Technology Developments for Arctic Observations and Beyond

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PMEL
Pacific Marine Environmental Laboratory

NOAA FISHERIES

ITAE
Innovative Technology for Arctic Exploration

MRV SYSTEMS

SAILDRONE
Outline

• Status and Challenges for Arctic Platforms
  – Saildrone
  – Profiling Floats (ALAMO)
  – New Coastal Underwater Glider (Oculus)
Saildrone Gen 4 Sensor Suite

**Atmospheric Measurements**
1. Temperature / Humidity
   - AT/RH @ +2.2 m
     - Rotronic HC2 - S3 with rad shield

2. Pressure
   - Barometric Pressure @ +0.2 m
     - Vaisala PTB210

3. Radiation
   - S & L wave Radiation @ +2.2 m
     - Eppley PSP & PIR

4. Sunshine Pyrometer @ +2.2 m
   - Delta-T Devices SPH1

5. Wind speed & Direction
   - Anemometer @ +4.5 m
     - Windmaster 3D ultrasonic 20Hz

**Sub-surface Measurements**
10. ADCP @ -0.2 m
    - RDI Workhorse 300 kHz

11. Chl, CDOM, Red Backscatter
    - Wetlabs Fluoro Triplet

12. Dissolved Oxygen @ -0.5 m
    - Aanderaa 4324

13. pCO2 & pH @ -0.5 m
    - PMEL MAPCO2 & Durafet

15. Thermosalinograph @ -0.5 m
    - Teledyne Citadel

**Surface Measurements**
7. Skin Temperature

9. Dual GPS & IMU
   - Vectorova / Kvh

10. Waveheight/period
    - ADCP -0.2 m
    - RDI Workhorse 300 kHz

11. Surface Currents
    - pCO2 @ -0.5 m / +0.3 m
    - PMEL MAPCO2 system

13. Magnetic field
    - Magnetometer @ 0 m
      - Barrington MAG 648

**Specifications**
- Length: 23’
- Height: 15’
- Depth: 7’
- Weight: 1200 lbs, loaded
- Speed: Transit ~ 3 Kt, Max ~ 8 Kt
- Payload Power: 30w Steady state
- Payload Capacity: 250 lbs
- Max deployed duration: 12 months
- Longest voyage: 10,000 miles
Bering Sea 2016

(N. Cokelet)
2016 Highlights: NOAAS Oscar Dyson - Saildrone Echosounder comparison

Day
SD 13% higher
SD 9.1 m shallower
shading is 95% CI

Night
SD 38% higher
SD 8.9 m shallower
shading is 95% CI

Saildrone observes higher, shallower backscatter

(A. De Robertis)
2016 Highlights: NOAAS *Oscar Dyson* - Saildrone Echosounder comparison

- Pollock are responding to Dyson (noise-reduced vessel)
- Larger response at night

(A. De Robertis)
2016 Highlights: Fish, fur seals, and Saildrones: using groundbreaking technology to understand predator-prey relationships

- Goal: Examine how the distribution and abundance of prey influence northern fur seal foraging behavior
- Tracked 29 fur seals as they foraged for ~70 days
- 65 Saildrone sampling days within the fur seals core use area (July-Aug)
- Echosounders used to map prey availability (walleye pollock)

(C. Kuhn)
2017 Saildrone Bering Strait Transit & $p$CO2 Survey

Goals:
Launch 3 Saildrones from Dutch Harbor late June (1 Bering Sea-Ecosystems, 2 Chukchi-Carbon)

Challenges:
• Route Planning subject to ice conditions
• Transiting Bering Strait
• Solar conditions quickly deteriorate in mid-Sept (Chukchi)
• Potential recovery off North Slope dock. Special recovery options (difficult to find 8’ harbor)
North Slope Operations

Considerations:
• Soundings are from a partial bottom coverage survey in 1950s with estimated accuracy of +- 160ft and +-3ft depth

Considerations:
• > 4nm from Oliktok Pt to open water North of Spy Islands
• U of Alaska Research Station/Airfield

Prudhoe Bay (BP)

Oliktok Point
MRV ALAMO
Air-Launched Autonomous Micro-Observer

Characteristics

• Air or ship deployable
• Controllable profiles
• Multiple sensors
  - Pressure
  - Temperature
  - Salinity
  - PAR…
  …others
• Near real-time data telemetry
• Bottom-following (or anchoring)
• Ice hardened antenna (in progress)
• Ice avoidance algorithm
• ~500 cycles

(K. Wood)
ICE CONDITIONS
Challenging drift of ALAMO 9058 and 9115

NWS Alaska Sea Ice Program
Sea Ice Concentration Analysis 12 June 2016

Confidence: High to Moderate
- Less Than 1 Tenth
- 1-3 Tenths
- 4-6 Tenths
- 7-8 Tenths
- 9-10 Tenths
- Fast Ice
- Ice Free

Chukchi Sea

(K. Wood)
ALAMO 9058<sub>PT</sub> & 9115<sub>CTD</sub>
June 6 to June 25 – 55 profiles

Modified Atlantic Water? (precursor evident at C-1 mooring)

(K. Wood)
Sea-ice detection techniques can be complementary, each contributing to different situations and ranges.

- ISA (Ice Sensing Algorithm), developed for S. Ocean [Klatt et al 2007]
- Active acoustic technique (~100m)
- Optical technique (~20m)
- Passive Acoustics (?)
- Mechanical (<1m)

Challenge: Sea Ice Detection for Surfacing

Linearly polarized source (500 mW @ 532 nm) + Optical detector (polarizing beamsplitter)

(C. Marec/U of Laval)
Oculus Underwater Glider

A new Coastal Glider (40-200m) based on U. of Washington Deepglider hardware and software

Arctic glider advantages:
- flexible, responsive
- scalable
- long endurance
- data shuttles

Challenges:
- under ice navigation
- logistics

New Buoyancy Engine

- 10 V Science battery, 2 ea 3.9 mJ
- TI8 CPU electronics
- Iridium modem
- Applied Acoustics Altimeter/Transponder
- Custom Seabird CT sensor
- Kistler Pressure sensor
- 10 kHz transducer
- Berea axial piston pump w/ Maxon gearmotor
- Skinner solenoid valve
- NACA 0009 wings
- 24 V battery 12.2 mJ
- Ring-stiffened pressure hulls
- 10 V battery 4.4 mJ
- Combined GPS/Iridium antenna
- Free-flooded aft fairing
- External Bellowfram piston, 3500 ccs
- Vishay linear potentiometer, 6" stroke
- Internal hydraulic piston, 3000 psi max
- Internal hydraulic reservoir, 600 cc
Oculus Underwater Glider

Advantages:

- Leverages Seaglider/Deepglider Technology for low cost/rapid development
- New buoyancy engine is 20X faster than a legacy glider, beneficial to minimize wind drift and surface hazards.
- High speeds of 100cm/s (2kts) when compared to legacy gliders
- Large scientific payload, carrying up to 6 kg of instrumentation
- Increased range with large wings that permit very shallow glide slopes and enable rapid turning.

Bering Sea Test Mission
April/May 2017
Kongsberg to Market Two New Underwater Gliders

Kongsberg Underwater Technology, Inc. announced it has completed negotiations with CoMotion, the University of Washington’s collaborative innovation hub, to obtain the sole rights to produce, market and continue development of two new underwater glider systems.

Ocean gliders are a specialized type of autonomous underwater vehicle (AUV). Rather than using a propeller to move through the water, they use fixed wings and changes in buoyancy to achieve both vertical and forward motion. The vehicles move through the water in a saw-tooth trajectory and surface periodically to communicate data on water properties, such as temperature.
Summary

- Arctic observing technology is rapidly advancing and networks of platforms/sensors are practical
- ASVs, like Saildrone can carry many sensors for interdisciplinary studies in the Arctic, proving long endurance, flexible and scalable options
- 1st year echosounder field work has already shown promising science results
- New, smaller profiling ALAMO floats have been air-deployed and returned profiles after overwintering
- A new <200m coastal glider has been designed for arctic work
Research to Operations (R2O)

Platform Design and Sensor Integration
Operations and Field Test Planning
Data Validation
Integrated Research Missions
Transition to Operations

Systematic Science & Engineering Development

Innovative Technology for Arctic Exploration

NOAA
PMEL
ITAE