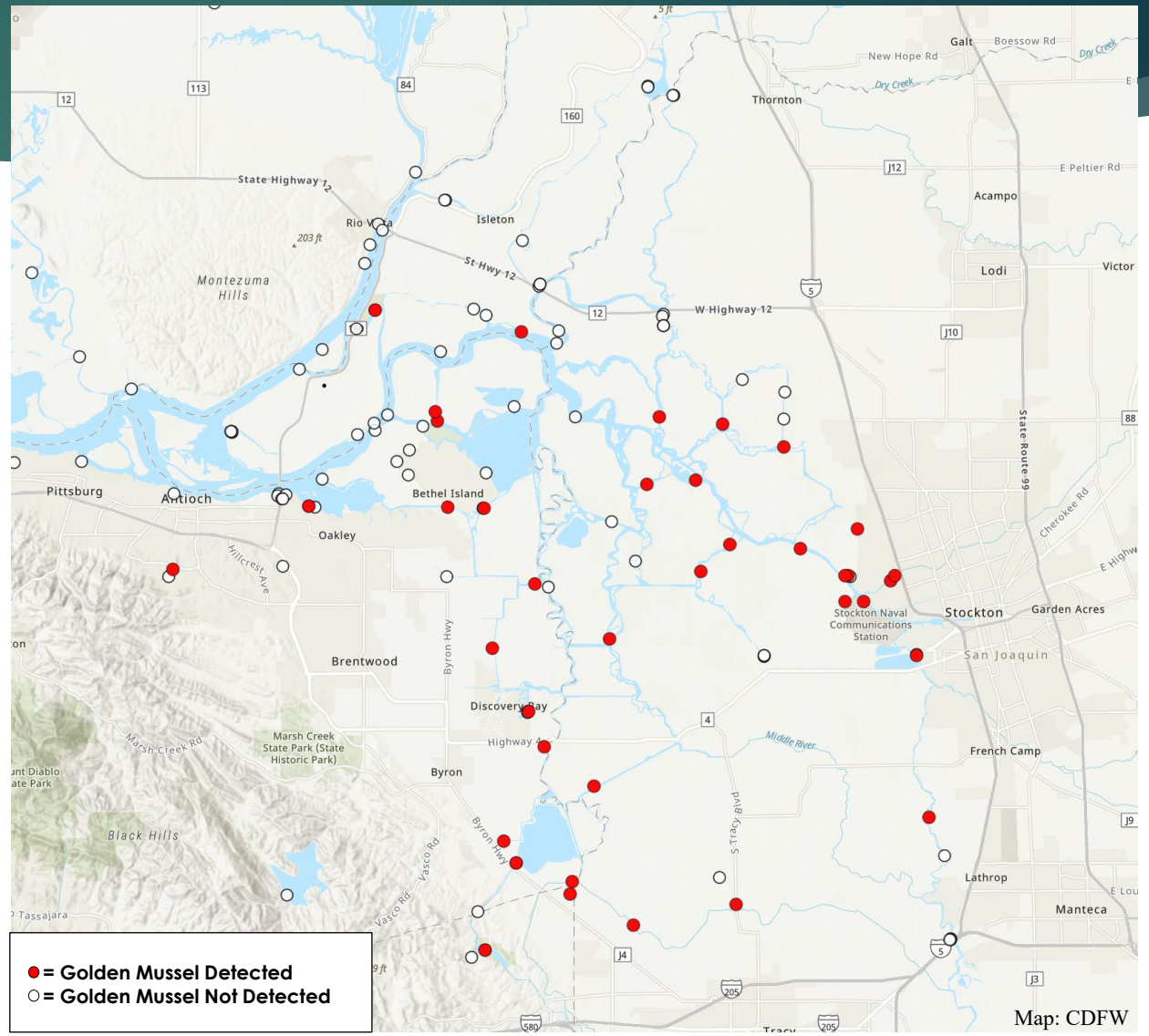
Fast Facts (DWR Bulletin 10/28/24)

- Golden Mussels (*Limnoperna fortunei*) were found at Rough & Ready Island near Stockton, California on October 17, 2024.
- The Golden Mussel has been identified as one of the **highest-risk** invasive species globally
- This is the **first-ever** detection of the Golden Mussel in North America.
- Capable of rapid spread (> 240 km/yr in Brazil), these mussels post an **immediate and urgent threat** to both the Delta ecosystem and water-based built infrastructure.
- DWR is contributing to a multi-agency team to monitor and report Golden Mussel sightings and coordinate on possible strategies for control and eradication.



Golden Mussel Detections – 4/4/2025

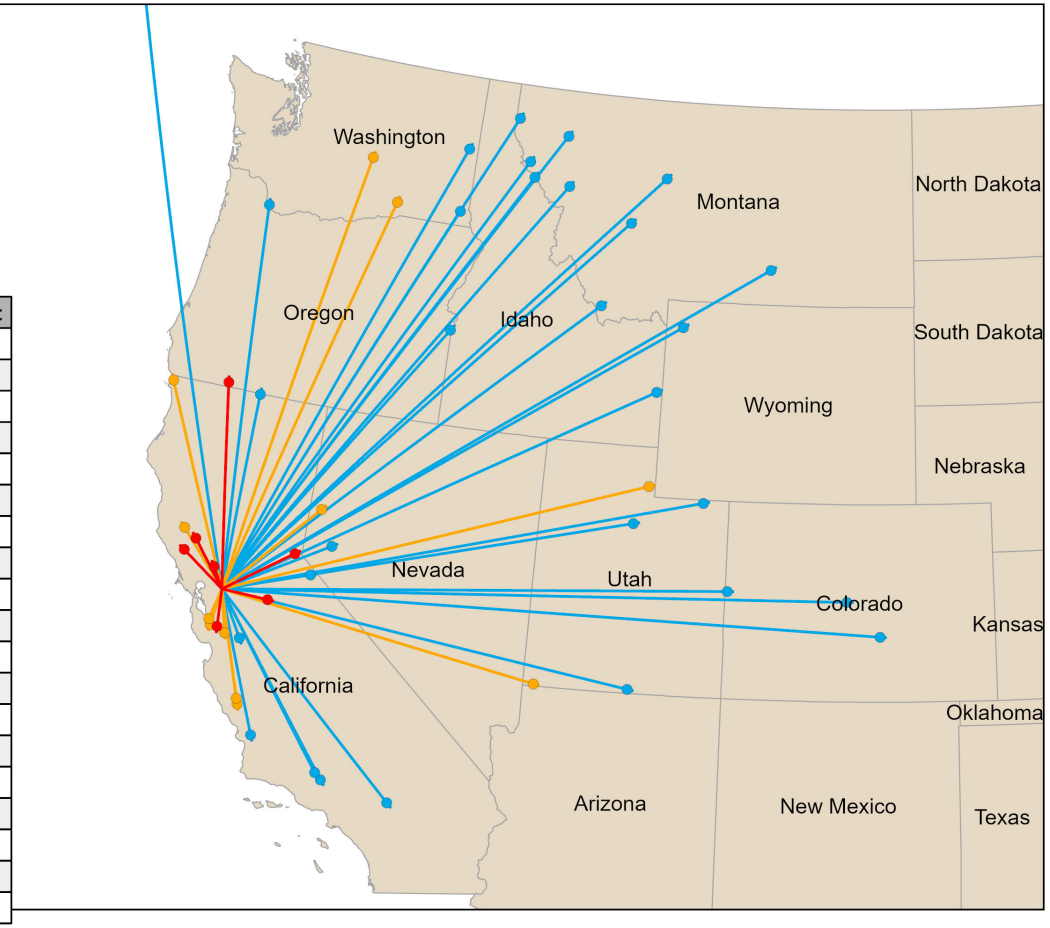




Boat Inspections Where California Delta Was Last Water Visited: 2024

Count
- 1 - 9
- 10 - 49
- 50 - 1000

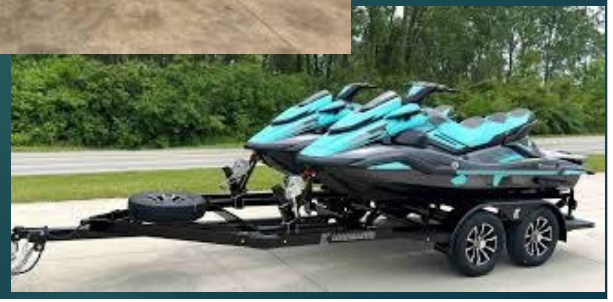
Location	State	Count
Lake Berryessa	CA	831
Lake Tahoe	CA/NV	291
New Melones Lake	CA	163
Clear Lake	CA	148
Ashland POE	OR	108
Calero Reservoir	CA	80
Lake Sonoma	CA	73
Lexington Reservoir	CA	42
Lake Nacimiento	CA	37
Evanston POE	WY	31
Cle Elum Eastbound	WA	28
Coyote Lake	CA	26
Stevens Creek Reservoir	CA	23
Pasco	WA	21
Pyramid Lake	NV	19
San Antonio Lake	CA	16
Brookings	OR	16
Lake Mendocino	CA	15
I-15 Port of Entry	UT	11



N

0 155 310 620 Miles

Map Produced by CPW ANS Program 11/8/2024



Golden Mussel Water Quality & Lifecycle

Species Comparison

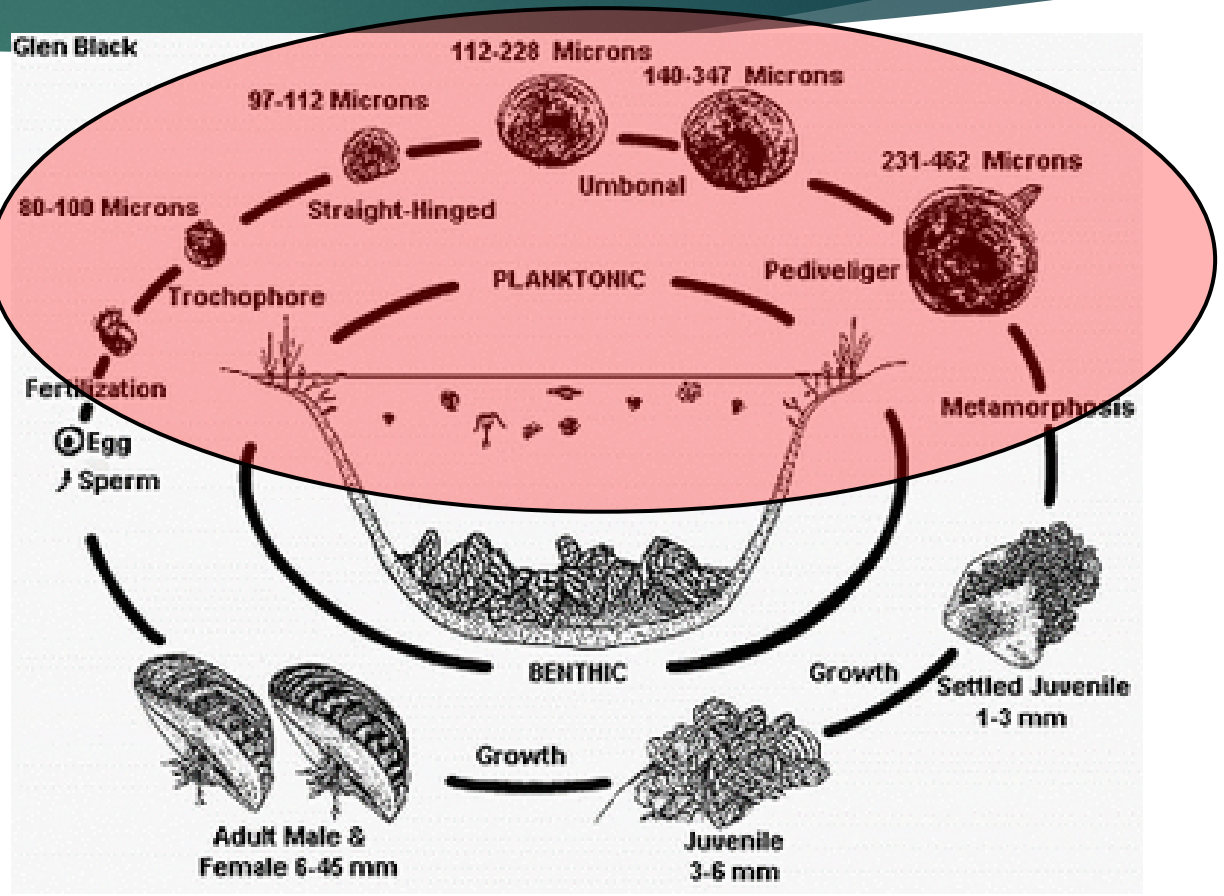
Parameter	Numeric Value		References
	Q/Z mussels	Golden mussel	
Calcium	10-25 mg/L	1–50 mg/L	Mackie and Brinsmead 2017
Salinity	≤4 ppt	0–3 ppt; up to 23 ppt w/ FW pulses	Sylvester et al. 2013
Temperature (adult survival)	1-32 °C (34-90°F)	5–35 °C (41-95°F)	Oliveira et al. 2010
Temperature (spawning)	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 (~⅓ in)	6-8 mm (~¼ to ⅓ in)	Xu et al. 2013

Table: DWR

Table 2. Ranges in values for some chemical and physical parameters of surface waters in which golden mussel have been reported in South America and Eastern Asia. Some of the temperature, salinity, and TSS data are based on laboratory experiments TSS = total suspended solids (organic + inorganic). Sorted by ascending author name. The bottom row gives a range in values that are typical for Ontario waters, taken from the Ontario Provincial Stream Water Quality Monitoring Network and the authors' unpublished data.

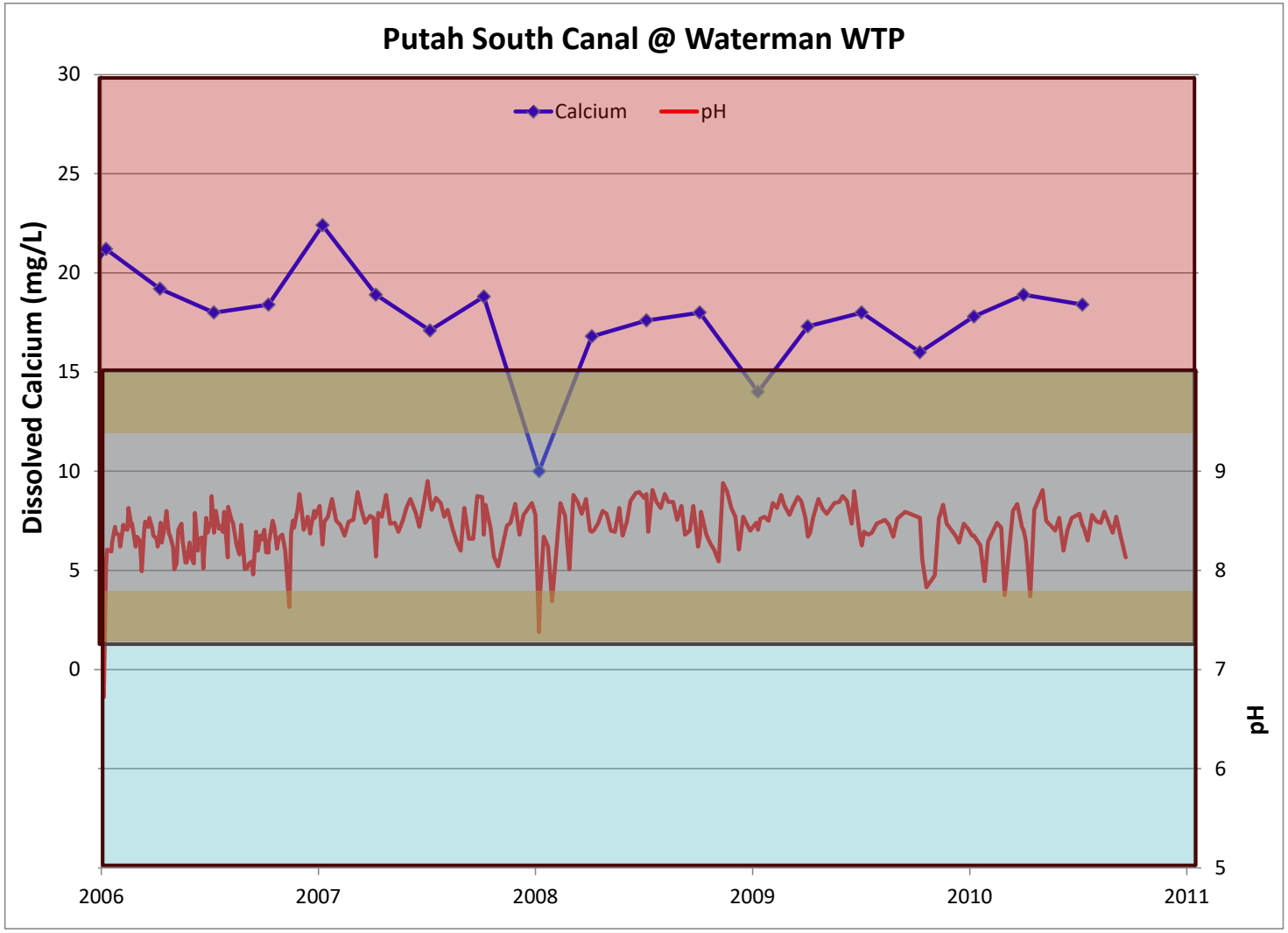
Source	pH	[Ca] $mg \cdot L^{-1}$	Dissolved Oxygen $mg \cdot L^{-1}$	Temp °C	Conductance µS/cm	Salinity ‰	Turbidity NTU Secchi depth m	TSS $mg \cdot L^{-1}$	Depth m
Boltovskoy et al. (2006)	5	2-10	0.5		60-80	14			
Cataldo and Boltovskoy (2000)	6.4-7.4		5.1-9.8	12.5-29	118-160	<5	1.4-5.5 m	17-104	
Campos et al. (2014)	5.8-7.9	1.7-23.5	5.1-10.4	18.0-30.4	14.0-58.0		0.3-7.0m		
Campos et al. (2014)	6.8-6.9	3.4-4.7	7.6-7.8	24.5-28.0	38.5-39.6		2.0-3.0m		
Darrigran (2002)	6.2-7.4	3.96		15.3-32.6		<3			
Darrigran et al. (2007, 2011)	6.2-7.0	2-46.0	6.8-7.5	26.2-29.7		0.10-0.31		66-88.0	40
Darrigran et al. (2012)	6-7.9	3-50	2.8-14	25.5-35.9	44-1470	0.05-0.86	Bed-1.5m	5-327	1-1.5
Dos Santos et al. (2008)	6.2-7.5		3.91-11.33	12-27.5	30-90		0.08-10 m	0.10-1.4	12.2
Nakano et al. (2010a,b)			<0.5-12	<5-24.5		0	0-150		~25
Nakano et al. (2011)	7.5-9.0	17.8-23.6	7.3-12.7	4.2-23.6	160-250	0	9-28		>9
Oliveira et al. (2006, 2010a)	5.0-7.8	1.0-11.6	0.2-1.3	5-31.8		<12			
Oliveira et al. (2011)	5.4-7.8	1.0-23.0	0-8.0	8.0-35.0			0.10-1.90m	20-120	
Pareschi et al. (2008)	7.3-10.0		6.8-10	19.9-33.1	44-232		3-62.4		
Sylvester et al (2013)						<2*, 23**			
Tokumon et al. (2015)								3000	
Ontario lakes	5.5-9.3	2.0-104	2.5-14	0-25.5	24-550	0	0.4-15.5m	2-85	1-406

Table: Mackie and Brinsmead (2017)



Golden Mussel Water Quality Tolerance Limits: Lake Berryessa

- Red Area represents calcium tolerances for golden mussel.
  - Range =1 – 50 mg/L.
- Blue area represents pH tolerances for golden mussels.
  - Range = pH 5 – 10.



Effects of Golden Mussels

ECOLOGICAL

REMOVE THE BOTTOM OF THE FOOD WEB & D.O. CRASHES

HUMAN HEALTH

PROMOTE HARMFUL (TOXIC) ALGAL BLOOMS

INFRASTRUCTURE

CLOG AGRICULTURAL AND URBAN WATER CONVEYANCE

RECREATION

DAMAGE BOATS/MARINAS, SHELLS ON BEACHES

Photo: Mountinho, 2021

Photo: Tom Archer

Photo: Western AIS.ORG

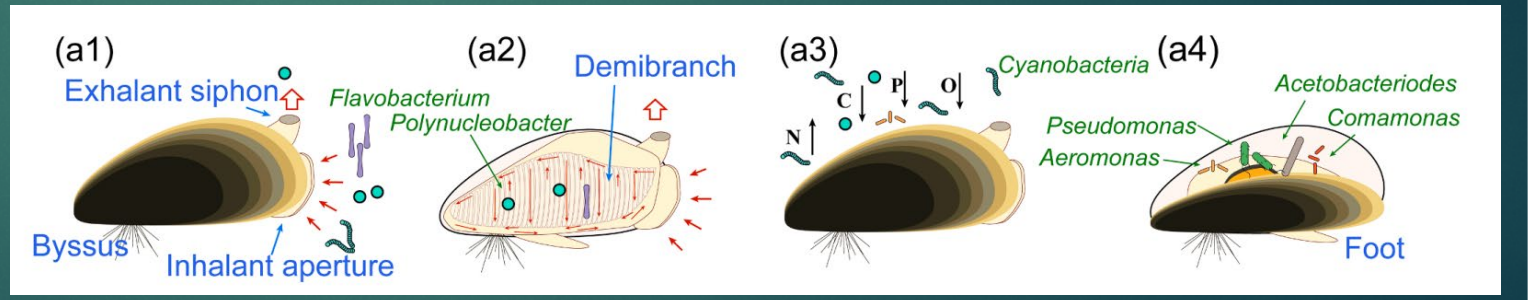


Image: Zhang 2022

Water Infrastructure Vulnerability Study (DWR)

Table 2. South Bay Pumping Plant Vulnerability Summary

Component/Structure	Vulnerability	Mitigation
Trash Racks, Grates	Partial plugging or plugged openings.	Trash rake for weed removal will help to remove large accumulations. Use divers for more thorough manual cleaning. Anti-fouling coatings will help extend time between cleaning.
Gates, Stop Logs	Leakage from trapped shells. Increased wear on seals.	Cycle gates to flush gate tracks.
Intake Tube	Increased hydraulic friction losses.	Manual cleaning when friction creates unacceptable losses of power or flow.
Small Pipes and Tubes for Pressure or Level Sensing	Can plug quickly resulting in inaccurate readings.	Manual cleaning or hot water flush.
Air Vents in Discharge Piping	Slow draining or pressure balancing. Leaking air release valves.	Check operation when vents are needed and clean as necessary.
Service Water	Impaired performance of equipment	Filtered to 200 microns with 40 micron filters on standby until mussels arrive. None required.
Unit Cooling Water Systems	Impaired performance of equipment. Stage 1 and 2 only	Keep mussels out of system or deal with individual equipment as described below.
Unit Cooling Water Pumps	Pump seals may see minor increase in wear. Motors are not vulnerable.	None required
Strainers (Wye, Duplex), Filters	Increased plugging.	Manual cleaning or install strainers with backwash capability.
Valves	Increased leakage especially air vent valves.	Manual cleaning.
Cooler Manifolds	Plugged with shells.	Manual cleaning.
Cooler Tubes and Plate Style Heat Exchangers	Plugged with shells.	Isolate cooler and lance tubes, dissolve shells with organic acid. Plate style coolers need to be disassembled for cleaning.
Pump Shaft Seal	Reduced cooling water flow: increased sleeve wear.	None required. Gland is supplied with filtered water.
Fire Water System	Uses system filters.	None required but consider corrosion inhibitors in the filter cavity
Sumps, Pump Intake Screens	Floats measure incorrect level. Plugged screens cause cavitation.	Manual cleaning.

TABLE: DWR

PHOTO: DWR

PHOTO: RNT CONSULTING

Lake Berryessa Seal Program

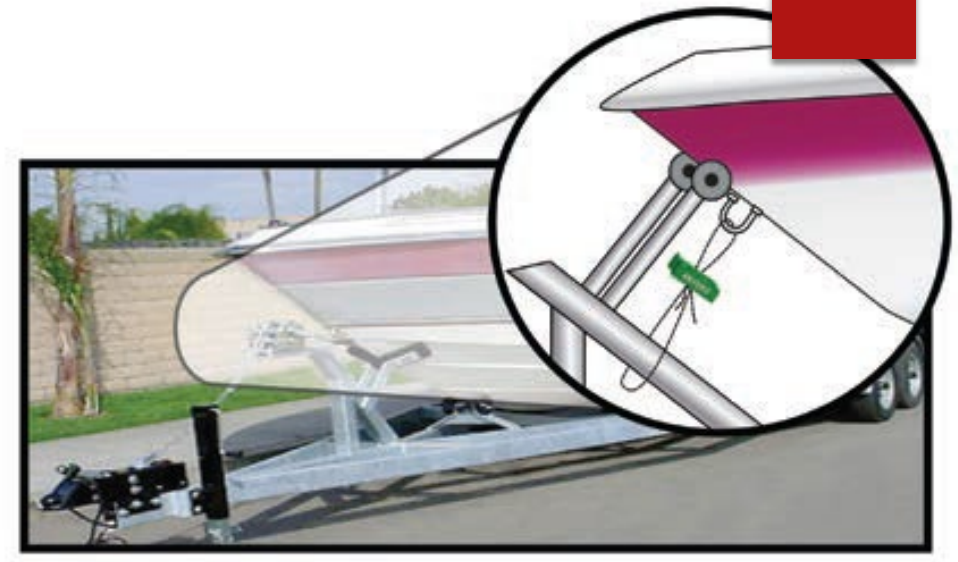
Any vessel wishing to launch must be inspected, logged into the WID system and a RED quarantine seal shall be applied for 30 days, and the vessel will not be permitted to launch at that time. The seal must remain intact, and the vessel will not have been launched in any other waterbody during the quarantine period.

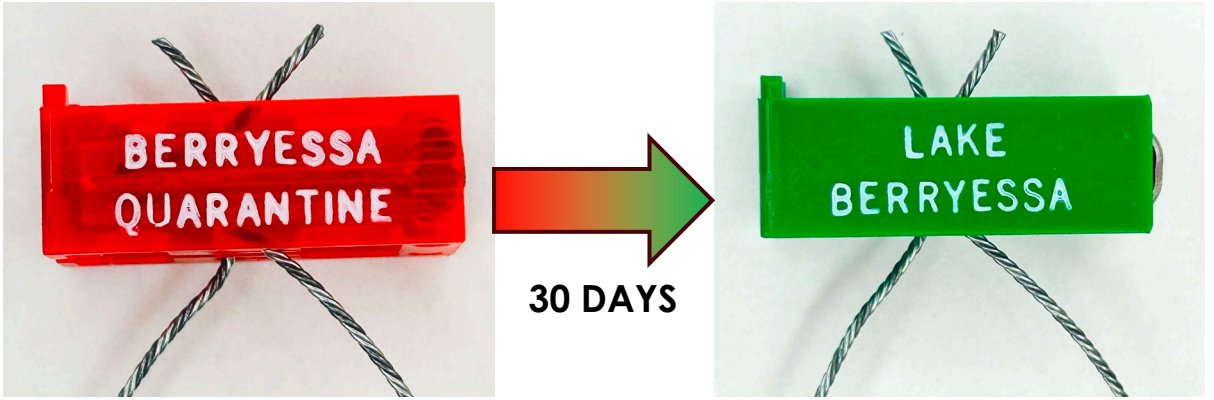
Vessels that have finished the 30-day quarantine may return to the lake and have the seal removed by authorized staff (e.g. SCWA, USBR, or Concessionaire) and will be allowed to launch.

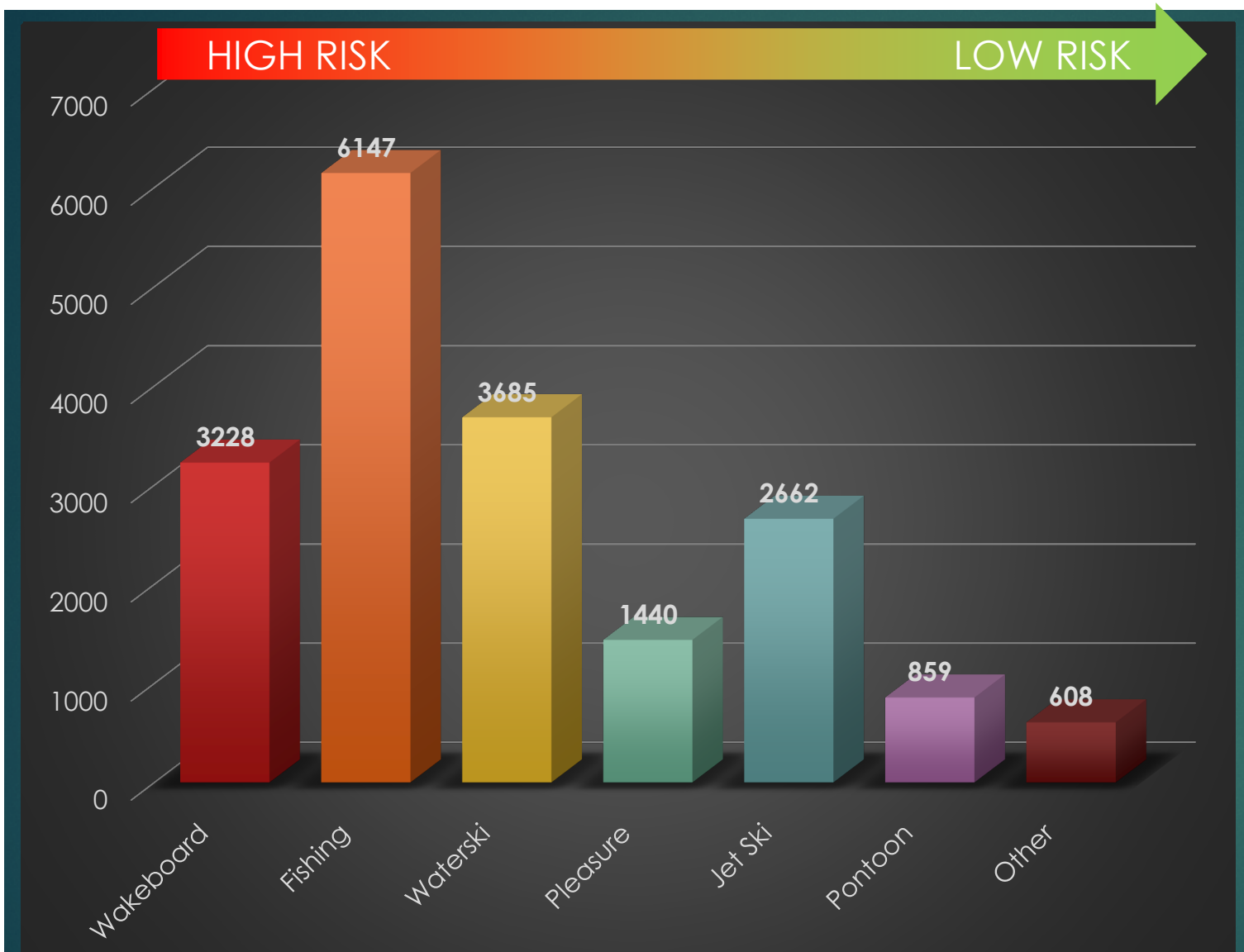
Any vessel wishing to launch sooner than the required 30-day quarantine period must have a hot-water decontamination performed by an approved entity. These vessels are allowed to launch immediately following decontamination.

Upon exit from the Lake, all vessels must have a GREEN seal attached by authorized staff to be allowed to freely launch at Lake Berryessa. Otherwise, the vessel will need to undergo another quarantine period or decontamination

Hand launched watercraft with electric motors like fishing kayaks, require an inspection prior to launch. Non-motorized watercraft, such as kayaks and paddleboards, are not subject to inspection, are encouraged to be inspected for free at any watercraft inspection station, or if you are instructed to do so by trained staff at popular launch locations





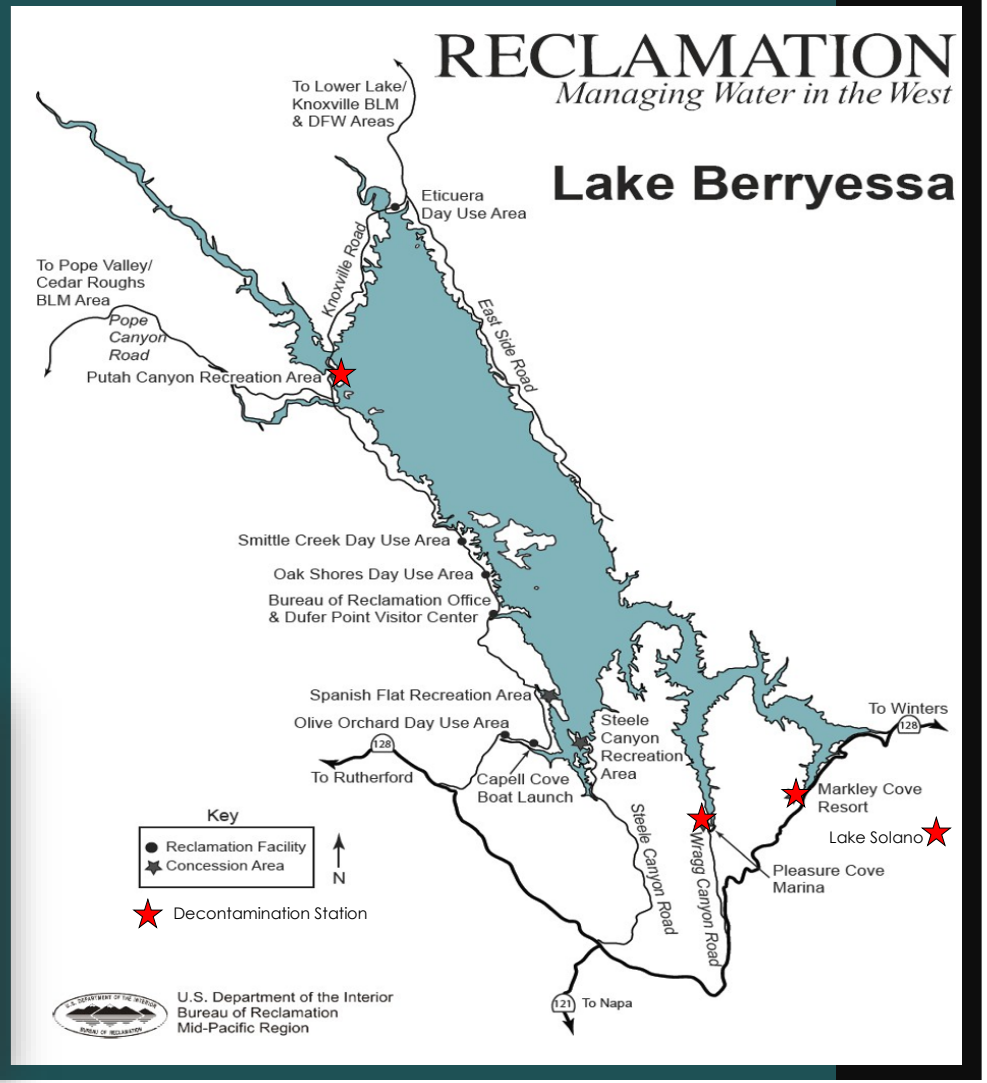


Types of Watercraft Inspected

Category	Watercraft Type	Risk Level
Very Complex	House Boats, Cabin Cruisers, Ski Boats, and Wakeboard Boats with Ballast Tanks	Very High Biological Risk
Complex	Large Open Boats, Sailboats, Ski Boats, Wakeboard Boats with no ballast tanks, and Personal Watercraft (PWC)	High Biological Risk
Simple	Open Hull, Single Motors, No Interior Containers or Compartments	Medium Biological Risk
Non-motorized, Hand-launched	Canoe, Kayak, Windsurfer Board, Sail Board, Belly Boats, Rafts, Float Tubes, Inner Tubes, Foldable Plastic Boat, Standup Paddleboard, and Rowing Shell	Low Biological Risk

Lake Berryessa Decontamination Program

- Can forego the 30-day quarantine
- Assume every boat has been in the delta
- Flush all suspect components of watercraft with hot water
- Fee structure effective April 7th
- Decontamination stations at:
  - Markley Cove Marina (USBR Concession)
  - Pleasure Cove Marina (USBR Concession)
  - Putah Creek Campground (USBR Concession)
  - Lake Solano County Park (SCWA Staff)
  - Currently looking for 3rd party partners



Other Regional Waters
Why isn't everyone on the same page!?

Lake Hennessey (Napa) Closed	Camanche Res. (EBMUD) Closed	Pardee Reservoir (EBMUD) Closed	Scott's Flat Lake (NID) Closed
Rollins Lake (NID) Closed	New Melones Reservoir (USBR) Seal Program	Lake Tulloch (Oakdale and SSJ Irrigation Districts) Closed	Folsom Lake (Multiple Agencies) TBD

San Justo Reservoir boat ramp on 10/10/2010. Photo by Ken W. Davis

San Justo Reservoir Hollister, CA

Thank you!
Questions?