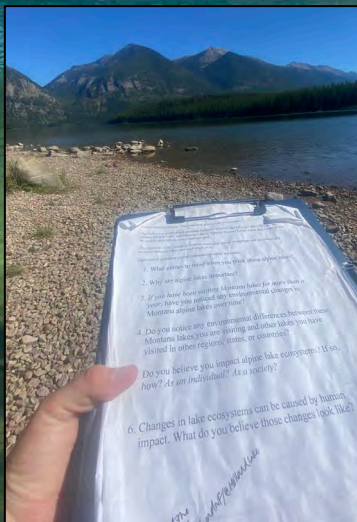


An Interdisciplinary Approach to Understanding Ecosystem Processes and Human Perceptions of Montana's Mountain Lakes

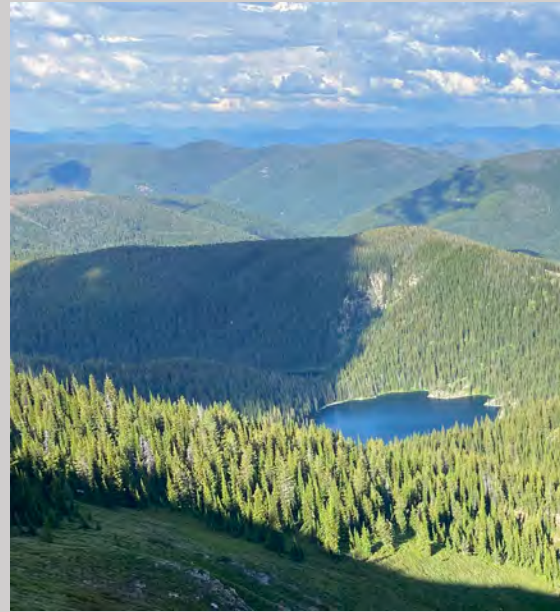
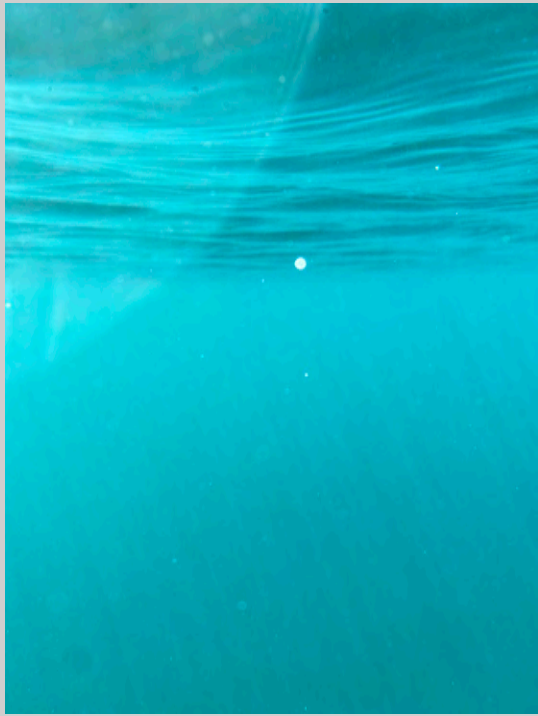
Carly Innis
University of Montana
MS Resource Conservation
Global Climate and Ecology Lab



Background

- Changes in mountain lake ecosystems cause shifts in ecological processes
- Metabolism is an indicator of ecosystem health
 - GPP- Gross primary productivity
 - ER- Ecosystem respiration
 - NEP- Net ecosystem productivity
- There is variability in ecological processes throughout lakes
 - Littoral zone- nearshore interface for ecological processing
 - Pelagic zone- mid-lake open water





Questions

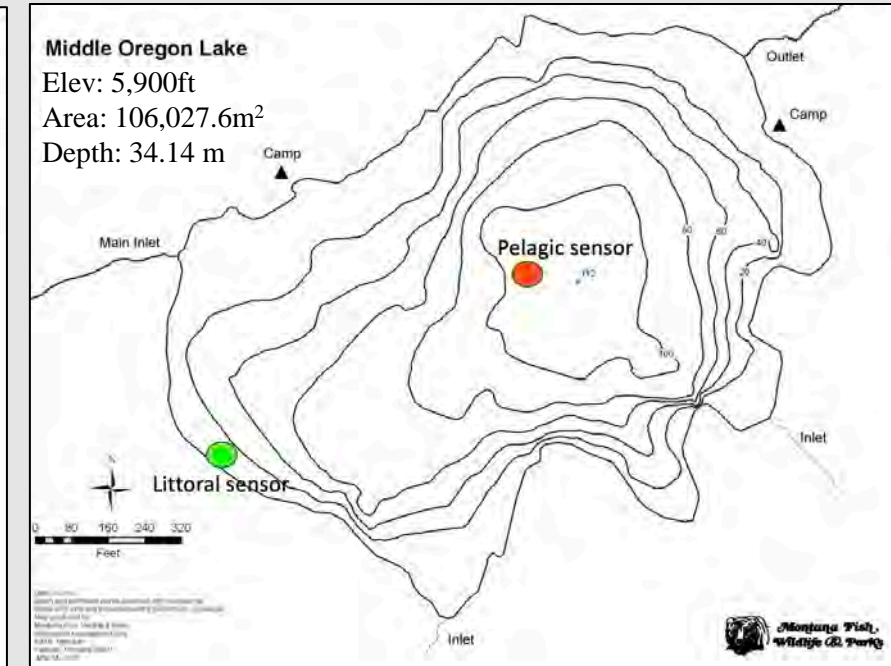
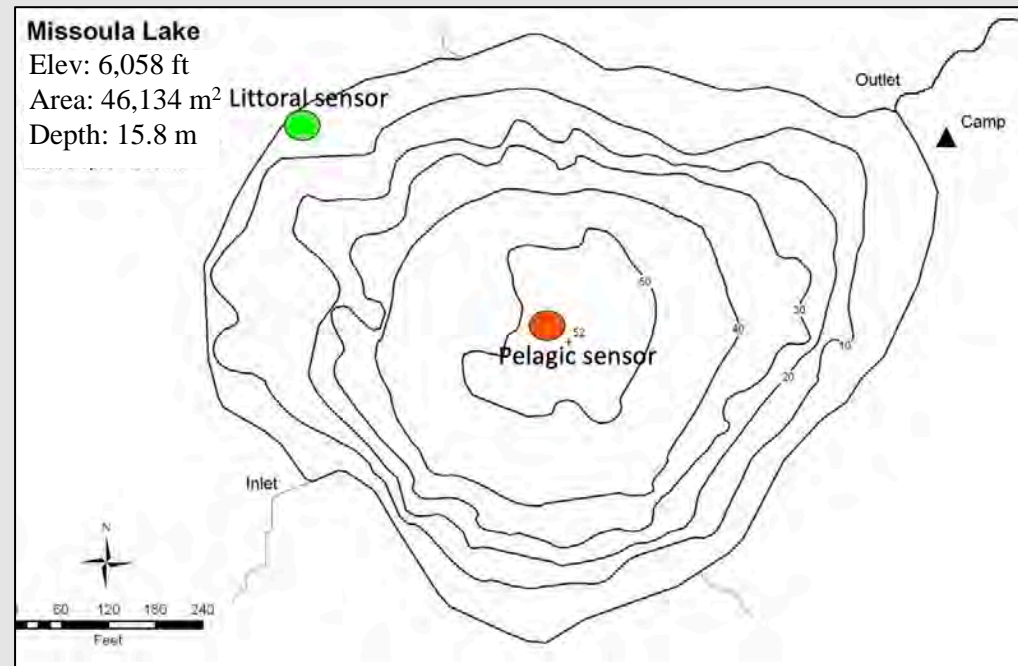
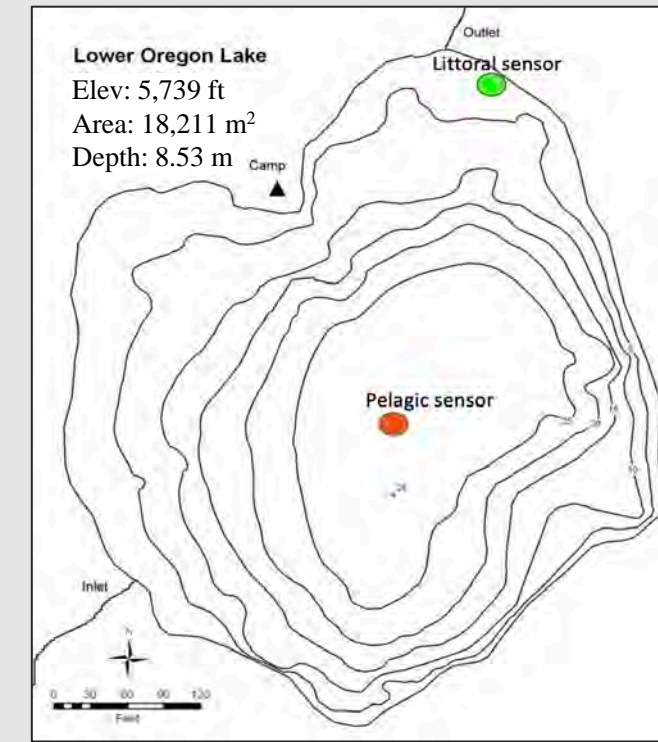
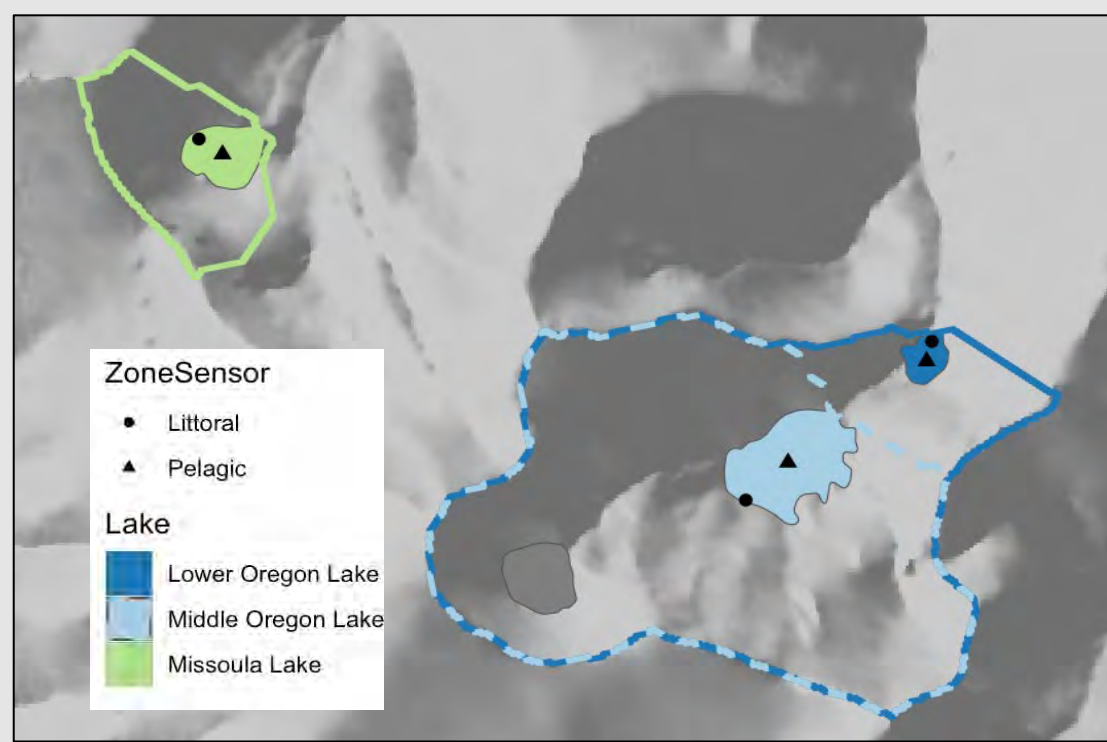
Q1: How much variation exists between littoral and pelagic metabolism in mountain lake ecosystems?

Q2: What environmental differences induce variation in the balance of littoral and pelagic metabolism?

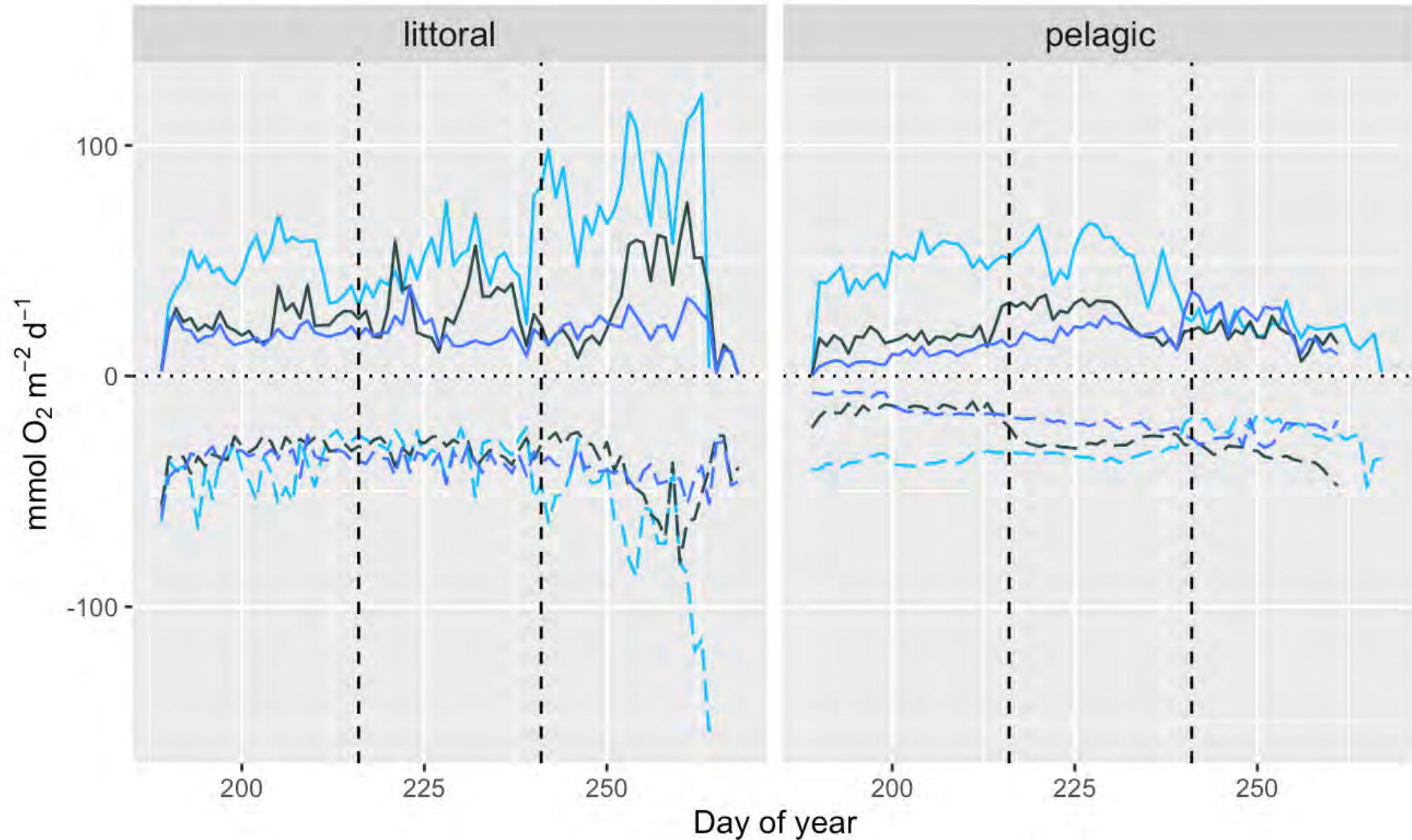


Our study

- Three sites
 - Two sensors
 - Littoral
 - Pelagic
- Measured
 - Dissolved oxygen
 - Temperature
 - Light
 - Chemistry
- Modeled
 - GPP
 - ER
 - NEP
 - Predictors

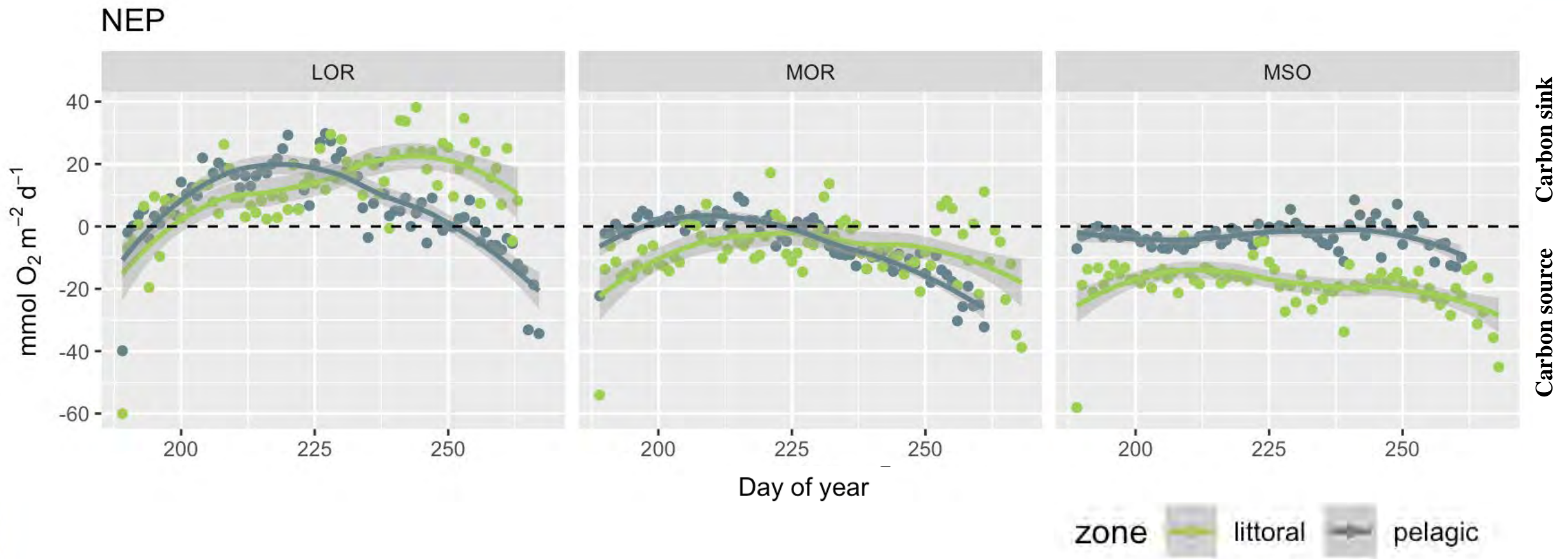


GPP and ER



- Overall more variability in the littoral zone of all lakes
- Differences between the zones, especially in GPP
- Much less variation in ER between zones and between lakes

Process -- ER — GPP **lake** — LOR — MOR — MSO
Lower Oregon Middle Oregon Missoula Lake



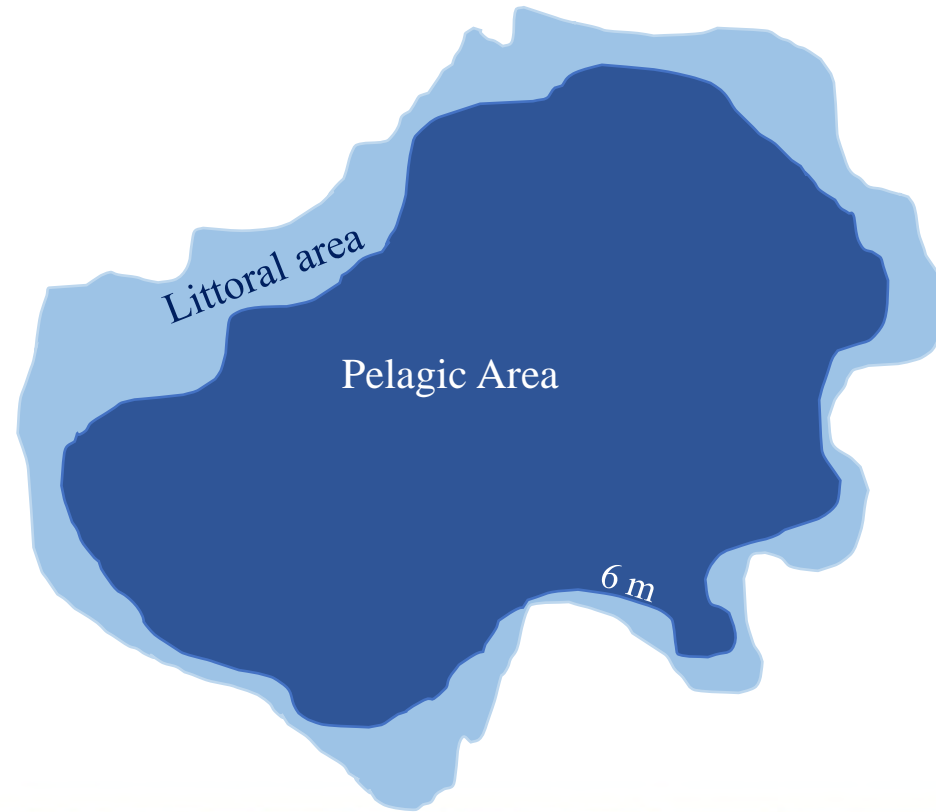
- Variation across lakes in NEP and trophic status
- LOR and MOR littoral and pelagic zones reverse
- MSO constantly more heterotrophic in the littoral

Designating zone areas:

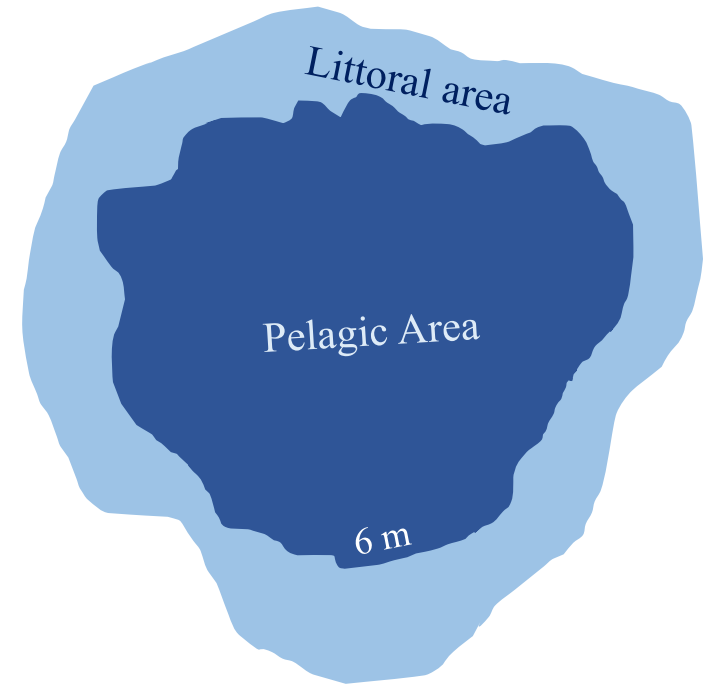
Defined boundary at 6 meters



Lower Oregon Lake

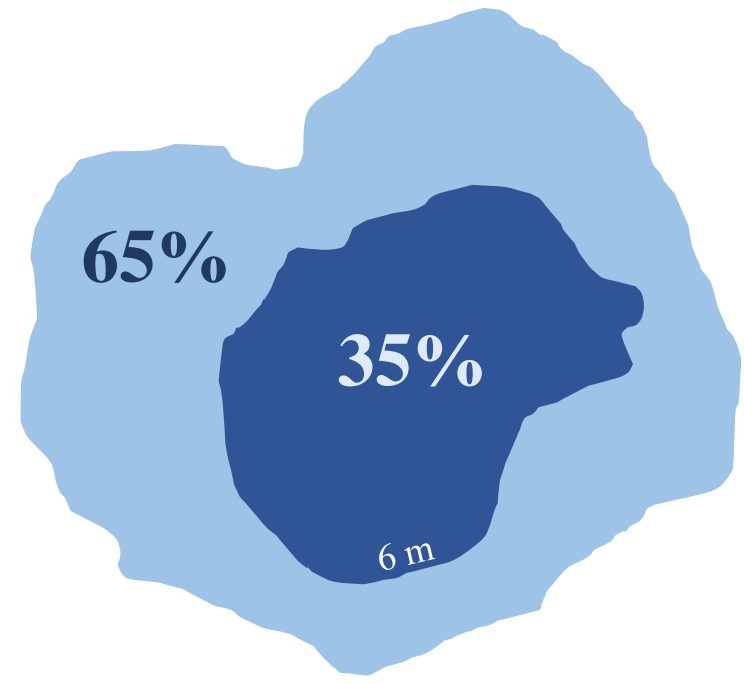
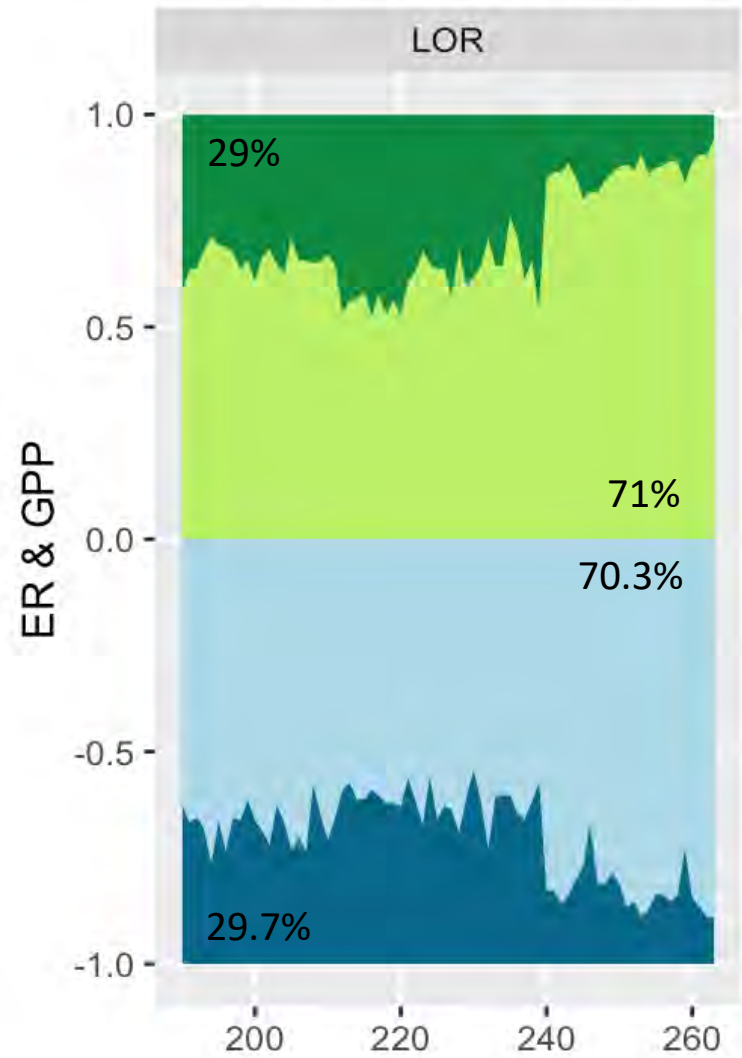


Middle Oregon Lake



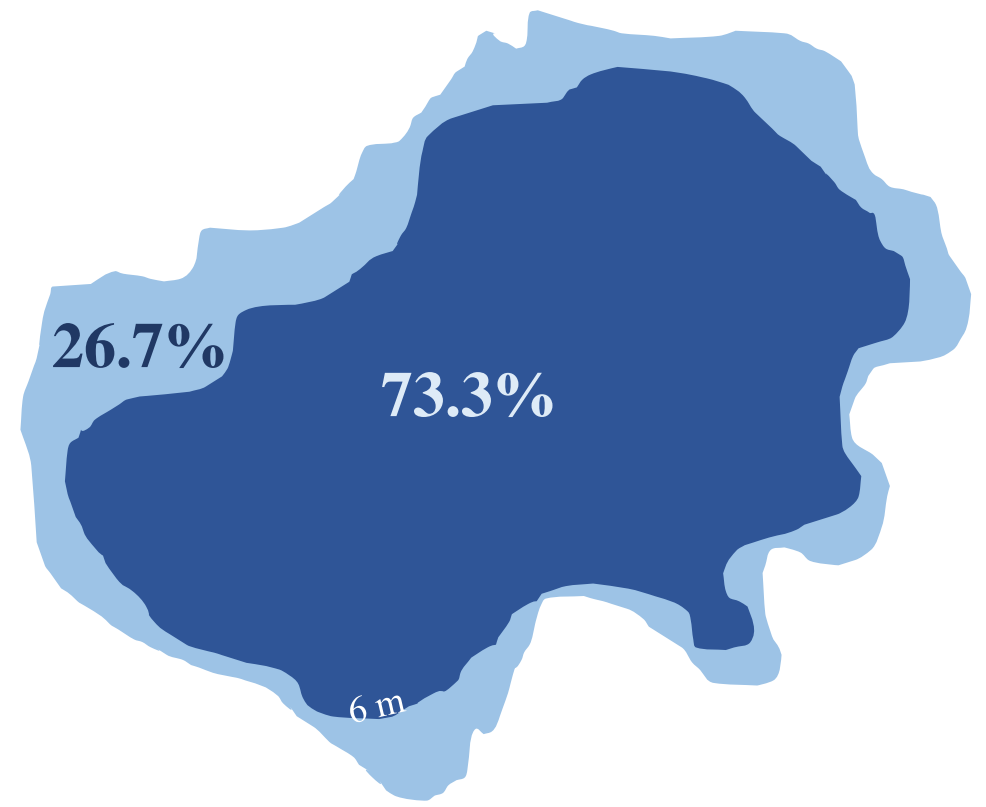
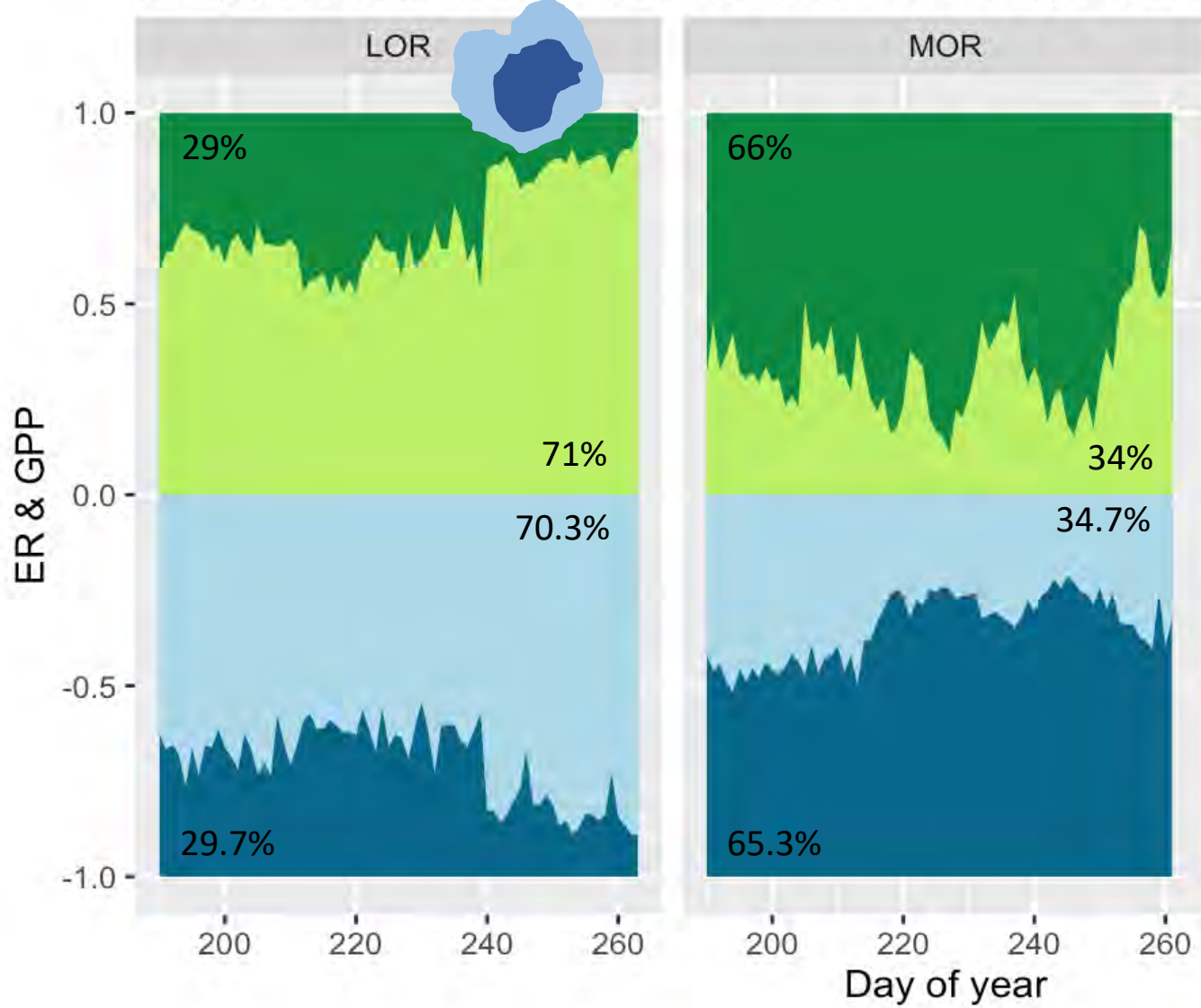
Missoula Lake

Daily proportions of total lake metabolism by zone



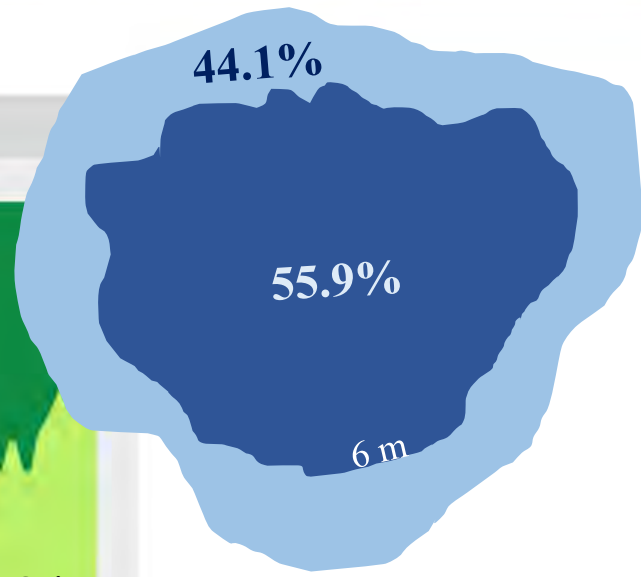
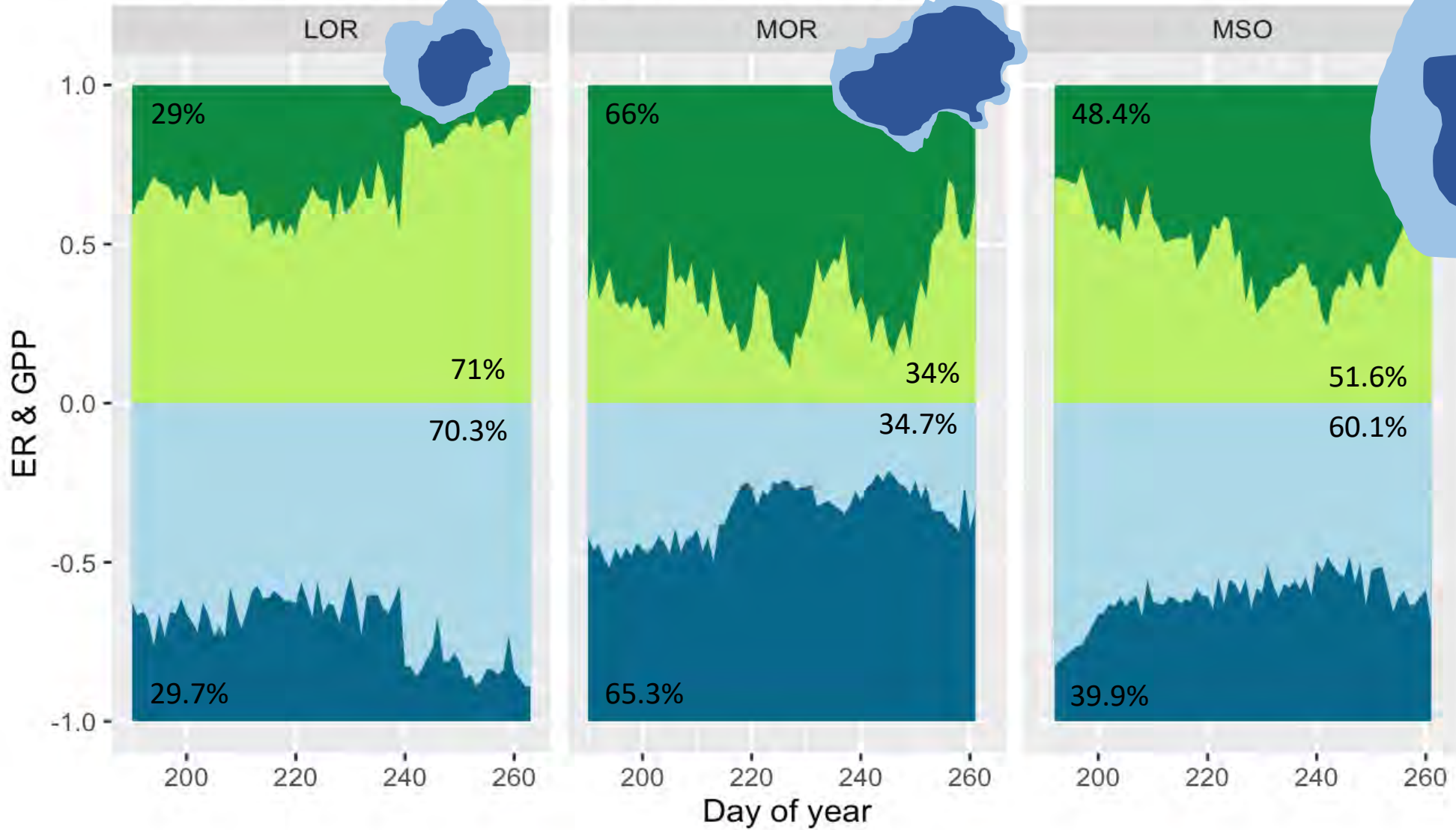
Zone metabolism ■ Littoral GPP ■ Pelagic GPP ■ Littoral ER ■ Pelagic ER

Daily proportions of total lake metabolism by zone



Zone metabolism ■ Littoral GPP ■ Pelagic GPP ■ Littoral ER ■ Pelagic ER

Daily proportions of total lake metabolism by zone

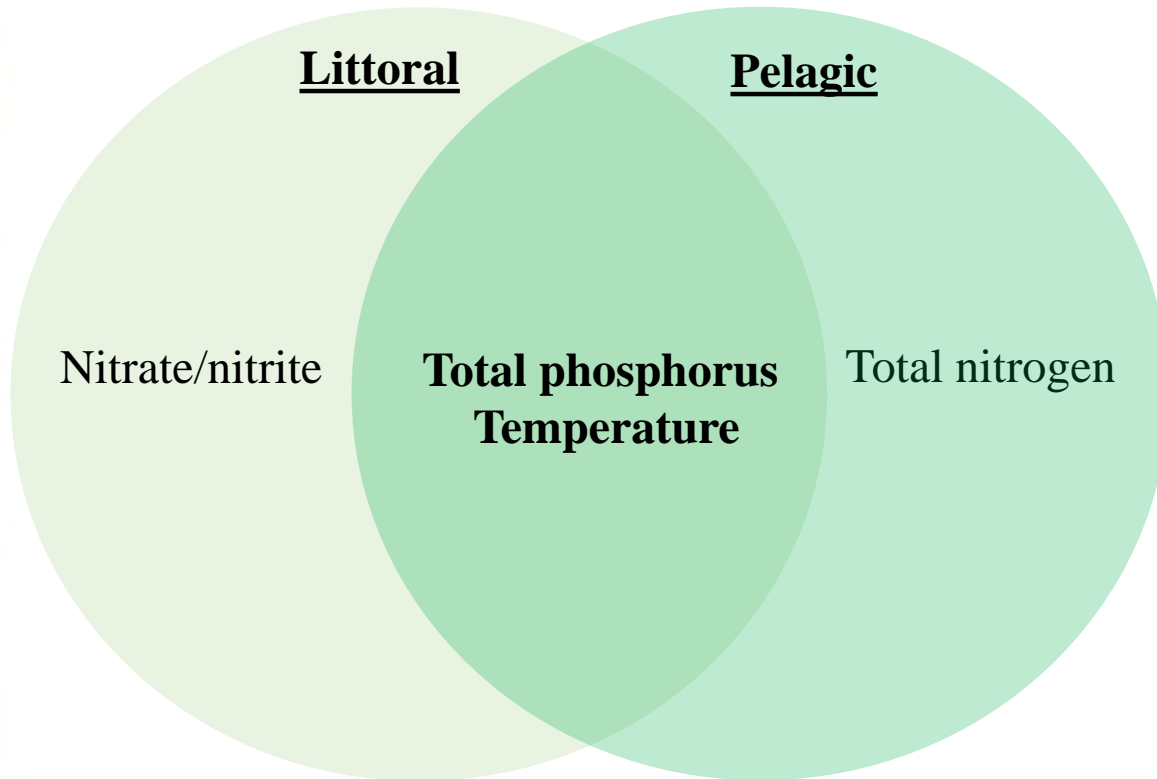


- Depending on lake morphology, zone contribution to whole-lake GPP and ER varies
- Measuring in just one zone is an insufficient representation of the whole system

Zone metabolism
■ Littoral GPP
■ Pelagic GPP
■ Littoral ER
■ Pelagic ER

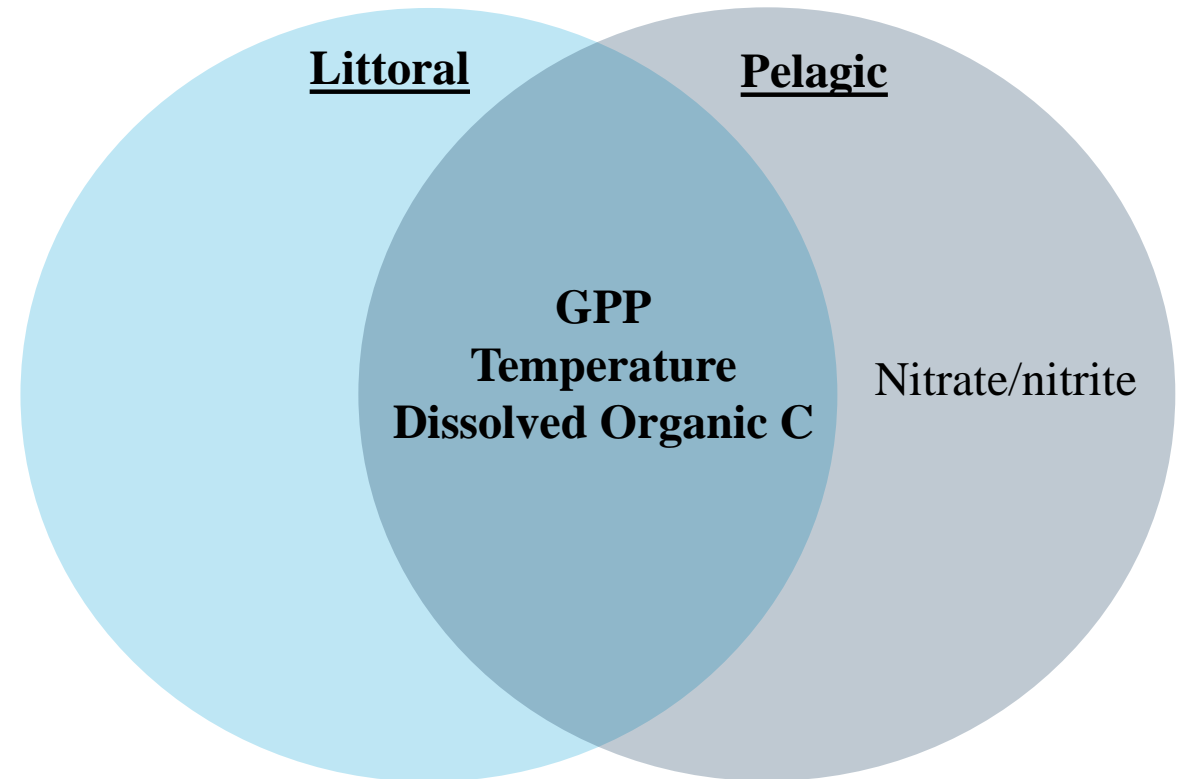
Why the variability? Analysis of predictor variables

Gross Primary Productivity



- Nitrogen and phosphorus are most significant predictors in both zones
- Nutrients are more significant predictors than temperature

Ecosystem Respiration



- DOC is a more significant predictor in the pelagic zone
- GPP is a more significant predictor in the littoral zone

Ecology summary

- Variability in GPP, ER, and NEP between littoral and pelagic zones in lakes
- Chemical predictors are more significant than temperature
- **It matters where you measure!**
- **Different zones and lakes will be disproportionately susceptible to environmental change; therefore, it is important to consider such variability in management and conservation initiatives...**

...but what does this have to do with people??

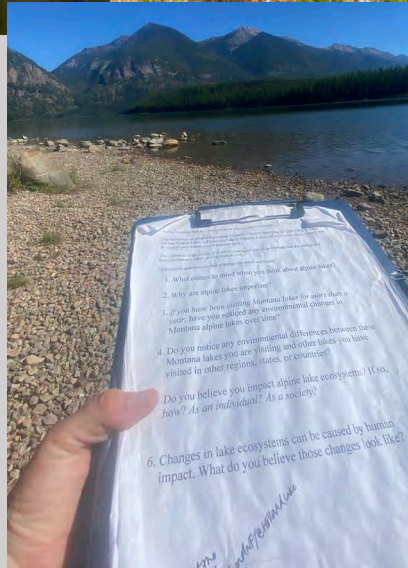
Littoral zone: An interface for ~~ecological processing~~ direct human interaction



Why are mountain lakes important?

“For the ecosystem, **I have no idea.**”

How do human perceptions of mountain lake ecosystem services, functions, and change align with the ecology?



Public intercept surveys:

- Two-part surveying
 - Open-ended, interview questions
 - Survey questions
- Two locations where people recreate at lakes
 - Missoula Lake
 - Holland Lake
- Responses
 - 50 total group survey responses
 - 130 participants engaged

Do you notice any environmental differences between these Montana lakes you are visiting and other lakes you have visited in other regions, states, or countries?

“It just seems to me that people here in Montana try to take care of things a little better”

“Water in Montana is a lot cleaner and a lot clearer”

“Well lakes in Montana just seem more clean and fresh to me”

“Prettier in Montana. Colder in Montana than other more southern lakes”

“We think that people tend to maybe respect the pack in, pack out in Montana a little bit better”

Do you notice any environmental differences between these Montana lakes you are visiting and other lakes you have visited in other regions, states, or countries?

Holland Lake References:

Yes, differences noticed: n= 91

No, no differences noticed: n = 3

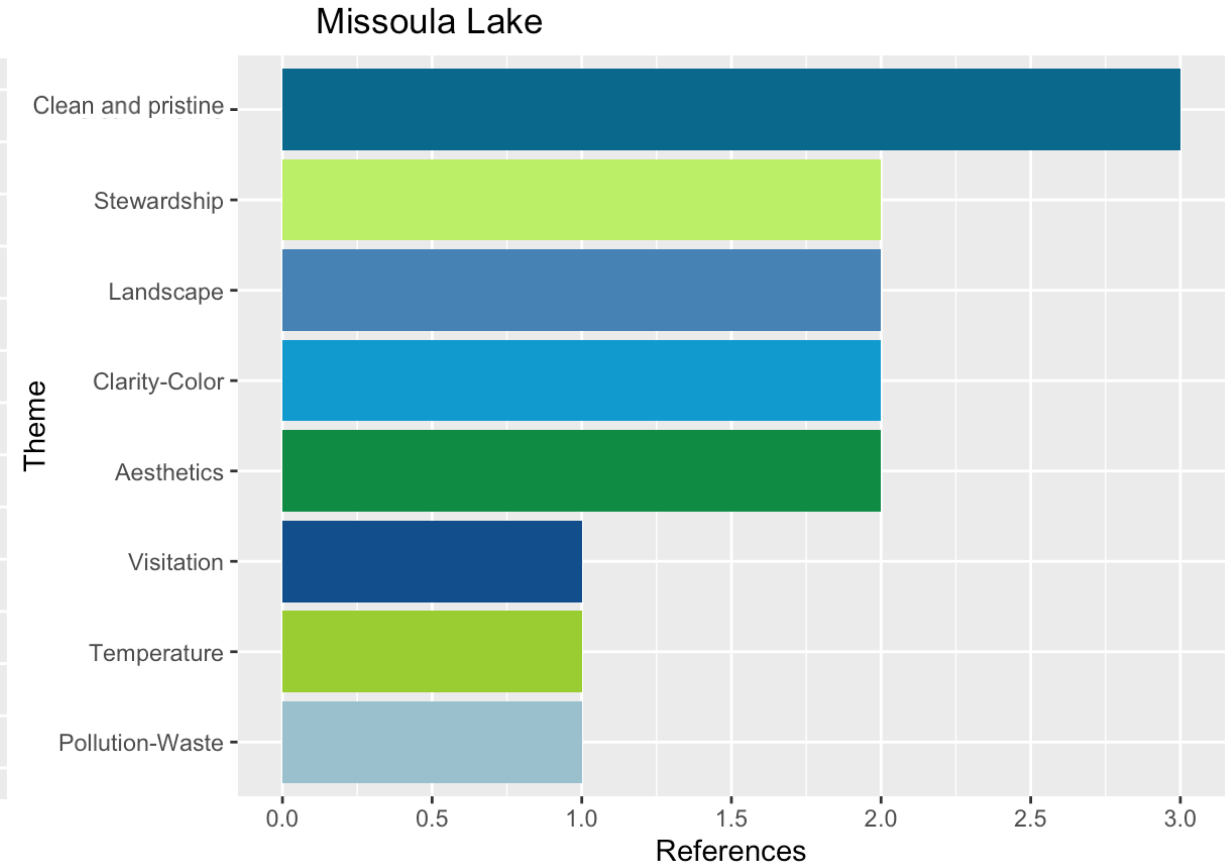
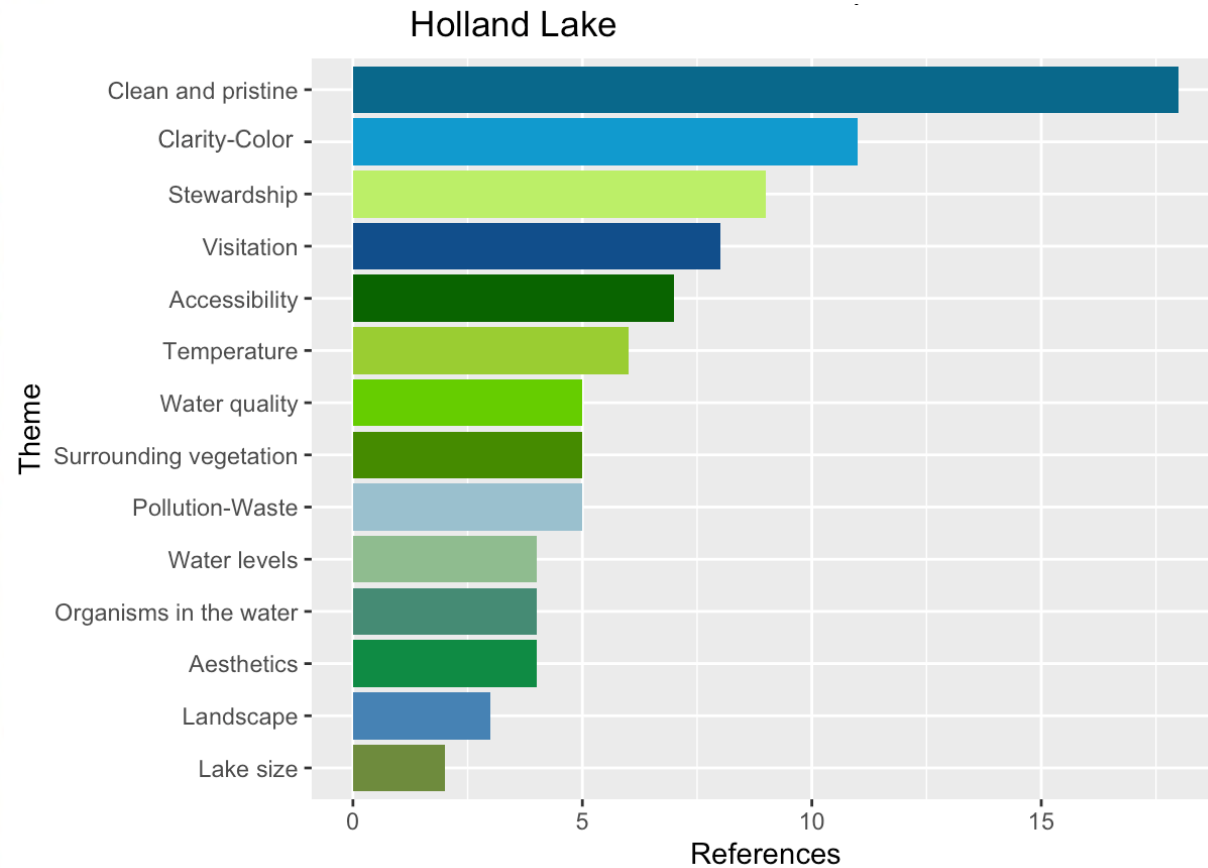
Not applicable: n= 3

Missoula Lake References:

Yes, change noticed: n= 14

No, no changes noticed: n = 3

Not applicable: n= 2



If you have been visiting Montana lakes for over a year, have you noticed any environmental changes in Montana alpine lakes over time?

“No. I’m actually struck by how pristine they seem.”

“I noticed here [at Holland Lake], more parts getting lily pads and lots of dust covering rocks in the lake.”

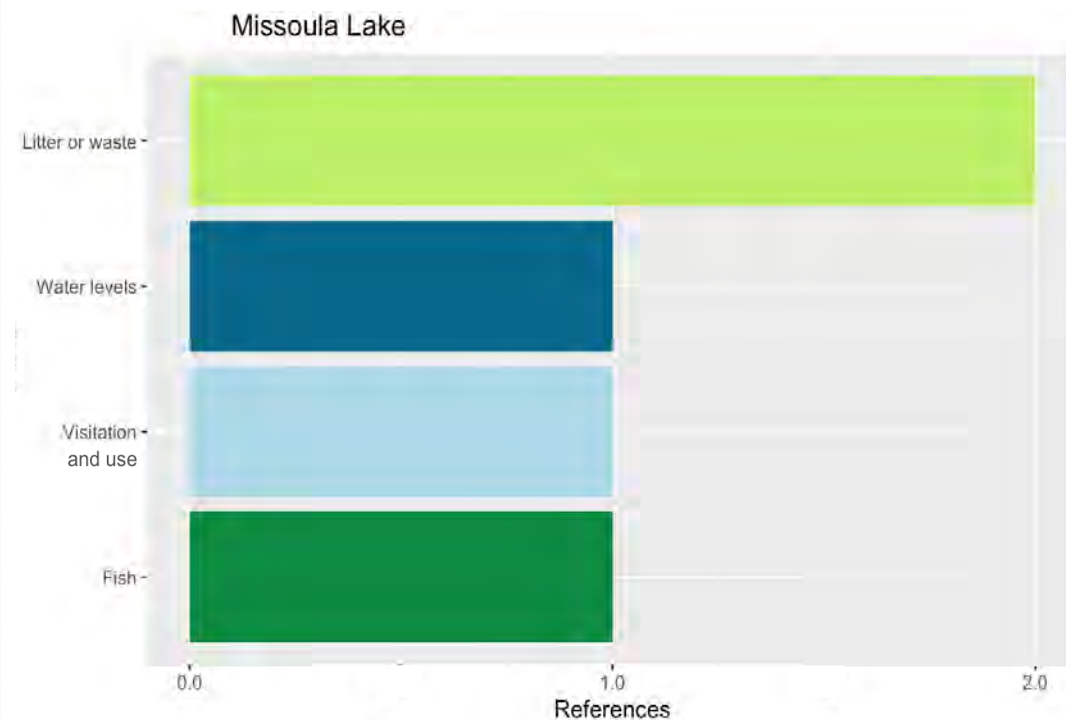
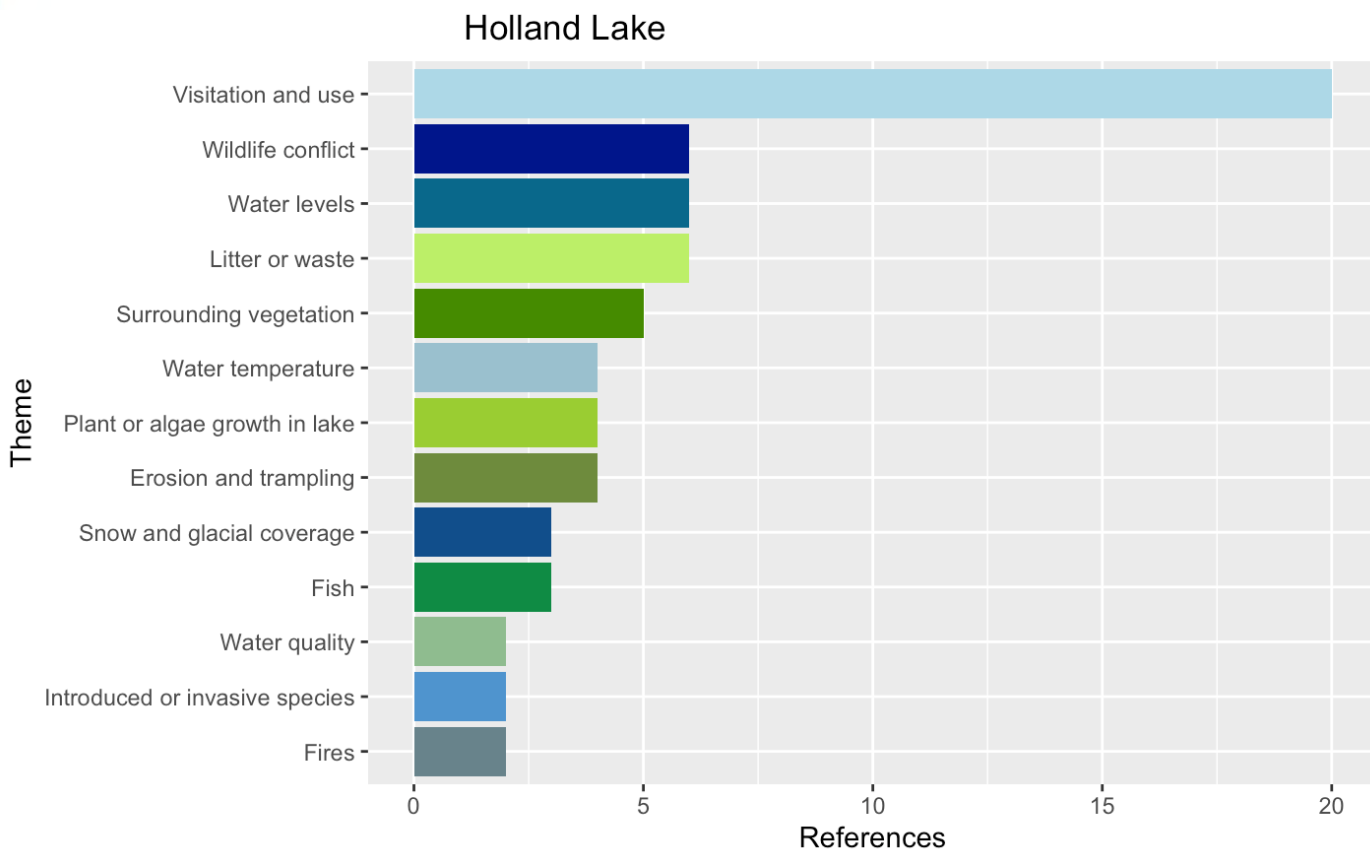
“Just a lot more people.”

“They’re getting warmer.”

“Overuse. That’s for a lot of them, a lot are being pounded.”

“What I have noticed is just with the lower elevation in this kind of area is the water is starting to turn green and I think the temperatures are maybe going up.”

If you have been visiting Montana lakes for over a year, have you noticed any environmental changes in Montana alpine lakes over time?



Holland Lake References:

Yes, change noticed: n= 61

No, no changes noticed: n = 8

Not applicable: n= 8

- Increases in visitation and use
- Increased problems with litter and/or waste

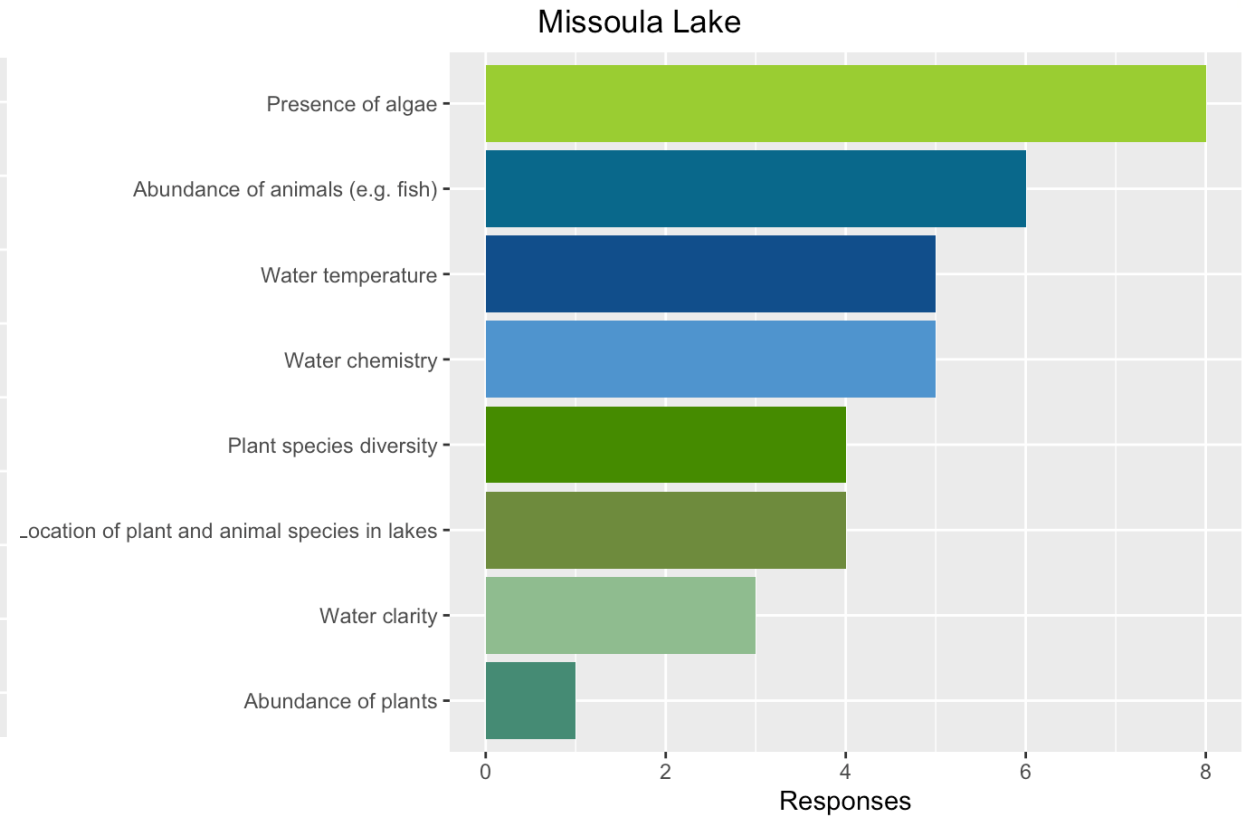
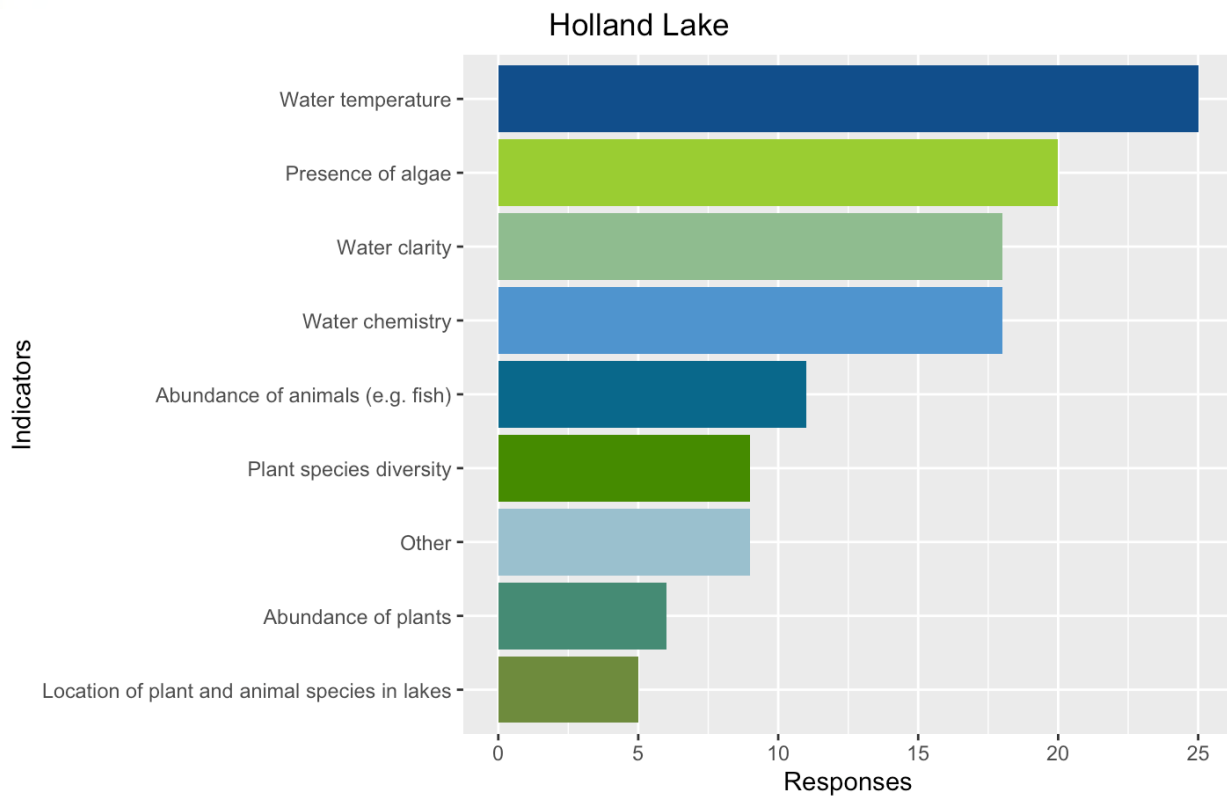
Missoula Lake References:

Yes, change noticed: n= 5

No, no changes noticed: n = 5

Not applicable: n= 2

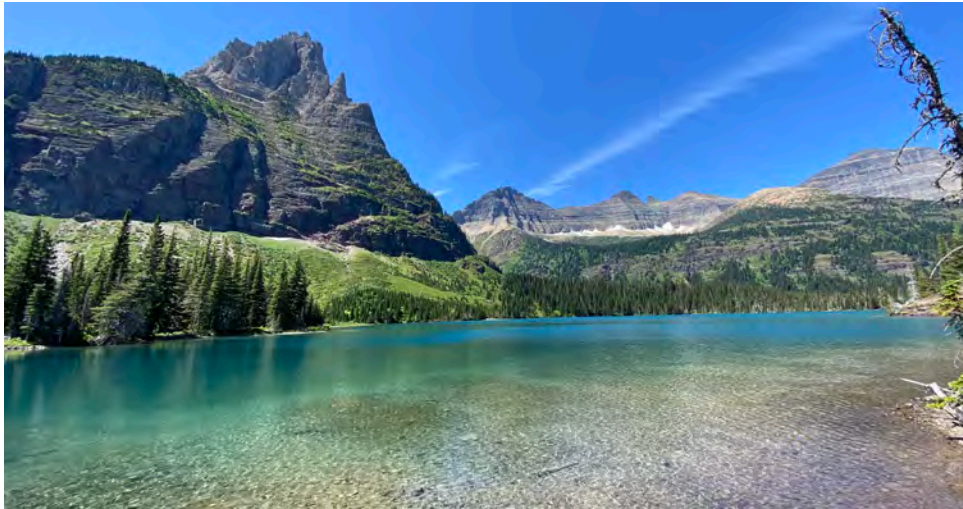
In your opinion, what are the top three indicators of environmental change in lakes?



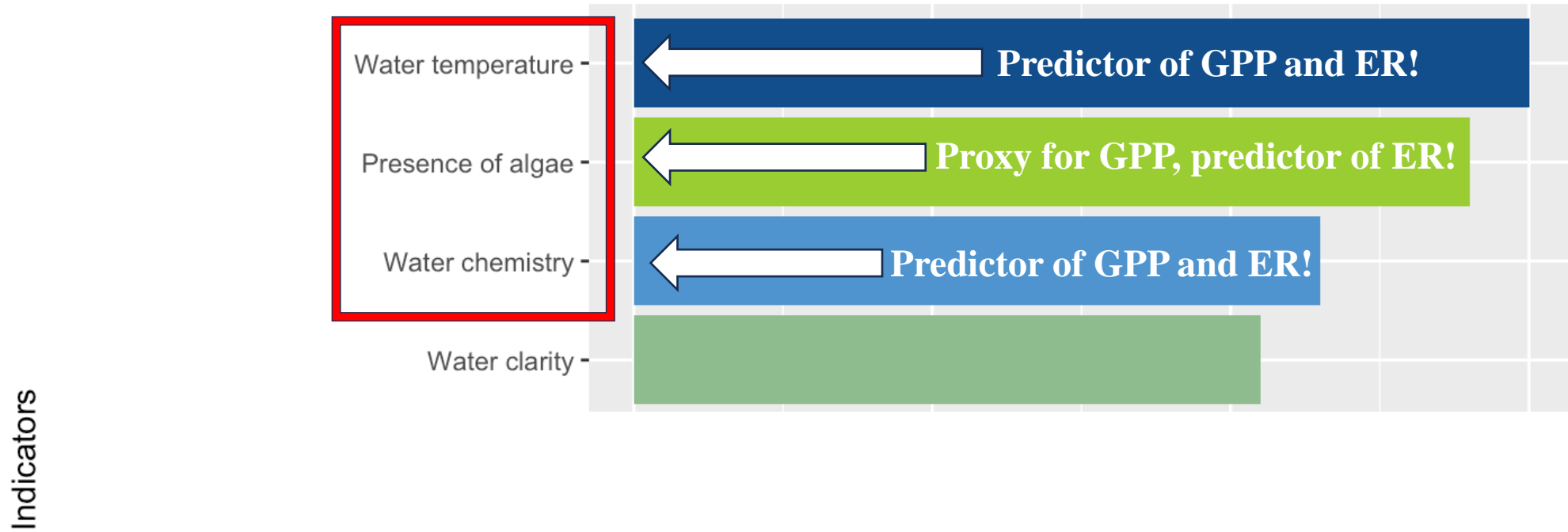
At both sites, visitors most recognized **water temperature** and **presence of algae** as important indicators of ecosystem change.

Summary of human perceptions

- Most observed change over time is an **increase in visitation and use**
- Locational differences emphasized our **clean, clear, cold, pristine Montana lakes**
- Recognized indicators of change were **water temperature, presence of algae, water chemistry, and water clarity**



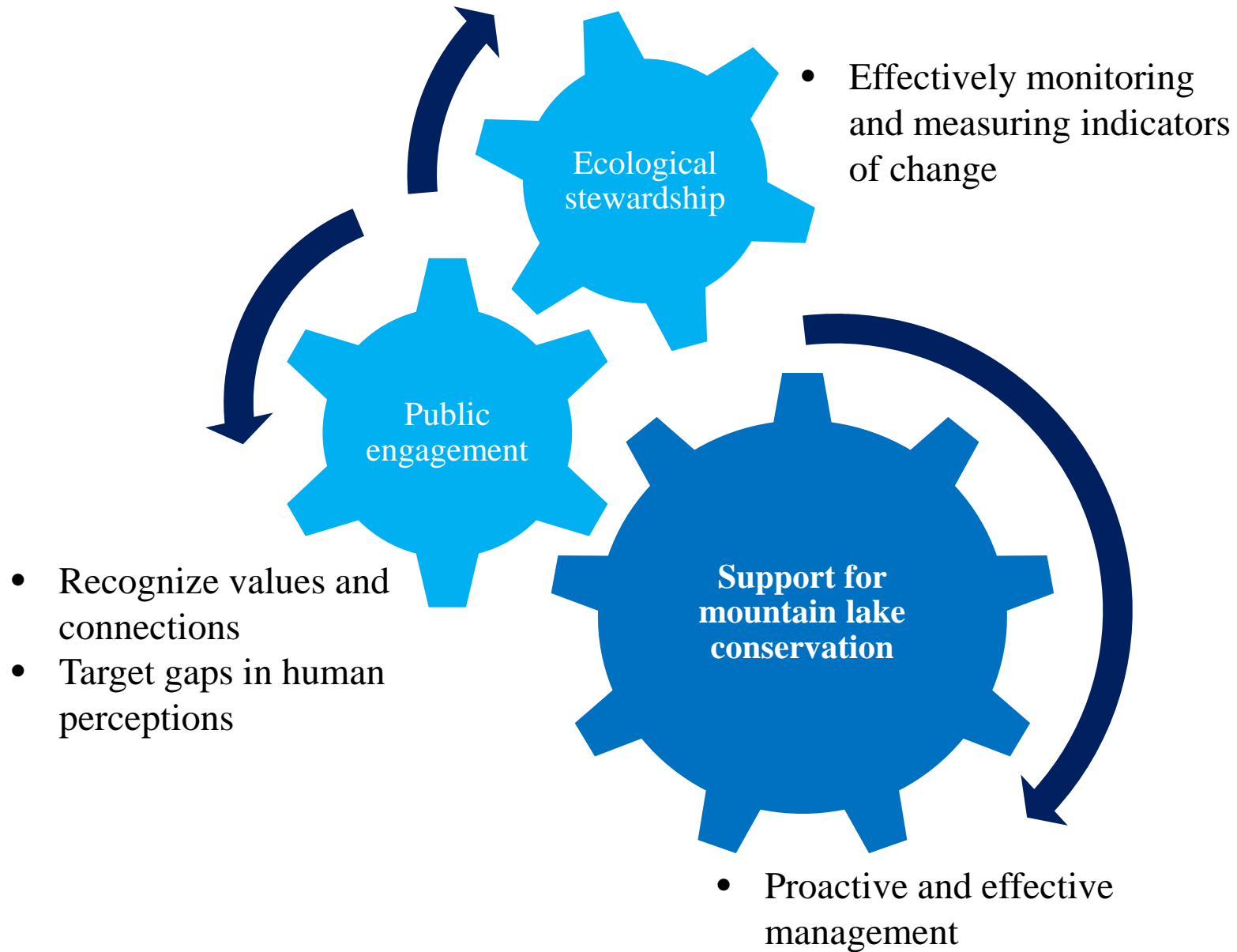
In your opinion, what are the top three indicators of environmental change in lakes?



Visitors recognize these ecological components!

Visitors also recognize the natural state of our “pristine” Montana lakes.

However, they do not as clearly understand how society contributes to such environmental changes in lakes...



“We were back east this summer and it was heartbreaking to see the changes...

...And it was like wow- is that lake becoming our future?”

-Holland Lake visitor

Thank you!!!

Special thank you to my advisor Ashley Ballantyne and lab mates Joe Vanderwall and Brooke Bannerman for the continued mentorship, support, and input.



Snorkelers diving for trash in Missoula Lake (yes, I surveyed them!)