2021 Alaska Coastal and Ocean Mapping Summit Report

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Alaska Mapping Executive Committee

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SURVEY

Executive Summary

Recognizing the value of coastal and ocean mapping data and products to enhance our future prosperity, health, and national security, on November 19, 2019, a Presidential Memorandum titled "Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska" was issued. The memorandum directed federal agencies to prepare a national strategy for mapping, exploring, and characterizing the Exclusive Economic Zone of the United States (U.S. EEZ) and prepare a strategy for mapping the Arctic and Sub-Arctic Shoreline and Nearshore of Alaska. These directives led to the following two strategies and associated implementation plans in 2020-2021:

1. National Strategy for Mapping, Exploring, and Characterizing the U.S. Exclusive Economic Zone (NOMEC)

2. A Strategy for Mapping the Arctic and Sub-Arctic Shoreline and Nearshore of Alaska (ACMS)

On December 1-2, 2021, the 2021 Alaska Coastal and Ocean Mapping Summit convened virtually. Over 300 people registered for the mapping summit, 211 people attended, and 47 people presented. Participants represented federal, tribal, state, and local governments; native corporations; non-governmental organizations; academia; and private sector organizations.

The summit was the fourth in a series going back to 2016. Previous summits focused on coastal mapping topics; however, this year, an ocean focus was added to bridge the gap between the coastal and ocean strategies. The summit was organized to cover the following topics: Alaska mapping updates, technology advancements, and potential opportunities to progress our mapping goals. For the ocean day, the summit also included a panel on why mapping is important.

This report is organized by day and concludes with a section of key takeaways to capture potential next steps. While detailed further in this report, some themes associated with the key takeaways include:

Data accuracy and precision;

Approaches to filling data gaps;

Communicating progress toward the mapping goals;

Addressing gaps in mapping assets and expertise in Alaska; and

Expanding outreach and participation.

The appendices in this report include an abbreviations and acronyms list, attendee list, agenda, polling results, and compilation of helpful web links that were shared during the summit.

Contents

Summit Format and Objectives

The Alaska Coastal and Ocean Mapping Summit was held virtually over two days on December 1-2, 2021. The event was Alaska's fourth coastal mapping summit and introduced a new ocean mapping component.

Day 1 focused on the Alaska Coastal Mapping Strategy (ACMS) and associated implementation plan with a focus on positional framework, collaboration, and new technologies or methods that may help fulfill coastal mapping goals for Alaska. The agenda for the coastal day included mapping updates; a review of the latest in airborne and satellite mapping technology developments; and a review of the status of geodetic control in the region. Dave Maune from Dewberry also presented some recommendations for pilot coastal mapping projects using both airborne and waterborne mapping technologies.

Day 2 focused on answering foundational questions in support of Seascape Alaska, a new regional mapping campaign in support of the National Strategy for Ocean Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone (NOMEC) and associated implementation plan. The agenda for the ocean day included introductions to NOMEC and Seascape Alaska; presentations from various stakeholder groups on why mapping is important to them; a review of some waterborne mapping capabilities and how they could be used to fulfill NOMEC goals; presentations on what we are doing in terms of both operations and opportunities; and a breakout room session on how to improve collaboration.

Throughout both days, participants were asked a series of poll questions.

The presentation slides and pre-recorded videos can be found at:

https://agc-coastal-soa-dnr.hub.arcgis.com/pages/2021aksummit

and

https://iocm.noaa.gov/projects/regional-activities.html#Alaska

Coastal Mapping Day

Alaska Coastal Hazards Program Manager, Jaci Overbeck, of the Alaska Division of Geological and Geophysical Surveys (DGGS) welcomed participants and introduced keynote speaker Senator Lisa Murkowski. NOAA's Juliana Blackwell spoke about NOAA's efforts to modernize the National Spatial Reference System to enable positional accuracy for alignment of geospatial data. NOAA's Ashley Chappell shared two jointly authored reports from the Alaska Mapping Executive Committee's (AMEC) Coastal Subcommittee: the first being the Alaska Coastal Mapping Strategy and the second, the Implementation Plan, which is open for public comment until January 31, 2022. Alaska's Geospatial Information Officer, Dr. Leslie Jones spoke about the coordination framework provided by the Alaska Geospatial Council and introduced the Coastal and Ocean Technical Working Group as a communication hub that's also open to the public.

SESSION 1: Agency Mapping Updates

The agency mapping updates session began with an introduction to the tracking dashboard and ArcGIS Hub site used by the AMEC Coastal Subcommittee. Agencies that presented coastal mapping updates were the Alaska DGGS, NOAA Remote Sensing Division (NOAA RSD), the National Park Service, the United States Geological Survey (USGS), the Joint Airborne Lidar and Bathymetry Technical Center of Expertise (JALBTCX), and the U.S. Fish and Wildlife Service.

Alaska DGGS

Jaci Overbeck, Coastal Hazards Program Manager, presented 2021 mapping updates for the State of Alaska DGGS. This program focuses primarily on providing assessments for coastal communities according to their flood and erosion hazards. The program has been around for over ten years now, and in the beginning, there was a lack of the good baseline data that is required for monitoring and predicting hazards faced by the people of these communities. There has been a big push in the last ten years to acquire the data that is needed to quantify and analyze the evolving situations in each community and help them plan for the future or develop strategies to mitigate these risks. The coastal hazards program has helped acquired some of this baseline data, such as:

- photogrammetric digital surface models and orthoimagery;
- UAV operations and training through collaborations with tribal and borough agencies crowd-sourced bathymetry data;
- lidar acquisition; and
- installed water level sensors.

In order to ensure these and other data collection efforts are well-coordinated, Jaci serves as the co-chair of the AMEC-Coastal Subcommittee and co-chair of the AGC Coastal & Ocean Technical Working Group. She is also chair of the Alaska Water Level Watch.

In 2021, the Bureau of Indian Affairs Tribal Resilience Program contracted out some work to the State of Alaska for the following communities of Napakiak, Kotlik, and Alakanuk.

Work under this contract included:

- UAV Imagery/Digital Surface Model (DSM) Creation
- Ground Control
- Single-beam Bathymetry
- Historical Flood Markers
- Lidar at Napakiak

Another project that involved coastal mapping this past summer was the State of Alaska ASTAR Coastal Hazards Project. This project sought to conduct baseline mapping in North Slope communities, where data gaps exist, in support of flood and erosion mapping. In 2021, field work began in Wainwright as well as collection of tidal datums in Point Lay.

For Wainwright, they surveyed coastal elevation profiles with a permafrost probe, sampled beach sediments, collected single-beam bathymetry data, and installed a community-based erosion monitoring system. Other mapping efforts that have taken place in this area include USGS 3DEP lidar collected in 2019, topobathy lidar was flown by JALBTCX in 2021, and NOAA Office of Coast Survey (OCS) collected offshore bathymetry for the area as well. In order to get community flooding, erosion, and permafrost risk assessment data into the hands of the users, the DGGS created an ArcGIS Dashboard that is embedded in a StoryMap.

Through the National Coastal Resilience Fund, DGGS has also been working to provide communities with detailed information about flooding and erosion hazards by building capacity and conducting coastal risk assessments in remote Alaska Native Communities. This project is conducted in collaboration with the Alaska Native Tribal Health Consortium (ANTHC) and the State of Alaska DCRA.

The Alaska Water Level Watch collaborative working group is primarily focused on improving water level observations across the state. Although VDatum has not been implemented in areas except for southeastern Alaska, it is the goal that every community have at least a datum conversion from water level to land. NOAA's OCS has begun collecting this data at community locations as a way to fill the gaps. In support of the NWLON, partner stations help fill the data gaps in real-time water level monitoring, including a sensor in Dillingham that was installed and should be coming on-line very soon.

Finally, the Alaska DGGS was recently awarded a 2022 Digital Coast Fellowship Grant that will fund a graduate student to begin working on coastal issues in Alaska and increase the engagement, inclusion, and equity among growing local, tribal, state, federal, and private partnerships which enhance data sharing and success. Applications for this position are due January 21, 2022.

NOAA Remote Sensing Division

Stephen White represented NOAA RSD and shared their plans to begin working on the shoreline vector delineation known as the CUSP, or continually updated shoreline product, for the upper Cook Inlet area, through the Shelikof Strait, and along the Alaska Peninsula. Approximately 62% of the CUSP has been completed for Alaska and over 42% of the CUSP that has been created was then used to update navigational charts to improve maritime safety. RSD is developing a satellite-derived bathymetry (SDB) tool which is now in alpha version 1.0 testing. One site in Pribilof Bay yielded some issues during the derivation process such as banding caused by a known Sentinel-2 issue over water from sensor construction or alternating detectors. For a site near Nunivak, the SDB data was clipped to the 3.5m Navigable Area Limit Line (NALL), so ships could stay safely offshore. The plan is to have this automated clipping at SDB extinction depth process implemented for operational testing in Beta v1.0 or 1.1. All of NOAA RSD's data is made available through the NOAA Shoreline Data Explorer and the Digital Coast.

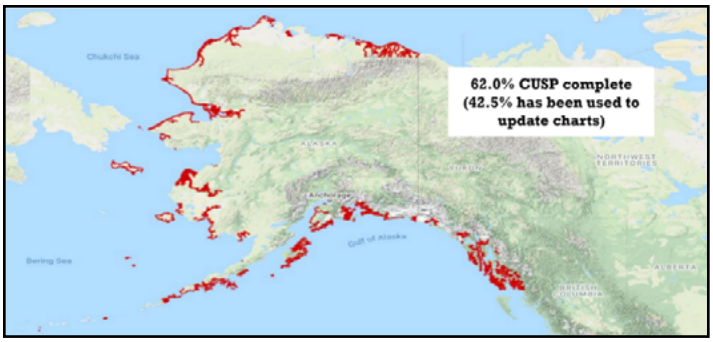


Figure 1 — Map depicting Alaska's latest coverage of Continuously Updated Shoreline Product (CUSP) in red.

Through the Coastal Shoreline and Change Analysis Program (CSCAP), NOAA RSD was able to complete 4-band, 25cm orthoimagery acquisition for 8 of 9 ports identified. The 9 ports in Alaska that are routinely monitored by NOAA RSD through the CSCAP are Anchorage, Juneau, Ketchikan, Kivalina, Kodiak, Nikiski-Kenai, Petersburg, Valdez, and Dutch Harbor. They hope to get out to Dutch Harbor as soon as possible to complete imagery acquisition for all 9 ports. Stephen also shared that the National Tidal Datum Epoch is anticipated for release in 2025.

National Park Service

Tahzay Jones presented for NPS to update their Structure from Motion (SfM) imagery collection efforts for 2021. This year most of their SfM efforts were focused on interior Alaska. NPS partnered with the University of Alaska Fairbanks (UAF) and USGS to map and characterize benthic habitats. Remotely operated vehicles (ROVs) were used to perform nearly 250 dives in the Cook Inlet, Kachemak Bay, and Shelikof Strait focusing on areas between 10m and 30m depth. Multibeam sonar was also collected during this time. These efforts will continue in 2022 and will primarily follow sea otter habitat areas. NPS will also focus on benchmark occupations and relocations within Southwestern Alaska. Several dozen benchmarks were recovered and submitted to OPUS Shared solutions. Single-beam between Yakutak and Icy Bay focusing on coastal lakes and lagoons in the area related to glacial retreat mapping to complement lidar, imagery and SfM in the region collected mostly by UAF.

Other work from the 2021 field season included pressure transducer retrieval of a tidal station in Chinitna Bay. A full year's worth of valuable data is currently in processing and should be helpful for establishing tidal datums in the area of this particular NWLON gap.

The NPS also recently acquired an autonomous surface vessel (ASV), equipped with a multibeam echo sounder (MBES), which they intend to use for coastal Kenai Peninsula and Western Cook Inlet keeping to depths less than 50m, working in concert with the diving ROV for improved benthic habitat mapping.

United States Geological Survey

Brian Wright, the USGS National Map Liaison for Alaska, gave an update on the status of the Alaska Mapping Initiative, part of the National Geospatial Program. The multi-agency coordination board known as the Alaska Mapping Executive Committee has begun tracking geospatial progress according to 7 themes: Hydrography, Gravity, Shoreline Mapping, Coastal Mapping, Wetlands, Elevation, and Imagery. Coastal Mapping is currently listed with a milestone status rather than an estimate of completion as a vetted gap analysis has not yet been completed.

Alaska Mapping Executive Committee Tracked Mapping Themes

Theme	Metric	2020 Goal	Oct 2021 Status
Hydrography	NHD WBD NHDPlus HR	Complete by 2030	13% complete
Gravity	% GRAV-D acquired	Mainland by 2019 Aleutians by 2022	100% mainland Alaska 50% Aleutians
Shoreline Mapping	% updated	Complete by 2026 Dependent upon budget appropriations	58.7% complete 42.5% has been used to update charts
Coastal Mapping	In development	Complete by 2030	Draft implementationPlan
Wetlands	NWI	Complete by 2029	75.4% contracted
Elevation	IfSAR	Completed in 2020	Establishing new requirements/ priorities
Imagery	1-m GSD	Complete this update cycle in 2023	Completed Establishing new refresh requirements/ priorities

The USGS also administers a broad agency announcement (BAA) competitive grant funding program for federal assistance in support of lidar acquisition. Federal agencies, state and local governments, tribes, academic institutions and the private sector are all eligible to receive funding under the BAA program. Qualifying coastal areas are specifically defined as extending to the 50-foot elevation line, farther if the areas overlap with other Federal priorities or FAA flight lines.

Ann Gibbs presented on the Shoreline Change Assessment program which is currently re-processing 1950's imagery of the Norton Sound area using SfM techniques to improve positional accuracy using modern geospatial reference information, which will help calculate the rate of coastal change for the area. They are also in the process of re-registering imagery for the Arctic National Wildlife Refuge (ANWR) using NOAA 2017 imagery. Future plans for this program include continued partnership with Alaska DGGS to update historic imagery using modern spatial reference systems in order to develop a more accurate picture of coastal change over time for Alaska. As new geodetic and tidal datums become available, the analysis will become more and more accurate. The Shoreline Change Assessment Program is also developing a program to automatically extract shoreline information from satellite imagery to enable more rapid change detection and projections.

Ann also briefed on the Future Flood Hazards Modeling efforts of the USGS in Alaska which aims to characterize past and future coastal flood hazards at coastal communities and areas with infrastructure. This effort, also called the Coastal Storm Modeling System (CoSMoS-AK), involves running a series of numerical models to map flood hazards out to year 2050, looking at multiple sea level rise scenarios and future storm scenarios. The final product will be flood hazard maps for all scenarios to help develop and inform adaptation strategies using a web-based decision tool. This tool will be developed in collaboration with the Alaska Native Tribal Health Consortium (ANTHC) and AK-CASC among others. Currently, the tool is limited to those coastal communities where adequate DEMs and Elevation datum information exist.

1. *Unalakleet*
2. *Utqiagvik*
3. *Kotzebue*
4. *Elim*
5. *Deering*
6. *Kivalina*
7. *Point Hope*
8. *Teller*
9. *Prudhoe Bay*
10. *Kaktovik*
11. *Golovin*
12. *Oliktok Pt.*
13. *Bullen Pt.*
14. *Lonely*
15. *Cape Simpson*
16. *Shaktoolik*
17. *Nome*

Figure 3 — Image of coastal community locations with adequate DEMs and elevation datum information.

The availability of new data including on-land elevation and especially nearshore bathymetry facilitate better storm surge and sea level rise predictions. An example use case from the east coast includes a 6-day forecast system for coastal flooding and probability of erosion with estimated wave runup based on foreshore slope and nearshore bathymetry. This program is currently expanding to the Gulf Coast, West Coast, and then Alaska.

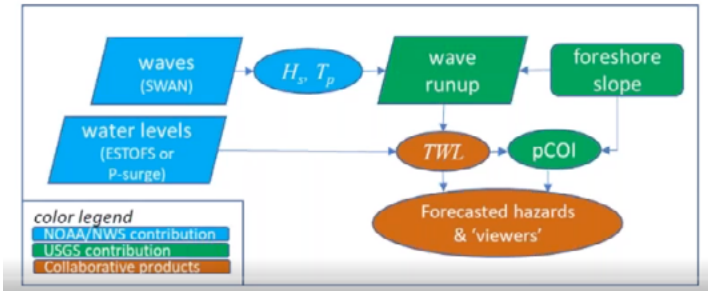


Figure 4 — Flow chart showing how waves, water levels, and foreshore slope inform wave runup and total water levels to inform hazard forecasts.

The USGS has installed several coastal observing cameras across Alaska including Unalakleet, Kaktovik, and Nuvuk Point Barrow this past year. The cameras at Barter Island were lost due to erosion.

Joint Airborne Lidar Bathymetry Technical Center of Expertise

Chris Macon briefed on mapping activities of the National Coastal Mapping Program looking at regional changes as they pertain to USACE projects. For 2 weeks in 2019, JALBTCX used forward operating bases in Nome, Anchorage, and Juneau from which to branch out and collect data. It was useful to have targets spread across the state in case one particular region was having bad weather, the team could jump to a different region chasing better weather. In 2021 JALBTCX targeted 35 or 36 sites, some of which were repeated for change analysis and methodology evaluation. This time forward operating bases were Utquiagvik, Nome/Kotzebue, Cold Bay, Anchorage, and Juneau. Exploratory lines were flown at Point Thompson and Kaktovik which yielded surprisingly good penetration and showed sandbar formations extending offshore. Exploratory lines were also flown at Copper River Delta where the lasers were not able to penetrate due to turbidity. JALBTCX also collected topobathy lidar for Utquiagvik, Point Lay, and Wainwright. In these areas of the North Slope Region, the bathymetry data yielded was of good quality in the coastal lagoon areas but the sensor wasn't able to achieve good bathy data offshore in these locations. Kivalina and Shishmaref as well as Cape Blossom were also collected where both nearshore and coastal lagoons yielded good bathymetry data. Shishmaref is posing a bit of a challenge with its very shallow, sediment-based environment so they are working through some different algorithms to get the data post-processed in the best way possible. Gambell and Savoonga were collected as well and topobathy yielded great returns but the short weather window prevented further collection.

At the conclusion of the agency mapping updates session, the audience was asked if they knew of any other agencies or entities who are mapping Alaska's coastal areas that could be invited to collaborate? Two responses were given, the first was the Alaska Department of Fish and Game, then second was Fairbanks Fodar.

U.S. Fish and Wildlife Service

Regional Wetlands Coordinator Sydney Thielke briefed a 2020 solicitation for input across USFWS Alaska staff to understand their data needs. Emerging as the top priorities were:

- Refuge administrative boundaries;
- Climate change and coastal erosion;
- Intertidal fish habitat;
- Shipping routes and infrastructure/oil spill response; and
- Trust resources and endangered species.

In 2015 and 2016, the USFWS was involved in a successful lidar project in Western Alaska involving several other partners. In 2022, the USFWS is leading a collaboratively funded lidar project for the terrestrial portions of the Copper River Delta which spans an estimated 700,000 acres.

Recently, the USFWS has acquired a Lucint12 Camera System for smaller, project level imagery acquisitions. The camera system contains nine different sensors and is currently mounted to a Super Cub but can also be mounted on a Cessna 206 to extend the reach from base or expand the area of acquisition.

SESSION 2: Technology Lightning Talks

Public and private sector presenters filled the next session called Technical Lightning Talks with 10-minute presentations about orthoimagery, terrestrial lidar, topobathymetric lidar (aka topobathy lidar), satellite-derived bathymetry, and water clarity measurement and prediction. Presenters included representatives from NV5 Geospatial, Planet, TCarta, EOMap, PolArctic, JALBTCX, and NOAA Remote Sensing Division.

SESSION 3: The Path Forward

The last session of the day focused on a theme of "the path forward." This forward-thinking session began with a presentation on SfM photogrammetry by Dr. Matt Nolan of Fairbanks Fodar, followed by a 30-minute presentation from Dr. David Maune of Dewberry outlining his recommended pilot projects for determining the feasibility of various technologies and methods for Alaska. Dr. Maune's recommended pilot projects were as follows:

Pilot #1: AXYS Tide Buoy/GNSS-R

We already know that NOAA has recently approved the AXYS Tide Buoy for determining tidal datums, but can this buoy be used to test the accuracy of GNSS-Reflectometry (GNSS-R) water level stations deployed in Alaska for potential designation as Tier B tide stations?

Pilot #2: VDatum Plan of Action

We already know there are major gaps in the National Water Level Observation Network (NWLON) in Alaska and that NOAA's Vertical Datum Transformation Tool (VDatum) only works in southeast Alaska, but can lessons learned from Pilot #1 help NOAA develop a VDatum Plan of Action to expand VDatum statewide?

Pilot #3: Topobathy Lidar

We know that several commercial vendors, NOAA and JALBTCX use topobathy lidar technology for mapping the intertidal zone for Alaska and other coastal communities, but can we determine how to best fill the missing gaps when topobathy lidar does not capture nearshore bathymetry to the desired 3.5m Navigable area Limit Line (NALL) below MLLW?

Pilot #4: USV Sonar Sensor Options

We already know that commercial vendors can use their Uncrewed Surface Vessels (USV) with a MBES to map nearshore bathymetry to the 2m depth contour, but can they cost-effectively map shallower waters at high tide, between zero and the 2m depth contour, using a dual-head MBES, side-scan or interferometric sonar? What works best?

Pilot #5: SeaSat SBES Shallow Surveyor USV/ASV

We already know that the lightweight and portable Shallow Surveyor by SeaSats is easily launched and operated as either a USV or ASV in the open ocean under close to gale conditions, but can it cost-effectively be flown in to remote Alaskan airfields and acquire high density but narrowly spaced SBES tracks at high tide for 0-3.5m depth bathymetry that may be unsafe for MBES?

Pilot #6: XOCEAN XO-450 Over-the-Horizon ASV

We already know that remote-controlled ASVs such as the XOCEAN's XO-450 can map portions of the Great Lakes with curved head MBES; but can it do so safely and cost-effectively to map Alaska's shallow shoreline bathymetry at high tide while controlled from thousands of miles away?

Pilot #7: Saildrone Voyager Over-the-Horizon ASV

We already know that wind-powered Saildrone Explorer ASVs with SBES can survey in the Arctic to help establish safe navigation routes; but can wind-powered Saildrone Voyager ASVs with MBES cost-effectively survey Alaska coastal waters deeper than the NALL to execute major portions of the Alaska Coastal Mapping Strategy?

Pilot #8: Satellite-Derived Bathymetry

We already know that SDB works in areas where waters are clear; but can it cost-effectively work in portions of Alaska where waters have significant levels of turbidity or where topobathy lidar cannot be safely acquired?

Pilot #9: GCPs & Checkpoints

We already know that professional land survey firms can survey Ground Control Points (GCPs) and QA/QC checkpoints to high accuracy standards; but can they cost effectively survey photo identifiable GCPs and wet and dry QA/QC checkpoints simultaneously usable for control and

accuracy testing of SfM photogrammetry, lidar and IfSAR on land, as well as sonar in the intertidal zone?

Pilot #10: Topographic Lidar

We already know that topographic lidar is the preferred technology for mapping broad areas of the U.S. for the 3D Elevation Program (3DEP); but can topographic lidar be cost effectively collected at low tide for mapping Alaska's narrow coastal corridors that might be crenulated with sharp turns?

Pilot #11: SfM R&D

We already know that Fairbanks Fodar's SfM photogrammetry is extremely cost-effective in collecting heavily overlapped imagery at low tide for mapping portions of the shoreline and intertidal zone for Alaska coastlines; but can Fairbanks Fodar SfM technology be relied upon for production of elevation point clouds comparable to lidar so systematic errors are corrected and there would be no future need for "z-bumps" for SfM DEMs to fit GCPs and better align with adjacent datasets?

Pilot #12: Type-I IfSAR 2m DSM/DTM

We already know that Intermap's mid-accuracy Type-II IfSAR, acquired from 28,000 ft. altitude, delivered 5m DSMs/DTMs with sub-meter RMSEz and 62.5-cm Orthorectified Radar Images (ORIs) and were cost effective in mapping 78% of Alaska between 2010 and 2020; but can this technology be used to cost effectively collect lower-altitude (18,000 ft.) IfSAR and deliver Type-I 2m DSMs/DTMs with 50cm RMSEz and 25cm ORIs for mapping Alaska's coastlines in selected AOIs?

Pilot #13: Coastal DInSAR

We already know that portions of Alaska are uplifting at rates between 10 and 25 mm/year while other areas are subsiding from permafrost thaw or other reasons, and we know that Differential Interferometric Synthetic Aperture Radar (DInSAR) technology can be used to map annual rates of subsidence at the cm and mm level; but can DInSAR be cost-effectively used to map "hot spots" and annual rates of isostatic rebound and subsidence along a coastal strip, 10 km wide, for the 10,000 km Alaska coastline?

Pilot #14: Topo/Bathy Data Merges

We already know that it is extremely difficult to seamlessly merge datasets produced by different topographic and bathymetric technologies acquired at different times with different standards, geoid models, horizontal/vertical datums, projections, coordinate systems and units; but can diverse topo/bathy technologies deliver metric ellipsoid height data in NAD83 and the Alaska Albers projection to standardize the merger of diverse datasets in Alaska's intertidal zone?

Dr. Maune concluded his description of recommended pilot projects with a disclaimer that none of the pilot projects which mention a specific company should be considered an endorsement as they were merely included based on technology capabilities. Any companies excluded from this list with similar capabilities should also be considered.

Following discussion of the pilot projects, Nathan Wardwell of JOA Surveys presented on tidal datums and positional control for Alaska, followed by Will Freeman of NOAA who talked about the NOAA Foundation CORS Program.

After this session the audience was asked to submit their suggestions about what they see as the path forward for coastal mapping in Alaska. Only one response was received, "Close water level gaps and pilot projects!"

Ocean Mapping Day

Similar to Day 1, Day 2 started with Jaci Overbeck, Alaska Coastal Hazards Program Manager of the Alaska DGGS welcoming participants. Due to technical difficulties on Day 1, Senator Lisa Murkowski's keynote address was played again. The following documents the discussions and highlights for Day 2 of the mapping summit.

SESSION 1: NOMEC and Seascape Alaska Introduction

Ashley Chappell and Meredith Westington from NOAA's Integrated Ocean and Coastal Mapping (IOCM) program introduced the National Strategy for Ocean Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone (NOMEC) and the new NOMEC regional mapping campaign, Seascape Alaska, respectively.

NOMEC

NOMEC complements the Alaska Coastal Mapping Strategy by extending the area of mapping interest to the outer limit of the U.S. EEZ. The two strategies work hand-in-hand and emphasize the importance of both Alaska coastal and ocean mapping to the national economy, security, and environment. There are five goals in the NOMEC strategy:

1. Coordinate interagency efforts and resources to map, explore, and characterize the U.S. EEZ
2. Map the U.S. EEZ
3. Explore and characterize priorities area of the U.S. EEZ
4. Develop and mature new and emerging science and technologies to map, explore, and characterize the U.S. EEZ
5. Build public and private partnerships to map, explore, and characterize the U.S. EEZ

The strategy came out in 2020 and the implementation plan came out in January 2021. At a high level, to identify areas in need of mapping and gauge our progress, we have the Progress Report on Unmapped U.S. Waters. The third annual report will be released around March 2022. For this analysis, bathymetry that are post-1960 at NOAA's bathymetric data repositories are contributing to the definition of mapped. A gap is no measurement in a 100x100m cell.

Goal 2 of NOMEC is the primary focus of today's summit. There are 3 objectives under Goal 2, as follows:

1. Establish a Standard Ocean Mapping Protocol (SOMP)
2. Coordinate and execute campaigns to map the U.S. EEZ
3. Make data usable and available

The SOMP is a protocol that looks at specifications, deliverables, and best practices for bathymetry, seabed backscatter, water column, sub-bottom profiler, side scan sonar, and magnetometer data. Most importantly, the SOMP provides guidance on how to manage these data in order to ensure their compatibility with central repositories such as at NOAA's National Centers for Environmental Information (NCEI) and support multi-mission use, i.e., "map once, use many times."

Acknowledging that there are a number of complementary objectives across the NOMEC strategy, today's summit will primarily cover topics in support of mapping campaigns mentioned in Objective 2. We will introduce Seascape Alaska today, but beyond Alaska, there are several existing regional campaigns across the U.S., including ASPIRE on the Atlantic Coast, EXPRESS on the West Coast, Lakebed 2030 on the Great Lakes, and the Florida Coastal Mapping Program.

Seascape Alaska

Seascape Alaska, is a new regional mapping campaign per Goal 2 of NOMEC. Its tagline is "working together to understand the depths of Alaska's vast seascape," and its central purpose is to coordinate mapping efforts to completely map U.S. waters off of Alaska deeper than 40m by 2030 and waters shallower than 40m by 2040.

Within NOMEC, there are themes underpinning how to deliver on the NOMEC goals. These themes are highlighted as values of the Seascape Alaska campaign, as follows:

- Making sure to share your high-quality data and products with public archives, primarily NCEI, but others may be identified along the way;
- Making sure that the data collected follow best practices, i.e., for all of our efforts, we want our data to be "good" and usable to the broadest set of users;
- Working with others to make the most of every survey opportunity in shared areas of interest;
- Encouraging innovation to make the most of our efforts; and

- Lastly, sharing plans and progress, so others may participate.

Seascape Alaska has an all-hands-on-deck collaboration model and individuals representing different organizations are contributing what they can to help achieve the campaign vision. Current members are from NOAA, BOEM, USGS, USACE, USCG, NPS, State of Alaska GIO, and Alaska Department of Fish and Game. The campaign is looking to expand participation beyond the government sector in 2022.

With common interests in mapping, the campaign primarily seeks to acquire bathymetry from MBES and/or lidar surveys; however, given that the scope of work is huge, contributions from single beam echosounder surveys as well as crowdsourced bathymetry are encouraged. Uncrewed systems as well as ships and aircraft are needed to support this effort. In-scope work is any mapping activity within the U.S. EEZ as well as any operations that could yield transit mapping data. Members of Seascape Alaska will be encouraged to utilize the SOMP, when it becomes final.

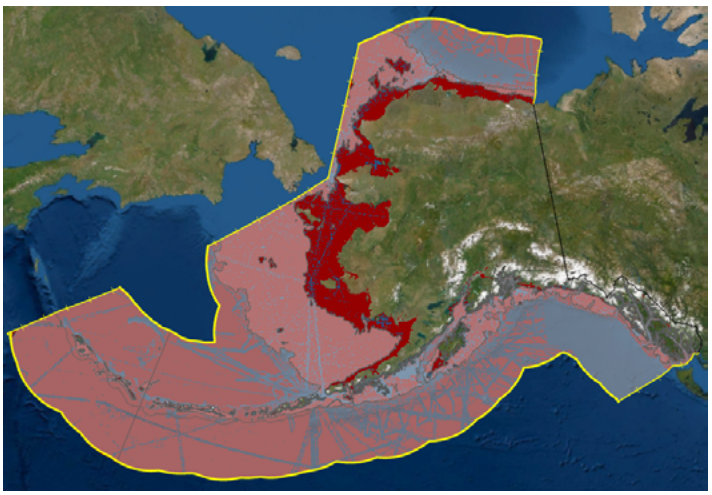


Figure 5 — Image of unmapped areas of Alaskan waters as of January 2021. Red denotes the unmapped areas between 0 to 40m depth; light pink is 40m to 200m; and deep pink is 200m and deeper.

Per the 2021 Progress Report on Unmapped U.S. Waters, Alaska is 72% unmapped. NOAA estimates that we need to collect ~70,000 snm of new bathymetry each year to reach NOMEC goals. The reality is we don't come close, which isn't surprising because the EEZ around Alaska is almost 1 million square nautical miles – a little less than twice the size of the EEZ around the contiguous U.S. with significant access challenges. The figure below is a quick snapshot of the unmapped area, split by depth bands – red is the unmapped area between 0 to 40m depths, which is the highest level of effort on the 2040 timeline; the lighter pink is the 40m to 200m depth band, which is also a high level of effort; and the darker pink is the 200m and deeper band. Everything in pink is on the 2030 timeline

So far, Seascape Alaska has formed three, smaller discussion groups: a Data Management Technical Team, a SE Alaska Planning Team, and an Aleutian Islands Planning Team. The Data Management Technical Team is requesting that people follow 2 basic steps, as follows:

- Review the U.S. Bathymetry Coverage and Gap Analysis, which is linked from **NOAA's Geoplatform**
- If you have data to fill gaps, please fill out the **data provider engagement form**.

From that basic task, the team will follow-up to get more details with an ultimate aim to get that data discoverable in centralized archives. Having this data available means that the campaign can focus its attention on truly unmapped areas.

The SE Alaska and Aleutian Islands Planning Teams formed to test and hone mapping collaboration activities. The SE Alaska area was chosen because it appeared to be the most achievable (size-wise relative to other geographic areas) and filling this gap along the shelf would possibly allow for products like seamless topo/bathy DEMs stretching from land all the way out to the U.S. EEZ. Pros for this region are the availability of modern high-resolution data in the nearshore as well as farther out, plus good geodetic control. The Aleutians area was chosen because it aligns with planned mapping, exploration, and characterization work between NOAA, BOEM, and USGS in FY22 and FY23.

For more information and to help spread the word, see this **fact sheet on the Seascape Alaska campaign**. In 2022, Seascape Alaska will be expanding its web presence and creating mechanisms to improve collaboration.

SESSION 2: Why is Mapping Important?

Within the session on why mapping is important, we heard from eight panelists representing tribal government, federal government, private sector organization, and academic perspectives. Many of those presenting today are current Seascape Alaska members or soon-to-be members.

For five minutes each, the panelists discussed the importance of mapping for:

- Identifying and addressing marine debris;
- Safe navigation and identifying mapping priorities to fulfill this mission;
- Fisheries management;
- Identifying critical mineral resources;
- Studying earthquake, landslide, and tsunami hazards;
- Identifying and studying methane seeps and submarine volcanism; and
- Identifying hydrokinetic energy potential.

Aleut Community of St. Paul Island Tribal Government Perspective

Veronica Padula, the Assistant Director of the Ecosystem Conservation Office (ECO) with the Aleut Community of St. Paul Island Tribal Government, spoke about some mapping priorities for the community. ECO has a long history of collaborating with others to further its research on and around St. Paul Island. Monitoring the ecosystem has been important to the tribal government.

Some of the mapping priorities for ECO revolve around marine debris. There is a lot of derelict fishing gear, specifically crab pots, around the island that not only damage the habitat, but also block the halibut fishermen from trawling in these areas. Fishermen have identified large areas where they have discovered derelict fishing gear. The community would like to develop a mitigation plan to remove those crab pots and open access for fishing.

Navigator's Perspective: Prioritizing Mapping Surveys Where Vessels Operate

Captain Ed Page, U.S. Coast Guard (retired) provided a navigator's perspective on mapping based on his work with the Marine Exchange of Alaska.

Alaska is heavily dependent on the blue economy – vessels transporting goods into the State and raw materials to the world without incident. Trade is becoming more diversified and vessels are heading to the new maritime frontier, the Arctic. Better mapping aids maritime safety and minimizes adverse environmental impacts.

The network of Automatic Identification System (AIS) receivers in Alaska is used to assess where to prioritize mapping based on where vessels operate. AIS heat maps help guide where best to re-survey and chart those waters. As an example, the Tanker EBONY CHAMPION ran aground in 2016 ago on soft bottom in Western Alaska. While the area had been mapped in 1977, the area had changed, creating shoals that ultimately led to the grounding. We need to be better aware of these changing conditions and make sure that those charted waters are up-to-date. We're in an information age, which demands more accurate information and better dissemination of that information, which NOMEC supports.

Hydrographic Health and Charting

Christy Fandel, Operations Branch Chief within NOAA's Office of Coast Survey (OCS), Hydrographic Surveys Division, explained the importance of mapping and identifying priorities in the context of the hydrographic health model and nautical charting.

OCS is responsible for hydrographic surveys through the U.S. EEZ and Great Lakes to support safe and efficient navigation. These data are used to update a suite of nautical charts as well as products and services including hydrodynamic models. OCS estimates that only 47% of U.S. waters are mapped to modern standards. On average, OCS surveys about 3,000 square nautical miles per year with existing resources. It would take over 600 years to get all U.S. waters mapped to modern standards at that rate. In Alaska, the numbers are bleaker. At only 28% mapped, it would take us 250 years to map these waters to modern standards. OCS needs to be strategic about applying resources to map and find partners to maximize mapping efforts.

The hydro health model is a risk-based model that OCS uses to prioritize where to map. It considers the desired accuracy of our hydrographic data based on existing vessel traffic relative to the quality of current hydrographic data holdings, which are then weighted by a hydrographic risk variable. A resulting heat map identifies where to prioritize surveys.

Ocean Mapping: Importance to Fisheries Science

Bob McConnaughey, a Research Fisheries Biologist at NOAA's Alaska Fisheries Science Center (AFSC), spoke about the importance of ocean mapping to fisheries

science. The AFSC is responsible for research on living marine resources in Alaskan waters. The area is vast, and there are a large number of valuable fisheries. There are 47 managed stocks that contribute more than 50% of the annual U.S. landings with an annual wholesale value of $4.7 billion.

The region is divided into operational units for research and management. The Northern Bering Sea, Chukchi Sea, and Beaufort Seas are an expanded mission area due to a loss of sea ice and fish stocks migrating from the south into these areas.

Within each unit, there are a number of scientific and management activities, including stock assessment surveys to support population modeling in support of sustainable fisheries; biological studies; habitat/ecosystem studies; and consultations with other federal agencies and groups regarding specific development activities. The Center commonly links fish abundance with physical and biological factors to address its mandates. Bottom-trawl fish surveys or midwater sonar data are combined with environmental data to create spatial models. For example, descriptive statistics are extracted from bathymetry and backscatter data and used to develop spatial models of trawlability that are intended to reduce bias in estimates of fish abundance from bottom-trawl surveys.

Brief overview of potential critical mineral resources near Alaska

Paul Knorr from the Bureau of Ocean Energy Management (BOEM) spoke about mapping to explore for marine critical minerals offshore of Alaska. Critical minerals are non-fuel mineral or mineral material essential to the economic and national security of the U.S. They serve a vital function in the manufacturing of a product and are vulnerable to supply chain disruptions.

About half of the 35 identified critical minerals are found on the outer continental shelf off Alaska. Cobalt, lithium, manganese, and rare earth elements are particularly important to green energy. The main deposit types are manganese nodules, which occur on abyssal plains at depths between 4000 to 7000m; ferromanganese crusts, which occur with seamounts at depths ranging between 600 to 7000m; seafloor massive sulfides or black smokers, which occur along active plate boundaries at depths between 100 to 7000m; and placer deposits, which are gravity accumulated particles that occur in sediments.

To support its stewardship interests, BOEM is not only interested in where minerals are, but also the surrounding habitat as well as where minerals are not located. The western Aleutian Islands is of interest for seamount benthic mapping and characterization of deep-sea corals, benthic ecosystems, and critical minerals. There are also iron-manganese crusts of interest in the Gulf of Alaska, particularly on Patton Seamount. And, there are several placer deposit areas of interest, including Bristol Bay, which is a protected area that has titanium rich sands; Goodnews Bay, which has a platinum group; Norton Sound/Bering Sea, which has tin just off of Tin City.

Examples of using multibeam bathymetry to study earthquake, landslide, and tsunami hazards in Alaska

Peter Haeussler, a research geologist and Alaska Coordinator for USGS' Earthquake Hazards Program, spoke about uses of multibeam bathymetry to study earthquake, landslide, and tsunami hazards in Alaska. Fault characterization is important for these studies, and bathymetry is critical for understanding how fault systems work and evolve.

Through the collection of multibeam bathymetry, we saw the Patton fault extending offshore from Montague Island, and also discovered a new fault, Cape Cleare fault. Sub-bottom profiles showed a very high slip rates on both faults, which are persistent tsunami producers.

Another example is the Queen Charlotte fault, which runs along southeast Alaska and is responsible for seven major earthquakes in the last 100 years. Between 2015-2018, the entire fault was mapped by multibeam bathymetry and sparker seismic data. Data analysis revealed a consistent ~5.3 cm/yr slip-rate over a 650 km distance making it the world's fastest continent-ocean transform fault.

Bathymetric data are also used to characterize landslides. For example, in Port Valdez, we compared new bathymetry against bathymetry collected before the 1964 earthquake and discovered large debris flows that formed a pattern which increases the tsunami hazard threat in this area. Subbottom profiles showed that these submarine landslides occurred several more times in the past and have been a major contributor to tsunami disasters.

Lastly, some of our biggest advances in understanding the hazards from megathrust earthquakes in the next decade will come from seafloor geodesy. This GNSS-A technique is being tested in the Shumagin Islands.

Submarine Volcanism and Methane Seepage: Why is mapping important?

Jeff Beeson, a research geologist from NOAA's Pacific Marine Environmental Laboratory (PMEL), spoke about the importance of mapping to study submarine volcanism and methane seepage to assess their potential resources and chemical impact on the ocean environment.

Mapping data provide some of the first clues to the location of submarine volcanoes and are used to design further research projects. Mapping is also important to the study of methane seepage. Methane seepage is an emerging science area because an unknown amount of methane is fluxing through continental margins. For the last 5 years, PMEL has been largely focused on the U.S. Cascadia margin, where there are more than 1300 methane emission sites. In Alaska, PMEL is confident that these methane seeps also occur, but the size and scale is unknown.

There are two bigger picture questions related to Alaska. The first is what impacts will a warming Alaska margin have on the carbon cycle? Over time, changing pressure temperature conditions in the shallow sediments will alter the state of methane hydrate in the subsurface and become a contributor to atmospheric carbon. Mapping data can be used to establish the size and scale of this phenomenon for an analysis of change over time. The second is how does submarine volcanism impact ocean chemistry and biology in the north Pacific? PMEL Acoustics will be deploying a quad hydrophone array north of Adak Island in Summer 2022 to detect submarine volcanic sources along the central and western Aleutian arc.

In closing, mapping is important because once you map something, further scientific questions reveal themselves.

Topobathymetric Requirements for Marine Energy

Jeremy Kasper, research faculty at the University of Alaska Fairbanks and Director of Research at the Alaska Center for Energy and Power, spoke about topo/bathymetric data requirements for marine energy in Alaska. Marine energy covers wave, tidal and river energy, but his group is primarily interested in wave and tidal energy.

There are IEC standards for resource assessments and project design. Within those standards, all marine energy areas require bathymetry to identify changes and hazards. The mapping requirements are pretty vague, but ~10m horizontal spacing is needed for the wave energy standard, the IHO standard is recommended to support river energy, and the recommended mapping requirements for tidal energy is somewhere between those two.

To model wave energy around Yakutat in 2016, basic bathymetry was needed. An existing DEM from NOAA was found to be about 90% accurate for their purposes; however, local community members flagged bathymetry changes and hazardous trees along the beach. Because there isn't a lot of vessel traffic or fishing activity, the area was not considered a priority for mapping by NOAA. Along with MBES and UAV data, we are experimenting with satellite imagery to help identify the coastline and change around Yakutat.

Wave and tidal energy hotspots around Alaska are along the NE Gulf of Alaska, including Yakutat. For tidal energy, there is a lot of focus on Cook Inlet, which is dynamic and will likely require new mapping. Offshore wind and wave energy needs are concentrated around communities. A wildcard is combining new technologies with mariculture, which will require mapping data that are offset from these areas.

SESSION 3: How Could We Fill Data Gaps?

In this next session, we heard from five panelists representing industry perspectives. For ten minutes each, the panelists discussed the latest in technology developments from their respective companies and how those technologies could be applied to the NOMEC goal of ~70,000 square nautical miles of new bathymetry each year.

To support this session, the panelists were given the following set of numbers to consider in their remarks:

As of January 2021, the U.S. Bathymetry Gap Analysis showed the following gaps with respect to different depth bands in Alaska:

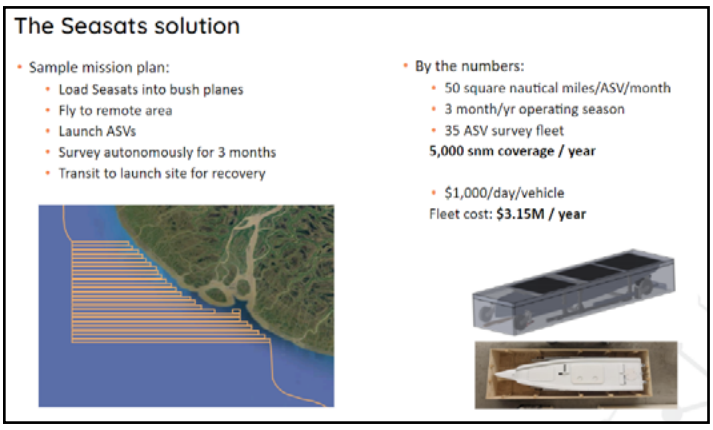
- 0 to 40m: 108,000 snm
- 40 to 200m: 228,000 snm
- 200m and deeper: 437,000 snm

Each of the panelists had strengths and weaknesses across the different geographies, i.e., some have greater capability in the nearshore rather than deeper waters and

vice versa. The following is a synopsis of the information presented.

SeaSats capabilities

Mike Flanigan, CEO of SeaSatellites Inc., spoke about their autonomous surface vehicles that primarily support mapping in the 0 to 40 m depth range. Founded in 2020, their mission is to make ocean operations easier, cheaper, and faster through the use of autonomy and a low level of logistics. The vehicles are lightweight and can be shipped in a small plane, deployed by two people from a dock, rolled off of a boat ramp, or launched from ships with a standard crane. The vehicles can go up to about 4 knots, but 1-2 knots is the suggested survey speed. The platform can accommodate swappable payloads, including communication devices, water sondes for water sampling, integrated SBES or MBES, and towed arrays for marine mammal monitoring.



To support Alaska coastal mapping, Seasats address common mapping challenges such as difficult to navigate shallow waters, high logistical costs due to inaccessibility, and limited effectiveness of airborne technologies due to high turbidity by deploying their vehicles from planes. The figure below breaks down how a single beam survey might be organized using a fleet of Seasat vehicles in shallow waters of Alaska. As explained in the introduction to this session, the ballpark annual milestone for mapping in this area is ~5,000 square nautical miles of new bathymetry per year to reach NOMEC goals. Seasats offers a general cost as $1,000 per day per vehicle.

Beyond producing data to support depth maps, Seasats is partnering with Navico and CMAP to measure backscatter intensity, bottom composition, and vegetation in inland water bodies.

Fugro: The Value of Innovation in Ocean and Coastal Mapping

Rada Khadjinova, Fugro's Alaska Program Manager, delivered a prerecorded presentation about Fugro's work in Alaska, specifically the acquisition and analyses of land and marine geodata. Fugro has two broad customer groups in Alaska: the public sector and the private sector. To support the private sector, Fugro starts with the public sector data and acquires engineering grade data. The private sector data are collected over smaller project areas, but the data accuracy, precision, and quality are much higher.

Fugro recommends a multi-sensor approach to address the need to maximize the scope, pace, and value of coastal and ocean mapping for end-users. Innovation isn't just about force multipliers, but also needs to leverage operations in cloud operations and systems integration. Fugro's RAMMS system is a rapid airborne multibeam system that leverages robotics, remote operations, sensor integration, and cloud automatic to increase both data density and depth penetration to support coastal mapping. It is deployed from small or uncrewed aircraft. To manage the risk to operations, Fugro uses satellite imagery for reconnaissance and characterizes numerous environmental conditions. Post-acquisition innovations include GIS tools for non-technical users that may want to integrate disparate data and make it more manageable and shareable.

Data sharing is key to filling the data gaps and successfully fulfilling the coastal and ocean mapping goals. Fugro leads and shapes private sector participation in international and domestic mapping initiatives by sharing transit data with NOAA in the U.S. and working with its clients to promote data sharing. In 2020, Fugro shared 350,000 sq km of transit data and has contributed 1,445,000 sq km to date. In Alaska specifically, Fugro also facilitated the transfer to NOAA of more than 1500 sq km of seafloor bathymetry that Fugro collected for a broadband company called Quintillion. These data were added to public archives and used to update nautical charts. Data sharing is of strategic importance among all stakeholders and more needs to be done to incentivize data sharing across sectors and unlock data archives.

In conclusion, there are important areas where the private sector can and should make contributions to help with Alaska's mapping goals:

- To bring efficiencies by leveraging innovation in mapping technology;
- Connecting research and development to operations; and
- Filling data gaps with our own data holdings and facilitating win-win opportunities with other data holdings.

eTrac: Capabilities and Autonomy

Dave Neff, a program director from eTrac Inc., spoke about eTrac capabilities and autonomy. The company has been performing hydrographic projects in Alaska for over 15 years and are involved in both large-scale projects to support nautical charting and infrastructure as well as small-scale projects for municipalities throughout Alaska. Both operations involve large and small vessels. eTrac is always looking at ways to improve their productivity and has invested a lot in autonomy.

This presentation covered one form of autonomy – a force multiplication model. The model starts with a mother ship that is driven by a human and has a crew of at least one hydro tech. Then, for example, they might add two ASVs from no specific vendor. eTrac has experience working with many vendors as an integrator of systems. A mesh radio network is the backbone of the force-multiplication model. It creates a high-speed wireless network where every vessel has visibility of the other vessels in the network. Leveraging the vessel network, a digital tether or a virtual tow is created between the mothership and the ASVs. The ASVs do not have a line plan; their only mission is to autonomously follow the mothership. The mothership and ASVs use intelligent SwathSync™ technology to calculate the swath width in real-time and autonomously position the ASVs to obtain the desired swath overlap.

Looking past the square nautical miles of coverage needed each year, we need to look at the line miles or track miles that a ship needs to travel in order to get the coverage. Dave provided some numbers based on a goal of acquiring 1 million linear nautical miles. As you add one ASV to the ship, there is an increase in cost and an increase in production. For example, with 1 ASV added, there is a 33% increase in cost, but you are doubling production. That said, there is a limit to productivity, i.e., productivity doesn't double with each additional ASV. ASVs need care, such as refueling and maintenance, so the productivity gains start to max out around the 4 ASV configuration with a 5th ASV as a spare. The estimated costs associated with one ship vs. one ship plus four ASVs ranged from $24,000 per day to $52,000 per day, respectively. The figure below shows the estimated costs and limit of productivity gains using this force multiplication model.

Let's do the numbers ... eTrac

	Ship	Ship + 1 ASV	Ship + 2 ASV	Ship + 3 ASV	Ship + 4 ASV	Ship + 5 ASV	Ship + 6 ASV	Ship + 7 ASV
Vessel	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000
ASV	$ -	$3,000	$6,000	$9,000	$12,000	$15,000	$21,000	$24,000
Sensors	$3,000	$6,000	$9,000	$12,000	$15,000	$18,000	$21,000	$24,000
Labor	$6,000	$8,000	$9,000	$9,000	$10,000	$10,000	$10,000	$10,000
Total Cost/Day	$24,000	$32,000	$39,000	$45,000	$52,000	$58,000	$67,000	$73,000
Cost +		33%	62%	87%	116%	141%	179%	204%
Production +		200%	300%	400%	500%	600%	700%	800%
	Ship	Ship + 1 ASV	Ship + 2 ASV	Ship + 3 ASV	Ship + 4 ASV	Ship + 5 ASV	Ship + 6 ASV	Ship + 7 ASV
Target LNM	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
LNM/Day	100	200	300	400	500	600	700	800
Days	10,000	5,000	3,333	2,500	2,000	1,667	1,429	1,250

XOCEAN: USVs – a safe, reliable, and low carbon solution to fill the data gaps

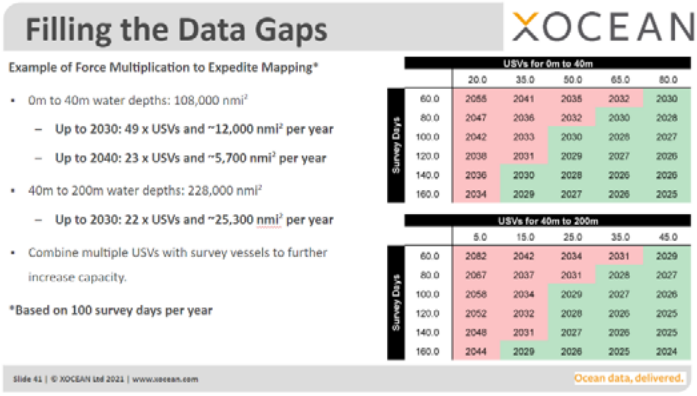
Matt Holland, Sales Manager for the Americas region at XOCEAN, spoke about USVs as a safe, reliable, and low carbon solution to fill the data gaps. XOCEAN is an ocean data company, and it uses uncrewed, not autonomous, systems to collect that data. Their primary business model is a fixed price, turnkey service with data delivery and quality guarantees. The USVs emit low amounts of carbon, which are offset for carbon neutral operations, and are about the size of a car for quick mobilization. Transport options include a road trailer or by air or sea in a 20-foot shipping container. The USVs may be launched and recovered from a slipway, crane from a pier, or vessel-based LARS. Onshore USV pilots and online surveyors monitor and control the vessels and survey system in real-time 24/7 up to 22 days at sea using full "over the horizon" satellite operations.

In the last ~5 years, XOCEAN has conducted over 100 projects around the world and is on target to displace one million tons of carbon in the next 5 years. Last summer, they did a survey in the Canadian Arctic with IIC Technologies for the Canadian Hydrographic Service. Currently, they have 12 USVs and 6 more in production. They will scale up to 30 USVs in the next year. The vessels can support multibeam bathymetry and backscatter data collection as well as other sensors including sub-bottom profilers. The vessels have a clearance of ~0.6m, so they can work in shallow waters.

The USVs could be used as force multipliers under 24/7 operations in sea states up to five. Staffing under this

model would be one pilot per USV, one online surveyor for multiple USVs, and two field operatives for many USVs. For data processing, they might establish local field offices to do weekly data downloads and USV services. In the future, with the availability of low orbit satellite internet, they could stream data directly to the cloud and do real-time data processing.

To address the question about how XOCEAN's USVs might be used to fill data gaps in Alaska, the figure below illustrates some ideas based on different assumptions on days at sea and number of USVs. Assuming 100 survey days at sea starting in 2022, it would take about 23 USVs to map approximately 5,700 snm per year in the 0 to 40m depth band to reach the 2040 goal. For the 40 to 200m depths, it would take about 22 USVs mapping ~25,300 snm per year to reach the 2030 goal. Combining multiple USVs with survey vessels would further increase capacity.



Saildrone

Brian Connon, VP Ocean Mapping with Saildrone, spoke about what they've done in the Arctic and how they might approach this mapping challenge. Saildrone primarily uses wind propulsion to drive their uncrewed vehicles. They have done greater than 15,000 days at sea and can stay out at sea for a long period of time. They have three mission areas: maritime domain awareness, ocean mapping, and ocean data.

Arctic waters are very challenging. Issues include a wide range of water depths – extremely shallow, which is slow and expensive to map, to very deep; extreme environmental conditions and weather, including narrow solar windows; local factors including the large presence of fishing vessels and marine mammals; and the sheer size with limited ports for logistical support. The figure below illustrates some ideas about how Saildrone might map about 5,000 snm per year in the 0 to 40m depth band and about 65,000 snm per year in the 40m and deeper depth band.

Long endurance survey systems that don't need to go back to port are needed in this region. Saildrone has been mapping the U.S. Arctic for the last seven years. They usually ship their vehicles to a local port (like Dutch Harbor) and don't rely on local field office support. They have three types of vehicles: Explorer, Voyager, and Surveyor. The Voyager and Surveyor can be equipped with MBES and both are outfitted with small diesel engines to recharge their batteries. The engines can be used for propulsion, but the vessels primarily use wind to sail. The Voyager can collect data in shallower areas from about 10m to 300m depth, and the Surveyor can map between about 200m down to 7,000m.

Panel Questions and Answers

There were a number of questions from attendees and panelists during this session, as follows:

1. What is the minimum depth and sea state limit for Seasats? Three feet, but working on a shallower vehicle with 1 ft clearance. Sea state 4.

2. Is there a way to tell if your system is recording remotely, i.e., what is the real-time data access to these systems; is it sufficient to check the data quality? Seasats: has a viewer to check the progress; but d/t file sizes, richer data files need to be post-processed. XOCEAN: through satellite communications or 4G cell connection, their online surveyors have full access at all times to the survey computer for real-time monitoring of data quality, coverage, and density.

3. Regarding your multisensor integration, do you (Fugro) have experience integrating seabed backscatter intensity from lidar with data collected from sonar systems? Yes, vast experience merging datasets, e.g., did the entire coastline of California which involved sonar from a vessel, the RAMMS system.

4. Are the XOCEAN's USVs self-righting? Yes, they're tested to remain upright in sea state 6.

5. How well does Saildrone stay on its tracklines when collecting multibeam? They stay within a meter or two of a predetermined line. They have done line spacing as tight as 15-20m with no issues.

6. Have you towed sound velocity profiles on some of the larger Saildrones? No, they are not towed. They are on a

winch, so we stop and drop. For the Voyager, it's about a 200m cable. Currently, the same specs for the Surveyor, but they're increasing the cable to about 500m.

7. What is the size of the Saildrone Surveyor class fleet at this time? There is one Surveyor and a version 2 design is going into production soon to produce another 2 or 3 of those class. Voyagers are prototyping now and will start mass production of those next year- hopefully getting 5 initially and ramping up to 20-30 throughout 2022.

8. How would you take advantage of the development of the port of Nome? Saildrone: port facilities are useful when work is needed on vehicles and helps to launch closer to a survey area. XOCEAN: having facilities to do launch/recovery operations are a key aspect of efficient data collection and to get the USV serviced in a timely manner.

SESSION 4: What are we doing? Operations and Opportunities

Within the session on what we are doing, we heard from nine panelists representing state government, federal government, academia, and the non-governmental sector. For five minutes each, the panelists walked us through their recent mapping operations and potential future opportunities.

Crowd-sourced Nearshore Bathymetry: the Hydroball

Jaci Overbeck from AK DGGS and Julien Desrochers from M2Ocean spoke about testing two new HydroBalls purchased by the Alaska Ocean Observing System this year as a way of getting additional bathymetric data collected by multiple partners without having to undertake a full bathymetry mapping program.

HydroBall is a singlebeam acquisition system with three sensors: GNSS for position, an inclinometer to measure attitude, and an echosounder to measure depths. There are two models: a shallow to mid-range model that maps between .5m and 50m and an ultra-shallow model that maps between .1m and 10m. AK DGGS used the shallow to mid-range model on vessels of opportunity. M2Ocean is working with NOAA NCEI to get the data added to the crowdsourced bathymetry pipeline.

Initial plans for deploying the HydroBalls were to send them out to rural communities; however, year one of operations involved testing first. AK DGGS partnered with UAF's Alaska Center Energy and Power to run the tests. DGGS collected data at Kotlik, Napakiak, and Wainwright. UAF collected data at Elson Lagoon and near Kaktovik. At 60 pounds, the HydroBalls were easily transported to remote locations by local commercial airplanes and towed from various small boats. However, the systems require experience with computers and the ability to operate multiple types of software, so some training would be required to enable rural communities to operate these systems. DGGS is looking forward to working with additional partners next Summer to conduct further mapping with HydroBall.

University of Alaska Vessel Ops R/V Sikuliaq and Nanuq

Doug Baird, Director of the Seward Marine Center, spoke about the University of Alaska vessel operations. The R/V Sikuliaq is a 261-foot, ice-capable vessel that is owned by the National Science Foundation and operated by the University of Alaska Fairbanks. She's homeported in Seward, Alaska, and spends about 250 to 260 days at sea. The vessel is rated as a polar class 5, which means she's capable of year-round operations in medium, first year ice with some multi-year ice inclusions. She operates with the MBES always on and collecting data, unless told otherwise. The echosounder is a hull-mounted Kongsberg EM302 and EM77.

In addition to operating the R/V Sikuliaq out of Seward, UAF also operates the R/V Nanuq, which is a new coastal research vessel. The vessel is a 40-ft monohull with a five foot draft. She has an approximate 400-mile range and a transit speed of 20+ knots. She can operate just about anywhere in the northern Gulf of Alaska. She mostly supports oceanographic and fisheries research, but can handle other types of gear deployments from a 1,000-pound hydraulic A-frame and a dive platform.

NOAA Navigation Manager Updates

LCDR Hadley Owen, Alaska Navigation Manager with NOAA's Office of Coast Survey, spoke about the office's mapping operations from 2021 and its plans for next season. In 2021, between the NOAA Ships *Rainer* and *Fairweather* and contractors Fugro and TerraSond, Coast Survey collected over 1,900 square nautical miles of bathymetric data for nautical chart updates. Areas surveyed included parts of Southeast Alaska, the Bering Sea, Glacier Bay, and Prince William Sound as well as

the waters around Egegik, Kodiak and Afognak Islands, Unimak Island, and Chernofski Harbor. TerraSond worked with Saildrone to map almost 10,000 linear nautical miles within the Bering Sea using single beam echosounders. Sea surface data were also collected. COVID restrictions caused Coast Survey's mapping plans farther north to be postponed. The data for this field season are not yet available at NCEI, but rainbow geotiffs of the data are available to view in **Coast Survey's 2021 StoryMap**.

For 2022, Coast Survey plans to survey around Nunivak Island, Nushagak Peninsula, Cape Newenham, and the Pribilof Islands. These plans are still under development, so if you have any concerns or questions, please contact LCDR Owen through the **ASSIST portal on Coast Survey's website**.

In addition to its survey operations, Coast Survey is transitioning to charts based exclusively on electronic data, and an announcement about the cancellation of raster nautical charts along the North Slope has already been released. Those charts will be discontinued in February and March 2022. Coast Survey is also rescheming the electronic charts to improve consistency of the information presented.

USCG: Alaska Mapping/Charting Support & White House OSTP Involvement

Chris Hill works at U.S. Coast Guard (USCG) Headquarters as a marine information specialist for the Office of Navigation System under the Office of Marine Transportation Systems. Chris spoke about his federal interagency liaison work. Since 2019, Chris has been getting USCG more engaged in federal ocean and coastal mapping efforts. He is currently working on transferring data off Alaska's coasts from the Coast Guard Buoy Tenders Hickory and Fir to NOAA's crowdsourced bathymetry pipeline at NCEI. Pending successful transfers, he's looking to add data from 60+ Alaska cutters before Summer 2022. USCG is assessing future fleet wide participation for 2022.

Dave Seris is the Assistant Branch Chief for the 17th Coast Guard District's Waterways Management Branch in Juneau, Alaska, which handles all USCG operations in Alaska. With field units located in Sitka, Petersburg, Cordova, Homer, and Kodiak, his office oversees around 1,350 aids to navigation (ATON) throughout the State of Alaska with a fleet of four seagoing buoy tenders, two coastal buoy tenders, and two ATON teams that deploy on helicopters out of Sitka and Kodiak to remote places. The program is staffed with about 250 people that are routinely deployed to the Aleutian chain as far as Adak; Bristol Bay approximately twice per year; and SE and Prince William Sound year-round. Most of the large buoy tenders are equipped with cranes that are capable of easily handling at least 20-ton payloads. USCG is very interested in opportunities for collaboration, so please reach out to Dave at David.M.Seris@uscg.mil.

Guided by an Executive Order and Congress, USCG is working on an Alaska Arctic Coast Port Access Route Study (AAC PARS) to develop ship corridors in the U.S. Arctic waters north of the Bering Strait and align with a similar effort happening in Canada. They are actively working with community members along the North Slope, the Alaska Eskimo Whaling Commission, and the U.S. Marine Mammal Commission to hone the plans. The effort will require a concerted, multi-year effort to bring the region up to modern survey standards prior to finalizing the ship routing recommendations to the International Maritime Organization.

NOAA Ocean Exploration FY 22-23 Plans

Caitlin Adams, the Deputy Chief of the Science and Technology Division at NOAA Ocean Exploration, spoke about her office's plans for the upcoming years. NOAA Ocean Exploration is the only federal program dedicated to ocean exploration. It facilitates its mission through a competitive grants program, a cooperative institute, interagency partnerships, and the NOAA Ship *Okeanos Explorer*.

NOAA Ocean Exploration conducts mapping only expeditions as well as ROV and mapping expeditions. They can also collect geological and biological grab samples and suction samples. All projects follow a common set of principles of exploration.

The Okeanos Explorer primarily works in areas deeper than 200m and plans to be up in Alaska in FY23 and possibly again in FY26. This will be the first time *Okeanos Explorer* has ever been in Alaskan waters, and exact operational areas for the May to September 2023 effort are still being determined. An expedition schedule is anticipated in Fall 2022. Alaska operations are centered on two goals: first, to increase deep-water mapping coverage in the Alaska EEZ. To address this goal, Saildrone Surveyor will conduct mapping operations in the Aleutians in FY22, with funding support from both NOAA and BOEM, and Okeanos

Explorer will conduct follow-on mapping in both the Aleutians and the Gulf of Alaska in FY23. The second goal is to further explore priority areas with both the Okeanos Explorer's ROV Deep Discoverer and other tools in the Aleutians and Gulf of Alaska. All work will be planned in coordination with Seascape Alaska and the NOAA Alaska Deep-Sea Coral and Sponge Initiative.

NOAA Fisheries Capabilities, Activities, and Opportunities

Bob McConnaughey, a Research Fishery Biologist at NOAA's Alaska Fisheries Science Center (AFSC), spoke about NOAA Fisheries' ocean mapping capabilities, activities, and opportunities. AFSC has a range of mapping capabilities, including different classes of sonars, benthic sampling, and water column characterization.

Some of AFSC's mapping activities are directly related to fish counting activities. For example, AFSC collects bathymetry and sphere-calibrated backscatter at multiple frequencies capturing both the seabed and water column. For the last 15 years, trawl surveys from charter vessels have been collecting single-beam bathymetry and backscatter from ES60 sonars that operate continuously. The geographic coverage is large and, in some areas, such as near Kodiak Island, the data density is also high. AFSC also conducts mid-water fish assessments using EK60 single-beam sonars from the NOAA Ship Oscar Dyson.

AFSC works simultaneously on fisheries research and nautical charting missions and, in the process, have developed standard operating procedures for acquiring and processing quantitative backscatter data.

In terms of opportunities, AFSC has research platforms all throughout Alaska, which work primarily in the Spring and Summer months. These are potential piggyback operations that could be discussed further via Bob McConnaughey or Dr. Laura Hoberecht, AFSC Planning Officer.

Crowdsourced Bathymetry

Georgie Zelenak, a bathymetry data manager at NOAA NCEI, spoke about the International Hydrographic Organization's crowdsourced bathymetry (CSB) initiative. CSB is the collection of depth measurements from vessels, using standard navigation instruments, while engaged in routine maritime operations. CSB is valuable because it comes at no cost to the public sector and can be used to fill gaps where data is scarce. This information is important because mapping the seafloor is incredibly expensive and CSB can be used to hone mapping priorities. For example, the Canadian Hydrographic Service has begun using CSB to prioritize survey areas for the following survey season and have been used to initiate the publication of Notices to Mariners.

CSB data may be accessed through the international Data Centre for Digital Bathymetry Viewer, which is hosted by NOAA NCEI, or NCEI's U.S. Bathymetric Data Viewer. Since 2014, nearly 200 vessels are contributing to this pipeline and nearly 25GB of data are accessible through this viewer.

Some CSB data providers include Rose Point Navigation Systems, MacGregor/Carnival Cruise Line, Navico C-MAP, and M2Ocean. The majority of the CSB data are provided by customers of RosePoint. Mariners can enable their electronic charting system log file to record position, depth, and time, and whenever their software or chart catalog is updated, the data are automatically transmitted to NCEI.

More information can be found in the IHO document guidance on crowdsourced bathymetry, and with the IHO CSB Working Group.

Data Provider Engagement and Agreements

Christie Reiser, a bathymetry data manager at NOAA NCEI and lead of the Seascape Alaska Data Management Technical Team, spoke about NCEI's bathymetry archive and outreach activities to encourage more data sharing. NCEI archives and makes publicly available over 60TB of uncompressed bathymetric data, including about 3,550 multibeam bathymetry surveys and approximately 5,500 single beam bathymetry surveys. Along with archiving NOAA and other federal agency data, NCEI collaborates with organizations like UNOLS Rolling Deck to Repository that provides data from the U.S. academic research fleet. NCEI also archives data from a growing number of commercial companies such as Fugro Geoservices and data from international partners like GEOMAR and the Geological Survey of Ireland.

As a national and international archive for bathymetric data, NCEI anticipates a huge influx of data in response to various mapping campaigns, including the UN decade of Ocean Science, the Nippon Foundation's Seabed 2030, IHO Crowdsourced Bathymetry initiative, and regional mapping campaigns like Seascape Alaska in support of the NOMEC Strategy.

To help make the data sharing process easier, NCEI offers several tools, including the document, Submitting Marine Geophysical Data to the NOAA NationalCenters for Environmental Information and the CruisePack data packaging tool.

Partnering with NCEI on data sharing outreach is the Office of Coast Survey's External Source Data (ESD) team. ESD is data that was not acquired (or contracted) by Coast Survey yet still could have good potential for nautical chart application. The team proactively identifies data to support hydrographic survey project planning and long-term priorities. Data are reviewed and additional products are created, depending on the data quality. The data are then submitted to NCEI's NOS Hydro archive. If you have sensitive data, the ESD team can often utilize it and apply it to the charts without revealing the sensitive information. This is one path to share sensitive data and avoid the trap of having it set unused and inaccessible at the archive.

NCEI, IOCM, and ESD are working together to improve communication with potential data providers and make submitting data to the archive a simple and smooth process.

Skipper Science

Aaron Poe, Coordinator of the Aleutian and Bering Sea Initiative (ABSI), spoke about the Indigenous Sentinel Network (ISN) and Skipper Science. The birth parent of Skipper Science is the ISN. ISN originally began as a program called Bering Watch, which the Aleut Community of St. Paul started about 20 years ago. As a means to assert their sovereignty and demonstrate a willingness to work with partners, the community wanted a way to collect and manage scarce environmental data alongside their own indigenous knowledge to influence the management of species and habitats. Today, the ISN encourages communities to help fill these data gaps through a series of nine smartphone apps. Through this citizen science initiative, data can be collected in remote areas by those that live there. Some of the apps are new this year, including Skipper Science.

ISN Skipper Science is a new collaboration between the Aleut Community of St. Paul and many partners including the Salmon State, Alaska Longline Fishermen's Association, and ABSI. The app taps into local and traditional knowledge in remote areas by providing skippers a platform to document observed environmental changes and anomalies through words, photos, waypoints, and other data. For $20,000, a Skipper Science pilot project was launched this past Summer to test the collaboration model. For the 2021 pilot, 100 skippers downloaded the app, 49 data entries were submitted by participants, 19 fishing trade organizations supported and endorsed the program, and there were 9 stories published in the local media highlighting what the fishing community can bring to this effort.

In terms of next steps, ISN Skipper Science is seeking funding to expand the effort beyond the 2021 pilot. They would like to link smartphones to systems on ships in order to collect additional information while underway as well as look at incentivizing targeted data collection using a micropayment system. The collaboration and app are a platform for distributed data collection and model ground truthing in remote regions as well as a model for productive partnerships between agencies, science providers, and fishing communities.

Panel Questions and Answers

There were a number of questions from attendees and panelists during this session.

1. For Bob at NOAA AFSC, is there any chance of switching from collecting single beam bathy to multibeam bathy in order to collect more data on the shelf? First, as background, the contracting arrangements that we have with chartered fishing vessels includes a bid package that asks for this mapping capability. Anything is possible based on our requirements and the daily costs would reflect any sorts of changes to the contracting arrangement. In sum, yes, it's possible, but hasn't been investigated before.

2. For Doug at UAF, what if any hydrographic capabilities does the Nanuq have? No multibeam, she has a single beam echosounder on board.

3. For Georgie at NCEI, have you thought about strategies for targeted incentives to get skippers to collect crowdsourced bathymetric data where you're really looking for something rather than just relying on volunteer contributions? The IHO CSBWG is looking at a lot of different sectors that could contribute data and is developing targeted communications materials inviting them to get involved in the initiative. Right now, there's no system for incentives, but the WG is actively talking about it.

4. Follow-up for Georgie, the Alaska Conservation Foundation uses a subscription service called Tipalti that provides the capability to send micropayments to

skippers for completing a particular mapping task under mini-service agreements. This is the same system used by companies like Uber. They're using it right now with the National Park Service for water sample collection and to fund speakers for events. Perhaps the feds could collaborate with a non-profit partner to enact this kind of model?

SESSION 5: Ideas to Improve Collaboration

The last session of this summit was a breakout room discussion. Due to limitations in the summit conferencing platform, participants were asked to join Google Meet breakout rooms, discuss the following question, and contribute sticky notes to a Google Jamboard associated with their room:

What are your suggestions to improve seafloor mapping collaborations?

There were four breakout rooms. A consolidated list of ideas from this brainstorming session are binned under four broad themes, as follows.

Outreach and Communications

- NOAA/NCEI: Increase outreach to potential data providers at more venues like this summit. Partner with more academic institutions to include lessons for students about how to package data for archive in addition to collecting it, e.g., NCEI is collaborating with UTIG on this topic and working to build a web page to help students discover their own submissions.
- Follow-up on fishing industry outreach. Try reaching out to groups and explaining value and show benefits to users – Alaska Whitefish Trawlers or Alaska Longline Fisherman's Association. Alternatively, share this group's work at Alaska Marine Science Symposium or Com Fish in Kodiak. Both of these have different audiences not represented in the current meeting.
- Setting goals and tracking progress; need to show more about how we're integrating existing efforts. Create an operations dashboard that is updated live with data acquisition progress. Focus on gaps by data type and automate and disseminate online information in an interactive manner (as opposed to asking about priorities from a blank slate like the Spatial Priorities Study or SeaSketch which has priorities, ongoing collects, and existing).

Partnerships and Funding

- Crowdsourcing – leverage the fishing fleets as potential new partners. Could we pay folks for crowdsourced data?
- Contracts – need to look more at multi-year contracts and do requests for bids. Utilize the Coastal Geospatial Services Contract Vehicle. Can we create a plan for spec data acquisition? As a partnership idea, identify program plans and an IDIQ so several private companies can work together to collect on spec for a portion. Commercial fishing vessels are supportive and willing (in some cases) to modify equipment onboard to assist. Need to think about contracting requirements and concise ways to integrate requirements within the budget/planning cycle.
- Funding – pool funds to add onto ongoing efforts. Need collaborations that help bring funding to local government and community members. Need to reach out and have honest and trusting partnership with boots on the ground people in these communities. Any funding partnerships with DOD, DOE, BOEM, and USGS? Any funds from the infrastructure or coastal resilience? Need to consider partnership opportunities in advance of deadlines. Time is a limiting factor with respect to partnerships, i.e., partnership opportunities suffer when time is short.
- Filling the gaps – the bathy gap analysis is helpful to convey gaps, but it is not good at incentivizing the community to fill data gaps. Can we monetize the portal for AK mapping coverage (completed/planned), so that ships of opportunity can fill gaps and get money? Look at a block-based survey scheme and a price per square. Can we divide unmapped areas into blocks and possibly get different people/groups to "own" an area such that the bathymetry in the area gets covered? Need a route planning system that helps identify the most efficient paths to fill gaps; need to consider environmental compliance
- Other partners – DOE Maritime Transitions need mapping capacity. Leverage the Arctic Executive Steering Committee, Arctic Council

Survey Assets and Operations

- Create open communication to identify needs for multiple sensors on survey platforms, e.g., simple add-ons to sensor configs, even with SVP casts. For example, can you add on water column measurements to the SVP casts done to support hydrographic surveys? Perhaps identify a pool of sensors within partners and leverage existing assets. Ships are expensive, so load them up to keep costs down! Need a catalog of Seascape Alaska participants relative to untapped vessels/mapping assets. Need to catalog ships and MBES systems that can be used.
- Use more ASVs that are easy to launch and mobilize. Can ASVs be deployed from fishing vessels?
- USCG is willing to work with partners that are looking for ship time or transportation needs. Can USCG operate uncrewed vehicles? Could USCG help with stevedore services to improve speed in unloading/loading of equipment? Can we take advantage of USCG buoy tenders and add single beam or multibeam while in transit?
- Can we have a MIST kit available for ships of opportunity (both contracted and federal)? For example, if USGS has contracted a ship to do support work in the Aleutians, how do we get a multibeam on it?
- NOAA expertise – Can they send physical scientists out on ships (agencies, private sector, academic) to show how to package data for submission as well as get technical help on data collection? Can we have more collaboration with UNH/JHC to provide support staff for mapping opportunities, e.g., one NOAA OCS lead and a student UNH intern?

Data Integration and Access

- Need to focus on what it takes to make the data collected seamless, particularly bathy and backscatter collected from airborne and waterborne technologies. Suggest a consistent naming of surveys across agencies and other collectors.
- Partner with CO-OPS to continue to develop VDatum in Alaska through NOS Water Level Datum Partnerships. CO-OPS is already working with OCM and USACE and can provide technical assistance with data collection and station stability to NOS standards as an in-kind service or as a cost share.
- NCEI needs to add data to the archives faster, in order to make their holdings useful for planning upcoming voyages. Need to know before you head out to sea because of bandwidth limitations. Increased broadband would help with data transmission and processing.
- Need to integrate R2R with NCEI to make data available to both project proposers and scientists on board. There is an outstanding issue with respect to academia not always sharing their data in a timely manner; there is no enforcement of this issue.
- Post-processing of multibeam/water-column is a barrier to upload potentially (lack of technical expertise on-board), can cruise-pack ingest raw?

Key Takeaways

On the coastal day, key takeaways included:

- the importance of positional control for ensuring data accuracy,
- a need to map broadly and generally first, and
- then fill the gaps later with more detailed data, where needed, e.g., coastal communities and areas with critical infrastructure.

Attendees were optimistic about the potential for remote sensing and innovation to complete the mapping mission, as well as the agency partnership possibilities due to the collaborative framework that has been created surrounding these two initiatives. Ultimately, it was the list of recommended pilot projects that piqued everyone's attention and focused the conversation on steps to take in coming years.

On the ocean day, there were numerous good ideas expressed. A few key takeaways included:

- a desire to hold an industry day to get more information on how to fill data gaps;
- a need to expand our Seascape Alaska outreach to increase participation from all sectors, specifically, the fishing industry was called out several times;
- a desire for an operations dashboard to track our data acquisition progress in real time (or close to);
- a desire to expand participation in crowdsourced bathymetry data collection;
- a desire to create a mapping gaps block scheme with a price per square and create an indefinite delivery/indefinite quantity (IDIQ) contract whereby several private companies can collaborate to fill the gaps on spec;
- a need to create a route planning tool, so opportunistic mapping and voyage planning can be accomplished against the NCEI data (via the U.S. bathymetry gap analysis);
- a need to improve NCEI outreach to potential data providers, including the need to encourage more academic institutions to not only teach best practices on data collection, but also include lessons on how to archive that data, following UTIG's example; and
- a critical need to address the notable lack of skilled mapping system operators in the region because this issue is limiting our ability to add systems to current vessels in order to make more with what we have.

Appendix A – Abbreviations and Acronyms

3D	three-dimensional
3D	3D Elevation Program (USGS)
AAC PARS	Alaska Arctic Coast Port Access Route Study
ABSI	Aleutian and Bering Sea Initiative
ACMS	Alaska Coastal Mapping Strategy
AFSC	Alaska Fisheries Science Center (NOAA)
AIS	Automatic Identification System
AMEC	Alaska Mapping Executive Committee
ANTHC	Alaska Native Tribal Health Consortium
ANWR	Arctic National Wildlife Refuge
ASTAR	Arctic Strategic Transportation and Resources project (Alaska)
ASV	autonomous surface vehicle
ATON	Aids to Navigation
BAA	Broad Agency Announcement
BOEM	Bureau of Ocean Energy Management
cm	centimeter
CSB	crowdsourced bathymetry
CSCAP	Coastal Shoreline and Change Analysis Program (NOAA)
CO-OPS	Center for Operational Oceanographic Products and Services (NOAA)
CORS	Continuously Operating Reference Stations
CoSMoS	Coastal Storm Modeling System (USGS)
CUSP	Continuously Updated Shoreline Product (NOAA)
DCDB	Data Centre for Digital Bathymetry (NOAA)
DCRA	Division of Community and Regional Affairs (Alaska)
DEM	digital elevation model
DGGS	Division of Geological and Geophysical Surveys (Alaska)
DInSAR	Differential Interferometric Synthetic Aperture Radar
DOD	US Department of Defense
DOE	U.S. Department of Energy
DSM	digital surface model
DTM	digital terrain model
ECO	Ecosystem Conservation Office (Aleut Community of St. Paul)
EEZ	Exclusive Economic Zone
ESD	External Source Data team (NOAA)
ft	foot
FAA	Federal Aviation Administration
GCP	ground control point
GEOMAR	Helmholtz Centre for Ocean Research Kiel, Germany
GIO	Geographic Information Officer
GNSS	Global Navigation Satellite System
GNSS-A	Global Navigation Satellite System-Acoustic ranging combination
IDIQ	indefinite delivery/indefinite quantity
IEC	International Electrotechnical Commission
IfSAR	Interferometric Synthetic Aperture Radar
IHO	International Hydrographic Organization
IOCM	Integrated Ocean and Coastal Mapping

Appendix A – Abbreviations and Acronyms

ISN	Indigenous Sentinel Network
IWG-OCM	Interagency Working Group on Ocean and Coastal Mapping
JALBTCX	Joint Airborne Lidar Bathymetry Technical Center of Expertise
km	kilometer(s)
lb	pound
LARS	Launch and Recovery Systems
lidar	Light detection and ranging
m	meter(s)
MBES	multibeam echo sounder
MIST	mobile integrated survey team (NOAA)
NALL	navigable area limit line
NCEI	National Centers for Environmental Information (NOAA)
NOAA	National Oceanic and Atmospheric Administration
NOMEC	National Strategy for Ocean Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone
NOS	National Ocean Service (NOAA)
NPS	National Park Service
NSF	National Science Foundation
NWLON	National Water Level Observation Network
OCM	Office for Coastal Management (NOAA)
OCS	Office of Coast Survey (NOAA)
OPUS	Online Positioning User Service (NOAA)
ORI	Orthorectified Radar Image
OSTP	Office of Science and Technology Policy (White House)
PMEL	Pacific Marine Environmental Laboratory (NOAA)
R2R	Rolling Deck to Repository
RMSEz	?
ROV	remotely operated vehicle
RSD	Remote Sensing Division (NOAA)
SBES	single beam echo sounder
SBD	satellite derived bathymetry
SfM	structure from motion
SOMP	Standard Ocean Mapping Protocol
UAF	University of Alaska, Fairbanks
UAV	uncrewed aerial vehicle
UNH/JHC	University of New Hampshire/Joint Hydrographic Center
UNOLS	University-National Oceanographic Laboratory System
US	United States
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USV	Uncrewed Surface Vessel
UTIG	University of Texas Institute for Geophysics
VDATUM	Vertical Datum Transformation Tool
yr	year

Appendix B – Summit Agenda

Day 1 – December 1, 2021		
Opening Session		
Time (AKT)	**Topic**	**Speaker**
09:00 – 10:00 AM	Welcome and Keynote Addresses	Alaska Coastal Hazards Program Manager, Jaci Overbeck Senator Lisa Murkowski
	Alaska Mapping Executive Committee Keynote	NOAA, Juliana Blackwell
	The Alaska Coastal Mapping Strategy Implementation Plan	NOAA-IOCM, Ashley Chappell
	Alaska Geospatial Council Update	Geospatial Information Officer, Dr. Leslie Jones
Session 1: Agency Mapping Updates		
10:00 – 11:30 AM	Intro to the Data Acquisition Dashboard	Hillary Palmer, Dewberry
	State of Alaska Mapping Updates	Jaci Overbeck, Alaska DGGS
	VDATUM Update	Stephen White, NOAA RSD
	NOAA Remote Sensing Division	Stephen White, NOAA RSD
	National Park Service	Tahzay Jones
	U.S. Geological Survey	Brian Wright & Ann Gibbs
	JALBTCX	Chris Macon
	US Fish and Wildlife Service	Sydney Thielke/Lew Coggins
Lunch		
Session 2: Technology Lightning Talks		
12:00 – 1:30 PM	Orthoimagery & Lidar	Adam McCullough, Quantum Spatial/NV5
	Satellite Imagery	Paulina Zubatov, Planet
	Satellite-Derived Bathymetry	Dave Flanagan, TCarta
	Satellite-Derived Bathymetry	Edward Albada, EOMap
	Satellite-Derived Bathymetry	Lauren Decker & Leslie Canavara, Polarctic
	Topobathy Lidar	Jennifer Wozencraft, JALBTCX
	Topobathy Lidar & Water Clarity	Stephen White, NOAA RSD
Session 3: The Path Forward		
1:30 – 3:00 PM	Modern Airborne Photogrammetry from a Manned Aircraft and its Applications in Alaskan Coastal Science	Matt Nolan, Fairbanks Fodar
	Alaska Coastal Mapping Pilot Project Recommendations	Dave Maune, Dewberry
	Tidal Datums and Positional Control	Nathan Wardwell, JOA Surveys
	NOAA Foundation CORS Program	Will Freeman, NOAA

Day 2 – December 2, 2021		
Opening Session		
Time (AKT)	**Topic**	**Speaker**
09:00 – 9:30 AM	Welcome and Keynote Addresses	Alaska Coastal Hazards Program Manager, Jaci Overbeck Senator Lisa Murkowski
	National Strategy for Ocean Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone	NOMEC Council Co-Chair, Ashley Chappell
	Introducing Seascape Alaska, a regional mapping campaign in support of NOMEC	NOAA IOCM, Meredith Westington
Panel Session 1: Why is Mapping Important?		
9:30 – 10:45 AM	Community Perspective	Veronica Padula, Aleut Community of St. Paul
	Navigator's Perspective: Prioritizing Mapping Surveys Where Vessels Operate	Ed Page, Alaska Marine Exchange (retired)
	Hydrographic Health and Charting	Christy Fandel, NOAA OCS
	Ocean Mapping: Importance to Fisheries Science	Bob McConnaughey, NOAA AFSC
	Brief overview of potential critical mineral resources near Alaska	Paul Knorr, BOEM
	Examples of using multibeam bathymetry to study earthquake, landslide, and tsunami hazards in Alaska	Peter Haeussler, USGS
	Submarine Volcanism and Methane Seepage	Jeff Beeson, NOAA Pacific Marine Environmental Lab
	Topobathymetric Requirements for Marine Energy	Jeremy Kasper, Alaska Center for Energy & Power
Panel Session 2: How could we fill the data gaps? Technology perspectives		
10:45 – 12:00 PM	Seasats Capabilities	Mike Flanigan
	Coastal and Ocean Mapping: The value of innovation and collaboration	Rada Khadjinova, Fugro
	eTrac Capabilities and Autonomy	Dave Neff
	USVs – a safe, reliable and low carbon solution to fill the data gaps	Matt Holland, XOCEAN
	Saildrone Capabilities	Brian Connon
Lunch		
Panel Session 3: What are we doing? Operations and opportunities		
12:30 – 1:55 PM	Crowd-sourced Nearshore Bathymetry: the Hydroball	Jaci Overbeck, AK DGGS and Julien Desrochers, M2Ocean
	University of Alaska Vessel Ops R/V Sikuliaq and Nanuq	Doug Baird, UAF
	NOAA Navigation Manager Updates	LCDR Hadley Owen

Day 2 – December 2, 2021		
	USCG: Alaska Mapping/Charting Support & White House OSTP Involvement	Chris Hill and Dave Seris
	NOAA Ocean Exploration FY 22-23 Plans	Caitlin Adams
	NOAA Fisheries Capabilities, Activities, and Opportunities	Bob McConnaughey
	Crowdsourced Bathymetry	Georgianna Zelenak, NOAA NCEI
	Data Provider Engagement & External Source Data	Christie Reiser, NOAA NCEI
	Skipper Science	Aaron Poe, Alaska Conservation Foundation and ABSI Partnership
Breakout Session: Collaboration Next Steps: who, where, when?		
1:55 – 3:00 PM	Google Meet Breakout Rooms for 30 min and Recap Discussion in GoToMeeting for 15 min	
Closing Remarks		

Appendix C – Attendee List

Day One 12/1/2021		
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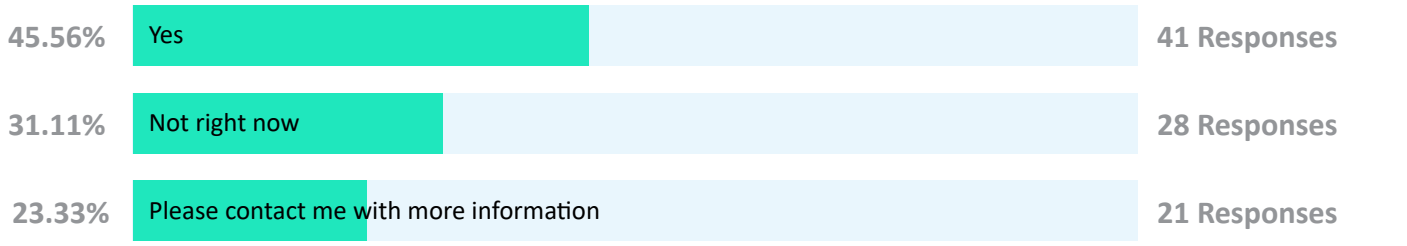
Appendix D – Summit Poll Results

On both days of the summit, attendees were asked a series of questions via the GoToWebinar polling capability. Noting that panelists and organizers were not able to participate in these polls, the attendees answered as follows:

Day 1 Poll Results

1. Would you be interested in joining the Alaska Geospatial Council's Coastal & Ocean Technical Working Group?

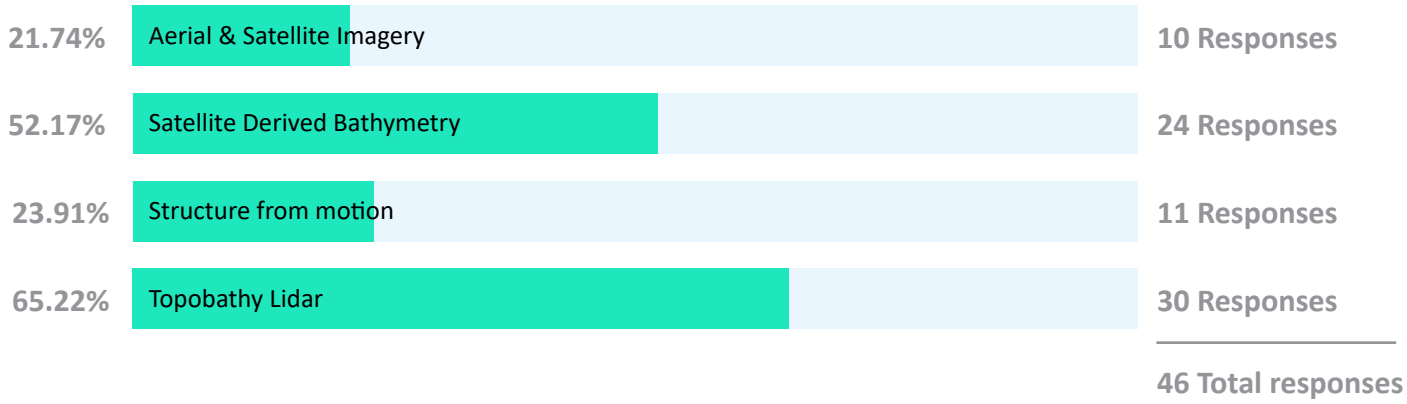


2. Do you know of any agencies/entities who are mapping Alaska's coastal areas that we should invite to collaborate?

Alaska Department of Fish & Game

Fairbanks Fodar

3. Which technology are you most excited about?

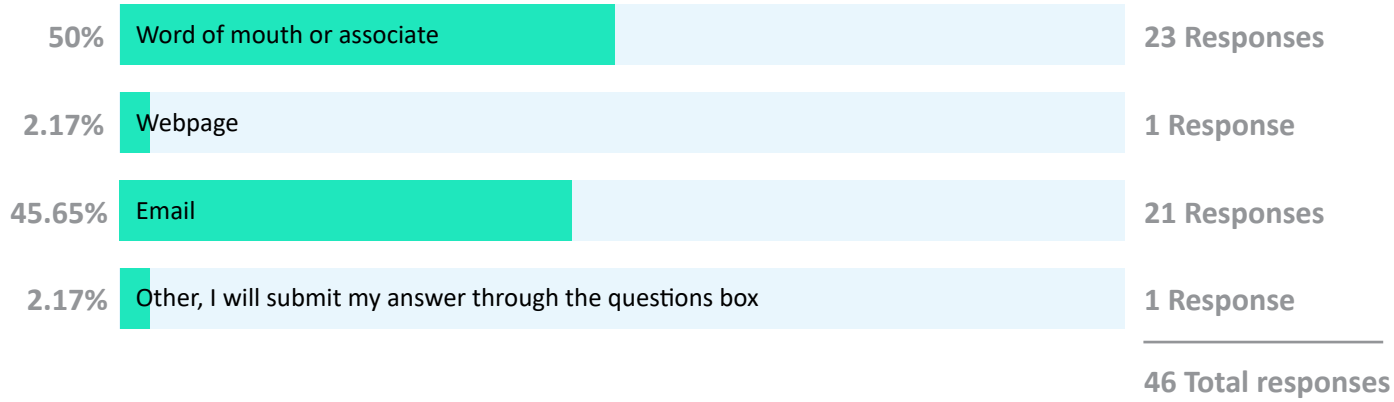


4. What do you see as The Path Forward for coastal mapping in Alaska?

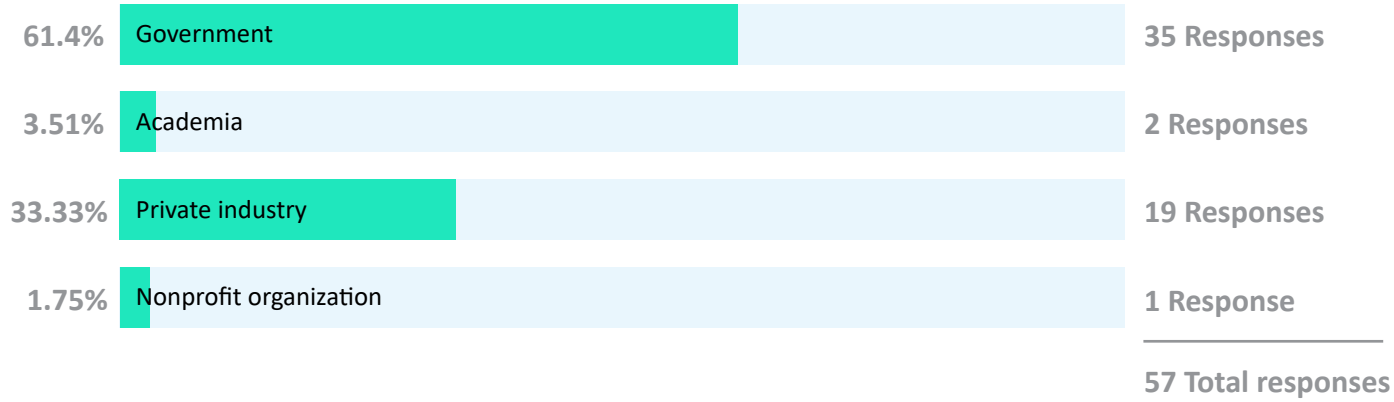
Close water level gaps and pilot projects!

Day 2 Poll Results

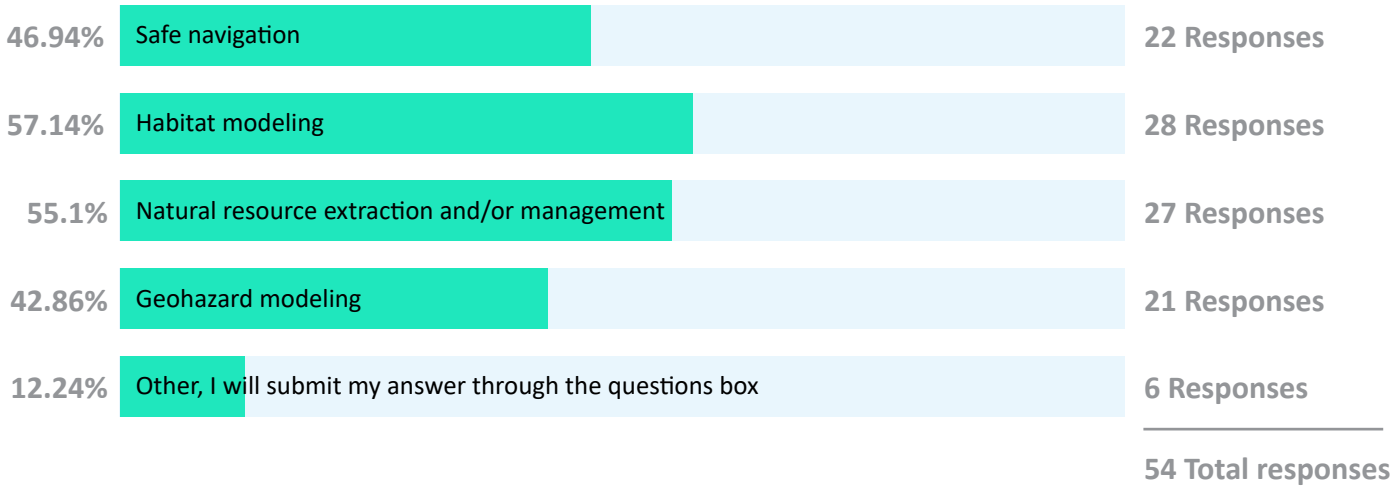
1. How did you hear about the Alaska Coastal and Ocean Mapping Summit?



2. What stakeholder group(s) do you best represent?



3. Why is mapping important to you?



4. Should we organize an industry day to hear more strategies for filling data gaps?

100%	Yes	30 Responses

30 Total responses and 1 comment

Comment – "For a vendor day, I think an RFI requesting proposals from vendors would be a great way to move forward, to put a real-world cost to things. Not meeting any specs, just let vendors propose various projects they'd like to do at whatever specs they can, targeting perhaps the strategy document. This way the cost/performance optimization can be assessed and then the committee would have a sense of how much money would chase."

5. What geographic region are you most interested in?

50%	Gulf of Alaska (South)	13 Responses
42.31%	Aleutian Islands (Southwest)	11 Responses
38.46%	Bering Sea (West)	10 Responses
53.85%	Chukchi and Beaufort Seas (Northwest and North)	14 Responses

26 Total responses

6. What coastal and ocean depths are you most interested in?

73.33%	Shallow waters less than 40 meters deep	22 Responses
36.67%	Shelf area between 40 and 200 meters deep	11 Responses
16.67%	Deeper waters between 200 and 500 meters deep	5 Responses
13.33%	Deep waters greater than 500 meters deep	4 Responses

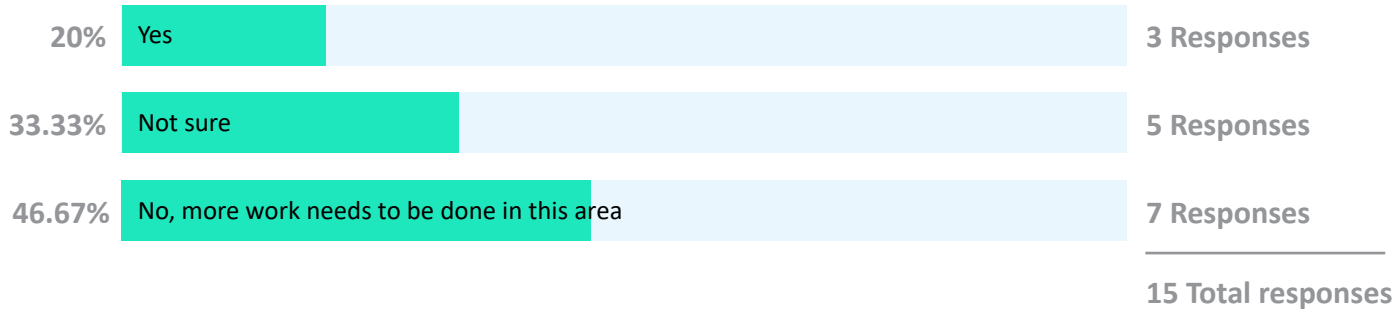
30 Total responses

7. Are you aware of other mapping operations and opportunities that were not covered in this panel?

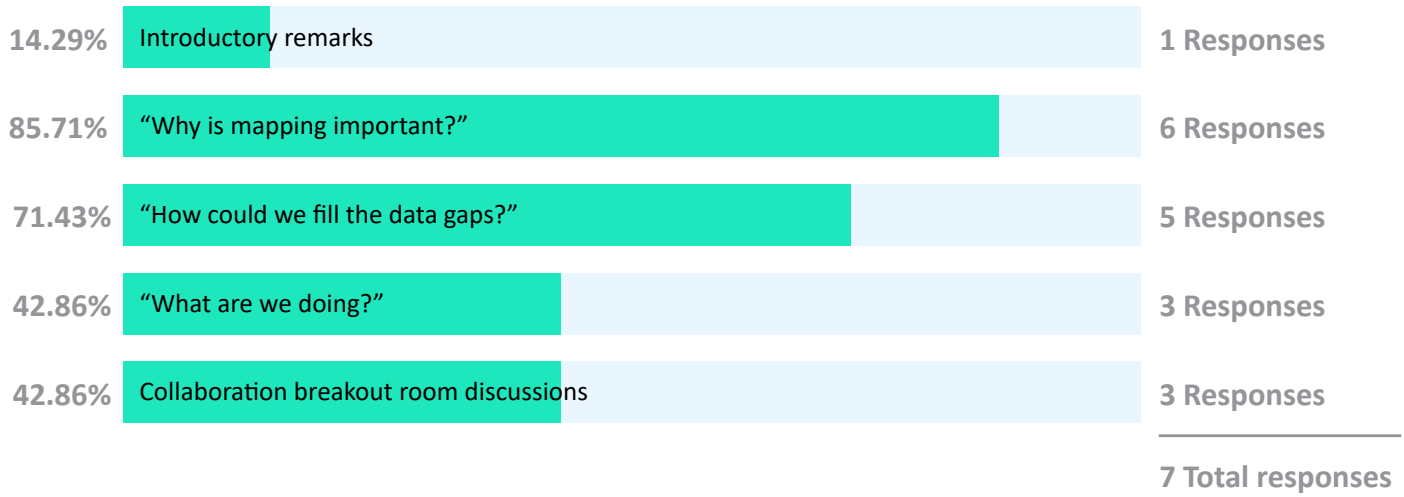
100%	No, everything was covered here	13 Responses

13 Total responses

8. Do you think that mapping in Alaska is well-coordinated and communicated?



9. Which sessions on this ocean mapping day were most interesting to you?



Appendix E – Summit Library of Helpful Hyperlinks

NOMEC Strategy and ACMS, plus related implementation plans – **https://iocm.noaa.gov/about/strategic-plans.html**

NOAA's Shoreline Data Explorer – **https://geodesy.noaa.gov/NSDE/**

For more info on NSRS updates – **https://geodesy.noaa.gov/datums/newdatums/**

Continually Operating Reference Station – **https://geodesy.noaa.gov/CORS/**

Link to Implementation Plan Federal Register Notice – **https://www.federalregister.gov/documents/2021/11/02/2021-23878/request-for-public-comment-on-the-alaska-coastal-mapping-strategy-implementation-plan**

Alaska Geospatial Council – **https://alaska-geospatial-council-soa-dnr.hub.arcgis.com**

Here's the Coastal & Ocean site within the Alaska Geospatial Council! **https://agc-coastal-soa-dnr.hub.arcgis.com**

Alaska Geoportal – **https://gis.data.alaska.gov**

AMEC-Coastal Subcommittee's hub site & dashboard – **https://alaska-coastal-mapping-strategy-dewberry.hub.arcgis.com**

Link to the DGGS Coastal Hazards page – **https://dggs.alaska.gov/hazards/coastal/**

Alaska Water Level Watch Build-out Plan StoryMap – **https://www.arcgis.com/apps/MapSeries/index.html?appid=c37fd52e07a74d6999b6855754d67914#**

AK Coastal Community Erosion Assessment page – **https://dggs.alaska.gov/hazards/coastal/erosion-assessment.html**

NOAA RSD Website – **https://geodesy.noaa.gov/RSD/rsd_home.shtml**

VDatum website – **https://vdatum.noaa.gov**

NOAA's Digital Coast – **https://coast.noaa.gov/digitalcoast/**

USFWS Coastal Program website – **https://www.fws.gov/coastal/**

JALBTCX website – **https://jalbtcx-live.azurewebsites.net**

YouTube link to our intermission drone video montage – **https://www.youtube.com/watch?v=77UxoZ6eISs**

NV5 Geospatial – **https://www.nv5.com/geospatial/**

Planet – **https://www.planet.com**

TCarta – **https://www.tcarta.com**

EOMap SDB – **https://www.eomap.com/services/bathymetry/**

PolArctic – **https://polarcticllc.com**

Dewberry Engineers, Inc. – **https://www.dewberry.com**

JOA Surveys – **https://joasurveys.com**

Fairbanks Fodar – **https://fairbanksfodar.com**

For more info about Seascape Alaska – **https://iocm.noaa.gov/documents/Seascape%20Alaska%20Factsheet_September%202021.pdf**

For more info about the Aleut Community of St. Paul Island – **https://www.aleut.com**

For more info about the Marine Exchange of Alaska – **https://www.mxak.org**

You can access the bathy gap analysis directly from NOAA's Geoplatform – **https://noaa.maps.arcgis.com/home/item.html?id=4d7d925fc96d47d9ace970dd5040df0a**

The link to the data provider engagement form is **https://iocm.noaa.gov/data-sharing/provider-engagement-form.html**. If you are aware of data that are not represented in the bathy gap analysis, please let us know via this form.

Methane Hydrate along the Cascadia Margin – **https://www.pmel.noaa.gov/eoi/Cascadia-margin.html**

Alaska Center for Energy and Power – **https://acep.uaf.edu**

NOAA Office of Coast Survey 2021 Alaska Data Collection Plans StoryMap – **https://storymaps.arcgis.com/stories/224ea9d51804433c84ec5b86f5bb2852**

NOAA Ocean Exploration Program – **https://oceanexplorer.noaa.gov**

Data Centre for Digital Bathymetry Viewer – **https://www.ncei.noaa.gov/maps/iho_dcdb/**

Aleutian Bering Sea Initiative website – **http://www.absipartnership.org**

Indigenous Sentinels Network – **https://www.beringwatch.net**

Skipper Science – **https://skipperscience.org**

For More Information

Alaska Coastal Mapping Initiative
https://alaska-coastal-mapping-strategy-dewberry.hub.arcgis.com
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Seascape Alaska
https://iocm.noaa.gov/documents/Seascape%20Alaska%20Factsheet_September%202021.pdf
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