Hydrographic Services Review Panel Federal Advisory Committee

Recommendations to NOAA for the Implementation Plan for the

Alaska Coastal Mapping Strategy

Prepared by the
NOAA Hydrographic Services Review Panel Federal Advisory Committee
NOAA HSRP Public Meeting, September 23-24, 2020

Hydrographic Survey Review Panel (HSRP) Recommendations to NOAA on the Implementation Plan for the

Alaska Coastal Mapping Strategy (ACMS)

EXECUTIVE SUMMARY

The HSRP supported all goals and objectives of the Alaska Coastal Mapping Strategy and prepared a detailed whitepaper with recommendations for NOAA's Implementation Plan for mapping the intertidal zone. The paper was authored by HSRP members with expertise in coastal mapping and was discussed and approved at the HSRP public meeting on September 23-24, 2020. For coastal mapping of Alaska, major recommendations were prioritized as follows:

1. To fill major gaps in the National Water Level Observation Network (NWLON) in Alaska and to make NOAA's Vertical Datum Transformation Tool (VDatum) operational throughout all of Alaska, use alternative lower cost systems for acquiring tidal data and establishing tidal datums in Alaska, using the NOAA Tidal Analysis Datums Calculator that enables partners to compute tidal datums themselves using CO-OPS methodologies and their data which may not be collected to NOAA's most rigorous NWLON standards. At a minimum, users must be able to predict high and low tides throughout Alaska.

2. Use NOAA's Water Clarity Climatology Tool for predicting times and locations when waters are clearest for topobathymetric lidar (Light Detection and Ranging) and satellite-derived bathymetry (SDB) – technologies that are ineffective when waters are too turbid. Determine locations where SDB works and doesn't work. For areas where SDB does not work, acquire topobathymetric lidar at times and locations when water clarity is predicted to be the best, collecting data within ±2 hours of low tide when most of the intertidal zone is exposed.

3. Where there are data voids in the topobathymetric lidar from either laser extinction or excessive turbidity, use uncrewed surface vessels (USVs) with multi-beam echo sounders (MBES) to fill remaining voids out to a depth contour of 4 meters, i.e., the Navigable Area Limit Line (NALL) in NOAA's Hydrographic Survey Specifications and Deliverables, a depth that satisfies all requirements for NOAA's National Shoreline, and the depth required by tug barges that supply coastal communities.

Appendix A: The 2004 National Research Council (NRC) report: *A Geospatial Framework for the Coastal Zone: National Needs for Coastal Mapping and Charting.* "7 Conclusions and Recommendations: A Seamless Bathymetric/Topographic Dataset for All U.S. Coastal Regions".
Appendix B: *The Importance of Vertical Datums, the VDatum Tool, and Shoreline Mapping* and the definition of the official shoreline of Alaska.
Appendix C: The written public comments from the HSRP public meeting on the implementation plans for both the Alaska Coastal Mapping Strategy and for Establishing a National Strategy for Mapping, Exploring, and Characterizing the U.S. Exclusive Economic Zone (NOMEC). Additional oral comments can be found in the meeting report and transcripts posted at https://www.nauticalcharts.noaa.gov/hsrp/meeting-webinar-september-2020.html.

BACKGROUND

This position paper provides HSRP recommendations to the NOAA Administrator on implementing the ACMS establishing a consistent, authoritative vertical datum for Alaska including:

1. Completing NOAA's Vertical Datum Transformation Tool (VDatum) to function in all of Alaska
2. Completing GRAV-D data collection in Alaska, and
3. Defining the official shoreline of Alaska, as explained at Appendix B in *The Importance of Vertical Datums, the VDatum Tool, and Shoreline Mapping*

In 2004, the Committee on National Needs for Coastal Mapping and Charting, Ocean Studies Board, Mapping Science Committee, Division of Earth and Life Studies of the National Research Council (NRC), published its report: *A Geospatial Framework for the Coastal Zone: National Needs for Coastal Mapping and Charting*[1]. That committee was chaired by Dr. Larry Mayer of the University of New Hampshire who is also a non-voting member of the HSRP. The Hydrographic Services Review Panel (HSRP) considers the recommendations of that NRC committee (see Appendix A) to remain valid today for coastal mapping of Alaska – from the necessity for VDatum to easily transform data between reference systems to the need for new remote sensing technologies that have since been developed to fill critical gaps at the land-water interface. Topographic/bathymetric lidar, acoustic sonar improvements, uncrewed surface vessels and the technical implementation of Gravity for the Redefinition of the American Vertical Datum (GRAV-D) are but some of these improvements.

In 2016, the Interagency Working Group on Ocean and Coastal Mapping released its draft guidance for the *National Coastal Mapping Strategy 1.0: Coastal Lidar Elevation for a 3D Nation*[2]. That coastal mapping strategy was finalized in 2018[3]. Table 1 of that strategy defines five bathymetric lidar Quality Levels and recommends bathymetric lidar be collected to at least $QL2_B$. These quality levels evolved from the partnership among USACE, NOAA, USGS and NAVO known as the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX), a partnership that continues today to inform standards and best practices for topobathymetric lidar acquisition and processing.

In November 2019, the Presidential Memorandum on *Ocean Mapping of the United States Exclusive Economic Zone and Shoreline and Nearshore of Alaska*[4] was issued. Section 2 called for an ocean mapping, exploration and characterization strategy. Section 3 of that memorandum directed the NOAA Administrator, in coordination with the State of Alaska and the Alaska Mapping Executive Committee (AMEC) – co-chaired by NOAA and the U.S. Geological Survey (USGS) - to develop a proposed strategy within 180 days to map the shoreline and nearshore of

[1] https://www.nap.edu/read/10947/chapter/1
[2] https://iocm.noaa.gov/reports/IWG-OCM-Natl-Coastal-Mapping-Strat-DRAFT-PUBLIC-COMMENT-4.29.16.pdf
[3] https://iocm.noaa.gov/about/documents/strategic-plans/IWG-OCM-Final-Coastal-Mapping-Strategy-2018-with-cover.pdf
[4] https://www.whitehouse.gov/presidential-actions/memorandum-ocean-mapping-united-states-exclusive-economic-zone-shoreline-nearshore-alaska/

Alaska and inform actions of the Ocean Policy Committee and relevant agencies. NOAA subsequently developed two strategies – one for the National Ocean Mapping, Exploration and Characterization (NOMEC) and another for the Alaska Coastal Mapping Strategy (ACMS).

In June of 2020, the White House released *Mapping the Coast of Alaska: A 10-Year Strategy in Support of the United States Economy, Security and Environment*[5] -- commonly referred to as the Alaska Coastal Mapping Strategy (ACMS). This strategy was written by the AMEC agencies, including NOAA, the State of Alaska, and the USGS. The Executive Summary of the ACMS affirms that Alaska's 66,000 miles of shorelines constitute a tremendous strategic economic and ecological resource to the Nation. It states: "Accurate and contemporary mapping of Alaska's coastal and nearshore regions are critical to informed use of these vast resources, maritime domain awareness, safeguarding of the health and security of coastal communities, and strengthening of the Blue Economy." The Executive Summary further states: "Subject to the availability of appropriations, implementing the Alaska Coastal Mapping Strategy would yield significant upgrades to Alaska's geospatial framework and mapping of the coastal zone by 2030. Products derived from topographic, nearshore bathymetric, and orthoimagery data, including the Alaska shoreline, would vastly improve life, safety, and economic opportunities for Alaska residents and the Nation."

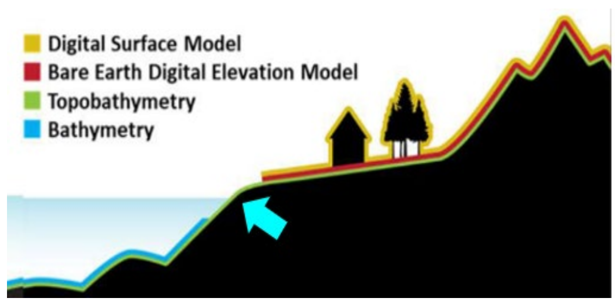

Figure 1. The aqua arrow points to the seamless topobathymetric 3-D surface that includes both underwater bathymetry (depths) and onshore topography (land elevations) with no data gaps at the land/water interface known as the coastal zone or intertidal zone.

HSRP RECOMMENDATIONS

The remainder of this white paper will provide HSRP recommendations for the Alaska Coastal Mapping Implementation Plan that address the four ACMS goals and eleven objectives.

ACMS Goal 1: Build on Existing Mapping Partnership to Meet Alaska's Coastal Mapping Needs.

Objective 1.1. Establish a Team for Alaska Coastal Mapping Implementation. The HSRP understands that NOAA and AMEC have already created a Coastal Mapping Subcommittee, co-chaired by representatives from NOAA and the AMEC, responsible for development of the ACMS Implementation Plan. HSRP recommends that NOAA and its Federal partners include representatives from academia and the geospatial industry to provide non-governmental insight to the strategy implementation. In addition, HSRP members are available to support that team in any way we can.

[5] https://iocm.noaa.gov/about/documents/strategic-plans/alaska-mapping-strategy-june2020.pdf

Objective 1.2. Refine Stakeholder Mapping Priorities, Costs, and Data Standards. The HSRP has specific recommendations on each of these topics below.

Mapping Priorities: Where new tidal datums need to be established to fill major gaps in the NWLON in Alaska, those tidal datums should have highest priority because knowledge of high and low tide is essential for all data acquisitions to follow.

NOAA needs to consider the needs and applications of all stakeholders (Federal agencies, defense and national security, local government, academia, or private community) who will benefit from the Alaska Mapping Program. The strategy indicates that needs were surveyed during 2019 from over 40 representatives from federal, state and local agency liaisons, Native corporations and associations, non-profit and professional organizations, and academia. The outcome of the aforementioned survey should be used as the base for setting priorities. Local communities need to be given a higher priority especially if such mapping provides means to enhance their life and wellbeing. The HSRP recommends that the ACMS Implementation Plan gives highest priority to coastal villages for solutions to their mapping needs and supporting infrastructure. The uninhabited coastal areas should be of lower priority when appropriations are insufficient to address the entire Alaska coastal areas unless there is a national security priority that dictates otherwise.

Presently, only 14% of the Alaska coastline has been adequately mapped; the missing 86% is critically needed for coastal zone applications. Subject to the availability of funds, mapping should commence immediately in areas in which there is the necessary geospatial infrastructure, i.e., Continuously Operating Reference Stations (CORS) for accurate positioning by the GNSS, and tide stations needed for accurate predictions of high and low tides and for completion of NOAA's VDatum tool in Alaska. Unfortunately, the areas with necessary geospatial infrastructure are believed to closely align with the 14% of the Alaska coastline that has already been adequately mapped. For the remaining 86%, NOAA should be proactive and act boldly to address the highest priority areas in time for implementation of the National Geodetic Survey (NGS) North American-Pacific Geopotential Datum of 2022 (NAPGD2022), now scheduled for release after 2024 because of Covid-19 delays. "But what are the highest priority areas?" -- we asked. When the HSRP met in Alaska in 2018, our members were impressed by the complexities of supplying coastal villages that have no airstrips and no roads to the mainland. Their supplies are delivered by tug barges providing logistics over-the- shore (Figure 2). Coastal villages normally have no docks and often have large tidal ranges -- up to 25 feet per day. They lack tide predictions to forecast high and low tides when supply barges can best come ashore. They need seamless topobathymetric data of their coastal zone, but they don't have it. Because they lack needed data, tug barges currently use sounding skiffs and sounding sticks to determine water depths (Figure 3); some skiffs have consumer-grade depth sounders in addition to sounding sticks. Mark Smith of Vitus Energy said that all barge operators need seamless topobathymetric data from dry land out to at least the 4m depth at low tide. Coincidentally, the 4-meter depth contour normally defines the Navigable Area Limit Line (NALL) in NOAA's Hydrographic Surveys Specifications and Deliverables[6].

Figure 2. Fuel barge from Vitus Energy that supplies coastal villages with fuel. They use sounding skiffs outfitted with a consumer depth sounder and a sounding pole for physical soundings of shallow water. This is archaic.

Figure 3. This shows a tug barge going up an Alaska inlet, preceded by the sounding skiff in the distance that determines safe depths for passage. They would be much more efficient with GPS/GNSS and known depth data.

Costs: *The National Coastal Mapping Strategy 1.0: Coastal Lidar Elevation for a 3D Nation* states: "The purpose of the plan is to coordinate the collection of new data and eliminate redundancy, reduce costs, and support the widest possible range of coastal data." A similar statement should guide the ACMS Implementation Plan. Various agencies involved in mapping the coast of Alaska should join efforts and pool their resources to implement the strategy according to stakeholder priorities.

The HSRP recommends consideration of alternative technologies to reduce costs for development of needed tidal datums where there are huge gaps in the NWLON network. We also make recommendations for cost efficiencies in acquisition of topobathymetric lidar, imagery, and sonar data for nearshore bathymetry. For optimal cost effectiveness, it is important to recognize the need for tasks to be performed in the correct sequence:

1. CORS: NGS's home page for CORS[7] describes plans for the Foundation CORS Network in Alaska and elsewhere. Alaska will have two Foundation CORS from NOAA, two from the National Science Foundation (NSF), and one from the National Aeronautics and Space Administration (NASA), for a total of five. The HSRP recommends that NOAA work with the NSF to expedite the Foundation CORS Network serving coastal areas of Alaska. The planned NASA Foundation CORS in Fairbanks will have minimal impact on mapping of Alaska's coastal zone. However, the current lack of Foundation CORS should not be a "showstopper" because the existing CORS network in Alaska is still able to support Precise Point Positioning of mapping aircraft, UAVs, and marine vessels. The addition of the proposed foundation CORS will provide the backbone for the use of Online Positioning User Service (OPUS) in Alaska. OPUS is a tool that provides access

[6] https://nauticalcharts.noaa.gov/publications/docs/standards-and-requirements/specs/hssd-2017.pdf

[7] https://geodesy.noaa.gov/CORS/foundation-cors.shtml

to high-accuracy National Spatial Reference System (NSRS) coordinates using the NOAA CORS Network (NCN) and will be used to support survey tasks described in this document. A dense network of CORS will also support the suite of tools being developed for OPUS Projects which will support geodetic activities needed for mapping in Alaska.

2. Where topobathymetric lidar or imagery is used, this data should be tide-controlled to capture as much of the intertidal zone surface as possible during low tide (see Figure 4).
3. To minimize costs, acoustic (sonar) data requirements should not be determined until after topobathymetric lidar data have been acquired and evaluated for data voids. An example of topobathymetric lidar data voids is shown at Figure 5. Only then should NOAA and AMEC determine where sonar data are required and determine where multi-beam sonar data should be acquired for higher priority areas (coastal villages) and where less-expensive single-beam sonar data would be acceptable for lower priority areas. Sonar data should be collected as near as feasible to high tides when swaths cover a broader area of the intertidal zone and require fewer swaths.

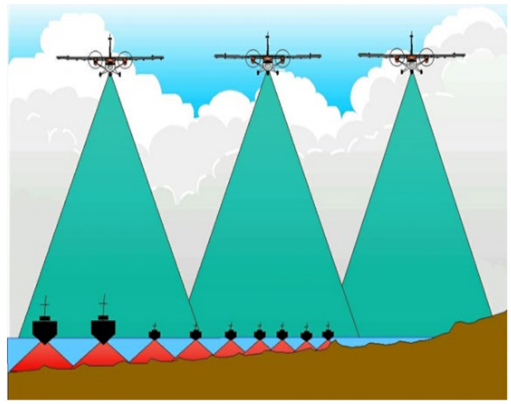

Figure 4. This figure shows why topobathy lidar is most efficient in shallow waters, where multibeam sonar is least efficient; topobathy lidar should be collected at low tide. But topobathy lidar may have data voids because of water turbidity; then sonar becomes the most efficient in deeper waters to fill those voids and is most efficient at high tide. This figure also shows why uncrewed surface vessels are better suited for acoustic mapping in shallow waters, compared with larger vessels that are more likely to run aground in shallow waters.

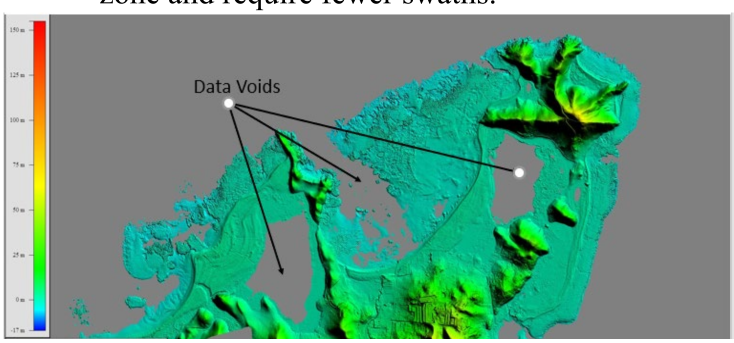

Figure 5. Example of bathymetric lidar data voids in areas where aquatic vegetation, bioluminescence or sediments in the water prevent penetration by the green laser. Other voids occur where the laser extinction depth is exceeded.

<u>Data Standards</u>:

While NOAA's 2020 Shoreline Mapping Project Instructions[8] agree with the lidar quality levels specified in the National Coastal Mapping Strategy, we believe the instructions lack a few "buy-up options" that users from outside NOAA may expect from a coastal mapping program. HSRP recommendations on standards and specifications include:

1. Select quality level(s) for topography and bathymetry that suit the mapping priorities as derived from the survey mentioned in our response to Objective 1.2 above.
2. Select topographic and bathymetric quality levels as described in NOAA's Shoreline Mapping Project Instructions and the National Coastal Mapping Strategy but encourage and allow other stakeholders to contribute additional funding for a "buy-up option" if they need lidar data of higher point density or accuracy, for example.

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[8] https://www.ngs.noaa.gov/RSD/topobathy/STYYXX-TB-C_Project_Instructions_v3.0.2.pdf

3. NOAA's Shoreline Mapping Project Instructions call for 4-band imagery (R, G, B, NIR) with ground resolution of 25-cm. While this may be suitable for NOAA's use, higher resolution imagery and/or hyperspectral imagery may be needed for other applications including coastal analysis, near-shoreline water quality, and benthic habitat mapping, for example. NOAA should encourage and allow other stakeholders to contribute additional funding for imagery "buy-up options" to satisfy coastal mapping requirements that exceed the NOAA standard.
4. The HSRP sees a good opportunity to develop a national standard for coastal mapping that focuses on defining the various uses and applications of products from the coastal mapping program and then align technologies and specifications to suit such applications.

Objective 1.3. Cost-Effectively Resource the Alaska Coastal Mapping Implementation Plan. The HSRP has no specific recommendations for this objective beyond proposed cost efficiencies documented herein and the importance of the private-sector involvement in addition to other federal and state agencies and universities. A good example to follow is what the AMEC did for IFSAR mapping of Alaska through extensive funding partnerships. Note: for the Alaska IFSAR mapping program, the USGS had primary responsibility for topographic mapping of Alaska; yet 46% of the funding came from other funding partners and stakeholders.

Objective 1.4. Integration with Complementary AMEC Mapping Priorities. The HSRP has no specific recommendations for this objective because the Coastal Mapping Subcommittee is already taking complementary AMEC mapping priority acquisition plans into consideration.

ACMS Goal 2: Expand Coastal Data Collection to Deliver the Priority Geospatial Products Stakeholders Require.

Objective 2.1. Execute a Flexible Alaska Coastal Mapping Campaign. The HSRP assumes that the Alaska Coastal Mapping Implementation Plan will prioritize diverse requirements and attempt to best satisfy specific requirements each year between 2020 and 2030. The HSRP agrees that the Alaska Coastal Mapping Implementation Plan needs to be flexible to accommodate a myriad of competing priorities and funding variables, especially when cooperative funding is received for a specific purpose that may not have been among NOAA's highest priorities in its initial plan.

Objective 2.2. Upgrade Alaska National Spatial Reference System Components to Support Mapping Data Acquisition. The HSRP has previously recommended the sequence in which data should be acquired by priority area, i.e., with establishment of Foundation CORS and tidal datums being highest priorities. The Alaska Water Level Watch (AWLW) Collaborative Working Group 2020-2025 draft Guidance Plan includes Figure 6, with 32 large gaps in NWLON coverage along Alaska's coasts including the Aleutian Islands. For Objective 3.2 below, the HSRP recommends that NOAA consider three alternative means for establishment of additional tidal datums in Alaska to fill these gaps.

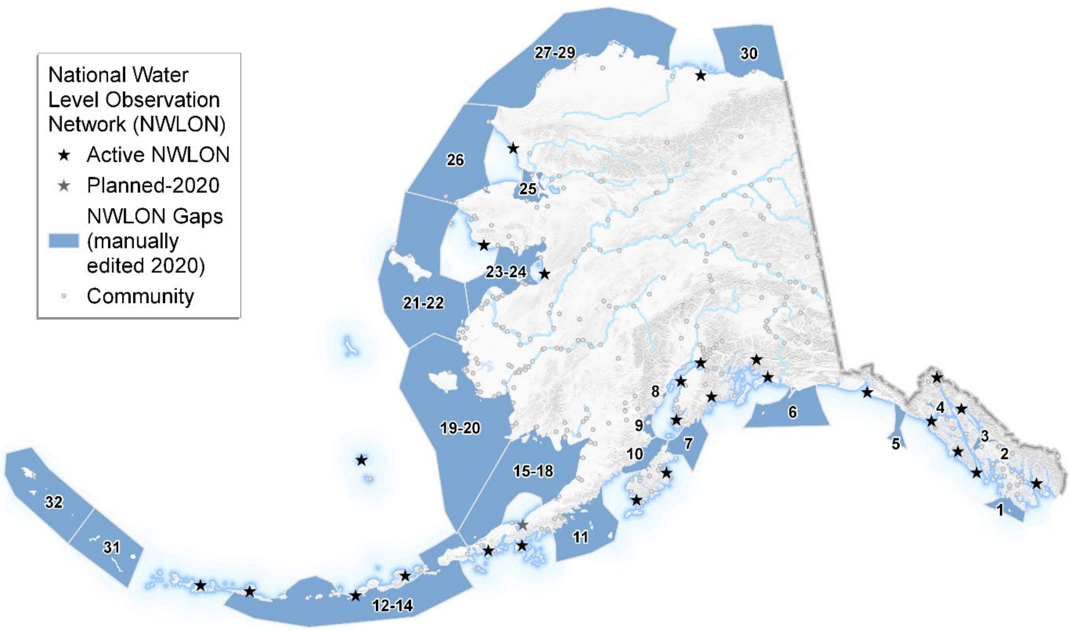

Figure 6. The blue areas show the major gaps in NWLON stations in Alaska, overlaid with small circles showing the location of Alaska communities, both coastal and inland. These gaps need to be filled either by NWLON or by more-affordable, temporary tide gauges in order to execute the Alaska Coastal Mapping Strategy.

<u>Objective 2.3. Produce and Disseminate Key Datasets and Products from Alaska Coastal Mapping Data.</u> The HSRP fully concurs with the approach to Objective 2.3 in the ACMS.

Goal 3: Leverage Innovation in Mapping Technology Development

<u>Objective 3.1. Upgrade Alaska Climatology Tool for Smart Application of Satellite and Airborne Lidar Bathymetry</u>. Satellite Derived Bathymetry (SDB) and Airborne Lidar Bathymetry (ALB) both require data to be acquired at the times and locations when waters are clearest. NOAA has developed a water clarity climatology tool[9], based on satellite image records, to identify patterns in time and space to maximize Alaska's potential for topobathy lidar

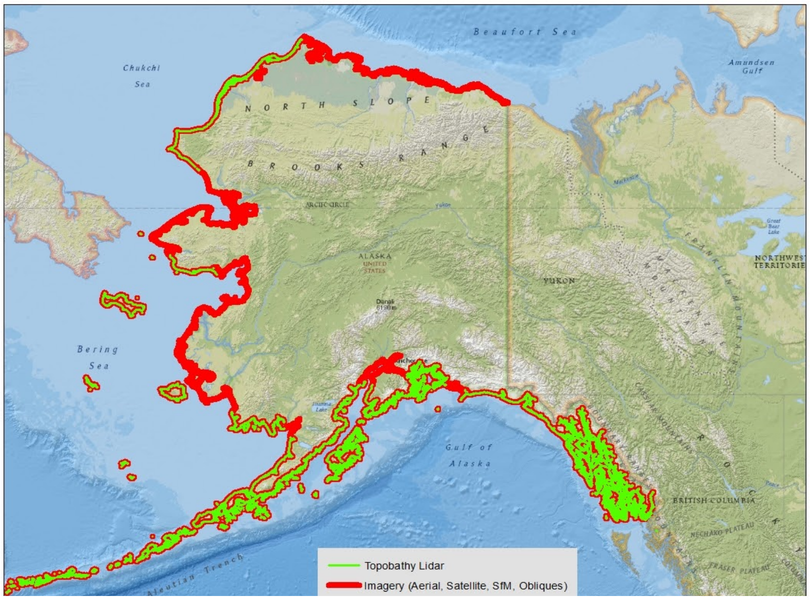

Figure 7. NOAA's Water Clarity Climatology Tool for predicting times and locations when waters are clearest for ALB or SDB.

[9] https://www.ngs.noaa.gov/RSD/topobathy_wc.shtml

for shoreline mapping. This tool is also relevant to SDB. Figure 7 shows a climatology tool map of Alaska where topobathy lidar and SDB are most likely to work. HSRP members concur that this climatology tool should be upgraded with lessons learned from actual projects in Alaska.

Objective 3.2. Monitor and Test New Technologies for Acquisition Efficiencies.

Continuously Operating Reference Stations (CORS):

- Consider adding CORS stations collocated with CO-OPS tide stations where practical
- Extend CORS network to offshore platforms, islands, etc., to support ellipsoid reference surveying and Online Positioning User Service (OPUS)
- For new installations, select coastal sites suitable for both positioning and measuring water levels via GNSS reflectometry
- Support and perform GNSS Reflectometry research to enable more use of this technology

National Water Level Observation Network (NWLON):

- Consider expanding the network using GNSS Reflectometry, especially in challenging coastal environments like Alaska. Consider extending offshore observations (buoys, platforms, bottom mount gauges, etc.)
- Improve the GNSS ties at the NWLON stations through leveling ties between NWLON stations and nearby CORS and a more robust GNSS observation campaign (NOAA Technical Memorandum NOS NGS-58)
- Consider using a Modified 5-yr Epoch for all tide stations. This would provide more consistency between the tidal datums and ensure the tidal datums are more current.
- Publish relationship of NAVD88 and/or the new NAPGD2022 on tidal datums page for all published stations.

Vertical Datums Transformation (VDatum):

- Extend coverage throughout Alaska, especially the major ports and coastal communities
- The current National Tidal Datum Epoch (NTDE) is 1983 to 2001. This will be updated to a new 19-year period soon. Some tidal datums reference a modified 5-year epoch. Incorporating transformations between different tidal datum epochs would be useful.
- Perform more robust GNSS ties at temporary tide stations. The current SOW is a single 4-hour observation of a single tidal benchmark. Increasing this to two marks and following NOAA Technical Memorandum NOS NGS-58 guidelines would significantly improve the tie between the tidal datums and a global reference frame.
- The tidal datum and ellipsoid height info for many of the tidal benchmarks used in the development of the VDatum grids reference different epochs. The reference epoch for the current NSRS is 2011. The center of the current NTDE is 1992. Combining tidal datum and ellipsoid heights referencing different epochs introduces errors especially in regions with significant vertical land motion.

Alternative Sensors for Tidal Datums. To fill gaps in the NWLON network, the HSRP recommends that NOAA consider alternative lower-cost systems for acquiring tidal data and establishing tidal datums in Alaska. NOAA's training module: "Using the NOAA Tidal Analysis Datums Calculator"[10] enables partners to compute tidal datums themselves using CO-OPS methodologies and their data which may not be collected to NOAA NWLON standards:

- Non-Vented Pressure Sensors: These systems have been used statewide in Alaska over the years because of their versatility over vented pressure sensors (Figure 8). For establishing authoritative tidal datums, non-vented pressure sensors have typically been secured to oceanographic anchors and deployed offshore with a vessel due to their size (Figure 9). This approach is not only expensive because of the vessel time but the anchors typically move which introduces measurement error that regularly exceeds the requirements in the NOAA tide station installation specifications. There are now low cost non-vented pressure sensors on the market with the power duration, sensor accuracy, sampling frequency, memory and size suitable for securing to natural coastal features. Figure 10 shows a picture of a non-vented pressure tide gauge installed in St. Michael Alaska to validate GNSS-Reflectometry water level measurements from UNAVCO station AT01. Figure 8 shows a vented pressure tide gauge being installed near the community of Gambell on St. Lawrence Island in the Bering Sea. The cost of the equipment, materials and labor to install the tide gauge in Figure 10 is significantly less than for the tide gauges in Figure 8 and 9.

Figure 8. Picture of a vented pressure tide gauge installed for tidal datum determination on St. Lawrence Island, Alaska. Field crew is securing air hose that runs from below MLLW to the electronics enclosure on top of the hill in the background.

Figure 9. Non-vented pressure, conductivity and temperature sensors secured to an oceanographic anchor prior to deployment south of the Alaska Peninsula.

Figure 10. RBR Solo Depth Logger installed at St. Michael, Alaska. This is a non-vented pressure sensor that was intentionally installed above MLLW to measure a portion of the tide range.

Photos courtesy of JOA Surveys

[10] https://www.meted.ucar.edu/training_module.php?id=10036#.X1-lXGhKgdU

- <u>GNSS Tide Buoy:</u> These systems consist of a GNSS receiver and antenna secured to a buoy hull. The buoy is deployed in the ocean and directs signals from GNSS constellations, used to precisely determine the 3D position of the antenna. These positions are then reduced to the water line. The two primary advantages of these systems are 1) measurements are referenced to a stable global reference frame, and 2) they do not require fixed coastal structures for deployment. Typically, measurements from pressure, microwave and acoustic tide gauges are referenced to the sensor. Movement of the sensor mounting structure (i.e. dock, seawall, bedrock, piling) introduces error, if the movement is not quantified and timestamped. Because GNSS Tide Buoys use direct signals from positioning satellites the buoy (i.e. sensor) movement is continuously quantified and timestamped thus eliminating mounting structure movement as an error source. Figure 11 is a picture of a GNSS Tide Buoy deployed in Shotgun Cove of Alaska's Prince William Sound.

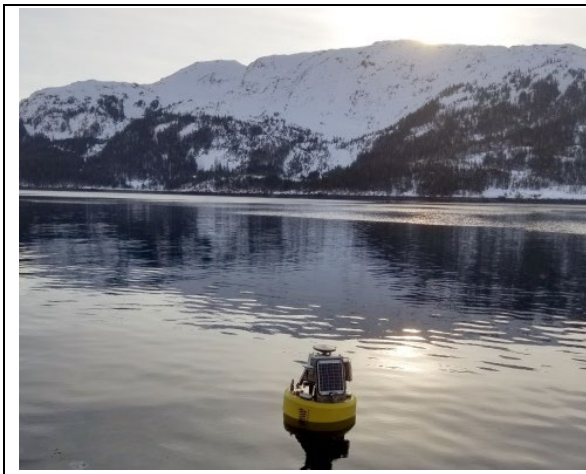

Figure 11. A GNSS Tide Buoy deployed in Alaska's Prince William Sound. Photo courtesy of JOA Surveys, LLC.

  The two predominant processing methods for GNSS Tide Buoy data are Differential GNSS (DGNSS) and Precise Point Positioning (PPP). DGNSS tends to provide more accurate results; however, this processing is relative and requires data from base stations such as CORS. There currently are not enough CORS along Alaska's coast to provide statewide coverage. In regions without CORS coverage a temporary base station must be installed. PPP does not require base stations which reduces operational costs by eliminating the need to install temporary base stations when CORS are not available.

- <u>GNSS-Reflectometry (GNSS-R):</u> The system shown at Figure 12 is essentially a GNSS base station (CORS or temporary CORS) that uses direct signals from GNSS constellations to precisely position the base station antenna and indirect signals (i.e. multipath) to determine the height of the antenna above a reflective surface. When the base station is placed close enough to the water this system can be used to measure the tidal variations. The two

Figure 12. GNSS-Reflectometry water level system installed in Koyuk, AK by JOA Surveys, LLC in support of the NOAA Office of Coast Survey Project OPR-R385-KR-20. TerraSond Ltd. was the prime contractor. Photo courtesy of JOA Surveys.

main advantages of this approach are: 1) it is a non-contact approach of measuring water levels at an oblique angle, and 2) movement of the sensor (i.e. GNSS antenna) can be monitored on a continuous basis. The main disadvantage of the system is that the measurements have more error than those from pressure, acoustic and microwave tide gauges, thus making them unsuitable for NWLON stations. However, much of the error is filtered out in the tidal datum computation process, making the measurements suitable for tidal datum determination especially along coastlines that are remote and unprotected. In 2019, *GPS World* published a relevant GNSS-R article entitled: *Innovation: Monitoring sea level in the Arctic using GNSS.*[11]

The HSRP recommends NOAA support additional research for consideration of technical and cost proposals of these or other alternative sensors at temporary tide stations in Alaska to establish the tidal datums necessary to achieve VDatum coverage statewide.

Uncrewed Systems. For collection of topobathy lidar, HSRP members conclude that uncrewed aerial systems would be of no benefit in Alaska as the depths, bottom types, and turbidity are extremely challenging to manned aircraft systems that have far superior capabilities. Instead, a combination of manned aerial topobathy lidar systems (Figure 13) and uncrewed surface vessels collecting single-beam or multi-beam sonar would be the most efficient way to collect nearshore bathymetry to depths where manned and uncrewed hydrographic assets are effective. Furthermore, uncrewed aerial systems (UAS) can play a role in collecting imagery in remote areas to specifications that will support Structure from Motion (SfM) photogrammetry for production of orthoimagery. NOAA has tested current UAS camera systems that have provided imagery that meet the same specifications as manned large format camera systems.

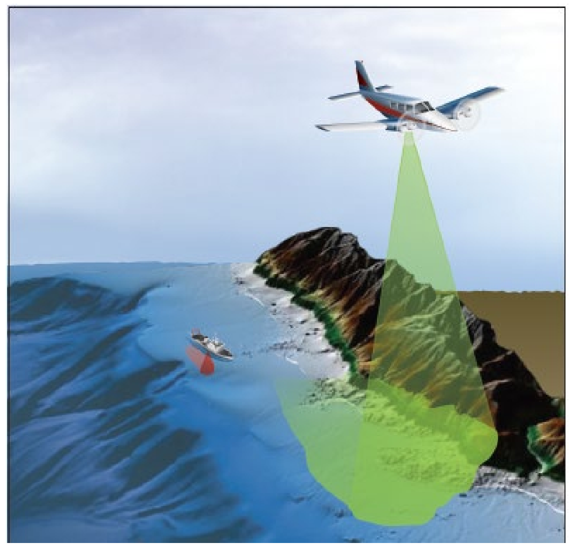

Figure 13. Dependent on water clarity, aerial topobathy lidar, collected at low tide, is the best way to map seamless topobathymetric surfaces in the intertidal zone; but tide-controlled aerial photography and uncrewed surface vessels with single- or multibeam sonar, collected at high tide, can map the intertidal zone where waters are too turbid for topobathy lidar.

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[11] https://www.gpsworld.com/a-tidal-shift-monitoring-sea-level-in-the-arctic-using-gnss/

Uncrewed Surface Vessels (USVs). To achieve 100% bathymetric bottom coverage from multibeam sonar, there are many USV options to choose from. The University of New Hampshire (UNH) Center for Coastal and Ocean Mapping (CCOM) and UNH-NOAA Joint Hydrographic Center (JHC) has already evaluated many of these.[12] [13] [14]

Figure 14. The uncrewed Z-boat, with multibeam sonar, is one option to choose from on surveying shallow waters for NOAA's coastal mapping program and to fill voids from topobathy lidar where waters are too turbid for full bottom coverage.

The fixed angle of the sonar causes the width of the swath across the seafloor to vary with depth; therefore, in order to achieve complete bottom coverage, neighboring survey lines must be spaced more closely in shallow water than in deepwater. The Z-boat, with multi-beam sonar at Figure 14, is just one of many uncrewed options designed for ocean surveying with waves that impact speed and bearing. Such USVs include data transmission and automated swath survey path planning. With input from the CCOM, NOAA should evaluate available technologies to determine which systems best satisfy requirements for Alaska.

Hydroball Buoy: The Alaska Ocean Observing System (AOOS) has been working closely with the Alaska Water Level Watch regarding alternative tide sensors. One such sensor now under evaluation is the Hydroball (Figure 15), a small (28 pound) fully autonomous buoy that includes a single beam echosounder, GNSS receiver, and a digital compass and can be moored, towed or drifted. Based on its usage in Canada, the AOOS is optimistic that it holds promise for meeting needs of nearshore bathymetry, especially at the mouths of frequently-changing rivers, while also leveraging the capacity of local workforces in Alaska.

Figure 15. Hydroball buoy.

Autonomous Surface Vessels (ASVs). The 2020 Arctic Mapping mission[15] was a single-beam sonar mission supporting NOAA's effort to provide modern, accurate mapping data of the Bering Sea and Alaska's North Slope. Using a fleet of Saildrones (Figure 16), the goal was to identify the 20-meter and 50-meter depth contours delineating a virtual lane to be mapped for safe passage of commercial vessels (Figure 17). Saildrones operate autonomously, but they are remotely monitored by Saildrone Mission Control 24/7. Missions can be adapted or adjusted on the fly. NOAA is working to integrate single-beam and multi-beam technology for shallow-water and coastal bathymetric missions. The HSRP recommends that CCOM investigate the feasibility

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[12] https://coastalscience.noaa.gov/news/noaa-evaluates-capabilities-unmanned-surface-vessel/

[13] https://www.nauticalcharts.noaa.gov/updates/noaa-ship-thomas-jefferson-tests-innovative-drix-autonomous-surface-vehicle/

[14] https://www.nauticalcharts.noaa.gov/updates/unmanned-surface-vehicles-evaluated-for-hydrographic-survey/

[15] https://www.saildrone.com/news/national-ocean-service-arctic-bathymetry-mission

and practicality of using Saildrones or other ASVs to survey shallow water coastal areas of Alaska for NOAA's Coastal Mapping Program where topobathymetric lidar may be unable to penetrate turbid waters.

Figure 16. Although the Saildrones operating in the Arctic are equipped with single-beam sonar, options are available also for multi-beam sonar.

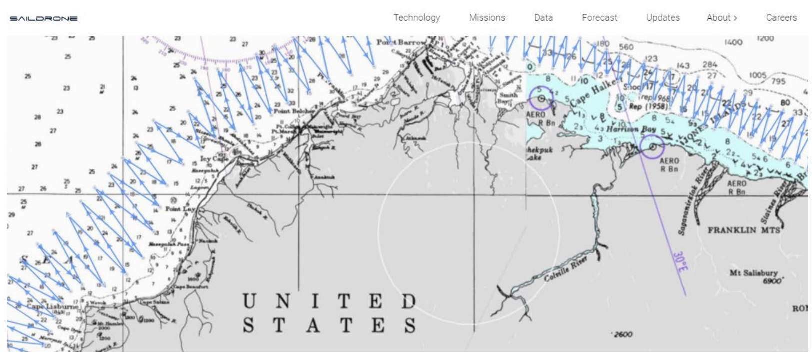

Figure 17. For the Arctic, the fleet of Saildrones perform a zig-zag pattern with a spacing of no more than five nautical miles between passes to delineate a corridor between the 20-meter and 50-meter contours for safe navigation of commercial vessels.

Goal 4: Conduct Strategic Communications to Promote Widespread Stakeholder Engagement.

Figure 18. NOAA's Coastal Mapping Summits and Reports are ideal ways to improve private sector involvement with NOAA and the AMEC.

Objective 4.1: Strengthen Stakeholder Communications to Grow Participation in the Alaska Coastal Mapping Campaign. HSRP specific recommendations for improving stakeholder communication and participation include:

(1) Develop an outreach and public engagement strategy that communicates the importance and value of mapping the coast and shoreline of Alaska; the Alaska Coastal Mapping Summits and Reports (Figure 17) have been outstanding in this regard.

(2) Develop mechanisms that ensure the participation of non-government sectors in the development and execution of the Alaska coastal strategy and Implementation Plan;

(3) Develop mechanisms that support the demonstration of innovative technologies/solutions from all sectors that would accelerate mapping the coast of Alaska with emphasis on autonomous solutions where warranted;

(4) Increase the profile and improve the transparency of the AMEC, e.g., as a minimum publish minutes that can be shared with the public;

(5) Develop a database (or some coordinated/integrated source) for all data required (existing and future) to map the shoreline of Alaska; develop a gap analysis in line with the work generated by NOAA for the USA EEZ;
(6) Develop a series of standards and protocols to ensure consistency of coastal mapping data acquired by many sources across all sectors, related to the broader standards above, and
(7) Engage stakeholders as early as possible in the process, and focus on getting their input early, rather than their feedback near the end.

Objective 4.2: Use Online Tools and Technologies to Communicate Plans and Performance.
The HSRP concurs with NOAA's approach to this objective.

Appendix A: "7 Conclusions and Recommendations: A Seamless Bathymetric/Topographic Dataset for All U.S. Coastal Regions"

A Geospatial Framework for the Coastal Zone: National Needs for Coastal Mapping and Charting

The National Research Council, 2004. Washington, DC: The National Academies Press. doi: 10.17226/10947.

Committee on National Needs for Coastal Mapping and Charting, Ocean Studies Board, Mapping Science Committee, Division of Earth and Life Studies
The National Research Council of the National Academies

One of the most serious impediments to coastal zone management is the inability to produce accurate maps and charts so that objects and processes can be seamlessly tracked across the land-water interface. Differences between agency missions, onshore topographic versus offshore bathymetric mapping techniques, differing vertical reference frames, and the inherent difficulty of collecting source data in the surf and intertidal zones have combined to produce this fundamental incompatibility. It will be impossible to properly understand processes, undertake planning, and establish boundaries in the coastal zone while two sets of disparate and non-convergent maps and charts are being separately maintained.

The barrier to the production of continuous integrated mapping products across the land-sea interface is the inherent difference in the horizontal and vertical reference surfaces (datums) and projections used for maps and charts. Horizontal datum and projection issues can be readily resolved with existing transformation tools, although these tools must be made more readily available to the user community. However, vertical datum issues present a serious challenge. In order to seamlessly combine offshore and onshore data, vertical datum transformation models must be developed. These models depend on the establishment and maintenance of a series of real-time tidal measuring stations, the development of hydrodynamic models for coastal areas around the nation, and the development of protocols and tools for merging bathymetric and topographic datasets.

The Tampa Bay Bathy/Topo/Shoreline Demonstration Project, a collaborative effort between NOAA and the USGS, has developed a suite of such tools (called Vdatum) and has demonstrated the feasibility of generating a seamless bathymetric/topographic dataset for the Tampa Bay area. This project has also demonstrated both the inherent complexity of such an undertaking and the substantial benefits that arise from interagency collaboration and coordination.

> **Recommendation 1: In order to combine onshore and offshore data in a seamless geodetic framework, a national project to apply Vdatum tools should be initiated. This will involve the collection of real-time tide data and the development of more sophisticated hydrodynamic models for the entire U.S. coastline, as well as the establishment of protocols and tools for merging bathymetric and topographic datasets.**

This dataset must be documented and disseminated in such a way that it can become the base for a wide range of applications, including the definition of local, regional, or national shorelines. As a result of this effort, it will be possible to merge data collected either on land or offshore into a common geodetic reference frame, while at the same time allowing application-specific maps and charts to be generated that maintain traditional tidal-based datums (e.g., for navigational charts) or orthometrically based datums (e.g., for topographical maps).

Shoreline Definition Protocols

Numerous agencies have identified the lack of a consistently defined national shoreline as a major barrier to informed decision making in the coastal zone. While a consistent shoreline is certainly desirable, many different definitions of the shoreline remain embedded in local, state, and federal laws, making it impractical to call for a single "National Shoreline." Rather, the key to achieving a consistent shoreline is the seamless geodetic framework referred to in Recommendation 1. With a seamless bathymetric/topographic dataset across the land-water interface, appropriate difference or tidal models, and consistent horizontal and vertical reference frames, any shoreline definition can be transformed and integrated within the common framework. The Vdatum tool kit and associated Web sites will be the key to establishing internally consistent shorelines between and among disparate surveys and studies.

> **Recommendation 2: To achieve national consistency, all parties should define their shorelines in terms of a tidal datum, allowing vertical shifts to be calculated between and among the various shoreline definitions, while at the same time permitting different agencies and users to maintain their existing legal shoreline definitions. In situations where legislation or usage does not preclude it, the committee recommends that the internationally recognized shoreline established by NOAA's National Geodetic Survey be adopted.**

The committee encourages the Federal Geographic Data Committee's (FGDC) Marine and Coastal Spatial Data Subcommittee to pursue implementation of this recommendation.

Easy Access to Timely Data

Easy access to timely data is an essential component of effective coastal zone management. Many agencies have created Web sites that offer access to data in a variety of forms as well as data manipulation tools. However, these sites still represent only a small percentage of existing coastal zone data.

> **Recommendation 3: A single Web portal should be established to facilitate access to all coastal mapping and charting data and derived products. The site should be well advertised within federal and state agencies, state and local governments, academic institutions, nongovernmental organizations and conservation groups, and to other potential users. The portal should work well with all Web browsers and on all computer platforms, to make it easily accessible to all users.**

The single portal is not intended to host all coastal data. Rather, it should serve as a focal point that links to many distributed databases maintained by individual agencies or organizations. This site would represent the one place where users, particularly new users, could begin their search for coastal data and derived products. A single, easily accessible data portal with appropriate data manipulation tools should also promote the timely entry and retrieval of data. Coordination of such a site logically falls under the purview of the FGDC and is fully consistent with the Geospatial One-Stop concept.

Data Integration, Interchangeability, and Accuracy

Providing easy access to data through a single Web portal is a critical starting point for addressing the needs of the coastal zone community. However, users must also be able to combine and integrate data collected by different agencies using a range of sensors and often based on different datums or projections. Users must also be able to assess the attributes and accuracy of the data provided. Integration of data and assessment of data quality are made possible by the establishment of data and metadata standards and the application of tools for data transformation.

Recommendation 4: All thematic data and other value-added products should adhere to predetermined standards to make them universally accessible and transferable through a central Web portal. All sources should supply digital data accompanied by appropriate metadata.

The FGDC is in the process of establishing a series of standards for the National Spatial Data Infrastructure (NSDI) that will be applicable to all coastal zone data. Unfortunately, implementation of the NSDI continues to be problematic for the coastal/marine community due to highly variable levels of commitment by different agencies and insufficient incentives to fully implement its principles. This may, in part, be due to the structural and budgetary barriers discussed in Chapter 6, the inability of a single set of standards to serve all applications and disconnects between those developing the standards and the user community. One approach to addressing this issue is for additional involvement by the private sector.

Recommendation 5: The private sector should be more involved in developing and applying data standards and products. Agency procurement requirements can be used to encourage the private sector to deliver needed products in a timely fashion.

The committee is aware of numerous examples where private-sector initiatives established well-accepted and easily used data protocols—in effect de facto standards—that significantly enhance the effectiveness of data products. The private sector is often capable of greater speed and efficiency in the adoption of standards and tools than its government agency counterparts. Access to data, metadata, and data standards must be complemented by readily available tools to easily convert between and among different data formats, scales, and projections.

Recommendation 6: Government agencies and the private sector should continue to develop tool kits for coastal data transformation and integration. This will facilitate data analyses and the production of a range of value-added products. The tools should be accessible through the Web portal.

Documentation of the tools and techniques used to process data must also be provided to help the user community understand the limitations and appropriate uses of various datasets. A variety of training courses and workshops will be essential to provide end-users with the knowledge and tools necessary for intelligent application of the available data.

Improved Coordination and Collaboration

Any activity that involves multiple federal, state, and local agencies, academic researchers, and the private sector has the potential for redundancy and overlap of effort. This is amplified when the activity requires expensive platforms, technologies, and sensors. In the area of coastal zone mapping and charting, the large number of agencies involved, their differing histories, the breadth of their mandates, and the complexity of the task offer ample opportunities for redundancy and inefficiency. Because data acquisition is unquestionably the most expensive aspect of coastal zone mapping, elimination of redundancy and overlap in this area is likely to yield large savings. Ensuring that all relevant agencies are aware of one another's activities will be an important first step toward improved coordination.

> **Recommendation 7: All federally funded coastal zone mapping and charting activities should be registered at a common, publicly available Web site. This combined registry should be accessible through the single Web portal for coastal zone information.**

Each entry in the registry should include a description of the mapping activity, its location and purpose, the agency collecting the data, the tools to be used, the scales at which data will be collected, and other relevant details. Non-federally funded agencies conducting coastal mapping activities should be encouraged to register their activities at the same site. A section of the registry should be dedicated to descriptions of planned but unfunded coastal mapping activities, as well as a prioritized compilation of coastal areas where surveying would be particularly helpful to state or local agencies. Technically, components of such registration may already be required under Office of Management and Budget (OMB) Exhibit 300, but Recommendation 7 suggests a considerably expanded effort focused on making all federally funded coastal zone mapping efforts more widely known.

Once implemented, this registry could serve as the focal point for national coordination of geospatial data collection and analysis efforts. Individual agencies would continue to set their own priorities, but through the registry process any overlapping efforts could be quickly identified and avoided. The registry would also facilitate increased efficiency by highlighting opportunities for "incremental" surveys, where one agency takes advantage of the mapping activities of another agency in a region of common interest by providing a small amount of additional funding to achieve an additional objective. Such "piggyback" collaborative efforts would allow additional agencies to acquire data that meet their needs at minimal incremental cost.

> **Recommendation 8: To be effective, coordination should be carried out among all the primary agencies involved in coastal zone mapping; it should be mediated by a body that has the authority and means to monitor and ensure compliance; and it should involve people who are knowledgeable enough to identify the most critical issues.**

Structurally, the FGDC appears to be an appropriate body to oversee such coordination, but many concerns remain about its effectiveness. Some restructuring of FGDC, and perhaps an empowered Marine and Coastal Spatial Data Subcommittee, will be required to allay these concerns. In this light the committee endorses the recommendations of a recent design study team that calls for major structural and management changes for the FGDC (FGDC, 2000). A less appealing alternative might be either a new government office or an extra-governmental body charged with establishing oversight of all national coastal mapping and charting activities.

> **Recommendation 9: Whichever body is charged to carry out the needed coordination activities, dedicated staff personnel should be assigned to maintain the Web portal (Recommendation 3), the activities registry (Recommendation 7), and associated Web sites, and to proactively search for areas where efforts can be coordinated, supplemented, or combined to increase efficiency.**

Specific areas where better coordination among federal agencies is urgently needed (with the agencies likely to be involved listed in parentheses) include the following:

- High-resolution topographic and bathymetric data acquisition at the land-water interface, including aerial and satellite imagery, Light Detection and Ranging (Lidar) surveys, and bathymetric surveys (Federal Emergency Management Agency [FEMA], National Aeronautics and Space Administration [NASA], NOAA, U.S. Army Corps of Engineers [USACE] and USGS.
- National seamless topographic/bathymetric Digital Elevation Models/Digital Depth Models (National Geospatial-Intelligence Agency [NGA], NOAA, and USGS).
- Derived products for mapping *shoreline change* (Bureau of Land Management [BLM], FEMA, NOAA, USACE, and USGS), *habitat change* (EPA, FWS, NOAA Fisheries, NOAA-National Ocean Service, and USGS), *hazard vulnerability* (FEMA, NOAA, and USGS), and *coastal inundation and erosion hazards* (FEMA, NOAA, USACE, and USGS).

Increased Data Collection

There is a widespread need for more and better data to be collected in the coastal zone. Growing pressure from a variety of constituencies (e.g., fisheries, shipping and navigation, Law of the Sea implementers, resource managers) will lead to ever-greater demands for useful information. The single most consistently cited need among the agencies and the user community is for enhanced bathymetric data, particularly in very shallow coastal waters. These data provide the basic geospatial framework for almost all other studies and are a key component for derived products such as offshore habitat maps.

> **Recommendation 10: The fundamental reference frame data for the entire coastal zone should be collected, processed, and made available. The dynamic nature of the coastal zone requires that there should be specific plans for repeat surveys over time. The important role of qualified private survey contractors in coastal zone mapping and charting should also be acknowledged. Much of the work done by this sector is contracted by government agencies, and accordingly the prioritization and tracking of surveys can be coordinated by the body called for in Recommendation 8.**

Given the number of agencies and private-sector companies involved in coastal mapping, and their disparate missions and budget directives, it is unrealistic to expect agreement on a single, unified and prioritized national mapping initiative. While each agency has responsibility for its own mapping priorities, a strong and enforceable mechanism for tracking and coordinating existing, ongoing, and planned mapping efforts (as outlined in Recommendation 7) would increase efficiency to the point where considerably more survey work could be carried out for each dollar spent. Inconsistencies in scale and resolution for new data collection efforts could be resolved by the coastal zone coordinating body called for in Recommendation 8. After surveying agency needs, the coordinating body could determine whether the incremental value of collecting data over a larger area or in a slightly different form (e.g., at higher resolution) warrants modification of a planned surveying effort.

Severe challenges remain for those attempting to map the coastal zone. As well as the fundamental conceptual problem of reconciling terrestrial and tidal datums, there are also a number of logistical challenges, including shallow depths, waves, turbid waters, and longshore currents, that make it difficult to operate survey vessels and other equipment safely, accurately, and efficiently.

Recommendation 11: New remote sensing and in situ technologies and techniques should be developed to help fill critical data gaps at the land-water interface.

There are a number of promising new technologies and techniques:

- Integrated bathymetric/topographic lidar, multispectral, hyperspectral, and photographic imaging systems;
- Sensors deployed on autonomous underwater vehicles;
- "Opportunistic" mapping using volunteer recreational boats equipped with specialized mapping sensors approved by issuing agencies;
- Autonomous bottom-crawling vehicles;
- Improved satellite imaging capabilities; and
- Data fusion capabilities.

Continued support from funding agencies for development of coastal remote sensing tools, combined with an increased emphasis on coastal needs, will greatly accelerate the development and implementation of these critically needed technologies. The private sector can play a major role in addressing this recommendation.

Underestimation of the importance of the coastal zone threatens the well-being of the nation, and those charged with management and maintenance of this critical environment carry tremendous demands and responsibilities. In order to understand and address the effects of complex natural and anthropogenic forces in the coastal zone, a holistic multidisciplinary framework must be developed to account for the interconnectivity of processes within the system. At the base of this framework is accurate geospatial information about the locations of important features and processes, both onshore and offshore. The recommendations and strategies outlined above call for the establishment of a consistent geospatial framework and the application of innovative new acquisition, integration, and data management technologies that should allow coastal zone scientists, engineers, and managers to efficiently produce easily accessible, fully interchangeable, accurate, timely, and useful geospatial data and mapping products that seamlessly extend across the coastal zone. The recommendations also suggest simple mechanisms to enhance collaboration and cooperation among those charged with acquiring data in this complex region. These mechanisms should facilitate efficiency gains that will allow most of the nation's coastal zone to be mapped in a timely manner. While simple in concept, implementation of the suggested strategies will require a focused effort on the part of the coastal zone community. If implemented, however, the committee believes that a major step will have been taken toward assuring the long-term well-being of the coastal zone.

Note: Subsequent to the publication of this NRC study in 2004, the FGDC published multiple drafts of its National Shoreline Data Content Standard[16] referenced in Recommendation 4 above.

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[16] https://www.fgdc.gov/standards/projects/shoreline-data-content/index_html

Appendix B

The Importance of Vertical Datums, the VDatum Tool, and Shoreline Mapping

Vertical Datums[17]. Whether mapping on land, sea or from the air, the Global Positioning System (GPS) and Global Navigation Satellite System (GNSS) provide ellipsoid coordinates relative to the center of the earth. Those coordinates need to be translated into horizontal coordinates (e.g., latitude/longitude, UTM or State Plane Coordinates) and vertical coordinates need to be translated relative to a vertical datum, i.e., *a surface representing zero height*. There are several types of vertical datums relevant to Alaska coastal mapping:

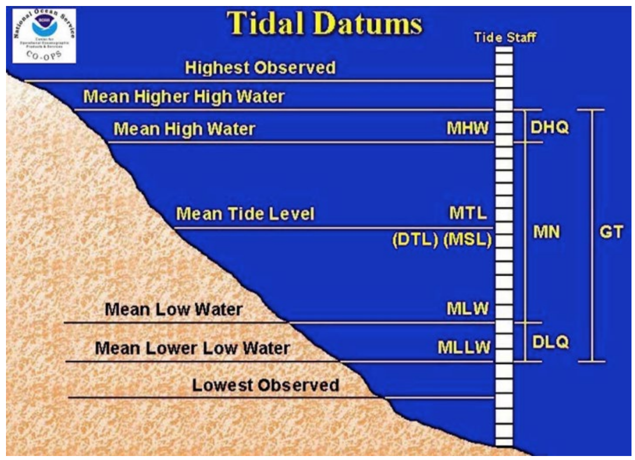

Figure 19. The relationship between various tidal surfaces.

- Tidal Datums[18]. For mapping wet areas, NOAA typically uses tidal datums as shown in Figure 19. A tidal datum is established by a tide gauge, a component of a modern water level monitoring station, fitted with sensors that record the height of the surrounding water levels. The "gold standard" for tide gauge observations is the National Water Level Observation Network (NWLON)[19] which operates continuously to the most rigorous standards. Figure 6, shown previously, provided by the Alaska Water Level Watch[20], shows major gaps in the NWLON network in Alaska, currently making it impossible to perform accurate coastal mapping for the major portions of Alaska's coasts currently unmapped. NOAA's Gaps Analysis Report[21] was used to identify these NWLON gaps. Geospatial changes in time and range of tide are used to delineate how much control a NWLON station can provide, and where there are geographic gaps between the control reach of adjacent NWLONs, there may be multiple gaps. Where there are multiple numbers in a gap, that means NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) believes there are several gaps within that area but does not have enough information to individually delineate those gaps. The HSRP was pleased to learn that CO-OPS is very supportive of and participates in the Alaska Water Level Watch (which includes the Alaska Ocean Observing System – AOOS) and their Build Out Plan. The Alaska Water Level Watch has a Build Out Plan[22] for filling these gaps with additional NWLON stations and/or less-expensive alternatives to NWLON

[17] https://www.ngs.noaa.gov/datums/vertical/
[18] https://geodesy.noaa.gov/INFO/facts/datum.shtml
[19] https://tidesandcurrents.noaa.gov/nwlon.html
[20] https://www.aoos.org/alaska-water-level-watch/
[21] https://tidesandcurrents.noaa.gov/publications/Technical_Memorandum_NOS_COOPS_0048_Updt.pdf
[22] http://arcg.is/0qqjDm

stations for which NOAA's CO-OPS has provided additional guidance[23] for tide gauges that do not need to operate continuously. This Build Out Plan includes an excellent video on the NWLON backbone. To help fill the major gaps in the NWLON stations in Alaska, NOAA should ensure adequate vertical control via short term gauges (90 days) operated to support completion of the VDatum models statewide. Comparison of long term NWLON data with short term gauges significantly reduces the uncertainty of those datums. It is imperative that the gaps shown in Figure 6 are filled by some affordable alternative to NWLON stations. In Goal 3, Objective 3.2, the HSRP introduced three innovative alternative methods for expedient tide gauge observations.

- Orthometric Datums. For mapping dry areas, USGS currently uses the North American Vertical Datum of 1988 (NAVD 88) for which *zero elevation* is based on mean sea level at a single point (Father Point/Rimouski) in Quebec. Then a level surface of equal gravity potential (the geoid) is extended throughout the U.S. to map *zero elevations* elsewhere. The geoid is an undulating surface that varies locally by changes in gravity mostly caused by local variables in the geophysical properties of the earth. NAVD 88 results in mean sea levels at other U.S. locations varying between -34 cm in Florida and +1.25 m in Washington, for example. NOAA's Gravity for the Redefinition of the American Vertical Datum (GRAV-D) program is in process of collecting gravity for all the U.S. and expects to complete the GRAV-D initiative by 2024. In the next few years (current target date is 2024), all vertical datums in the National Spatial Reference System (NSRS), including NAVD 88, will be replaced with the North American-Pacific Geopotential Datum of 2022 (NAPGD2022).

Vertical Datum Transformation Tool (VDatum)[24] NOAA developed VDatum to address the inconsistent datum problem, primarily the major differences between tidal and orthometric datums, the primary reference levels to which geospatial data are gathered.

VDatum translates geospatial data between 36 different vertical reference systems and removes the most serious impediments to data sharing, allowing for the easy transformation of elevation data from one vertical datum to another. Geospatial data can be seamlessly integrated for the benefit of the U.S. public for applications such as Homeland Security and natural disaster preparedness. VDatum also allows NOAA to make full use of recent technological advancements such as integration of depth data from an aircraft using topobathymetric lidar that will greatly improve the efficiency with which it acquires new and more accurate data for NOAA's nautical, navigational, and geospatial products and services. VDatum will also improve the efficiency and accuracy of hydrographic surveys for nautical charts by eliminating the need for time-consuming water level corrections and post processing.

[23] http://www.ioosassociation.org/sites/nfra/files/documents/boardmaterials/meetingmaterials/springmeeting2016/External_Source_Policy_22December2015.pdf

[24] https://vdatum.noaa.gov/about.html

However, because of the large gaps in the NWLON network, VDatum in Alaska only exists in the Southeast Alaska regional model, added in 2019. Future development of coverage for the remainder of Alaska will commence once foundational geodetic and tidal data are established to allow for valid model construction. This is extremely urgent because of the pending introduction of the new North American-Pacific Geopotential Datum of 2022 (NAPGD2022).

When the VDatum tool is complete for all of Alaska, advancements in the awareness of electronic charting systems and Electronic Chart Display and Information Systems (ECDIS) for the Electronic Navigational Chart (ENC) will be possible. A vessel's exact orientation in the water can be accurately determined using Differential GPS. This information can then be incorporated into the charting system along with real-time display of water depths corrected for tides for the entire body of water. Danger areas can be displayed automatically that will adjust depending on the vessels draft and water level as a vessel transits through areas of concern. This is especially important for tug barges that provide critical logistical support to coastal villages in Alaska. VDatum will also provide a tool for coastal restoration projects that require high-resolution wetland, bathymetric, and water level inundation maps.

<u>Alaska's Shoreline</u>. The NOAA Shoreline Website[25] provides the history and applications of shoreline mapping, e.g., boundary determination, shoreline change analysis, cartographic representation, and nautical chart production. Figure 20 shows how the Mean High Water (MHW) line divides privately-owned uplands from state-owned lands (or federal lands in Alaska), whereas Mean Lower Low Water (MLLW) is used as the chart datum for safety of navigation and establishes boundaries for territorial seas and the Exclusive Economic Zone (EEZ).

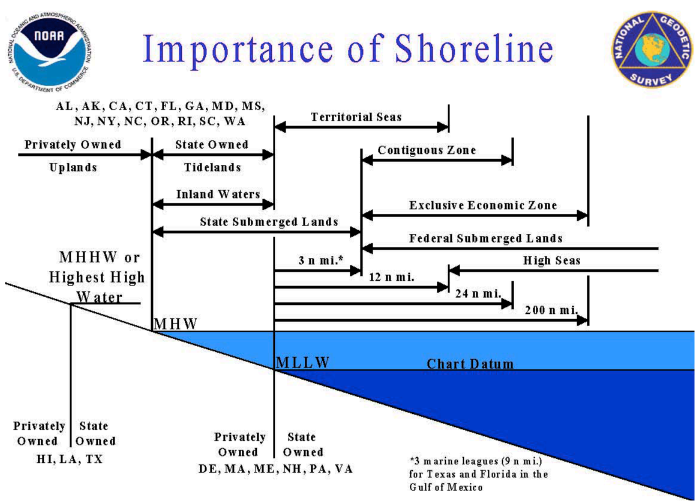

Figure 20. This graphic shows the importance of the MHW and MLLW lines in Alaska.

[25] https://shoreline.noaa.gov/

Appendix C: Public Comments for the NOAA HSRP meeting on the NOMEC and ACMS implementation plans
NOAA HSRP public meeting, September 23-24, 2020

Number of comments: 21

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1 Name: Clint Edrington, PhD Date: 9/14/2020
Organization: NOAA National Centers for Environmental Information
NOMEC/ACMS/Both: Both Goal#: 2.1 SOMP
Comments: My comment for the HSRP is in regard to ground-truthing the acoustic data to be acquired from NOMEC (and ACMS). Under Goal #2, NOMEC establishes a Standard Ocean Mapping Protocol (SOMP) for mapping the EEZ, but it appears to be entirely focused on the specifications for acquiring and managing acoustic data. From what I can see from the public "Strategy", there is no mention of ground-truthing the acoustic data as a standard or best practice in the SOMP. (NOMEC does mention ground-truthing in its Goal #3, but it is in the context of after-the-fact detailed characterizations of identified priority areas.) My belief/comment is it would be good to see some level of ground-truthing included as an integral component of the SOMP. My concern is that if ground-truthing is not done in parallel with acoustic acquisition, then some areas or regions of the EEZ, as you know is quite large, may never receive adequate ground-truthing, if anything at all, and I think the resulting "first-order maps" would be less for it. With limited resources, perhaps the existing SOMP (i.e., no ground-truthing) is the most pragmatic approach. But if possible, I believe most end users of the data would appreciate ground-truthing being integrated into the SOMP.

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2 Name: William Nye Date: 9/14/2020
Organization:
NOMEC/ACMS/Both: Both Goal#:
Comments: This responds to the NOAA/HSRP request for public comments, published in the Federal Register (85 FR 52956). You are requesting public comments for the development of the implementation plan for an ocean mapping strategy*, and the development of an implementation plan for the Alaska coastal mapping strategy**. Each strategy is published in a separate PDF document, as referenced in the Federal Register. The Alaska coastal mapping strategy states the “Coastal Mapping Subcommittee” is responsible for the “coordination and development of an implementation plan” (Alaska strategy, pg. 6). It therefore appears the subject of the Alaska implementation plan is before the wrong body. I may be overlooking something, so it would be helpful if NOAA/HRSP could clarify its role vs my observation.

Regarding the implementation plan for the ocean mapping strategy, it is stated “the Council and subordinate bodies will develop an Implementation Plan” (ocean mapping strategy, pg 7), and “The Council will solicit public comment on the components of a draft Implementation Plan . . .” (pg 8), where “council” refers to “National Ocean Mapping, Exploration, and Characterization Council”. Again, it appears the subject is before the wrong body. I may be overlooking something, so it would be helpful if NOAA/HSRP could clarify its role vs my observation. This issue is not a minor procedural detail. It should be more obvious that all public comments are reaching the right people, as directly as possible, and the right panels or subcommittees are involved.

The Federal Register notice also asked for comments on any other topics. In that regard, the Exclusive Economic Zones (EEZ), which is a subject of the ocean mapping strategy, are charted as shown in NOAA's electronic navigational charts (ENCs). NOAA has a web page where the ENC files can be downloaded, but once downloaded, the question becomes what to do with, or how to view, these specially-formatted files. It would be helpful if NOAA provided this information. Several years ago NOAA did provide a list of third party viewers, but then deleted it (see http://web.archive.org/web/20150503053021/http://www.nauticalcharts.noaa.gov/mcd/enc/resource.htm) The URL is an archive of NOAA's web page, for May 2015, and shows a list of free ENC viewers and other software. I am not clear why NOAA deleted this, and discontinued such references. NOAA talks about building public/private partnerships, but deletions like this, without any apparent reason or replacement, seems counter productive to that cause.

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3 Name: Joyce Miller Date: 9/14/2020
Organization: Former HSRP Member and Chair, University of Hawaii (ret.)
NOMEC/ACMS/Both: both Goal#:
Comments: Since the early 2000's NOAA, USGS, USACE, and other governmental agencies have held at least yearly meetings to discuss Integrated Coastal and Ocean Mapping (IOCM). Major foci early-on were to develop an application that would help to coordinate mapping missions and to create a national mapping plan. While these IOCM discussions were on-going, NOAA's Coral Reef Conservation program funded mapping of shallow (0-100m) and medium depth (100-3000 m) areas in the Pacific and the Caribbean US EEZ starting in 2001. No direct funding or input was provided by IOCM, but all data collected were provided to NOAA's Office of Coast Survey and submitted to the National Geophysical Data Center, now part of the National Center for Environmental Data (NCEI).

In 2009 the Integrated Coastal and Ocean Mapping Act (OCMIA) was passed into U.S. Law and some funds have been used to support data centers and (again) provide a national mapping plan. While collaborative IOCM projects were undertaken to provide shallow water lidar and radar mapping; very little direct IOCM funding has been provided to actually map the seafloor deeper than 100 m. Many academic research ships with functional shallow and deep-water mapping capabilities have had relatively few dedicated mapping missions in the past decade, since the OCMIA was passed, because there has been no funding.

Two NOAA groups, the Office of Coast Survey and the Ocean Exploration program, have continued their missions for charting and exploration, and the U.S. Dept. of State funded the Extended Continental Shelf program; these programs have provided invaluable publicly accessible data sets to the growing U.S. and world bathymetry maps. All of these groups have worked closely with the University of New Hampshire's Center for Coastal and Ocean Mapping/Joint Hydrographic Center (CCOM/JHC), which is, I believe, the best example of what IOCM has actually accomplished.

In the past decade groups such as the Schmidt Ocean Institute, the Nautilus Live Ocean Exploration Trust, Calladan Oceanic LLC, and Fugro have privately provided millions of dollars in free ship time and have made public access to privately collected data a high priority. The data sets collected by these groups have significantly added to the world's bathymetric data base. These programs have been highly productive and should be recognized for their significant contributions. They prove what can be accomplished if funding is made available. When the Seabed 2030 program was announced in 2017, the first phase of the program that was funded was to collect and organize data and produce an international mapping plan, while few, if any, funds have been allocated to actual seafloor mapping to date.

And now in 2020 A National Strategy for Mapping, Exploring, and Characterizing the U.S. Exclusive Economic Zone, June 2020, has been developed and published, eleven years after the OCMIA was passed. In reviewing this document, yet again I see a plan to develop a plan for mapping our EEZ, but no action or funding for actual mapping. Obviously, the point is that if there is no funding for actual mapping, we can plan for another two decades and not really accomplish that much.

There is a significant opportunity in this year of the pandemic. Many multibeam-equipped NOAA and academic ships are sitting idle or are significantly underutilized; some maintain a full ship's crew, including experienced mapping technicians. A few continue to conduct research cruises in areas that are not too distant from medical facilities, after rigorous testing and quarantine of crew and scientists for COVID-19 contamination. The National Science Foundation, the Office of Naval Research, and the University-National Oceanographic Laboratory System have worked to develop safety protocols for continuing operations on a limited basis. Looking at NOAA's U.S. Bathymetry Coverage and Gap Analysis web site, there are areas within a day or two's travel from medical facilities in the U.S. EEZ around Hawaii, Alaska, Oregon, the Gulf of Mexico, and the Caribbean that could be mapped if funding were made available.

Comments, Sept 24: There are two existing NOAA documents about mapping standards dating to 2011 and 2012 that I have sent to Lynne. Please post them for the panel. Also, HSRP asked NOAA about interagency mapping standards several years ago. Ask RDML Smith whether anything has happened. Correction. HSRP asked NOAA about interagency funding mechanisms.

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4 Name: Guy Noll Date: 9/15/2020
Organization: ESRI
NOMEC/ACMS/Both: NOMEC Goal#:
Comments: WRT the IOCM coast mapping strategy, we are actively working to create machine learning routines to automatically flag shoreline changes (change detection) and ideally extract new shoreline vectors from imagery. Combining that with the work of TCarta in SDB (Satellite Derived Bathymetry) extraction should provide a means to automate near-coastal mapping for remote areas such as the Arctic as well as improving timeliness of updates in man-made features near ports. NOAA should continue to leverage the initiative of private industry to harness the technology and provide government-wide access of these data and patterns of usage by following the Geospatial Data Act to ensure broad participation among partner agencies. Avoiding duplication of effort is critical for the value to the public as well as alignment among agencies as using authoritative sources for resolving conflict is key.

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<u>Comment, Sept 23, 2020:</u> A few more thoughts on SOMP strategy. I think the underlying challenge is defining "observation or measurement" strategies for specific use cases. A map is a product from such measurements. As with statistics, maps can mislead or even lie about their truth.

If the objective of the mapping strategy is a set of procedures through which meaningful observations are acquired, similar to what Coast Survey had to do to create effective multibeam echosounder usage, or similar to the definition of Navigational Area Limit Line (NALL) that we did after the 2002 death of AB Koss, then the map product can use those measurements to (ideally automatically) conflate the measurements to meet product specifications. For the relatively simple use case of achieving a given bathymetric resolution, the IHO has spent decades refining S-44 standard to classify observations per specific Orders of quality. I submit that their result was 'good enough' but that the underlying assumptions may need to be examined to be an effective model for the deep water corollary. In short, the chemical/physical/biological oceanographic properties of the deep water ocean are of sufficient variance that standard error analysis may be insufficient for determining uncertainty of measurement within the desired resolution.

A simple test - can a repeatable measurement be made within the requisite accuracy and resolution, and that measurement confirmed by another means at that depth? If not, then the products created by the conflated observations may not be robust enough to match the desired criteria of resolution after all error sources are considered. Another approach may be to consider the original 'Patch Test' criterion of detecting change. If no change can be determined, how do we know the measurement is correct? If we assume that the repeatable observation OVER TIME has been corrected for the aforementioned oceanic properties as well as any variance in the measurement system itself, then we have assumed a 'baseline' has been conducted. Once a baseline is achieved, then any change will be attributable to either differences in the measurement system or in differences in the environment. The latter would be of interest to the community invested in the production of the 'map', while the former would be of interest to the engineers trying to achieve a robust observation.

<u>Comment, Sept 24, 2020:</u> Perhaps the Geospatial Data Act can be leveraged by the HSRP to bring NOMEC some clarity in terms of coordination among agencies, private industry outlays, and meaningful collaboration with value identified?

<u>5</u> <u>Name:</u> David Miller <u>Date:</u> 9/15/2020
<u>Organization:</u> Fugro
<u>NOMEC/ACMS/Both</u>: NOMEC <u>Goal#:</u>
<u>Comments:</u> In response to the "notice for open public meeting, and request for public comments" related to NOAA's Hydrographic Services Review Panel that was published in the Federal Register – Volume 85 – Number 167, published on 27 August 2020, I am pleased to provide the following comment on the development of the implementation plan for the "National Strategy for Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone" (NOMEC):

The NOMEC strategy that was published in June describes itself as a strategy to map the United States EEZ, identify priority areas within the United States EEZ, explore and characterize these priority areas, leveraging the expertise and resources of multi-sector partnerships. It further states that deploying new and emerging science and technologies at scale, and doing so in partnership with private industry, academia and non-governmental organizations, are essential components of the strategy. Clearly, the NOMEC strategy is a bold and ambitious initiative that will require a "whole of nation" response. Despite this, the administration and governance that has been established by the NOMEC strategy, in part to support collaboration with non-government partners and stakeholders, does not include non-government partners and stakeholders. Membership in the new "National Ocean Mapping, Exploration, and Characterization Council" and it subordinate bodies, the new "Interagency Working Group on Ocean Exploration and Characterization" and the existing "Interagency Working Group on Ocean and Coastal Mapping" represents Federal agencies that have programmatic responsibilities and resources needed to implement the strategy.

Furthermore, these bodies are tasked with developing an Implementation Plan for the NOMEC strategy within 180-days. So, the bodies that are responsible for developing an implementation plan for a strategy that must include the deployment of new and emerging science and technologies at scale in partnership with private industry, academia and non-governmental organizations do not include these non-government stakeholders nor is it clear and obvious from the NOMEC strategy how these non-government stakeholders will be consulted or contribute to the process.

The private sector is already mapping, exploring and characterizing portions of the US EEZ on privately funded projects and the private sector is already developing and deploying new and emerging science and technologies in support of these activities. To fully leverage the resources, expertise, data, innovation and partnership opportunities that are available within the private sector to support the NOMEC strategy, there must be clear, meaningful and transparent mechanisms for engagement and collaboration in the development of the implementation. Ideally, the private sector should be a co-developer of the implementation plan and not just a provider of public comments when it is complete.

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6 Name: George Dellas Date: 9/15/2020
Organization: US Power Squadron
NOMEC/ACMS/Both: Other Goal#: N/A
Comments: I'm a member of the US Power Squadron in Naples, Florida. NOAA's mapping is commendable and most accurate for those areas with commercial shipping. Can groups like ours help out more in the areas of non-commercial shipping like Naples. Particularly in depth surveys. Can you help train and/or provide equipment for our pleasure craft so that we may take and document depths?

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7 Name: Sean Murphy Date: 9/15/2020
Organization: Business Unit Manager, Subsurface Applications, MARTAC
NOMEC/ACMS/Both: Both Goal#:

Comments: Coverage area is determined by water depth. The only thing that we can try to control is the speed in which we collect data and how many sensors are on the water. I personally believe in swarm bathymetry utilizing unmanned surface vessels. If unmanned systems are not utilized, then you still need more sensors on the water. I would try to create smaller contracts close to shore and use federal resources further out to sea. Coverage area is determined by water depth. The only thing that we can try to control is the speed in which we collect data and how many sensors are on the water. I personally believe in swarm bathymetry utilizing unmanned surface vessels. If unmanned systems are not utilized, then you still need more sensors on the water. I would try to create smaller contracts close to shore and use federal resources further out to sea.

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8 Name: Irv Leveson Date: 9/17/2020
Organization: Irv Leveson Consulting
NOMEC/ACMS/Both: Both Goal#:
Comments: The two reports are excellent but could go a little further. NOMEC could provide preliminary priorities like the Alaska report does. Both reports could use more on timetables. To what extent will some aspects of implementation in Alaska have to wait for completion of the new NSRS? Should the islands strategically closest to China be done first and quickly in view of China's territorial expansionism? Is that already covered in confidential DoD documents and is it accepted federal policy? Does its immediacy outweigh the importance of moving quickly on Alaska?

There may be a need for immediate action on a "Plan to Make a Plan" which sits between the strategy and a detailed plan and says more about responsibilities. There is a risk that what's everyone's business is no one's business or that because of inertia nothing happens until the next Administration and/or Congress gets around to it.

Comment, Sept 24, 2020:
The U.S. may get a large scale infrastructure program in as little as 6 months. While NOAA appropriately take a long view, especially in view of program implementation times and technology lead times, enough work should be done early on phasing so infrastructure funds can be utilized. NOAA should be ready to articulate the benefits of the early phases in terms of higher paying jobs, safety and the environment. It also should make clear that such efforts bring longer term environmental benefits closer. The role of the two programs in relation to each other should also be addressed. NOAA wouldn't want to be blindsided by emphasizing Alaska while a nations security decision targets the Pacific. Regarding technology, I agree that most of the information about what is coming can be obtained from industry, what else can be learned from efforts of other nations' agencies and what mechanisms can be employed for that?

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9 Name: Helen Brohl Date: 9/21/2020
Organization: Chair, CMTS
NOMEC/ACMS/Both: Both Goal#:
Comments: Mr. Chairman and members of the HSRP:
Thank you for the opportunity to provide brief comments during the Fall 2020 Hydrographic Services Review Panel (HSRP) meeting at which you will discuss, among other items, recommendations on the development of the implementation plans for the two ocean and coastal mapping strategies.

CMTS members have been directly engaged in the development of these plans for which the Committee is very supportive. In particular, the September 2019 report by the CMTS entitled, "Ten Year Projection of Vessel Activity in the U.S. Arctic Region: 2020-2030," noted that, in the last decade, the number of vessels operating in waters north of the Bering Strait around the Chukchi and Beaufort Seas has increased by 128% and is now 2.3 times larger than the number of ships passing through the region in 2008. Further, despite limited growth in the total number of ships using these waters during the 2015–2017 period [after Shell Oil discontinued oil exploration], the length of the navigation season has been growing by as much as 7–10 days each year. Extrapolated out over the next decade, the navigation season in and around the Bering Strait may extend 2.5 months longer than present, potentially upending the region's highly seasonal navigation. The CMTS recognizes the value of enhancing coastal mapping in Alaska, particularly to support this growing vessel traffic. [https://www.cmts.gov/downloads/CMTS_2019_Arctic_Vessel_Projection_Report.pdf].

As a Federal interdepartmental maritime policy coordinating committee, the CMTS is directed to improve the Nation's marine transportation system (MTS) through interagency engagement. RDML Timothy Gallaudet, Commerce Assistant Secretary for Oceans and Atmosphere and Deputy Administrator of the National Oceanic and Atmospheric Administration (NOAA) is the most recent past chair of the CMTS Coordinating Board and emphasized the importance of the Blue Economy and the role of marine transportation into the CMTS work plan. Much of the subject matter expertise to the CMTS from NOAA resides within the National Ocean Service, including in the Office of Coast Survey and Center for Operational Oceanographic Products. We recognize the complementary nature of the National Ocean Mapping, Exploration, and Characterizing the U.S. Economic Zone (NOMEC) and the Alaska Coastal Mapping Strategy (ACMS) to the existing NOS programs and simply ask that these new initiatives not overshadow the reliance of the MTS on the foundational mapping, charting, observing programs.

NOAA NOS programs are but one of the Federal agencies providing real-time navigation services to the MTS. For example, the CMTS Future of Navigation Integrated Action Team (FutureNav IAT) which is co-led by NOAA, the U.S. Coast Guard, and U.S. Army Corps of Engineers, is engaged in very exciting and forward thinking work to advance navigation safety and security. The team recently held a navigation data interoperability roundtable with agency information and data officers in order to further the efficiency to share data amongst agencies in a manner that will, ultimately, make it more available and discoverable to stakeholders. In particular, the CMTS members are enthusiastic about the future of NOAA's Precision Navigation, while supporting all of the routine survey, charting, observing, and response programs of the navigation service agencies. It is a very successful and interdependent partnership within the Federal government.

In summary, we are very pleased and supportive of the progress made to develop implementation plans for the NOMEC and ACMS and suggest that the HSRP may want to also recognize the foundational navigation service programs in support of a safer and stronger marine transportation system. Please let me know if I can provide additional information. Helen Brohl, Executive Director

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10 Name: Joseph Zhang Date: 9/21/2020
Organization: Virginia Institute of Marine Science
NOMEC/ACMS/Both: Both Goal#:
Comments: Summary of my research and advisory work:

We have been working with multiple agencies in this country (NOAA, EPA, DOE, state governments) and overseas (e.g. Central Weather Bureau, Taiwan; Helmholtz-Zentrum Geesthacht, Germany) in various studies of coastal ocean, estuaries, rivers/lakes and watersheds around the world. Bathymetry and topography information is fundamental in all of our work and we have been actively using various DEM (digital elevation model) sources from OCS, e.g. CUDEM, NCEI's lidar data etc. Since most of our work focuses on seamless cross-scale ('basin to creek') studies that cover both nearshore (0-40m) and offshore (40-200 m and beyond), we are in constant need of seamless bathy-topo DEMs that are built on consistent vertical datums. We are heartened to see multiple agencies actively supporting this important effort to close the knowledge gap by seamlessly mapping the sea floor from shoreline to deep ocean, e.g., as part of "a National Strategy for Mapping, Exploring, and Characterizing the U.S. Exclusive Economic Zone" as mentioned in NOMEC.

Why is bathymetry so important? While the information for topography has been greatly improved over the past decades due to the emergence of advanced aerial survey technology, the same cannot be said of the bathymetry, especially at nearshore locations. For example, we have been working on the Chesapeake Bay system for the past 20 years, and even today we are still badly in need of updated and more accurate bathymetry in parts of the main Bay and most tributaries. On the other hand, our studies strongly demonstrated the critical need for very accurate bathymetry, a view echoed by many participants of a NSF sponsored workshop (Fringer et al. 2019). For example, Ye et al. (2019), Nunez et al. (2020) and Cai et al. (2020) convincingly demonstrated that the bathymetry is the first order and perhaps the most important forcing in nearshore processes and small uncertainties in it can result in system-wide responses for major physical and biological variables, including the surface elevation and 3D currents. Our estimate suggests a smaller tolerance on the order of 1cm or less for the bathymetry errors is required in depths of 0-10m. The recent advances in the modeling technology have further underscored this need: in particular, we are at the stage where the next-generation models are now capable of very faithfully resolving the nearshore bathymetry with little compromise (Zhang et al. 2016). In summary, a full coverage of bathymetry from shoreline to deep ocean, with higher accuracy nearshore will greatly reduce the uncertainties in many coastal studies.

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11 Name: Molly McCammon Date: 9/22/2020
Organization: Alaska Ocean Observing System
NOMEC/ACMS/Both: ACMS Goal#:
Comments: First, I appreciate the opportunity to provide comments and apologize for the delay in submitting these comments to you. Second, I want to congratulate you on your thoughtful review of Alaska's Coastal Mapping Strategy and recommendations for development of the strategy's Implementation Plan. AOOS is pleased to have participated in development of the Strategy, as well as more than a year's effort with NOAA and the Alaska Department of Natural Resources in working with stakeholders to prioritize and identify priorities for mapping needs in advance. With a consortium of funders, we are currently supporting the Alaska Coastal Mapping Strategist position.

Coastal mapping is one of the key components of an overall strategy to respond to Coastal Hazards in Alaska, and in particular coastal storms, flooding, and erosion. AOOS hopes in the next two years to collaborate with our federal, state, and tribal partners to revisit the recommendations developed in a 2012 coastal hazard workshop. In the meantime, AOOS is continuing to prioritize increased collection of water level data, especially for western and northern Alaska, and pilot alternative means of collecting coastal bathymetry.

We appreciate the recognition of the Alaska Water Level Watch, a collaborative working group co-founded by AOOS with state and federal partners in your recommendations under Objective 2.2. The AWLW annually reviews gaps and priorities. The latest draft guidance document that you reference will soon be reviewed by the AWLW Steering Committee for final action and available on the AWLW website: https://aoos.org/alaska-water-level-watch/. The document identifies the need for both water level data for flood risk assessments and modeling, as well as for establishing tidal datums.

AOOS has been piloting the use of GNSS reflectometry, largely funded by the National Weather Service Alaska Region, for the past four years with sites operating at St. Michael, Alaska (AT01), and a new site planned at Utqiagvik (delayed one year due to covid-19 travel restrictions). Your recognition of the value of this technology is welcome and could be enhanced by referencing its current use at AT01 as an example. AOOS was chosen by NWS to develop these pilot efforts because of our ability to pool funds from multiple sources (federal, state, private, etc.) over multiple fiscal years. Non-governmental entities such as AOOS should be looked to as key partners in development and execution of future implementation activities related to Alaska's coastal strategy.

Regarding use of single-beam sonar systems for collection of nearshore bathymetry, we note your recommendations regarding the use of unmanned systems to complement traditional hydrographic surveys. However, your recommendations should also note the piloting by AOOS and the Alaska Department of Natural Resources, and NOAA's Office of Coast Survey of the Hydroball, a small (28 pounds), fully autonomous buoy that includes a single beam echosounder, a GNSS receiver, and a digital compass, and can be either moored, towed, or drifted. Testing of this technology was expected to occur in summer 2020 but has been delayed due to covid-19 travel restrictions. However, based on its usage in Canada, we are optimistic that it holds promise for meeting needs of nearshore bathymetry, especially at the mouths of frequently-changing rivers, while also leveraging the capacity of local workforces in Alaska. Again, AOOS – along with our state and federal partners - is being used to help pilot this technology because of our ability to pool funds over multiple fiscal years.

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12 Name: Denis Hains Date: 9/23/2020
Organization: H2i
NOMEC/ACMS/Both: NOMEC Goal#:
Comments: Thank you to NOAA for this open and transparent process, allowing public comments & suggestions via the "Hydrographic Services Review Panel (HSRP)" on September 23-24, 2020 Webinar. All this, in order to complement, clarify and improve the important "National Strategy for Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone (NOMEC)". Here 2 suggested changes to integrate to the NOMEC plans to represent the scope of "Hydrospatial" challenges:
In the NOMEC Summary, it is mentioned for the implementation plans: …" two ocean and Coastal strategy"… It is suggested to reframe and modify this high level statement to be more open and inclusive by stating specifically as: …"three ocean, the Great Lakes and Coastal strategy"… where the third ocean is the challenging Arctic ocean…
Due to the multinational impacts of NOMEC implementation plans; it is suggested as being very important to name specifically the essential international collaborations needed with neighbouring countries to NOMEC by identifying and naming all of them: Canada, Mexico, Russia, Caribbeans countries, and others…

Comment, Sept 24, 2020: Public Comments on NOMEC:

(1) If it has not been clarified in writhing in the Presidential Memorandum on NOMEC yet; it shall be stressed and written down officially that NOAA-NOS has the LEAD role and the ACCOUNTABILITY for funds distribution and the delivery of outcomes and outputs of the whole NOMEC program, through US Federal Agencies and Departments;
(2) It is important to make sure that Capacity Building Strategy be developed through means such as: Crowd-Sourced Bathymetry; and by transfer of traditional knowledge take place with aboriginal communities of the Alaska Coast and remote communities everywhere in US to mobilize and engage all in strategic alliances.

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13 Name: Robert A. McConnaughey Date: 9/23/2020
Organization: Research Fishery Biologist, Alaska Fisheries Science Center, NOAA Fisheries
NOMEC/ACMS/Both: Both Goal#:
Comments: There are multiple and dissimilar societal needs for NOMEC mapping. How will these different needs be prioritized, and translated into an operational sequence? Thank you.

I am a fishery biologist with the NMFS Alaska Fisheries Science Center. My specialty is habitat science. Earlier discussion has addressed the regional prioritization challenge – with my question, I would like to take the conversation one level higher. I led the NMFS team that identified and prioritized areas for mapping under NOMEC. To do this, we surveyed all our scientists and managers and, as you can imagine, the result was a complicated mix of requirements and justifications ("just" for AK fisheries).

My question: The Presidential Memorandum identifies multiple societal needs (security, minerals, navigation, fisheries, etc.) from a national perspective. How will these different needs (not regions/sites) be prioritized and translated into an operational sequence (considering Security vs Minerals vs Navigation vs Fish etc.)?

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14 Name: Eric Fischer Date: 9/23/2020
Organization: Oceaneering
NOMEC/ACMS/Both: Both Goal#:
Comments: I am really enjoying this webinar and have a few questions:
Will NOAA be looking to additional industry contractors to meet the mapping goals for the National Mapping Plan? If so would those work through IDIQ type contracting vehicles?

Will NOAA be integrating bathymetry data collected from BOEM permitted survey activities to add to this? With the increase in surveys for Offshore Wind farms on the US Atlantic coast, and potentially Pacific as well, this could be a large addition to the data set.

With new offshore wind farm development, is NOAA and NGS looking to have operators required to install some CO-OPS and CORS stations on offshore structures to provide additional coverage out to 60m water depths? These can also be used to increase accuracy of weather reporting (GPS Meteorology), provide a network of improved positioning for hydrographic and geophysical surveys (Network RTK), and to monitor any seafloor movement of structures over time.

How do any NMFS permitting requirements affect national mapping plans? This may impact the ability of opportunistic mapping (from UNOLS vessels in transit for example).

Comment, Sept 24, 2020: Would NOAA consider leading a Joint Chiefs of Staff type organization? With leaders from NOAA OCS, NGS, USGS, BOEM, USCG, Navy, etc to share information, data, funding and priorities. With each organization still maintaining is own operations, public/private and academic relationships.

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15 Name: Vicki Ferrini Date: 9/23/2020
Organization: Lamont Doherty / SEABED 2030
NOMEC/ACMS/Both: Both Goal#:
Comments: The federal investment in mapping technology for the US Academic Research Fleet, coupled with investments in developing a coordinated approach for best practices, calibration and operations (MAC, http://mac.unols.org), a fleet-wide solution for data management (R2R, http://www.rvdata.us), and data synthesis efforts (GMRT, https://www.gmrt.org), have resulted in the creation of high quality bathymetry data for vast areas of the global ocean. These data are the bulk of publicly available data in the NOAA/NCEI multibeam archive and contribute significantly to the Gap Analysis. These investments have positioned the academic community well for contributing to the goals of mapping and characterizing the US EEZ - particularly in deep water.

Increasing coordination will ensure that we leverage assets, experience, knowledge and technical solutions that can help us accelerate toward mapping and characterizing the US EEZ. The GMRT (Global Multi-Resolution Topography) is a global data synthesis, an architecture for storing and managing data, an infrastructure for data access, and an approach for QA/QC of data. Recognizing the need to accelerate toward the goal of global ocean mapping, we are currently working to adapt our tools and workflows so we can increase the rate of data ingestion and product creation. We anticipate that these tools can be used by other mapping specialists and hopefully can be integrated into training programs to engage students in the process of creating data products for deep water environments. These tools offer a common solution for (1) baseline gridding, visualizing and assessing data to ensure that data acquired, even during transits, meet data quality standards based on existing high quality data, (2) accelerating the rate of data integration into a publicly available bathymetry data compilation while (3) minimizing the need for reprocessing and versioning of processed swath data files made available through the NOAA/NCEI archive.

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16 Name: Rada Khadjinova Date: 9/24/2020
Organization: Fugro USA, Inc., Area Manager-Alaska
NOMEC/ACMS/Both: ACMS Goal#:
Comments: In response to the "notice for open public meeting, and request for public comments," related to NOAA's Hydrographic Services Review Panel published in the Federal Register, I am pleased to provide the following comment related to Strategy to Map the Coast of Alaska. Fugro has been performing project work in Alaska since the 1970s. We know firsthand the geospatial data deficiencies that exist in the state, particularly on the coast where activities of public, commercial, recreational, and indigenous users intersect. That's why Fugro has advocated for the creation of an Alaska coastal mapping program for the last eight years. We are encouraged to see progress on this issue since the release of the November 2019 Presidential Memorandum and appreciate the HSRP's work feeding into the Alaska Coastal Mapping strategy and its future implementation.

The current focus of the Alaska Coastal Mapping Strategy is on those areas that can be mapped with airborne and satellite remote sensing technologies. This is a sensible first step. In areas where airborne and satellite methods prove unfeasible due to water clarity, shallow-water acoustic bathymetry techniques will need to be used. This work, which mirrors NOAA OCS hydrographic surveys, could amount to two-thirds of the state by current predictions.

Since the Alaska Coastal Mapping Strategy does not yet account for these areas, which fall under the purview of the National Strategy for Mapping, Exploring, and Characterizing the US EEZ, the effort may be managed through two separate coastal mapping programs. From our experience in the US and abroad, this approach is inefficient. Moreover, because water clarity changes spatially and temporally, it is difficult to predict in advance with (with a high degree of certainty) when and where airborne and remote sensing methods will work.

That's why we believe a highly integrated and flexible approach that combines airborne and satellite remote sensing with shallow water acoustic bathymetry will prove more efficient and cost effective than two separately executed and managed strategies. The Alaska Coastal Mapping strategy also calls for collaboration and coordination with the private sector and leveraging partnerships to ensure program success. Of particular importance is the incorporation of new technologies to achieve acquisition efficiencies.

The private sector, including Fugro, is already mapping coastal areas of other states. Fugro is also developing and using new, cutting-edge technologies in the realm of communication, sensors, platforms, and data processing to support these activities. To fully leverage the resources, expertise, innovation and partnership potential that is available through the private sector, there must be clear, meaningful, and transparent mechanisms for engagement and collaboration during the remaining development of future implementation of the Alaska Coastal Mapping Strategy. The private sector appreciates having a larger role beyond providing comments.

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17 Name: Alice Doyle Date: 9/24/2020
Organization: UNOLS Deputy Executive Secretary
NOMEC/ACMS/Both: Both Goal#:
Comments: The federal agencies have invested significant funding to the US Academic Research Fleet's (ARF) deep water mapping capabilities making them exceeding capable platforms. They are managed within a proven framework that optimizes multi-agency collaboration for everything from vessel scheduling to instrumentation and data management to technical support. As Vicki Ferrini mentioned yesterday, successful data-focused ARF programs like Rolling Deck to Repository (R2R) and the Multibeam Advisory Committee (MAC) have proven the fleet-approach can greatly improve the quality and accessibility of the data. Due to these programs and capabilities, the ARF vessels have collected the majority of the publicly accessible multibeam data that currently reside in the NOAA/NCEI archive.

As Larry Mayer mentioned yesterday, the coordination of the NOMEC initiative is an intimidating task. UNOLS and the ARF look forward to working closely with NOAA to find synergies, with both the data quality/management aspects and the mapping/characterizing aspects, to leverage the ARF's expertise to assist in this initiative."

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18 Name: Kyle Goodrich Date: 9/24/2020

Organization: President & Founder TCarta Marine LLC
NOMEC/ACMS/Both: Both, other Goal#:
Comments: TCarta Marine is a 15-person small business based in Denver, CO specializing in marine remote sensing and Satellite Derived Bathymetry, awardees of a Phase 2 National Science Foundation SBIR grant; we are seen as global innovators in the field. We are a WOSB, HUBZone certified and on several US Gov IDIQ geoservices contracts as a subcontractor, yet still we face an utter struggle working with the US government.

In order to work with the agencies on the contractual side, we have had to work as a subcontractor to a Prime. This then prevents direct and efficient communication and specification discussion between TCarta and the US government. All the while time, technology and payroll march on. TCarta has had an easier time working with the British and other international governments, not due to contractual vehicles but due to the U.S government's non-pragmatic approach when it comes to utilization of our satellite based remote sensing product, often relegating it to a research product or at the bottom of the priority pile.

TCarta has invested considerably in technology development, business relationships with vital imagery suppliers and countless hours forging into the US federal government with nascent technologies as a small business over the past 5 years. We have made inroads and gained technical approval at NOAA, NGA, and US Navy and on many levels we see and hear of a tremendous need and interest in utilizing our capabilities. Yet, in each case, we encounter obstacles that take months, even years to overcome, including lack of access to these entities, government SMEs who will not engage with TCarta, and pointing to other agencies as the true technical gatekeepers of this technology.

Each of the Federal agencies with hydrography in their remit, NOAA, NGA, USACE and US Navy, have all evaluated our data, requested proposals, run pilot projects, received countless technical briefings, yet will not make a pragmatic decision to use industry to produce these data and seem to maintain a "developed-only-by-the government" approach, contrary to all things we hear at conferences and committee meetings TCarta attends. From TCarta's experience, this message of partnering with small business and fostering industry partnership is stated at the high level but not evidenced on the ground level.

Since 2018, the NSF has awarded TCarta nearly $1M in grant funding to pursue these hydrographic technologies; international governments and hydrographic organizations have taken up the resulting products, all while we wait for the various US agencies to evaluate our data and work through legacy in-house government technology or perspectives. Commercial, high resolution satellite imagery providers, which are vital for the success of this technology, will not continue to support Satellite Derived Bathymetry if the US government continues to drag its feet in how - or if - they will use it beyond an esoteric research topic.

TCarta has developed technologies, workflows and experience required to do the work. We can contribute to the national bathymetric surveying effort and complete vast areas of essential coverage. There is no Covid in space, satellites are still operating and TCarta can contribute significantly to the national bathymetry mapping effort while other technologies are idled. I am sitting here in front of the first use of SDB on a NOAA nautical chart, published in 2012. This map has been a target, an ambition for TCarta - to be a supplier for NOAA. This map is evidence that the POC was established by NOAA years ago to use SDB, and this should have paved the way for establishing protocols for commercial providers. Technology has evolved by orders of magnitude since 2012, yet NOAA's acceptance and implementation of this technology from commercial providers has not progressed.

In order to foster small business relationships, government must work faster to meet both the pace of technology development and the operational cadence of small business which, by their nature, must be nimble and quick to solutions and end product delivery. Small business and emerging marine technologies: this is the place where pragmatic, fit-for-purpose solutions are designed and engineered. Government research should be focused on how to work with these solutions, not prevent them through indecision and inaction.

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19 Name: Geoff Douglass; John Houston Date: 9/24/2020
Organization: Founder & CEO, Mythos-AI; Founder & CTO
NOMEC/ACMS/Both: Both, other Goal#:
Comments: The founders of Mythos AI have managed autonomous surface vehicle (ASV) programs and the self-driving car autonomy development for Uber, Lyft, and Argo-AI (Ford and Volkswagen). Mythos AI's developers apply state-of-the-art self-driving car technologies to create robust, scalable autonomous solutions for the maritime sector. At Mythos AI we are developing a next generation autonomy framework we believe will revolutionize the hydrographic industry by enabling the adoption of advanced machine learning and true automation in the sector.

Our ambition is to create the first autonomy framework vertically integrated from the ground up focusing on hydrography and coastal survey. We have confidence our technology will solve many of the challenges associated with hydrographic workflow. Our plan is to use this technology to gather and provide data more efficiently than current technologies allow. Given this business model the government is one of our largest customers. As a tech start up we find it difficult to obtain and leverage government funding in the hydrographic technologies and services space. The contracting process is burdensome and can span over several months. We could partner with research institutions, but may have to share some of our IP. It would be very helpful for tech startups developing enabling technologies in this space, to have efficient access to funding.

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20 Name: Jessica Podoski Date: 9/24/2020
Organization: USACE Honolulu District
NOMEC/ACMS/Both: Other Goal#:
Comments: Aloha! Jessica Podoski from USACE Honolulu District. I would like to bring the panel's attention to a specific data collection need in the US territory of American Samoa. Bathy data has recently been collected in other US territories of Guam/CNMI, but not American Samoa. This is a need for many reasons one of which is that subsidence of the islands is causing extreme Sea Level Rise and continued coastal inundation. Bathy data (LiDAR) would work well (clear water) here, and data would help to evaluate SLR vulnerability. It is a heavy lift logistics/cost wise, but perhaps there is an opportunity for USACE and NOAA to collaborate on cost/implementation. Thank you

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21 Name: Capt. Jorge Viso Date: 9/25/2020
Organization: President,American Pilots' Association
NOMEC/ACMS/Both: Both Goal#:
Comments: On behalf of the American Pilots' Association (APA), I am pleased to submit these comments in response to the NOAA's call for input on the following topics: (1) NOMEC or "Establishing a National Strategy for Mapping, Exploring, and Characterizing the U.S. Exclusive Economic Zone, June 2020"; and (2) ACMS or "A Strategy for Mapping the Arctic and Sub-Arctic Shoreline and Near shore of Alaska, June 2020."

APA has been the national association of the piloting profession since 1884. Virtually all of the more than 1,200 state-licensed pilots working in the 24 coastal states, as well as all of the U.S. registered pilots operating in the Great Lakes system under authorization by the Coast Guard, belong to APA member pilot groups. These pilots handle well over 90 percent of large ocean-going vessels moving in international trade in the waterways of the United States. The role and official responsibility of these pilots is to protect the safety of navigation and the marine environment in the waters for which they are licensed. As a result, APA and our member pilots take a keen interest in many National Ocean Service (NOS) and Office of Coast Survey (OCS) products and services and has advocated that Congress ensure these products and services are adequately authorized and funded.

While we recognize the benefits NOMEC and ACMS can provide and can support NOAA's efforts in these areas, our principal concern is that NOMEC and ACMS not detract – in either focus or funding – from other important NO support and assist marine pilots in their vital work. Pilots rely upon and strongly support NOAA programs that provide surveys, charting and real-time data that help pilots ensure the safe, environmentally responsible and efficient transport of maritime commerce in U.S. waters. For example, OCS conducts hydrographic surveys and maintains nautical charts, including Electronic Navigational Charts (ENC), covering 95,000 miles of shoreline of U.S. coasts and the Great Lakes. In order to carry out their duties, pilots use the most modern maritime navigation technology, including their carry aboard Portable Pilot Units (PPU), and rely heavily on port and near coastal surveys and ENCs. In addition, NOS's Physical Oceanographic Real-Time System (PORTS) provides trusted inputs to PPUs on port-specific hydrographic and meteorological conditions and is therefore critically important to pilots around the country. Regardless of any new or emerging mission area, NOAA must ensure that these products and services are appropriately prioritized and budgeted.

Again, APA supports NOAA exploring strategies to better survey and map areas of the U.S. EEZ and arctic and subarctic waters, but only to the extent these priorities do not divert attention and badly needed funding away from other, more traditional products and services that directly support navigation and pilotage in ports, harbors and approaches around the U.S. If these two strategies are to be pursued, they should be adequately funded beyond the current NOAA, NOS and OCS budgets.

APA appreciates the opportunity to offer constructive comments on NOMEC and ACMS, and most importantly on NOAA's important products and services that assist APA and our member pilot groups in providing safe, efficient, modern and reliable pilotage services.
