

Mono Lake: Ecology and Limnology

Lake is in a closed hydrologic basin and is sensitive to climatic variations and water diversions.

Lake's high salinity (70 to 100 g/L) and high pH (10) results in a low species diversity with strong biological signals

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Outline

Offshore organisms and their ecology

Limnology over last 35 years

Recent conditions

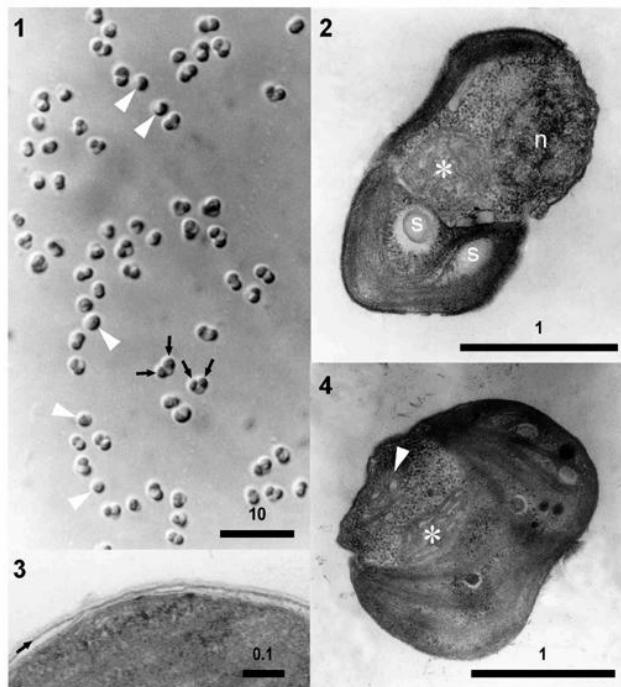
Ecological trends



Phytoplankton in offshore waters

High nutrients lead to high algal growth and abundance

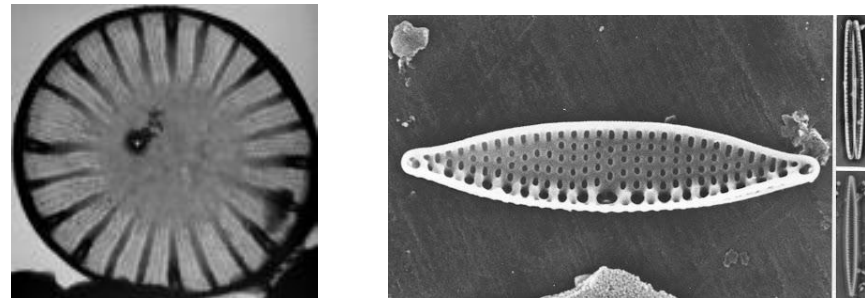
Picocystis sp.



Scale bar: one micrometer

Phytoplankton are important source of food for *Artemia*

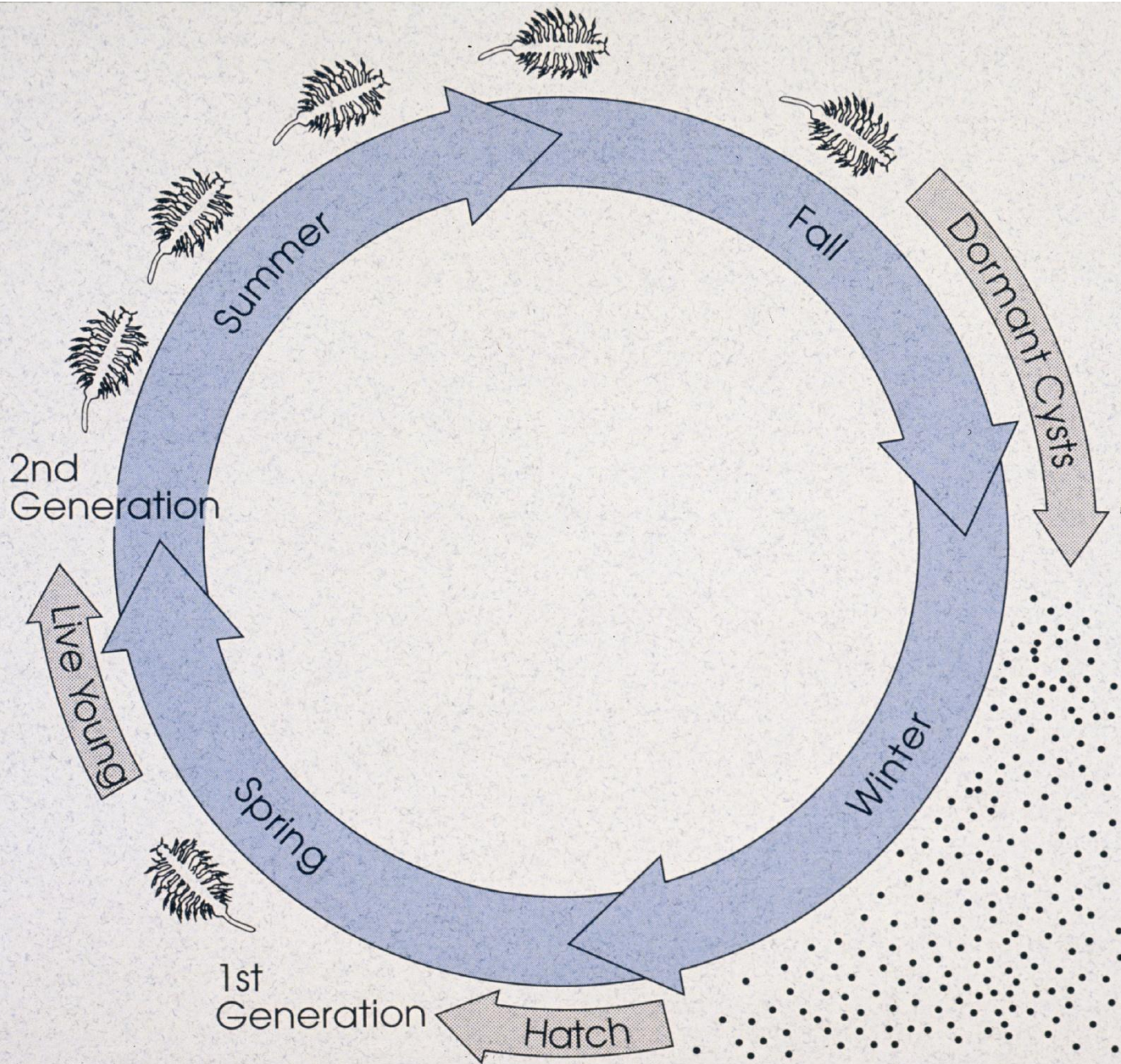
Diatoms: *Nitzschia* spp.



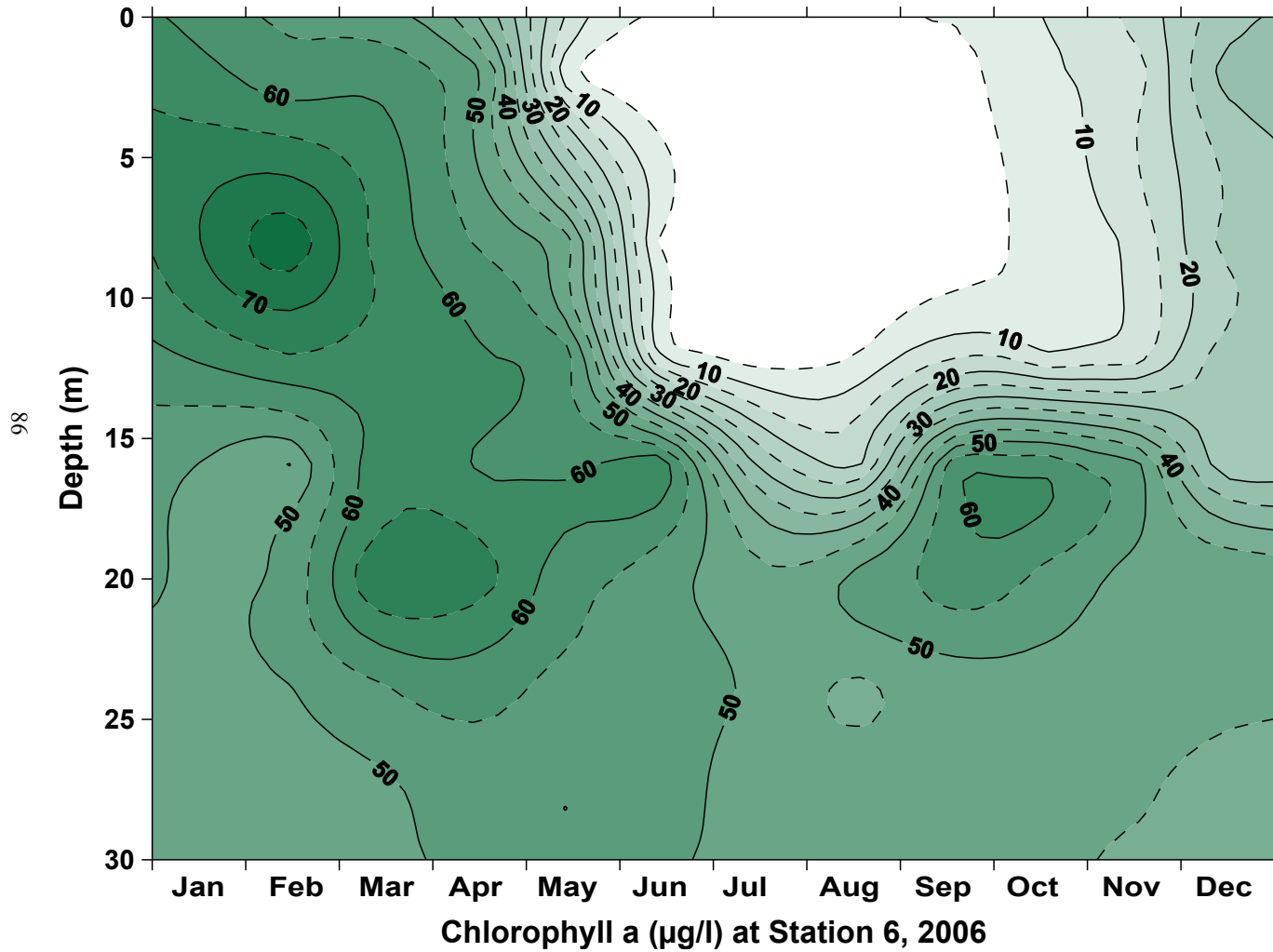
Artemia monica



Mono Lake Brine Shrimp Life Cycle

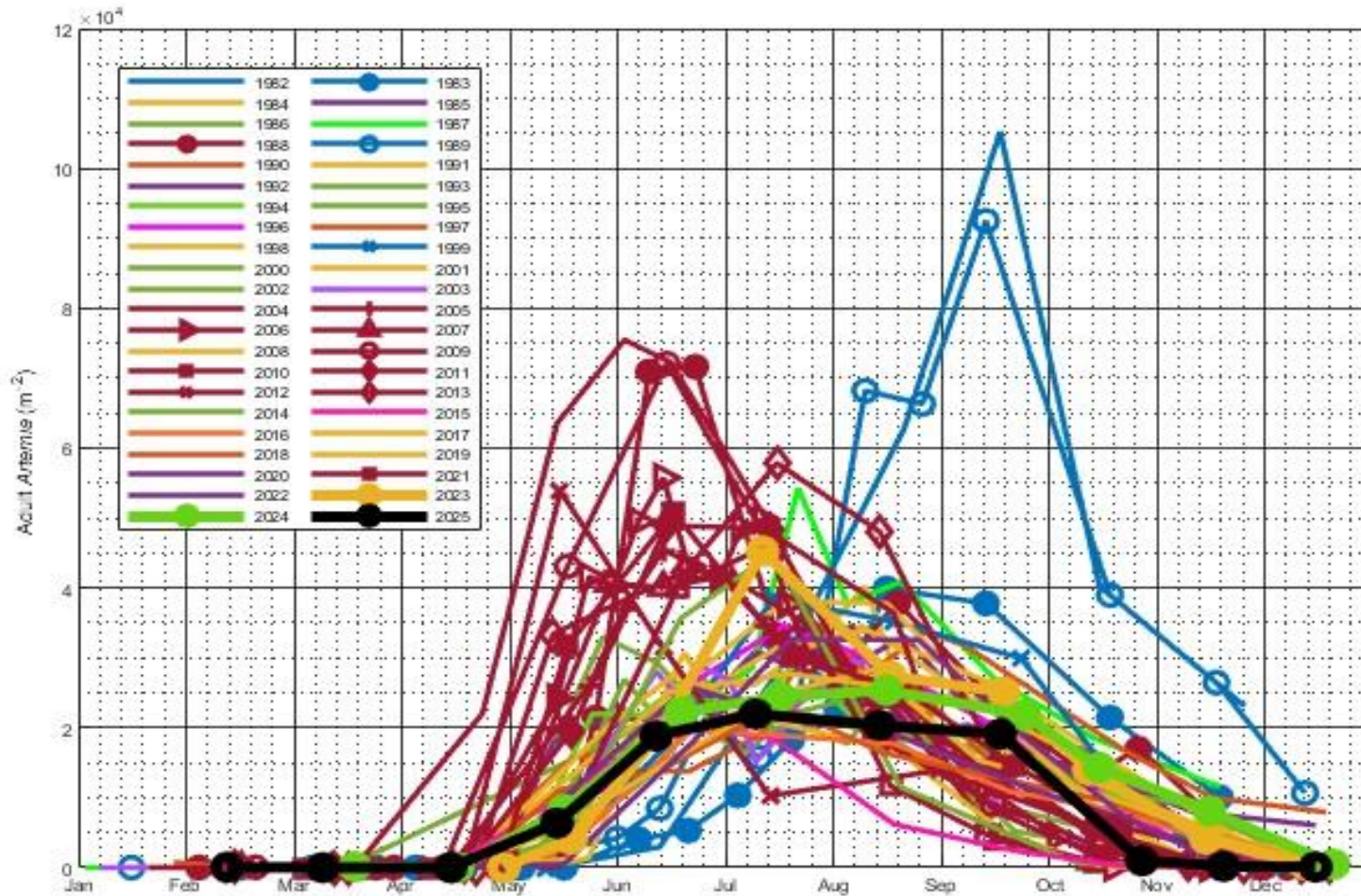


Chlorophyll concentration indicates phytoplankton abundance



Abundance of phytoplankton is less in summer
due to *Artemia* grazing

Adult *Artemia* abundance, 1982–2025



Red lines - years with May-June abundance above $40,000 \text{ m}^{-2}$

Blue lines - years of exceptionally high autumn abundance

Recent years have lower abundance and lack spring or autumn peaks

Mono Lake, California



California
Gulls -
spring

Phalaropes-
summer



Grebes-
autumn

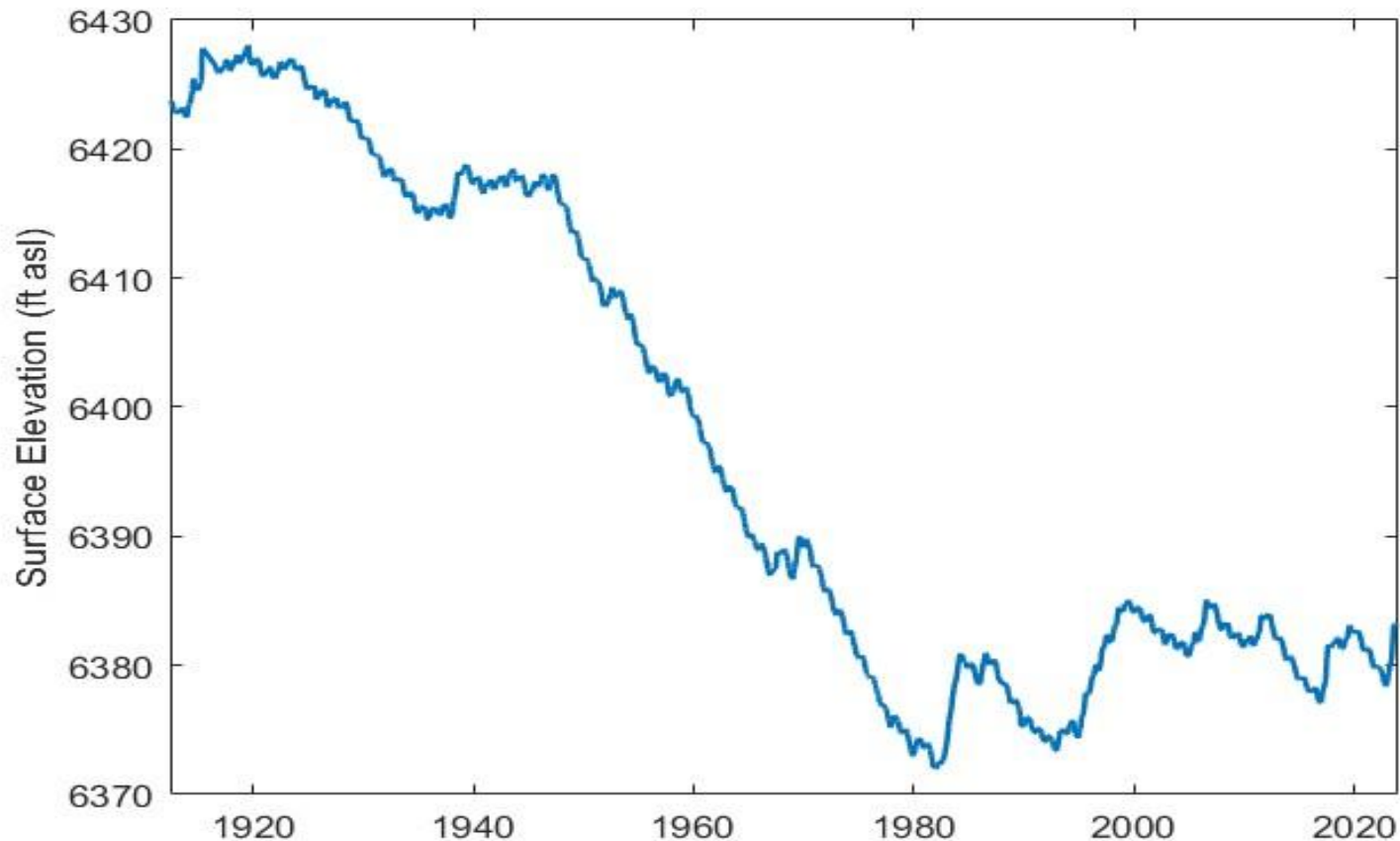
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Mono Lake surface elevation 1910 to present

LADWP stream diversions began in 1941;

increased in 1970s

Exceptional runoff in 1983, diversion reduction in 1994 and climate variations led to oscillating levels since 1982



Long-term UCSB research

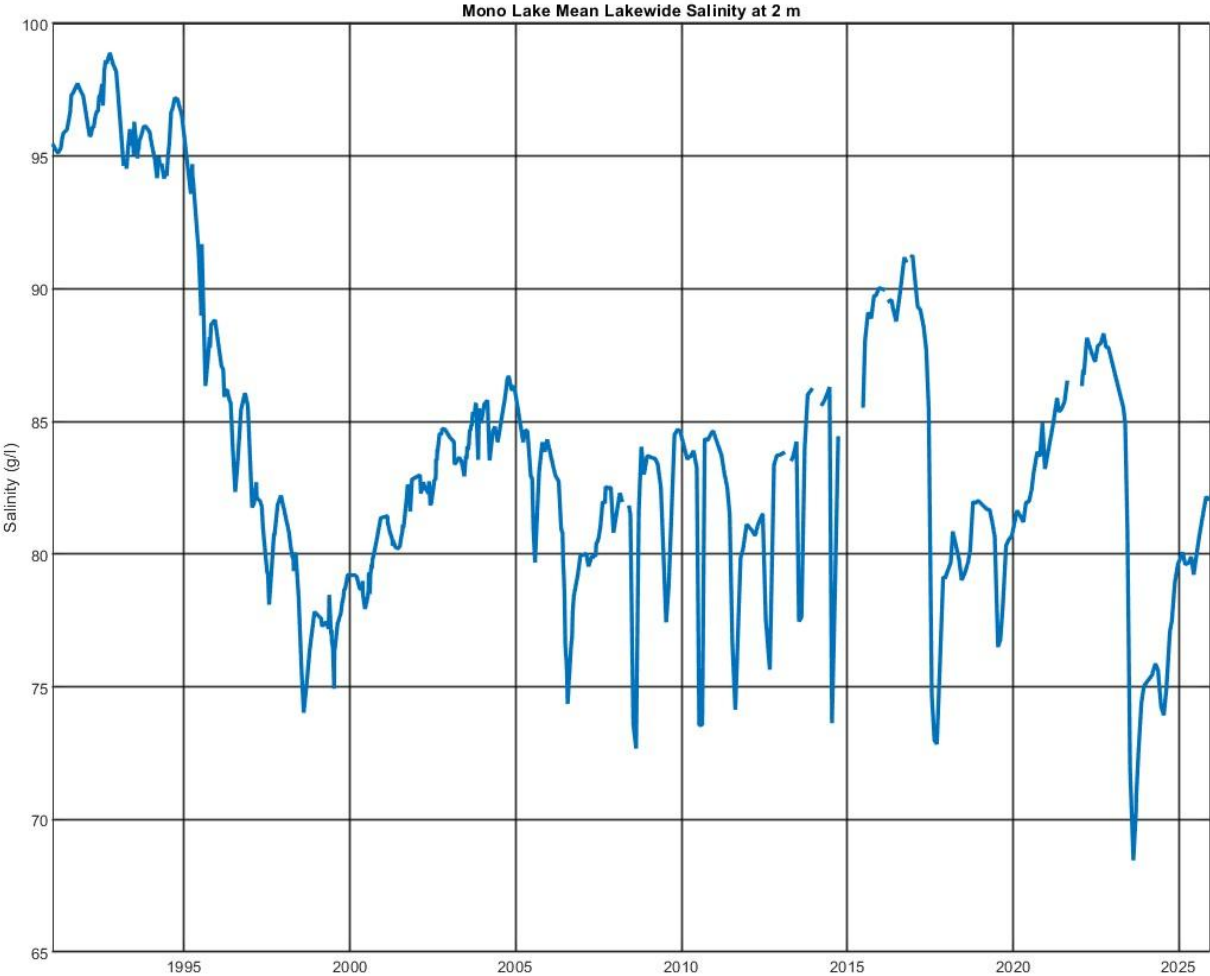
1979 to
present

Field measurements, laboratory analyses and experiments document ecological responses to differences in salinity and mixing processes within the lake often related to inter-annual changes in stream inputs.

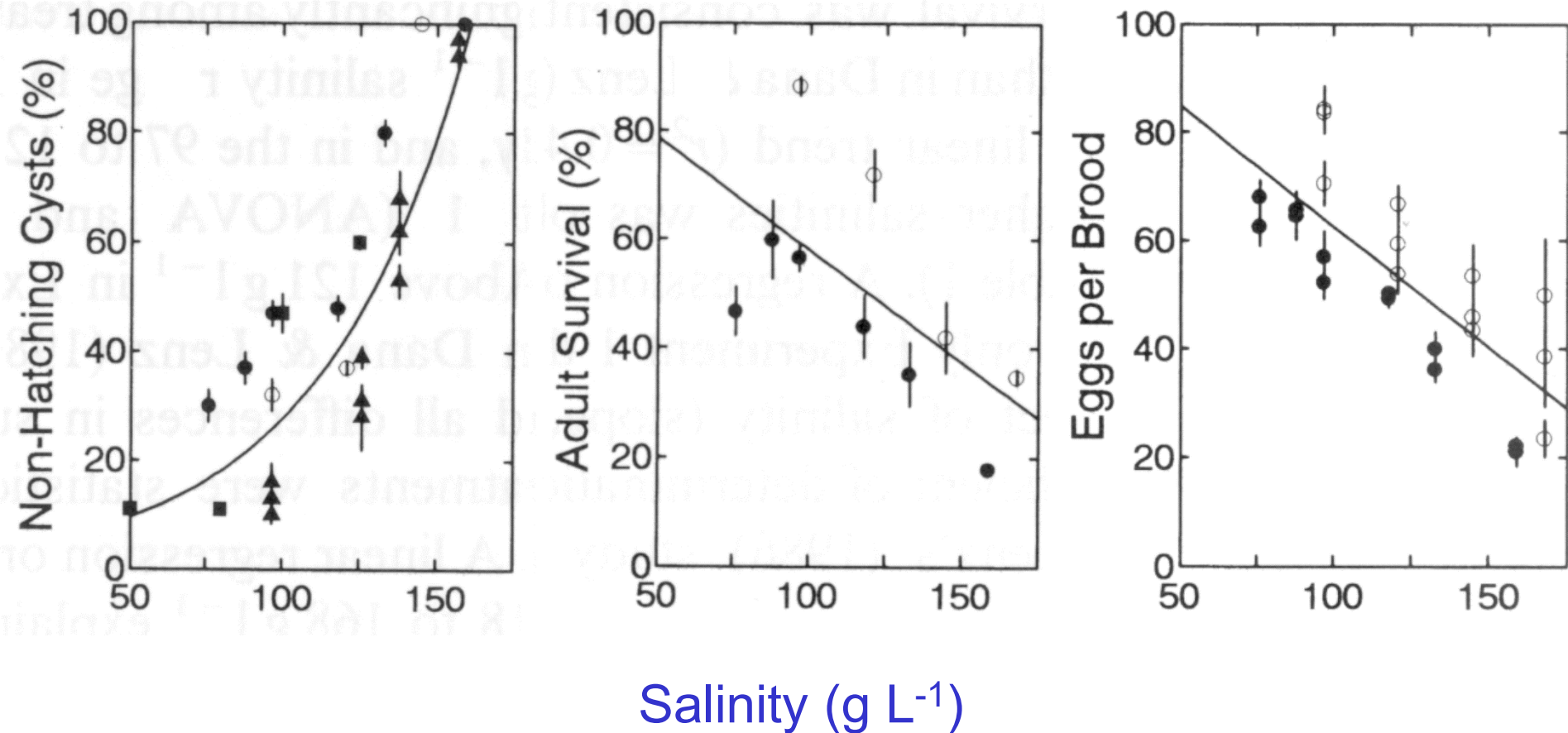


Photo by Galen Rowell

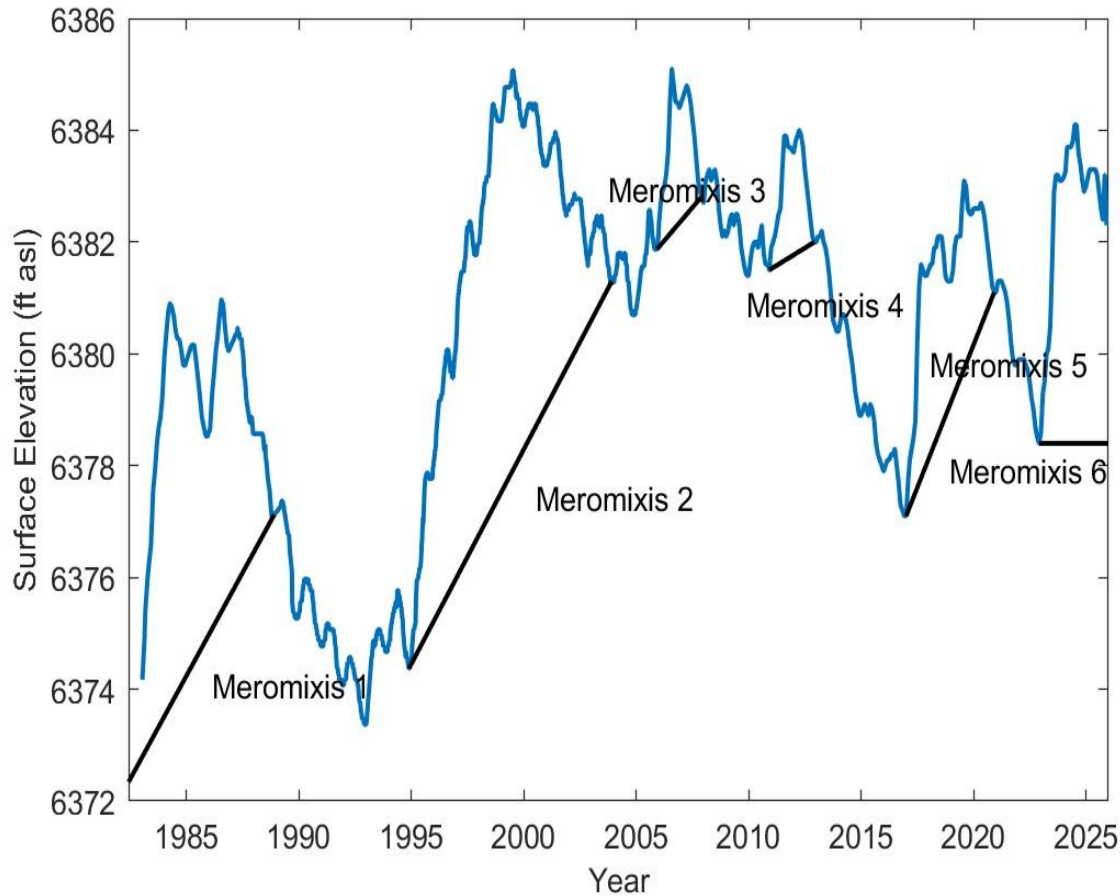
Salinity (g/L at 2 m) 1990 to present



Artemia monica life history characteristics vs. salinity

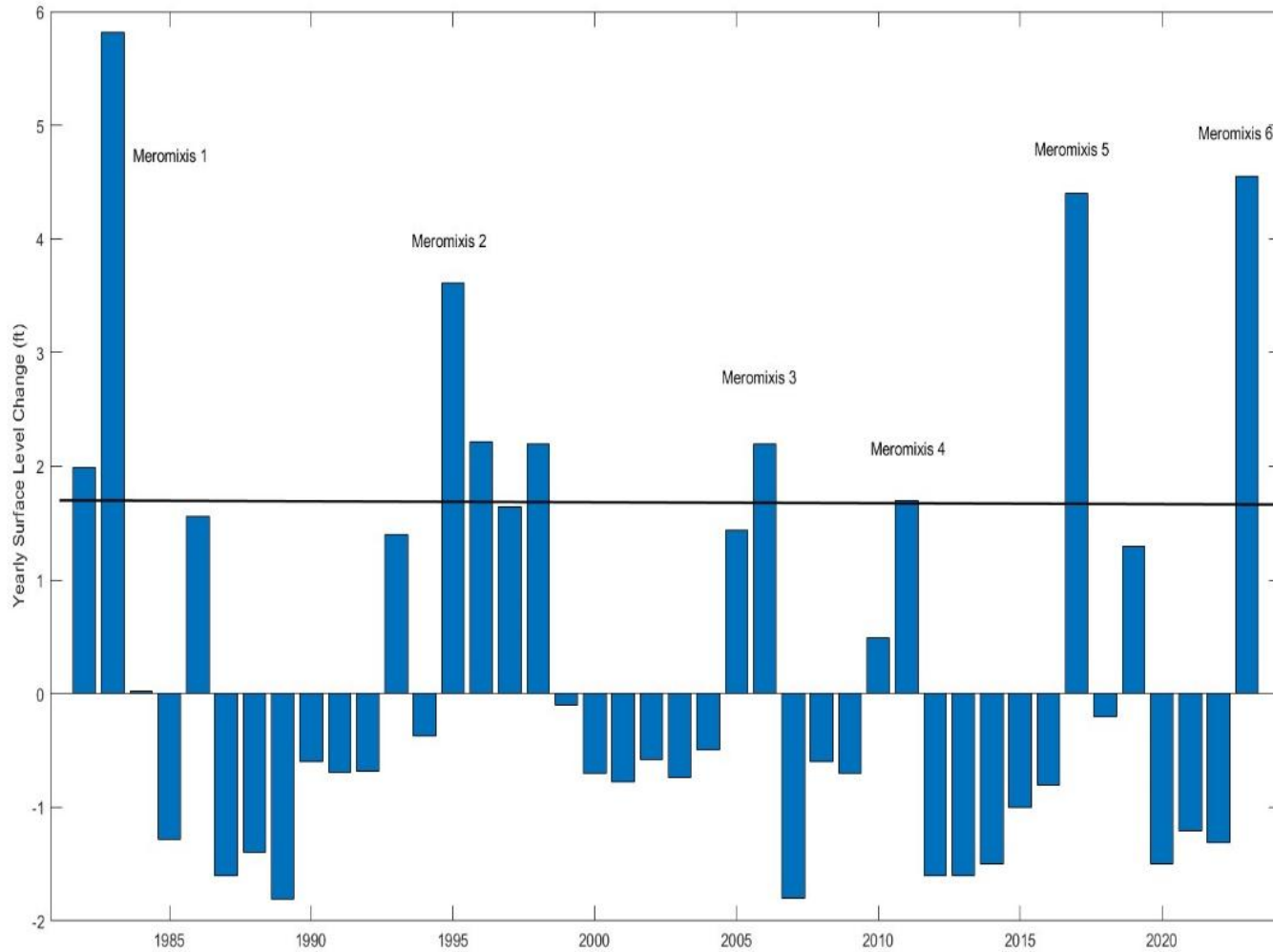


Lake elevation changes and episodes of persistent stratification (meromixis)



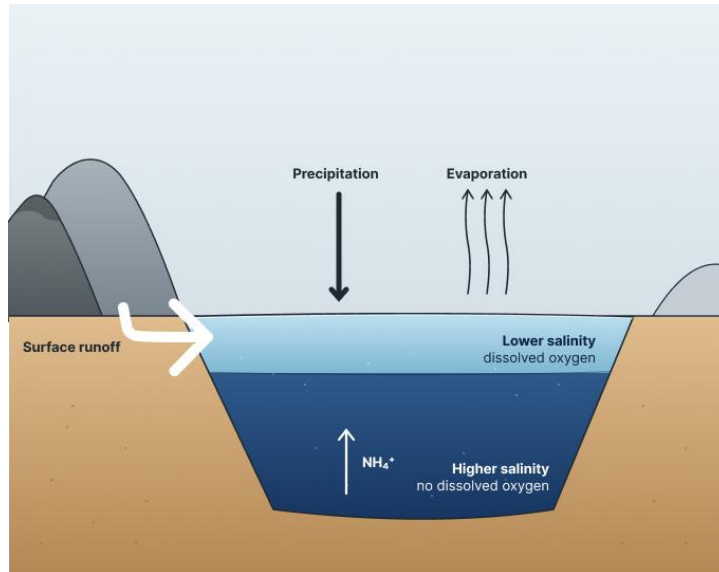
Straight lines indicate the duration of meromictic episodes

An annual increase in lake level greater than about 2 ft =
persistent stratification



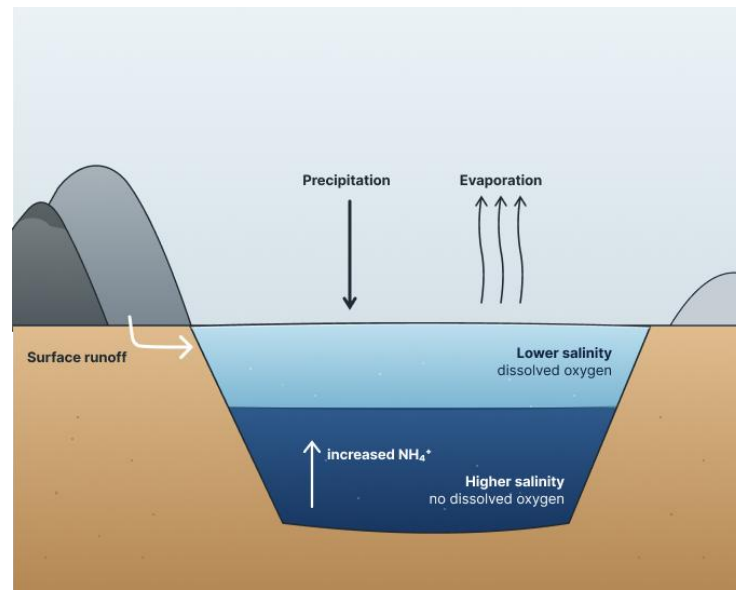
Sequences of chemical stratification after large runoff year

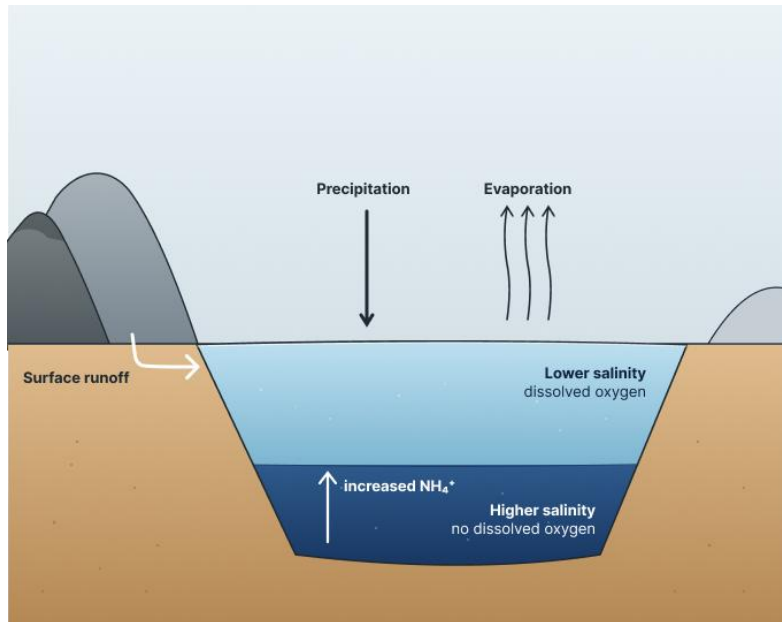
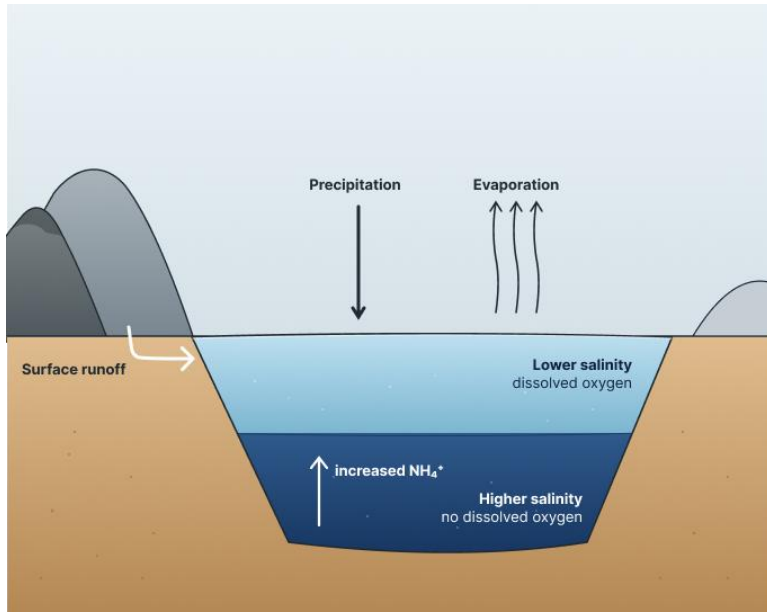
Conditions illustrated for winter period without thermal stratification



A. Dilute runoff reduces salinity of upper water, steep chemical gradient reduces vertical mixing leading to elevated ammonium and anoxia in deep water.

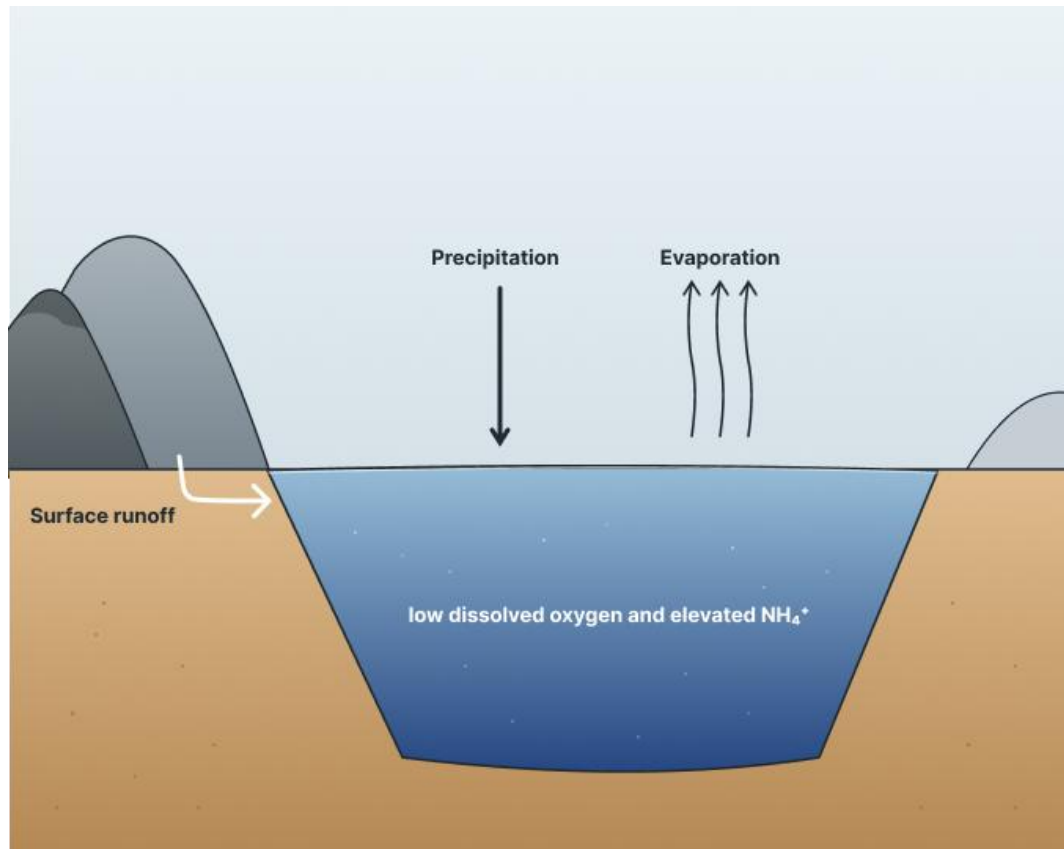
B. Evaporation of surface water and vertical mixing deepen upper less saline water. Deep water continues anoxic with increased ammonium.





C & D. Evaporation of surface water and vertical mixing continue to deepen upper water and reduce salinity gradient. Dissolved oxygen overlies larger area of sediments, increasing cyst hatching. Deep water continues anoxic with increased ammonium, but more supply of ammonium to upper water.

E. Combination of evaporation of surface water and vertical mixing destratifies lake leading to low dissolved oxygen and elevated ammonium throughout water. Higher ammonium enhances algal growth. Low dissolved oxygen stresses *Artemia*.



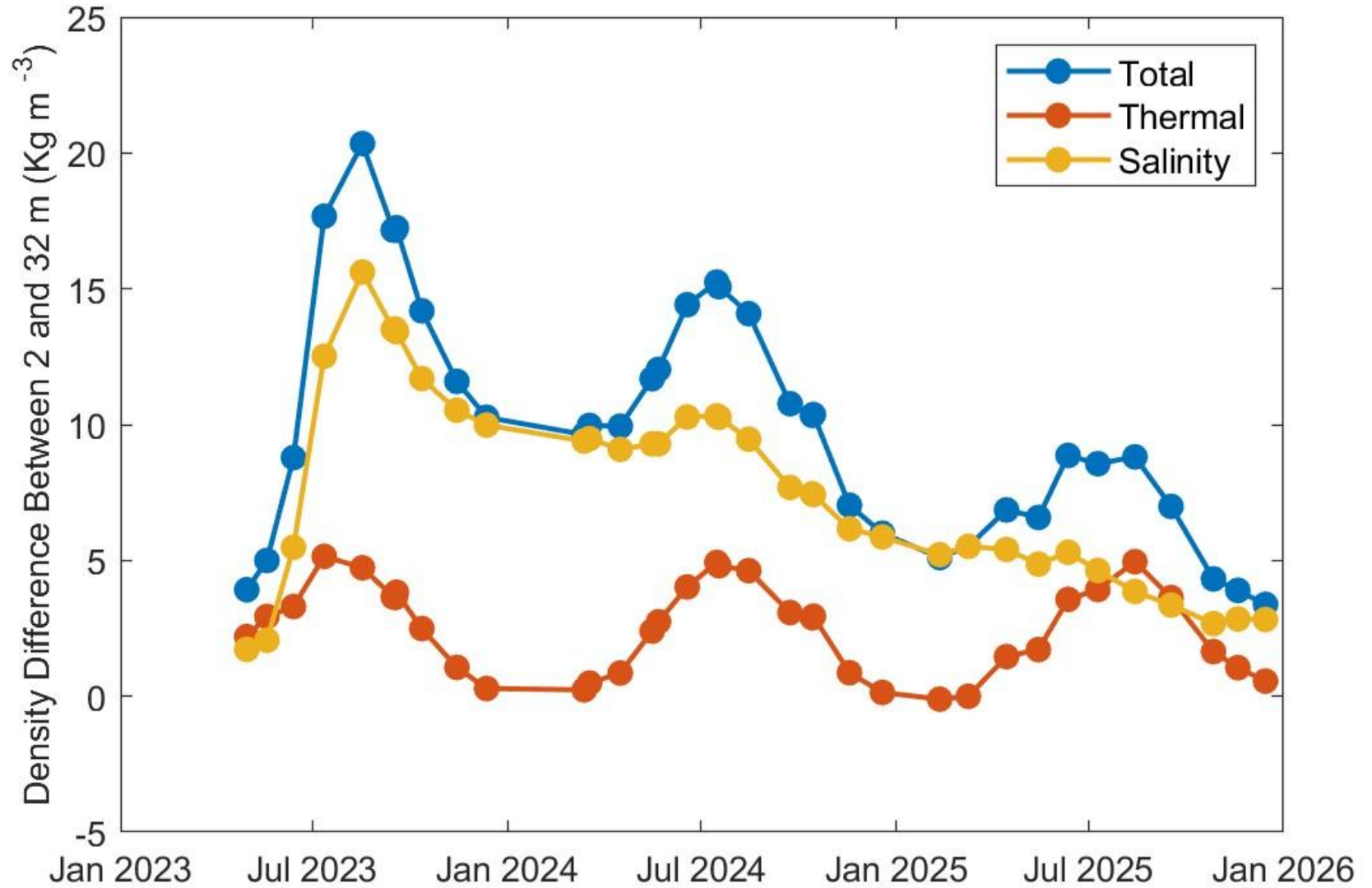
Recent conditions

Large snowmelt runoff in 2023 initiated a sixth episode of persistent stratification that has continued through 2024 and into 2026 with upper layer deepening.

Vertical profiles of ammonium, chlorophyll, and dissolved oxygen reflect the effects of strong temperature and salinity gradients

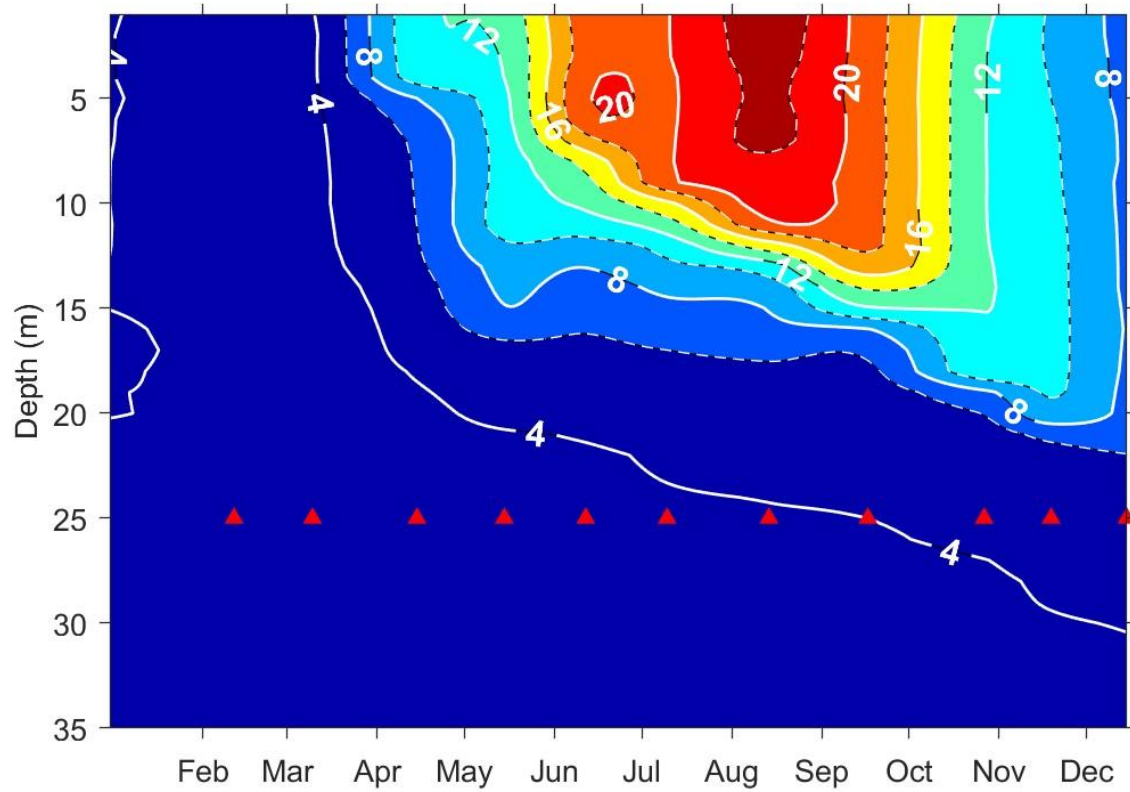
Low levels of chlorophyll and high transparency occurred throughout the summers

Density stratification between 2 and 32 m, 2023–2025

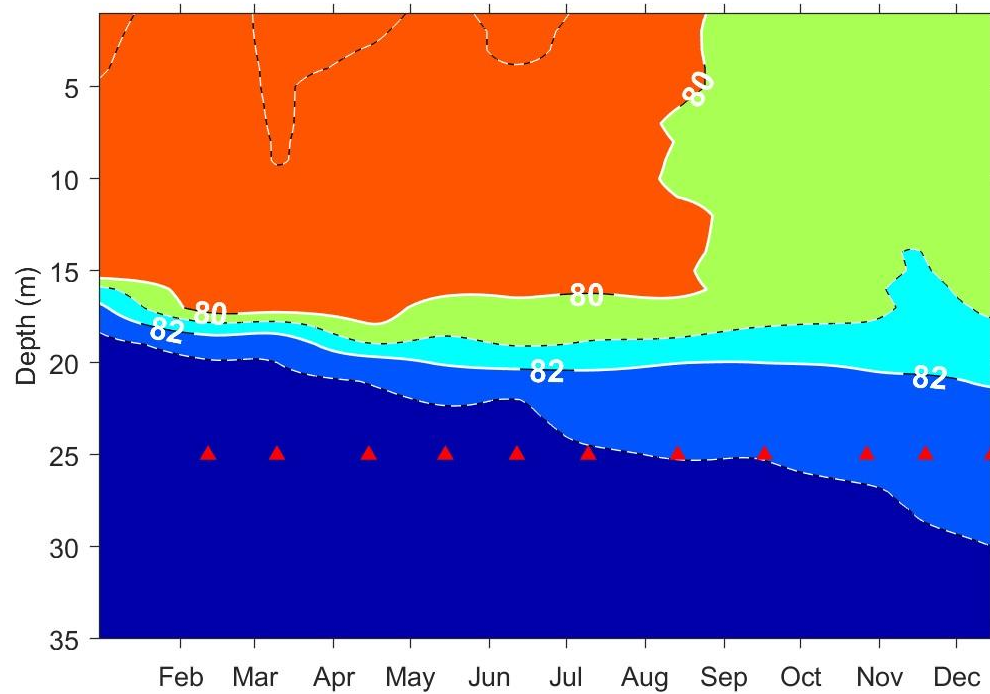


Temperatures ($^{\circ}\text{C}$) at Station 6, 2025

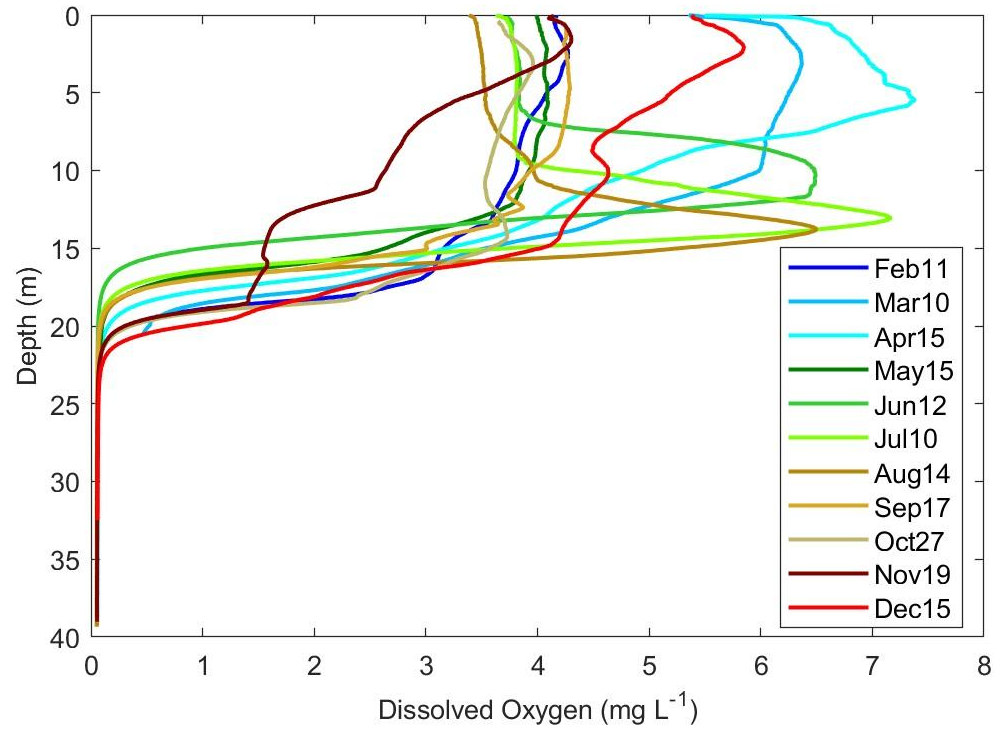
(red triangles indicate sampling dates)



Specific conductance (mS cm^{-1} at $25\text{ }^{\circ}\text{C}$) at Station 6, 2025

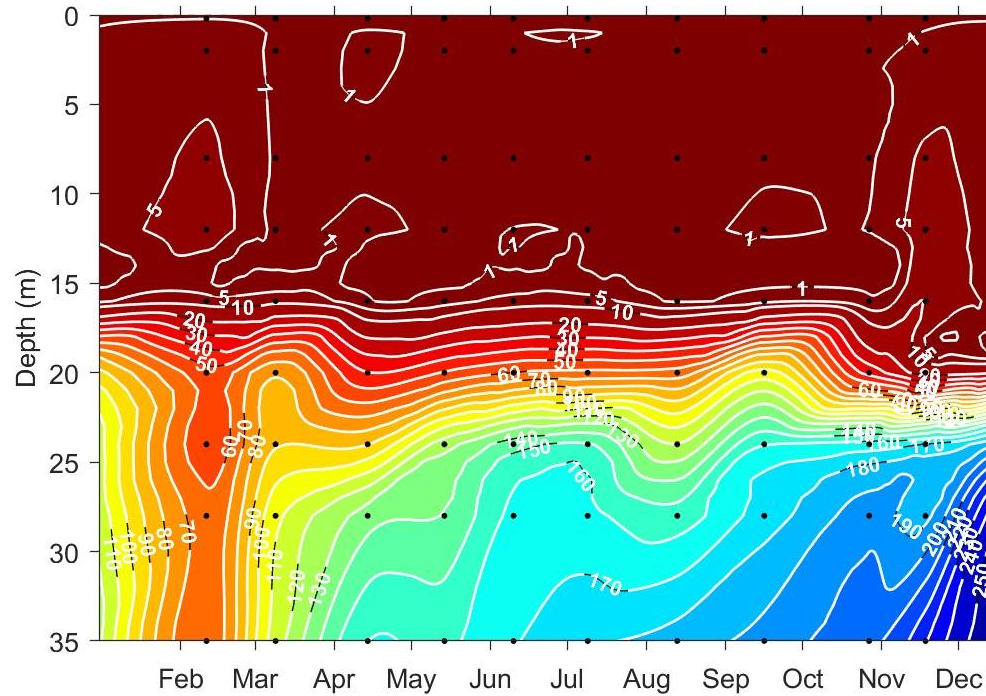


Seasonal dissolved oxygen at Station 6, 2025

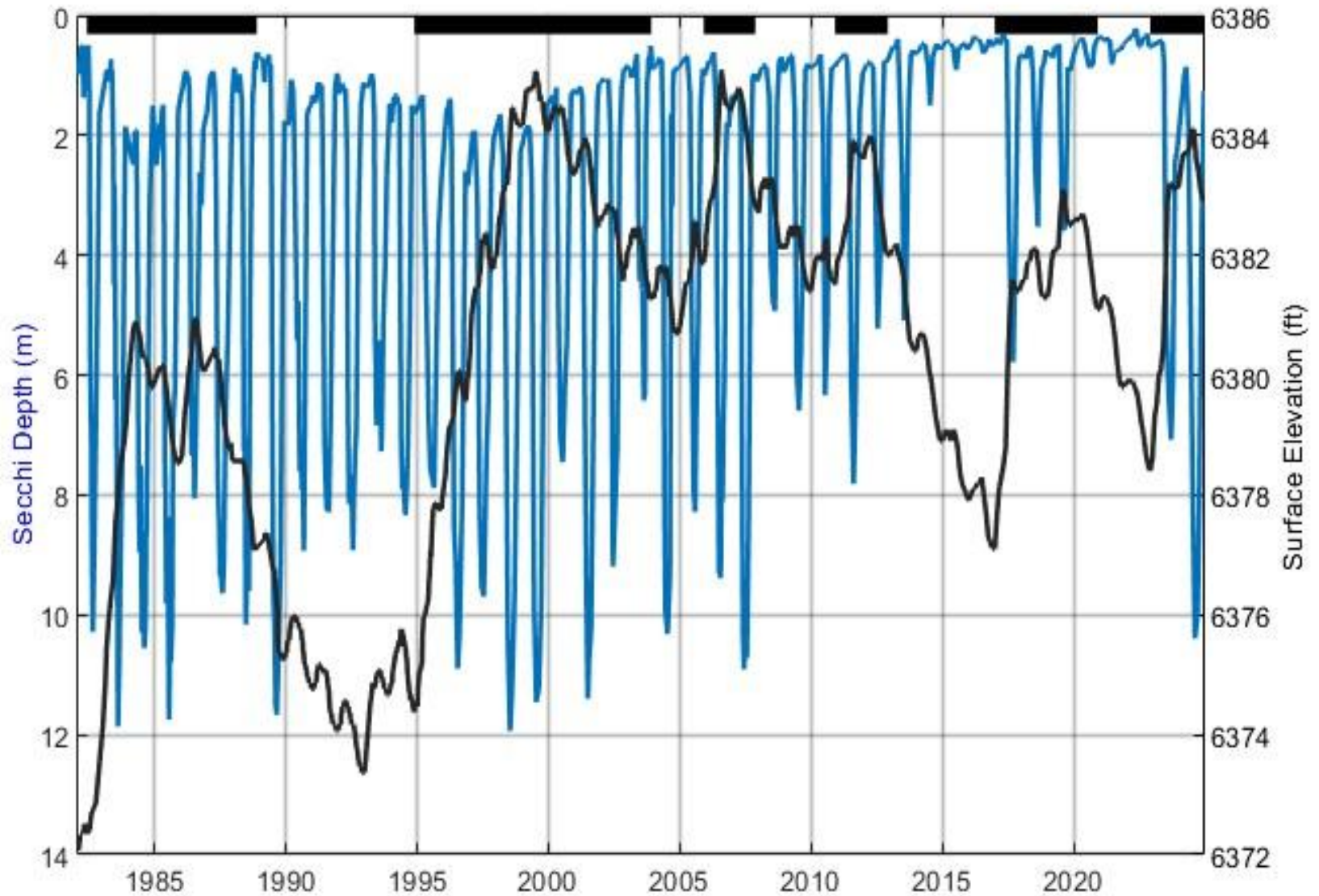


Ammonium at Station 6, 2025.

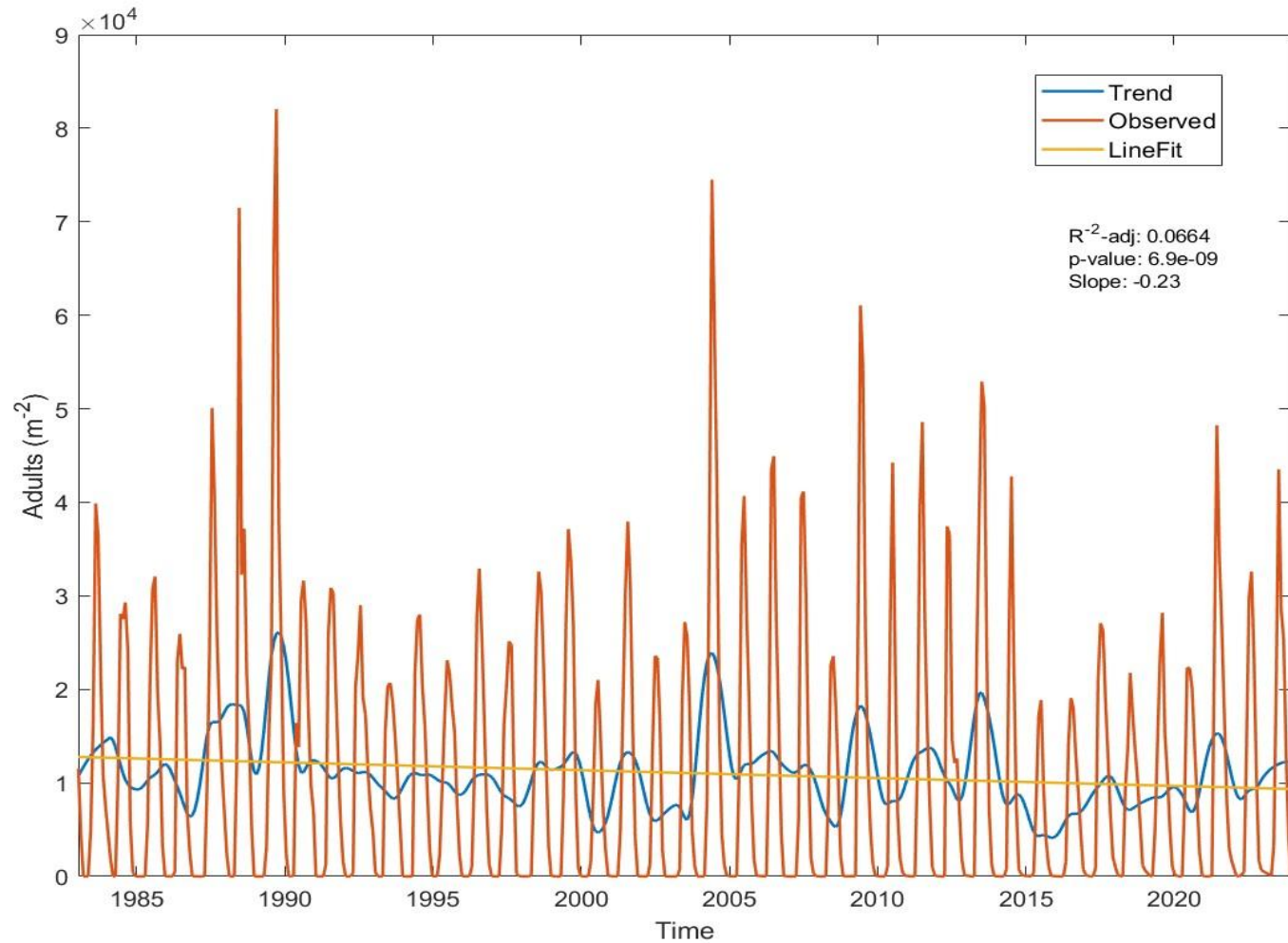
Isopleths, ammonium concentrations (μM)



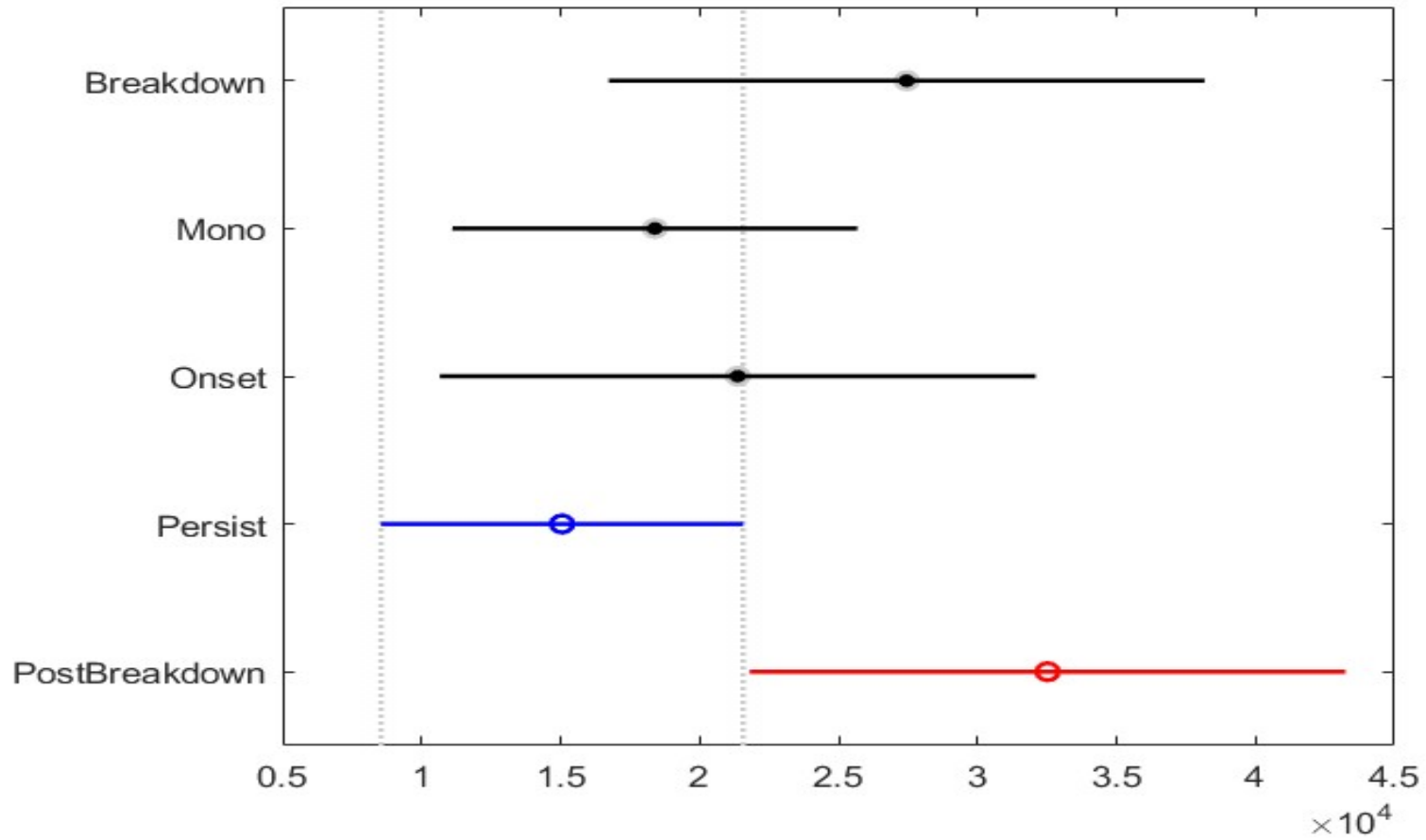
Transparency (Secchi depth, blue), lake elevation (black), and meromictic episodes (black bars), 1982–2024.



Long-term trend of adult *Artemia* with seasonal component removed

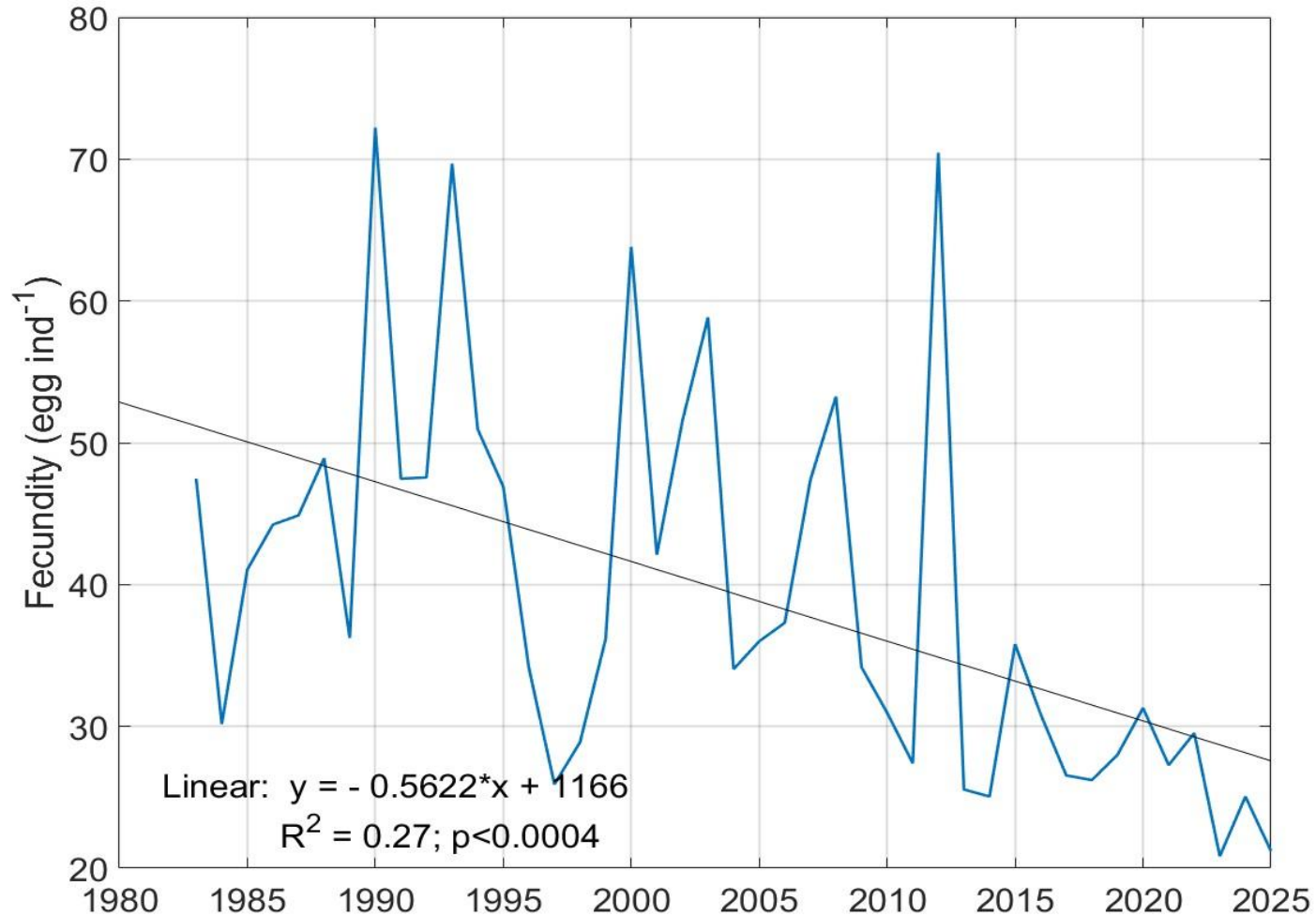


Mean spring (April–May) adult *Artemia* lakewide abundance during different mixing regimes

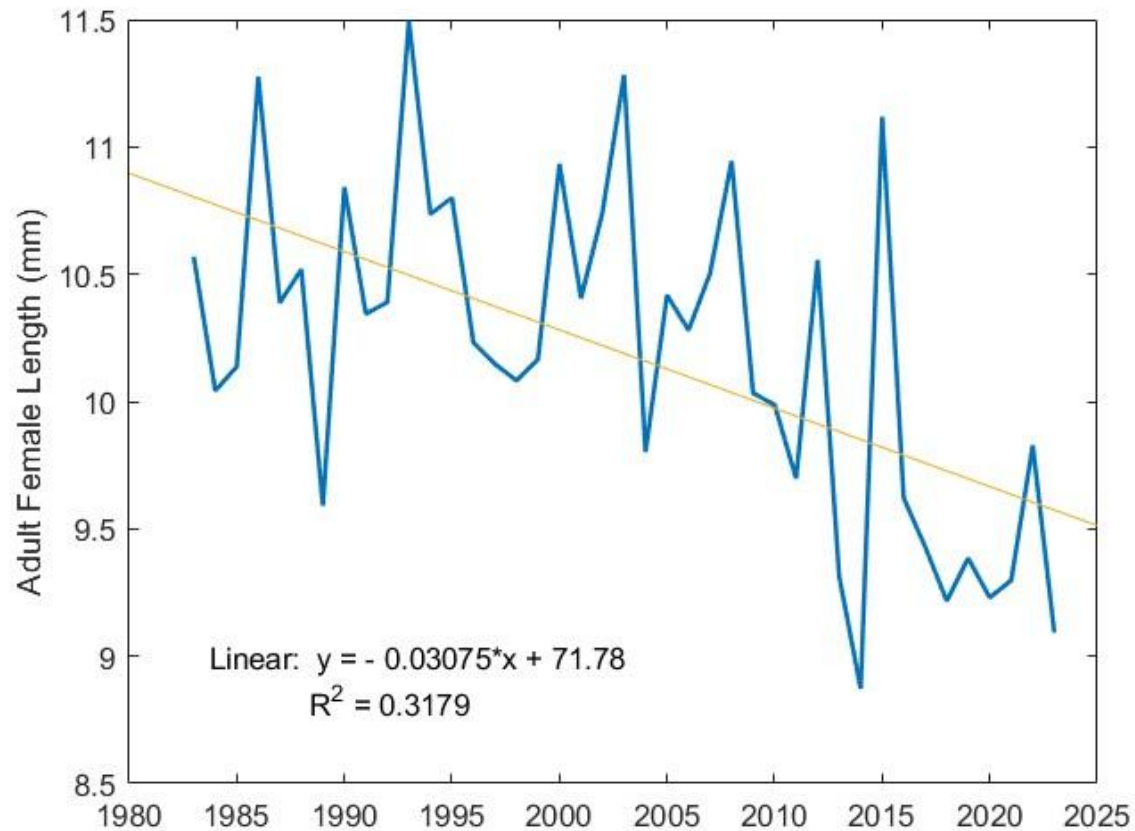


Mean abundance-weighted fecundity of ovigerous females (1983–2025)

Significant decrease and reduced variability in recent years



Time series of adult female length indicates high variability and trend toward shorter females



Key trends in *Artemia*

40% decrease in annual production of over-wintering cyst

42% decline in abundance-weighted fecundity

11% decrease in adult female length

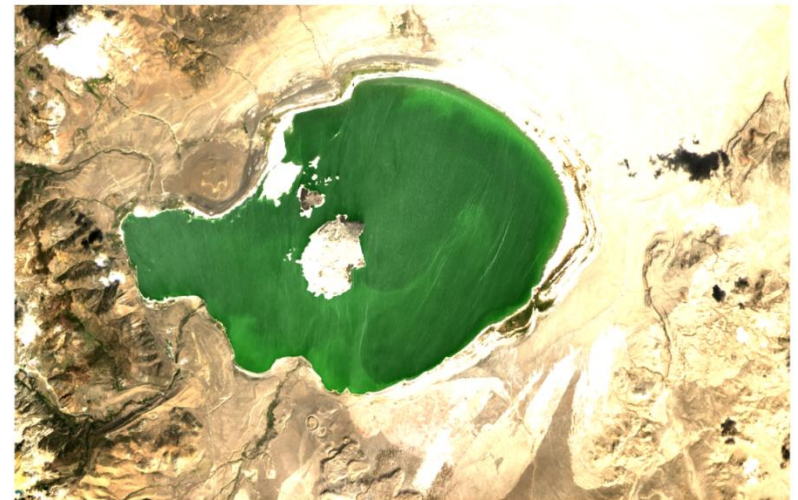
Smaller adult mean abundance in May–June values during meromictic compared to post-meromictic years

Key trends and anomalies in transparency and phytoplankton

Greater transparency and lower phytoplankton abundance typical of meromictic episodes

Low midsummer transparencies and high phytoplankton abundance (2014–2016; 2020–2022) had not been observed from 1979 to 2013 or 2023 to 2025.

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At higher lake levels, likelihood of meromixis
and length of meromictic periods decrease
because more water is required to raise level
and salinity gradient is less

Lake level change ft asl	Lake volume change km ³	Salinity gradient g/L
6392 to 6394	0.1214	4.85
6382 to 6384	0.1118	6.03
6372 to 6374	0.0932	6.82

Salinity gradient computed by adding volume to upper water (top 33 ft) and expressing as salinity difference with water below (undiluted salinity).

At current range of lake levels
episodes of persistent stratification will continue to
cause –

periods of reduced algal abundance

decreased Artemia fecundity

lack of dissolved oxygen in deep water

reduced Artemia cyst hatching

altered periods of peak Artemia abundance
with consequences for birds