An Autonomous Approach to Arctic Mapping

ARHC10 (2020)
08.11.2020

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COO, Saildrone Inc

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

SAILDRONE

SAILDRONE IS A LEADING UNMANNED SURFACE VEHICLE (USV) MANUFACTURER, OPERATOR AND PROVIDER OF CRITICAL OCEAN DATA SERVICES FOR DEFENSE AND CIVILIAN USG PARTNERS

U.S. COAST GUARDS	NGA	SOUTHCOM
NSW	NOPP	DIU
NOAA	NASA	PMEL
WOODS HOLE	SCRIPPS	U OF NEW HAMPSHIRE

DEPLOYABLE ASSETS:
100 x USV (23ft)
1 x MUSV (72ft)

U.S. OWNED AND OPERATED COMPANY BASED IN ALAMEDA, CA
U.S. BASED MANUFACTURING (IN FORMER NAVAL AIR STATION FACILITY)

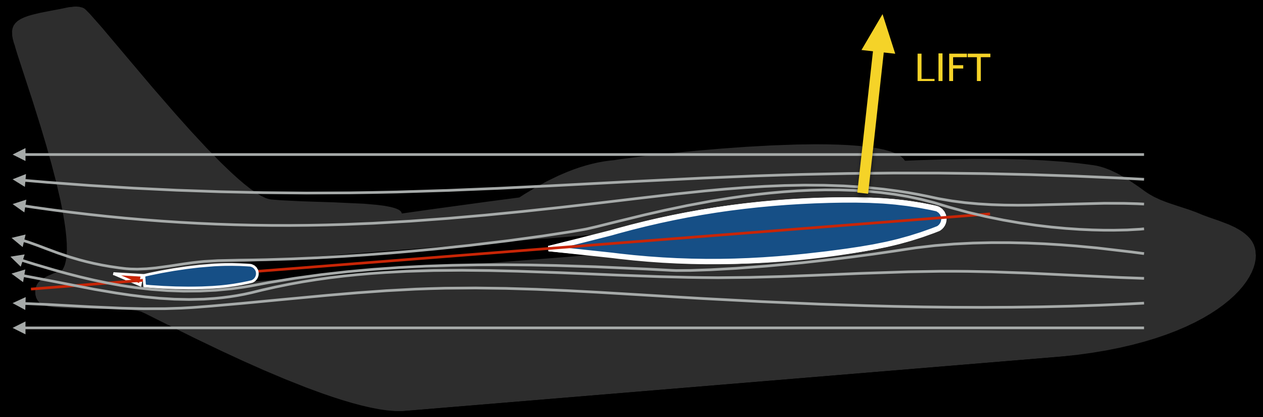
OUR MISSION: TO COLLECT DATA AT SCALE AND ENABLE NEW INSIGHTS

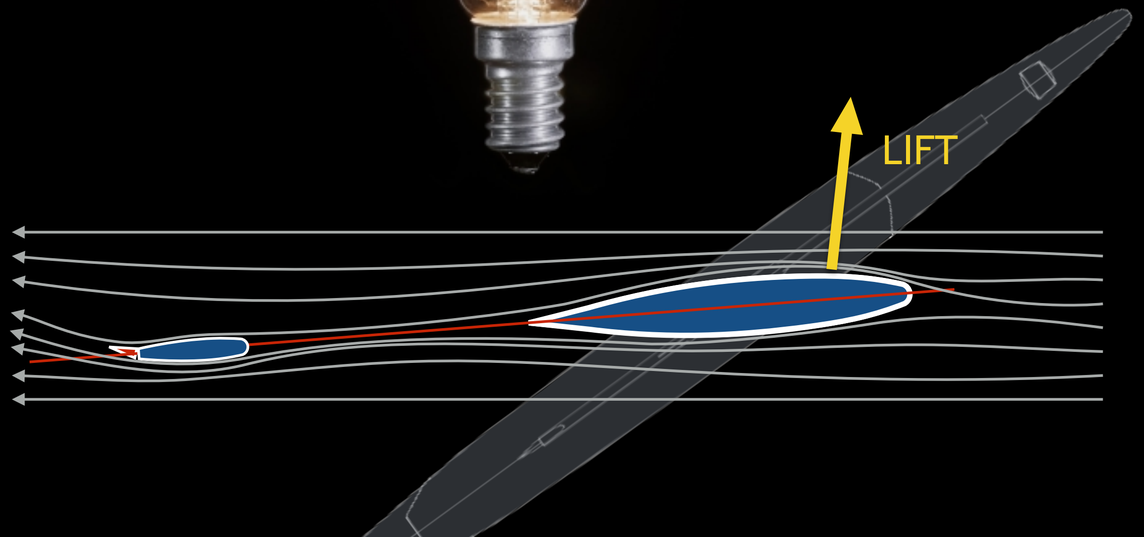
AUTONOMOUS DATA COLLECTION → BIG DATA INGESTION → DATA QUALITY CONTROL → DATA PROCESSING → DATA DELIVERY

USING LONG ENDURANCE AUTONOMOUS VEHICLES AS A KEY ENABLER

THE SAILDRONE WING DESIGN RESULTED FROM 10 YEARS OF R&D

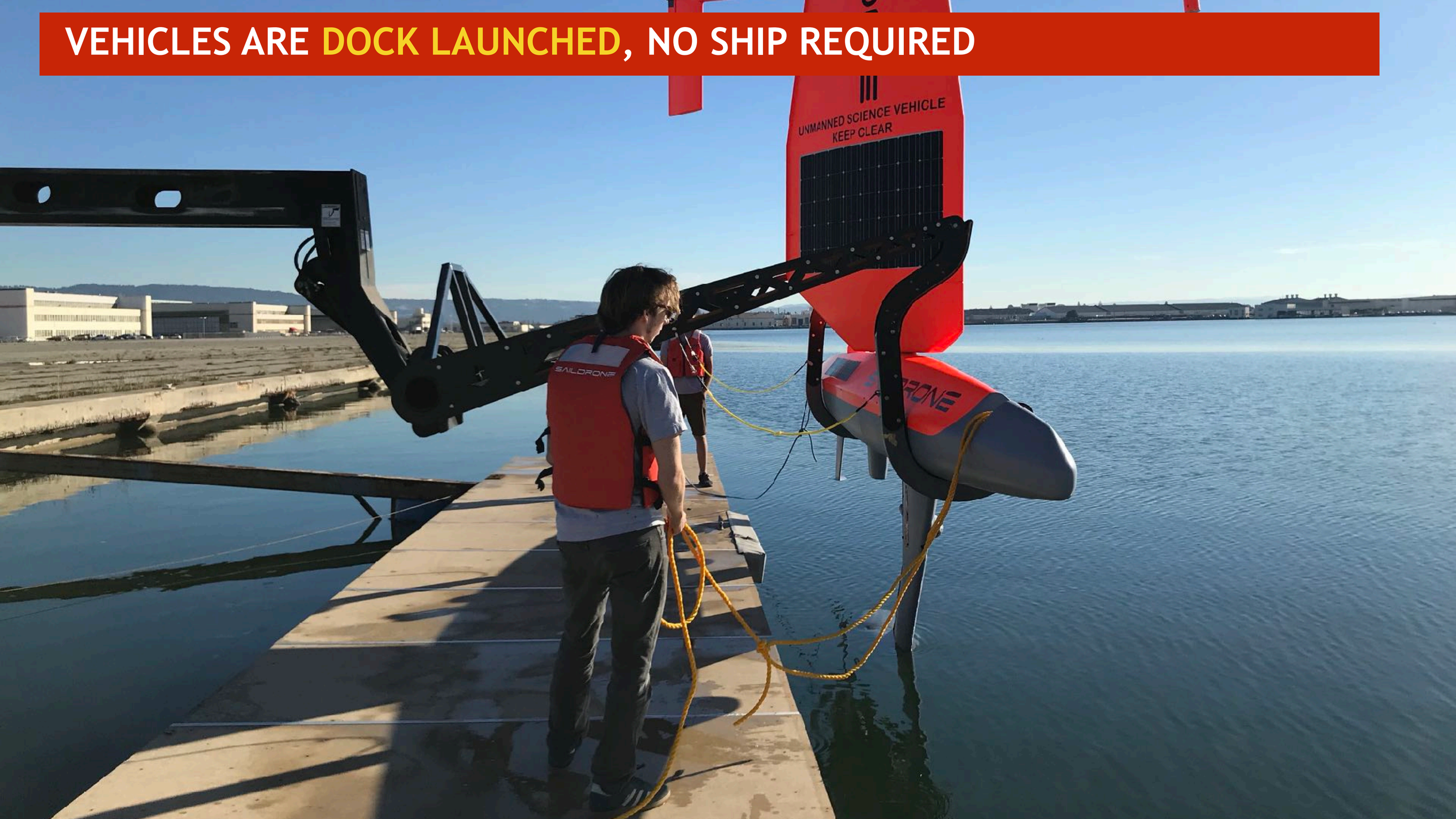
A USV THAT CAN CROSS OCEANS USING UNDER 10 WATTS OF POWER





NO CREW, NO FUEL, NO MAINTENANCE, NO EMISSIONS, NO NOISE

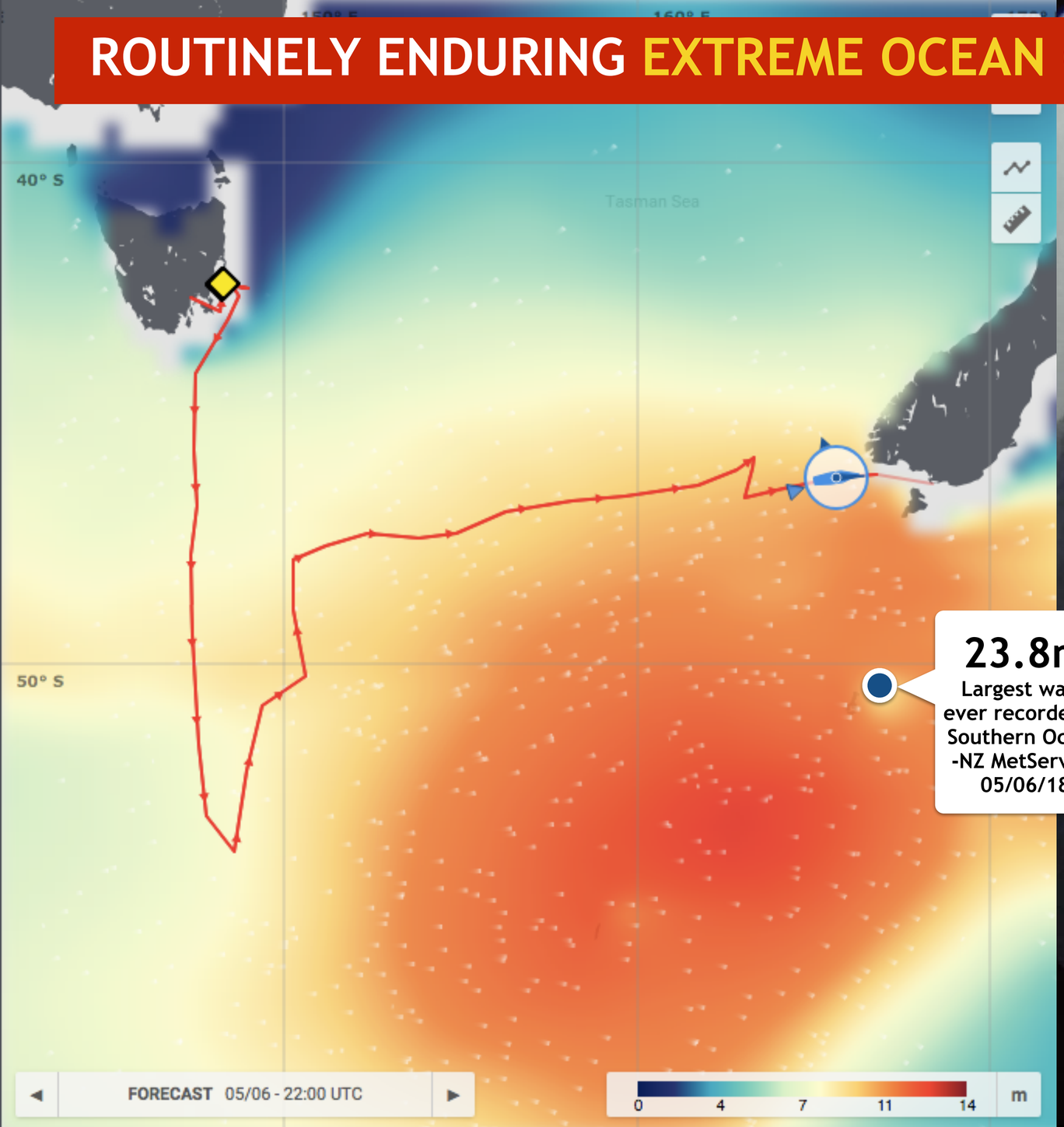
VEHICLES ARE DOCK LAUNCHED, NO SHIP REQUIRED



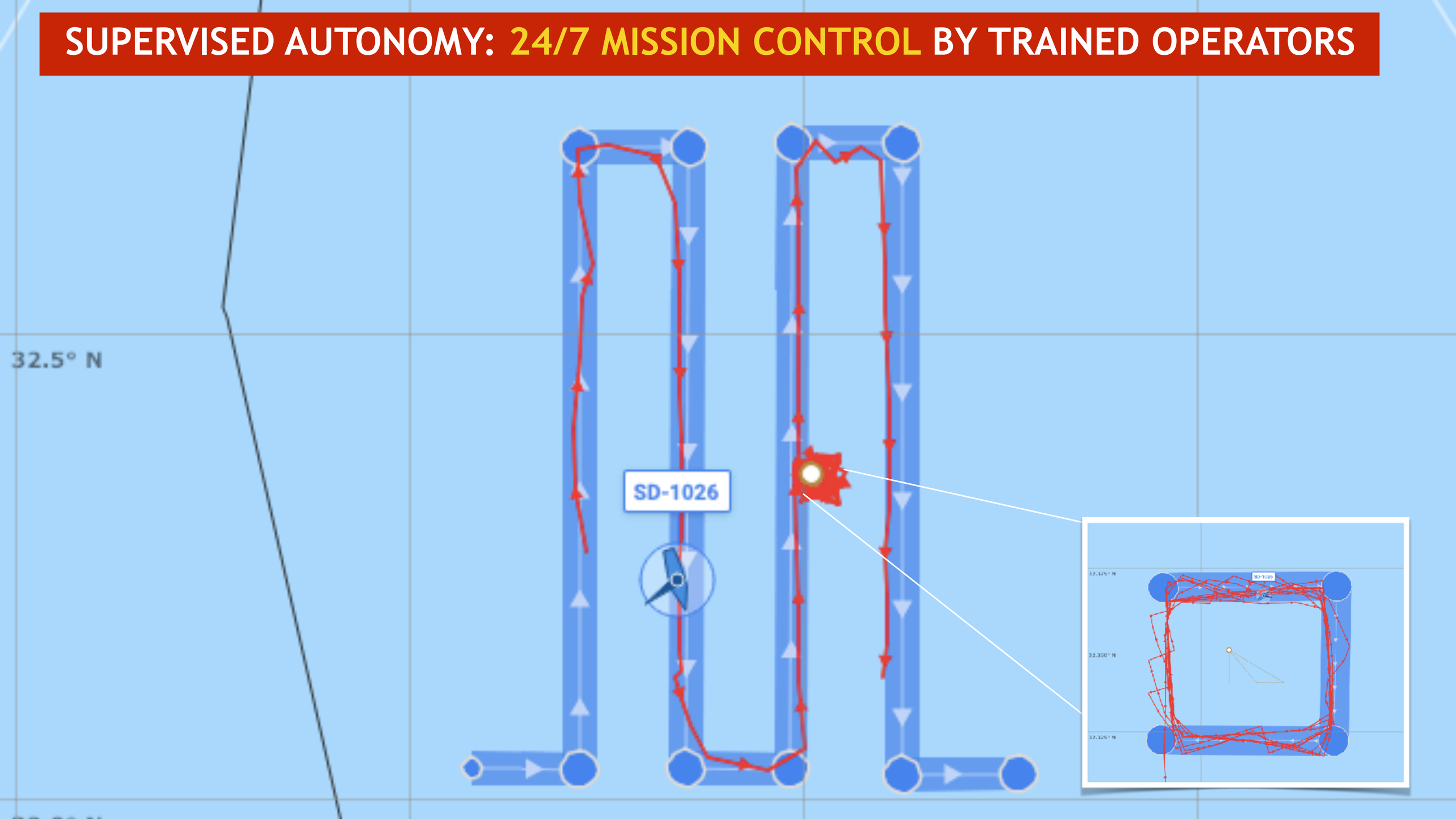
CAPABLE OF REACHING ANY OCEAN LOCATION IN UNDER 30 DAYS

DEMONSTRATED MISSIONS DURATION OF UP TO 12 MONTHS

ROUTINELY ENDURING EXTREME OCEAN CONDITIONS



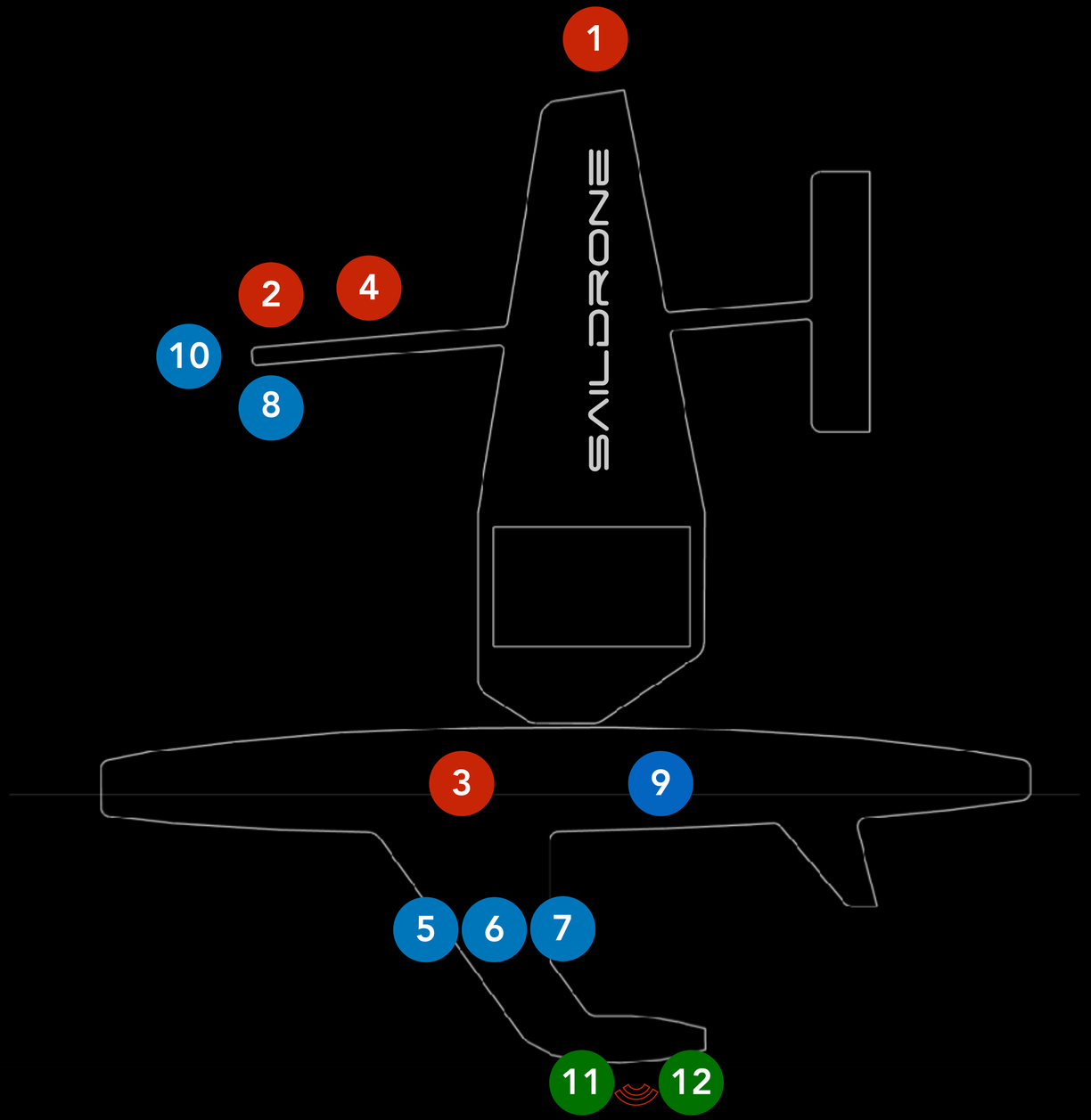
SUPERVISED AUTONOMY: 24/7 MISSION CONTROL BY TRAINED OPERATORS



TRACK RECORD: 500,000 MILES OF SAFE OPERATIONS

SENSOR PAYLOAD DEVELOPED IN PARTNERSHIP WITH NOAA

STANDARD SENSOR SUITE (MISSION SPECIFIC OPTIONS)



Atmospheric Measurements

1	WIND	Gill Windmaster 3D 20Hz @ + 5.0 m
2	AT / RH	Rotronic HC2 - S3 @ + 2.2 m
3	PRESSURE	Vaisala BAROCAP PTB210 @ + 0.2 m
4	RADIATION	LICOR LI-192SA @ + 2.2 m

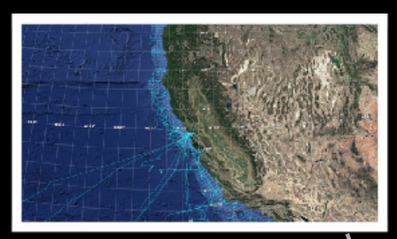
Ocean Measurements

5	CTD	SBE 37 & RBR Conductivity @ -0.5 m
6	DO & TEMP	RBR Coda ODO & SBE 37 ODO @ -0.5m
7	CHL-A	Wetlabs ECO-FL-S G4 & Turner Cyclops-7F
8	SKIN SST	Heitronics CT15.2 @ +2.2 m
9	WAVES	Dual GPS aided IMU - VN 300
10	CAMERAS	Sky, Sea and Horizon Cameras

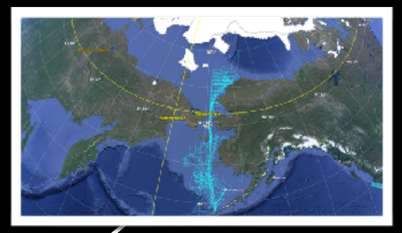
Acoustic measurements

11	ADCP	Teledyne RDI Workhorse 300 kHz @ -2.0 m
	OR	
12	ECHO-SOUNDER	EK80: Simrad WBT Mini @ -2.0 m SBES: Airmar DT800 / Teledyne echotrac E20 MBES: Norbit iWBMS

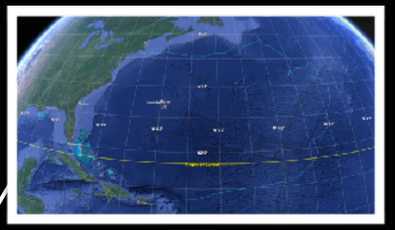
IN PRACTICE: WE OPERATE A COLLECTION OF REGIONAL FLEETS



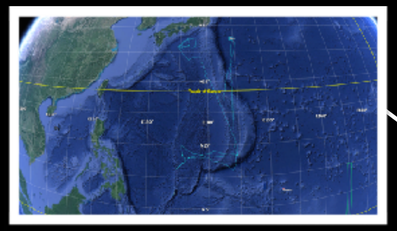
US West Coast
Fish stock assessment
bathymetry, oil spill
and metocean monitoring



US Arctic
Fish stock assessment
Bathymetry, metocean

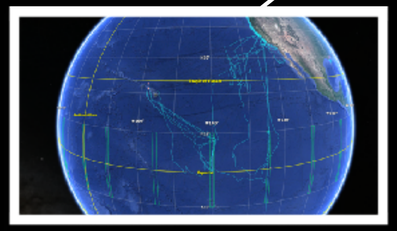


North Atlantic
Current, carbon, hurricane
monitoring

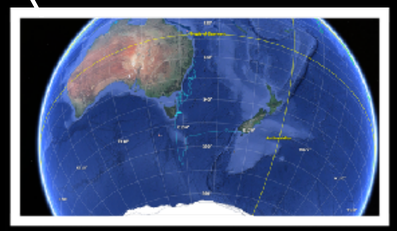


Western Trop. Pacific
Current, biogeochemistry,
typhoon monitoring

Gulf of Mexico
Oil spill, hypoxia
and bathymetry



Eastern Tropical Pacific
Satellite cal/val, El Nino
monitoring, Shark tracking

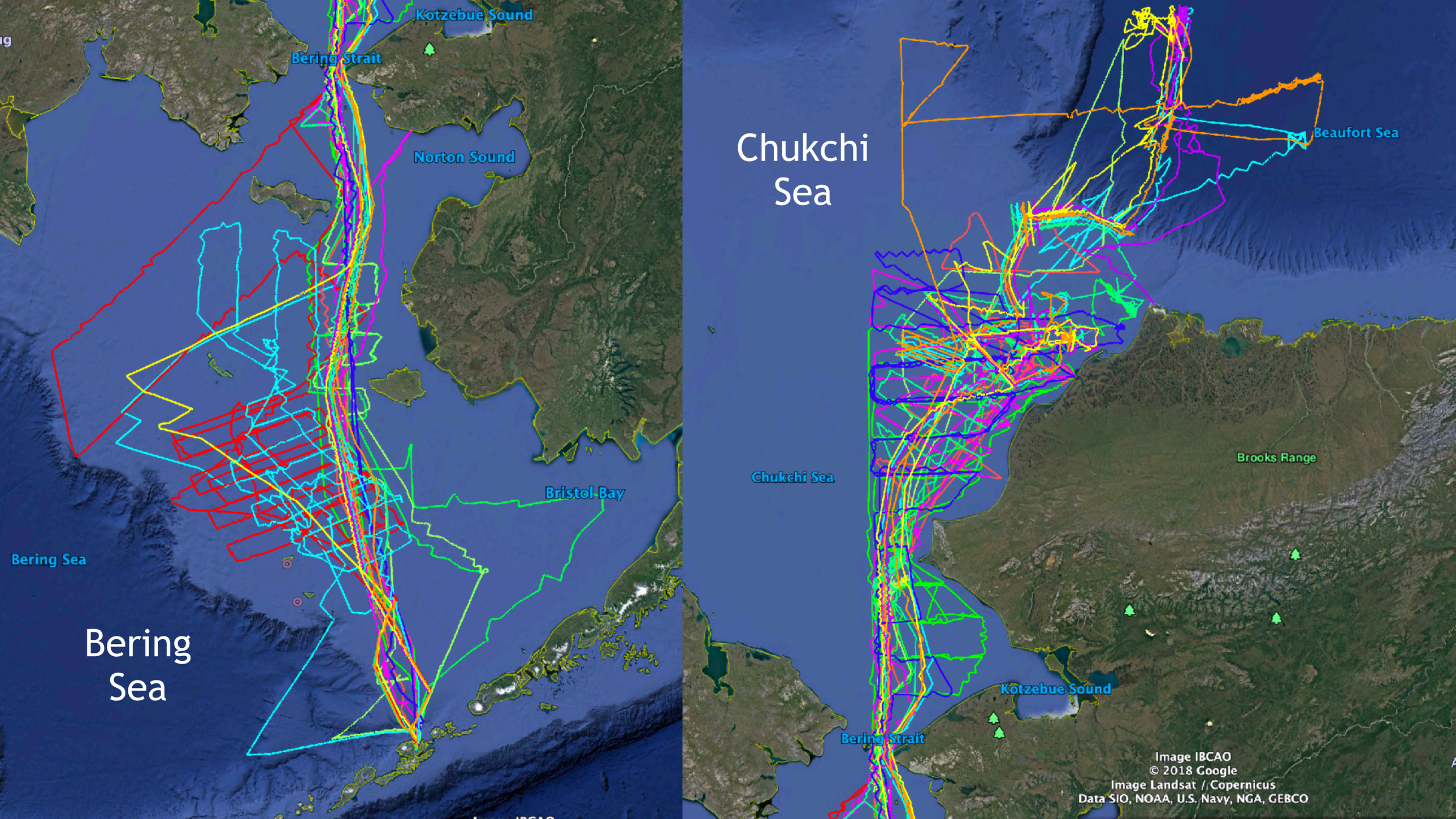


Southern Ocean
Australia, New Zealand
Antarctic Circumnavigation

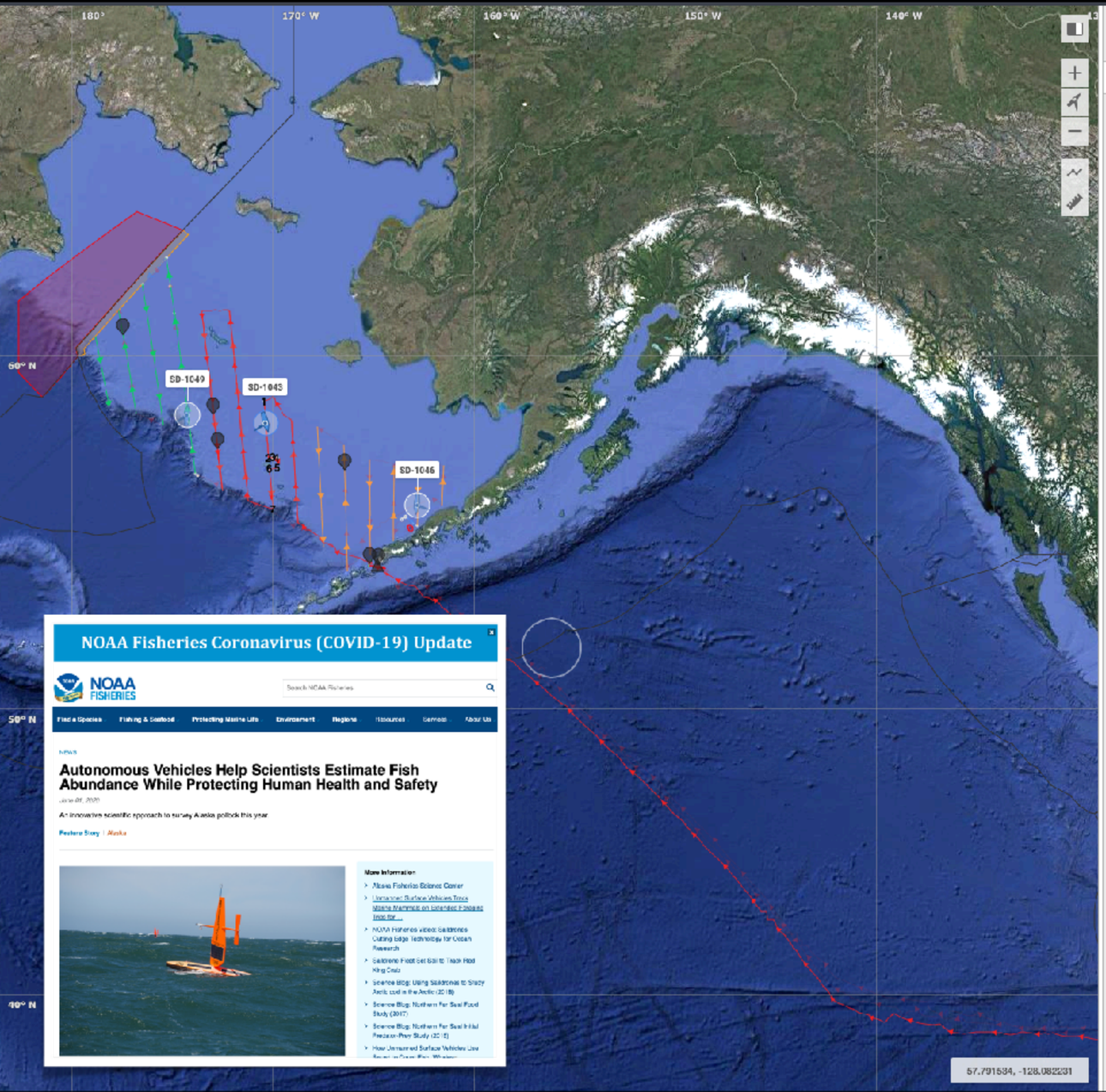
https://data.saildrone.com

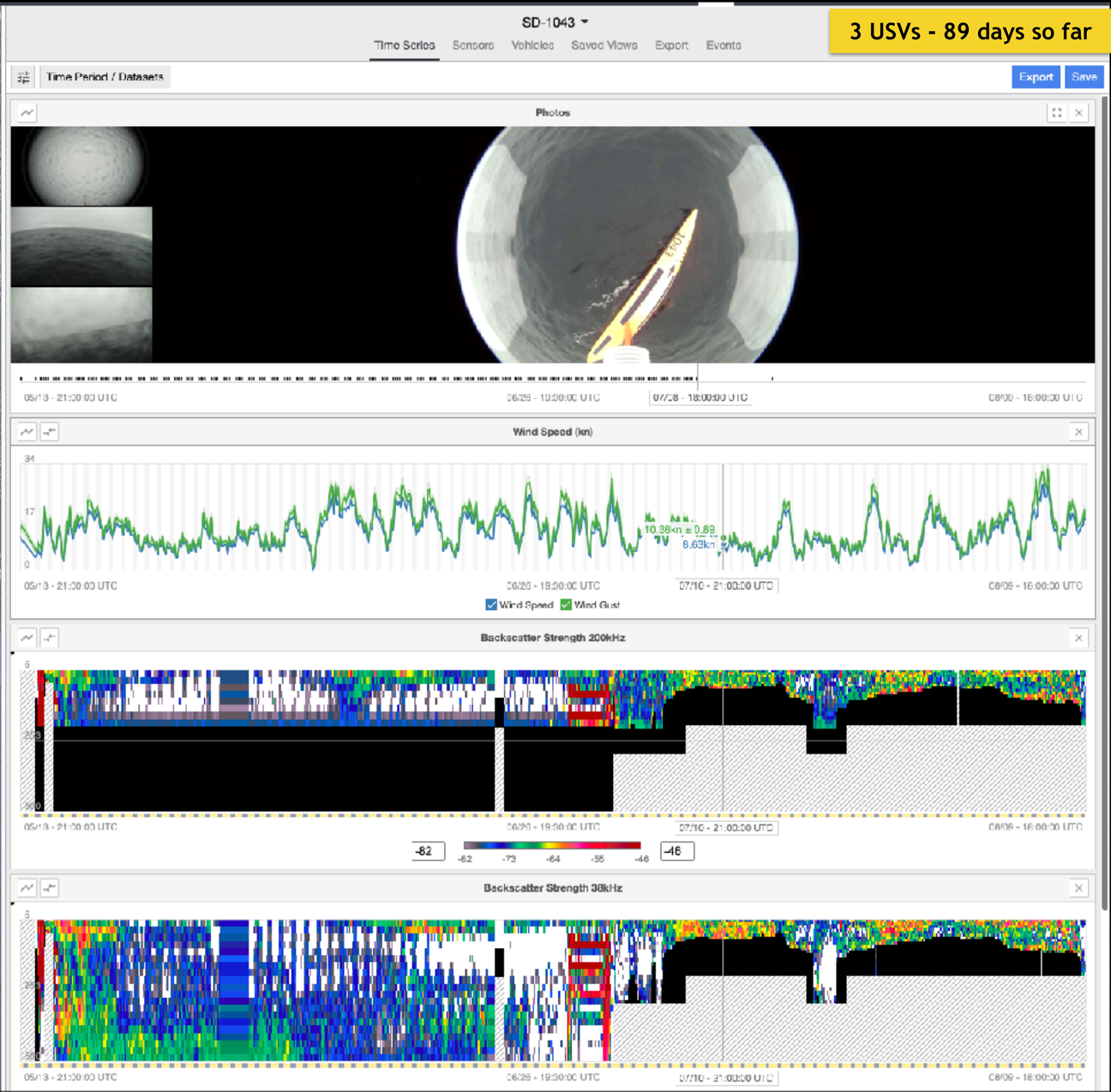
COMPLETED 5TH CONSECUTIVE YEAR OF SUCCESSFUL SURVEYS IN THE US ARCTIC

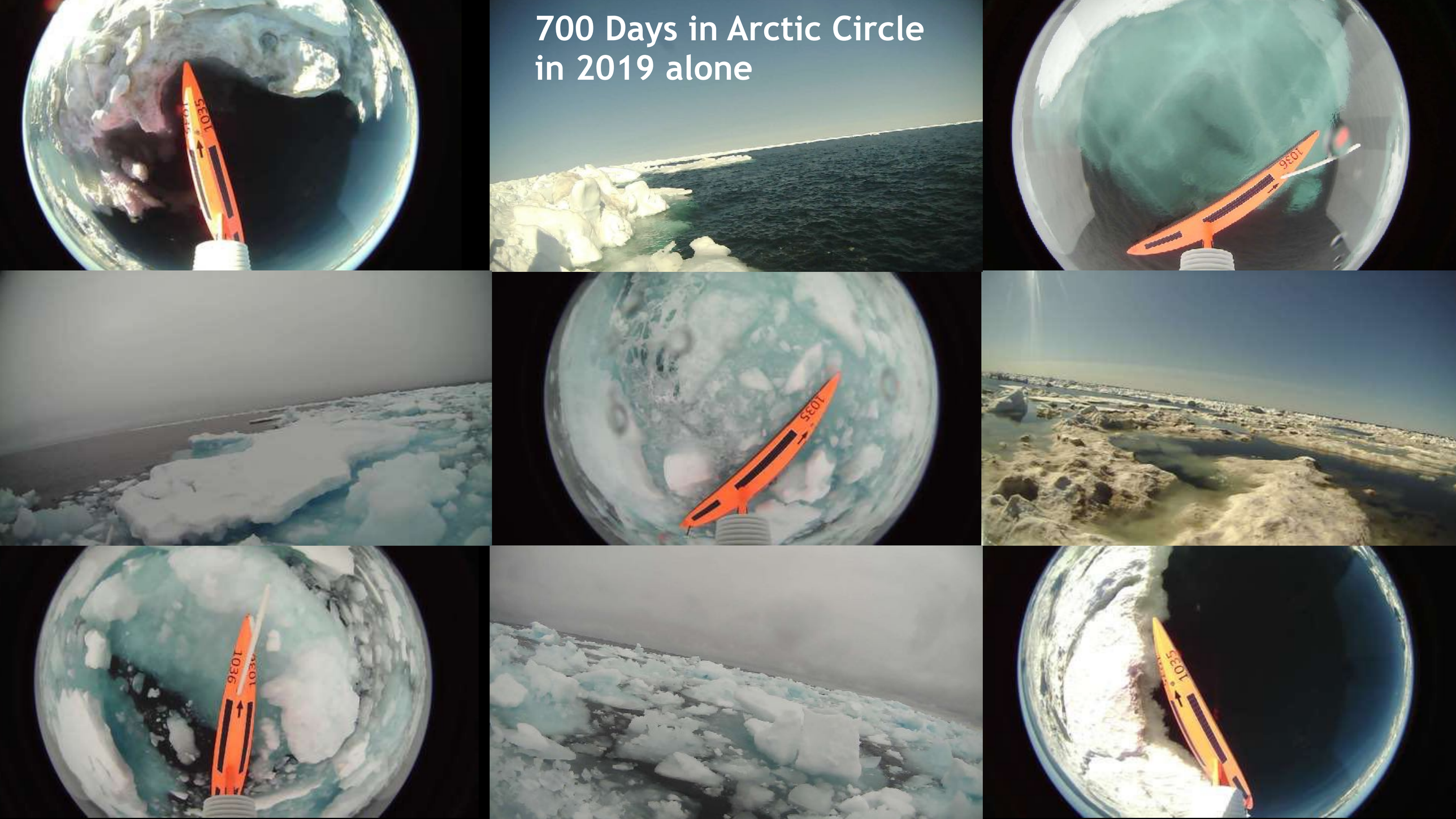
De Long Strait
Chukchi Sea
Kotzebue Sound
Bering Strait
Norton Sound
Bering Sea


Kotzebue Sound
Bering Strait
Norton Sound
Bristol Bay
Bering Sea
Bering
Sea
Chukchi
Sea
Beaufort Sea
Chukchi Sea
Brooks Range
Kotzebue Sound
Bering Strait
Image IBCAO
© 2018 Google
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

BERING SEA MISSION IN PROGRESS DESPITE COVID: NOAA FISHERIES- BERING SEA FISH ABUNDANCE SURVEY (POLLOCK) successfully transit from CA to AK, survey near completion during COVID






700 Days in Arctic Circle
in 2019 alone

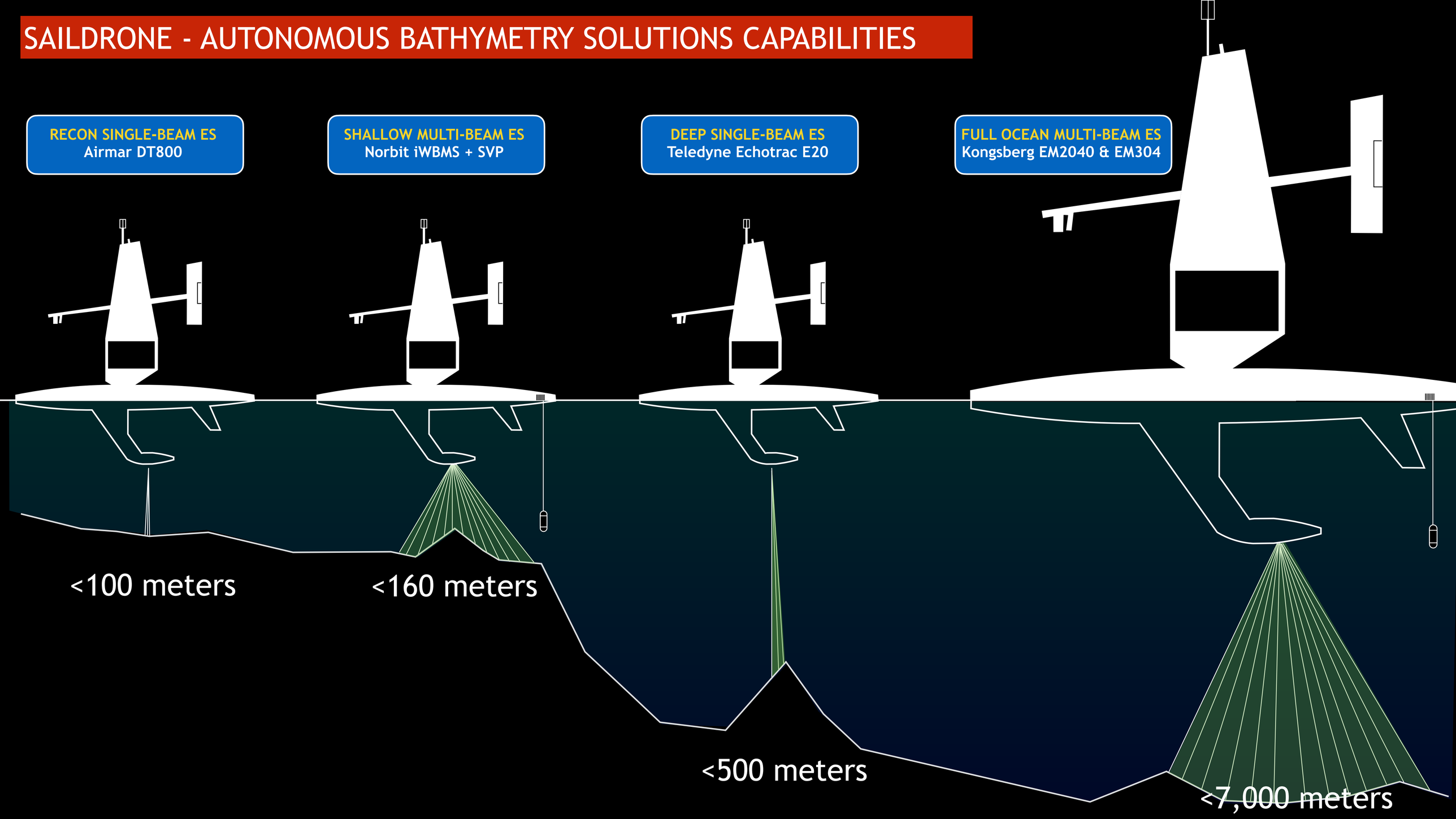
SAILDRONE - AUTONOMOUS BATHYMETRY SOLUTIONS CAPABILITIES

RECON SINGLE-BEAM ES
Airmar DT800

SHALLOW MULTI-BEAM ES
Norbit iWBMS + SVP

DEEP SINGLE-BEAM ES
Teledyne Echotrac E20

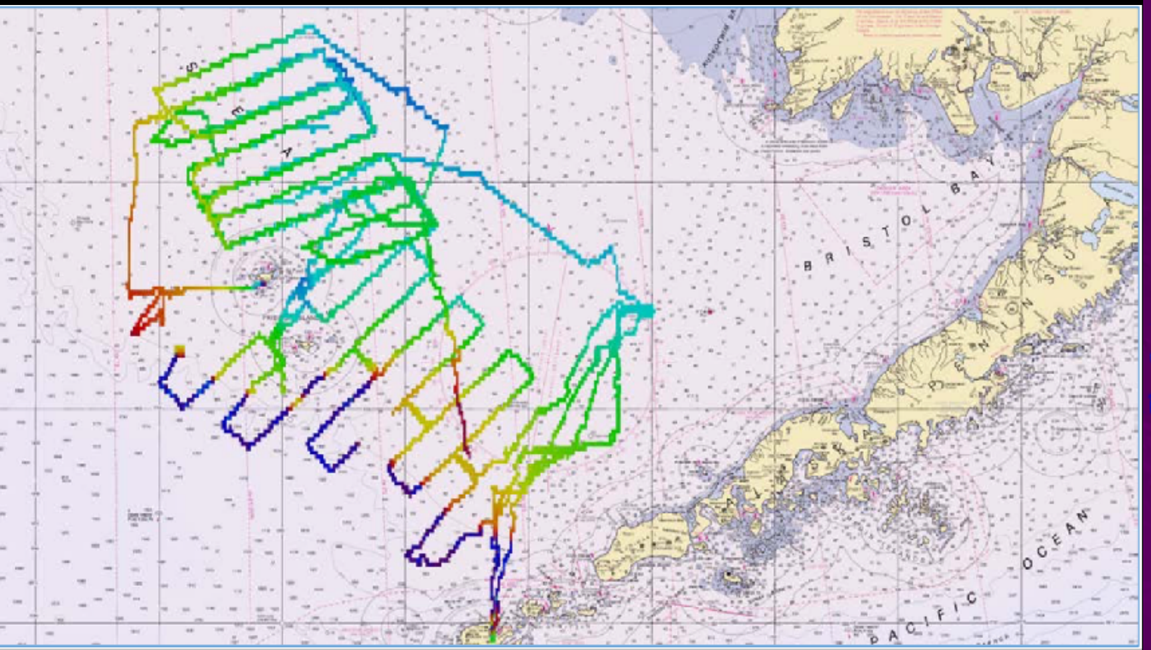
FULL OCEAN MULTI-BEAM ES
Kongsberg EM2040 & EM304

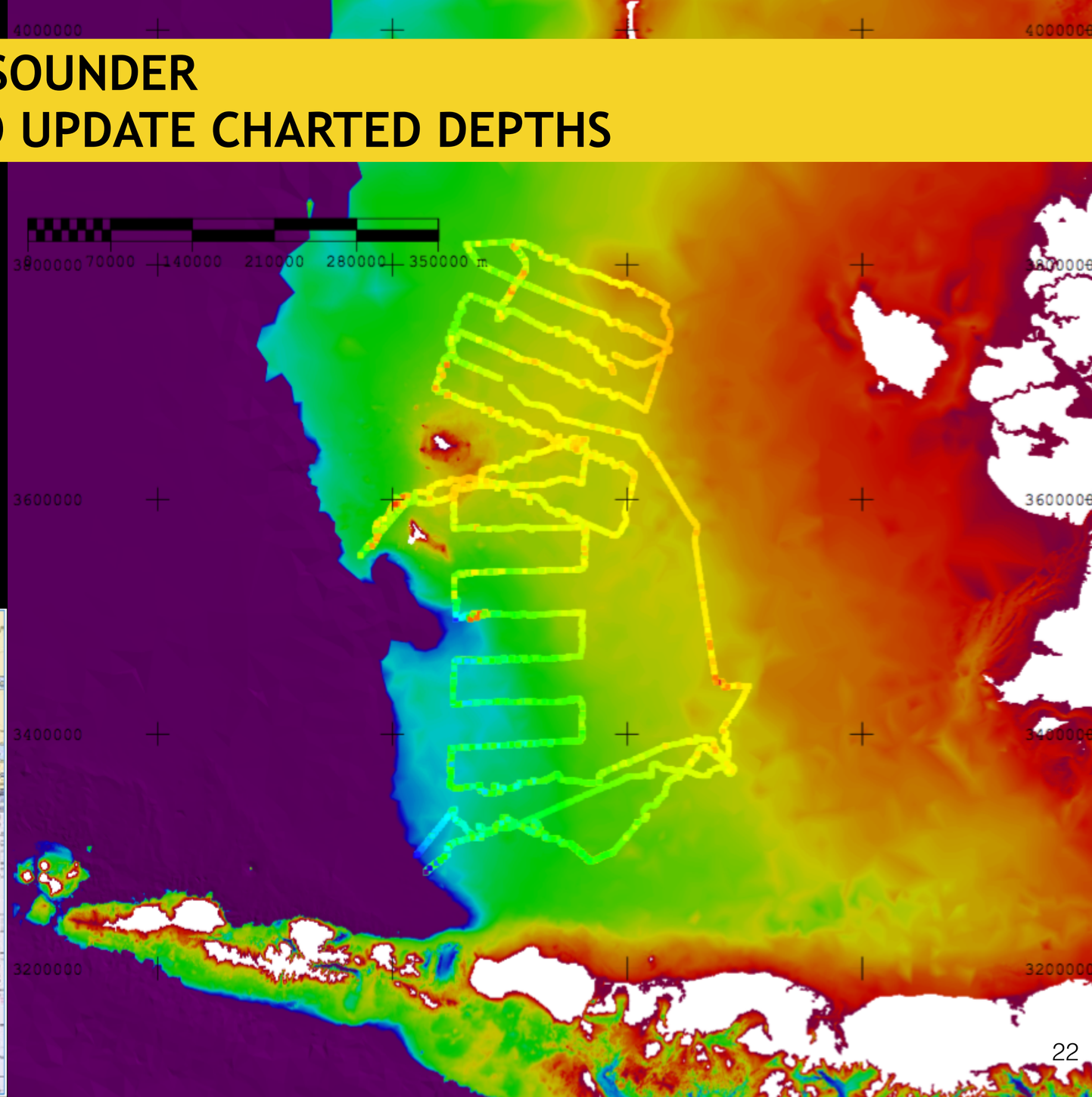


SBE CAPABILITY: SINGLE BEAM ECHOSOUNDER
BATHYMETRY DATA USED BY NOAA TO UPDATE CHARTED DEPTHS

"The data from this system is internally consistent, compares well with the NOAA r/v Rainier with little observable bias, and generally is consistent with currently charted soundings. We recommend updating charted depths with the gridded depths from this system, particularly in areas currently with sparse or no coverage."

- NOAA Office of Coast Survey





AUTONOMOUS SB BATHYMETRY USING UNMANNED SURFACE VEHICLE (USV)

1 Autonomous Data Acquisition

Anywhere in the world, without ship support, using Saildrone USV equipped with E20 Single Beam Echosounder

2 Real-time Data Transmission

subset of survey data is exfiltrated over Iridium satlink:
- E20- 1minute averages of min/max/mean depth and std deviation
- Novatel GPS- PDOP 1 minute average
- Vectornav IMU: 1 minute averages of pitch/roll/yaw
- METOCEAN sensors: 1 minute averages

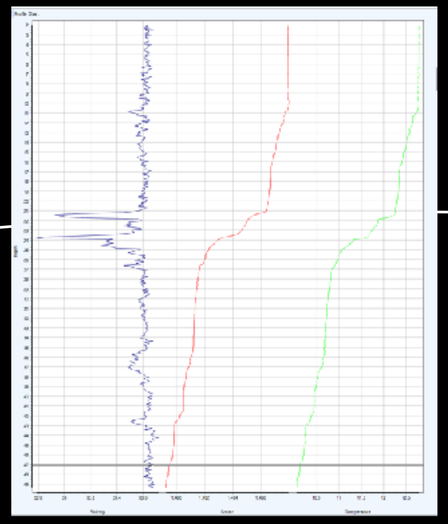
3 Post-mission Raw Data Processing

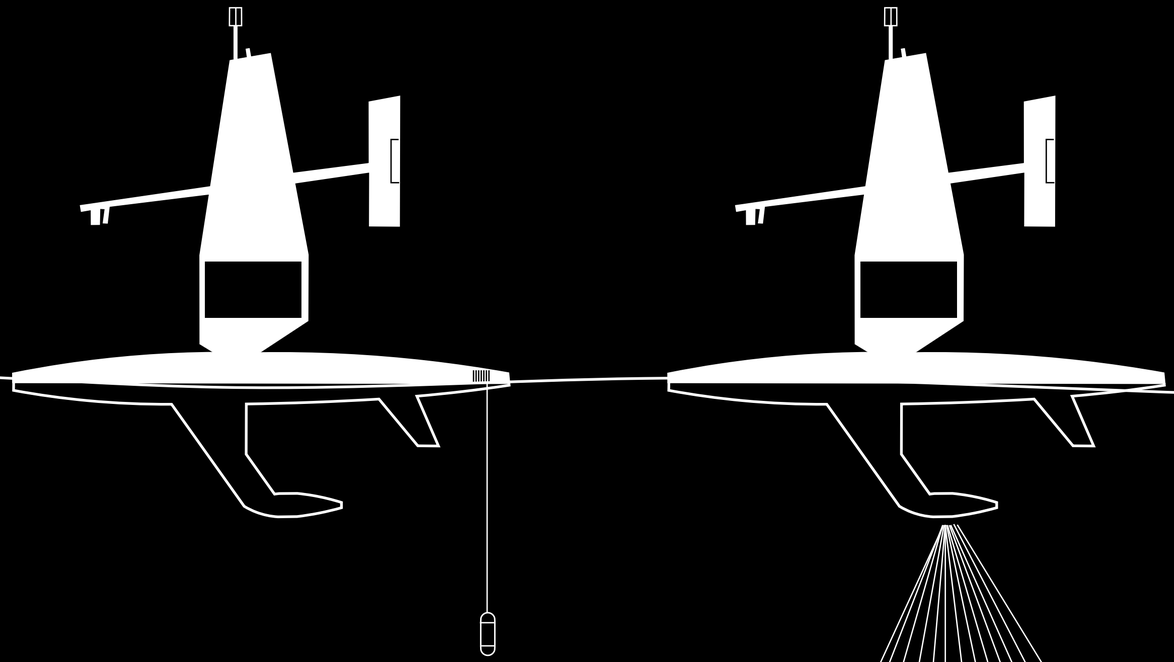
Raw data delivered post-mission includes:
- E20- full depth data (all individual soundings)
- Novatel GPS- full 1Hz dataset including Lat/Lng, PDOP, HDOP, VDOP, and all ephemeris data
- Vectornav IMU: 20Hz pitch/roll/yaw dataset
- METOCEAN sensors: full dataset

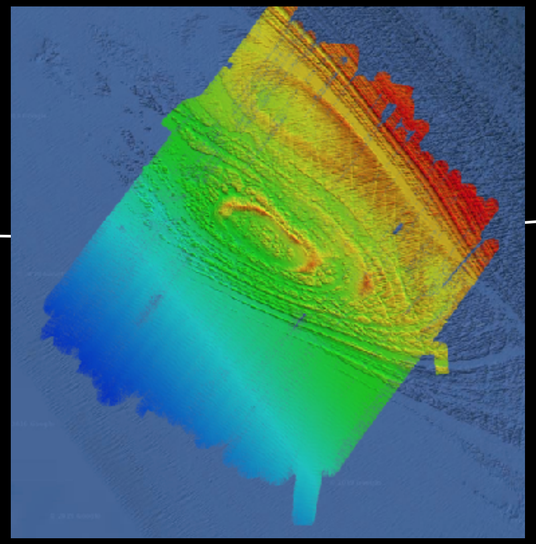
Submerged hazard

JOINT DEVELOPMENT OF ARCTIC-READY SHALLOW MULTI BEAM AUTONOMOUS MAPPING CAPABILITY (NOAA OCS | USM | SAILDRONE)

High quality over-the-horizon multi beam survey capability using arctic-ready long range USVs: USV #1 ‘Surveyor’ acquires MBES data 24/7 while USV #2 ‘Profiler’, acquires SVP profiles 24/7







PROFILER
Valeport SVP

SURVEYOR
Norbit MB

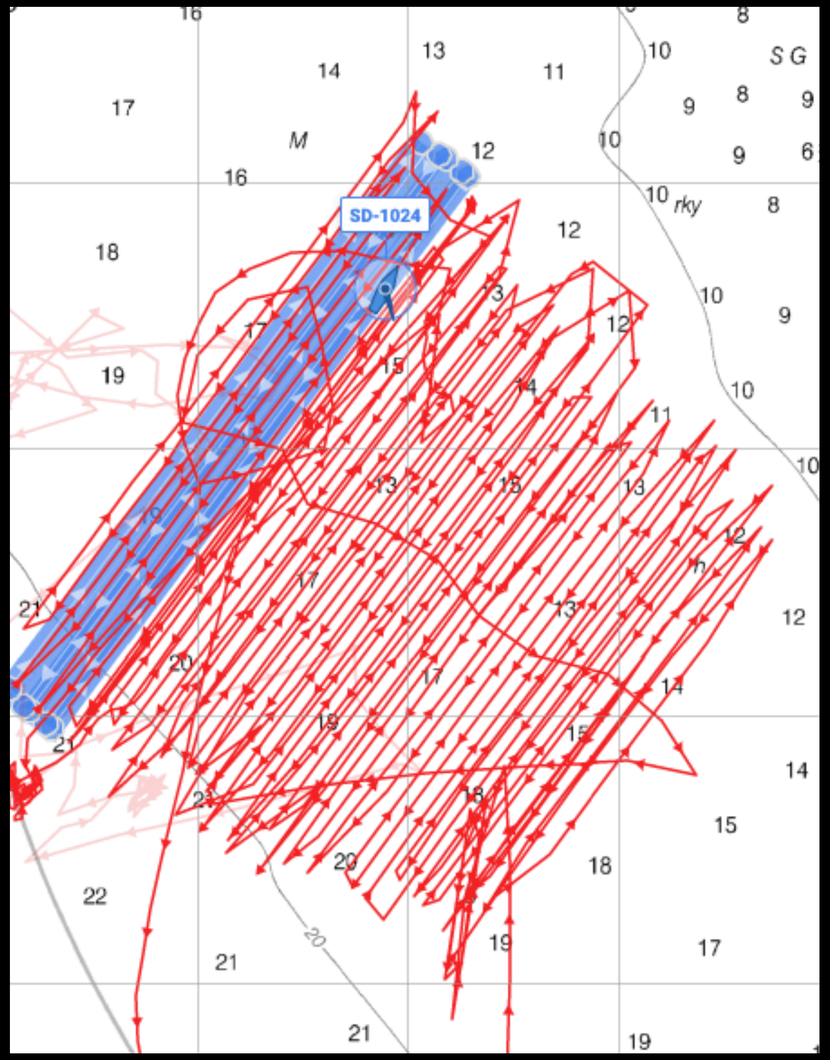
Saildrone Winch
100m depth capability
Single command automates entire
SVP cast (deploy/retrieve/upload data)

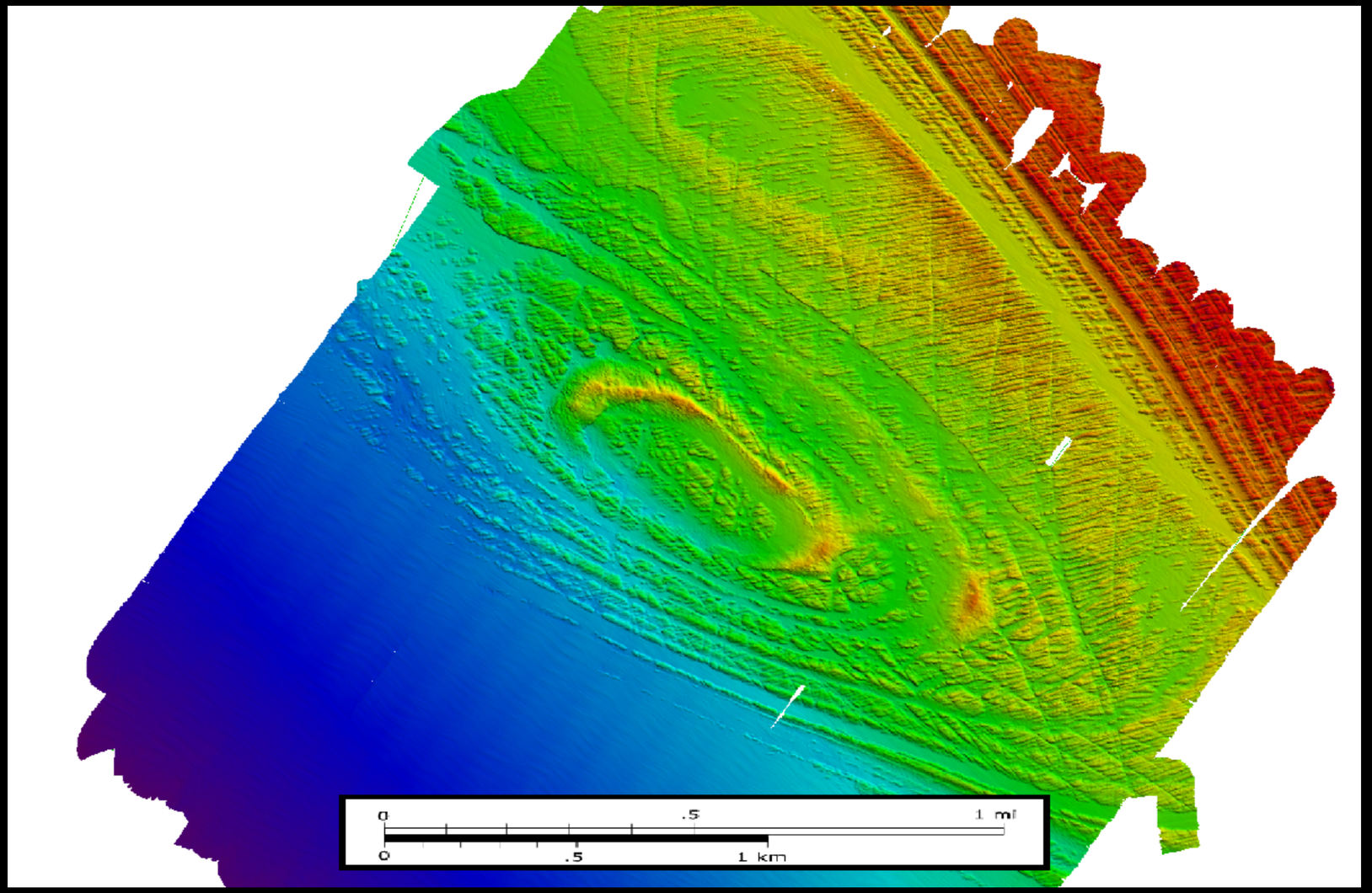
SVP Valeport SWiFT SVP
GPS geolocation
500m depth rating
Accuracy +/- 0.02 m/s
Bluetooth Communication
Battery life up to 30 days
(low power sleep mode enabled)

Norbit iWBMSh STX
400 kHz
160m depth range
Integrated GNSS/IMU (Applanix POS MV)

Applanix POS MV Oceanmaster
Pitch/Roll Accuracy 0.01 deg
Heading Accuracy 0.02 deg
Heave Accuracy 2cm or 2%
Positional Accuracy <10cm

Pilot survey: 100% met IHO Order 1a specifications, 96% of data met IHO Special Order





NEW CAPABILITY: 72 FT SAILDRONE SURVEYOR LAUNCHING IN 2020; CAPABLE OF SHALLOW & DEEP OCEAN MULTIBEAM MAPPING.

PARTNERS: The National Ocean Partnership Program, NOAA OER, the University of New Hampshire, and the Monterey Bay Aquarium and Research Institute

SAILDRONE SURVEYOR

An unmanned, long endurance, multi beam system for deep ocean

Payloads:

- Kongsberg EM 304
- Kongsberg EM 2040
- SIMRAD EK80
- SIMRAD 150 kHz ADCP
- RDI Pinnacle 45 ADCP
- eDNA ESP

Stats:

- Survey Speed: 7 Knots
- Utilization: 330 Days / Yr
- Coverage: 5,000 Sq km / day
  1.6m Sq km / Yr

Autonomous Arctic mapping, a first step: NOAA OCS | Terrasond | Saildrone

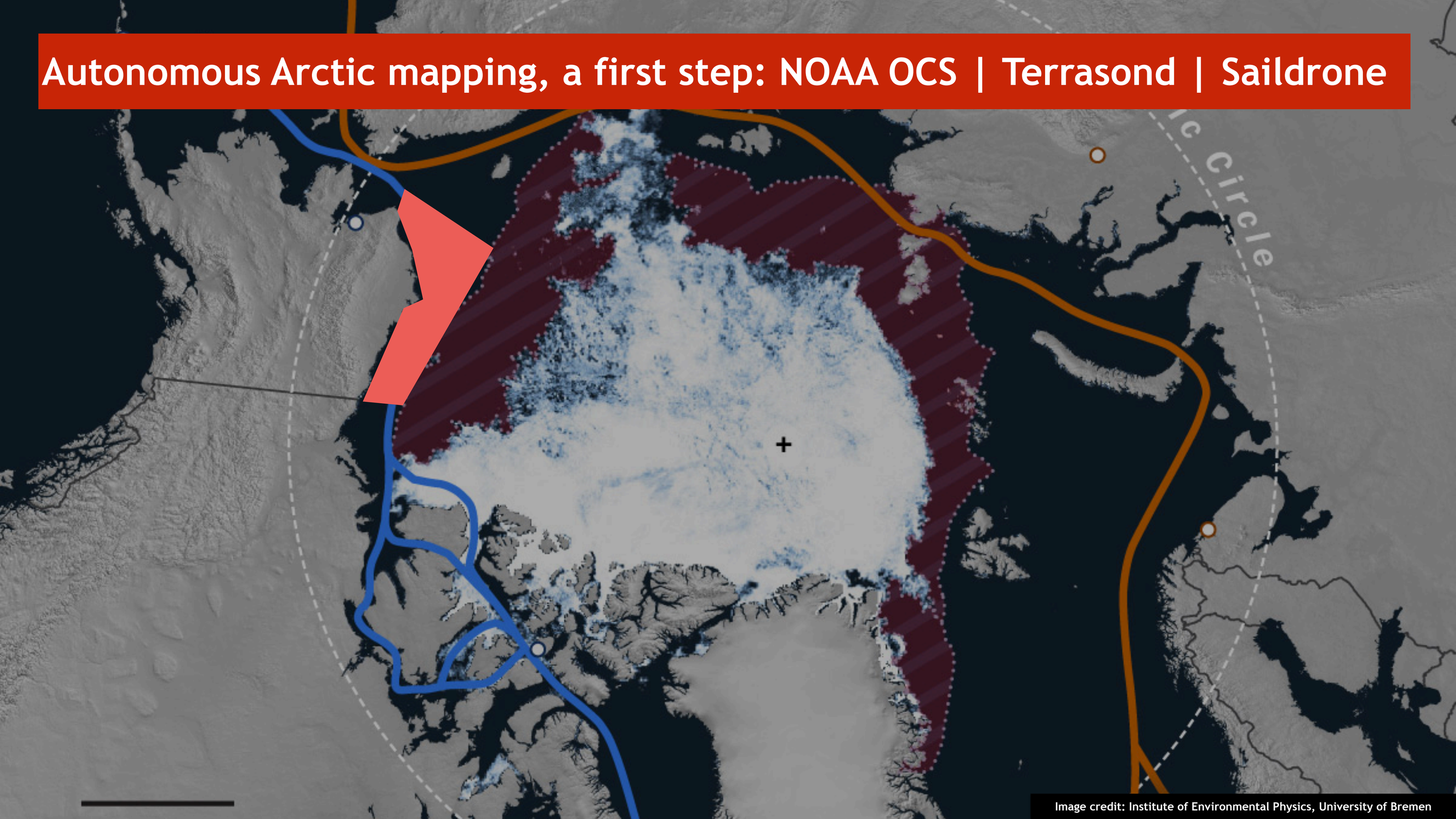
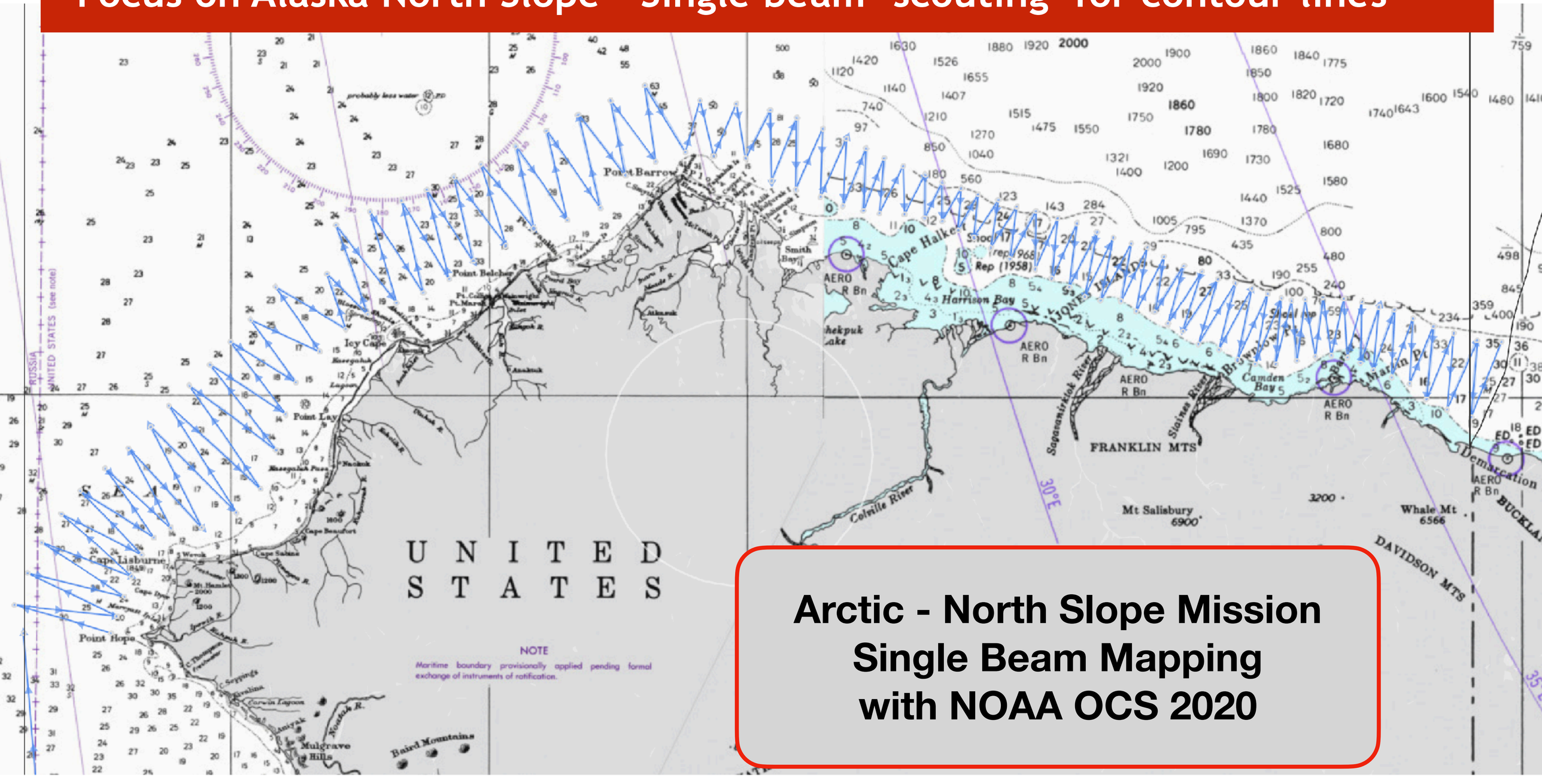


Image credit: Institute of Environmental Physics, University of Bremen

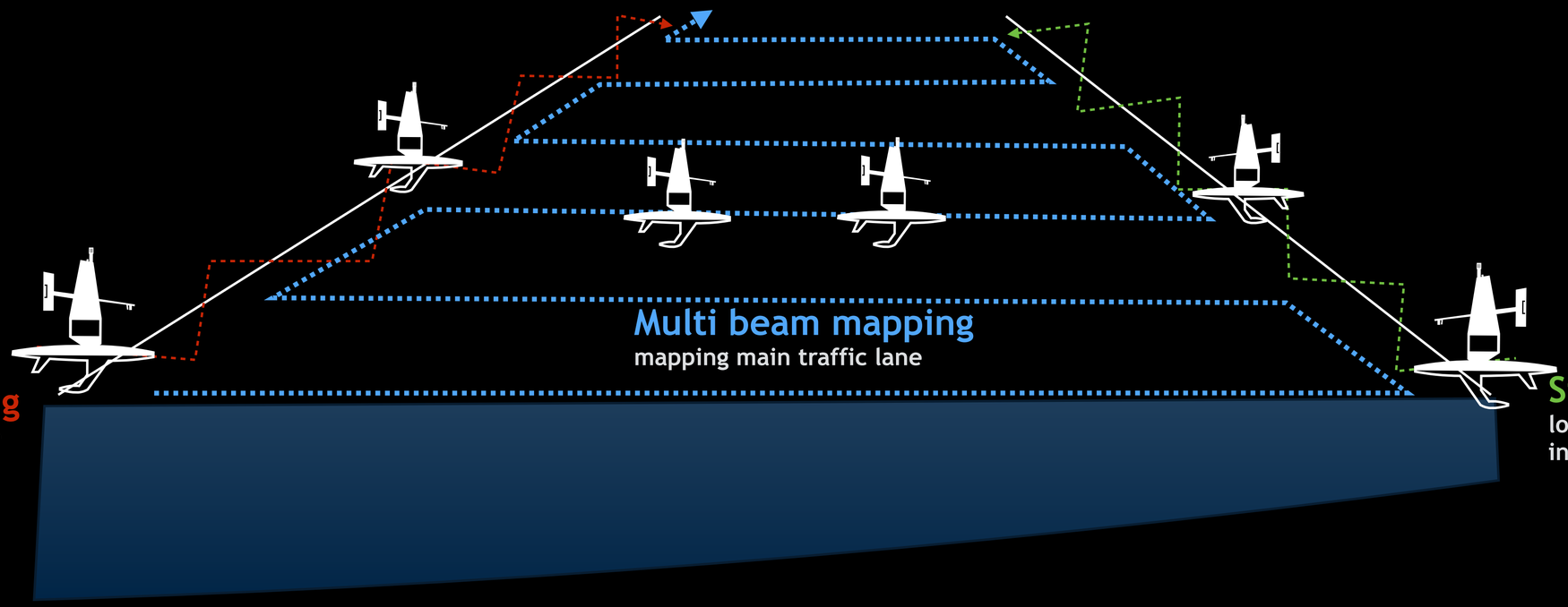
Focus on Alaska North Slope - Single beam ‘scouting’ for contour lines



Arctic - North Slope Mission
Single Beam Mapping
with NOAA OCS 2020

Focus on Alaska North Slope - Single beam ‘scouting’ for contour lines

AUTONOMOUS MAPPING
CONCEPT OF OPERATION



Single beam scouting
locating the 50m contour line
in-shore lane limit

Single beam scouting
locating the 20m contour line
in-shore lane limit

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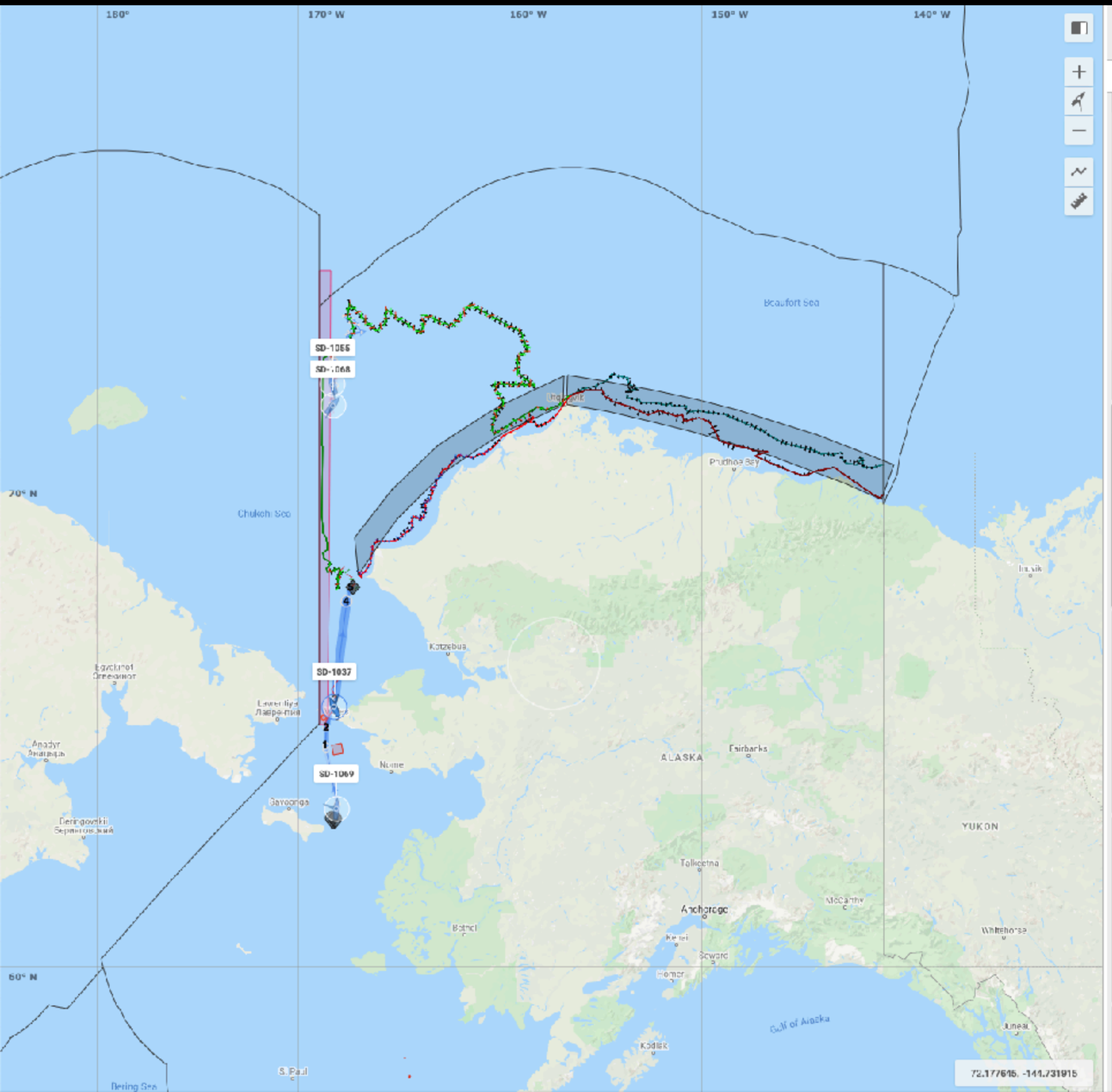
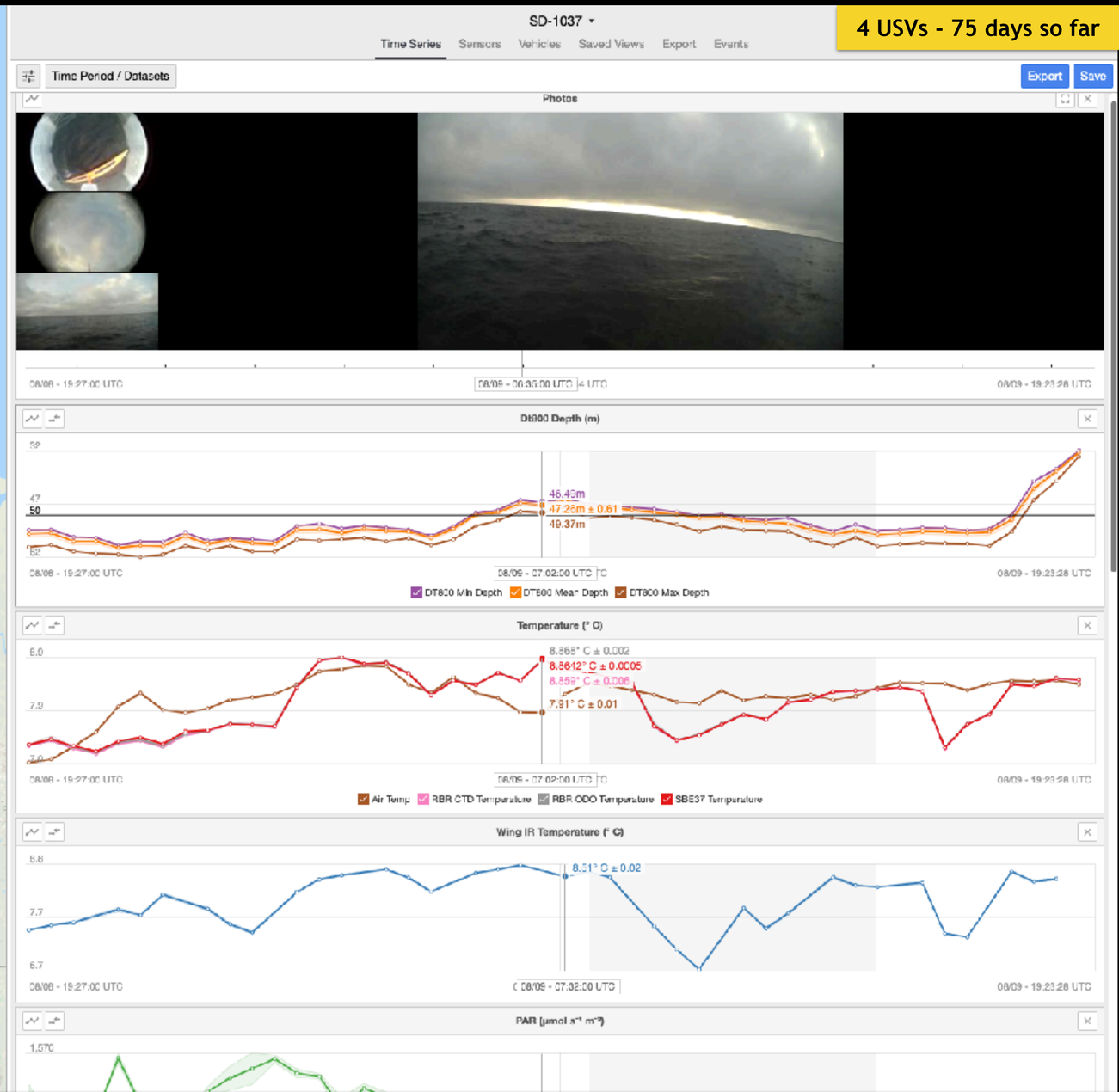
U.S. Department of Commerce

SAILDRONE

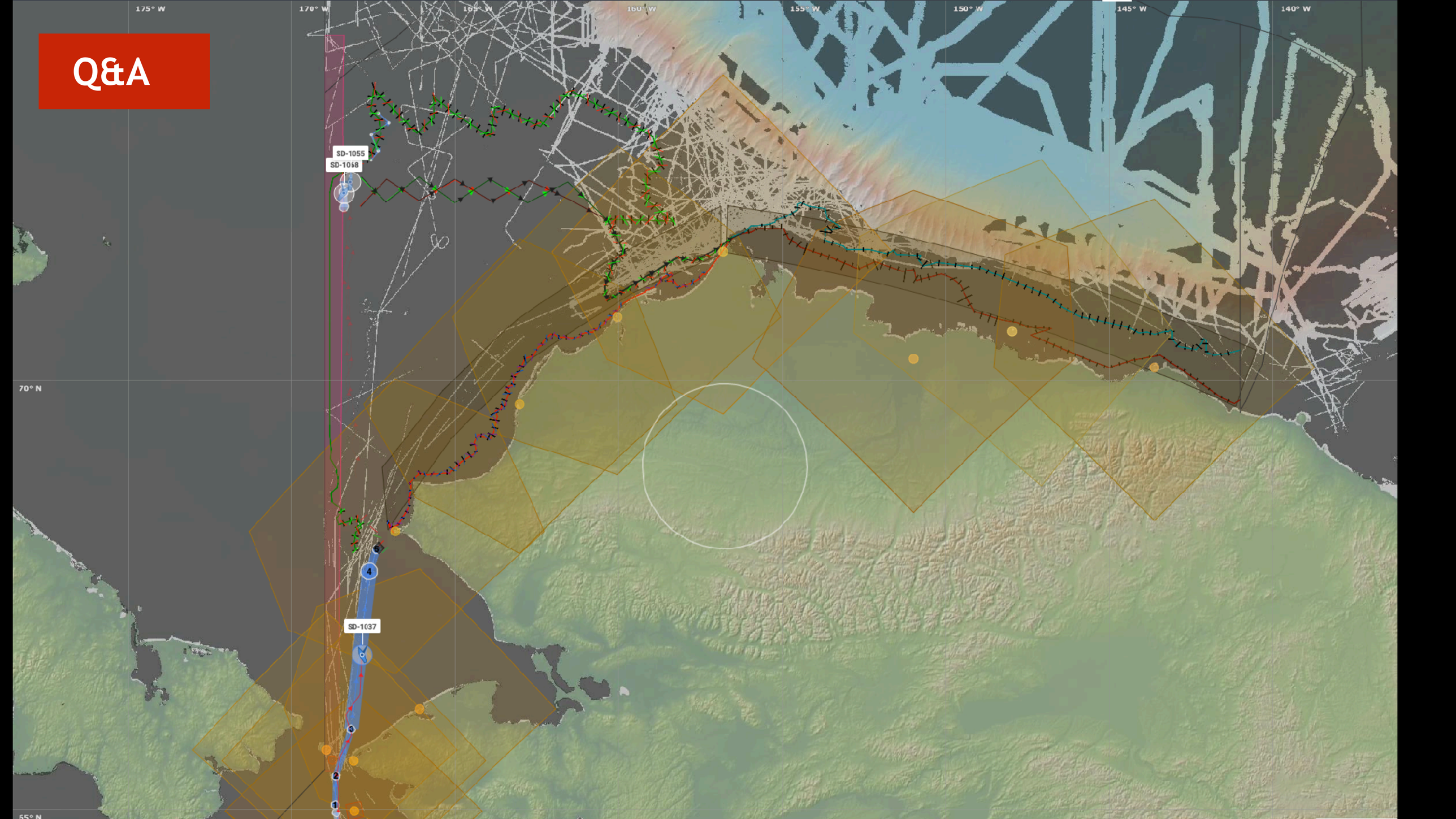
TERRASOND

ARCTIC MAPPING MISSION IN PROGRESS: After a succcessful sailing transit from CA to AK, SB survey underway during COVID





4 USVs - 75 days so far


Q&A
175° W
170° W
165° W
160° W
155° W
150° W
145° W
140° W
70° N
65° N
SD-1055
SD-1068
SD-1037
1
2
3
4
5

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