ARCTIC SEA ICE MONITORING FOR CLIMATE CHANGE RESEARCH

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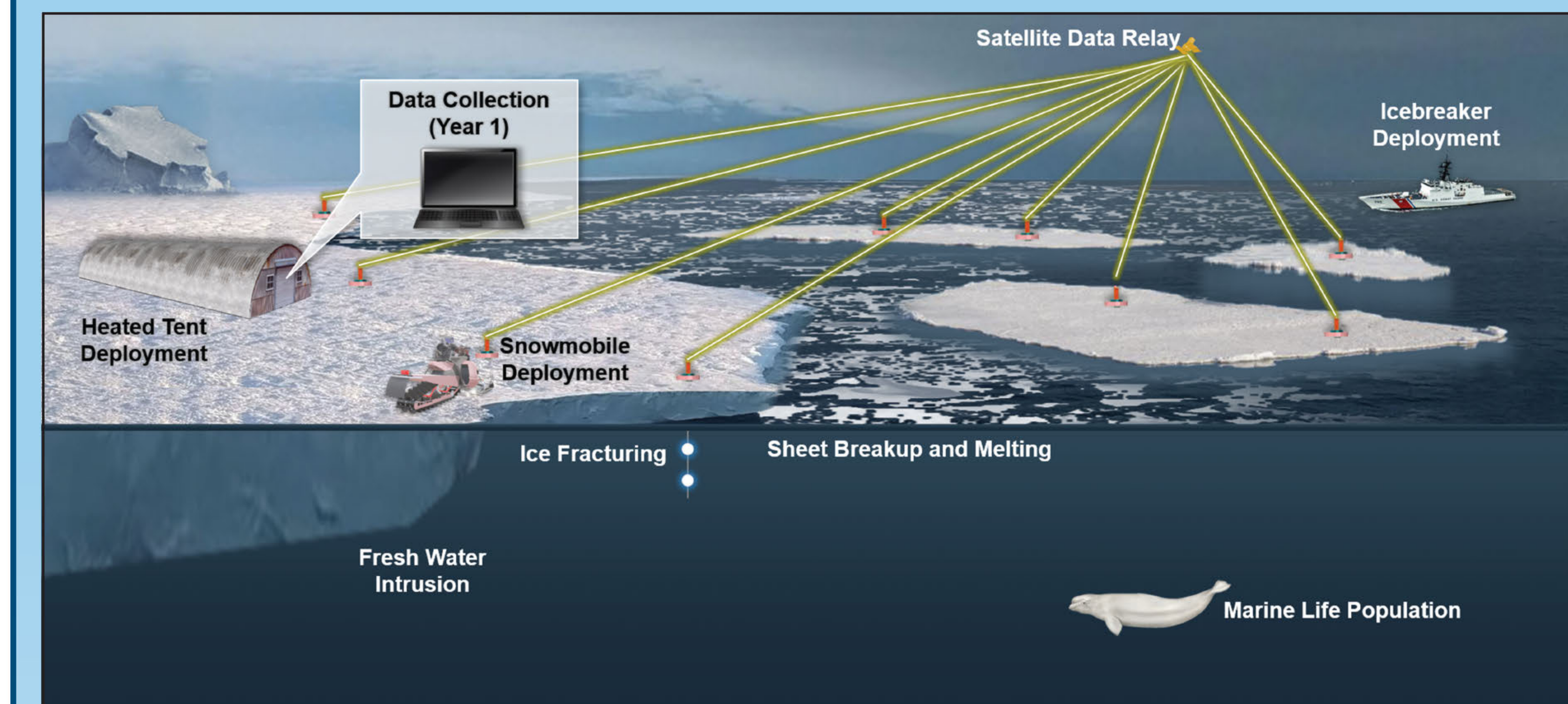
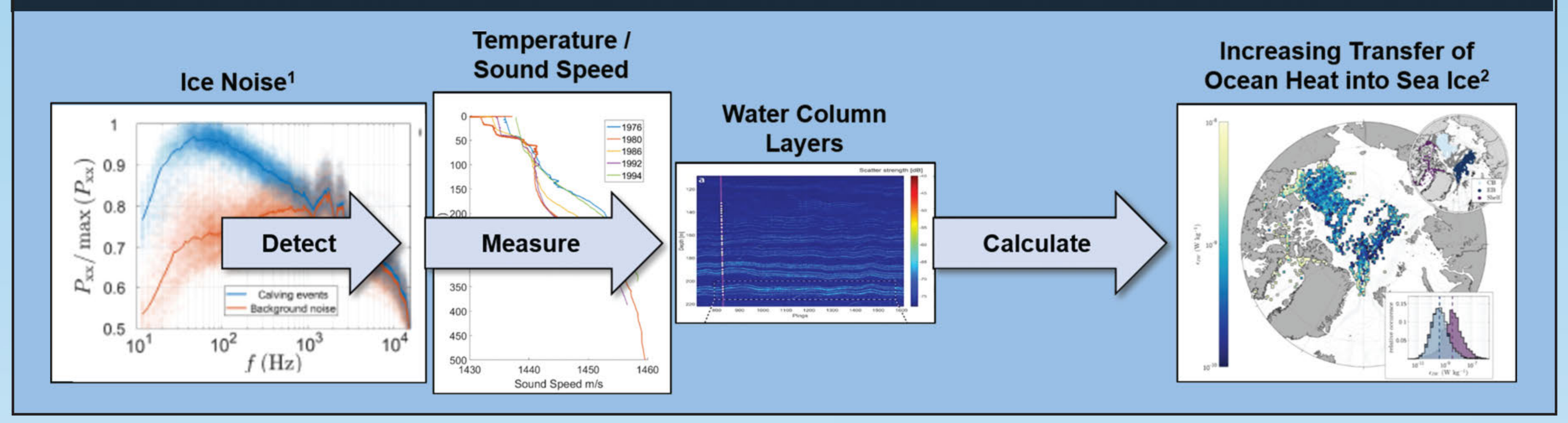
MOTIVATION

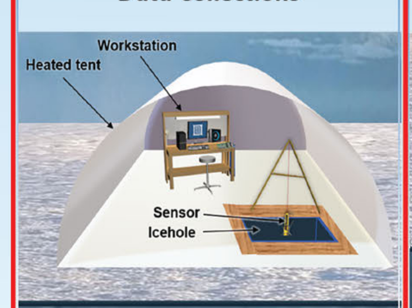
The Arctic climate and environment is changing rapidly and needs persistent, unattended monitoring.





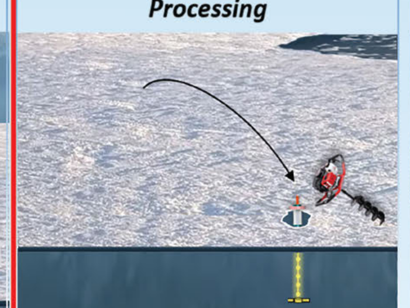
Goal: a sensing network that enables understanding the impact of global climate change on the Arctic and its consequences.

Year 1 — Phase 1 — Data Collections



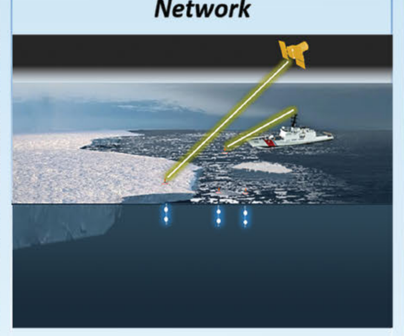
- Multiple COTS sensors deployed as part of ICEX 2022
- Data processing to identify ice events, correlations between modalities
- Trade study to identify future sensor package

Year 2 — Phase 2 — Sensor Design and Automated Processing



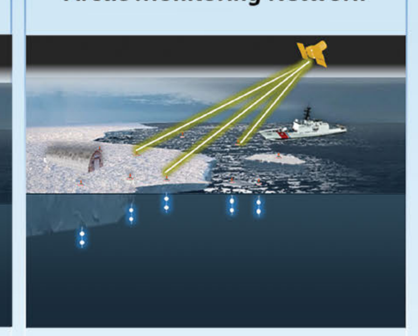
- Integrated sensor design and fabrication
- Automated detection of ice events and water column data report back
- Prototype sensor deployment via snowmobile

Year 3 — Phase 3 — Small Marginal Ice Zone Network



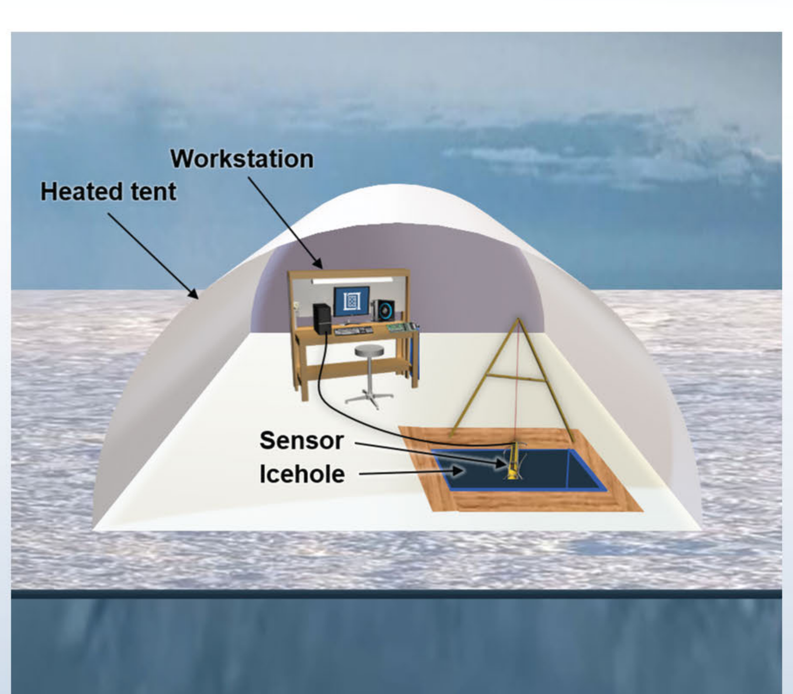
- Small number of sensor deployed
- Automated detection and geolocation of ice events
- Data report back of water column microstructure

Sponsored Program — Phase 4 — Arctic Monitoring Network



- Large network of sensors deployed in Arctic
- Connection of ice events, weather, and heat transfer
- Enhanced coupled Arctic – global climate analysis

Build a dataset of recorded ice events (acoustic and seismic) with concurrent measurements of the environment (i.e. water column salinity / temperature, wind speed / direction, and water column layer structure).

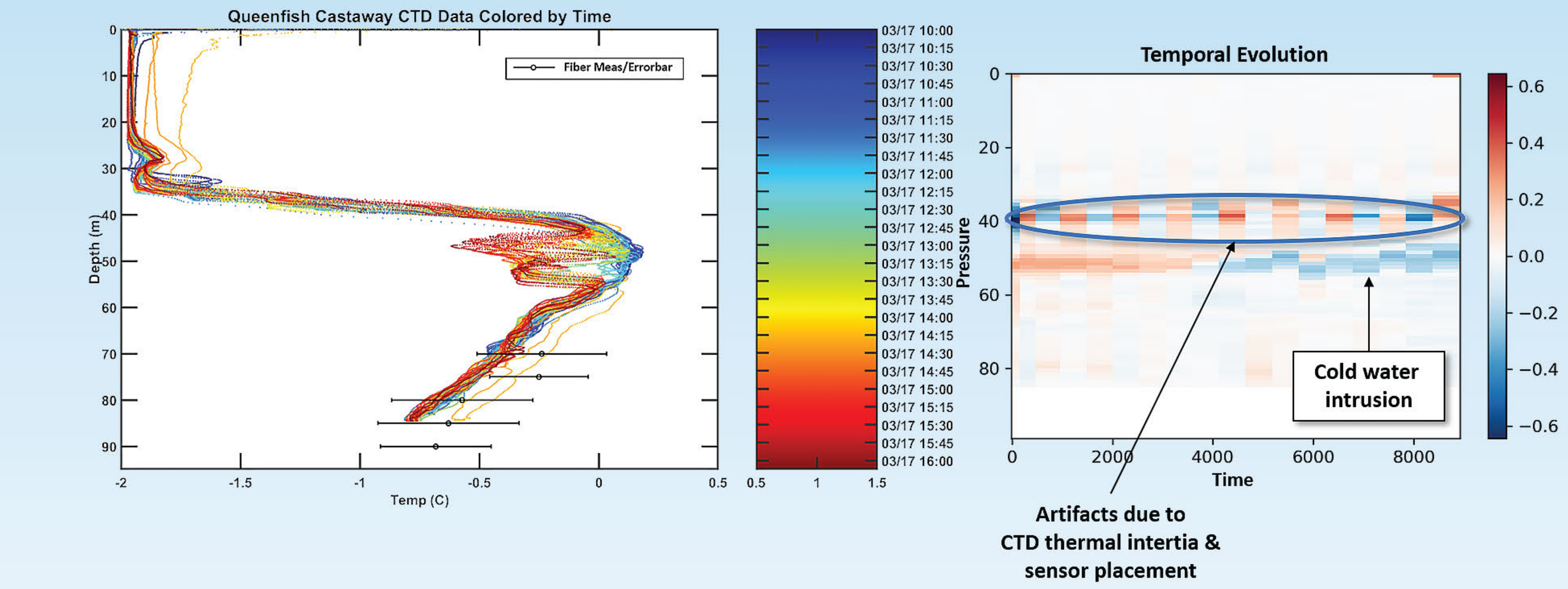


- Deploy sensors in a heated tent
  - 1 seismometer
    - One in ice and one on buoy in water
    - Identify the transfer from ice events into the water
  - Hydrophone
    - Record acoustics of ice events
  - High-fidelity acoustic profiler
    - 200 kHz sensor on pan / tilt mount (UNH owned)
    - Identify water column microstructures
  - Temperature and salinity profiler
    - CTD and fiber sensor (AFFOA)
- Sensors connected to laptop with staff operating

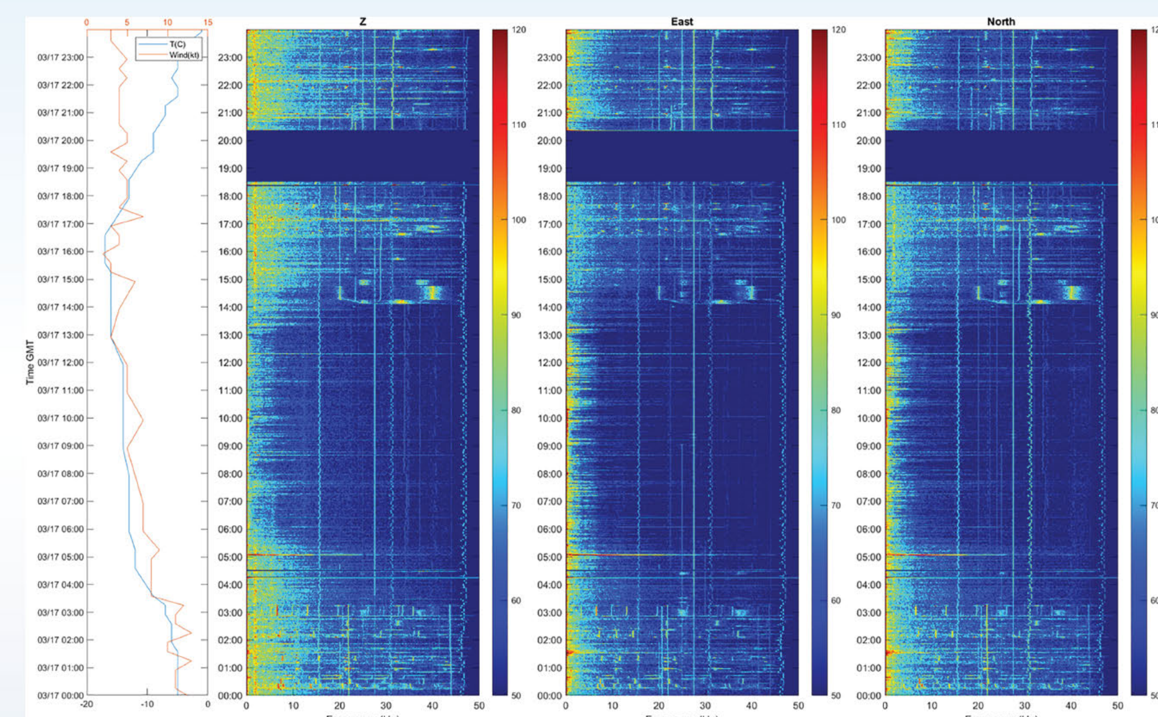
ICE CAMP QUEENFISH DATA

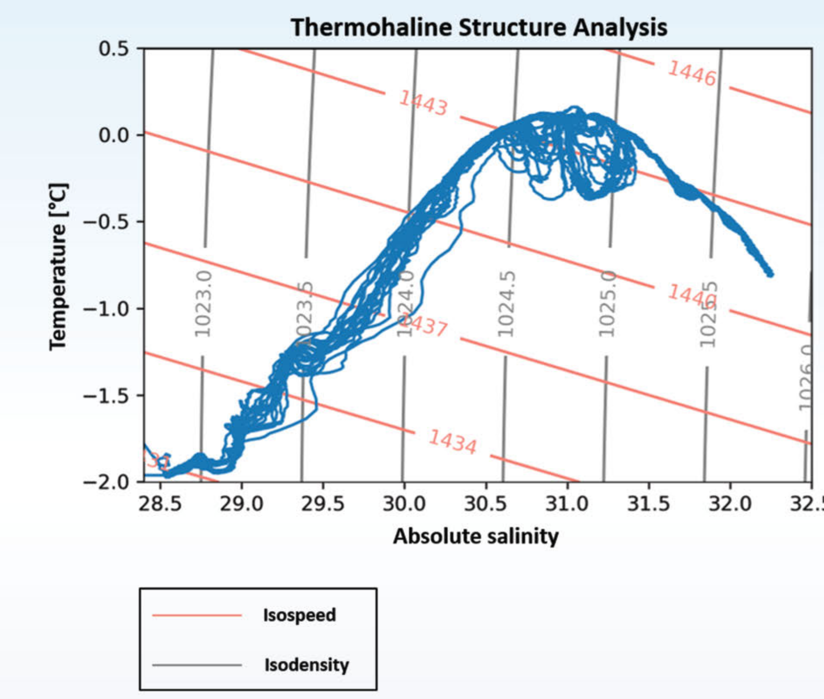
Sheet Breakup and Melting

CTD Casts (~15 min Intervals)



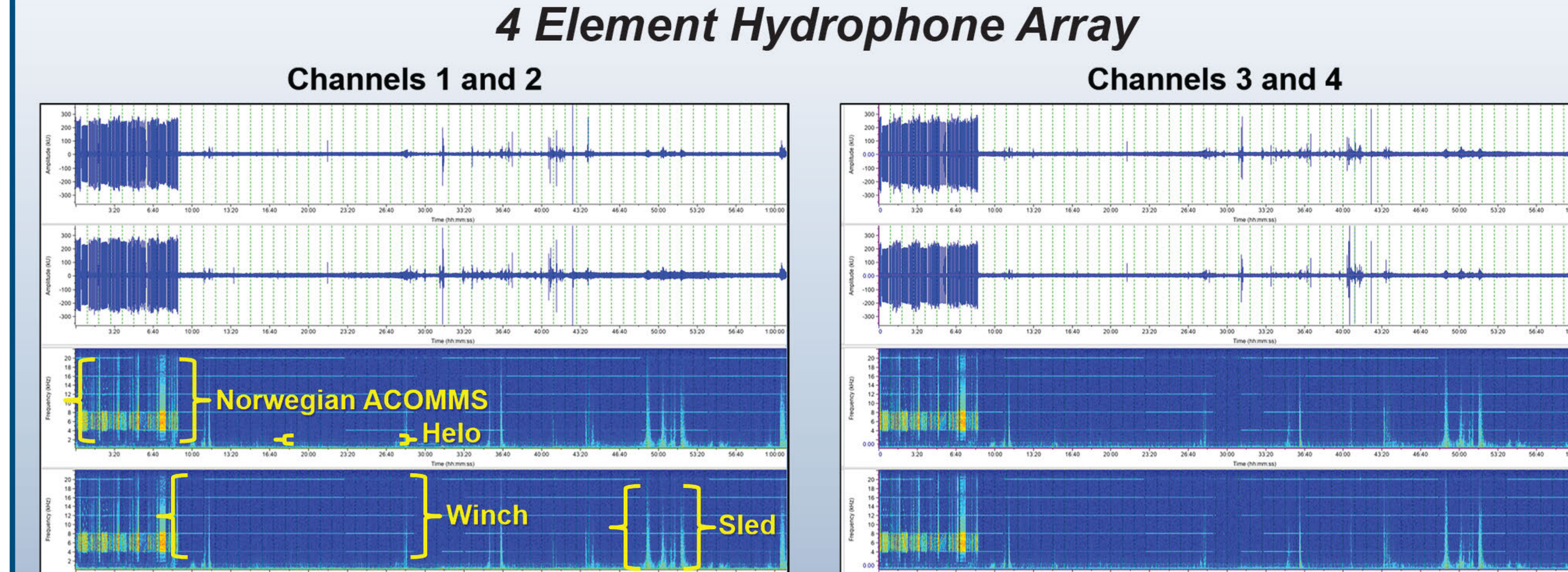
Seismic (Raspberry Shake)





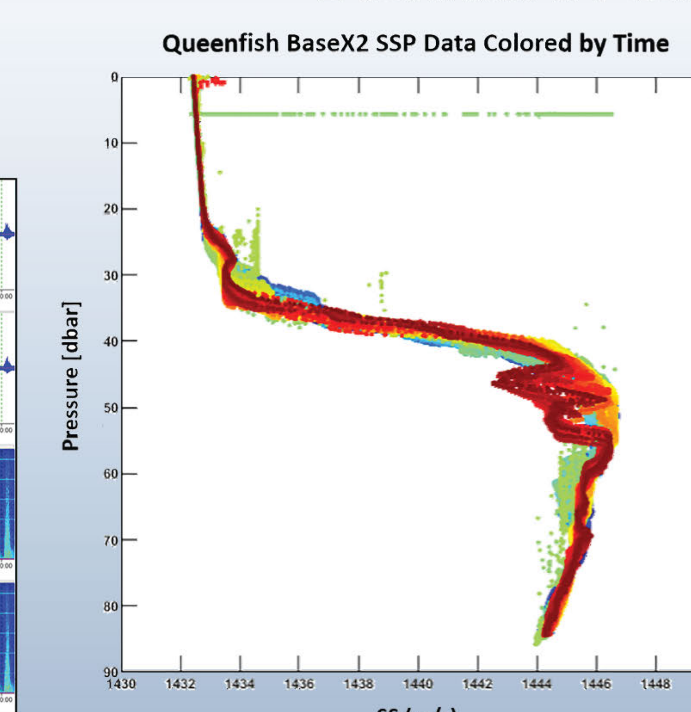
- Water mass intrusions are, unusually, anomalies in sound speed but not density
- Sound speed anomalies are easy to create and sustain in the Arctic
  - Minimal energy required to move water masses along isodensity lines
  - Atypical that sound speed can vary substantially along isodensity lines

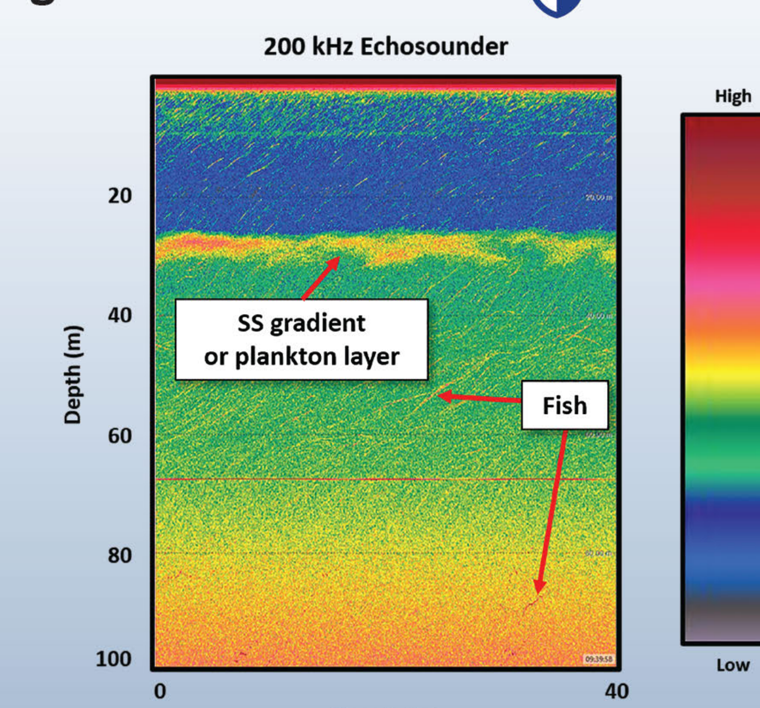
4 Element Hydrophone Array



Downward Pointing Echosounder

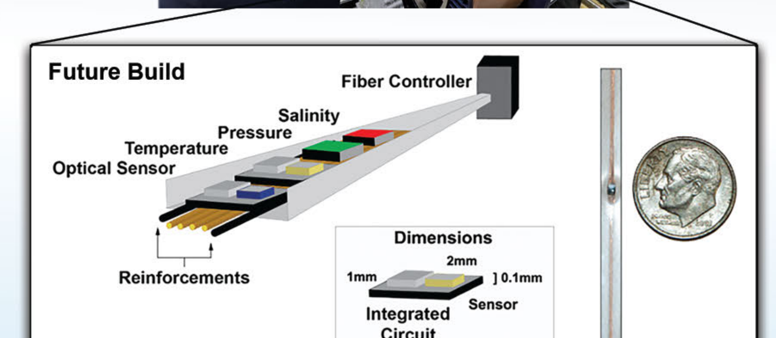
University of New Hampshire





TECHNOLOGY HIGHLIGHT

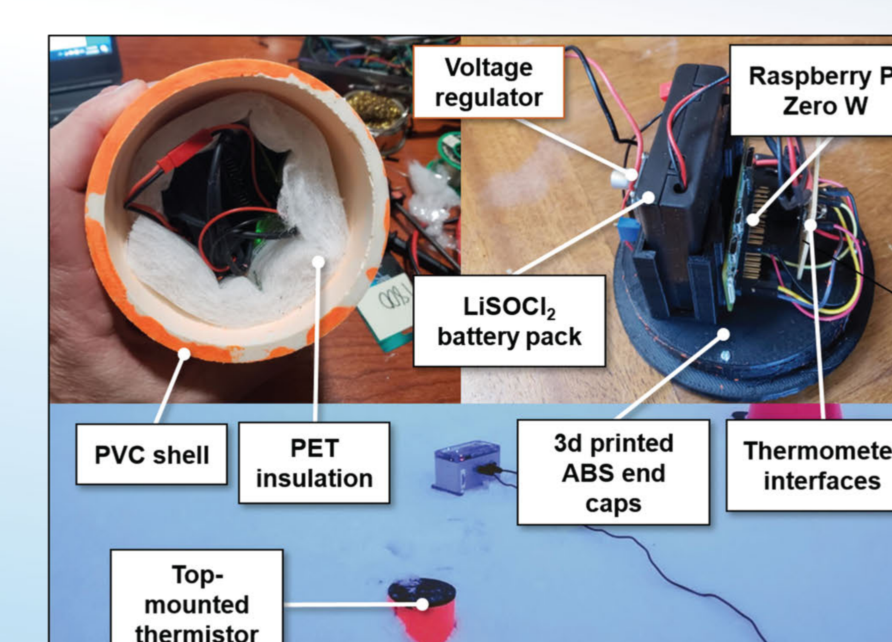
- Multiple, discrete, individually addressed sensors distributed along thin fiber report measurements to a control unit
- MIT LL New Technology Initiative (NTI) internal funding matched by AFFOA IRAD
- Two-track development:
  - Each approach addresses different challenges of overall technology
- MIT LL leverage temperature-sensing ASIC in parallel (multi-drop bus)
  - Very small and low power sensors
  - No inherent depth or spacing limitations
  - No pressure / depth or salinity measurement in Phase 1
- AFFOA integrating COTS devices with I^{2}C communications protocol
  - Temperature plus pressure and accelerometer measurements to estimate depth



PATH FORWARD

Build and test hardened, better integrated sensing node with sufficient power for extended, unattended deployment.

- Collected data on battery performance
  - Determine low-power electronics lifespan in arctic conditions
  - Explore processing load (and power draw) correlation with internal housing temperature
- Explore energy harvesting in the Arctic environment
- Investigate energy balance between sensing, processing and off-boarding data
  - Potential use of low-power sensors to wake system during key events



[1]Glowacki, O., et al. "Quantifying Iceberg Calving Fluxes with Underwater Noise," The Cryosphere, 14, 1025—1042, 2020. [2]Dosser, H. V., et al, "Changes in Internal Wave-Driven Mixing Across the Arctic Ocean: Finescale Estimates from an 18-Year Pan-Arctic Record," Geophysical Research Letters, 48, c2020GL0911747.

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