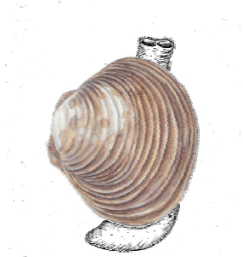
The Asian clam (*Corbicula fluminea*) invasion in Lake Tahoe: The ecology and management of an invasive bivalve in an oligotrophic lake

Presentation to the Interagency Ecological Program Workshop:
May 26, 2010



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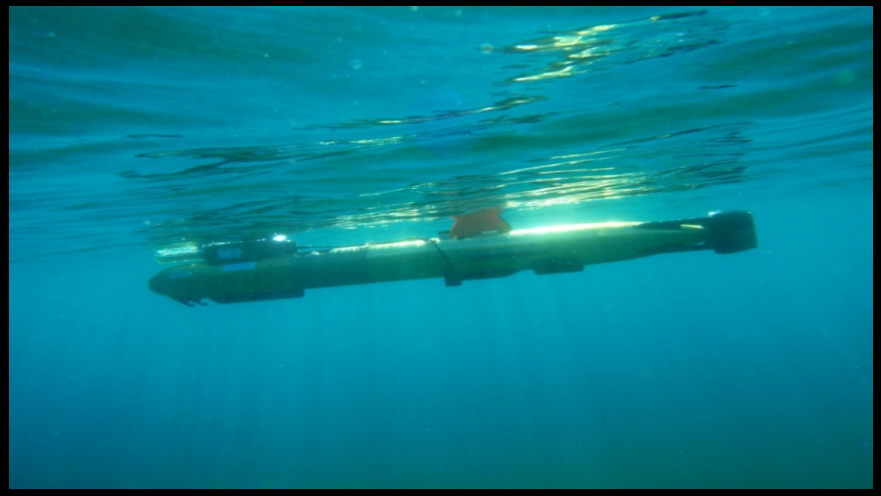
Aquatic Ecosystems Analysis Laboratory
University of Nevada, Reno

Asian clam populations are currently restricted to S/E shore

- Patchy, continuous from Cave Rock to East Tahoe Keys channel
- A few satellite populations (Emerald Bay, Cave Rock, Glenbrook)
- Found at variable depth (~2 to 70 m)



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C. fluminea densities (clams/m^2) in different systems

System	Mean	Max	Citation
River Minho Estuary, Portugal (tidal freshwater)	1320	2152	Sousa et al. 2008
Lake Constance, Germany (large, sub-alpine oligotrophic lake)	~2000	3520	Werner and Mortl 2003, Werner and Rothhaupt 2007
Lake Arlington, Texas USA (artificial reservoir)	32	95	Aldridge and McMahon 1978
Sacramento-San Joaquin Delta River system, CA-USA (highly managed with agricultural returns)	33	201	Brown et al. 2007
Goose Creek, Virginia USA (4th order stream)	1372		Hakenkamp and Palmer 1999
Altamaha River, Georgia	2480	>10,000	Sickel 1977
Lake Tahoe, CA-NV (large, pre-alpine oligotrophic lake)	2000	6130	

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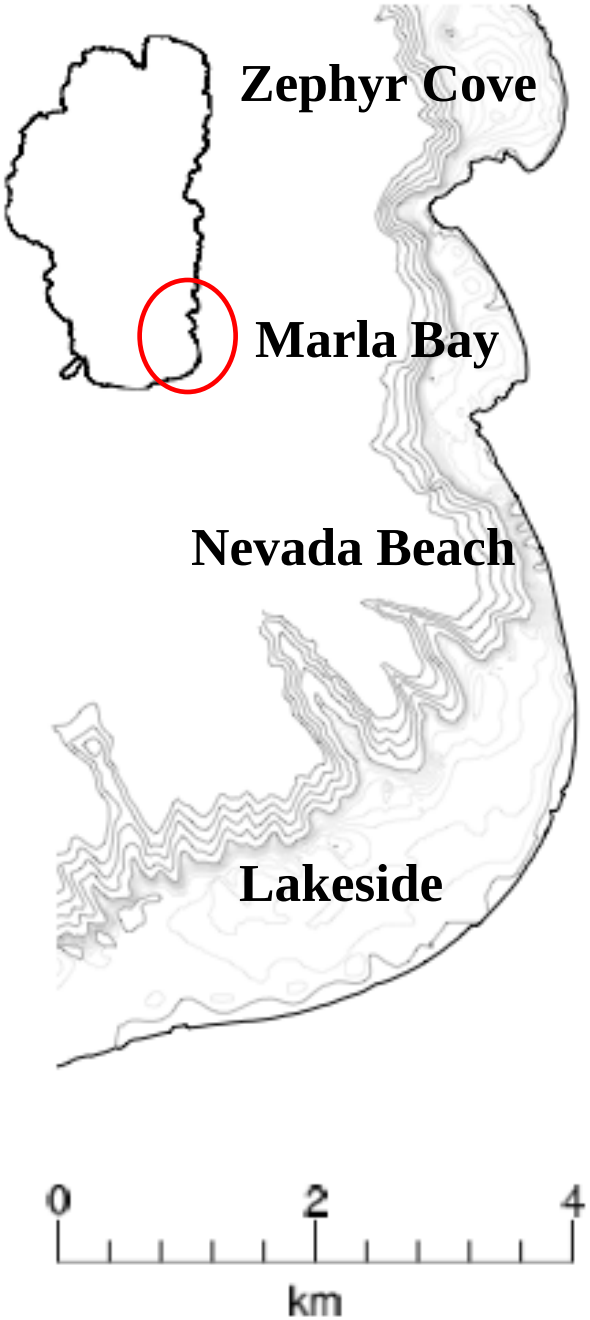
C. fluminea is altering Lake Tahoe's littoral zone

- Sediment porewater chemistry changes
- Filamentous algal blooms (*C. glomerata*, *Spirogyra sp.*, *Zygnema sp.*)
- Native benthic macroinvertebrates (biodiversity decreases)
- Aesthetic values



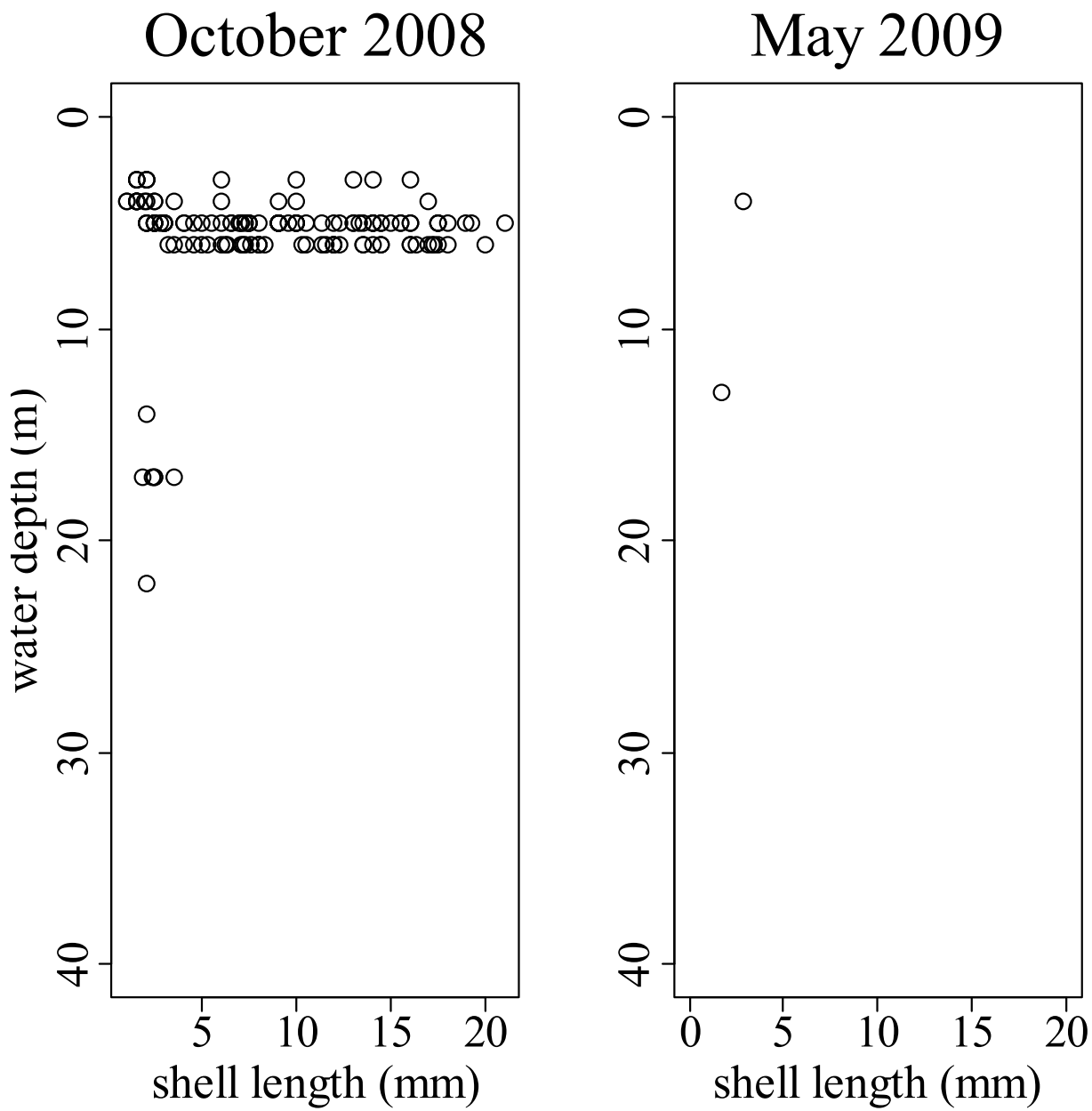
What *C. fluminea* means to Lake Tahoe's nearshore

- Distribution
- Reproduction
- Growth rates
- Mortality rates

Population dynamics

- What drives/limits population expansion?
- Are life history strategies unique in Lake Tahoe?
- How can climate change impact the invasion?
- Do clam populations impact native biodiversity? Algal blooms? Sediment chemistry?
- Is management possible?

Zephyr Cove: *C. fluminea* populations are patchy in space and time



None in October 2009!!

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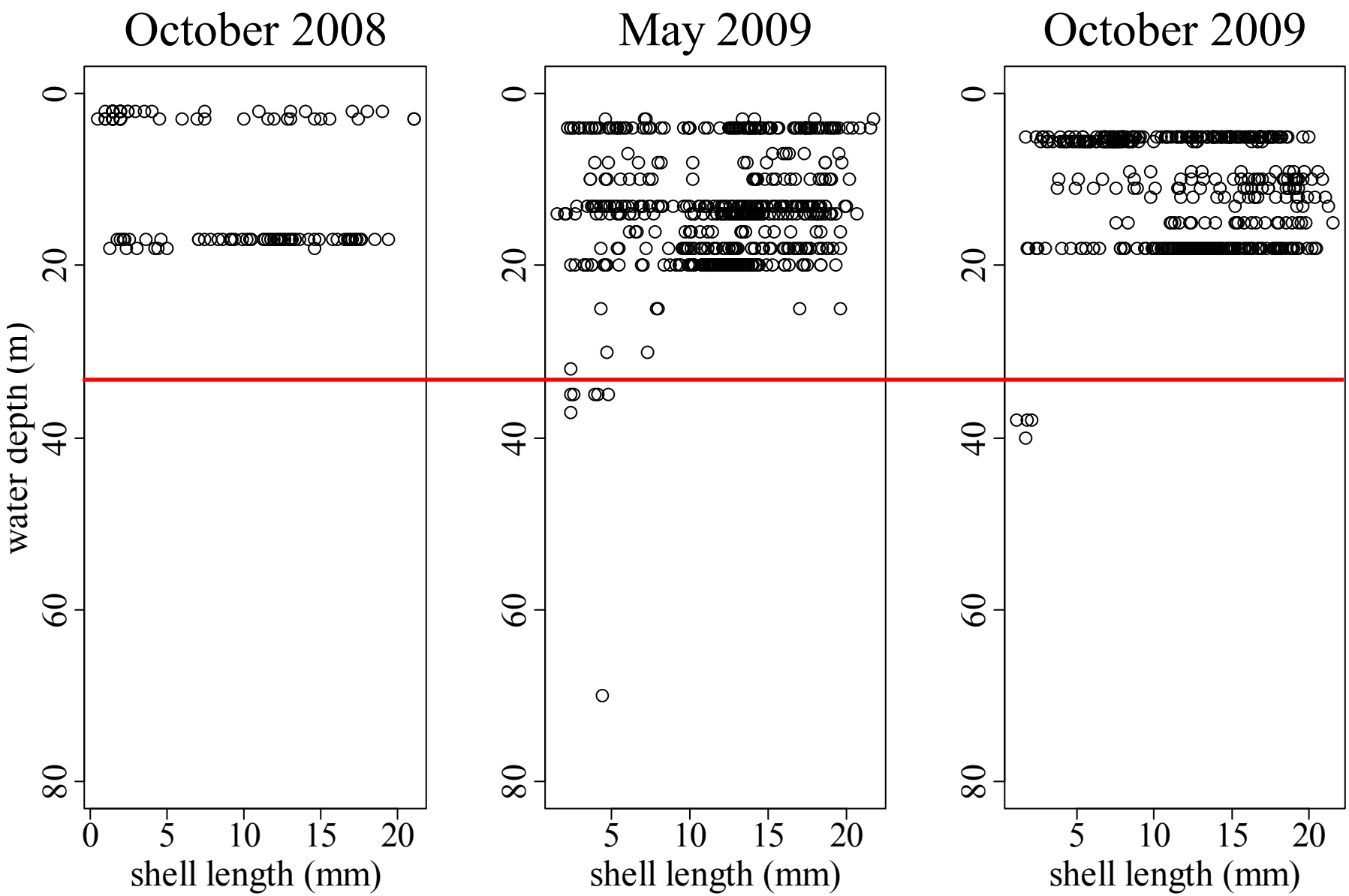
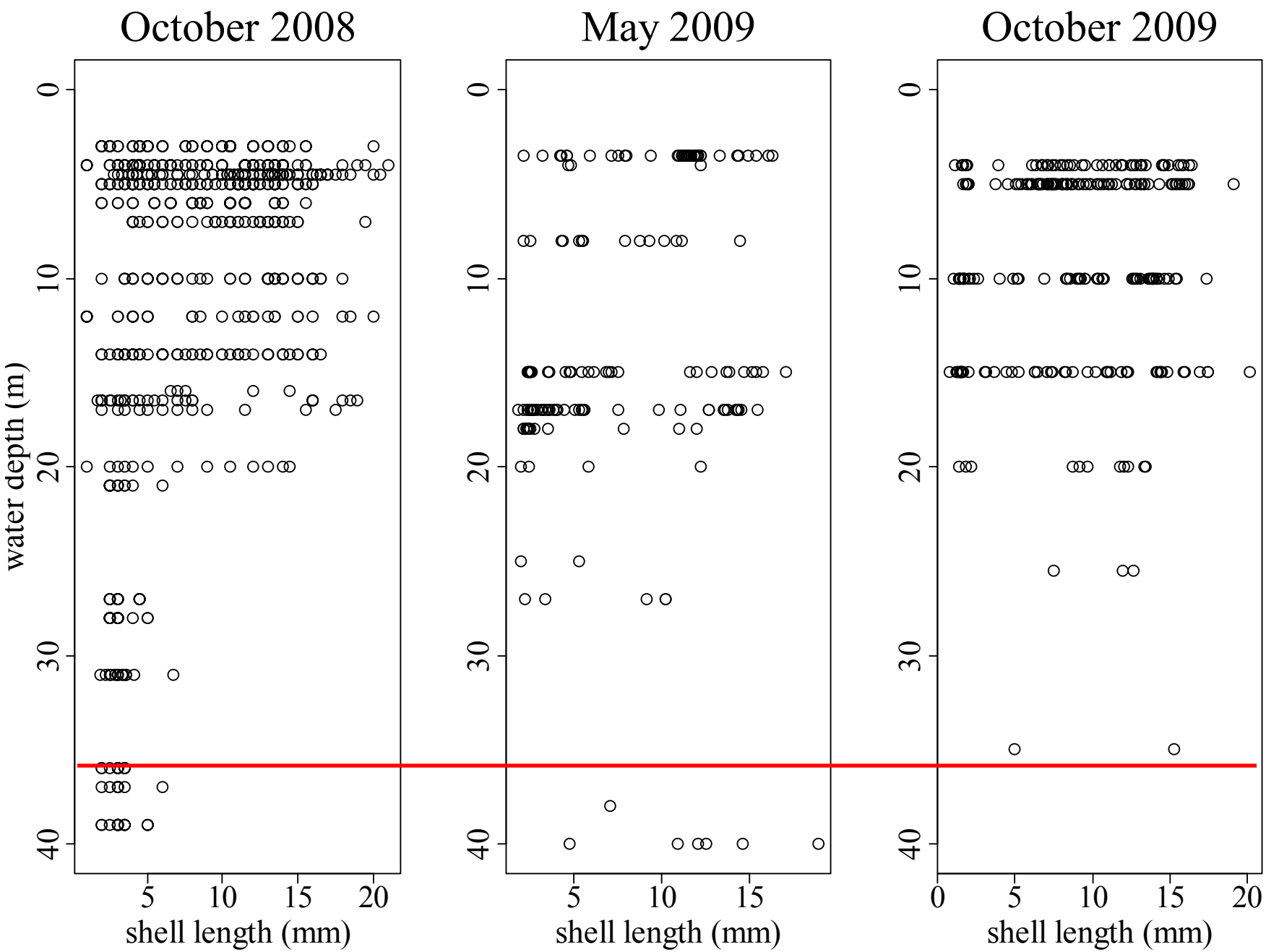
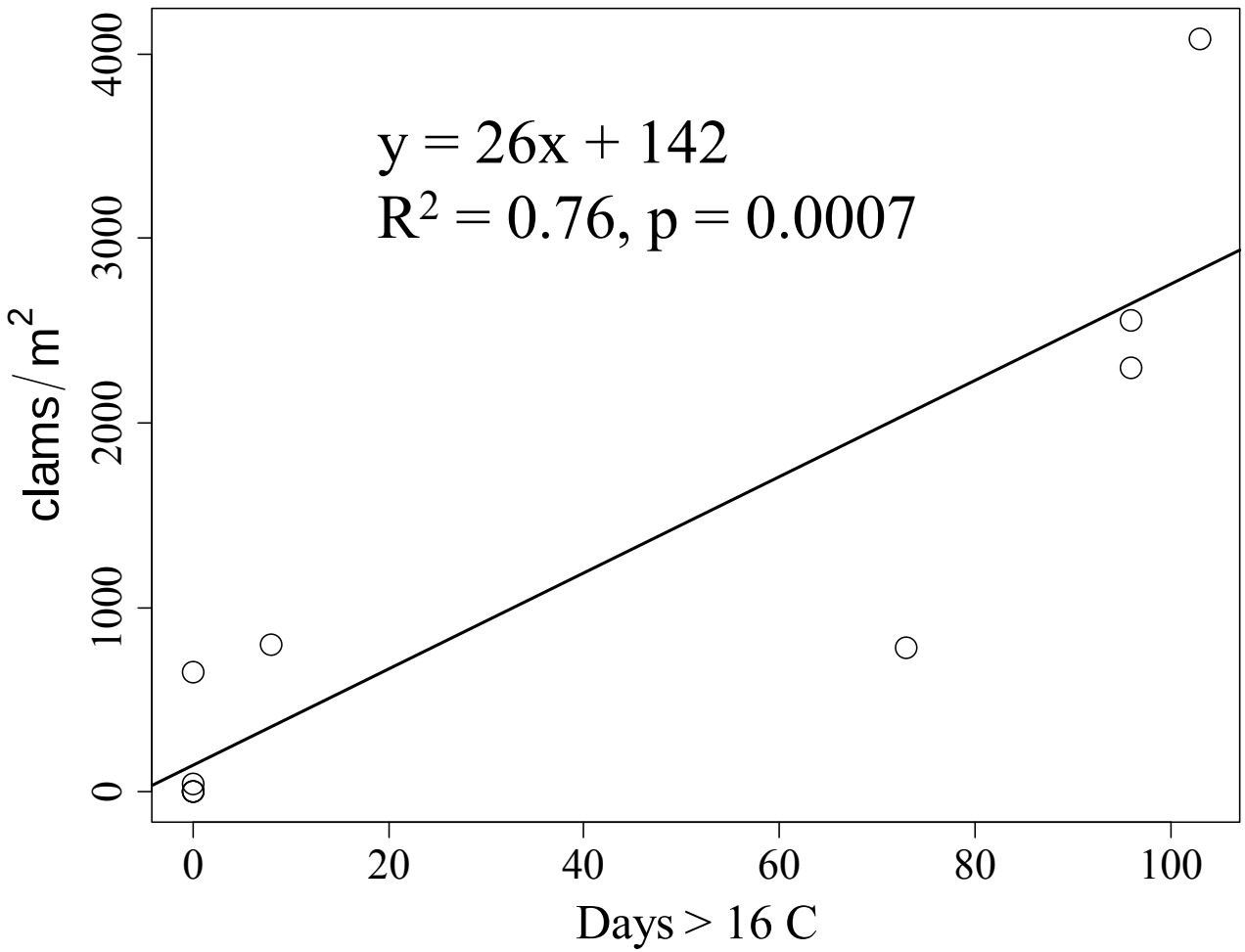
C. fluminea abundances focused at 5 , 20 m water depth at **Nevada Beach**

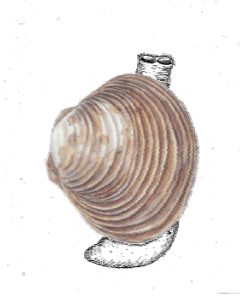


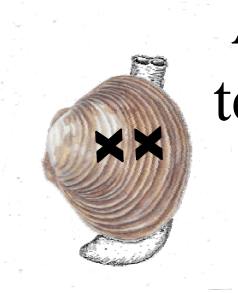
C. fluminea are widely distributed in **Marla Bay**



C. fluminea densities are dependent on the number of days ≥ 16 °C



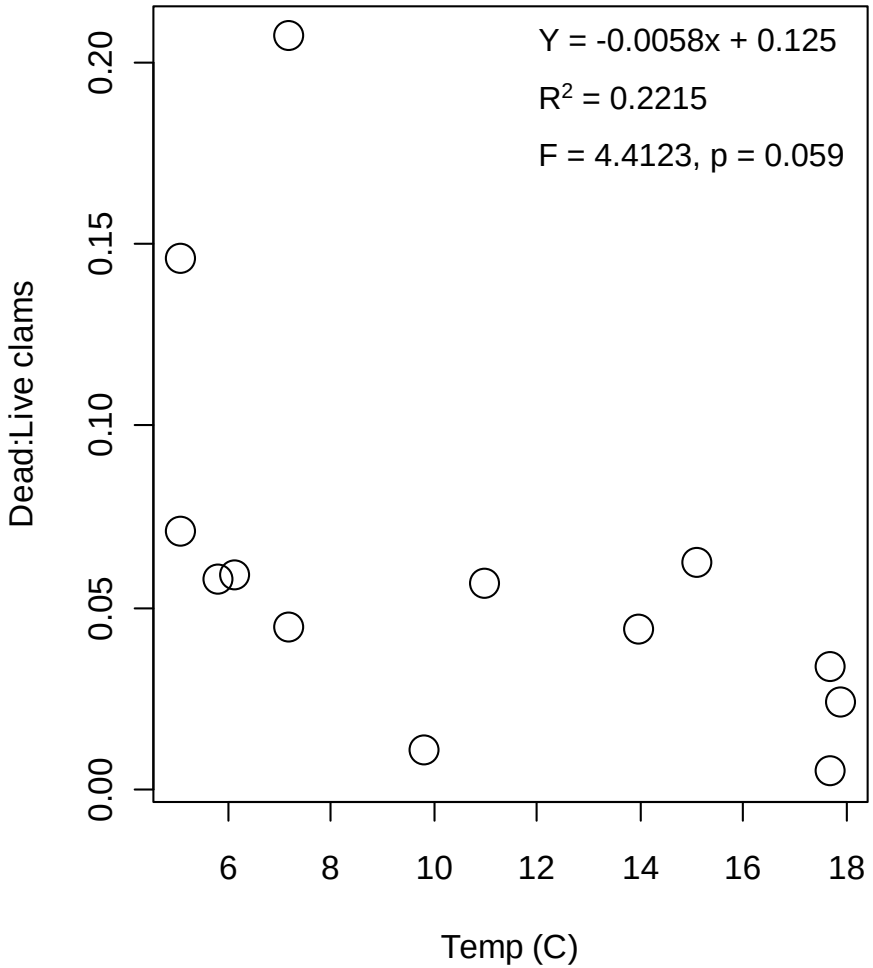


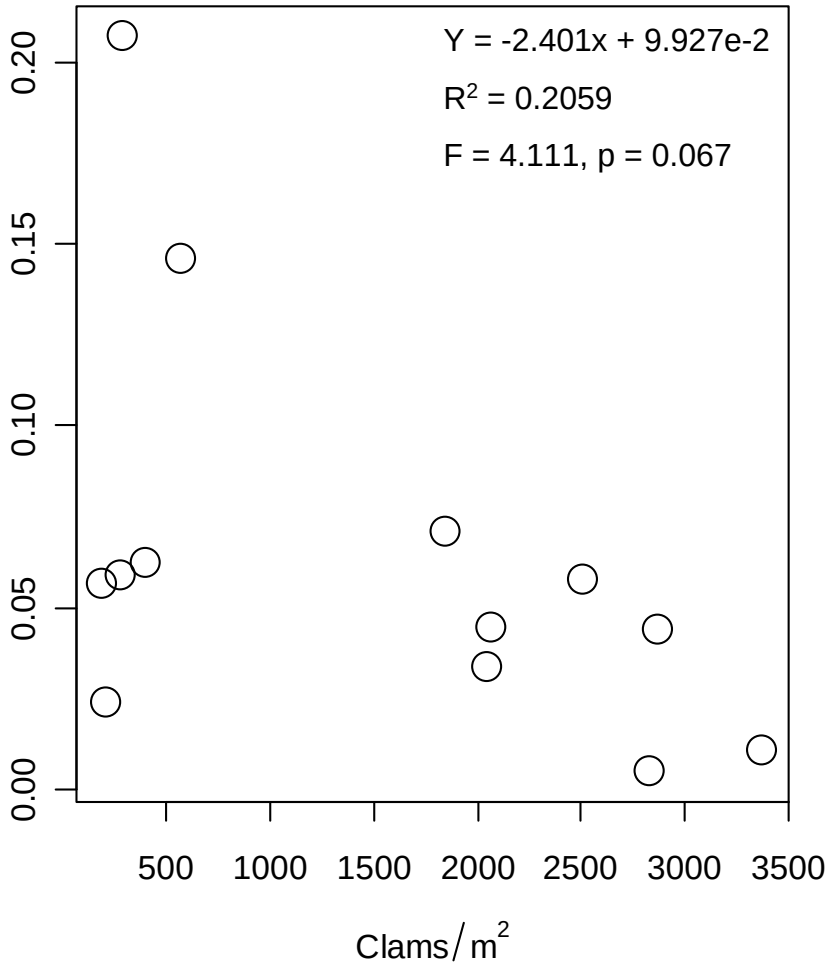


Asian clam experience increased **mortality rates** during low temperature periods, not showing signs of density dependence

Mortality Rate ~ temp + density

$R^2 = 0.41$, $F = 5.317$, $p = 0.029$, AIC = -76





There have been efforts to experiment with management of *C. fluminea* in Lake Tahoe: **Diver-assisted suction removal** and the application of **bottom barriers**

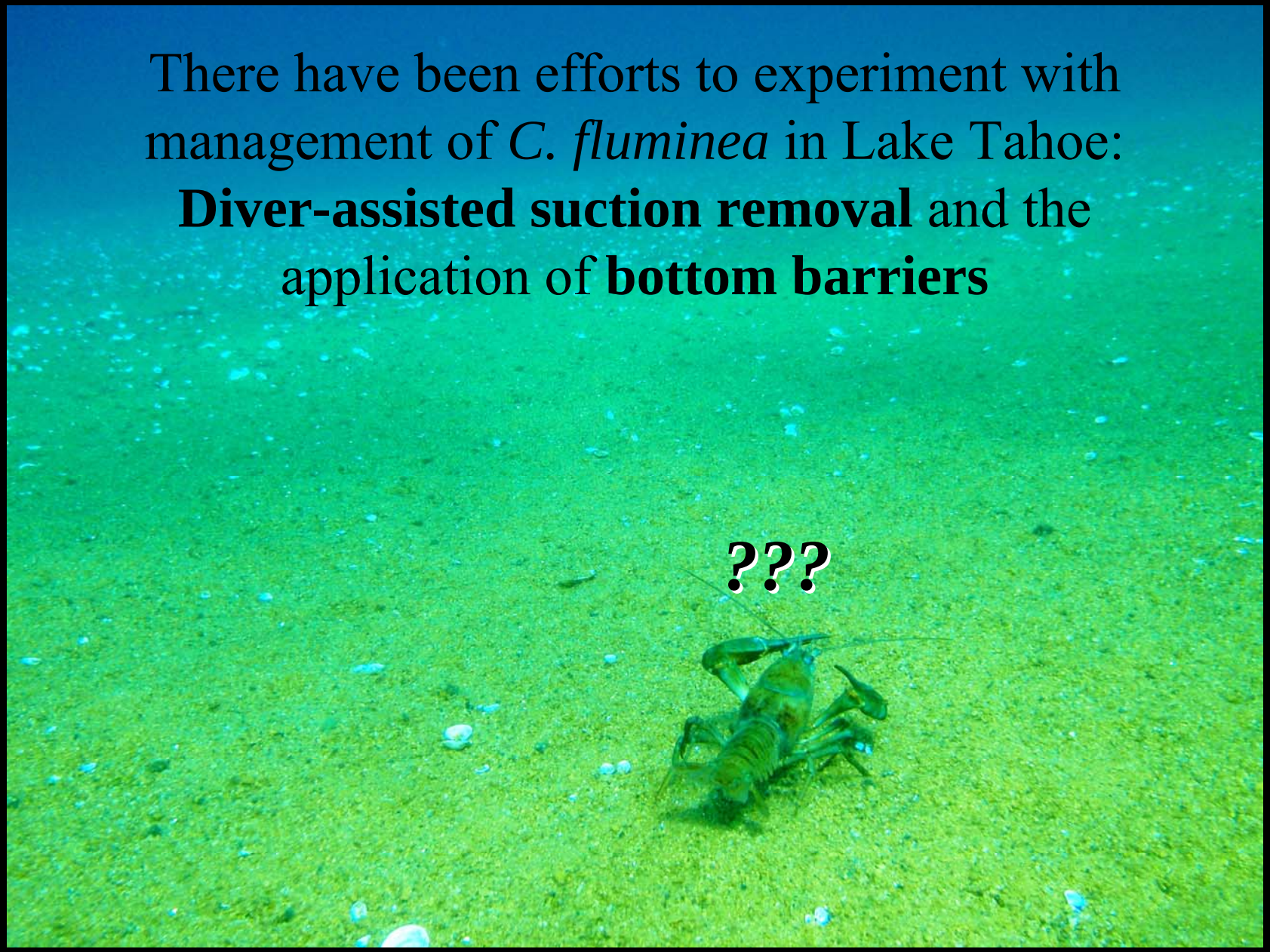


Photo: Brant Allen

Non chemical control experimentation

	Diver assisted suction removal	Bottom barriers
Mechanism	Removing clams from substrate	Reducing dissolved oxygen concentrations to induce mortality
Period of application	Any time during year	Warmer temperatures accelerate time to mortality
Frequency of re-application	*Dependant on recolonization rates and costs. Pilot studies currently underway*	
Ecological costs	Removes native species, alters benthic habitat, short term impacts to water chemistry, sediment resuspension	Impacts to native species, alters benthic habitat, sediment chemistry
Economic costs	Professional divers, barge and equipment, substrate disposal	Professional divers, bottom barrier material, barge and equipment
Benefits	Non-chemical option, removes a bulk of the population	Non-chemical option, reduces populations without having to remove materials from lake

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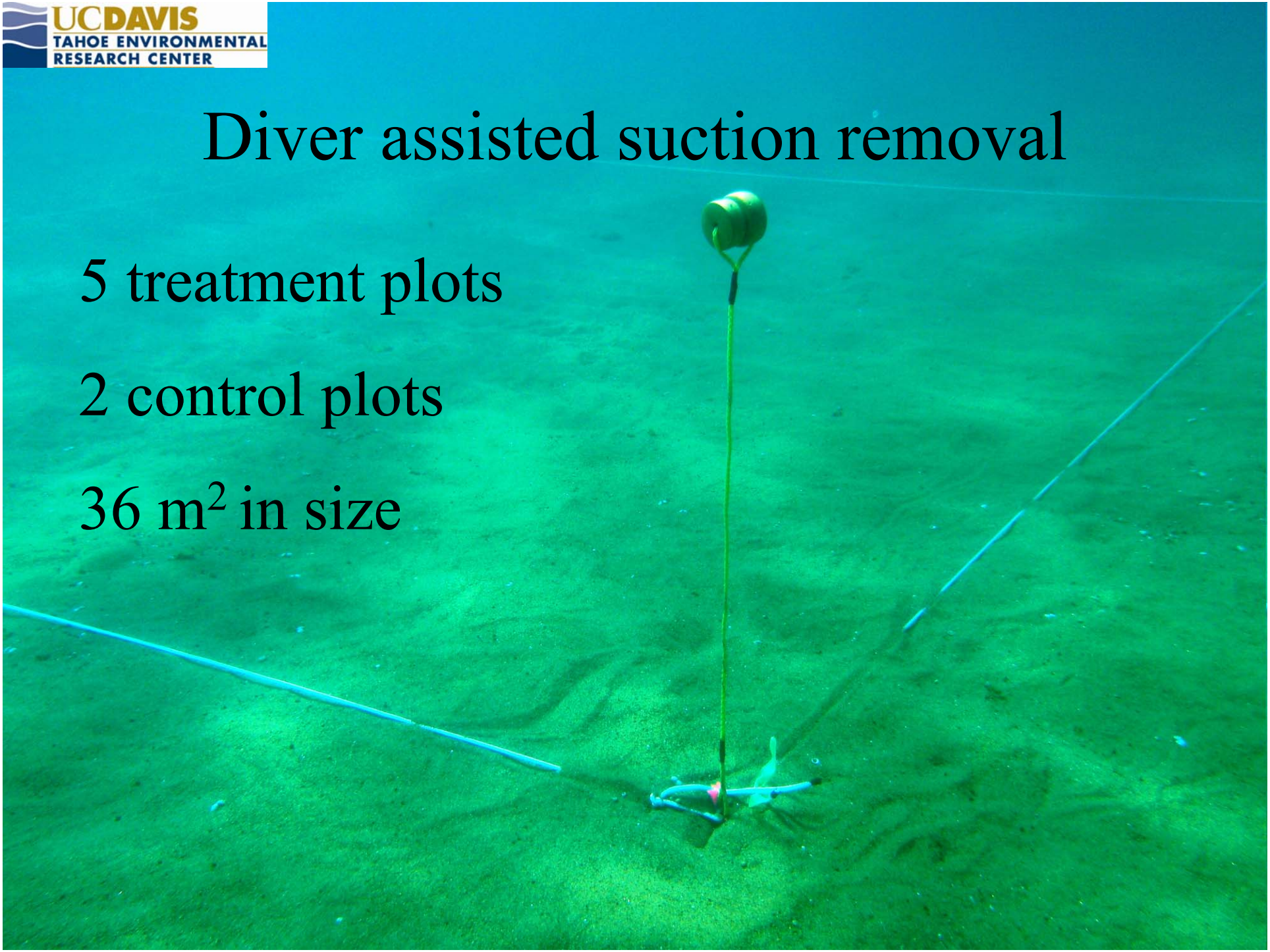
Diver assisted suction removal

5 treatment plots

2 control plots

36 m^2 in size



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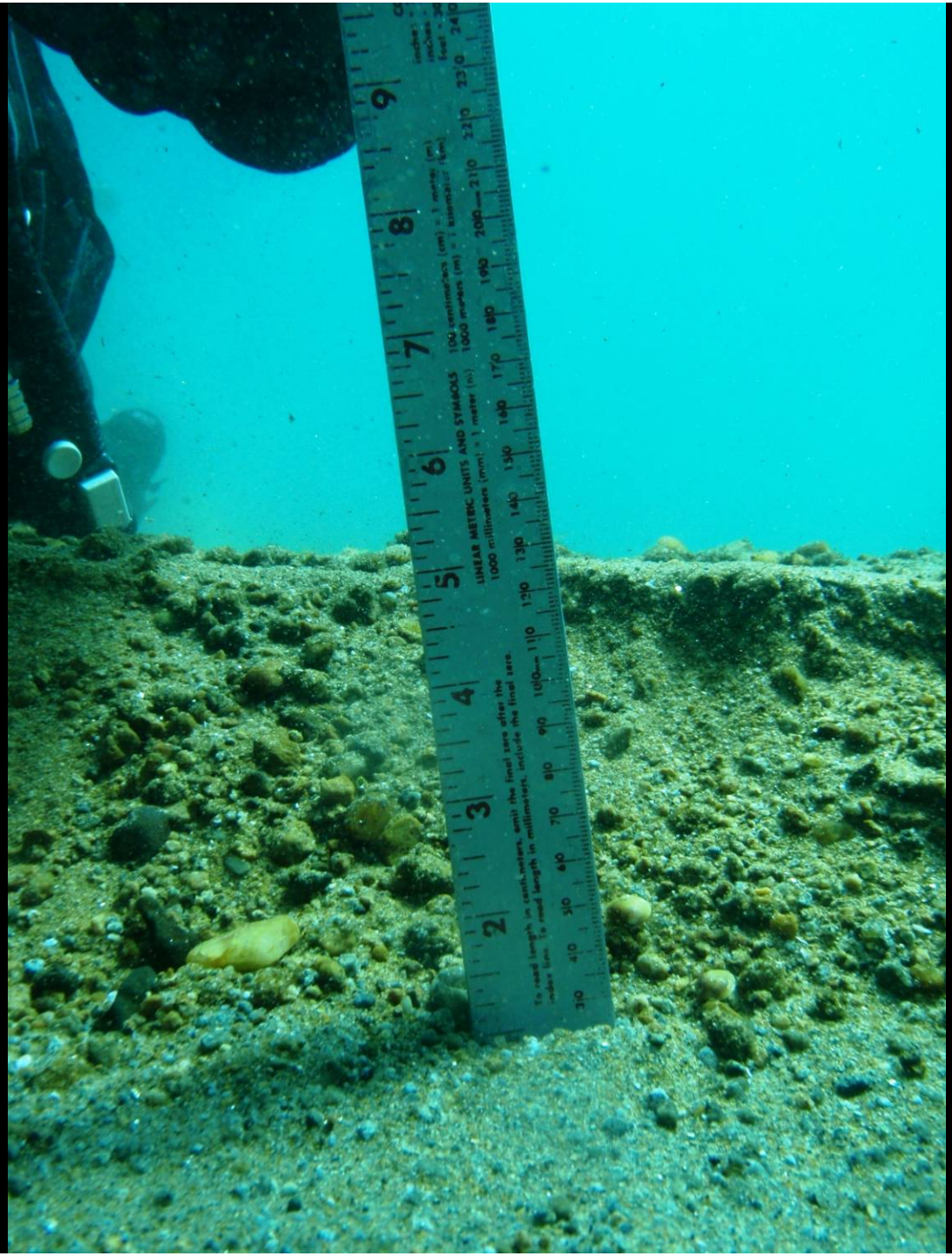
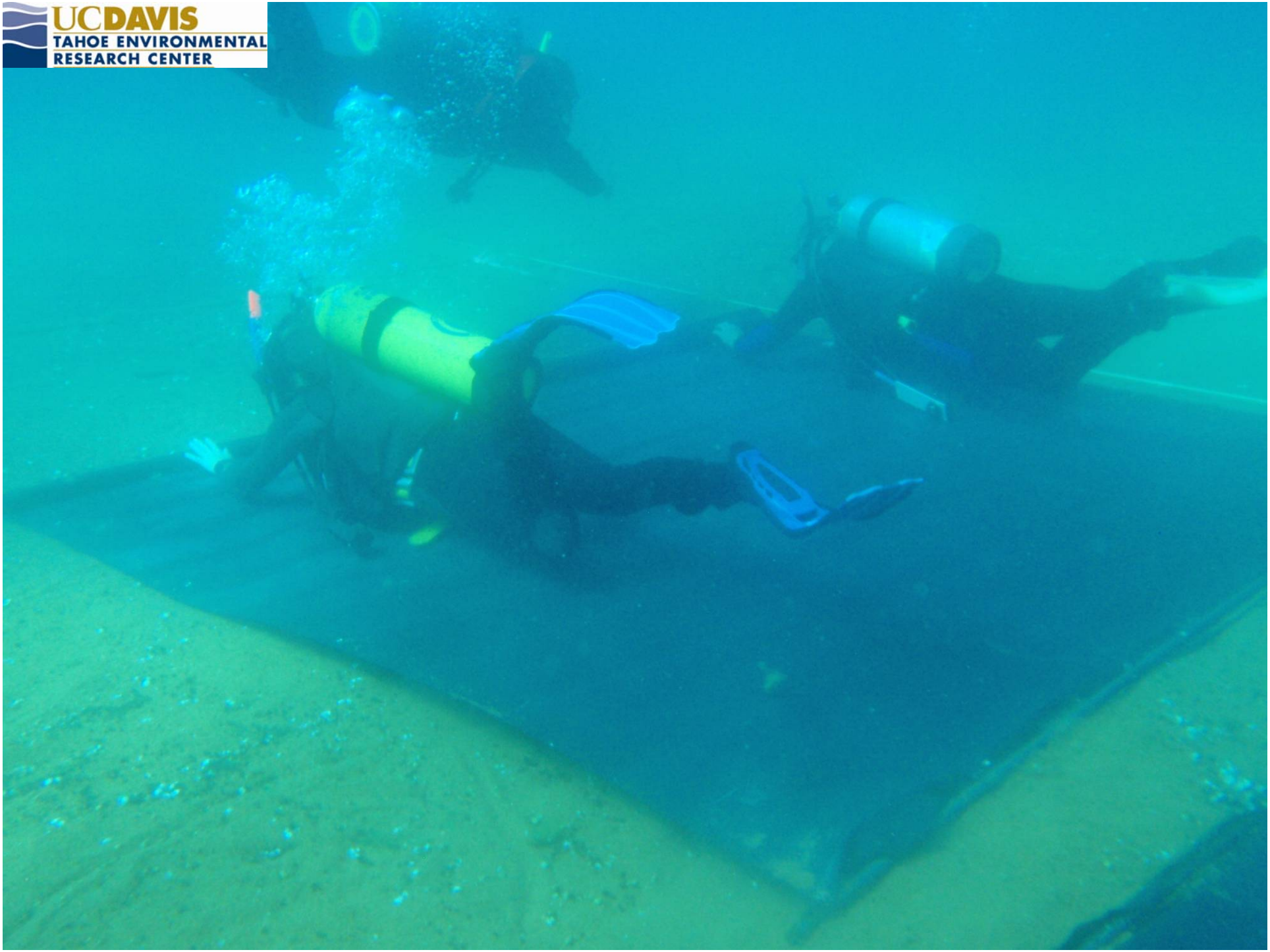


Bottom barrier application

- Rubber EPDM pond liner
- High density, lightweight material
- 12 plots in two locations, 9 m^2 area each
- Deployed from Aug 5 – Sept 30 2009
- Average water temperature 18.01°C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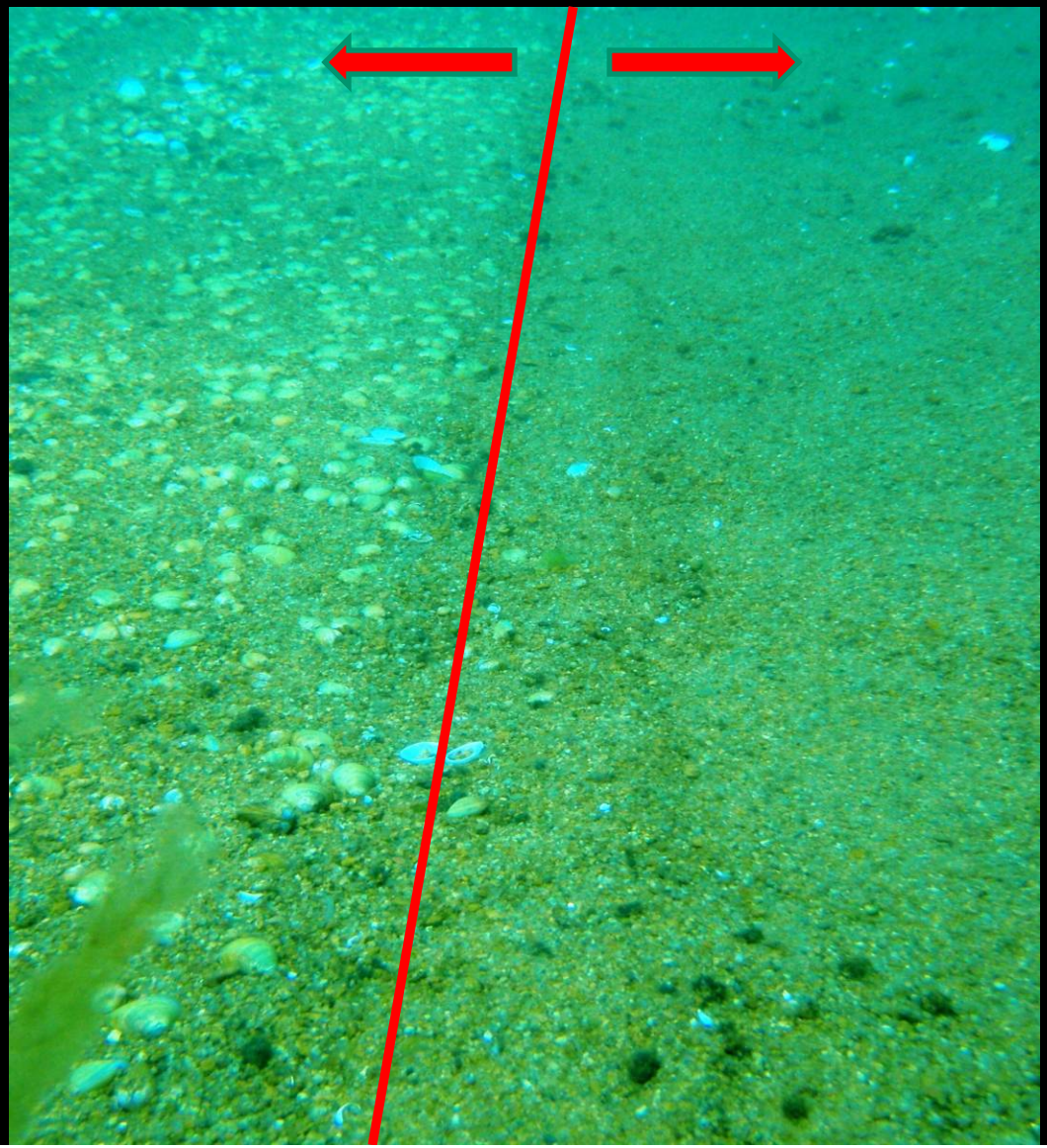
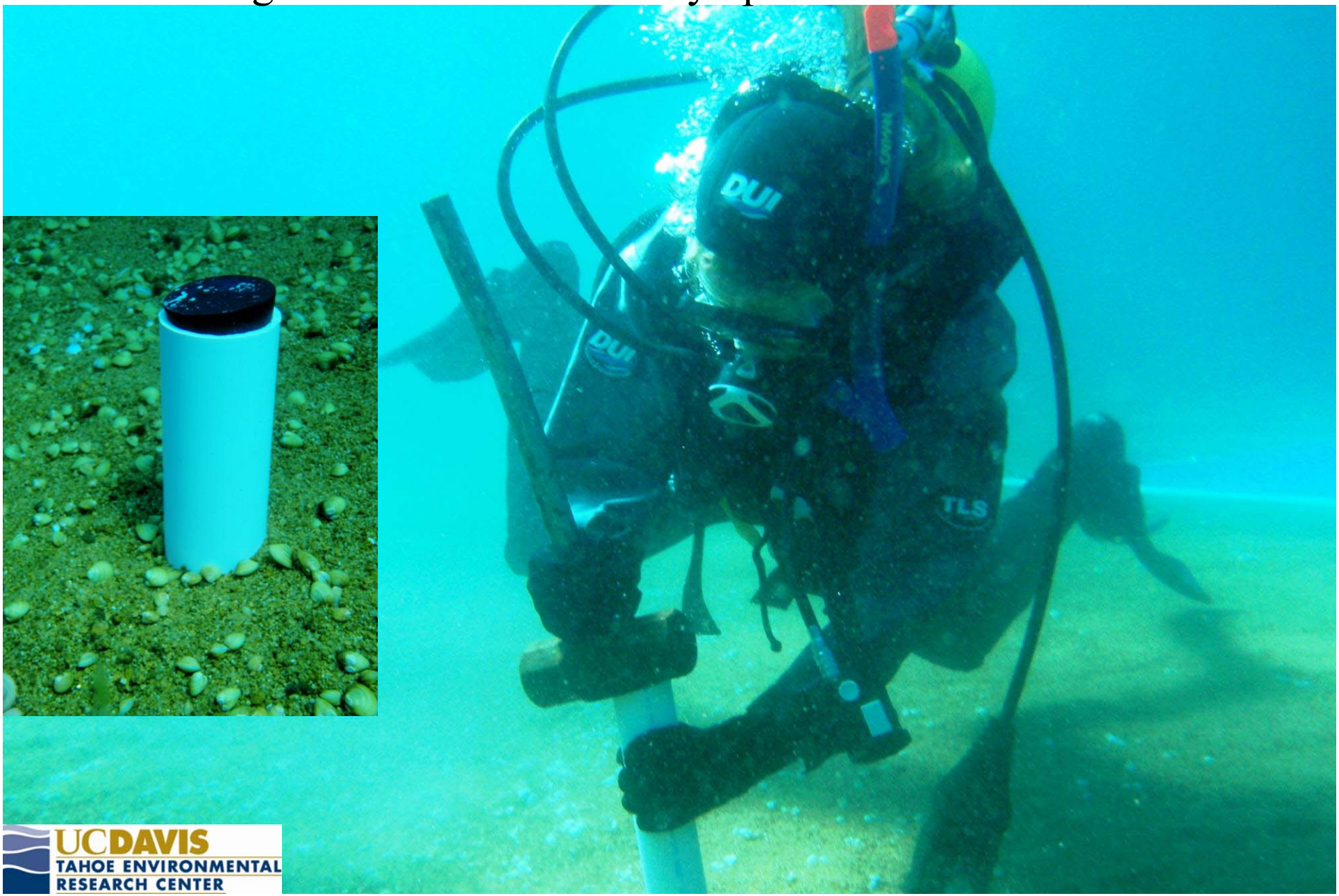
C. fluminea responds to anoxia induced stress by migrating to the top of the sediment column

Treatment



Non-Treatment

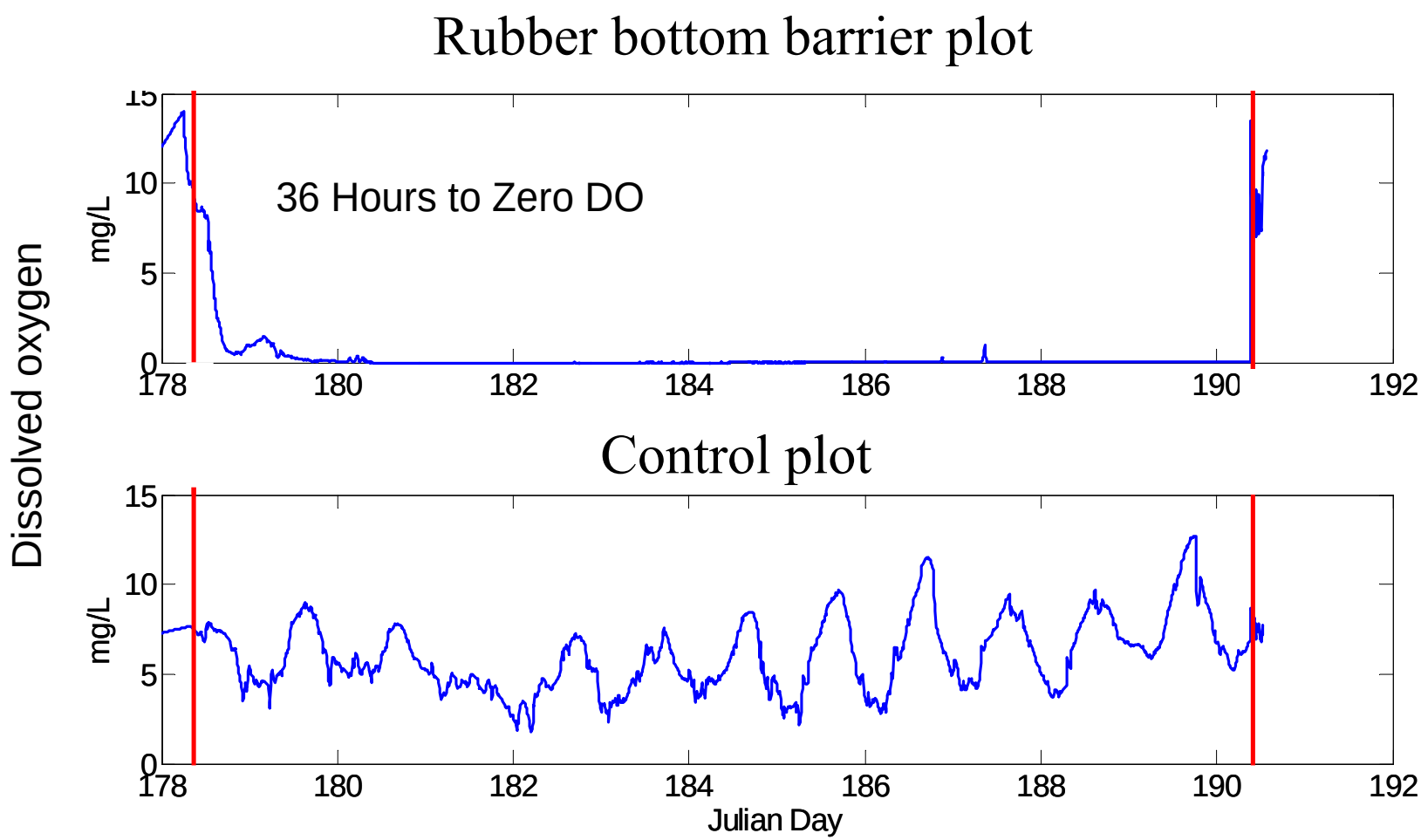
Bottom barrier plots are sampled for *C. fluminea* presence and mortality using hand cores immediately upon removal of barriers



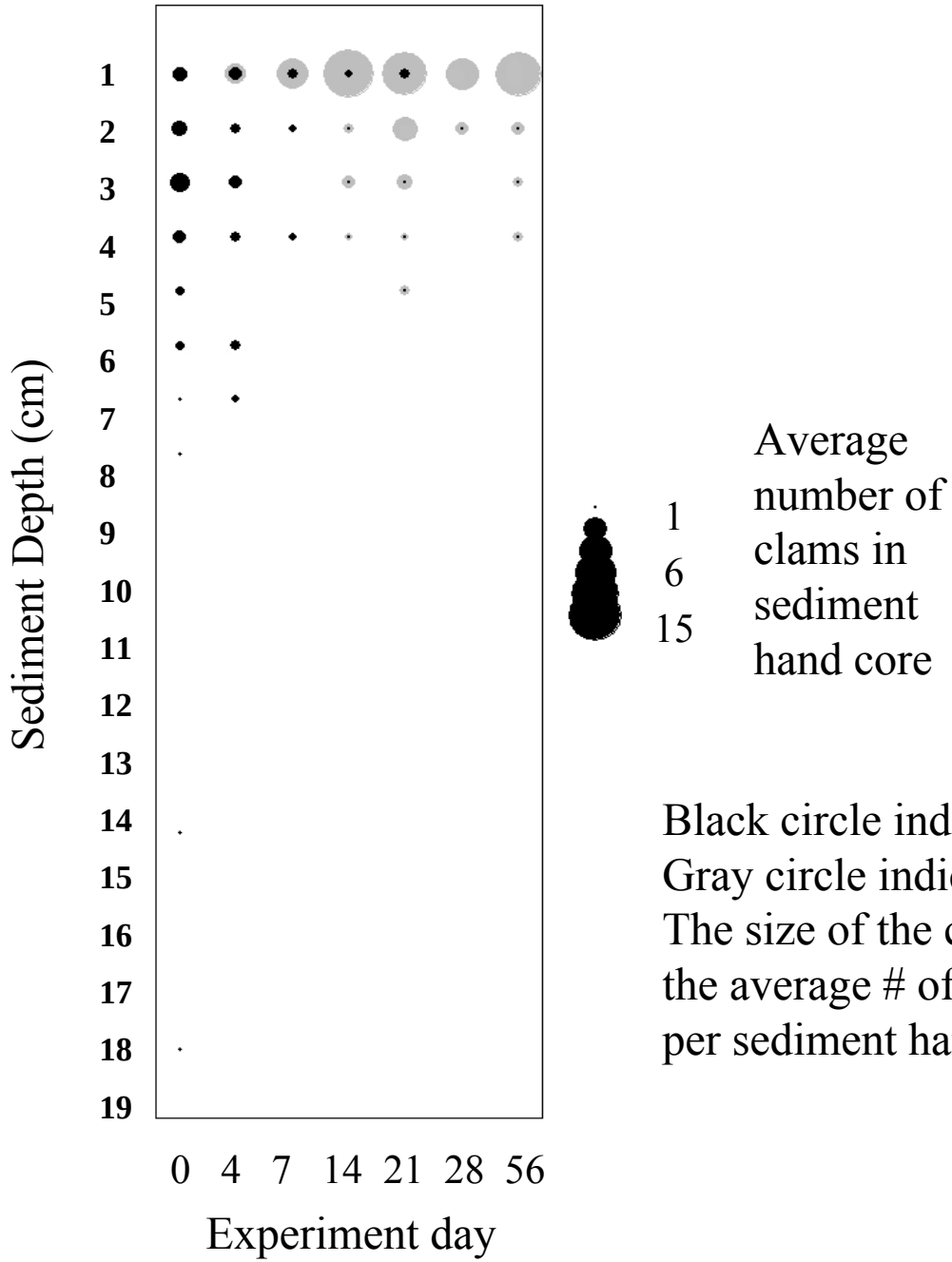
Results

- Impacts from rubber bottom barrier application
- Diver assisted suction plot recolonization

Bottom barrier mechanism: Reduce dissolved oxygen concentrations to induce *C. fluminea* mortality



Marla Bay treatment: 100% clam mortality after 28 days



Black circle indicates live clam.
Gray circle indicates dead clam.
The size of the circle indicates the average # of clams found per sediment hand core.

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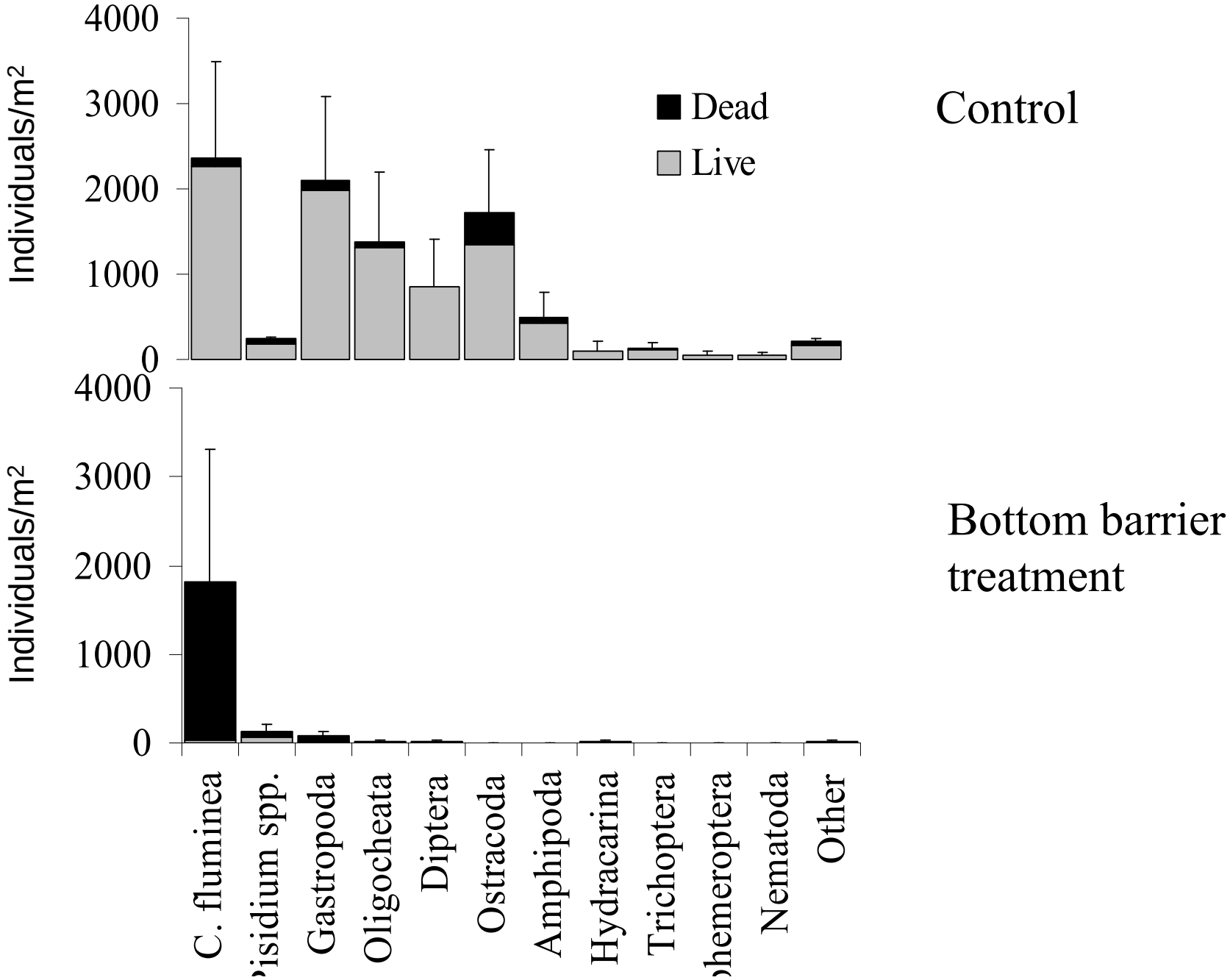
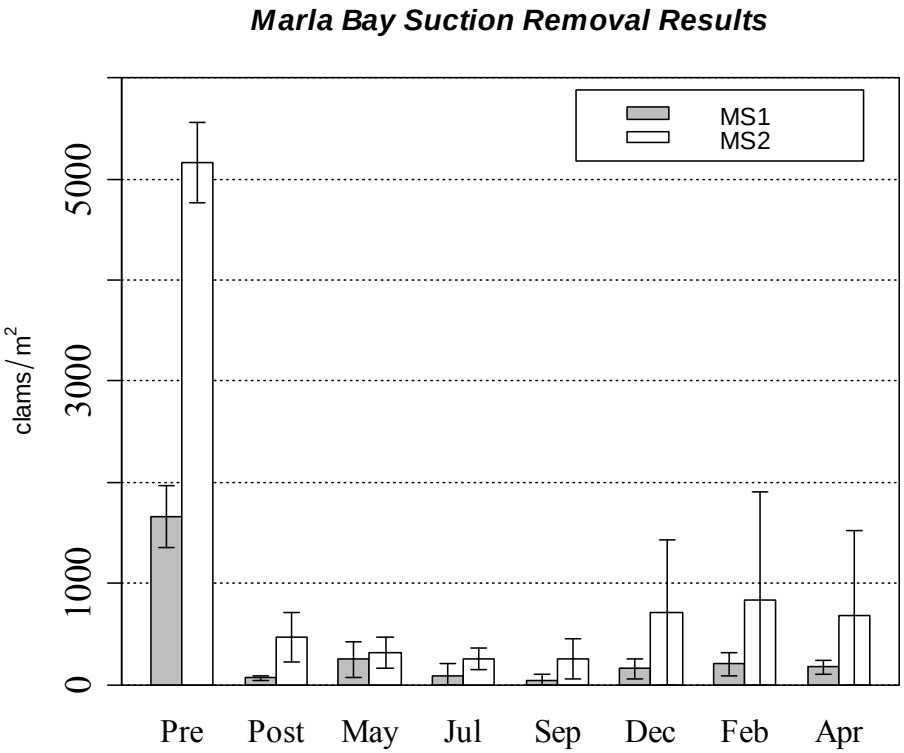
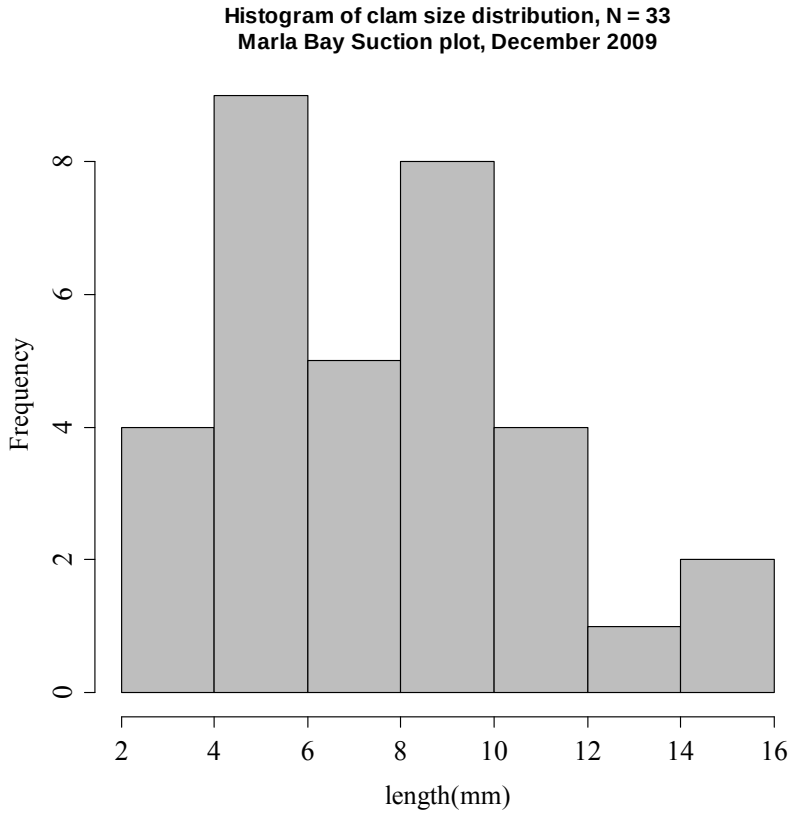
Marla Bay: 95% reduction in invertebrate density

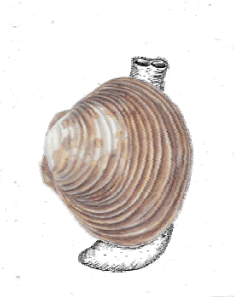


Suction Removal: Recolonization of all size classes





Conclusions



- *C. fluminea* populations are variable in time and space
  - Wide depth distribution (2 to 70 m)
  - Continuous and patchy from Cave Rock to East channel of Tahoe Keys
  - Population densities high at depth (20 m at Nevada Beach)
- Reproduction
  - Positive relationship between population density and time of veliger release
  - Reproductive season falls within 16°C threshold
  - Are populations reproducing at depth? Advective transport?
- Mortality rates:
  - Some variability explained by temperature and density (inverse relationship)
  - Known population controls: Temperature
  - Other possibilities: Food availability, competition?
- Management:
  - Suction removal is costly and recolonization occurs
  - Bottom barriers is less costly, unknown recolonization
  - Impacts to native species and nutrient cycling as a result of both

Acknowledgements

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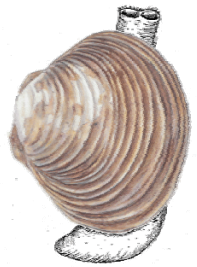
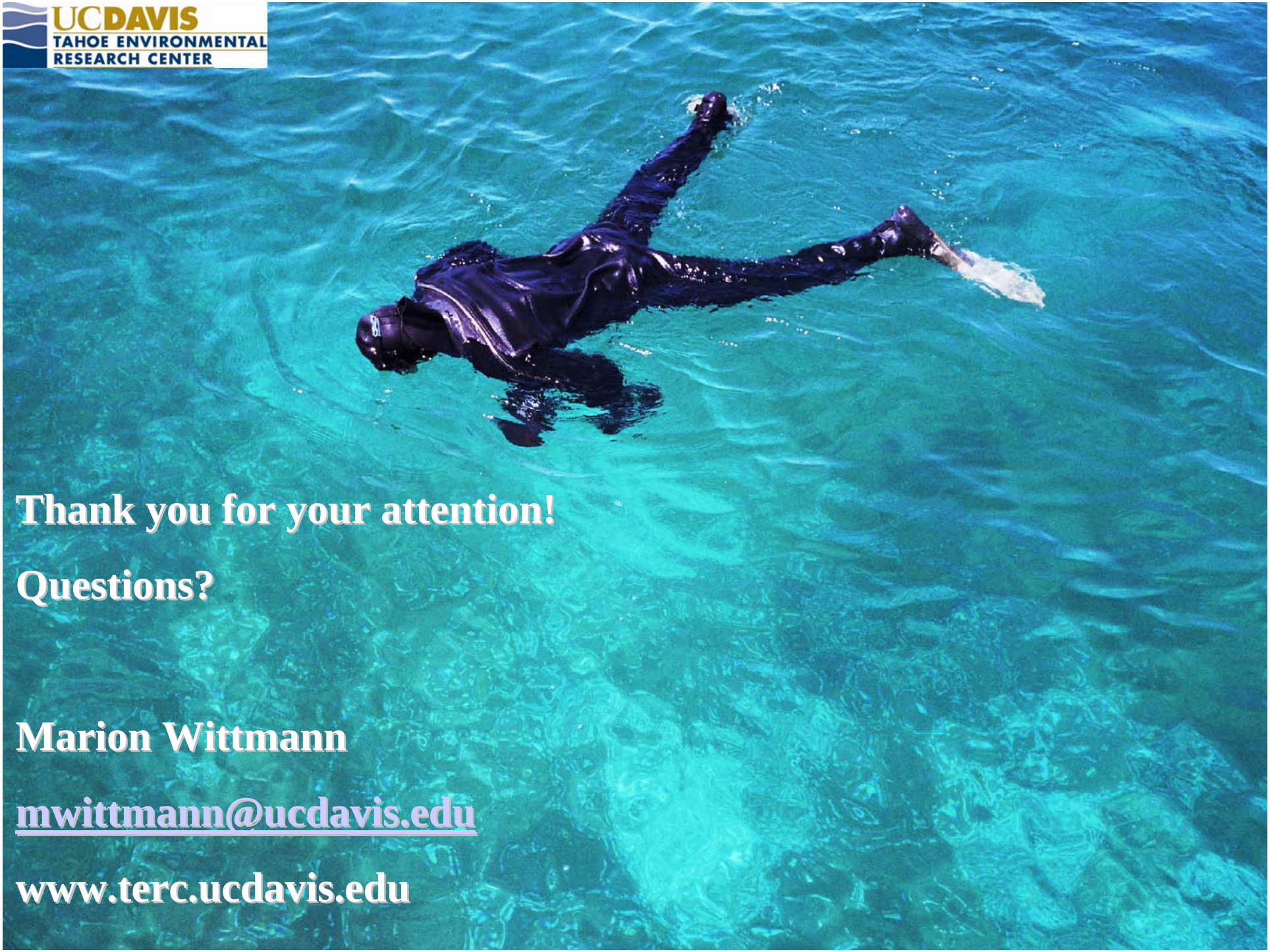


- Scott Smith, Marla Bay Homeowners Association
- Frank Forvilly, Round Hill Pines Beach Resort
- Bob Hassett, Lakeside Marina
- **Pickers and pullers from UNR and UCD (this is hard work!!)**
- Zach Hymanson and Tamara Sasaki for their diving help
- All the experts we've consulted about this work—R. McMahon, Jan Thompson, Karen Gehrts, K.O. Rothhaupt, F. Parchaso, M. Beutel



Thank you for your attention!

Questions?

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