# ONR Arctic Research Plans for AICC
# January 10, 2018

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*Office of Naval Research*
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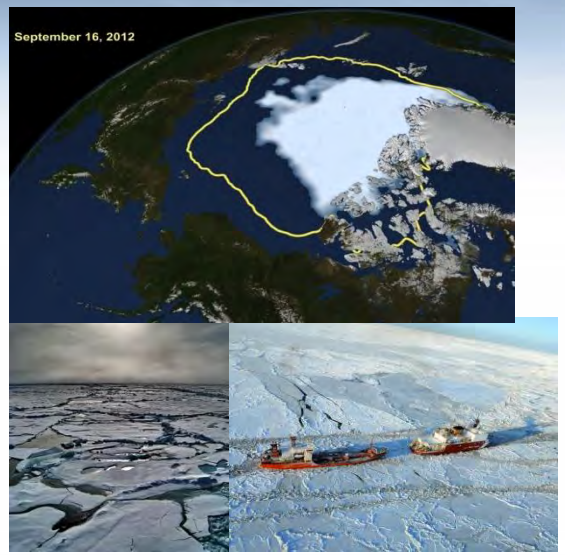
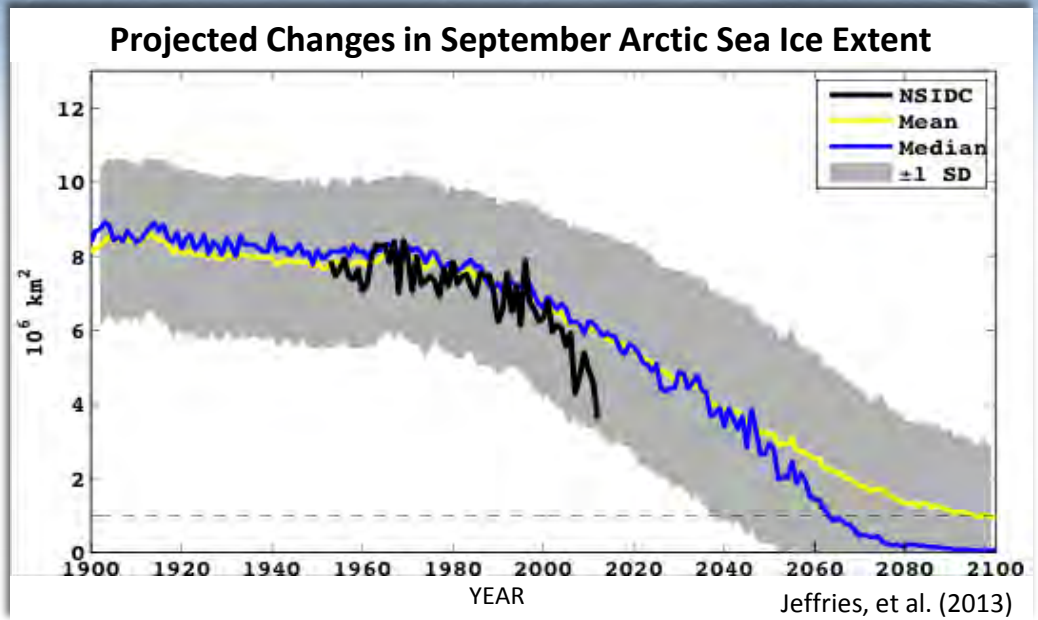
# The Changing Arctic

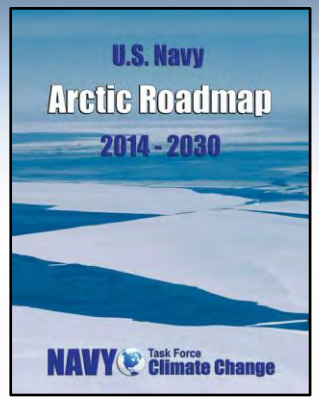


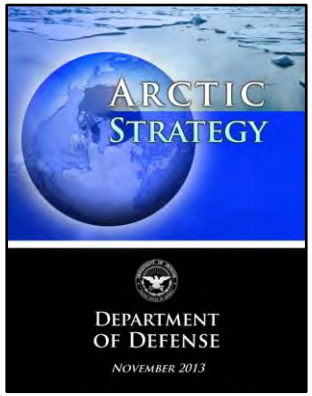



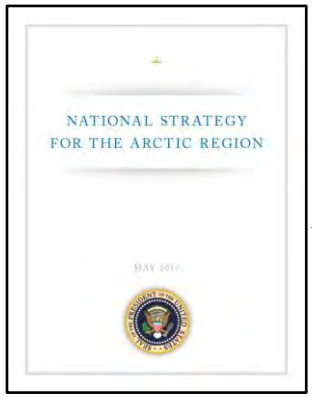

Jeffries, et al. (2013)

- How little sea ice will there be, and when will the key changes occur?
  - Need better prediction capability underpinned by basic research.
- How is the Arctic region as a whole going to be different?
  - Need research into how the entire Arctic environmental system functions.
- What does the Navy need to know to operate in the Arctic?
  - Need sustained observations and improved predictions of the state of the Arctic.
- How will the changing Arctic affect the rest of the earth, and vice-versa?
  - Need an Arctic environmental system model integrated within global prediction models

# Emerging Arctic Requirements




## *Navy's Strategic Objectives for the Arctic Region*

- Ensure U.S. Arctic sovereignty and provide homeland defense
- Provide ready naval forces to respond to crises and contingencies
- Preserve freedom of the seas
- Promote partnerships within the U.S. Government and international allies

**SOURCES**

- The United States Navy Arctic Roadmap for 2014 to 2030, February 2014
- National Strategy for the Arctic Region Implementation Plan, January 2014
- Department of Defense Arctic Strategy, November 2013
- COMSUBLANT/COMSUBPAC Arctic Requirements Letter, Ser N3/0644, 04 SEP 2013
- NORAD-USNORTHCOM FY18-22 S&T Integrated Priority List (STIPL)
- NORAD-USNORTHCOM Arctic Maritime Capability Requirements Study:
  - Phase 1 Final Technical Report, 15 OCT 2015
  - Appendix E, Non-releasable Material, 31 JUL 2015
- Classified Companion to the National Strategy for the Arctic Region, 2014
- N52 Arctic Engagement Plan Memo, 02 APR 2015
- NORAD-NORTHCOM Arctic Capabilities Based Assessment, May 2017

## *Develop a Framework of Observations and Modeling to Support Forecasting and Prediction of Sea Ice*

**Lead Agency: Department of Defense (Navy)**

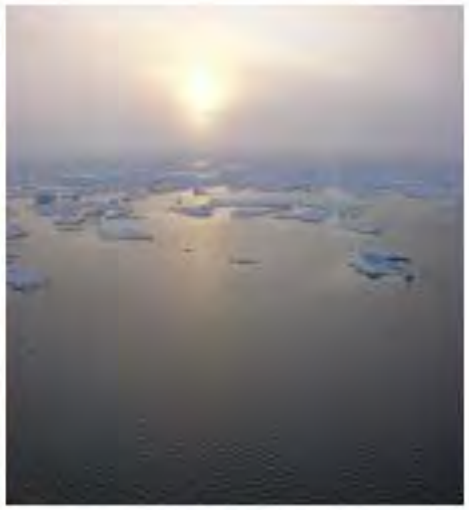
*"increased certainty and accuracy of sea ice forecasts and predictions, and by showing improved understanding of feedback processes driving sea ice variability"*

# ONR Arctic Research Program

***To Better Understand and Predict the Arctic Environment***
***Program Initiated in FY2012***

## Major Program Thrusts:

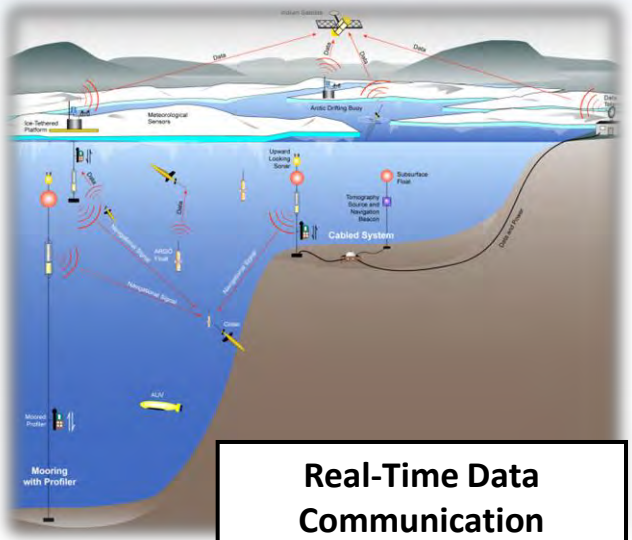
- Improved **Basic Physical Understanding** of the Arctic Environment
- **New technologies** to enable persistent Arctic observations
- Development of new fully-integrated **Arctic System Models**
- **Exploitation of Remote Sensing** for both Basic Understanding and to constrain the new Arctic System Models



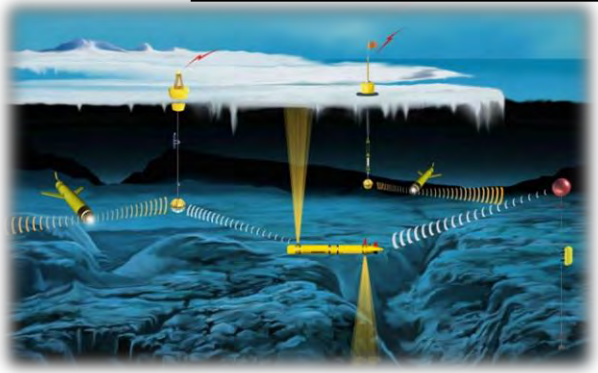
# Technology Development

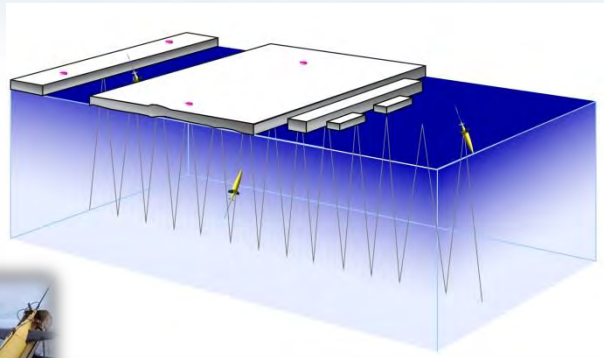
**An Arctic sensing system must be developed to provide persistent observations that can further scientific understanding, provide long-term monitoring, and help constrain the predictive numerical models.**

Autonomous platforms – Robust Sensors – Real-time Data Delivery – Key Environmental Variables

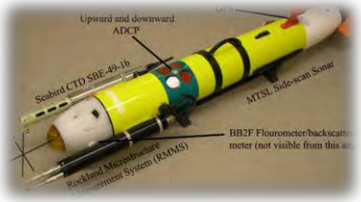



**Real-Time Data Communication**

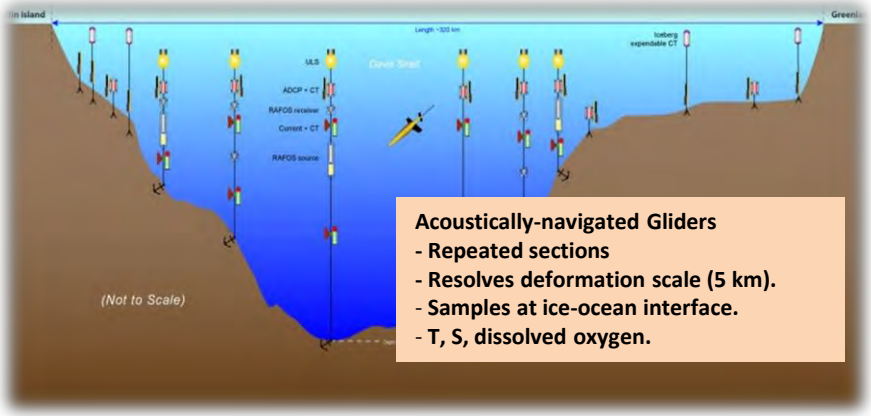




**Novel Sensing Systems**




**Autonomous Platforms and Enabling Technologies**

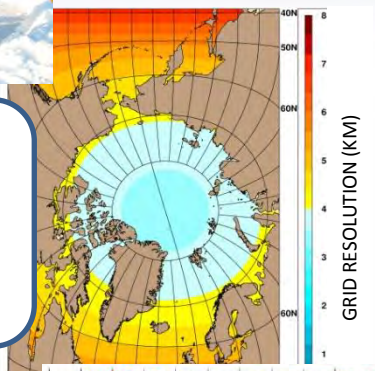



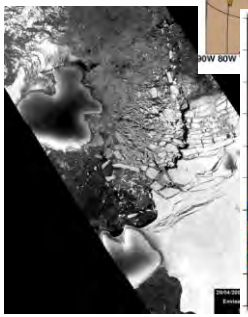

**Acoustically-navigated Gliders**
- **Repeated sections**
- **Resolves deformation scale (5 km).**
- **Samples at ice-ocean interface.**
- **T, S, dissolved oxygen.**

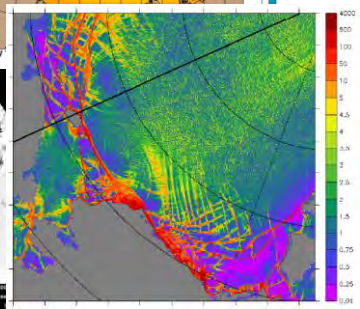
# Development and Transition of Arctic Prediction Systems

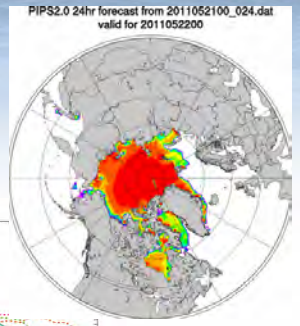
Fieldwork to better understand key physical processes

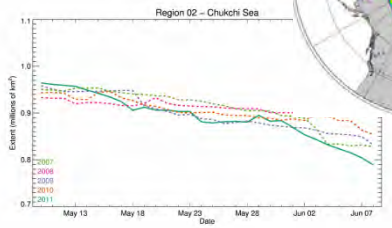
Improved physics built into data-assimilating integrated models

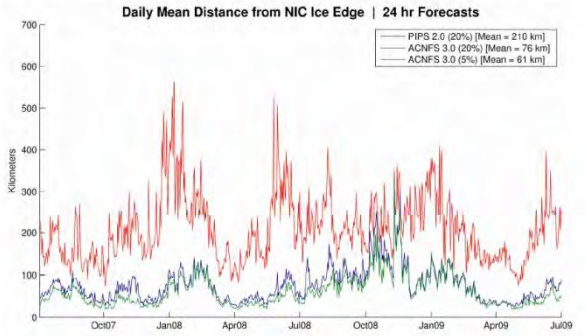







NAVAL METEOROLOGY AND OCEANOGRAPHY COMMAND

NATIONAL ICE CENTER
WASHINGTON D.C.

**Arctic Prediction System Development**

**Observing System Development**

**Validation and Verification**

**Testing, Prototyping and Experimentation**

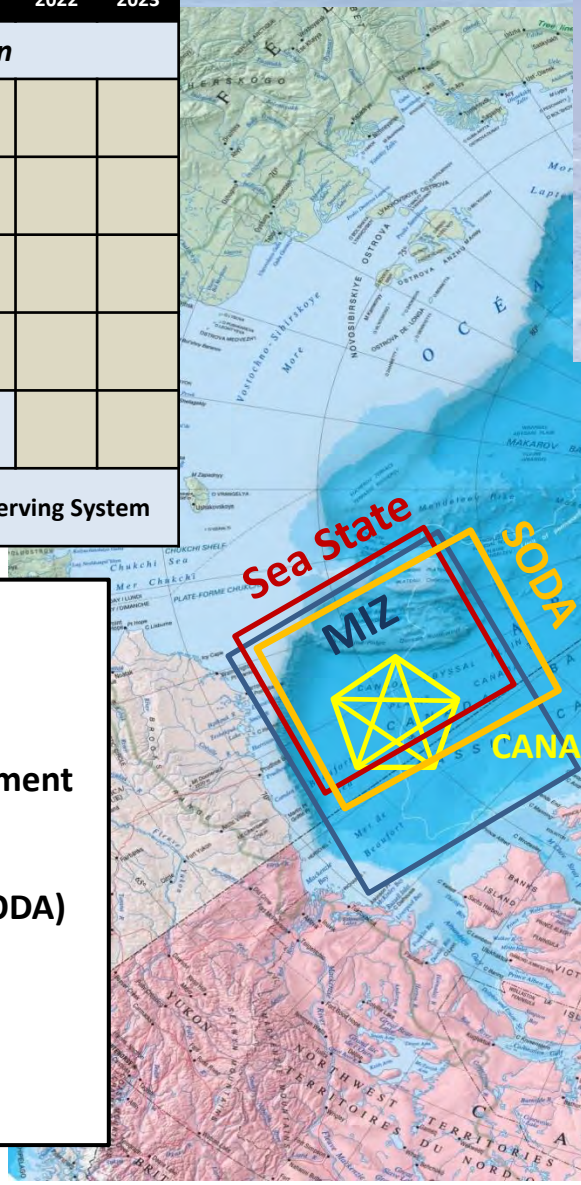
**Transition to Operational Use**

**Transition to Operational Use**

# ONR Major Arctic Research Initiatives

| 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ONR 'Core' Program, ***Arctic and Global Prediction*** | | | | | | | | | | | |
| **Marginal Ice Zone DRI** | | | | | | | | | | | |
| | **Waves and Sea State DRI** | | | | | | | | | | |
| | | | **CANAPE (acoustics)** | | | | | | | | |
| | | | | **Stratified Ocean Dynamics DRI** | | | | | | | |
| | | | | | **Sea Ice Dynamics Experiment** | | | | | | |
| | | | | | | | **Arctic Mobile Observing System** | | | | |

- **Marginal Ice Zone (MIZ) Initiative**
  - *2014 Field Program*
- **Waves and Sea State Initiative**
  - *2015 Field Program*
- **Canada Basin Acoustic Propagation Experiment (CANAPE)**
  - *2015, 2016-2017 Field Programs*
- **Stratified Ocean Dynamics in the Arctic (SODA)**
  - *2017-2019 Field Programs*
- **Sea Ice Dynamics Experiment (SIDEx)**
  - *2019-2020 Field Programs*
- **Arctic Mobile Observing System (AMOS)**
  - *2020-2023 Field demonstrations*


# Stratified Ocean Dynamics in the Arctic (SODA)

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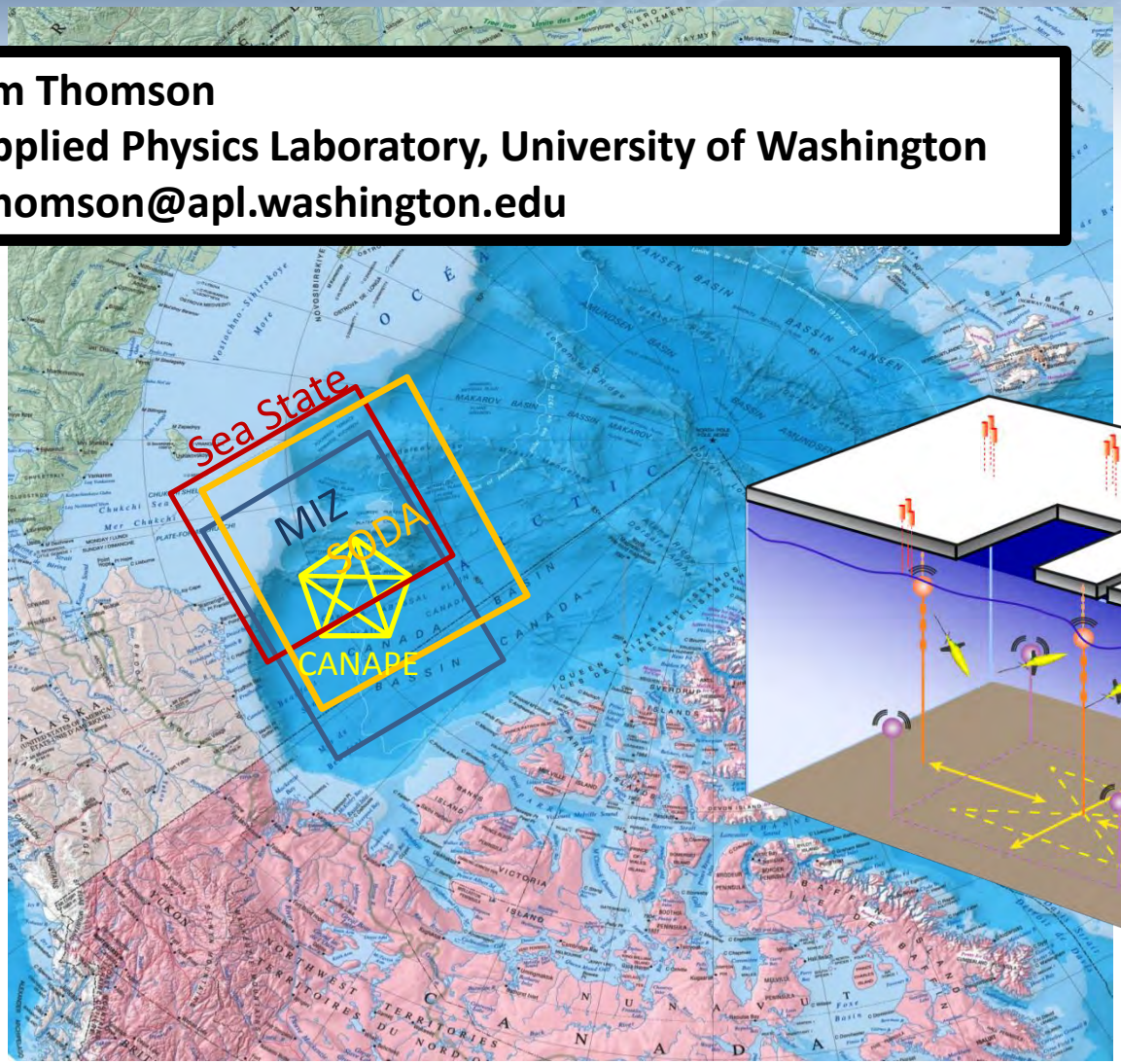
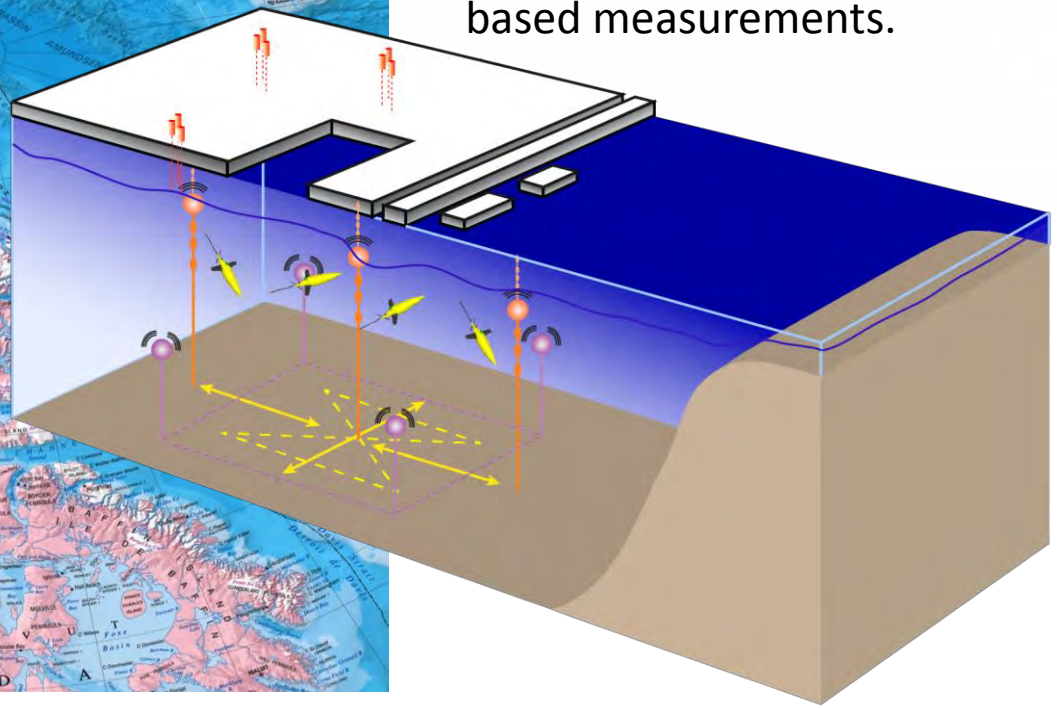
**jthomson@apl.washington.edu**

- 2018-2019.
- Central Beaufort Sea.
- One year of autonomous sampling (moorings, gliders, ice-tethered sensors).
- Autumn service cruises, ship-based measurements.



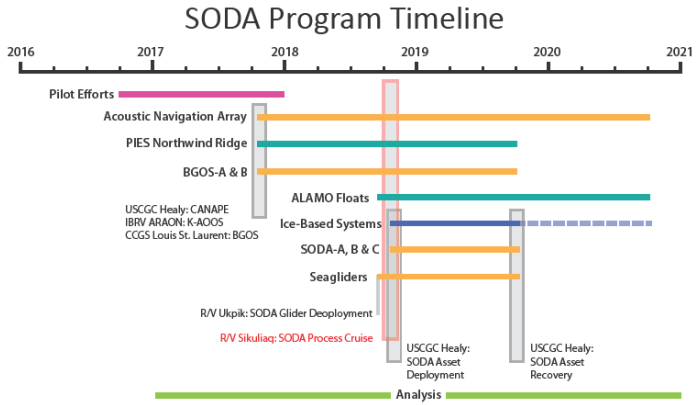



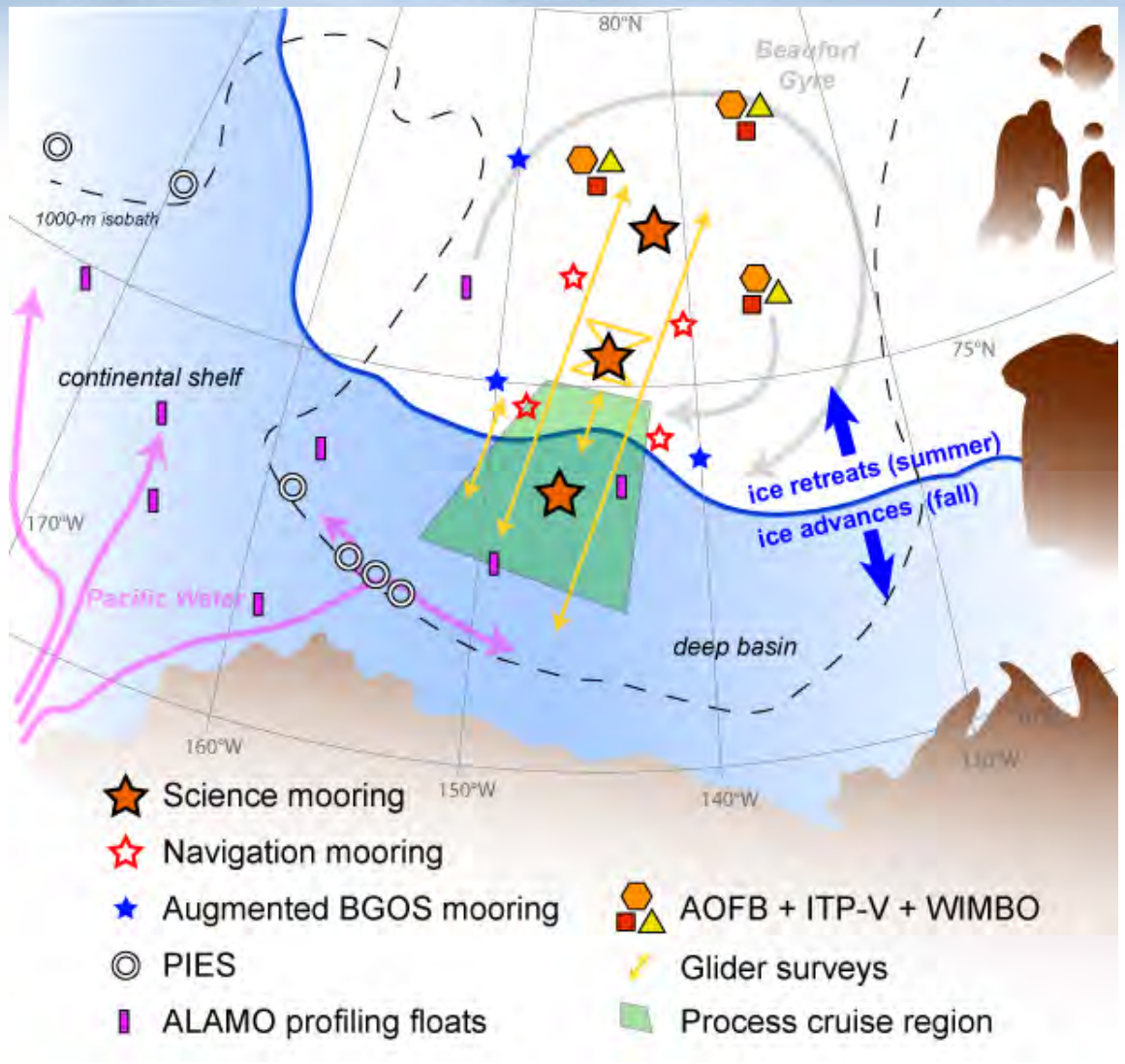
# Stratified Ocean Dynamics in the Arctic
## 2018 – 2019 Field Efforts

## SODA Objective

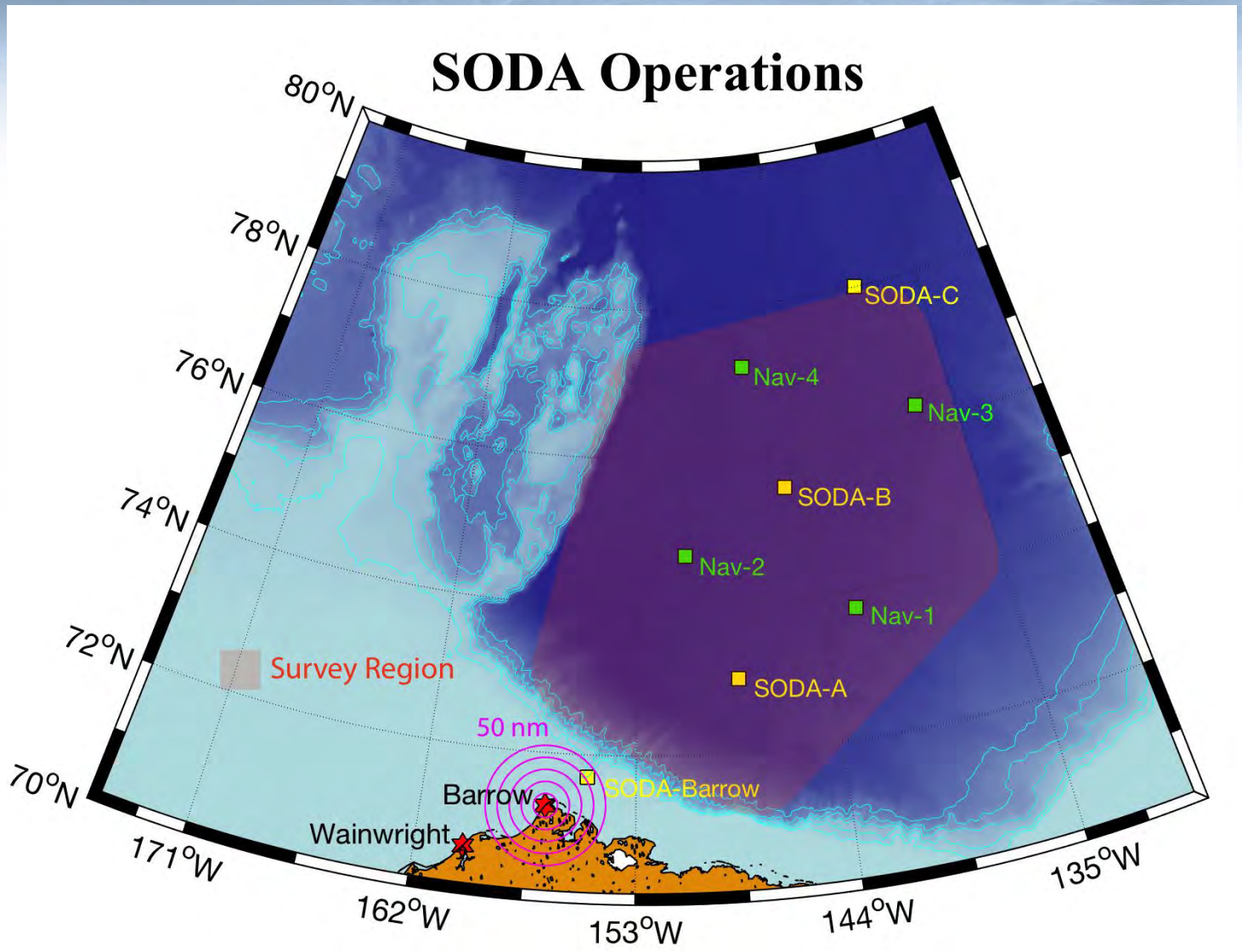
SODA is a process study to better understand the response of the upper Arctic Ocean to changes in oceanic inflow and surface forcing over ice-free waters or areas of reduced sea ice cover.

The program will include extended autonomous observations as well as intensive ship-based data collection during several cruises.



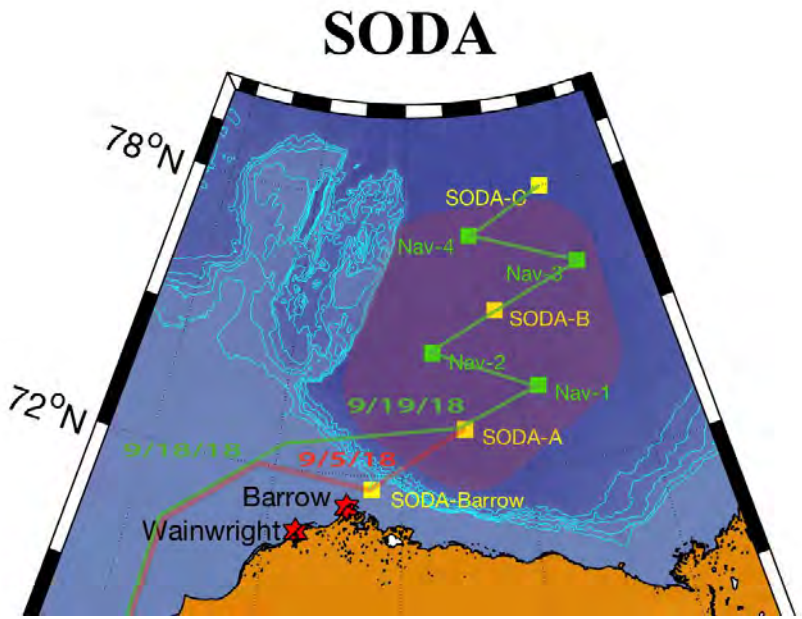
# SODA region

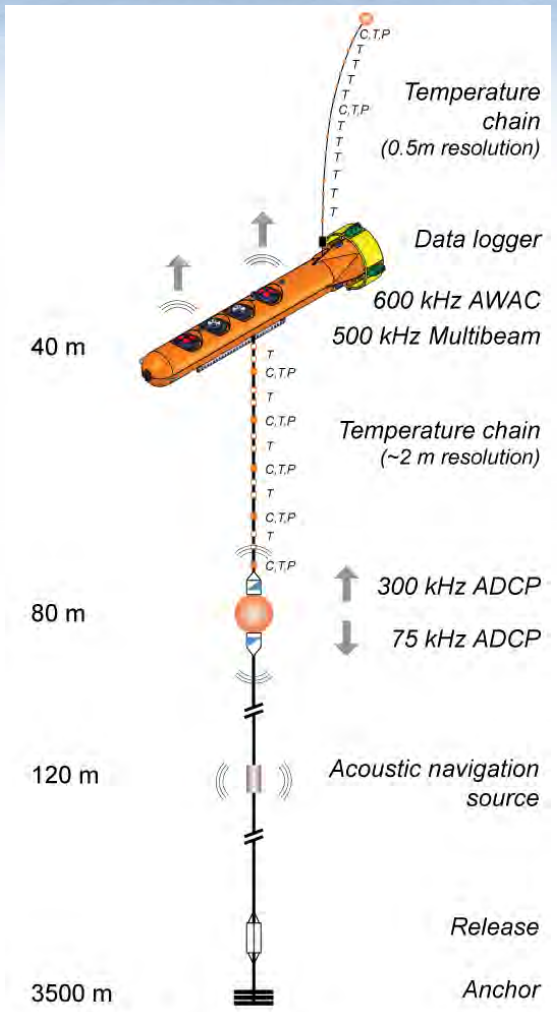

SODA Operations
80°N
78°N
76°N
74°N
72°N
70°N
171°W
162°W
153°W
144°W
135°W
SODA-C
Nav-4
Nav-3
SODA-B
Nav-2
Nav-1
SODA-A
Survey Region
50 nm
SODA-Barrow
Barrow
Wainwright

# USCGC HEALY cruise (Sept 2018)

Focus on mooring deployments:

- SODA A, B, C
- Navigation moorings
- Ice-based platforms



# R/V SIKULIAQ Cruise (Sept 2018)



Focus on process, in three modules:

1. Eddy survey
2. Mooring survey
3. Ice edge survey

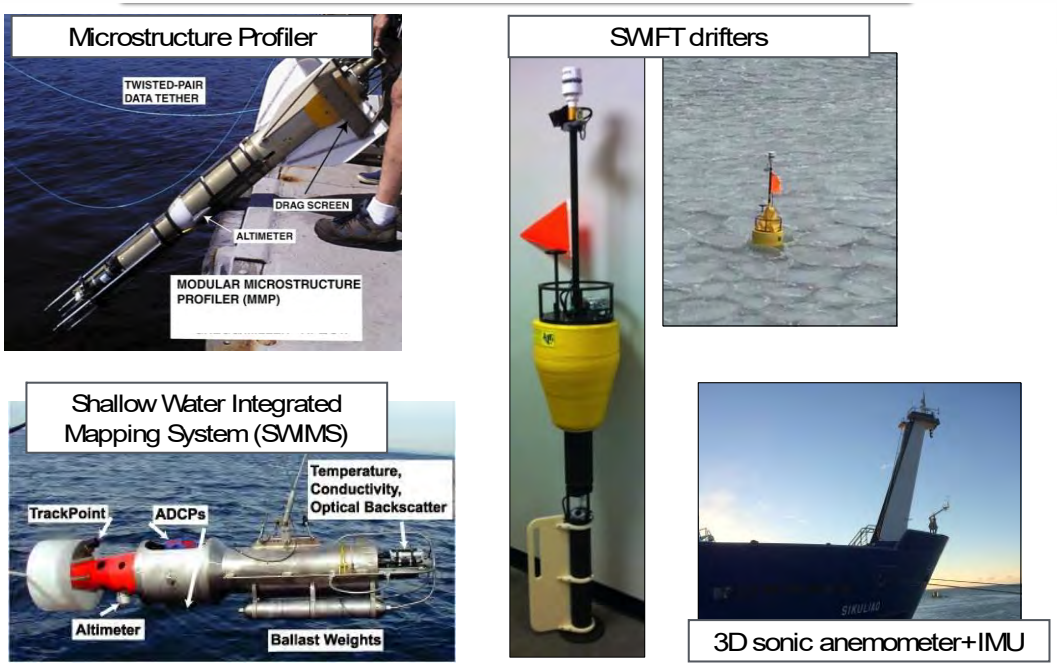


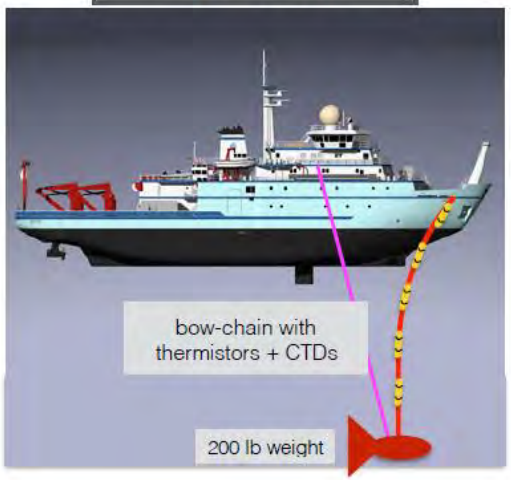

**Figure 10.** Proposed tools to be used during the process cruise. Clockwise from upper left: the Modular Microstructure Profiler (rapid tethered profiling down to 300 m), SWIFT drifters for short deployments from the ship (new versions have ADCPs and C-T chains), meteorological instrumentation on the mast, and the SWIMS towed body.

# SODA DRI: R/V SIKULIAQ Field Effort

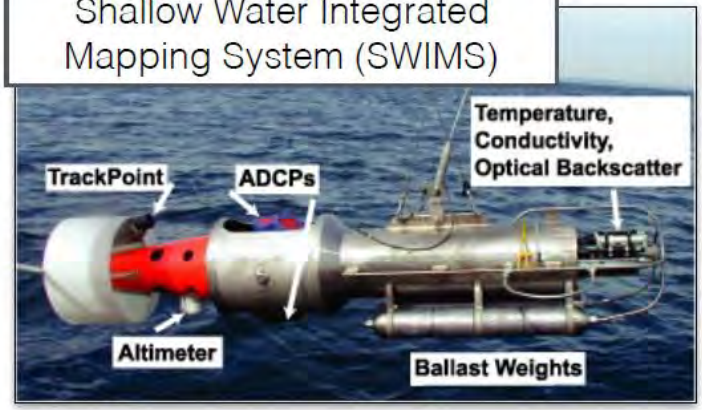
## Process cruise tools: ship-based

Microstructure profiler on outboard boom


Bow Chain




Shallow Water Integrated Mapping System (SWIMS)





3D sonic anemometer+IMU

# SODA DRI: R/V SIKULIAQ Field Effort

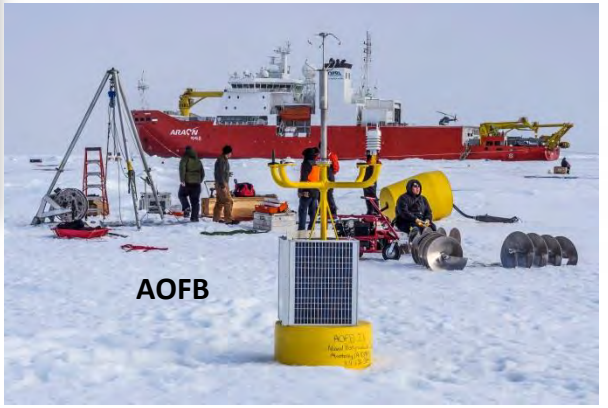
## Process cruise tools: near-ship


Wave Glider

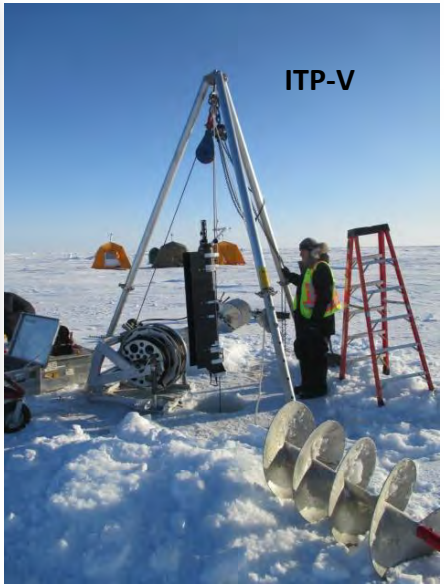
SWIFT drifters

# Autonomous Instrumentation





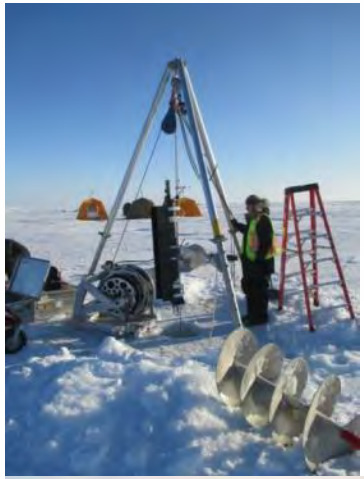


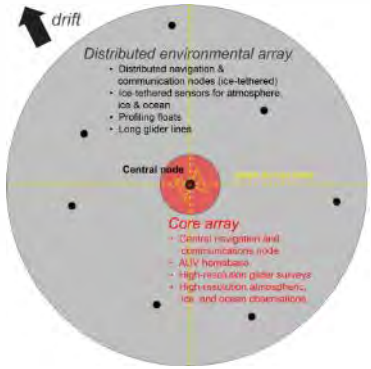


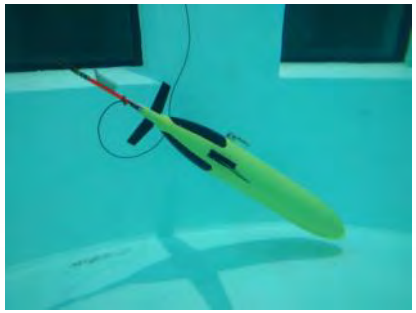
# Sea Ice Dynamics Experiment (SIDEx)
## 2019 Field Effort

**Objective**

Using a distributed array of unattended sensors and platforms, understand the fine scale behavior of different sea ice types under a variety of stress and strain conditions to enable the development of high-resolution numerical sea ice models that can accurately simulate and forecast the formation, deformation, and break-up of Arctic sea ice due to atmospheric, wave, and ocean forcing.

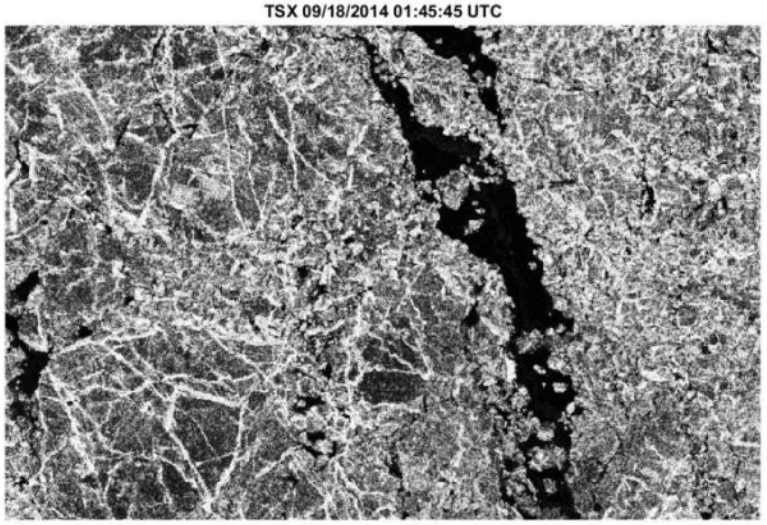




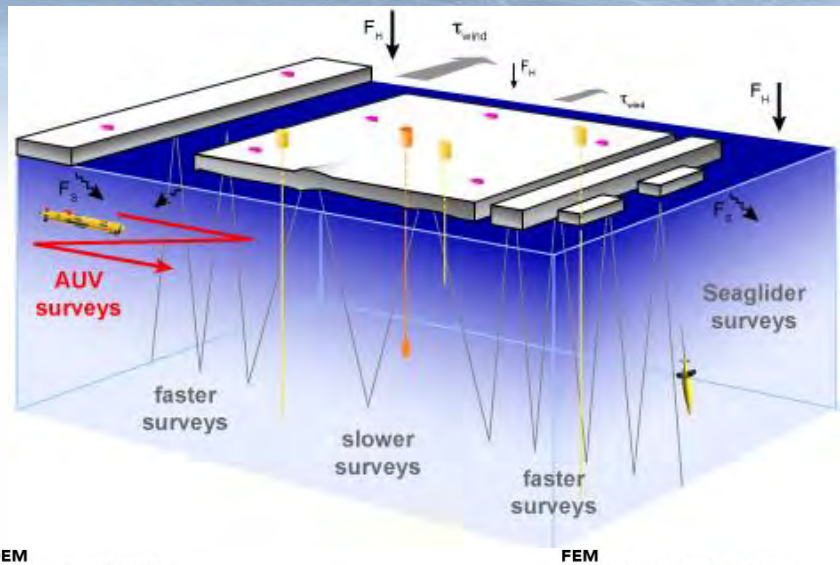
**SIDEx Observing Array**

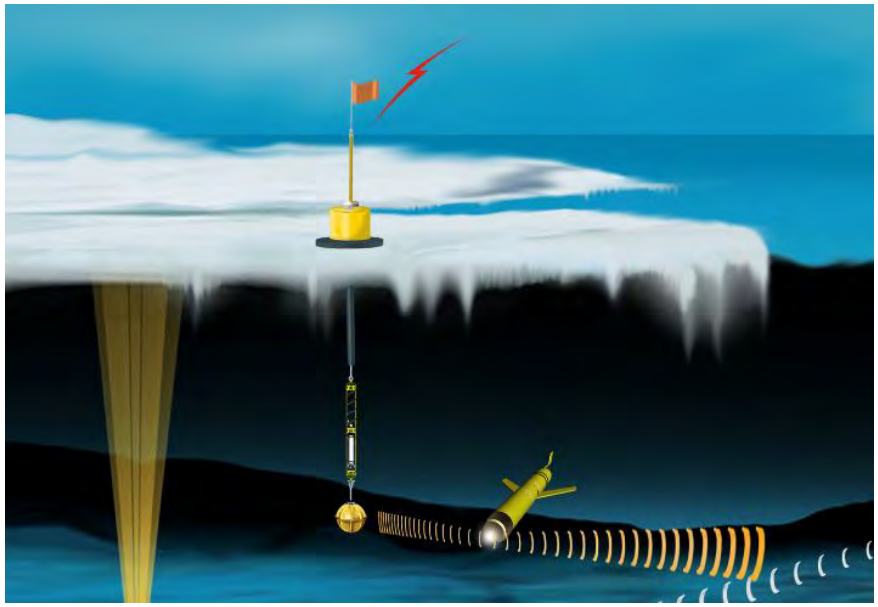
- Will combine in situ platforms and satellite remote sensing to track sea ice motion and forcing over several months

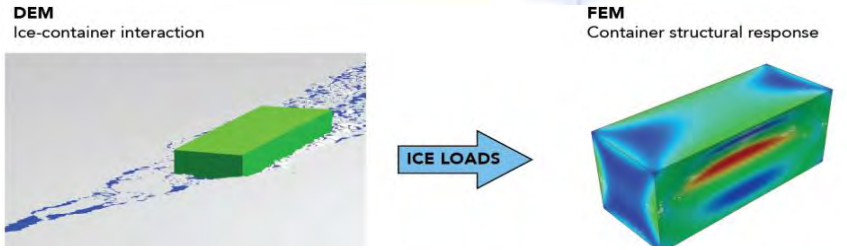


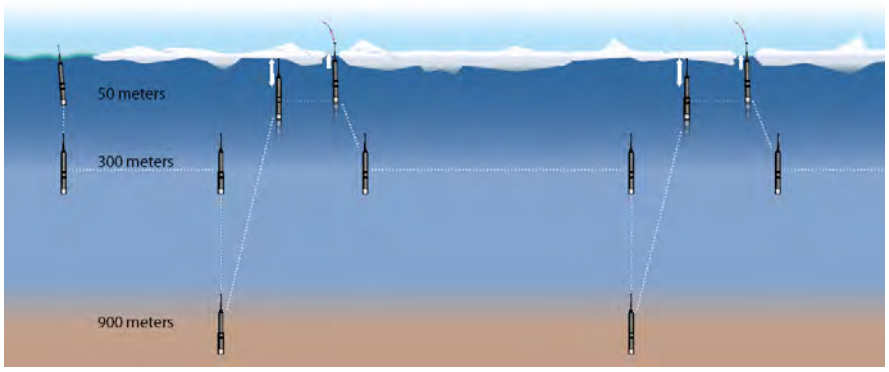

# Arctic Mobile Observing System (AMOS)

- **Mobile Sensing System for Arctic Observation and Prediction**
- **Multiple unmanned platforms with under-ice capabilities – UUVs/buoys/floats will collect data around a central buoy node drifting with the sea ice that provides power/comms**
- **Bi-directional data transfer and mission adaptability with autonomy improvements**
- **Designed to characterize the Arctic environment & prototype CONOPs for persistent robotic observing systems in the Arctic**



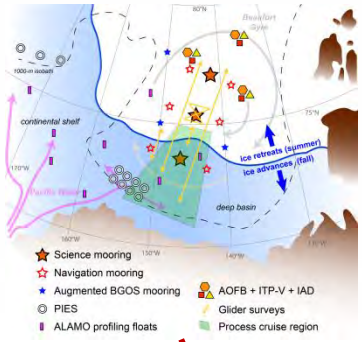





# AMOS
## Key Technical Goals and Deployment Opportunities

**SODA DRI (6.1)**
Will further develop under-ice navigation and communication with autonomous platforms

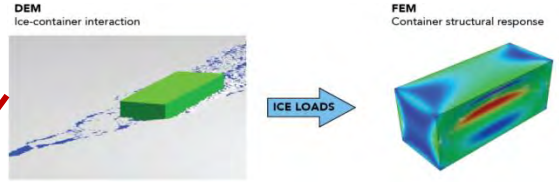



**AMOS Kick-Start Funding**
Supports design and testing of initial node designs in FY17 and FY18

## Leap Ahead Technical Goals

**Domain-Specific Engineering Development**
- Upgrade UUV platform designs for the Arctic environment
- Develop the power and communication buoy node for the Arctic domain
- Incorporate mature and maturing UUV sensing capabilities into vehicles and ensure suitability for Arctic operations

**Develop Under-ice CONOPS for Autonomous UUV Network**
- Build on capabilities developed under previous efforts for vehicle autonomy, re-charging, sensing, communication, and C4I, and develop new capabilities for operating under sea ice
- Enable an under-ice acoustic navigation system for unmanned platforms (suitable for use in any GPS-denied operational area)




**With Canada (DRDC)**

**With Norway and Denmark (tbd)**

| FY17 - FY18 | FY19 | FY20 | FY21 | FY22 | FY23 |
|---|---|---|---|---|---|

- Begin Node Design and Evaluation
- ICEX 18
- SODA DRI Field Deployment
- Contracts Awarded
- SDR
- FIELD TEST
- ICEX 20
- Learning Gate 1
- DEMO 1 BEAUFORT
- Learning Gate 2
- ICEX 22
- EXPAND DEMO
- Learning Gate 3
- FDR
- DEMO 2 SVALBARD

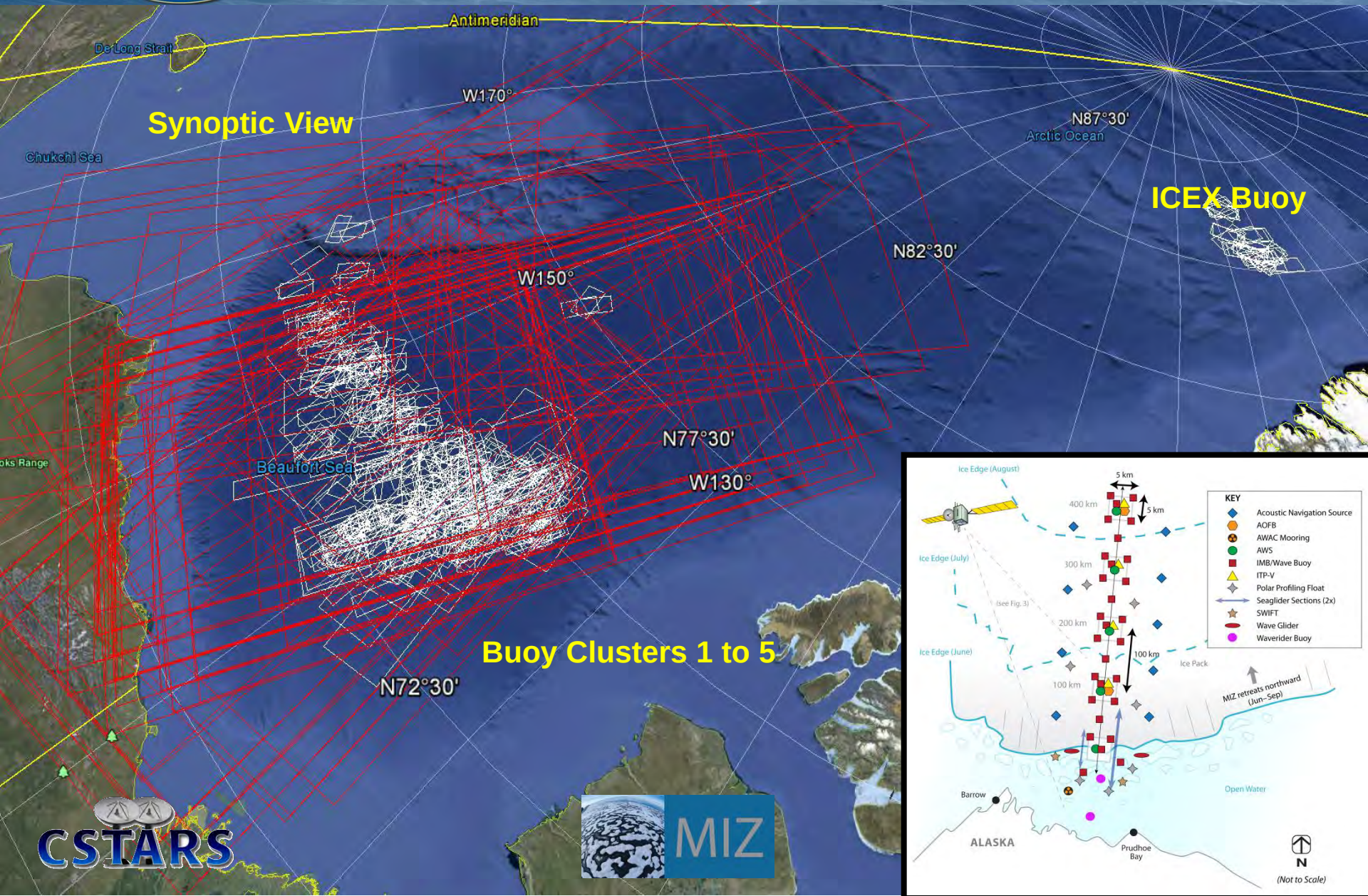
# ONR Arctic Access Concerns

ONR is interested in autonomous observing systems in the Arctic, and will require the ability to deploy, test, and evaluate prototype platforms, systems, and components .

In particular, ONR will need, in SODA and in follow-on programs, the ability to deploy sensors and systems on the ice. With that in mind…

- How successful have recent deployments onto ice floes been from the HEALY?
- How are decisions made regarding risk and approval to put people on the ice?
- How are the candidate floes chosen?
- Is there anything ONR can do to help ensure, or at least maximize, the opportunity to get scientists and engineers on the ice to deploy their gear?
    - Remote sensing support (high-resolution SAR)?
    - Dedicated weather forecasting for ship locale?
    - Other?

# Satellite SAR Collections, MIZ 2014



# ONR Arctic Research Summary

**ONR's Arctic Program is investing in research that will enable the Navy to prepare for and respond to future Arctic missions and concerns in recognition of the emerging interest in the region.**

**Primary thrusts:**

- **Development and use of new observing tools, with an emphasis on autonomous platforms and sensors**
- **Basic understanding of the emerging physical Arctic system**
- **Development of the Arctic component of Earth system numerical prediction models to enable improved forecasts**