TERRASOND®

PRECISION GEOSPATIAL SOLUTIONS®

terra \terə\ n. [Latin]
the planet earth; land or territory

sond \sänd\ n.f. [French]
an instrument for measurement

2020 Unmanned Vessel Deployments: ASV and Saildrone

Andrew Orthmann, TerraSond Charting Program Manager

www.terrasond.com

Who?

Office of Coast Survey
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

- **Responsible for creating and maintaining nautical charts since 1807**

TERRASOND
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- **Geospatial services, specializing in seafloor mapping, since 1994**
- **Palmer, Alaska**

SAILDRONE

- **Designs, builds, and operates unmanned science vessels**
- **Alameda, California**

L3HARRIS | ASV

- **Designs, builds, and operates autonomous surface vessels**
- **Broussard, Louisiana**

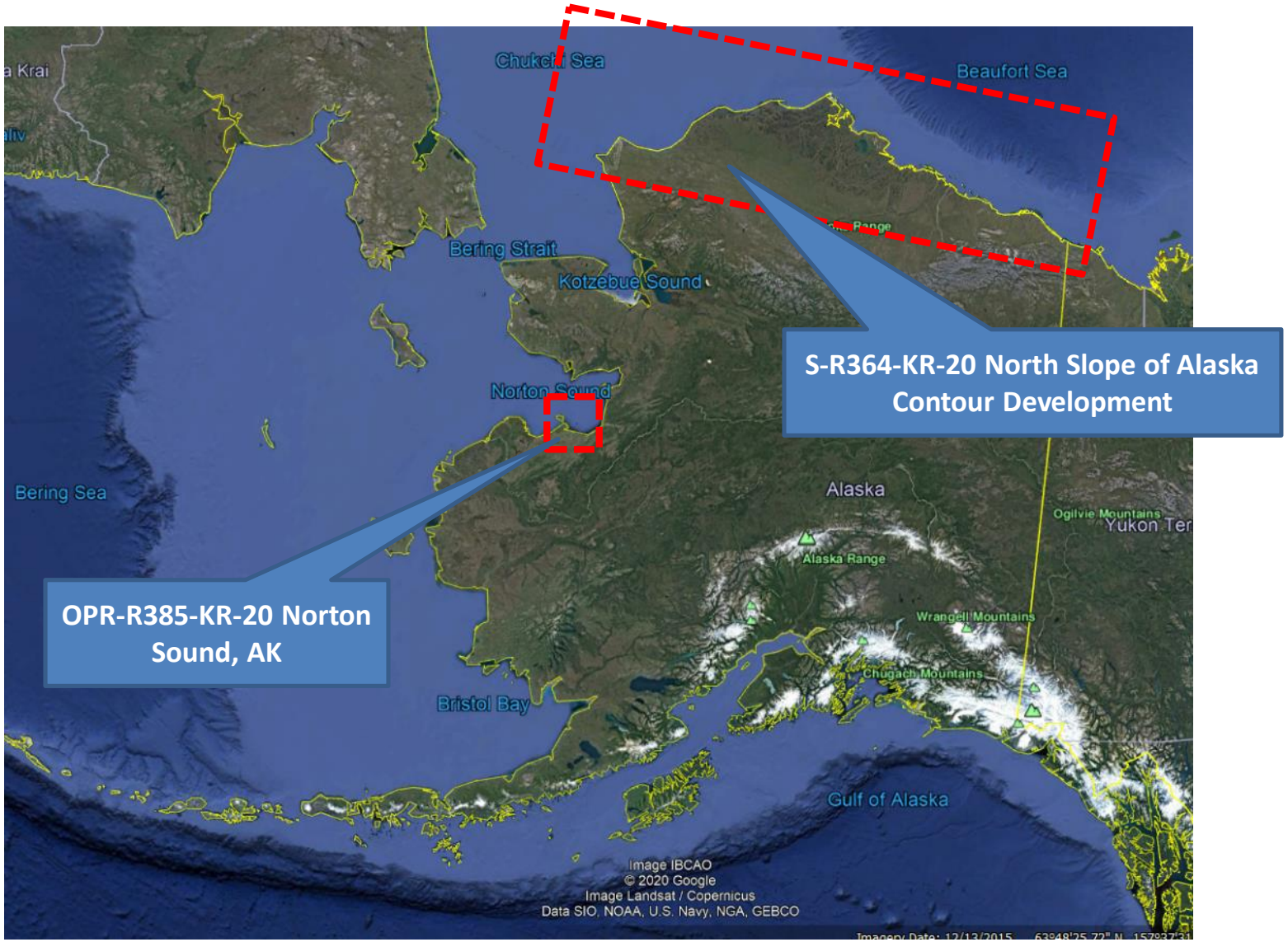
Chukchi Sea
Beaufort Sea
Bering Strait
Kotzebue Sound
Norton Sound
Bering Sea
Alaska
Alaska Range
Ogilvie Mountains
Wrangell Mountains
Chugach Mountains
Bristol Bay
Gulf of Alaska
Image IBCAO
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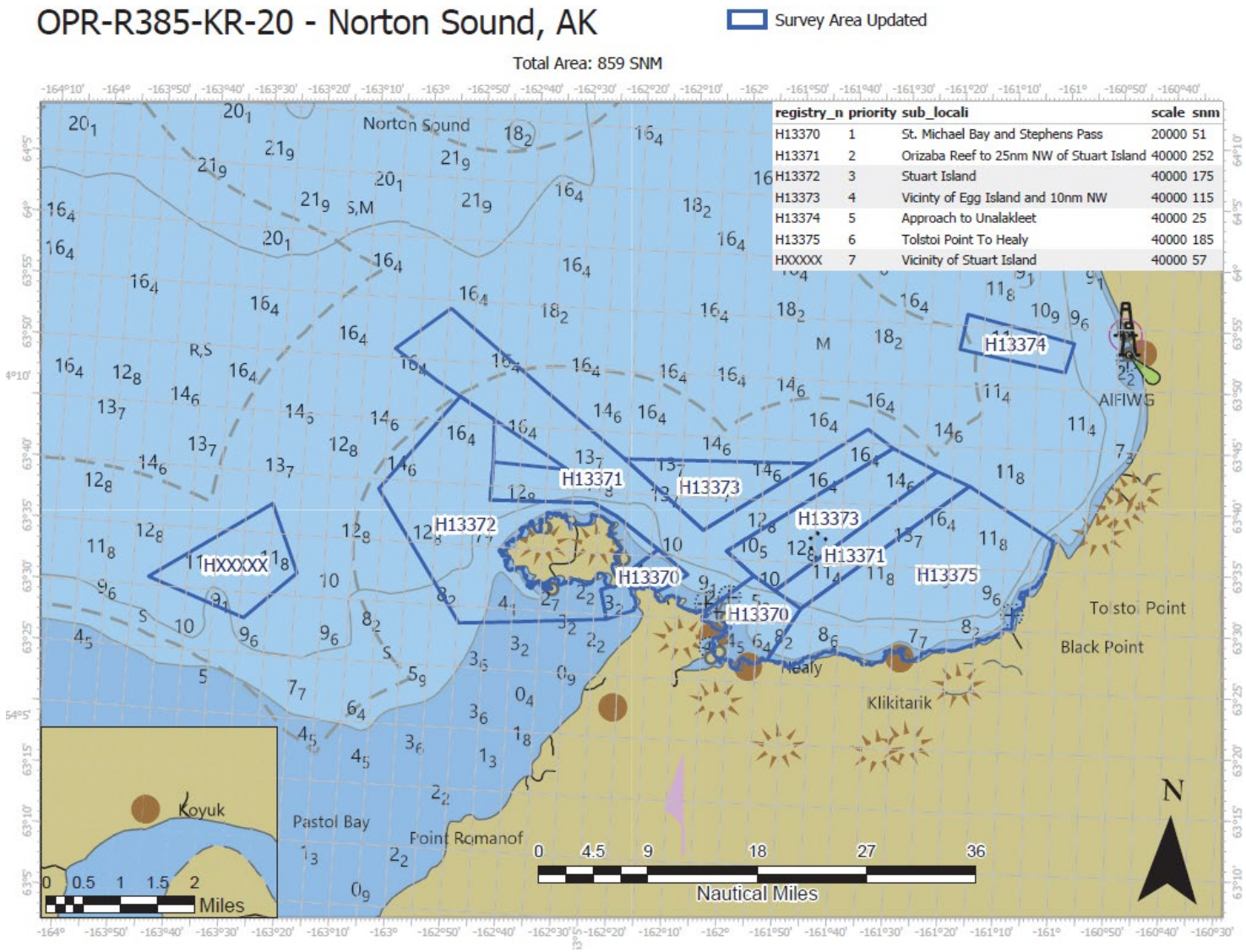
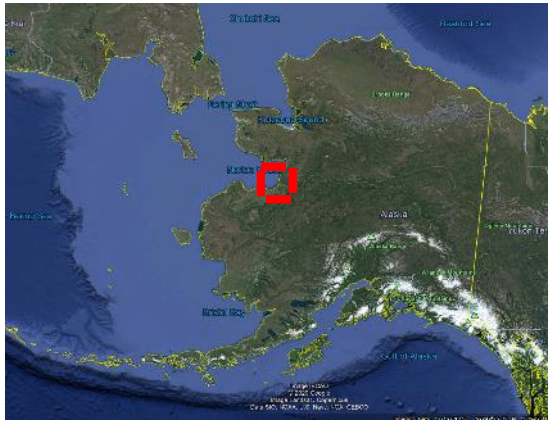
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
S-R364-KR-20 North Slope of Alaska Contour Development
OPR-R385-KR-20 Norton Sound, AK

2020 Norton Sound

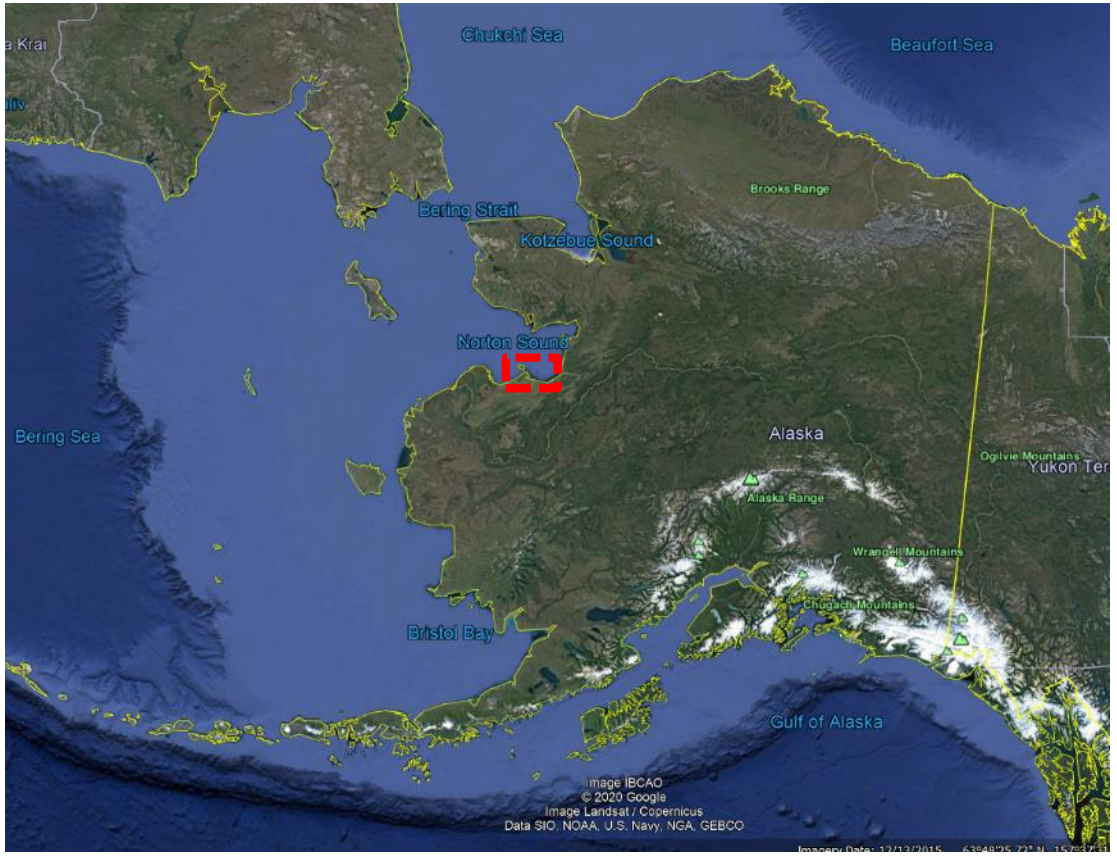




- **Standard NOAA charting survey**
- **859^2 nautical miles**
- **20m to 2m water depth**
- **Multibeam sonar coverage**

2020 Norton Sound

- Remote area
- Long transit (>1,000 NM)
- Large amount of data collection (>9,000 LNM)
- Limited season to work due to weather and ice



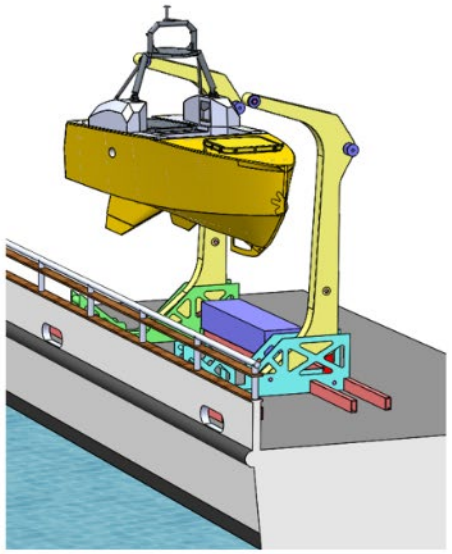
- **Requires good production rates**
- **Ability to work shallow water**
- **Traditionally done with ship and manned launches**

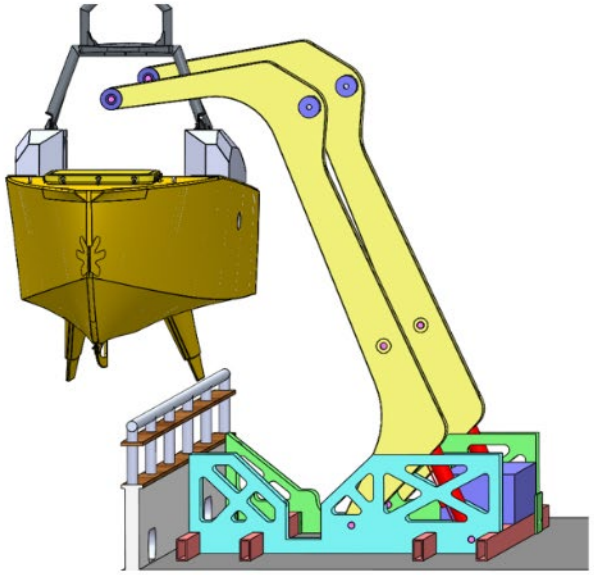
2020 Norton Sound

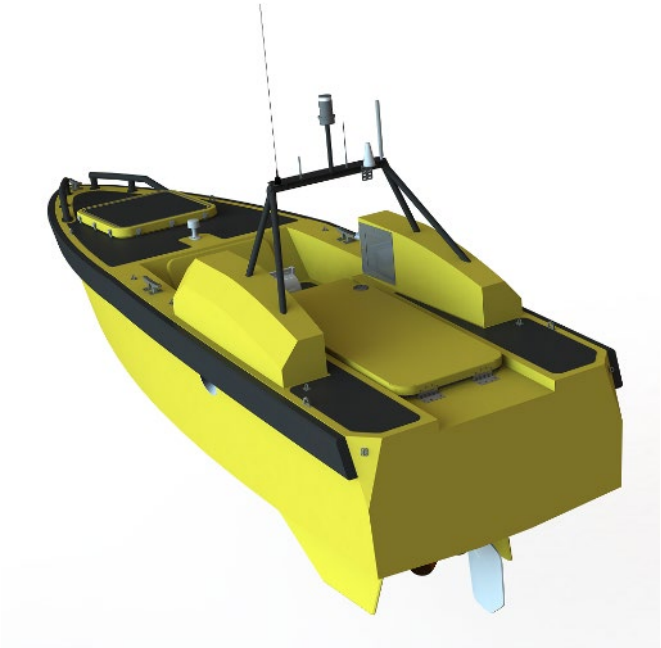
- **TerraSond began using unmanned vessels on Alaska projects in 2015 with a military drone modified for survey**
- **L3 Harris ASV** L3HARRIS | ASV
- **Good experiment but issues with endurance, deployment, and payload capabilities**

2020 Norton Sound

- L3 Harris ASV C-Worker 5 (CW5) starting in 2016
- 18’ unmanned vessel, purpose-built for survey
- Launch and Recovery System (LARS)
- Greater survey equipment options
- Endurance up to 7 days continuous survey

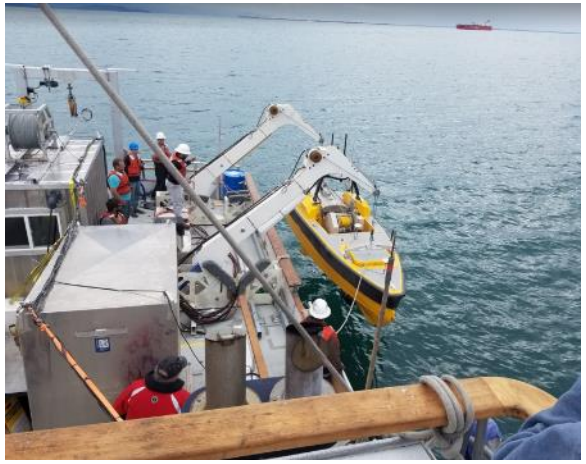






2020 Norton Sound

- **Mobilize on a 105’ “mother” vessel**
- **Mother vessel mods: LARS install, radio antennas, container on deck to support additional personnel**



2020 Norton Sound

- **Works alongside the larger vessel 24/7 as a “force multiplier”**
- **Collecting the same data types as the larger vessel on parallel survey lines**

2020 Norton Sound

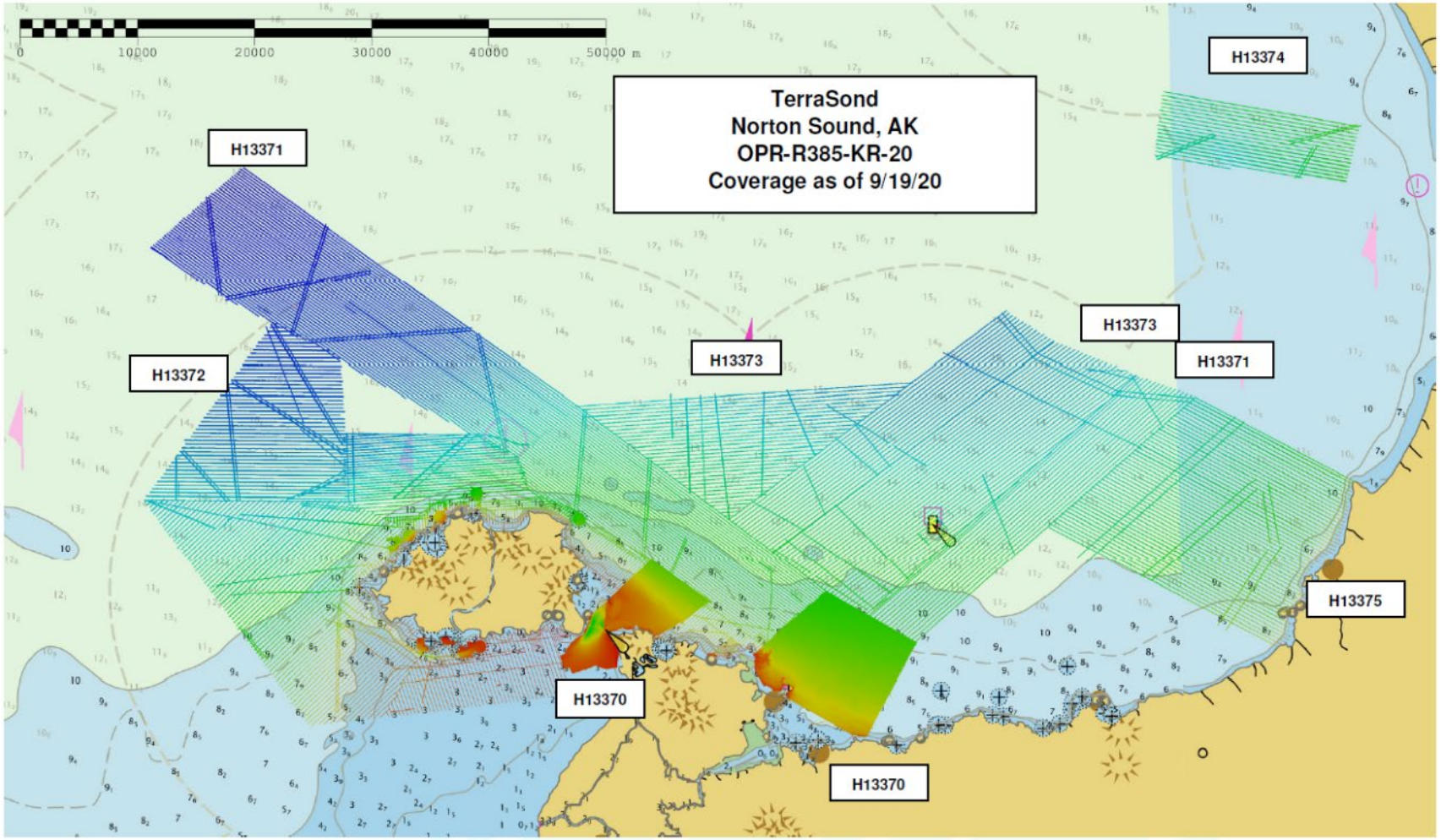
- **Also relied on to work shallow water unsafe for larger vessel**
- **Shallow draft, maneuverable**

2020 Norton Sound

- Radio links for control and data, 2-3 km reliable range
- Two technicians per shift: 1 ASV control, 1 survey
- Not fully “autonomous”: Unmanned but continuously monitored
- Entirely remote controlled at times

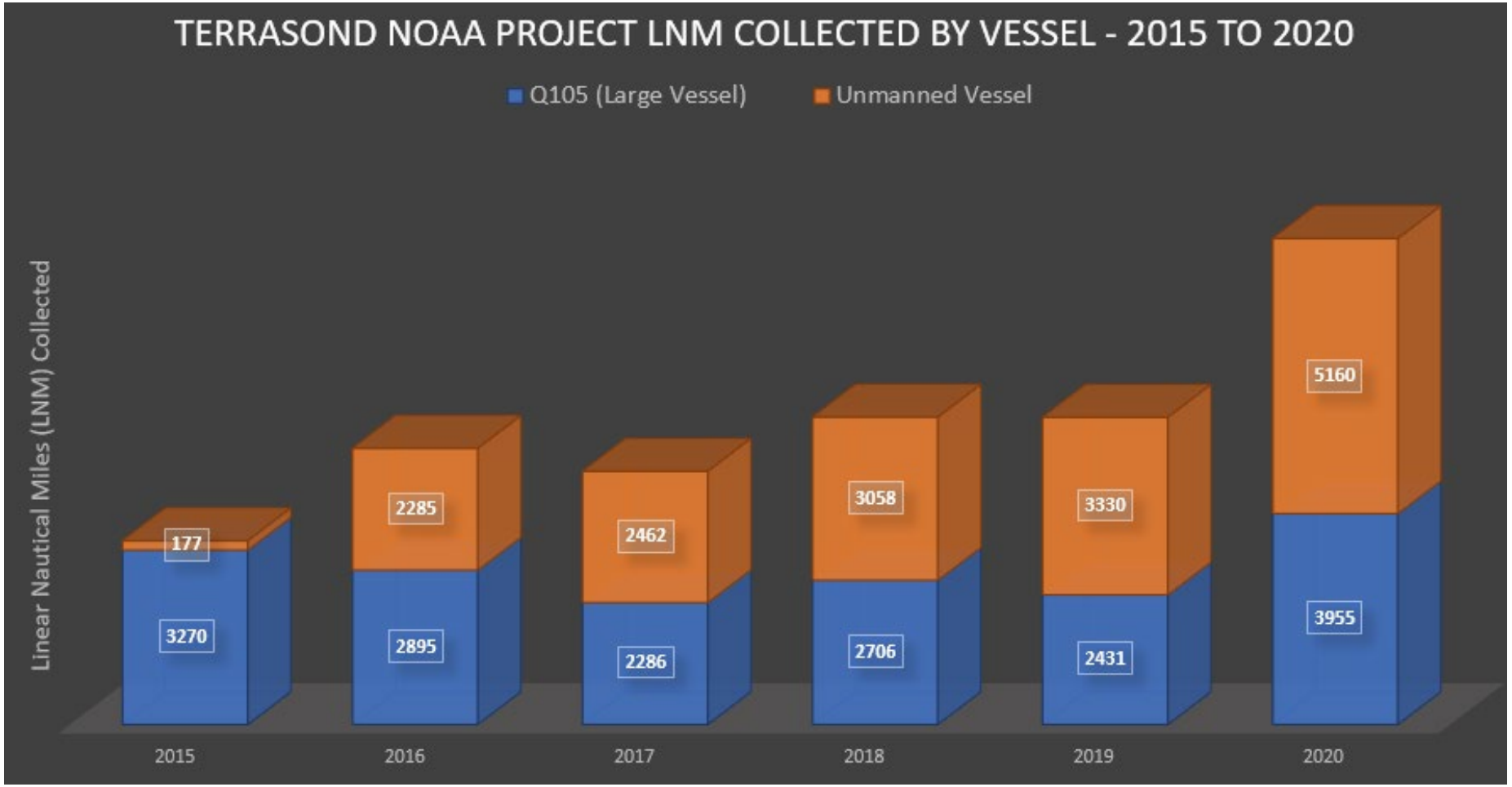
2020 Norton Sound

- Norton Sound Survey Area
- July – September, 2020
- Required collection of 9,100 LNM of multibeam sonar data



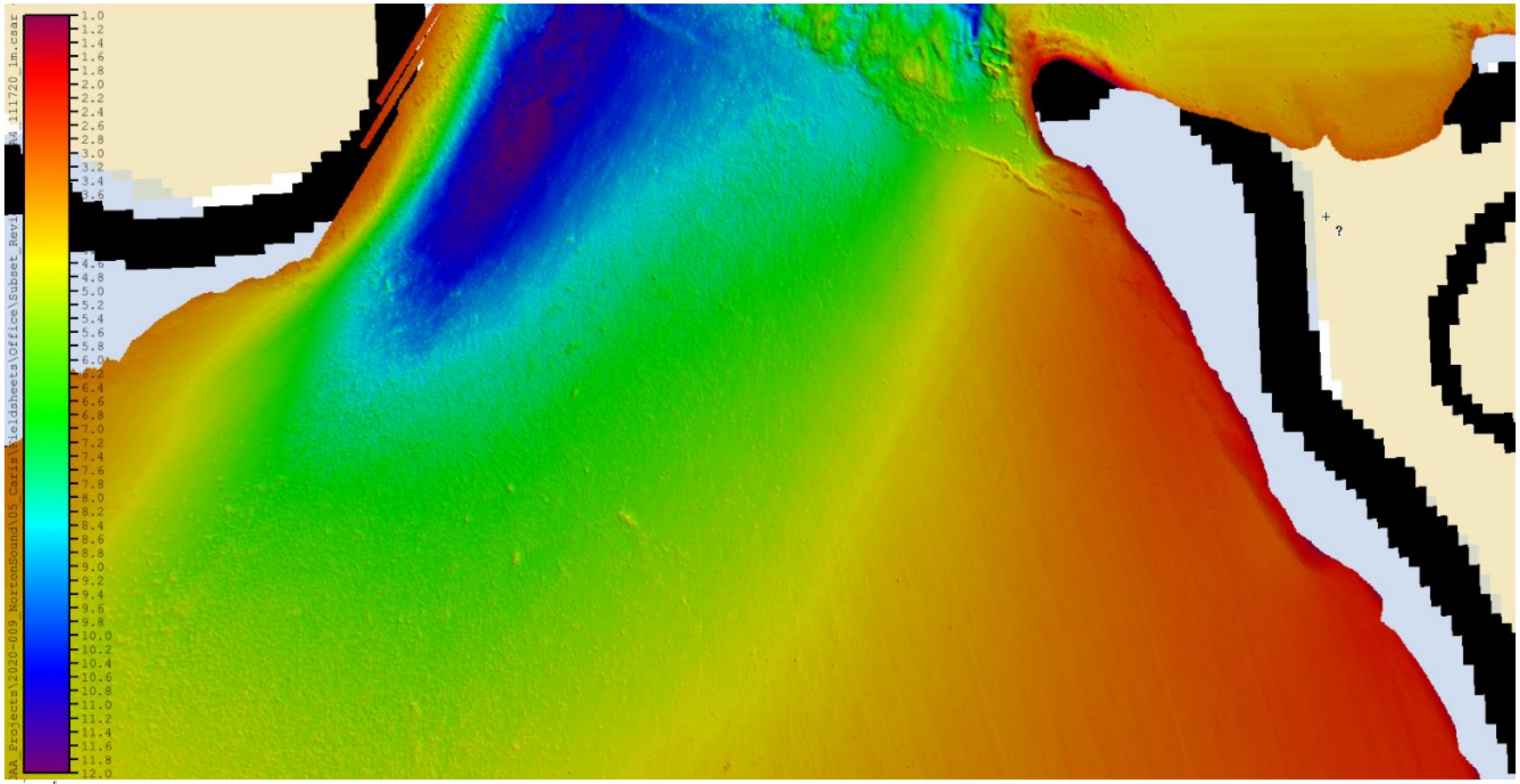
2020 Norton Sound

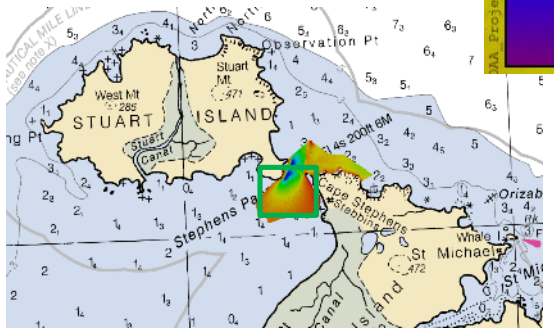
- **CW5 ASV acquired most of the data on the project (~ 57%, or 5160 of 9115 LNM)**
- **Continues a trend of increasing unmanned vessel LNM since 2015**



2020 Norton Sound

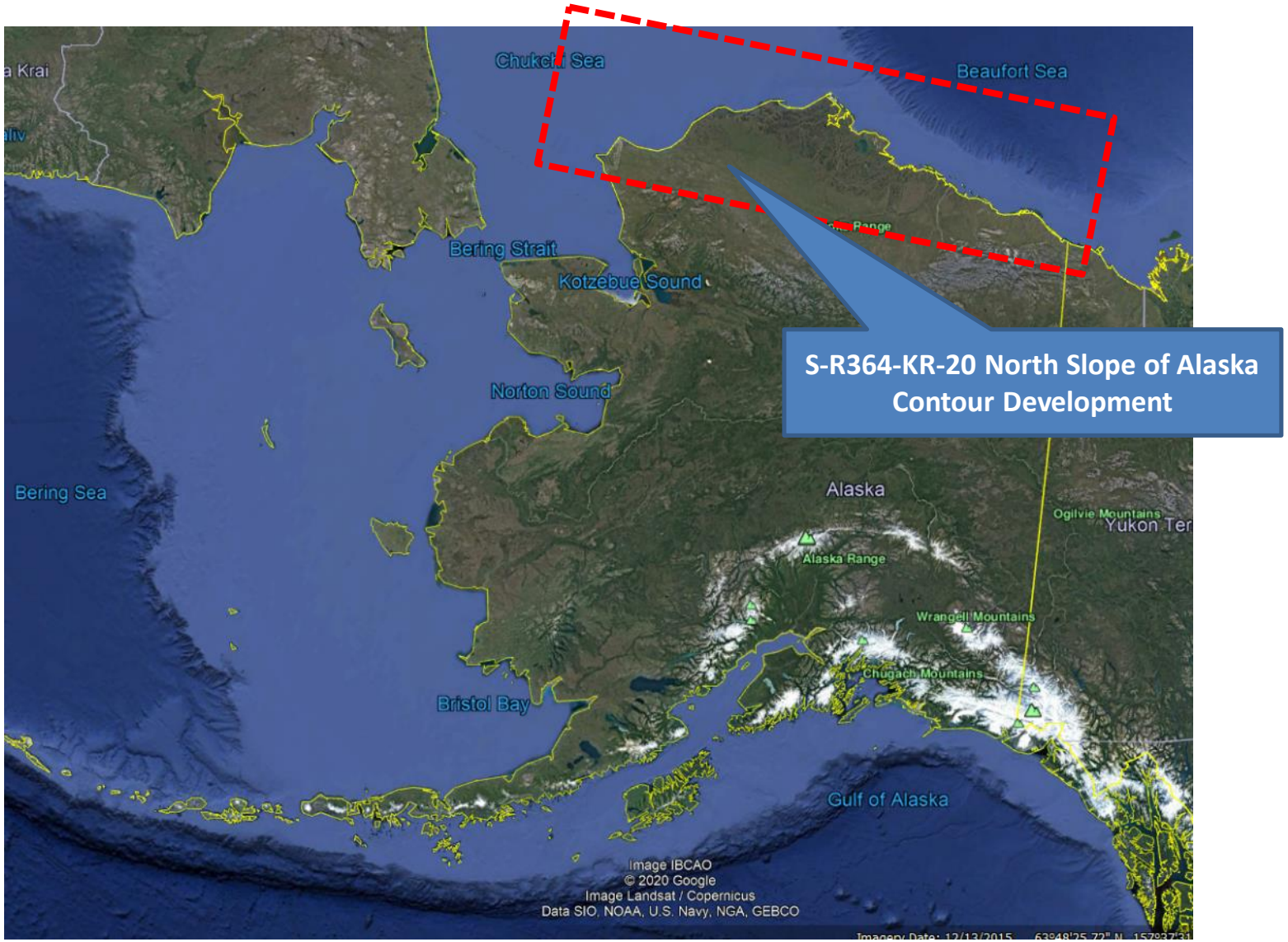
Example multibeam (Reson T50) data collected with the CW5 ASV in Stephens Passage:





- **Processing of dataset in progress; will be delivered to NOAA OCS in January for application to nautical charts**

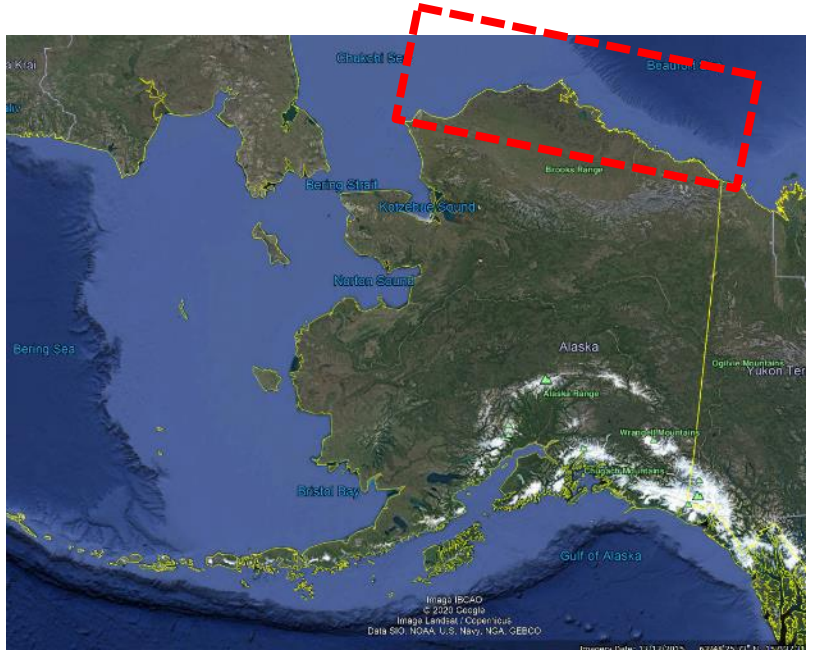
2020 North Slope of Alaska Contour Development



2020 North Slope of Alaska Contour Development

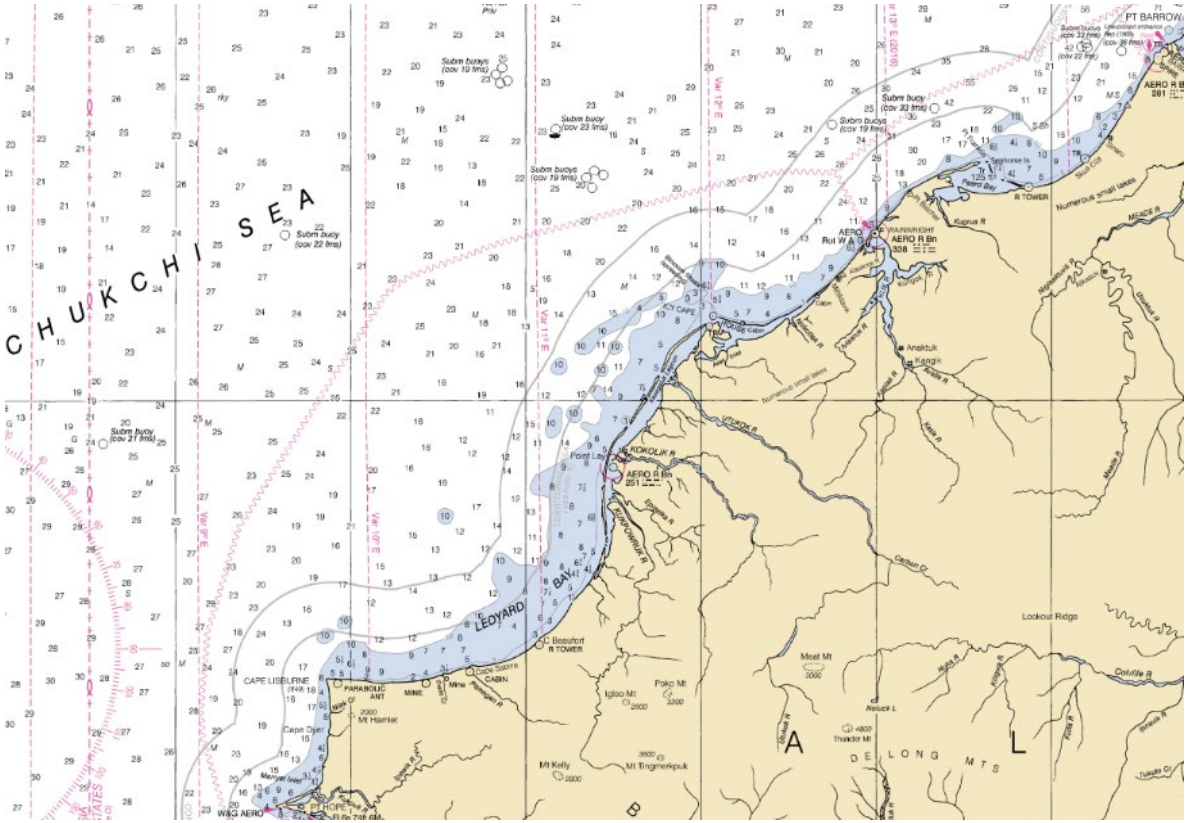
Primary Mission Objectives:

- **Locate 20 m (65’) and 50 m (164’) depth curves off the North Slope to assist with planning future surveys**
- **Demonstrate ability to accomplish unmanned seafloor surveys in remote areas**
- **Test feasibility of saildrone technology for mapping and derive lessons learned**



2020 North Slope of Alaska Contour Development

- **Ocean off of Alaska's North Slope are poorly charted**
- **The Arctic area is of increasing priority for chart updates**
- **The area is difficult and expensive to reach with conventional means (large vessel with launches)**



NOAA ship Fairweather – example of conventional survey approach

2020 North Slope of Alaska Contour Development

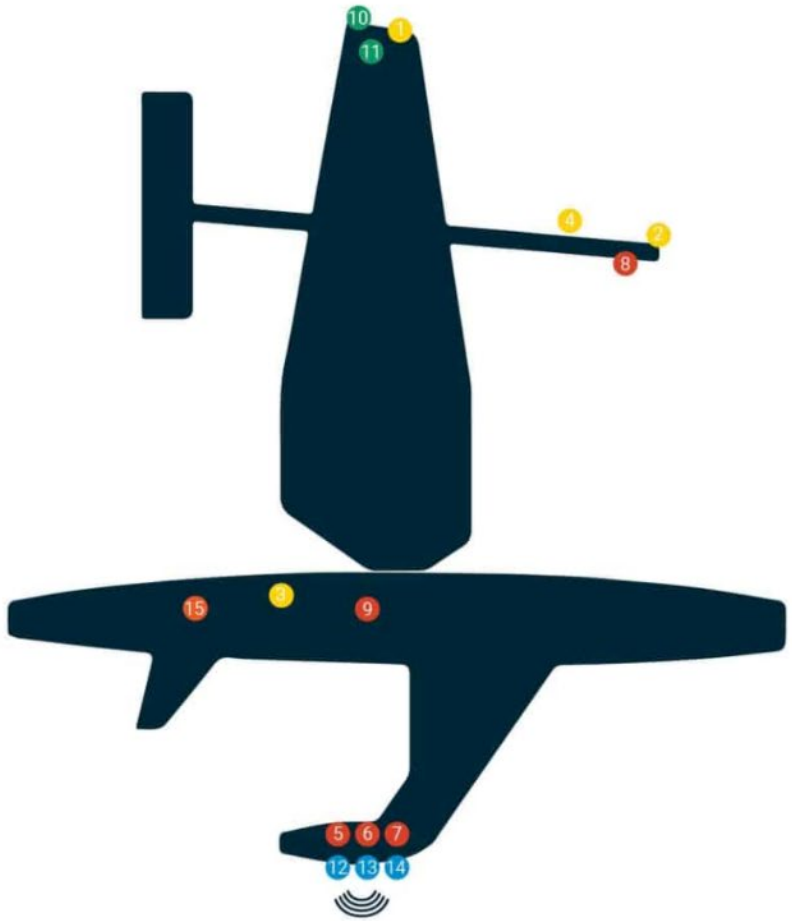
- **Unmanned science vessel (USV)**
- **Wind-driven sailboat (no engine or prop)**
- **Slow, normally 2-3 knots**
- **Solar panels for electronics, zero emissions**
- **23’ length, 16’ height, 8’ draft**
- **World-wide range, up to 1 year durations**

SAILDRONE

2020 North Slope of Alaska Contour Development

- **Carries suite of scientific instruments**
- **Highly visible, includes AIS, lights, radar reflectors, and cameras**
- **Remotely monitored by satellite**
- **User access through online web portal**

Standard Saildrone Sensor Suite



ATMOSPHERIC MEASUREMENTS

1	WIND SPEED & DIRECTION	Gill Windmaster 3D ultrasonic 20 Hz @ +5.0 m
2	AIR TEMP & HUMIDITY	Rotronic HC2 – S3 with rad shield @ +2.2 m
3	ATMOSPHERIC PRESSURE	Vaisala Barocap PTB210 @ +0.2 m
4	PHOTOSYNTHETICALLY ACTIVE RADIATION	LI-COR LI-192SA @ +2.2 m

OCEAN MEASUREMENTS

5	SALINITY & TEMPERATURE	Seabird SBE 37 @ -2.0 m
6	DISSOLVED OXYGEN	Seabird SBE 37 ODO @ -2.0 m
7	CHLOROPHYLL-A	Wetlabs ECO-FL-S G4 @ -2.0 m
8	SKIN TEMPERATURE	Heitronics CT15.2 @ +2.2 m
9	WAVE HEIGHT & PERIOD	VectorNav VN300 Dual GPS aided IMU

MARITIME DOMAIN AWARENESS

10	SMART CAMERA ARRAY	High-resolution optical cameras with AI/ML target detection
11	AIS TRANSCEIVER	Class B AIS transceiver

ACOUSTIC MEASUREMENTS

12	OCEAN CURRENTS	Teledyne RDI Workhorse ADCP 300 kHz @ -2.0 m
	OR	
13	FISH BIOMASS	Simrad WBT Mini (EK80) @ -2.0 m
	OR	
14	BATHYMETRY	Shallow single-beam: Airmar DT800 Deep single-beam: Teledyne Echotrack E20 Shallow multibeam: Norbit iWBMS

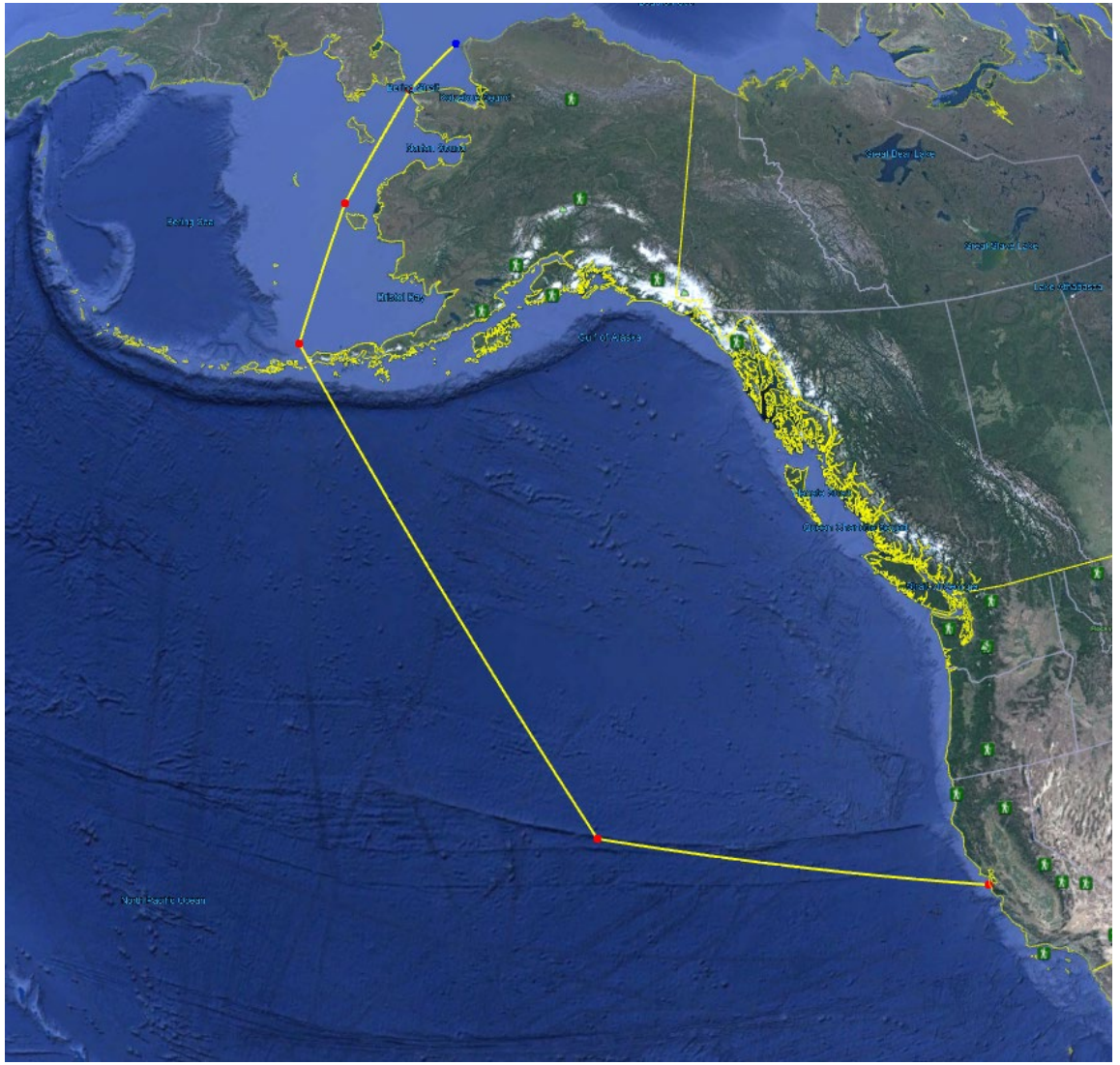
OPTIONAL INSTRUMENTS

15	CARBON	NOAA PMEL ASVCO2 (pCO_2) atmospheric & dissolved pCO_2

2020 North Slope of Alaska Contour Development

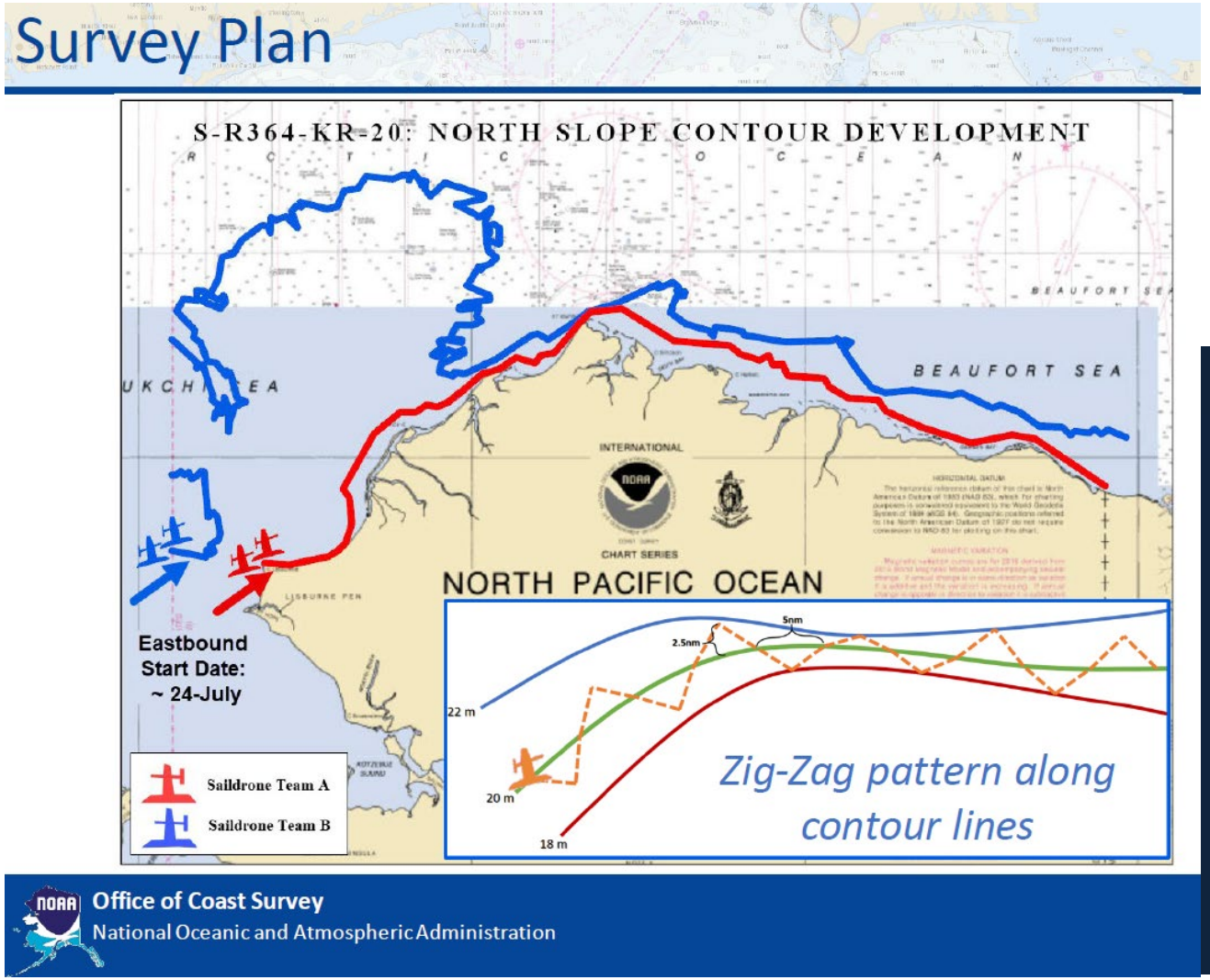
California to Alaska:

- **Four saildrones were used: SD1037, 1055, 1068, and 1069.**
- **Not feasible to launch from Alaska due to COVID19 travel restrictions**
- **Departed San Francisco, California May 28th, 2020**
- **Began to arrive off Point Hope August 2nd, 2020 (66 days)**
- **About 3000 nautical mile transit**



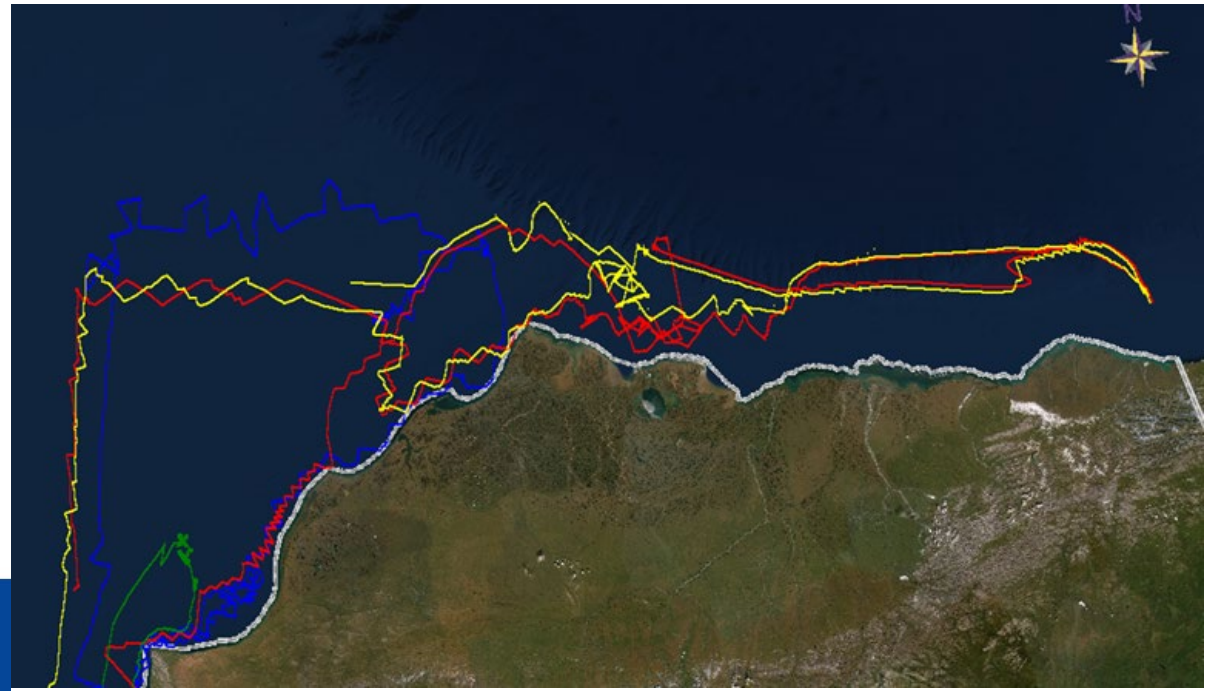
Approximate route the saildrones took from San Francisco to Pt. Hope

2020 North Slope of Alaska Contour Development



Planned vs Actual:

- **Ice pack encountered**
- **Early bowhead whale migrations**
- **Equipment issues**

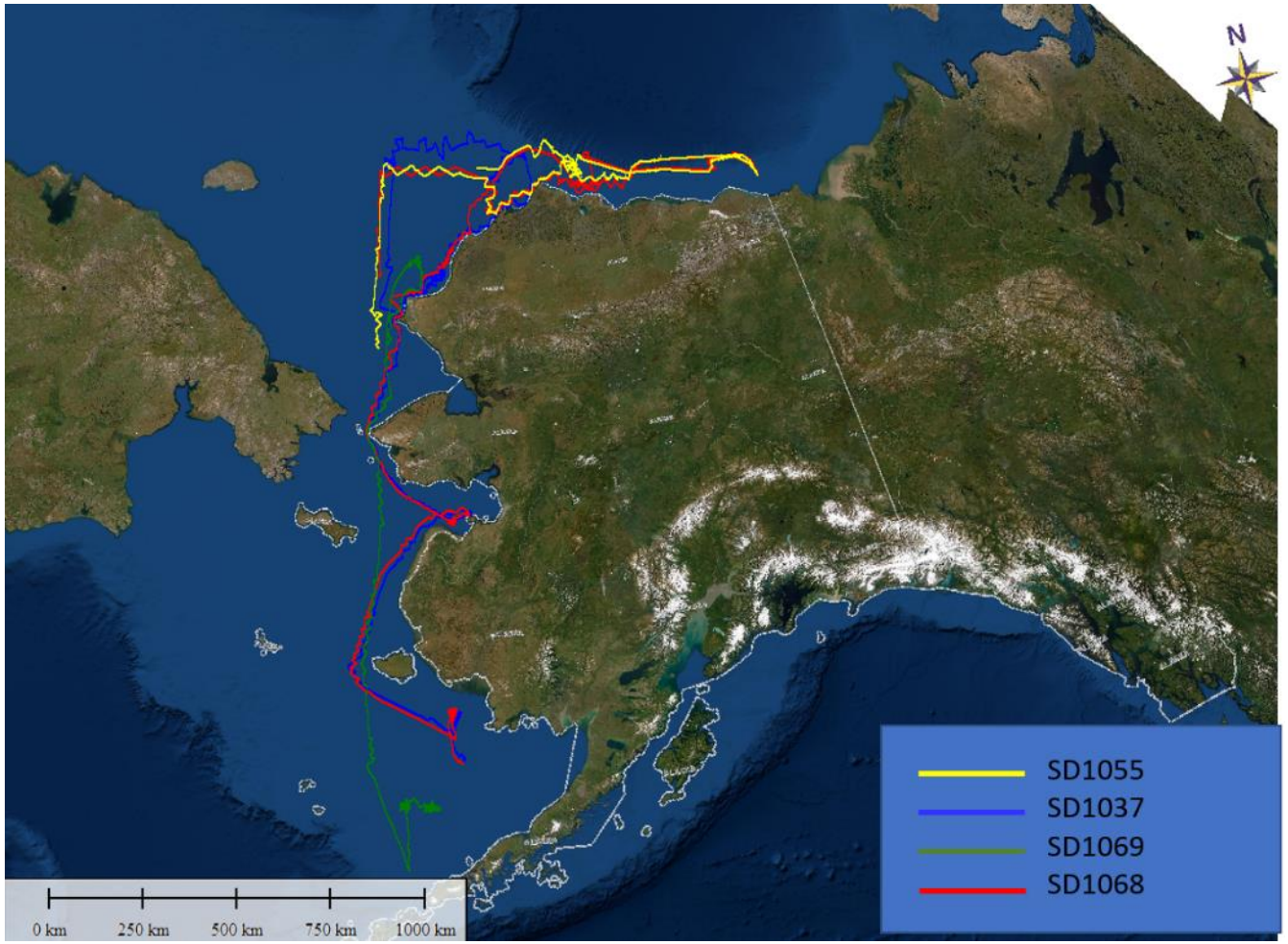


Overview of survey plan. LCDR Bart Buesseler, NOAA Navigation Manager

2020 North Slope of Alaska Contour Development

Following the Arctic mission:

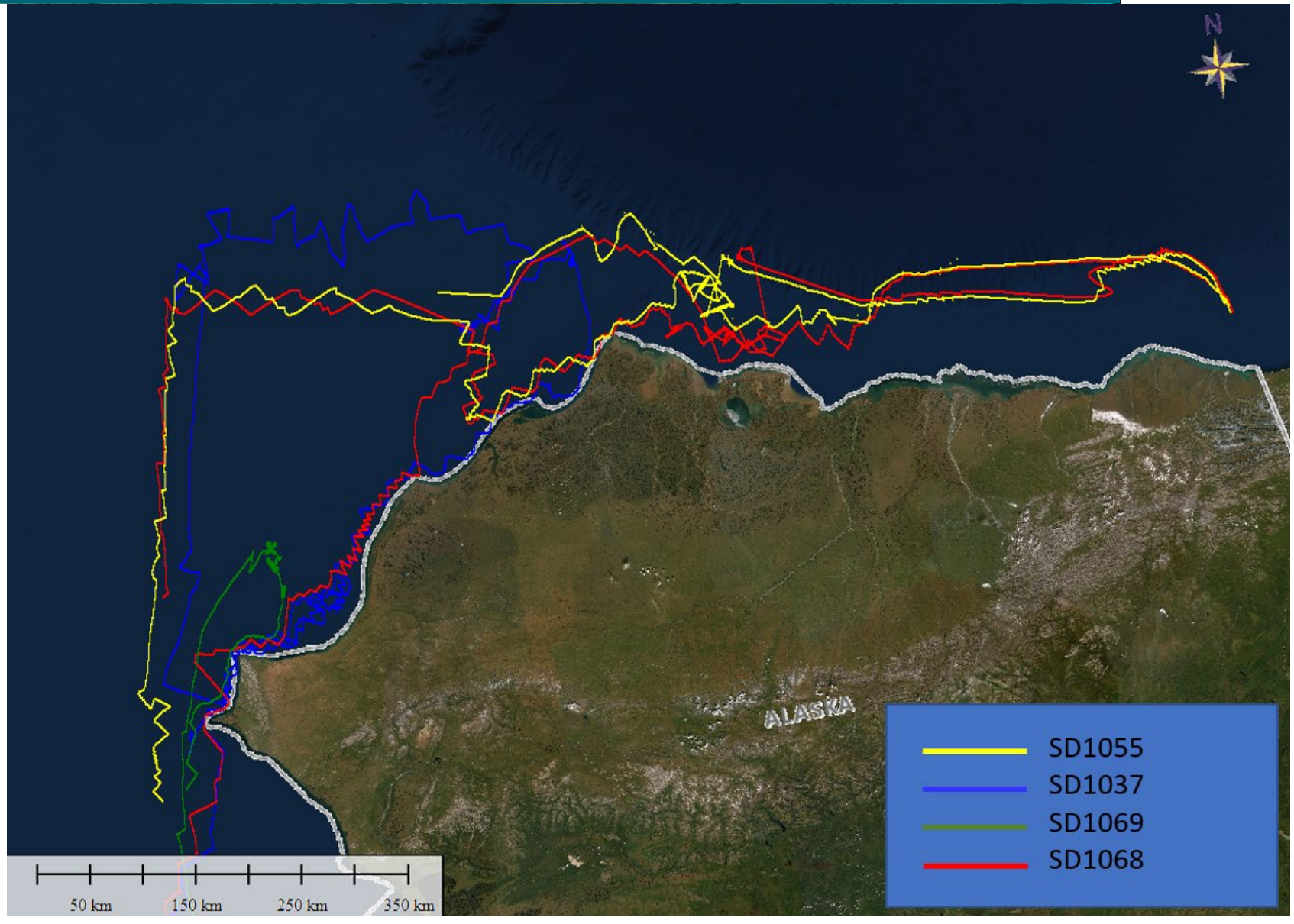
- **All south of Pt. Hope by 9/26**
- **Did additional work in Norton Sound and Kuskokwim Bay**
- **Departed Alaska 10/31, three arrived California by 12/2, one damaged in a storm and still in transit**
- **Dataset will be delivered to NOAA OCS in February for review and application to nautical charts**



Overview of the saildrone's operations in Alaska this season.

2020 North Slope of Alaska Contour Development

- **4,300 nautical miles new sounding data Pt. Hope to the Canadian Border**
- **Proof of concept for using unmanned vessels for remote surveys, especially capability to work during COVID19**
- **Lessons learned sending unmanned vessels to/from the Arctic**



Summary

- **Two different use scenarios: Force multiplier and independent (unaccompanied) ops**

- **Both with clear benefits to safety, productivity, and capabilities**

- **We will continue to deploy and help develop the technology**

Force multiplier

Independent / unaccompanied operations

Special Thanks to:

- **NOAA OCS**
- **Saildrone, Inc. and L3 Harris ASV**

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