The alkali fly and near-shore littoral zone ecology of Mono Lake: salinity and lake level effects

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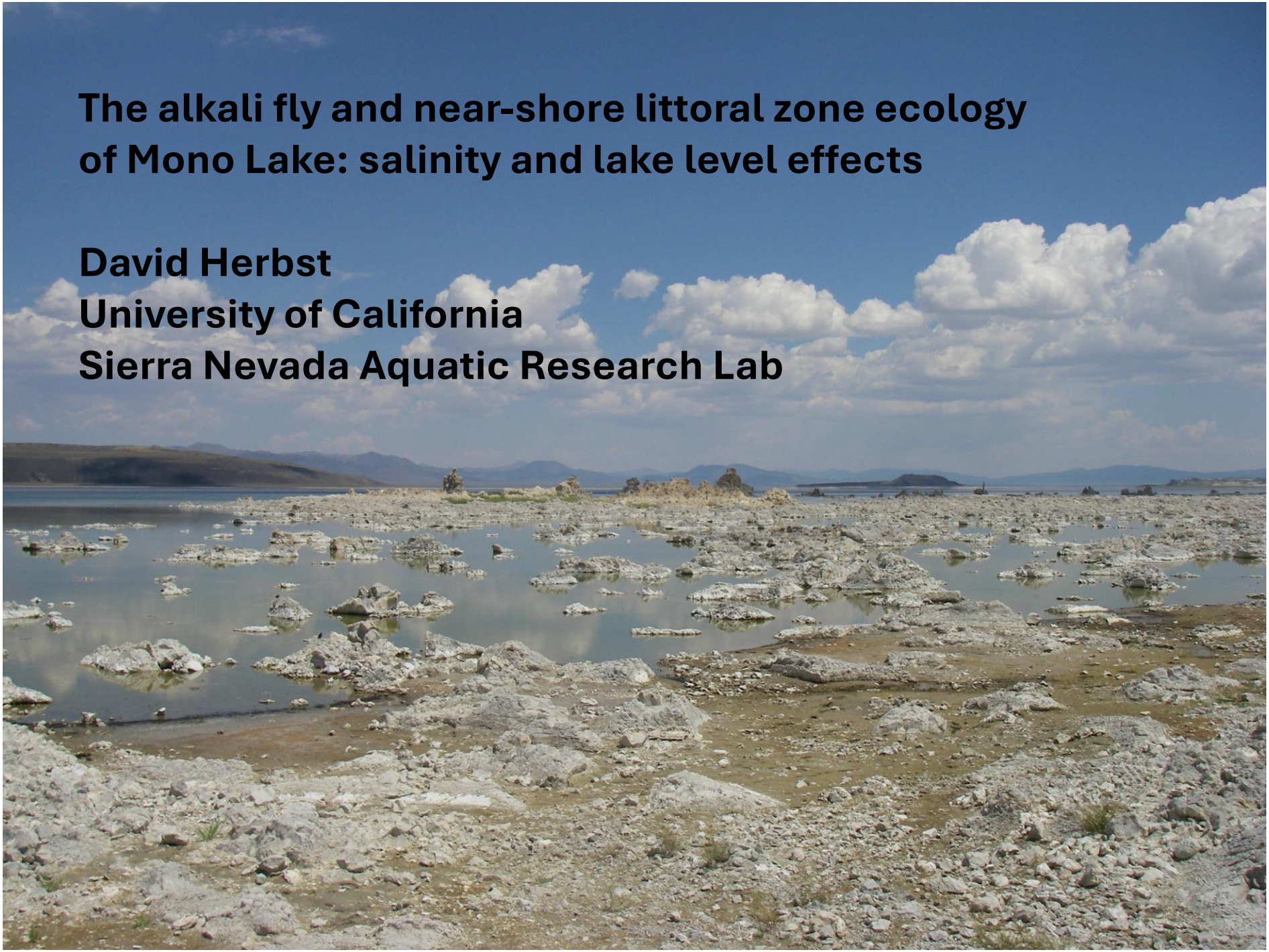
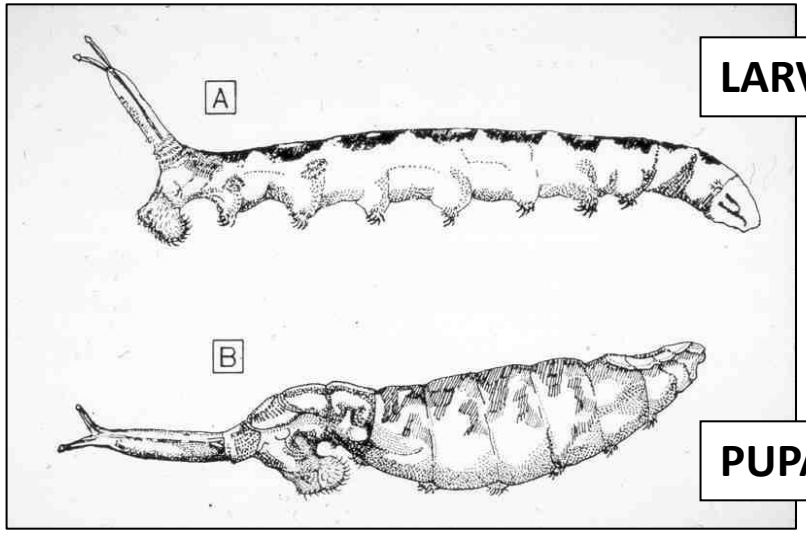


What data sets are used?

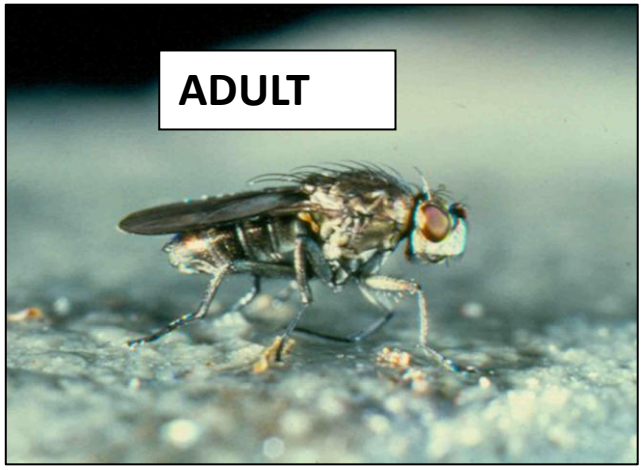
- Experimental evidence from laboratory, field and comparative ecology (other lakes) as natural experiments provides the best foundation for making predictions
- Field monitoring is quite variable but long-term trend monitoring is a powerful tool for tracking how lake responds to changing conditions as they develop and reveal complexities not always observed in experimental manipulations of single variables

Alkali Flies are key food web components in all life stages



LARVA

PUPA

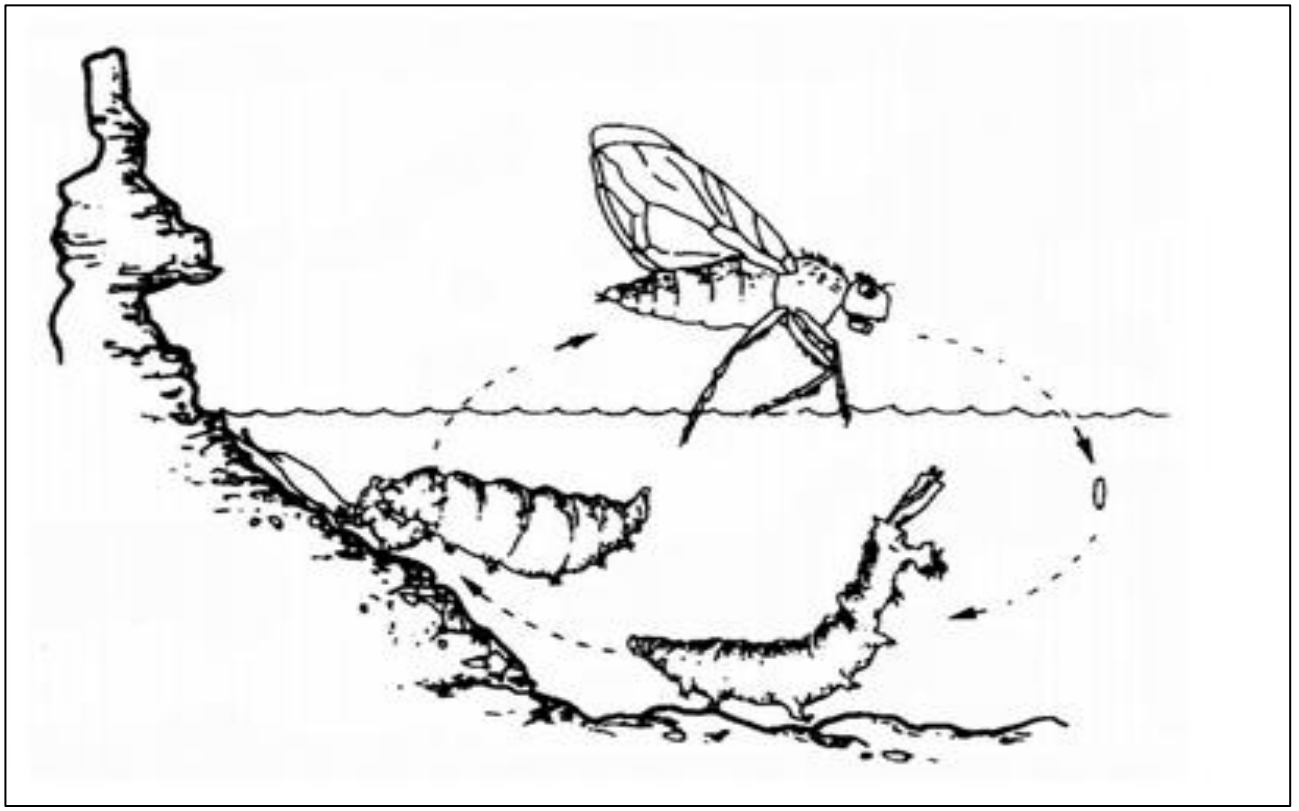


ADULT

Ephydra (Hydropyrus) hians

Aggregations of adults, larvae and pupae are focal points for birds feeding:
Easy pickins for foraging

Alkali fly life cycle



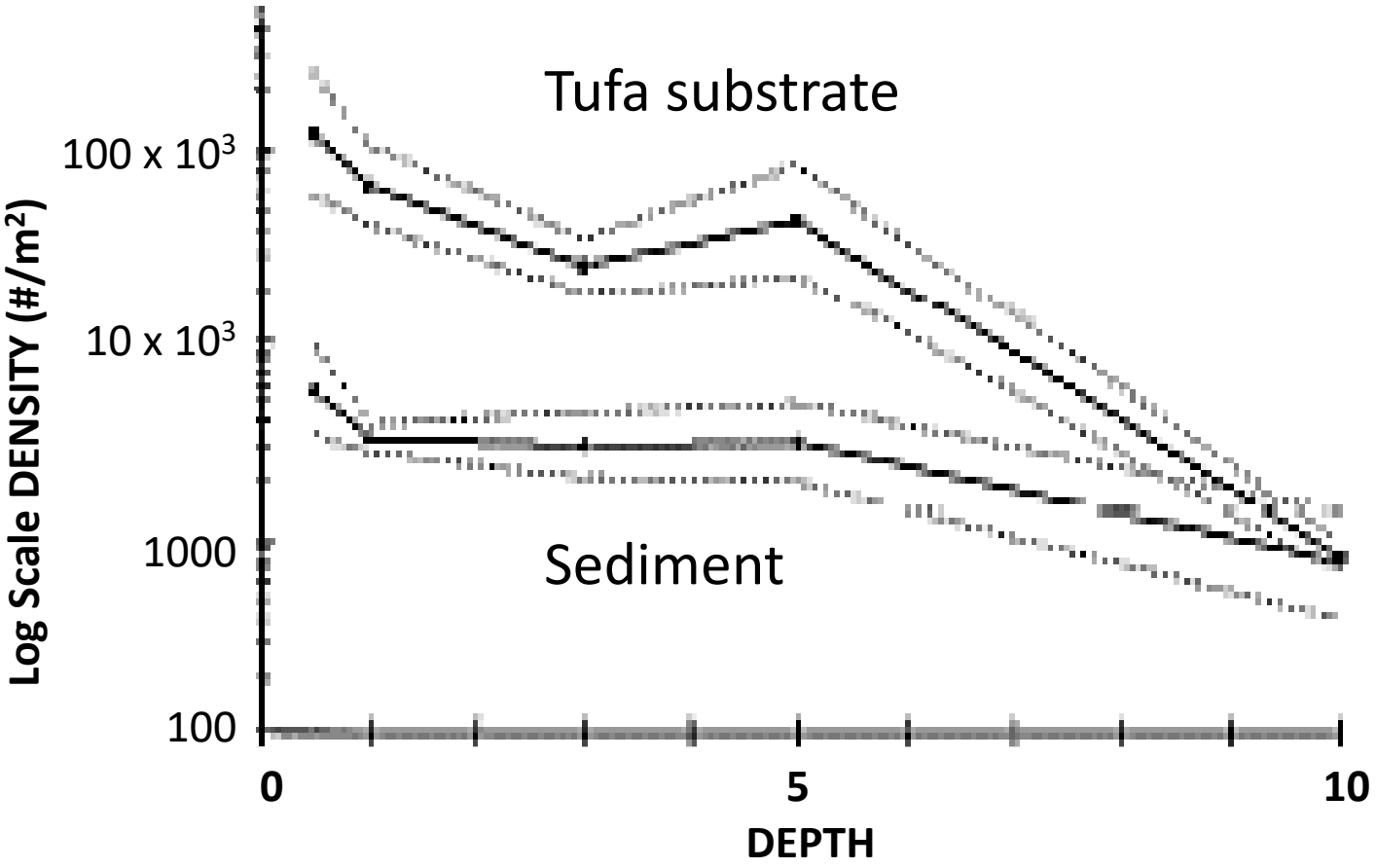
- Adult flies feed on algae on shoreline sediments and underwater
- The underwater adults are mostly females, grazing algae and laying eggs
- Larvae develop through 3 instars during warmer months (>10 °C)
- At maturity the pupae are formed and attach to stable substrata with clamp-like legs
- After about a week developing, the adult fly emerges, by popping off a hatch cover
- Approximately 4 generations in a year depending on salinity and temperature

- Adults feed on algae, lay eggs underwater, larvae continue to feed on algae (diatoms best for nutrition), develop to maturity then seek out protected habitat on tufa in the "rocky intertidal" littoral zone of the lake (approx. 5 m depth)
- Full life cycle (summer growth period) is about 1-2 months (current conditions)
- Development rates depend on salinity and temperature

Tufa formation

- Freshwater spring interaction of calcium in spring water with carbonates in lake water to form limestone aggregates
- Transformation of gaylussite crystals forming in deeper water or cold temperatures into aragonite encrusting on other substrata nucleation sites like pumice (below right)
- Biomineralization related to fly osmoregulatory products secreted onto existing tufa (also possible role of benthic algae in biomineralization?)

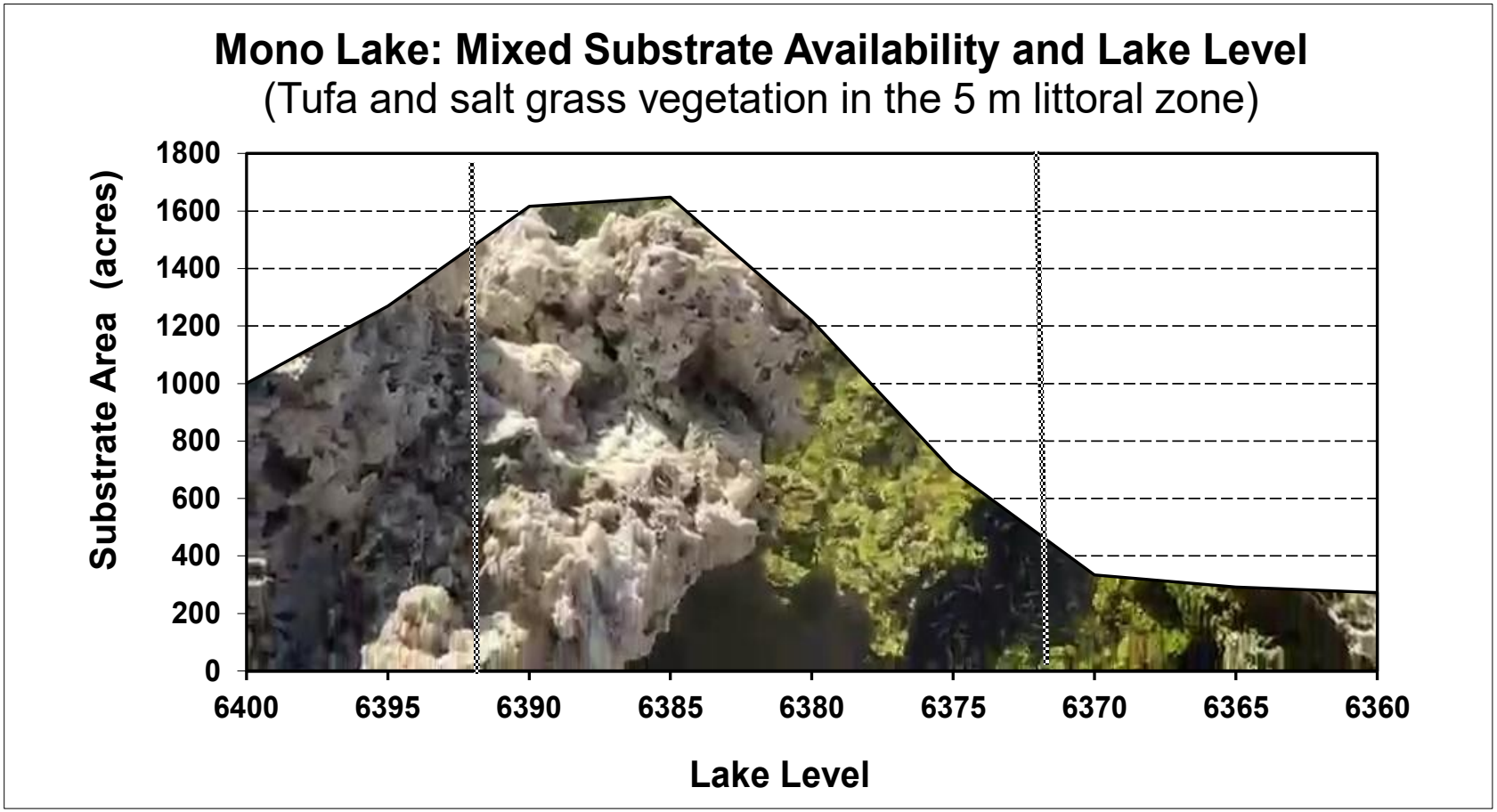
Littoral zone densities of fly larvae and pupae on tufa to 5 meter depth are most important locations for growth



Salt grass littoral habitat (dead, but intact rhizome mats remain)

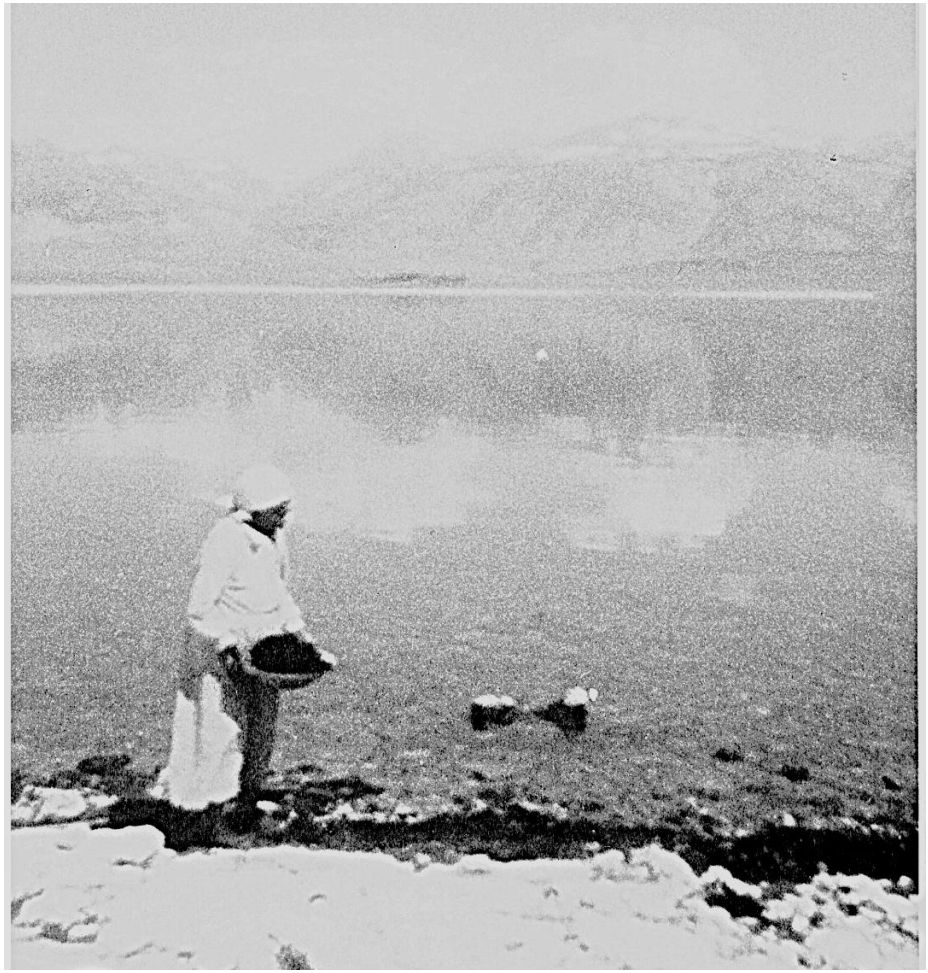
Salt grass is a quick invader as lake levels fall and then rise again forming stable habitat for pupation

Area of high quality fly habitat available to the 5 m littoral depth zone vs lake level



< Markers at 6392 and 6372 >

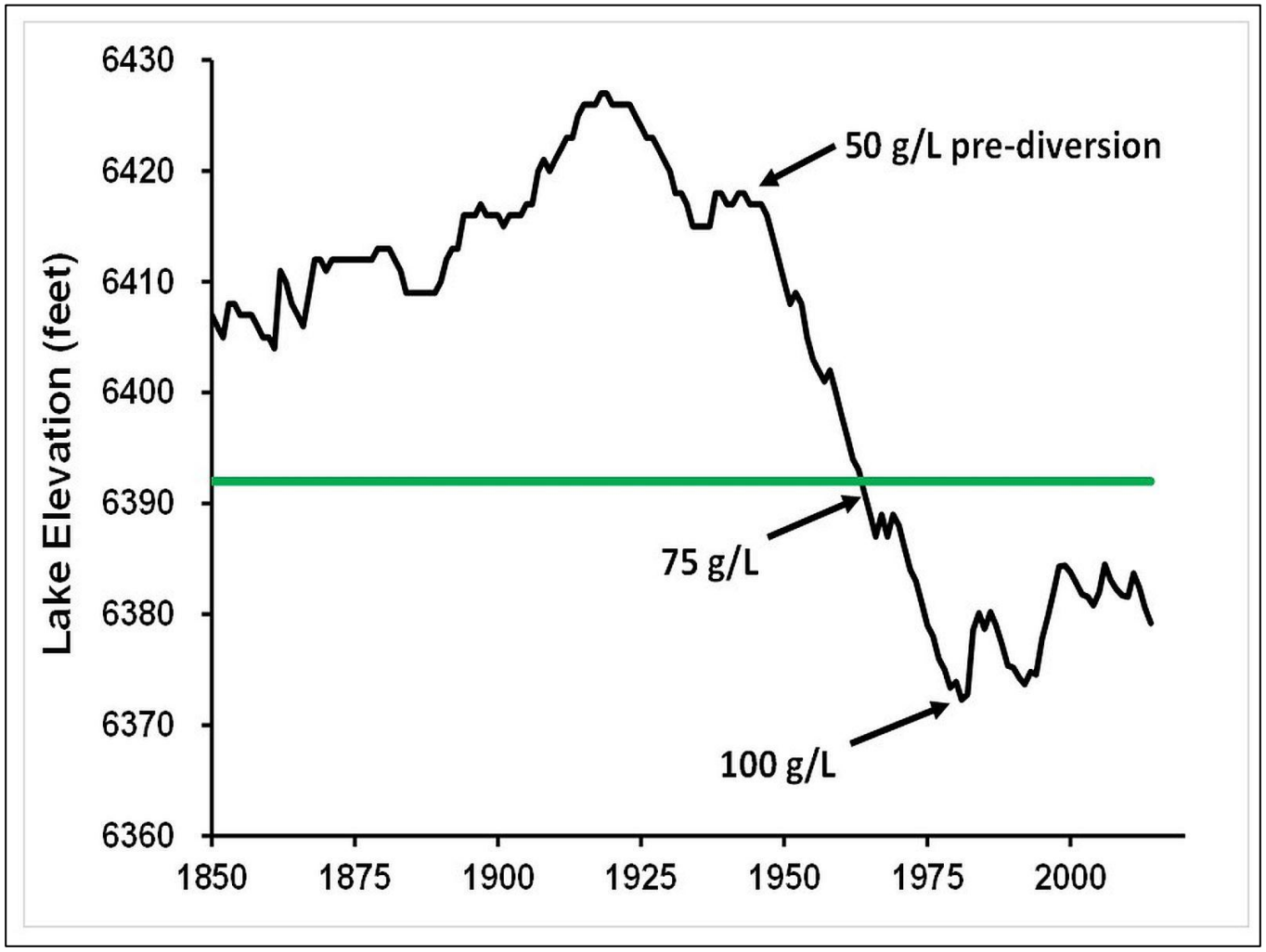
Onshore windrows of pupae show how productive the lake can be



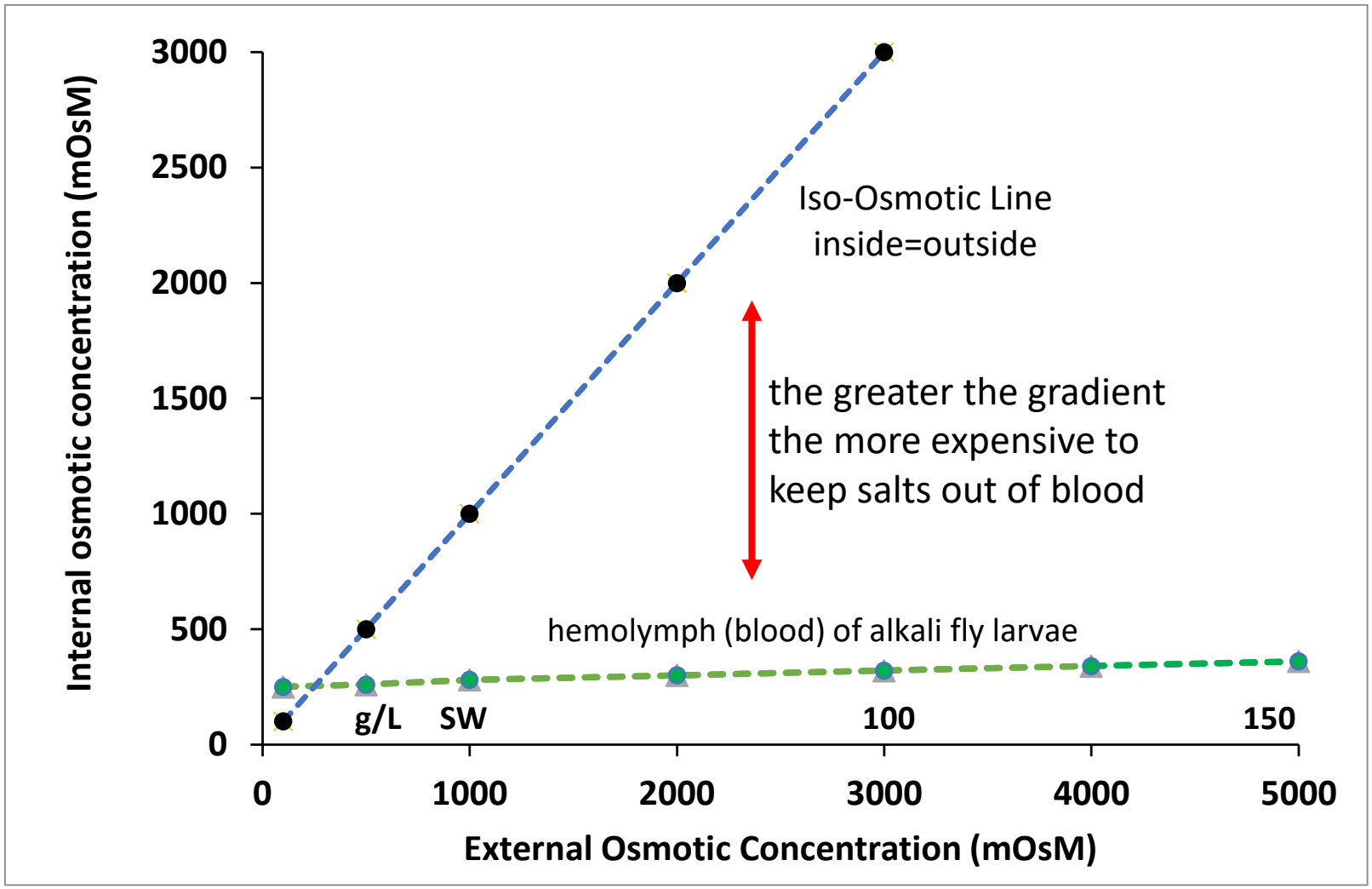
Flies were productive enough in the past to support traditional tribal use of pupae harvest as a food source (“Koo-chabve”)

Windrows of pupae at Abert Lake show salinities of 50-75 g/L are conducive to massive productivity

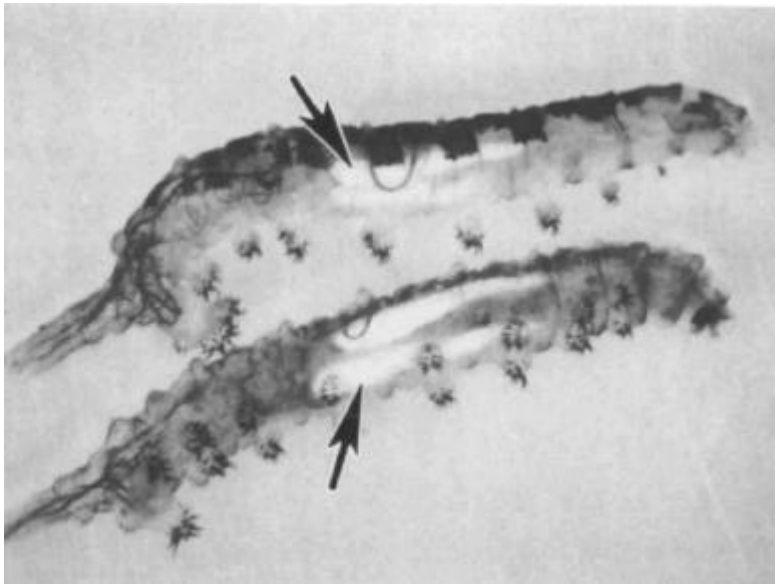
Range of lakes levels and salinity under consideration here: 6372’-6392’ and ~100 g/L to 75 g/L over that range



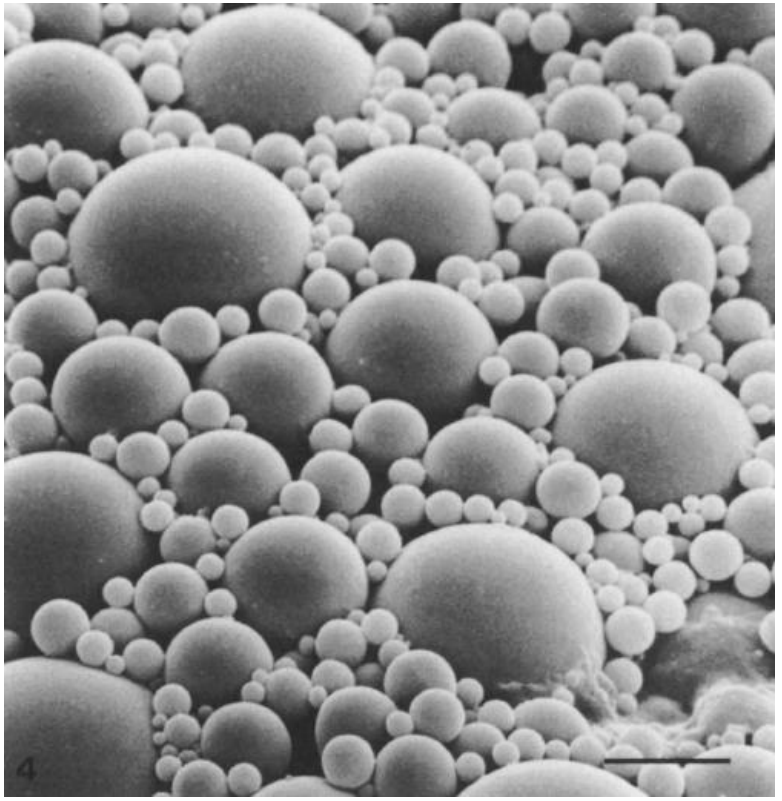
Fundamental to fly larva physiology: osmoregulation and the cost to growth & development



PHYSIOLOGICAL SETTING OF SALINE LAKES



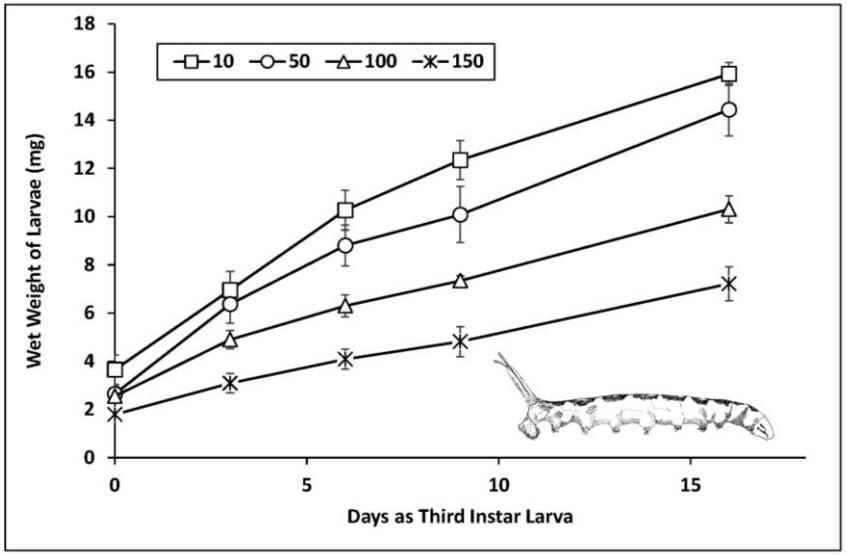
Lime gland and calcium carbonate microspheres within that attach to and build tufa when pupating

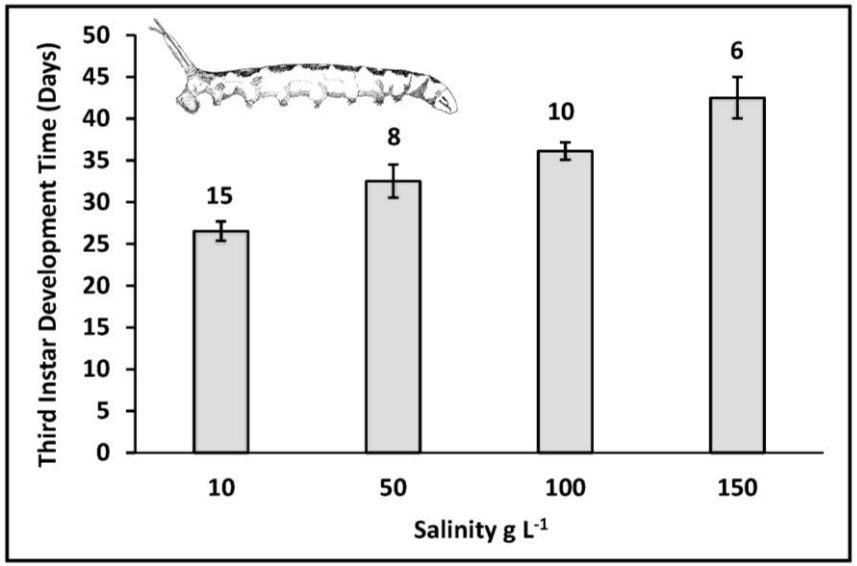


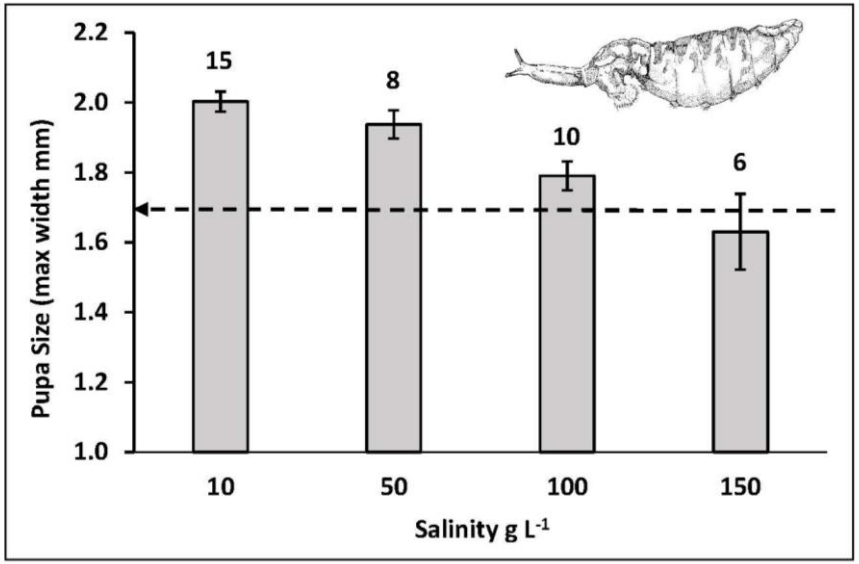
Scale bar 5 microns

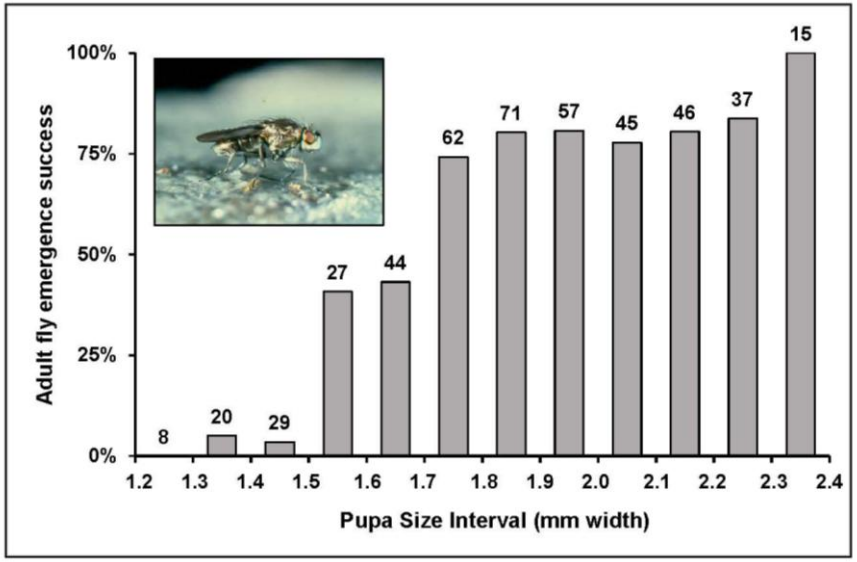
Osmoregulation is a costly process

Developmental and reproductive costs of osmoregulation: Lab experiments on growth and development

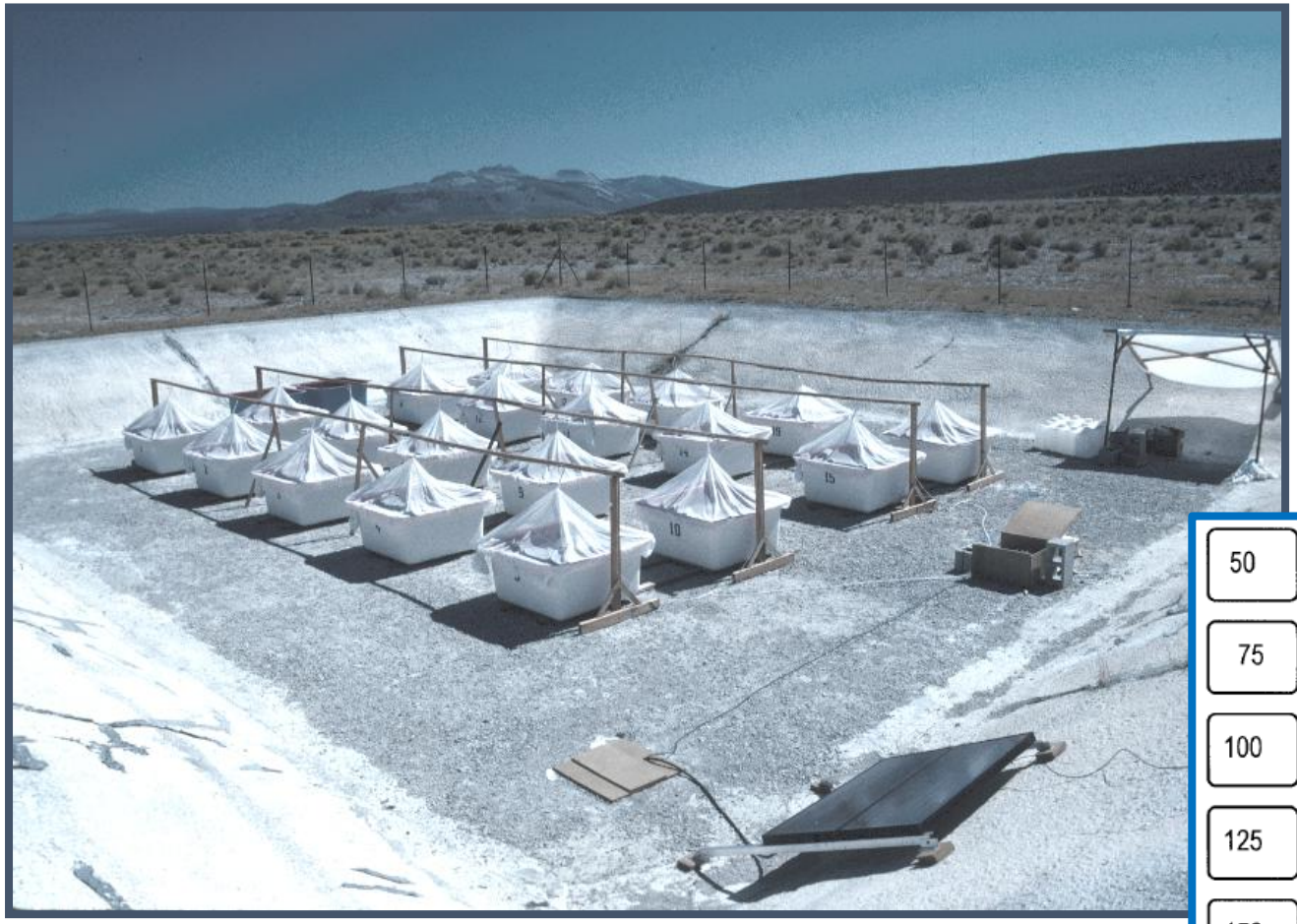








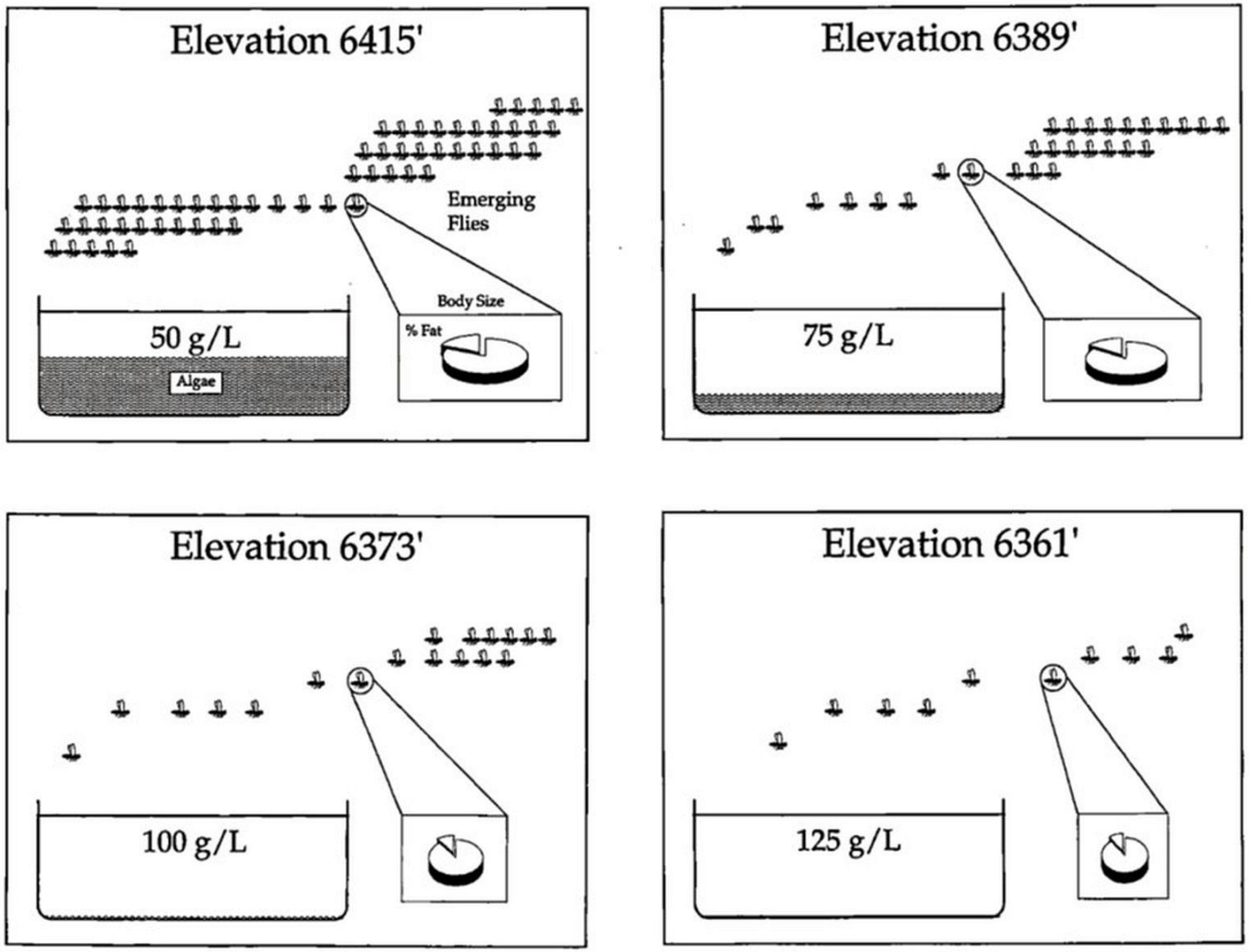
Field Experiments: mesocosm tanks



Latin square tank array

50	125	75	150
75	150	100	50
100	50	125	75
125	75	150	100
150	100	50	125

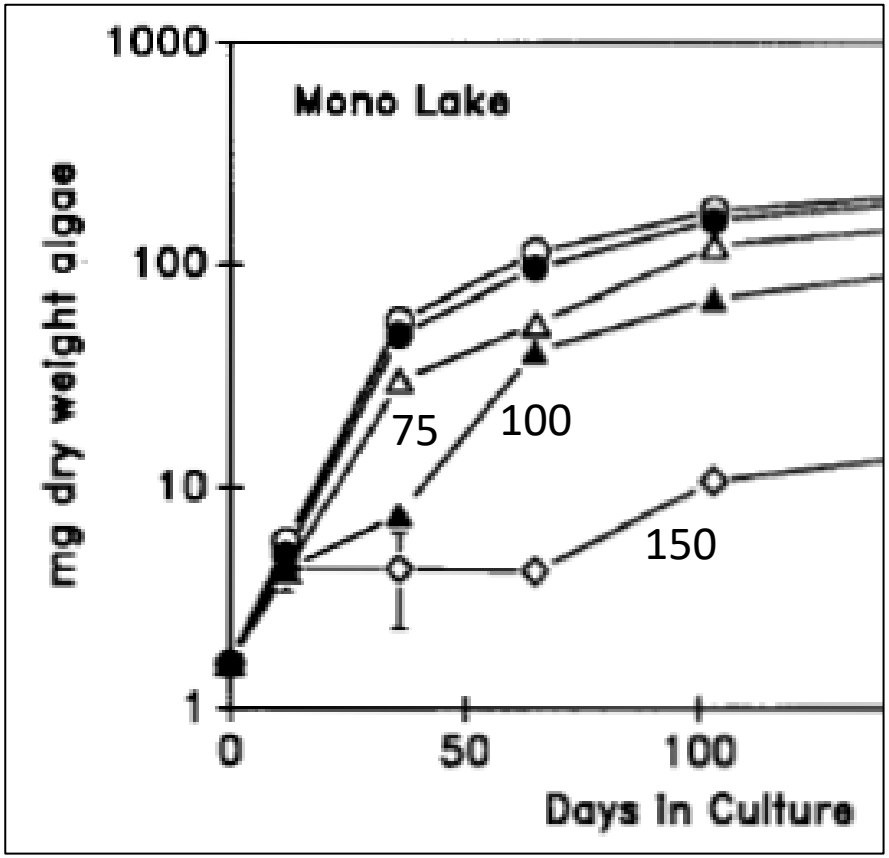
Run for >2 months in large volume of water (500 liters)
Stocked with eggs and larvae and other invertebrates
From Mono, and other water bodies of lower and higher salinity
Larval development and adult emergence monitored



These experiments demonstrate that while the 6392 lake level is more protective of ecological values than lower lake levels, the optimum conditions for fly productivity are at higher lake levels yet – near the 50 g/L level prior to water diversions

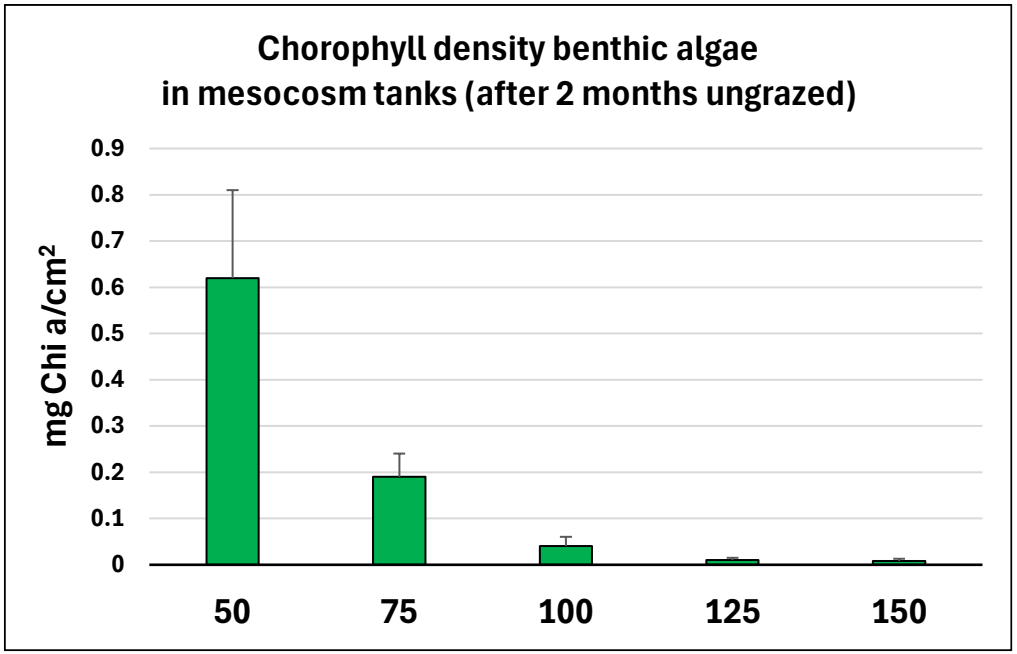
Salinity Effects on Benthic Algae Growth and Nitrogen Fixation by Cyanobacteria

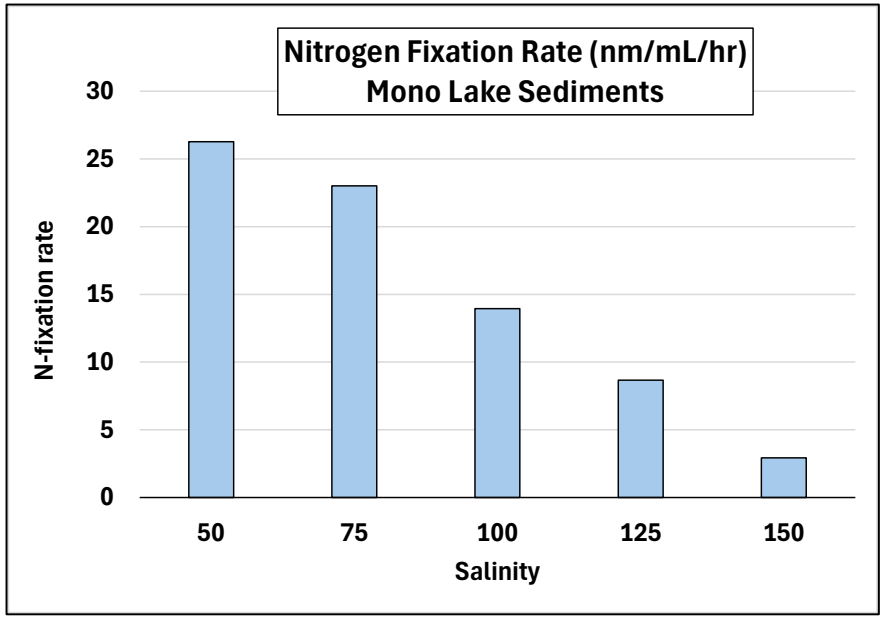
Initial growth rates of the green alga *Ctenocladus* when nutrients are not limiting

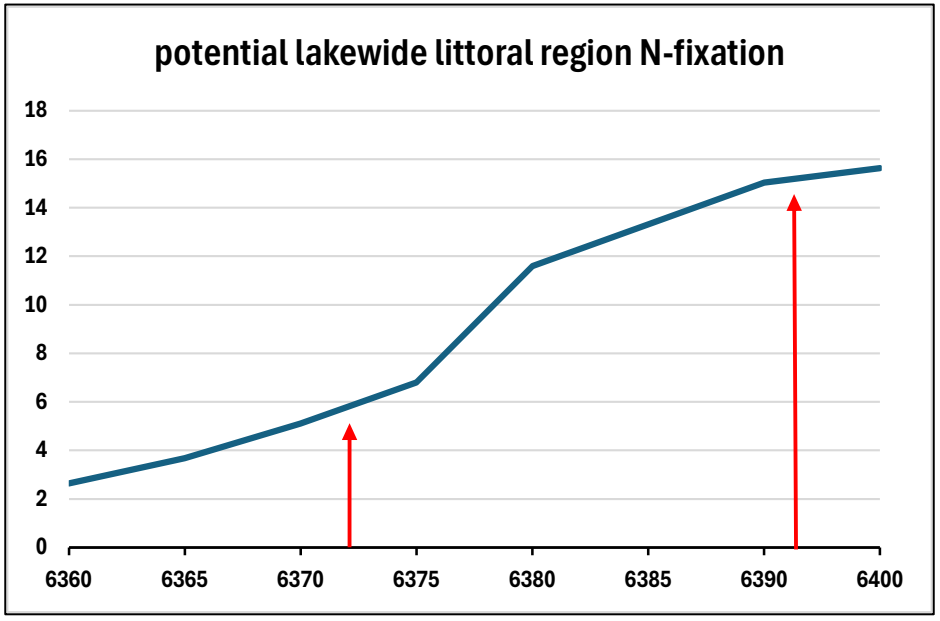


Benthic algae food resources Limited by salinity (mesocosms)>

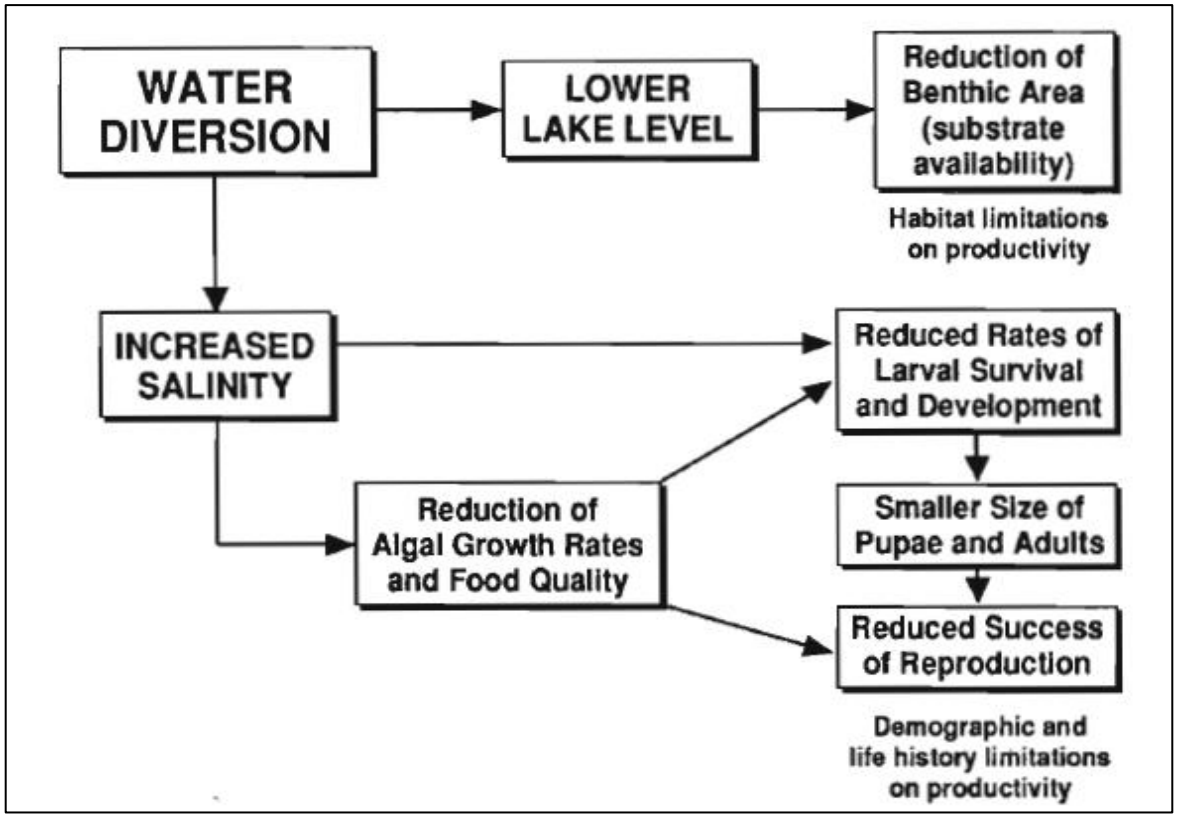
And by nitrogen fixation rates inhibited by salinity and littoral zone area available at different elevations (nutrient availability)







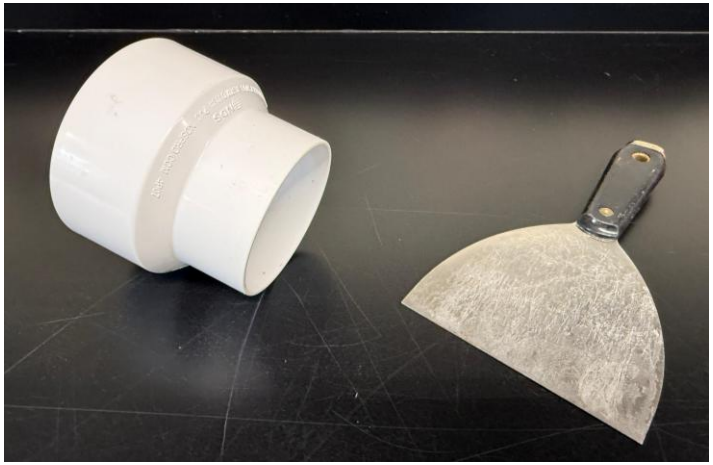
Summary of limitations by lower lake levels and higher salinity:
Supply & Demand *less food supply & more energy demand; less habitat*



- **Not only does salinity limit growth and reproduction due to the cost of osmoregulation, it also reduces the growth and type of benthic algae, and reduces the area of preferred rocky habitat for larvae to attach and form pupae**
- **Salinity is a "vice" > demand increases, food supply decreases while habitat also becomes limiting, so food quality and availability to birds is reduced**

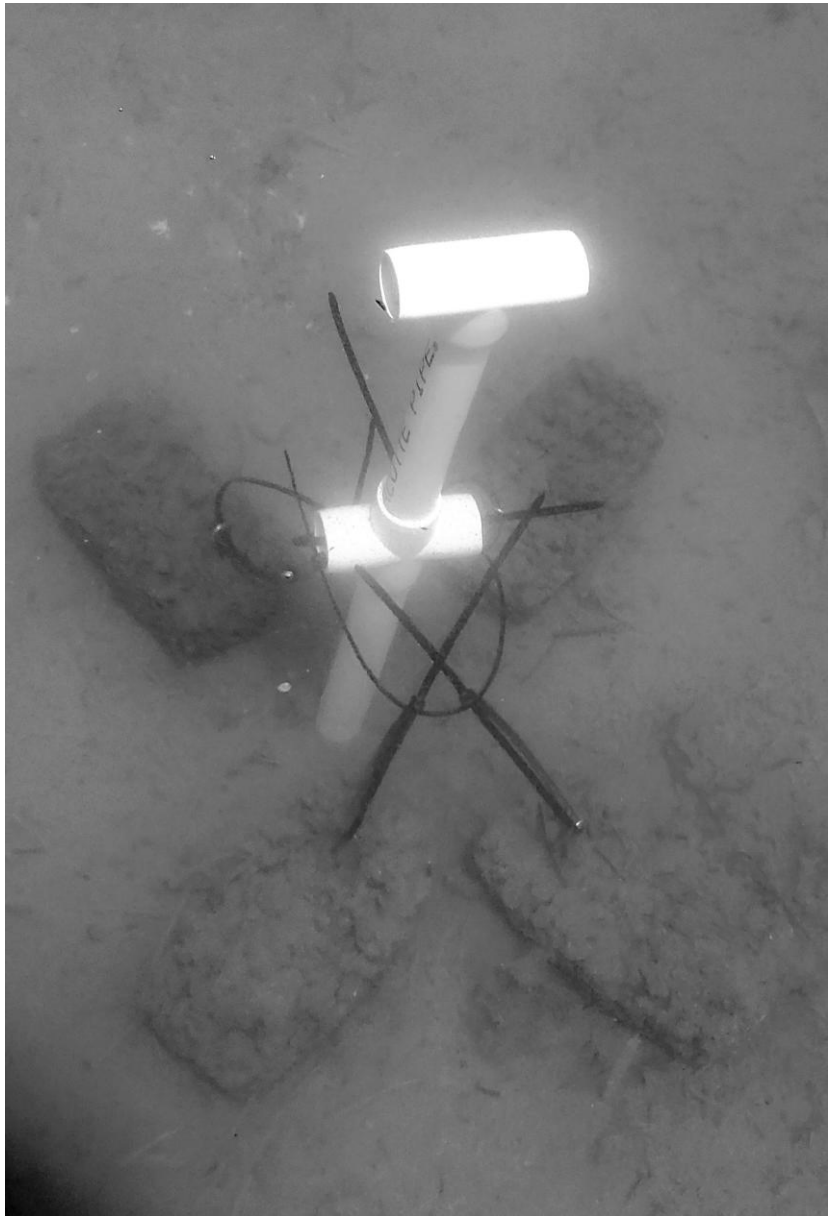
Monitoring of population densities and demographics of aquatic life stages on natural substrates in shallow water

Tufa fragments collected underwater within mesh nets



Sediment cores taken with PVC pipe
Cut out with wide putty blade

Data is still being compiled from
1991-1993
1999-2001 and
2024-2026 (current)



Supplementing natural substrata sampling….

Artificial substrate samplers: Standardized mimics of coarse tufa substrate

Cumulative colonization over time

Conclusion

- **Question from the water board: is there reason to accelerate increases in lake level and can we expect 6392 to benefit improved ecological status of the lake?**
- **Yes, the data argues that we would expect conditions in Mono Lake to become more productive by raising the lake level to 6392 and the attendant improvements for growth, development, reproduction, population productivity and habitat availability for the alkali fly**