Makak: Community-Driven Microclimate Sensor Development for Wild Rice Conservation

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Manoomin

Northern Wild Rice

- Manoomin: “good berry”, “*the food that grows on the water”* — Anishinaabe (Ojibwe or Chippewa)
  - Stewardship of Manoomin is central to Ojibwe culture and identity
  - Harvested in the Great Lakes region for millennia by Indigenous peoples.
- Considered a being; *Rights of Nature*

Manoomin

Northern Wild Rice

- Requires flowing water, shallow waters (6 in. - 3 ft.), **goldilocks water fluctuations**, and soft organic “muck” sediment.

- Currently in great decline and threatened by climate change, industrialization, and agricultural development

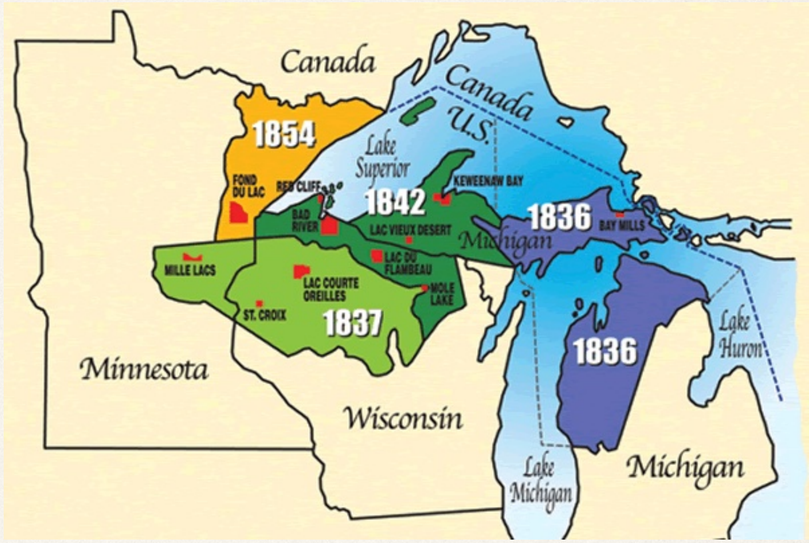
Ojibwe Partner Organizations & Tribal Nations

Great Lakes Indian Fish & Wildlife Commission

LAC DU FLAMBEAU OJIBWE NATION

1854 TREATY AUTHORITY
• BOIS FORTE
• GRAND PORTAGE

LAC COURTE OREILLES
Pride of the Ojibwe



1836 – 1854 Ceded Territories with GLIFWC member tribes
glifwc.org

Academic Research Team

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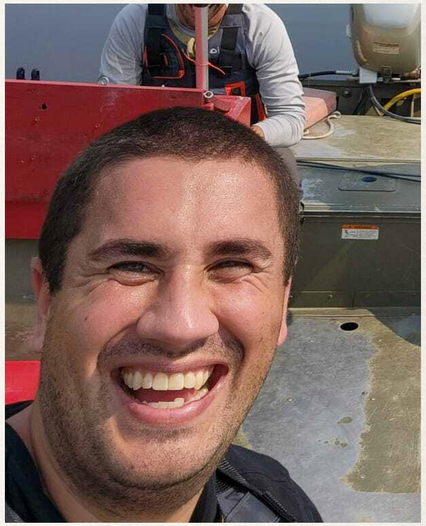

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Professor

Georgia Institute of Technology

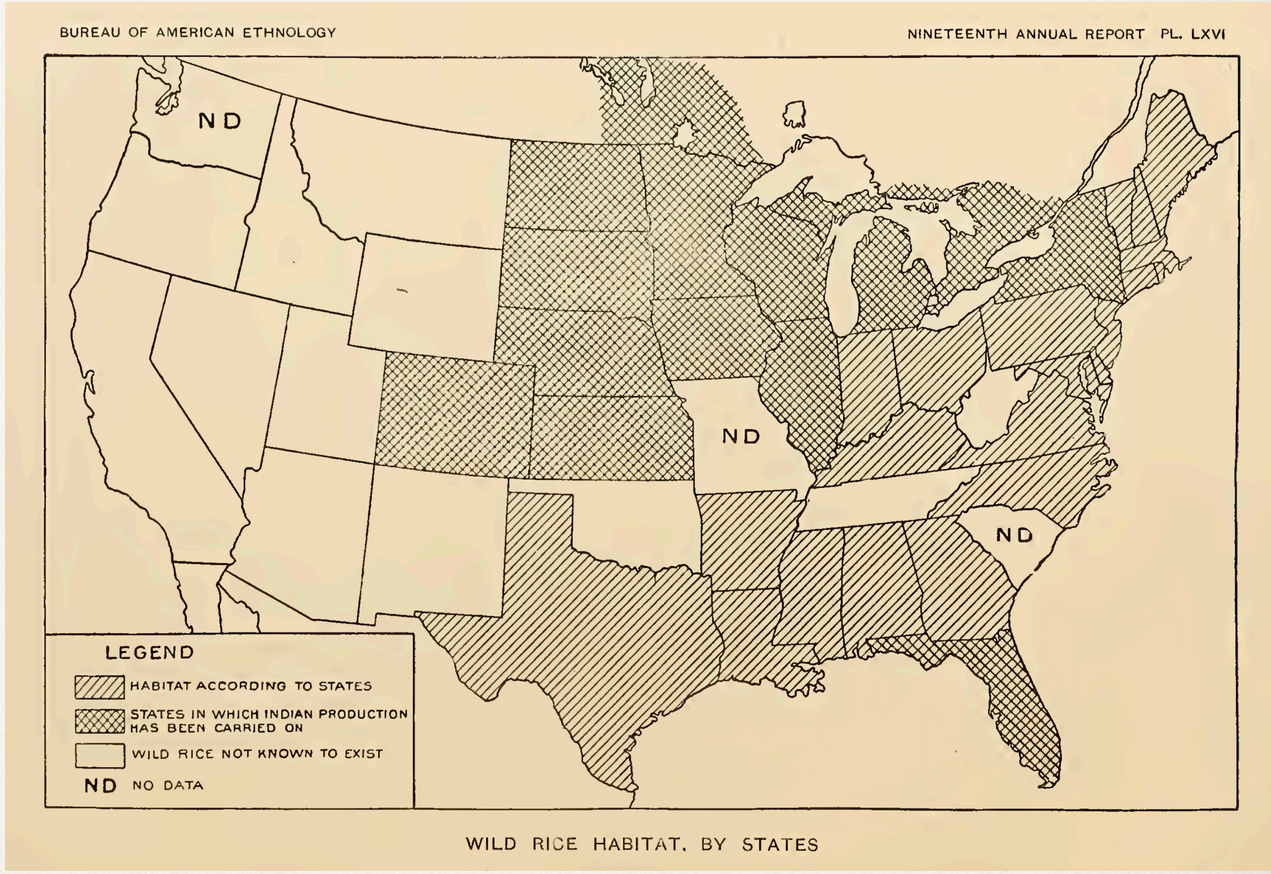
Northwestern University

Georgia Tech

Protecting Manoomin

Wild Rice Abundance

- Around the turn of the century, wild rice was present widely across the eastern United States.
- Since, it has declined by “at least a third”

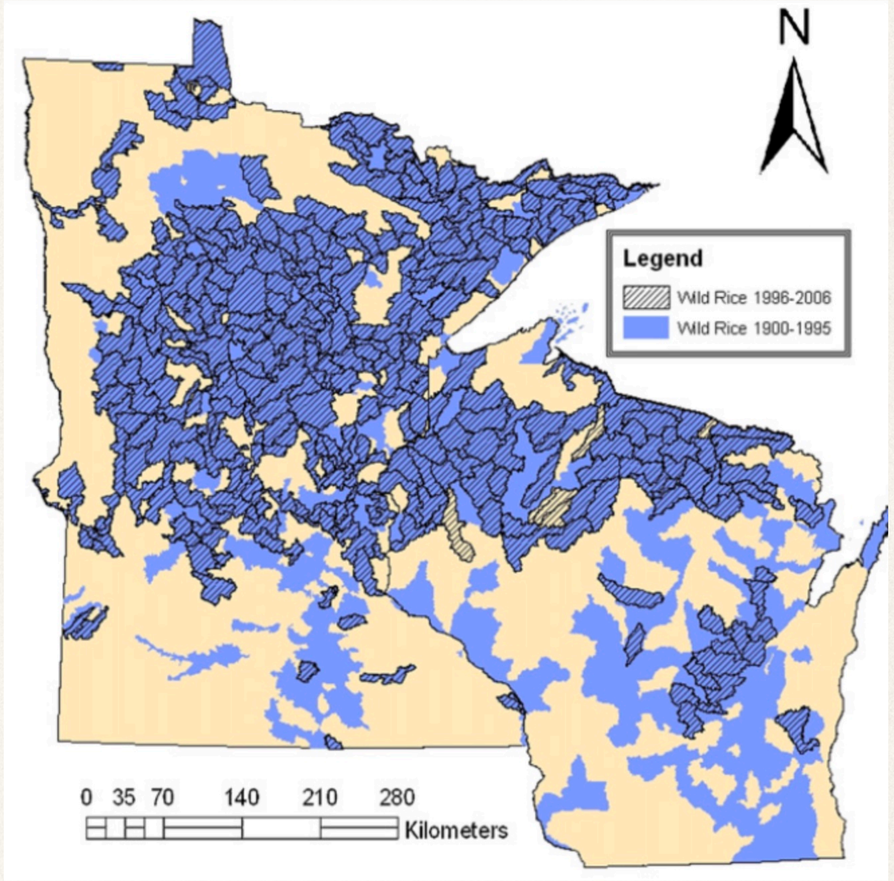


Jenks, Albert Ernest. *The wild rice gatherers of the upper lakes: a study in American primitive economics*. Vol. 19. US Government Printing Office, 1901.

Drewes, Annette D., and Janet Silbernagel. "Uncovering the spatial dynamics of wild rice lakes, harvesters and management across Great Lakes landscapes for shared regional conservation." Ecological Modelling 229 (2012): 97–107.

Wild Rice Abundance

- Rice beds have been lost or in great decline (estimated 6-7% per year since the ‘90s).
- Family yearly harvest 1920s @ LDF: **200 lbs**.
  - Today: **<80 lbs**.
- “By mid-century, it might be wiped out”

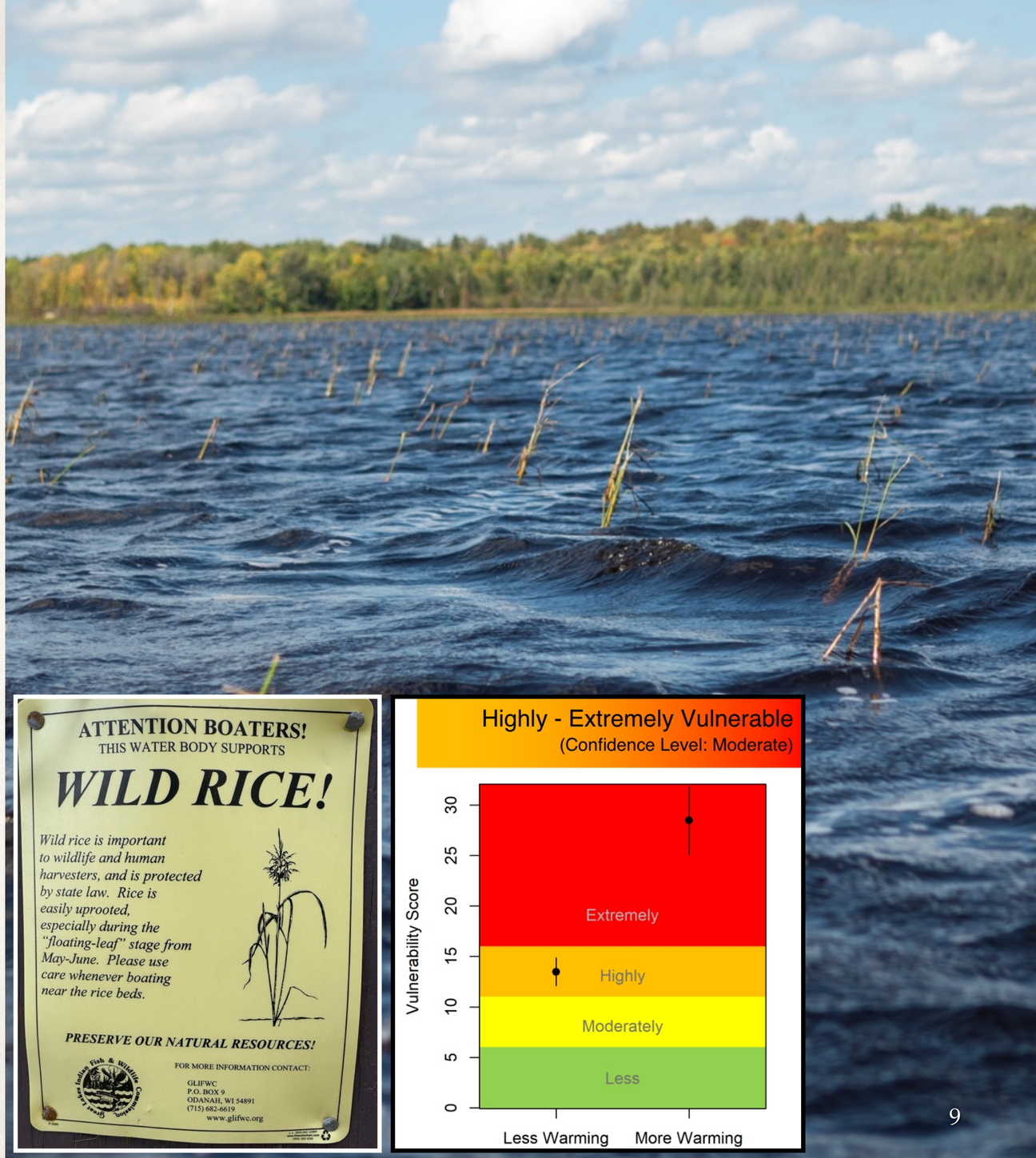


scientificamerican.com

Drewes, Annette D., and Janet Silbernagel. "Uncovering the spatial dynamics of wild rice lakes, harvesters and management across Great Lakes landscapes for shared regional conservation." Ecological Modelling 229 (2012): 97–107.

Wild Rice Conservation

- Known phenomena affecting Manoomin
  - Brown spot disease (humidity, precipitation, abnormal wind)
  - Water level & Flow rate (abnormal weather, dams)
  - Herbivory (altered migration patterns)
  - Boat wakes
  - High Sulfate Levels (tailings ponds of nearby mines)
- Known from regional research, traditional ecological knowledge (TEK), and indigenous knowledge
  - Very expensive to quantify, and not widely accomplished (hundreds of water bodies)



Hannah Panci, Melonee Montano, Aaron Shultz, Travis Bartnick, and Kim Stone. 2018. Climate Change Vulnerability Assessment, Version 1. Technical Report. Great Lakes Indian Fish and Wildlife Commission (GLIFWC). 30 pages.

Project Goals

- Support manoomin conservation efforts
  - Lead by knowledge of tribes and conservation organizations
  - Weaving western science and Traditional Ecological Knowledge; **two-eyed seeing**
- Promote Tribal sovereignty
  - Low cost and long-term sustainability
- Where appropriate, communicate learnings with others

Engagement

- Started in 2019 - listening and participating at Tribal meeting and symposiums.
- Western approaches to conservation science often clash with Indigenous methods and ways of knowing.
  - Establishing Memorandum of Understanding (MOU)
  - Practices borrowed and adapted from regional collaborators, CARE and FAIR principles.

Makak Funding

Strengthening Resilience of Ojibwe Nations across Generations (STRONG): Sovereignty, Food, Water, and Cultural (in)Security

NSF Smart and Connected Communities Award #2233912

Focused CoPe: Strengthening Resilience of Manoomin, the Sentinel Species of the Great Lakes, with Data-Science Supported Seventh Generation Stewardship

NSF Coastlines and Peoples (CoPe) Award #2209226

Manoomin Sensor Design

Low cost in-situ environmental sensor promoting Tribal sovereignty

Initial Interests

Environmental (Guided by TEK)

- Water Level/Depth
- Temperature
- Humidity
- Boat wake detection (disturbance)

Learning from Manoomin/Psíŋ:
A Community-Driven Sensor for Monitoring and Protection

Eric Greenlee, Blaine Rothrock, Ellen Zegura, Josiah Hester
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Northwestern

How can we create an environmental sensor for Manoomin/Psíŋ in a good way?

Current options are:

- Not specific to Manoomin/Psíŋ
- $$$ Expensive
- Slow to Deliver Data
- Cumbersome to Use and Maintain

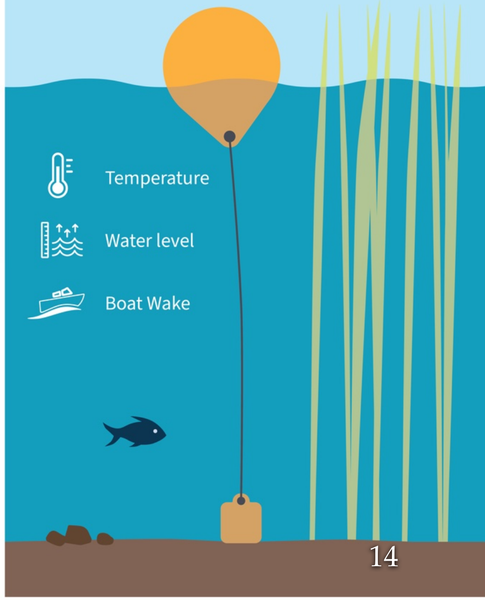
By spending months alongside tribal partners during their field work, we have designed a **low-cost**, **internet connected**, and **easy to use** sensor **specific to Manoomin/Psíŋ.**

This sensor will enable **on-site validation**, remote **long-term data collection**, and **customizable data sharing**, as well as a range of novel uses:

- Providing context to inform additional data collection
- Engaging with the public, especially tribal youth
- Informing warden enforcement

Sensor Design

- Localized bluetooth connection for sensor validation and configuration
- Cellular streaming for remote data collection and sensor status



Initial Interests

Features

- Low cost (< $1,000 USD)
- On-site validation without reliance on internet connectivity
- Real time data
- Last the length of grown season (May - September)

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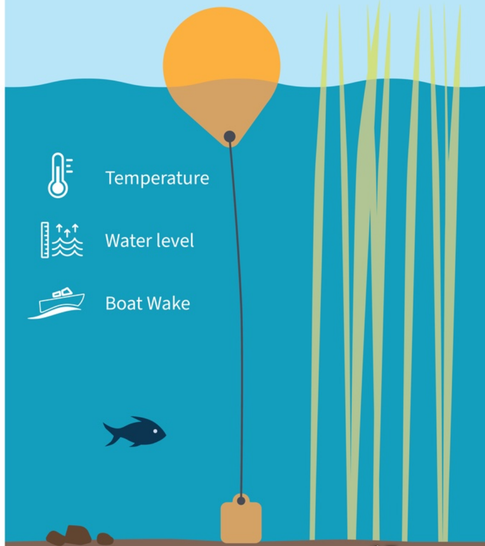


Timeline

Manoomin learning and co-design

Pilot Makak Design & Initial Testing

Pilot Makak Field Deployments

Iterative Co-Design & Planning

Makak Improvements & Validation

Scaled Up Makak Deployment

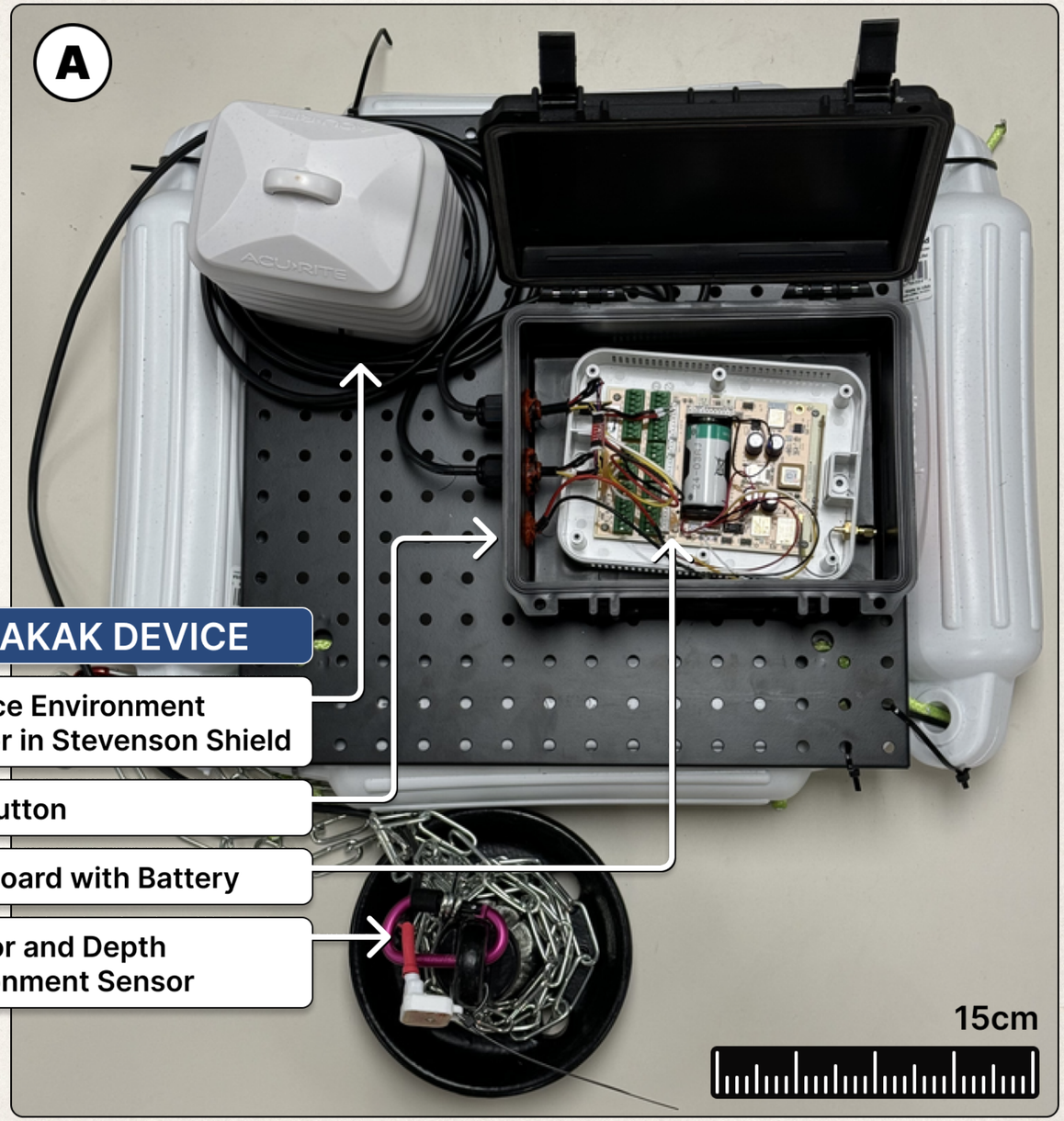
...

Makak Pilot

Makak: “*a basket (especially one of birch bark), a box*”

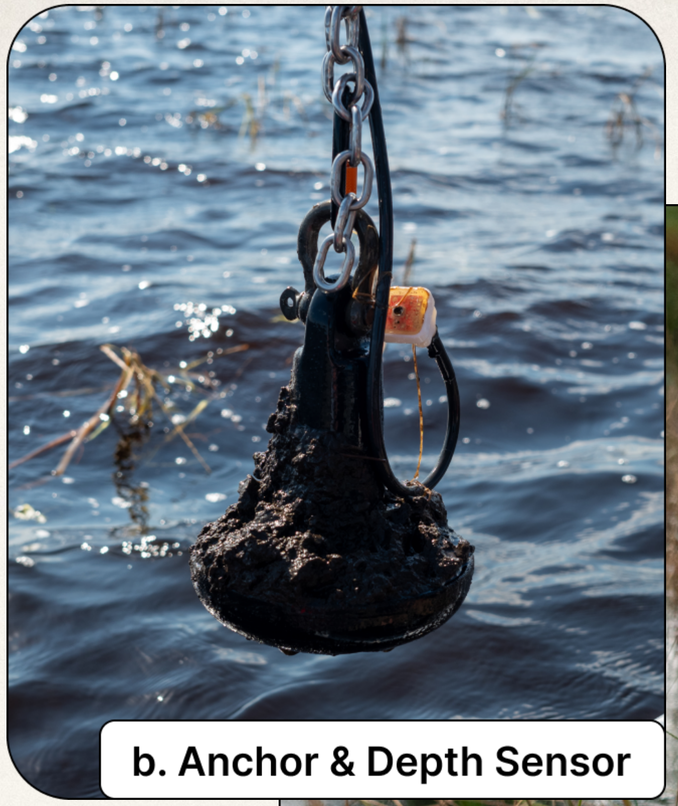
Technical Specifications

- Hardwario Chester Mainboard
  - nRF52840 (application + BLE)
  - nRF9160 (LTE)
  - Zephyr RTOS
  - LISDH12 IMU
- BME280 surface sensor (temperature, humidity, air pressure)
- MS5803 Depth Sensor (water pressure, temperature)



Buoy Mechanicals

- Sensor Platform with floatation
  - Waterproof container
  - Stevenson Shield
  - Project info & contact information
- Anchor
  - Custom waterproofing for depth sensor
  - Chain tethering



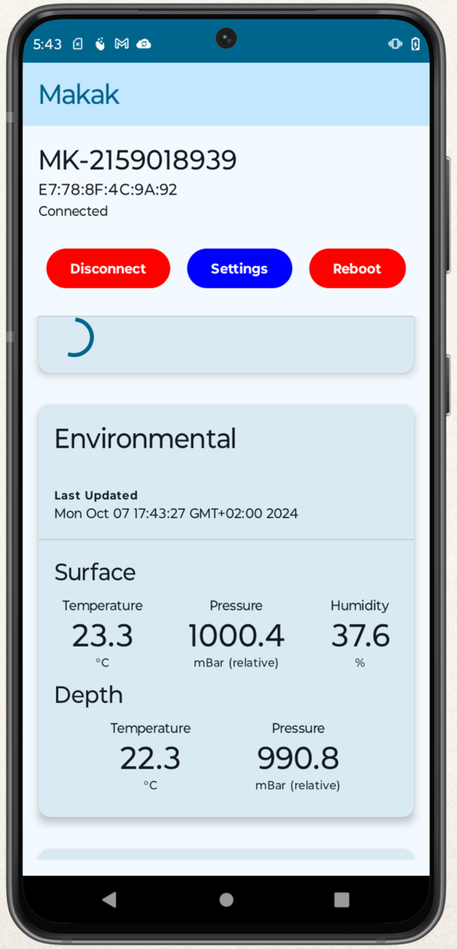
b. Anchor & Depth Sensor

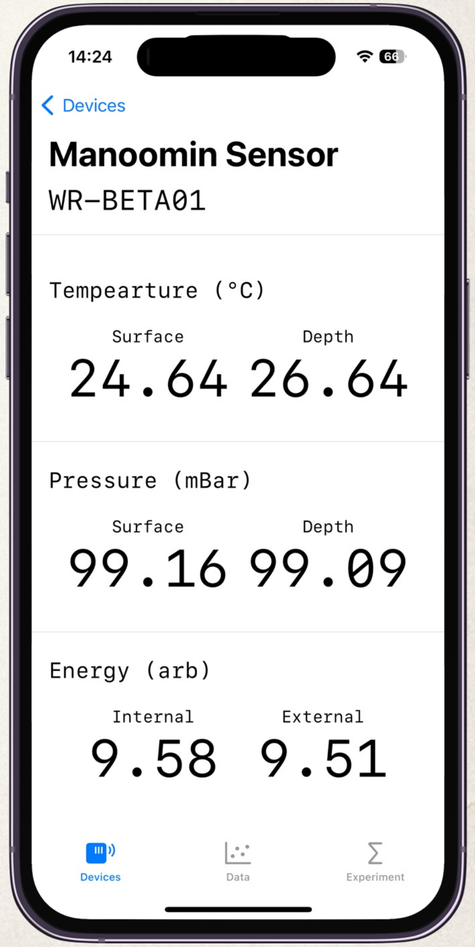
c. Initial Deployment

Deployment Validation

On site validation over BLE

- Environmental data
- LTE-M connection status
- Configuration & troubleshooting





Makak Pilot

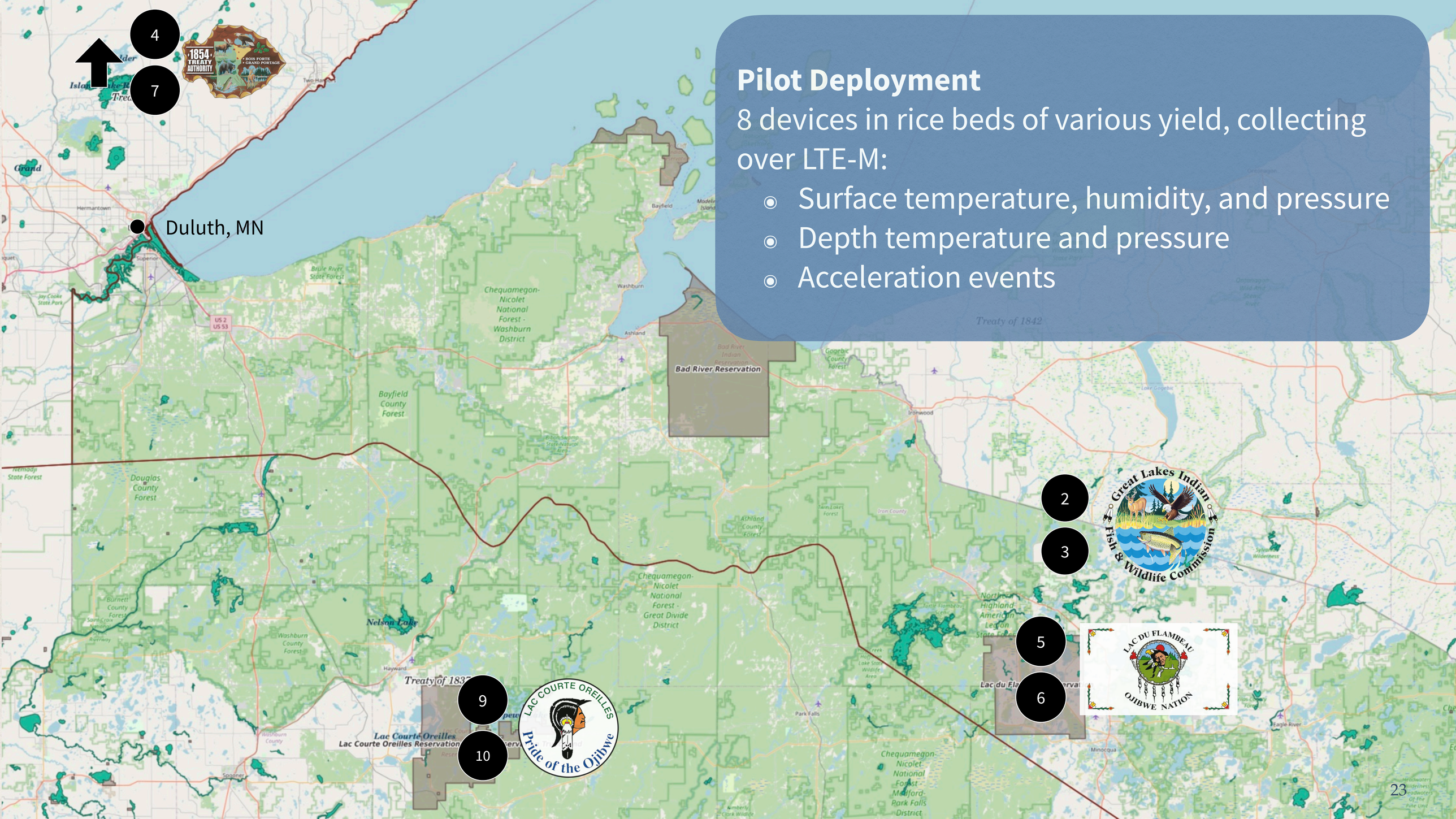
Co-design goals

- Deliver on promises
- Learn from Manoomin rice beds
- Understand and refine deployment
- Further knowledge sharing and relationship building

Makak Pilot

Technical Goals

- Mechanical & electronic stability
  - ~4 month deployment
- Collection of surface and depth environment
- Experiment acceleration wave detection
- Test on-site validation and deployment burden



Pilot Deployment

8 devices in rice beds of various yield, collecting over LTE-M:

- Surface temperature, humidity, and pressure
- Depth temperature and pressure
- Acceleration events


Columbia


Old Town

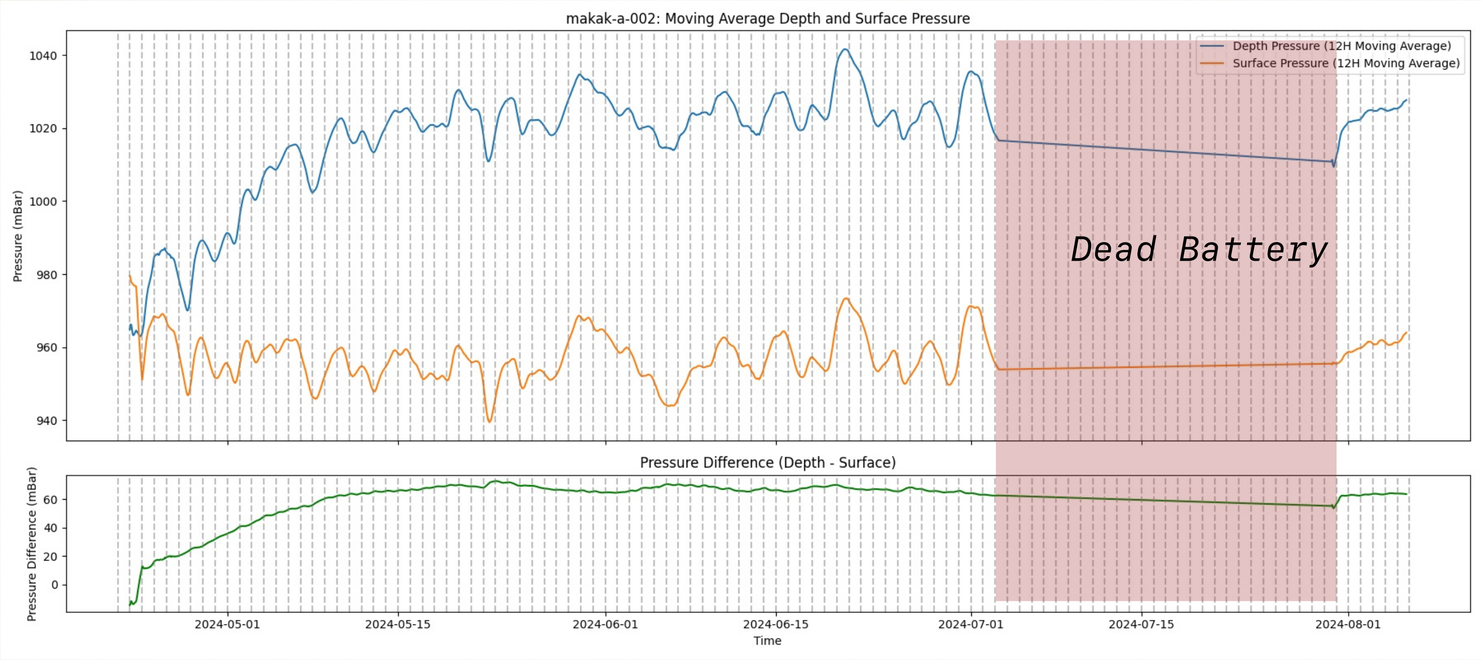
Pilot Study Results

Makak Retrieval

Device	Location	Partner	Data	Mechanics	Notes
2	Active bed lake inflow	GLIFWC	9,561 records 105 days	Recovered	Success (battery replaced)
3	Active bed lake outflow	GLIFWC	3,892 records 18 days	Recovered	Unknown early disconnection
4	Inactive bed center of lake	1854 Treaty Auth.	3,028 records 19 days	Recovered	Unknown early disconnection
5	Active bed river meander	Lac du Flambeau	N/A	Recovered damaged wires	Unable to establish LTE-M Connection
6	Active bed river	Lac du Flambeau	N/A	Recovered damaged wires	Unable to establish LTE-M Connection
7	Inactive bed edge of lake	1854 Treaty Auth.	7,948 records 103 days	Recovered damaged wires	Inconsistent end-of-season recording
9	Active bed river	Lac Courte Oreilles	119,827 records 100 days	Recovered	Consistent connection Failed depth sensor
10	No rice artificial marsh	Lac Courte Oreilles	3,299 records 100 days	Recovered	Periodic LTE-M connection

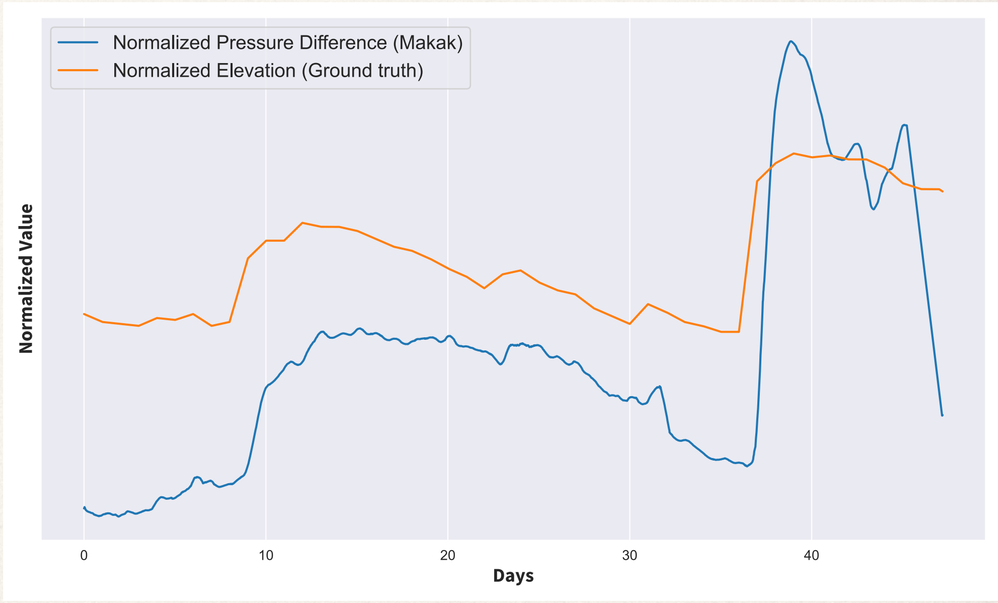
Water Depth Proxy

Pressure Differential



Pressure Differential

(p<0.001)

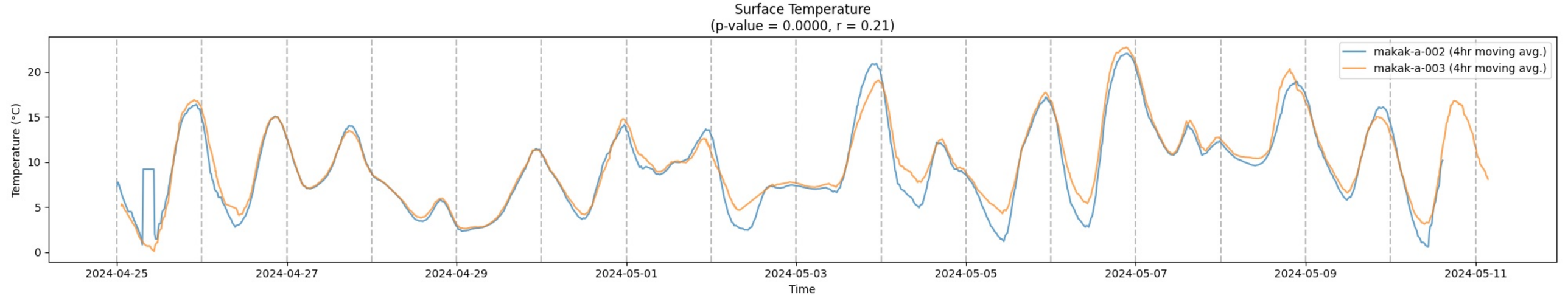


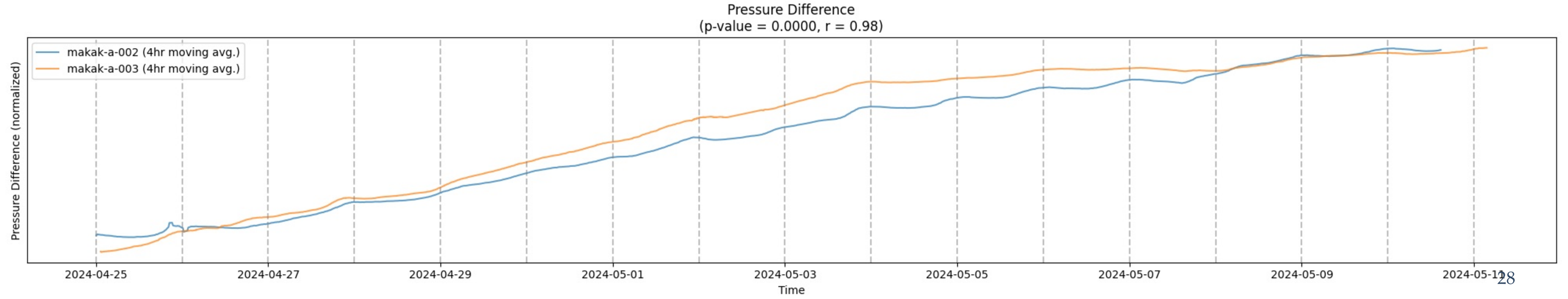
Compared to In-Situ TROLL

(p<0.001)

Device Correlation

Co-deployment on same water body





Mechanicals

Lessons

Pilot Deployment

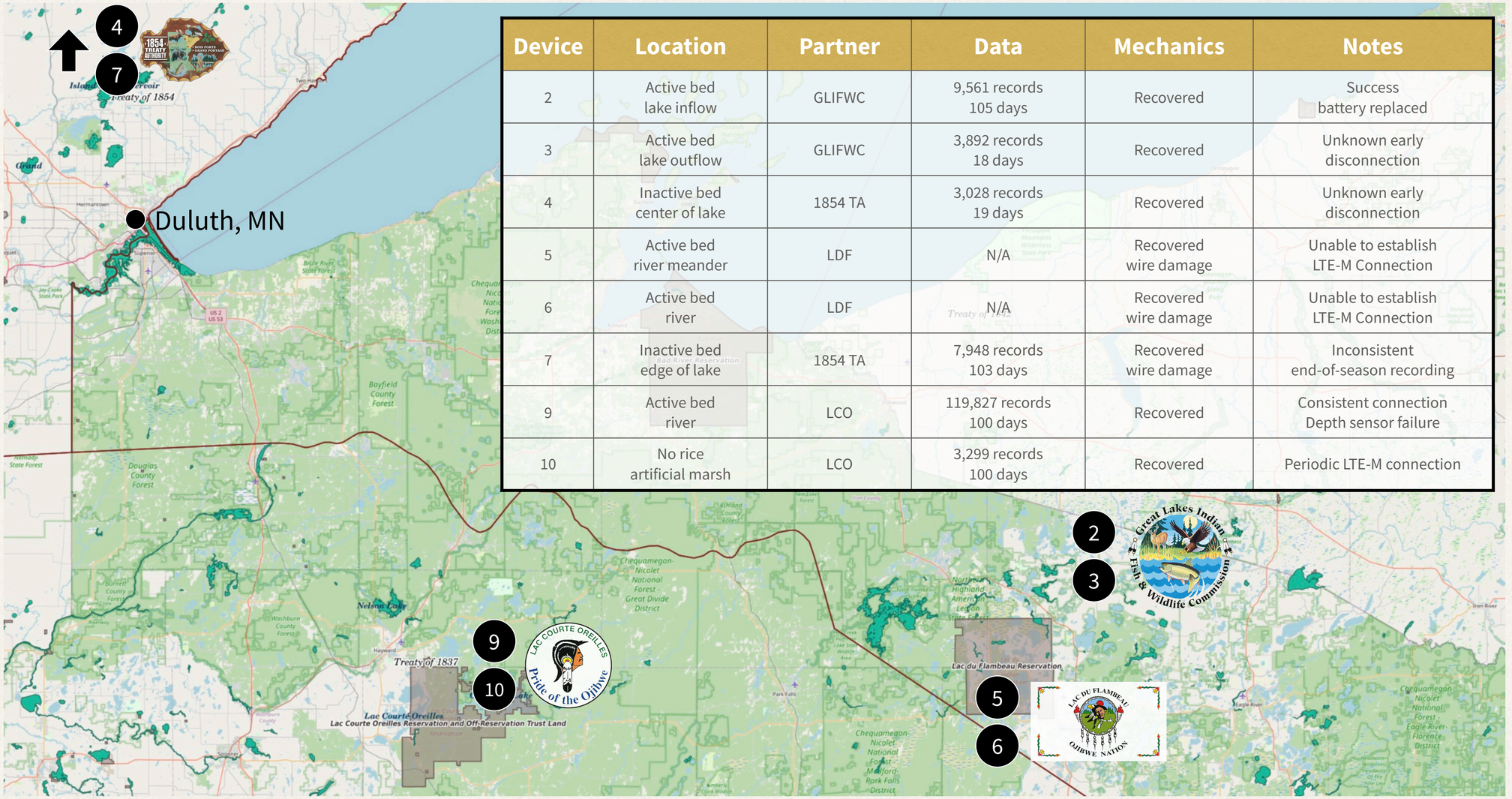
- Data Sharing vs. Data Sovereignty
- Sturdiness and Durability of Sensors; and Indigenous-Centered Approaches
- Hardware, Firmware, Software, and Connectivity Iterations
- Ground Truth
- Openness to New Directions

Co-design Methodology

- Building projects without **ownership**
- Long-term planning for sovereignty
  - PhD’s and grants are **short**, conservation is a long game
- Failures are good as long as incremental progress is made
- Building and **maintaining** trust.

Miigwech!

Thank you!



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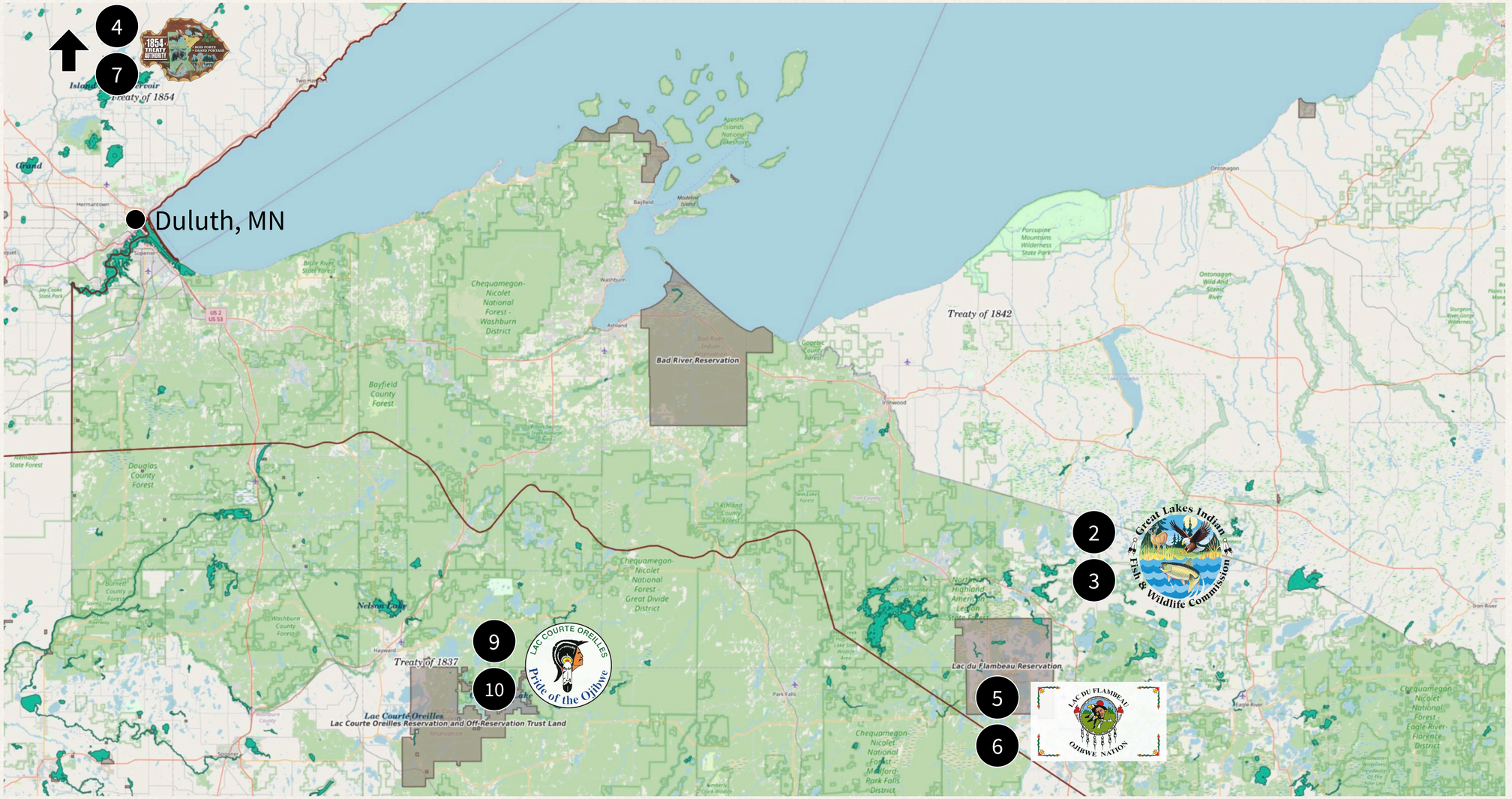
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7
Duluth, MN
Treaty of 1854
Bad River Reservation
Treaty of 1842
2
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Great Lakes Indian Fish & Wildlife Commission
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LAC COURTE OREILLES
Pride of the Ojibwe
Treaty of 1837
Lac Courte Oreilles
Lac Courte Oreilles Reservation and Off-Reservation Trust Land
Lac du Flambeau Reservation
5
6
LAC DU FLAMBEAU
OJIBWE NATION