Proceedings of the
2022 Mid-Atlantic Marine Heavy Mineral Sands Forum

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2022 Mid-Atlantic Marine Heavy Mineral Sands Forum

ABSTRACT

The Virginia Department of Energy (Virginia Energy) hosted the 2022 Mid-Atlantic Marine Heavy Mineral Sands Forum on March 31, 2022. Virginia Energy and the United States Bureau of Ocean Energy Management (U.S. BOEM) co-sponsored the event. The idea and purpose for the forum was originally conceived as an information gathering activity to support Virginia Energy's Cooperative Agreement with BOEM, *M21AC00010 - Analysis of Critical and Strategic Mineral Recovery from Sand Used for Beach Nourishment*. The virtual forum was open to the public and included sixteen invited speakers. This proceedings document serves as partial fulfillment of Virginia Energy's commitment under the Cooperative Agreement.

The virtual forum began at 9:00 am Eastern Standard Time (EST) with a brief description of meeting logistics by the moderator, Christina Wood-Smith (Virginia Energy). William Lassetter (Virginia Energy, Economic Geology Projects Manager) provided an overview of the major goals and objectives for the forum. Jeffrey Waldner (BOEM, Project Officer) provided a brief introduction and opening comments on behalf of BOEM. A total of 74 registered participants including scientists, regulators, consultants, representatives of non-profit organizations, and other stakeholders heard prepared presentations and engaged in open discussions on the capacity of extracting heavy minerals containing critical commodities from marine sand deposits. An important objective of the forum was to examine the viability, costs, and benefits of extracting mineral resources as an integral part of coastal resiliency improvement projects under the current regulatory, permitting, and environmental framework. Marine sand deposits containing domestic sources of critical minerals could help achieve the goals of Federal Executive Order 13817 ([1]2017) to ensure secure and reliable supplies of materials that are vital to the Nation's security and economic prosperity.

Organizers arranged the forum into five sessions with common themes. Presenters provided an overview of critical commodities and heavy minerals in placer deposits, with examples from domestic and global mining operations. BOEM presented an overview of the federal marine minerals leasing program and regulatory framework. The City of Virginia Beach Public Works Coastal Engineering Section provided a history of beach nourishment activities in Virginia Beach, with details on specifications for beach sand and source areas. Several state agencies provided insight into the permitting and regulatory processes for mineral mining and coastal resources. Before the lunch break, breakout group discussions evaluated hypothetical scenarios for offshore and onshore mineral extraction. The last two sessions of the day included an overview of federal and Virginia environmental policies applicable to marine minerals, and current methods and techniques utilized to assess heavy minerals. The forum concluded at 3:45 pm EST.

1: Exec. Order No. 13817, 82 FR 60835 (2017). https://www.govinfo.gov/content/pkg/FR-2017-12-26/pdf/2017-27899.pdf.

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PRESENTATION SUMMARIES

Introduction and statement of purpose for the Mid-Atlantic Marine Heavy Mineral Sands Forum

Presenter affiliation: Economic Geology Projects Manager, Virginia Department of Energy, william.lassetter@energy.virginia.gov

(William Lassetter provided the following transcript)

Good morning, I am William Lassetter, the Economic Geology Projects Manager for the Virginia Department of Energy, Geology and Mineral Resources Program. The program serves as the state geological survey.

I want to start by thanking the Bureau of Ocean Energy Management (BOEM) for supporting our continuing partnership in offshore sand and heavy mineral assessments, and supporting this forum.

Since you have taken the time to join today, you are probably aware of the current interest in critical mineral commodities, and the imperative of federal government agencies that oversee our nation's natural resources to better understand where domestic resources are located. The possibility that modern seafloor sand deposits along the eastern coastline and the Atlantic Ocean continental shelf, might contain some of these critical minerals underpins what we will be discussing in the forum today. That these resources might be extracted as an integrated operation associated with existing programs dredging large volumes of offshore sand for beach restoration is also a key factor.

As a brief refresher, the U.S. Department of Interior published a list of critical minerals in 2018 that was subsequently revised in 2022 to include 50 mineral commodities (mostly elements). These commodities include non-fuel minerals that are considered essential to our nation's economy and national security. For most of these, the U.S. is heavily reliant on foreign imports and the supply chains are vulnerable to disruption. As far as we are aware, there has never been significant commercial recovery of economic or critical minerals from sand deposits on the Mid-Atlantic Continental Shelf in the past. Thus an opportunity awaits.

Our purpose today is to gather information that will inform a feasibility study for the recovery of marine economic critical minerals. Beach renourishment using suitable sand resources from the continental shelf has been conducted for several decades, and expected to continue to be an important tool for sustaining our coastlines that are subject to erosion and loss of beach resources.

Our plan for today:

In session 1, we will lay the foundation for why and how we should seriously consider the economic value of extracting critical minerals, conducted as an activity offshore during the dredging operation, or perhaps onshore when the sand material is delivered to the beach. We will hear about operations in other countries around the globe; and get an inside-the-industry perspective on heavy mineral recovery operations. The economic view is only part of the story. There are environmental and public safety considerations, regulatory requirements, and a wide range of competing interests in the offshore region that are equally important.

In session 2, we will hear about BOEM's federal marine minerals leasing program, followed by a review of the practical applications of OCS sand along the Virginia Beach – Sandbridge Beach coastline. This will be followed by a short combined break and open discussion period, and during this and all the discussion sessions today, we would like to address any questions that arise during the preceding talks.

In Session 3, our invited speakers will describe the current state permitting and regulatory requirements in Virginia, Maryland, North Carolina, and South Carolina. This will be a key session in identifying possible issues and concerns for a potentially new offshore industry that may take place in state or federal waters. Again, this will be followed by a quick break and discussion session that will lead into two breakout sessions in which we will consider a couple of hypotheticals.

We plan to break for lunch at 12:30, leave the virtual streaming platform open, and reconvene around 1:30 pm.

In Session 4, our invited speakers will provide insight on current environmental standards and best practices, and the scope of issues and concerns that are important to stakeholders in the marine and coastal environment. Again followed by an open discussion during which time we would like to address any questions and concerns.

In our final session 5, scheduled to begin at 2:30, we are going to pivot our focus to speakers describing key tools that are being used now to search for, identify and characterize critical mineral occurrences and ultimately economic deposits. Our invited speakers have expert knowledge concerning the importance of extending good geologic map coverage from the terrestrial sources of heavy minerals to the marine environment, state-of-the-art geochemical and mineralogical analytical techniques, and geophysical methods for identifying potential resources.

We have organized the forum to include a lot of time for discussions, Q&A, gathering and recording comments and suggestions. During all the discussion sessions we would like to address any questions that arise during the preceding talks. We ask that you hold questions till that period, and also post them using the chat box so that we can record them and make sure they are addressed.

This will include documenting what are bound to be many uncertainties that will need to be evaluated. Each discussion will start off with a quick poll using the poll box in the lower right corner, the results of this will be posted within a minute or so, so as to stimulate the following discussion. Our plan is to compile a written proceedings of the forum, published as a publication or open-file report from our department, made available from our web store.

Finally, special thanks to all the invited speakers who agreed to give presentations covering many of the concerns and issues that deserve full and careful consideration as part of the feasibility study.

<u>Session 1: Marine mineral sands – feasibility of extracting critical mineral resources</u>

LASSETTER, W.L. – Marine mineral sands on Virginia's Outer Continental Shelf (OCS) – The case for extracting critical minerals as part of beach restoration projects (WLassetter.pdf)

Presenter affiliation: Economic Geology Projects Manager, Virginia Department of Energy, william.lassetter@energy.virginia.gov

(William Lassetter provided the following abstract)

Since the mid-1980s, Virginia's state geological survey (Department of Energy, Geology and Mineral Resources Program) has worked collaboratively with the U.S. Bureau of Ocean Energy Management, the U.S. Geological Survey, and the Virginia Institute of Marine Science at the College of William and Mary to assess marine sand resources on the continental shelf. Reconnaissance survey cruises have collected subbottom seismic profiles, side-scan sonar images of the seafloor, vibracores, and seafloor sediment samples for the analysis of grain size characteristics and mineral compositions. To date, substantial deposits of clean, fine- to medium-grained sand have been identified in two main areas: (1) in shoal and sheeted sand deposits located offshore of Assateague and Wallops Islands, and (2) shoal deposits located about 5 kilometers offshore of the community of Sandbridge. These deposits occur within 10 feet of the subbottom at shallow water depths of less than 60 feet, and are accessible by marine dredging operations for use as beach nourishment sand. In addition to providing resources for future shoreline protection projects, these sand deposits contain heavy minerals including ilmenite, zircon, rutile, and monazite, among others that are potential sources of critical mineral commodities such as titanium (Ti), zirconium (Zr), and rare earth elements (REE).

A capacity assessment study is presently underway evaluating alternative methodologies for recovering economic heavy minerals in marine sands. Three main goals of the study are to: (1) assess separation and recovery methods that may be integral to beach nourishment operations, (2) develop a field protocol for rapid screening of critical elements using portable X-ray fluorescence (pXRF) and gamma scintillometer equipment, and (3) assess environmental and public safety concerns associated with mineral separation processes. The positive benefits of recovering heavy minerals from beach sand placements are threefold. First, the value of these

marketable minerals has the potential to significantly offset the economic costs of coastal restoration projects. Second, these mineral occurrences represent a potential source of domestic critical commodities that by definition are essential to economic and national security. Third, the removal of opaque heavy minerals from beach sand placed in resort and tourist areas results in a more desirable lighter, cleaner appearance.

The total heavy mineral content assessed in over 600 sediment samples taken from shallow core and seafloor grab samples averages 2.7% by weight, ranging from 0.01% up to 14.7%. The average composition of the separated heavy mineral fractions indicates ilmenite 25.4%, rutile 7.3%, and zircon 3.4% are the main components, with lesser amounts of leucoxene 1.6%, xenotime 1%, titanite 0.6%, and monazite 0.2%. Based on recent market prices of mineral concentrate commodities, the estimated value of 1 cubic yard of offshore sand containing 2.7 wt% total heavy minerals is about $10.80. Applying this unit value to a recent beach nourishment project that placed about 1.8 million cubic yards of sand on Sandbridge Beach, the estimated value of the contained heavy minerals is nearly $20 million.

HAWKINS, D.W. – Overview of global coastal and nearshore mineral recovery operations (DHawkins.pdf)

Presenter affiliation: Geologist, Virginia Department of Energy,
david.hawkins@energy.virginia.gov

(David Hawkins provided the following abstract)

Heavy mineral sand (HMS) placer deposits are mined across paleo- and modern-beach complexes, typically along trailing-edge passive margin coastlines. Highly weathered high-grade metamorphic rocks and mafic igneous rocks provided mineral source material to these paleo-beach strandlines and marginal marine sediments. Placer deposits are associated with transgressive and regressive sea-level cycles and occur in shallow, unconsolidated packages up to 45 meters thick and are on the scales of up to a few kilometers wide by tens of kilometers in length. The primary mineral commodities in these deposits are Ti-bearing minerals such as ilmenite and rutile, zircon, and REE-bearing minerals (e.g. monazite). Most domestic and global operations involve Ti-bearing minerals, but may extract zircon and monazite as co-products. Australia, South Africa, China, Madagascar, Mozambique, and India have typically dominated in the production of ilmenite, leucoxene, and/or rutile. Australia and South Africa have been dominant producers of zircon. Historically and presently, Brazil and India have mined monazite for stockpiling of thorium for energy reserves. Presently in the United States, the primary locations for mining are in Georgia, Florida, and Tennessee. Types of operations range from dry mining using bulldozers and mechanical separation, to dredge mining, which employs the use of an artificial pond to create a slurry of material for the gravity separation plant. To date, offshore marine mining has not occurred for HMS placer deposits, although some projects are in feasibility study stages.

KARST, A.T. – Onshore heavy mineral sands: Exploration, mining, processing, and reclamation (AKarst.pdf)

Presenter affiliation: President/Principal Geologist, Karst Geo Solutions, LCC, atkarst@gmail.com

(David Hawkins summarized this presentation)

Mr. Adam Karst is a consulting geologist with 17 years' experience working in the mineral sands industry across the U.S. and international localities. Mr. Karst provided a general overview of the exploration, mining, processing, and reclamation techniques and considerations for terrestrial shallow unconsolidated sand placer deposits. Generally, explorations methods start with desktop research and lead into field reconnaissance and mapping. As part of initial assessments, geophysics including radiometric and magnetic methodology may be useful to help identify potential localities that may host economic heavy minerals (e.g. monazite and zircon via airborne radiometric surveys). Scientists use drilling and sampling to identify deposits in the subsurface. Mr. Karst expanded on the two primary mining methods: 1) dredging, commonly used where shallow deposits intersect the water table; and 2) dry mining, involving excavation via bucket and haul methods.

Following mining, wet separation using a gravity separation method produces a heavy mineral concentrate (HMC) consisting of up to ~90% HM. The HMC is then dried and further refined via dry separation techniques at a mineral separation plant (MSP). The MSP may be located off-site and involves electrostatic and magnetic separation to produce the following general end products: ilmenite, leucoxene, rutile, zircon, and monazite. Some additional dry mill tails will be present comprising non-valuable minerals. Mr. Karst expanded on the reclamation stage of a mining project, which involves restoration of the land to pre-mining conditions to the best extent possible.

Lastly, Mr. Karst discussed the importance of properly managing naturally occurring radioactive material (NORM) as a result of concentrated monazite, and to lesser extents, zircon concentrates. Mining operators must meet each of the appropriate permits and licenses to properly ensure safe handling and disposal. To achieve reclamation, the existing mine tailings will need to be dried, diluted, and restored back to existing mined areas and/or sold. Mr. Karst's talk was an overview of the traditional land mining techniques and served as a framing discussion for further talks in the forum.

(Adam Karst provided the following abstract)

Offshore mineral sands/critical mineral development opportunities will need to leverage current technologies and techniques from current onshore heavy mineral sands exploration, mining, processing, and reclamation. This will also need to include the management of potential NORM (naturally occurring radioactive material).

Session 2: <u>Current offshore sand mining operations for beach replenishment</u>

KNORR, P.O. – Federal marine minerals leasing program in the Mid-Atlantic (PKnorr.pdf)

Presenter affiliation: Critical Minerals Geologist, U.S. Bureau of Ocean Energy Management, paul.knorr@boem.gov

(David Hawkins summarized this presentation)

Dr. Paul Knorr is a Critical Minerals Geologist with BOEM's Marine Minerals Division. Dr. Knorr provided an overview of the OCS marine minerals leasing program and discussed the types of aggregate materials and minerals under the leasing program. The leasing program consists of Non-Competitive Negotiated Agreements (NNAs), typically used for coastal resiliency projects, and competitive leasing. Since 1995, the program has executed 64 NNAs in the East Coast and Gulf of Mexico OCS regions. Dr. Knorr expanded on the NNA process, which covers federal shore protection, beach restoration, coastal wetlands restoration and federal construction projects and briefly mentioned the environmental assessment components which fall under the umbrella of the National Environmental Protection Act (NEPA). Dr. Knorr touched on the domestic competitive leasing framework for commercial prospecting and leasing of marine minerals. Under the current federal regulations (30 CFR Part 581), BOEM has not yet issued a competitive lease for commercial minerals. Dr. Knorr closed the presentation with some questions for how the current regulations and leasing process may be different when considering heavy mineral processing and extraction.

ADAMS, D.F. – City of Virginia Beach, Beach Nourishment Program (DAdams.pdf)

Presenter affiliation: Coastal Program Manager, City of Virginia Beach, dadams@vbgov.com

(David Hawkins summarized this presentation)

Mr. Daniel Adams, the Coastal Program Manager with the City of Virginia Beach, provided an overview of beach nourishment programs for the Resort Beach, Sandbridge Beach, and the Bay Beaches. Since 2002, the Resort Beach area has received 6.8 million cubic yards of sand from the Thimble Shoals Channel and/or the Atlantic Ocean Channel (2001-2002; 2012-2013; and 2019). Sandbridge Beach has received 9.1 million cubic yards of sand since 1998, with the most recent replenishment in 2020, sourcing material from Sandbridge Shoal. The Bay Beaches consist of Chesapeake Beach, Ocean Park Beach, and Cape Henry Beach along the northern shoreline of the City of Virginia Beach. Within the last decade, multiple projects along the Bay shoreline have been completed delivering volumes of sand typically less than 400,000 cubic yards for each event. Mr. Adams closed his talk by emphasizing the importance of collaboration in maintaining partnerships with federal agencies such as the U.S. Army Corps of Engineers (USACE) and BOEM, and continuing to identify new sand resources and beneficial uses for the material.

Session 3: Permitting and regulatory framework for marine minerals: Federal and state waters

HAMM, S. – Permit requirements for mineral mines in Virginia (SHamm.pdf)

Presenter affiliation: Compliance/Permit Review Specialist, Virginia Department of Energy, sarah.hamm@energy.virginia.gov

(Sarah Hamm provided the following abstract)

This presentation reviews the requirements to obtain a new, on-shore, mineral mining permit and license in Virginia from the Virginia Department of Energy. For offshore mining, Virginia's State Subaqueous Minerals Management Plan authorizes the Virginia Marine Resources Commission as the lead agency for any mining and extraction activities taking place on subaqueous lands. Additional permits from other state agencies, such as a radioactive materials permit from the Virginia Department of Health or permits related to air and water quality from the Virginia Department of Environmental Quality, may be required for processing mineral sands in Virginia.

VAN RYSWICK, S. – Maryland permitting and regulatory framework for marine minerals (SVanRyswick.pdf)

Presenter affiliation: Program Chief of the Coastal & Environmental Geology Program, Maryland Geological Survey, stephen.vanryswick@maryland.gov

(David Hawkins summarized this presentation)

Mr. Stephen Van Ryswick, the Chief Geologist of the Maryland Geological Survey's Coastal and Environmental Geology Program provided an overview of Maryland's marine minerals permitting requirements. The Maryland Department of the Environment (MDE) is the state regulatory agency providing oversight for offshore sand resources in state waters and the USACE Baltimore District oversees federal regulatory requirements. For marine minerals, MDE would require a Section 401 Water Quality Certification when a federal license or permit is required for a project. Additionally, the project would need a Coastal Zone Management Act (CZMA) consistency determination if federal funds are used and a Joint Permit Application for work within state tidal waters. The MD Board of Public Works (BPW) Wetland Administration would issue a Tidal Wetland License if warranted by MDE. Mr. Van Ryswick mentioned other potential screening requirements to consider for a project, including but not limited to, historical resources, rare, threatened, endangered species, sensitive habitats, and time of year restrictions. Mr. Van Ryswick stated that if a project occurs in state waters, then the MD BPW would likely expect compensation for the extraction of mineral rights. Onshore processing would likely require additional upland regulations as there is currently no offshore mineral separation projects.

TAYLOR, K.B. and FARRELL, K.M. – Status report on marine offshore heavy mineral sands, North Carolina (KTaylor_KFarrell.pdf)

Presenter affiliation: Kenneth Taylor, PhD, PG, State Geologist, North Carolina Geological Survey, kenneth.b.taylor@ncdenr.gov; Kathleen Farrell, PhD, PG, Senior Geologist, North Carolina Geological Survey, kathleen.farrell@ncdenr.gov

(Kathleen Farrell, PhD provided the following abstract)

The NC Geological Survey (NCGS) summarized: 1) the legal status of mining offshore NC; and 2) the history of heavy mineral research offshore NC. The North Carolina Mining Act of 1971 defines the permitting process for on-land mining above the low-tide zone. The area seaward of the low-tide zone is available for beach renourishment, but 'mining' offshore is not authorized. The current law does not recognize, authorize or accommodate a permitting process for offshore mining of placer sands or any other commodity such as phosphate. As a consequence of funding provided by the MMS-AASG Continental Margins Program, NCGS participated in a series of studies to characterize heavy mineral assemblages in sands from surficial grab samples and cores from the continental shelf (YRS 6 -10). The analytical results are posted in a series of OFRs published by the NCGS (OFR 90-3; OFR 91-3; OFR 93-37; OFR 94-2; OFR 97-2; https://deq.nc.gov/about/divisions/energy-mineral-land-resources/north-carolina-geological-survey/ncgs-maps/open-file-reports-maps-2004-to-1943).

NEALE, B. – Permitting in SC waters (BNeale.pdf)

Presenter affiliation: Senior Program Analyst, S.C. Department of Health & Environmental Control, nealeb@dhec.sc.gov

(David Hawkins summarized this presentation)

Ms. Barbara Neale, with the South Carolina Department of Health and Environmental Control (SCDHEC) provided an overview of applicable regulations within the South Carolina Coastal Program. Ms. Neale mentioned the importance of the tourism and fisheries industries, ports, and natural resources along the South Carolina coastal zone as drivers for the need for coastal management, protection and oversight. SCDHEC oversees activities within eight coastal counties through indirect certification and direct permitting. SCDHEC's indirect authority applies to federal permits and licenses, direct federal activities, federally-funded projects, and the OCS. The Department's direct coastal authority covers coastal waters, tidelands, beaches, and beach/dune systems. SCDHEC has direct authority for permitting activities associated with coastal recreation, dredging, beach renourishment, and coastal infrastructure. Projects pertaining to offshore energy siting and development and transmission cable locations in state waters may also warrant review from SCDHEC under their indirect authority.

Session 4: Environmental standards, compliance, best practices applied to marine minerals

WIKEL, G.L. – Synopsis of the federal environmental review process for marine mineral extraction in the marine environment (GWikel.pdf)

Presenter affiliation: Oceanographer, U.S. Bureau of Ocean Energy Management,
Geoffrey.wikel@boem.gov

(Geoffrey Wikel provided the following abstract)

A robust federal environmental review and consultation process would be followed if heavy minerals were actually proposed to be separated from offshore borrow area material typically dredged for navigation or coastal resilience projects. The exact process, documents, consultations, and public engagement strategies would depend on the details of the proposal, its location and timing, agencies involved, and the nature of public participation and concerns. The resources potentially affected, or nature of potential effects, in the marine environment would depend on the details of that proposal - dredging, handling, separation, transport, processing, tailings and material management. Impacts related to onshore stockpiling, processing, and material management may also need to be evaluated if those activities were to occur in context of typical beach nourishment or coastal restoration operations. No such proposals exist at this time.

If such a proposal were to emerge, detailed environment impact assessments, public involvement opportunities and meetings, and coupled technical analyses would be led by the lead federal agency. Typically, such an environmental impact assessment and review would be a collaborative effort between multiple federal agencies and cooperating entities, notably the USACE, National Oceanic and Atmospheric Administration (NOAA), and BOEM provided OCS resources were implicated. The lead agency would comply with the complex and important fabric of federal environmental requirements in play in the marine environment, the centerpiece of which is the National Environmental Policy Act. Numerous federal laws and requirements, coupled with potential state or local environmental review requirements, dictate the scope, timing, and nature of environmental review. The ultimate goal of the process would be to meaningfully disclose and mitigate potential environmental effects of federal decisions, relying on high-quality or best-available scientific information and effective public engagement.

PEABODY, R. – State regulatory and permitting framework, onshore mineral beneficiation (RPeabody.pdf)

Presenter affiliation: Director of Coastal Policy, Restoration and Resilience, Virginia Marine Resources Commission, rachael.peabody@mrc.virginia.gov

(David Hawkins summarized this presentation)

Ms. Rachael Peabody is the Director of Coastal Policy with the Virginia Marine Resources Commission (VMRC). Ms. Peabody discussed the regulatory and permitting framework for use of Virginia's submerged lands for natural resources. VMRC has authority over marine fisheries, habitats, and shellfish management within state-owned bottomlands, wetlands, and coastal primary sand dunes and beaches. The review process for projects involves a joint permit application where VMRC acts as a clearinghouse for the review and provides the application to other applicable regulatory authorities such as the Department of Environmental Quality, U.S. Corps of Engineers, and local wetland boards. Ms. Peabody stated that all projects involve a public interest review as part of the process. In the context of dredged sand material, VMRC prefers beneficial use of the material for use in beach nourishment, living shorelines, and/or wetland creation. VMRC also provides Coastal Zone Management Program consistency review authority. VMRC recommends evaluation and utilization of existing upland and overboard sediment disposal sites for beneficial use. This includes the ever expanding Craney Island and the Virginia Ocean disposal site prior to the creation of new ocean mining sites off our coast.

MCKAY, L. – Coastal/ocean policy and planning (LMcKay.pdf)

Presenter affiliation: Program Manager, Virginia Coastal Zone Management Program,
laura.mckay@deq.virginia.gov

(David Hawkins summarized this presentation with consultation and additions from Laura McKay)

Ms. Laura McKay is the Program Manager for the Virginia Coastal Zone Management (CZM) Program, which is a network of state agencies and coastal localities. The program is housed at and led by CZM staff at the Virginia Department of Environmental Quality. The program incorporates state coastal laws and policies approved by NOAA. Ms. McKay discussed the formation of the Mid-Atlantic Regional Council on the Ocean (MARCO), and its Mid-Atlantic Committee on the Ocean (MACO) and how these initiatives have allowed for inter-state, tribal and federal collaboration in the conception of the 2016 Mid-Atlantic Ocean Action Plan. Ms. McKay shared information on the MARCO Ocean Data Portal (https://portal.midatlanticocean.org/), which contains over 6,000 data layers that can help with ocean planning and resources of concern. Ms. McKay touched on the current CZM 5-year grant strategy to develop a Virginia Ocean Plan, and CZM's interest in involving more stakeholders in its development as part of this long-term grant effort.

Session 5: Advanced technologies for heavy minerals identification, assessment, and monitoring

TOMLINSON, J. – Insights from the BOEM Atlantic Sand Assessment Project (JTomlinson.pdf)

Presenter affiliation: Geologist, Delaware Geological Survey, jaimet@udel.edu

(Jaime Tomlinson provided the following abstract)

In 2020, the Delaware Geological Survey published a detailed surficial geologic map of the Atlantic seafloor of Delaware from the shoreline to approximately 15 km (9.3 mi) offshore (Mattheus et al., 2020). Thirteen stratigraphic units were recognized and mapped from examination of 500 km of subbottom high-resolution chirper data ground-truthed by approximately 60 cores and descriptive logs from an additional 200 cores. The data were supplemented by 47 radiocarbon dates of organic material and over 200 amino acid racemization analyses of shells from cores used to determine if the mapped units were Holocene or pre-Holocene. In addition to mapping the surficial stratigraphic units, the geophysical data allowed for mapping of the thickness and extent of sand bodies as well as onshore-offshore buried Pleistocene paleovalleys that transected the map area.

A detailed offshore geologic map such as this is an important tool for future resource exploration and for providing a scientific basis for resolving competitive use issues. The map by Matthaeus and others is being used for sand resource analysis for areas of beach-replenishment material in both state and federal waters. The map is also being used to help delineate potential cable routes from a planned offshore wind farm to the shoreline.

GRAMMATIKOPOULOS, T. – Mineralogical and geochemical investigation of REE offshore sands from Virginia, USA (TGrammatikopoulos.pdf)

Presenter affiliation: Senior Geoscientist, SGS Canada Inc., tassos.grammatikopoulos@sgs.com

(Tassos Grammatikopoulos, PhD provided the following abstract)

Ore deposits are complex and display a high degree of variability, arising from their inherent geological and mineralogical characteristics, which impact their beneficiation. Automated mineralogy is established as an integral part for both exploration and mineral processing in the mining industry for critical minerals. The TIMA (Tescan Integrated Mineral Analyser), coupled with geochemical assays, X-ray diffraction and mineral chemistry, were used to characterize twenty (20) mineral sand samples on behalf of the Virginia Department of Energy Geology and Mineral Resources Program. Each sample was submitted for heavy liquid separation (HLS) at a specific gravity (S.G.) of 2.9. g/cc^3 to upgrade the heavy minerals. The sink fractions account for 4% to 72% of the total mass of all samples. The sink fractions were analyzed for REE and a large suite of other elements. The total REE+Y ranges from <509 ppm to 7,292 ppm, reflecting mainly monazite and, less commonly, xenotime.

TIMA data show that the main economic minerals include monazite and traces of xenotime and columbite, significant zircon, rutile and ilmenite. The remainder of the minerals include spinels (Fe-Cr-oxides), staurolite, kyanite, and other minerals. The economic minerals are well liberated; monazite liberation ranges from 71% to 100%, zircon from 90% to 99%, rutile from 54% to 93%, and ilmenite from 87% to 98%. Electron microprobe analyses show that monazite is enriched in LREE, has a similar average concentration of the major oxides, and it contains significant thorium, and minor uranium. Xenotime is Y-bearing and carries some of the heavy REE. Zircon is barren of detectable REE but it hosts traces of yttrium. Rutile and ilmenite hosts traces of niobium.

TIMA analysis is extremely useful because it can provide quantitative mineralogical parameters, speciating the minerals and their mass% and providing data on liberation and association, morphological characteristics, grain size, elemental deportment among other parameters. This technique is more advantageous than other bulk mineralogical techniques (i.e., XRD) because it provides accurate mineral identifications at low detection limits, and additional mineralogical parameters.

SHAH, A.K. – Geophysical approaches to imaging heavy mineral sand content in offshore environments (AShah.pdf)

Presenter affiliation: Research Geophysicist, U.S. Geological Survey, ashah@usgs.gov

(Anjana Shah, PhD provided the following abstract)

Geophysical data play a key role in "connecting the dots" between geologic samples by showing the continuity of certain characteristics and facilitating an interpreted geologic context. With respect to heavy mineral sand concentrations, grain size information can be obtained from lidar data onshore and sonar data offshore. Geophysical tools, especially radiometric, magnetic, and induced polarity (IP) methods, are helpful with determining compositional variations.

On land, one of the most efficient and effective approaches to imaging heavy mineral sand concentrations is the radiometric method, i.e. gamma ray spectrometry for K, Th, and U (Force et al., 1982; Grosz et al., 1989; Shah et al., 2021). Heavy mineral sands in the southeastern U.S., both onshore and offshore, typically contain some amount of monazite, which is highlighted by radiometric Th. Surveys are conducted using a passive sensor most often from an airplane, but other platforms are also suitable. In the offshore environment, the gamma rays can't be sensed though the fluid medium, so the sensor is towed deep enough to maintain contact with the seafloor (Jones, 2001). The tow speed may be anywhere from 4-10 knots, depending on survey conditions and depth of the seafloor, with deeper areas requiring longer cables and slower speeds.

IP methods, which involves measuring the time-response to an induced electrical charge, have also been deployed offshore using a system that requires continuous contact with the seafloor (Wynn, 1988; 2012). This method is especially sensitive to ilmenite. The tow cable includes both electrical transmitters and receivers and the system is typically towed at speeds of about 3 knots, so it is best for very targeted surveys over small areas. System noise can impact the resolution of the data.

Magnetic field measurements can be conducted using an airborne sensor or tow fish since they are not impacted by the presence of water. The magnetic field responds to minerals such as magnetite, hematite, and maghemite, which may be present in small amounts in a heavy mineral assemblage. Measured anomalies are typically dominated by sources in crystalline basement, but if the platform allows the sensor to be closer to the ground, such as with shipboard or walking surveys, subtle anomalies due to heavy mineral sand concentrations may be detectable (Siddiquie et al., 1984; Mudge and Teakle, 2003). Post-processing such as high-pass filtering can enhance such anomalies (Shah and Harris, 2012; Shah et al., 2012). Such anomalies are most easily observed in relatively calm waters where there is limited sensor motion due to currents, waves, etc. Systems may be towed at speeds of 8-10 knots, facilitating surveys of larger areas.

Cited references are available from the Author upon request.

HAWKINS, D.W. and LASSETTER, W.L. – Field methods for assessment and monitoring of heavy mineral sands: Terrestrial and offshore insights (DHawkins_WLassetter.pdf)

(David Hawkins provided the following abstract)

To assess heavy mineral sand (HMS) deposits, we rely on an array of field methods and techniques. Starting with a regional-scale reconnaissance approach, scientists can target HMS deposits for more detailed and localized assessment. Up-to-date geologic mapping data is critical to understand the depositional environment, mineral provenance, and overall distribution of HMS deposits in the surface and subsurface geologic units. Airborne radiometric data, such as equivalent thorium (eTh) is a proxy for the presence for thorium-bearing minerals (i.e. monazite), which can accumulate in placer deposits. Additionally, scientists can interpret crystalline bedrock types from aeromagnetic data, providing data for mineral provenance. Targeted sampling will typically involve drilling, field screening, and processing of heavy mineral concentrates for laboratory analysis. Due to the extensive history of HMS mining globally, most techniques focus on terrestrial deposits. To aid in offshore exploration, it is important that scientists emphasize geologic mapping and seismic stratigraphy to understand the marine deposits. As LiDAR provides interpretative insight for geomorphic and topographic features on land, bathymetry data provides details on morphologic features that may concentrate HMS deposits on the continental shelf. As part of this capacity assessment study, we are working on developing a rapid field screening protocol using a portable x-ray fluorescence (pXRF) analyzer to apply to sediments during and/or following the dredging process as well as for exploration, environmental, and regulatory purposes. Through laboratory testing, correlation with analytical results and other screening tools, we hope to be able to provide a protocol to assist with critical commodity evaluations in terrestrial and marine sand deposits in the field.

FACILITATED DISCUSSION FINDINGS

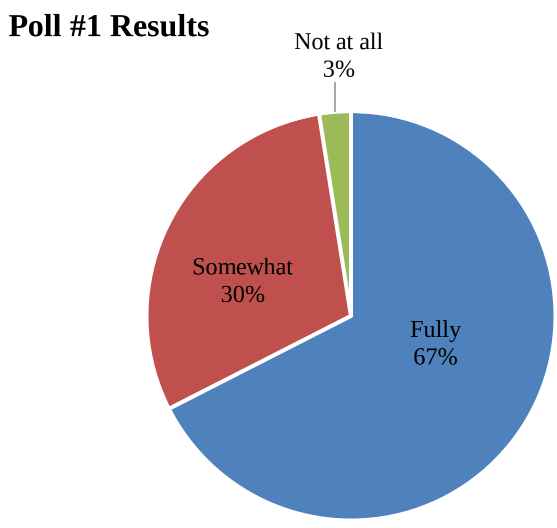
Facilitators structured the forum into five sessions hosting presentations relating to a common theme. Open discussion was encouraged at the end of most sessions as outlined in the agenda. Virginia Energy compiled questions and comments from the virtual platform chat function into a document shared with participants during the discussion periods.

Polling Results

As part of participant engagement, four survey questions were polled throughout the forum as follows:

#1 Prior to this forum, I was _____ aware of the presence of minerals containing critical materials such as titanium, zirconium, rare earth elements in association with marine sand deposits on the OCS:

A. Fully
B. Somewhat
C. Not at all

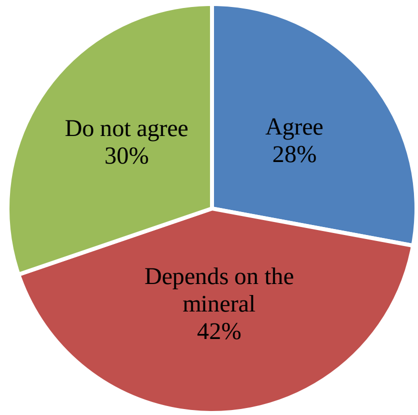


Note: data based on 40 responses

#2 Timelines for permit application reviews and decisions related to marine mineral extraction operations that would increase the availability and supply of domestic critical minerals should be expedited because of the "critical" nature of these commodities:

A. Agree
B. Depends on the mineral
C. Do not agree

Poll #2 Results

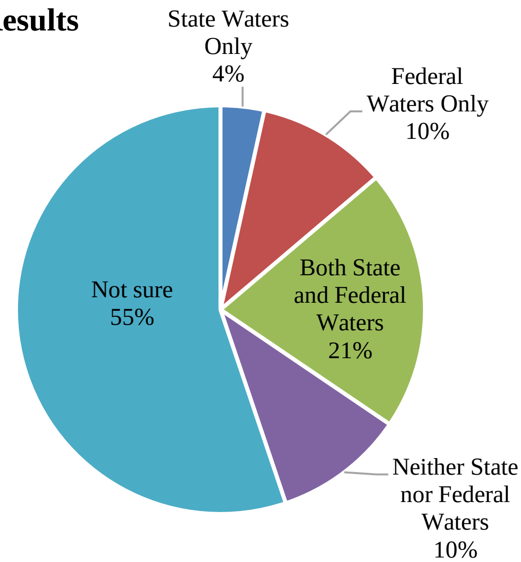


Note: data based on 43 responses

#3 Current operational permitting requirements and environmental protection standards that would apply to the separation and recovery of marine minerals other than sand on the OCS are adequate for:

A. State waters only
B. Federal waters only
C. Both state and federal waters
D. Neither state or federal waters
E. Not sure

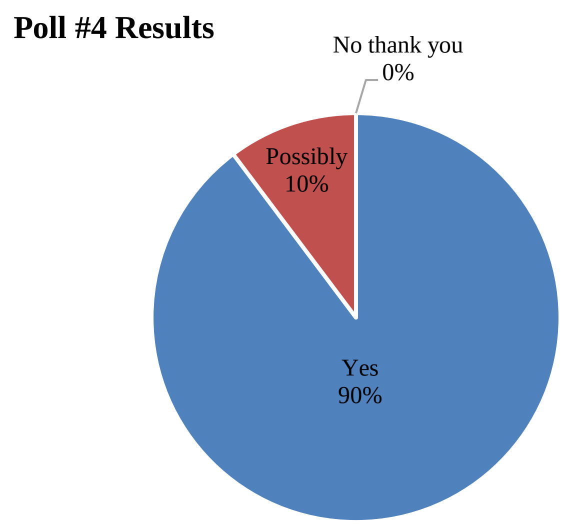
Poll #3 Results



Note: data based on 29 responses

#4 I would consider participating in a future workshop to learn more about technologies used to identify and assess marine critical mineral resources (on the OCS):

A. Yes
B. Possibly
C. No thank you



Note: data based on 39 responses

Observations for the polling results indicated a general awareness of critical commodities on the OCS, variable opinions on the applicability of current permits and regulations as they apply to OCS mineral recovery and processing, and a majority interest in participating in a subsequent workshop. Not every attendee provided a response to each polling question. After running each poll, Virginia Energy opened the forum to discussion. This document addresses questions and comments raised throughout the forum in the subsequent sections under *Discussion Periods*. We also provide a synopsis of significant talking points and potential follow-up items in the *Findings and Recommended Actions* section of this document.

Discussion Periods

Virginia Energy utilized polling results and compiled questions and comments from each respective session to kick-off open discussions between the attendees. The following bullet points provide general topics and/or open-ended questions posed throughout the forum. This is not a complete list of questions and comments from the forum; these discussion points help to provide additional context and "take-home" ideas.

Introduction and Session 1: Marine mineral sands – feasibility of extracting critical mineral resources

- A discussion period did not follow the introduction for the forum and three presentations in Session 1. Facilitators informed the participants that the first discussion period would follow Session 2.

Session 2: Current offshore sand mining operations for beach replenishment

- According to Dr. Paul Knorr, BOEM has not issued a competitive lease for commercial mineral mining under current federal regulations.
- Mr. Dan Adams presented an overview of beach nourishment projects in Virginia Beach which have occurred within the past few decades. Mr. Adams mentioned that the City of Virginia Beach has not used state funding for beach nourishment projects.
- "Beach quality" sand typically has a median grain size of 0.30 to 0.32 millimeters, but that definition may vary by state. Some states may specify requirements for color as well.
- According to Mr. Adam Karst, a total heavy mineral (THM) content of at least 1% by weight would be appropriate to consider an OCS mining operation. Other variables to consider may include the location and capacity of an existing processing mill near the OCS operation; the percentage of zircon and rutile in a deposit as being primary drivers for prospecting a potential resource; and the practicality of such operations in the context of current technology and economic needs.
- Some participants raised questions about potential re-use of existing dredge spoil material (i.e. Craney Island facility-Portsmouth, VA; offshore dredge waste disposal areas) for heavy mineral assessments, rather than assessing new locations.
- Many participants were interested in how to quantify the amount of fine-grained sediment lost during the dredging process (i.e., silt, clay). Several studies have been published by BOEM and the USACE pertaining to the quantification of fines during the dredging process(https://espis.boem.gov/final%20reports/BOEM_2019-010.pdf;https://erdc-library.erdc.dren.mil/jspui/handle/11681/36997; https://erdc-library.erdc.dren.mil/jspui/handle/11681/37656).
- Participants were interested in the typical feed rate of the sand slurry mixture coming onto a dredger into the hopper, and the typical pump-out rate of the material onto the beach. Rates may be variable depending on the project.

Session 3: Permitting and regulatory framework for marine minerals: Federal and state waters

- Two breakout groups followed Session 3, and a joint discussion after the two groups convened. These breakout sessions were hypothetical scenarios for extraction, processing, and transport of heavy mineral sand concentrates either in an onshore beach setting or offshore in federal and/or state waters. These ideas serve as talking points and "food for thought".

- Breakout group #1 (onshore heavy mineral separation):
  - Logistics:
    - Determine if a mobile mineral concentrator would be located just offshore or if a separation operation would or could occur onshore.
    - The initial separation in the vicinity of the operation would be for the bulk material and further separation would be completed offsite at another facility.
    - Consider the logistics of processing the material from a stockpile or directly from the pump-out pipe.
    - General logistics with having an operation in a popular beach destination.
  - Uncertainties and challenges:
    - Need to determine appropriate ownership of the heavy mineral concentrates once onshore.
    - Consider necessary easements and origin of the source material (i.e. federal vs. state waters).
    - Address ownership rights of the sand material and whether the material falls under public domain. Projects would need to clearly define royalties.
    - Consider time of year restrictions or preferences for potential separation operations.
    - Involvement of each appropriate regulating agency.
- Breakout group #2 (offshore heavy mineral separation):
  - Logistics:
    - Determine the logistics between offshore and onshore processing.
    - Determine the best separation method as part of the normal hopper dredging process.
    - Appropriate to know the THM concentration offshore prior to an extraction operation. Preliminary data collection and analysis is important.
    - Evaluate the potential for the extraction to occur as part of a beach nourishment project.
    - Consider all of the relevant marine stakeholders and the overall geographical presence of these industries and where shared resources between states and federal entities are located (e.g. fisheries industry, offshore renewables, and conservation).
    - Determine the volume of sand to dredge to account for potentially lower THM grades and/or if more sand than original specifications would need to be dredged to offset removal of heavy mineral sands.

        - Quantify the effluent from the dredge during the extraction process and what may be lost to the sea, and how this could affect the marine ecosystem (i.e. turbidity considerations, marine life, substrate environments).
    - Uncertainties and challenges:
        - Consider the necessary permits for offshore heavy mineral exploration and if the current permitting framework would be appropriate for these non-fuel type minerals.
        - Marine species habitat protection and conservation needs in the context of dredging operations. Ensure all of the appropriate stakeholders are involved throughout the process.
        - Time of year considerations, fishing activities, marine mammals, ocean space sharing considerations.
        - Establish clear commitments and plans between the mining companies and appropriate owner(s) of the material prior to the consideration of operations.
        - Consider all possible waste products or handling requirements for concentrates and spoil material, including naturally occurring radioactive material (NORM) in environmental assessments and studies prior to the conception of a project and throughout a project's life cycle.

Session 4: Environmental standards, compliance, best practices applied to marine minerals

- Importance of being transparent with the available data and information in the environmental assessment stage; take efforts to mitigate environmental risks.
- BOEM wants to ensure that each of the applicable stakeholders are involved in these assessments and decisions, and that thorough environmental assessments and/or environmental impact statements are completed.
- Review and evaluate the available data and involve the relevant stakeholders throughout the process.
- Determine if the current environmental regulations are appropriate for existing heavy mineral extraction methods and technologies.

Session 5: Advanced technologies for heavy minerals identification, assessment, and monitoring

- Detailed offshore geologic mapping provides pertinent information for mineral resource assessments.
- Certain geophysical methods may be more appropriate than others when considering regional-scale or more localized heavy mineral assessments.
- Utilize knowledge and data from terrestrial assessments and methodology to apply to the marine environment
- Determine the limitations with current geophysical and geochemical methods for marine heavy mineral assessments.

FINDINGS AND RECOMMENDED ACTIONS

This forum provided a broad overview of critical commodities contained in heavy minerals, commonly found in shallow marine sand deposits on the OCS. The forum brought together a diverse group of stakeholders across industries and public entities to discuss a common interest, marine resources and responsible stewardship of these resources. The primary goal of the forum was to facilitate information sharing and gauge ideas from those involved to help with the development of a capacity assessment study for the recovery of heavy minerals from marine sand deposits as part of future beach nourishment projects. The implementation of Federal Executive Order 13817 (2017) requires that the United States support projects and work that will further characterize domestic critical mineral resources. The USGS lists titanium, zirconium, and REE (among others) as "critical minerals" (https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals) and this project supports the goals of the Executive Order by producing new data for offshore sand and mineral resources.

To support the capacity assessment, we compiled the following recommended actions that should be considered in preparation for a future pilot study:

1) Current federal and state regulatory agencies should discuss how lease terms may vary for non-fuel minerals, other than sand and gravel from federal and state waters. Current regulations do not explicitly differentiate between non-fuel minerals and sand/gravel aggregate on the OCS and where there should be a distinction.
2) The U.S. Army Corps of Engineers and dredging community were not present for this forum. It is critical to gather input from those stakeholders prior to development of a pilot study. Additionally, industry stakeholders from the mining community stated the need for long-term commitments for there to be investments in a potential operation. This may involve collaboration between federal, state, local government and other marine and coastal stakeholders.
3) There should be clear distinction made between heavy minerals and heavy metals. Heavy minerals refer to specific minerals that are present based on density through sorting through geological processes and may include non-metallic minerals (i.e. silicates).
4) As part of the current environmental processes (i.e., NEPA), regulators will need to address transport and disposal requirements of THM concentrates from the marine and/or coastal environmental to a land facility. Additionally, if a project intends to produce a monazite product, then the project plan will need to clearly address management of NORM in accordance with the current environmental and regulatory standards.
5) Stakeholders should outline ownership rights of sediment material and royalty payments in the planning stages of the project.
6) Part of this capacity assessment will assess the heavy mineral content in fine material (silt, clay). Published studies have addressed the quantification of fines lost during the

dredging process, which may allow for projects to target areas with finer material that have otherwise not been assessed to allow for greater flexibility in sourcing material for beneficial use projects. For example, if an existing maintenance dredging project of a shipping channel could continue to provide a sediment source for concurrent beneficial use projects and has a prospective heavy mineral fraction, this may be economically feasible.

7) Many stakeholders mentioned evaluating existing dredge spoil areas offshore and onshore for heavy minerals. A reconnaissance level sampling event would be appropriate to determine if heavy minerals are present within these disposal areas prior to a pilot study.
8) Studies should look at the costs associated with typical dredging and beach nourishment operations, and start-up and operating costs with a mobile-capable separation method.

The recommended actions listed above will be considered in greater depth as part of the development of a future pilot study, the recommended next step. We will utilize new sample analytical data from two localities in federal waters (Sandbridge Shoal Borrow Area and the Atlantic Ocean Federal Navigation Channel) to provide a reconnaissance-level resource estimate based on current market commodity prices. We plan to incorporate this data into cost savings scenarios to demonstrate how coastal resilience projects may benefit from extraction of heavy minerals during beach sand placement and serve as a potential future domestic critical mineral resource.

The presentations summarized above are included in digital format as separate PDF files in Appendix C for additional reference for the reader, and provide more detail pertaining to those topics. We thank each of the speakers and participants for their involvement and contributions to the forum. The capacity assessment study (to be released as a separate technical document) will incorporate information gathered from this forum, reflecting each of the stakeholder’s input, and will contribute new publicly available data that can be utilized in future studies.

APPENDIX A: 2022 Mid-Atlantic Marine Heavy Mineral Sands Forum Agenda

Mid-Atlantic Marine Heavy Mineral Sands Forum
Virginia Department of Energy and the U.S. Bureau of Ocean Energy Management

March 31, 2022 – 9am – 4:30pm (EST)
Virtual format – *Cisco Webex*

The Virginia Department of Energy (Virginia Energy), in collaboration with the U.S. Bureau of Ocean Energy Management (BOEM), is developing a feasibility study for the recovery of economic minerals from marine sand deposits, ideally as an integral part of coastal resilience projects. Economic minerals include critical minerals[1] containing titanium, zirconium, and rare earth elements, as well as other valuable commodities such as garnet, sillimanite minerals, and precious metals. Among the key factors we are considering as part of the study are alternative methodologies for mining and economic mineral separation, potential environmental impacts at mining and processing locations, current Federal, State, and local regulatory requirements that apply to mining and mineral recovery operations in coastal and offshore areas, and impacts on stakeholders with interests in coastal and marine policymaking.

Purpose:

The goals of the Forum are to convene scientists and stakeholders from Federal, State, and local government and industry to gather information pertaining to: 1) the Federal, State, and local permitting and regulatory framework that impacts mining and mineral extraction operations in coastal and offshore areas; 2) environmental standards and best practices for management of marine seafloor mineral resources on the Continental Shelf; and 3) logistical criteria and economic feasibility for mining of critical commodities as part of ongoing coastal resilience projects. From this Forum, we will cultivate a list of questions and data needs to help inform our feasibility study, potentially leading to future cooperative studies.

The Forum will be held on March 31, 2022 from 9:00 am to 4:30 pm Eastern Standard Time (EST) and will be conducted in a virtual format, moderated by Virginia Energy, using the Cisco Webex video conferencing platform. The agenda includes speakers whom have been involved with offshore marine minerals and/or critical mineral assessments, particularly in the Mid-Atlantic region. Invited speakers will share experiences related to the mapping, assessment, and recovery of mineral sand resources, including sands for beach replenishment and economic heavy minerals.

1 – Nassar, N.T., and Fortier, S.M., 2021, Methodology and technical input for the 2021 review and revision of the U.S. Critical Minerals List: U.S. Geological Survey Open-File Report 2021–1045, 31 p., https://doi.org/10.3133/ ofr20211045.

Objectives and Outcomes:

Utilizing a virtual format, we have grouped presentations into five (5) session themes:

1) An overview of critical mineral commodities associated with marine mineral sands and the feasibility of extracting mineral resources;
2) Current offshore sand mining operations for beach replenishment;
3) Federal and State regulatory framework and permitting requirements;
4) Environmental standards and best practices; and
5) Current technologies for heavy minerals assessment.

We will cover each of these topics at a relatively high level to allow for a comprehensive scoping of additional informational needs. There will be multiple discussion and information sharing opportunities throughout the day. We will emphasize applications and scenarios focused on economic mineral extraction from a sand replenishment source area under the currently known permitting and regulatory framework.

Agenda

Morning Sessions

Introduction and statement of purpose for the Forum (Virginia Energy, BOEM)

9:00-9:10 EST	Overview, desired outcomes, plans for Forum proceedings

Session 1: Marine mineral sands – feasibility of extracting critical mineral resources

9:10-9:20 EST	What are economic (critical) heavy minerals? (William Lassetter, Virginia Energy)
9:20-9:30 EST	Overview of global coastal/nearshore mineral recovery operations (David Hawkins, Virginia Energy)
9:30-9:40 EST	Onshore heavy mineral sands: Exploration, mining, processing, and reclamation (Adam Karst, Karst Geo Solutions, LLC)

Session 2: Current offshore sand mining operations for beach replenishment

9:40-9:50 EST	Federal marine minerals leasing program in the Mid-Atlantic (Paul Knorr, U.S. Bureau of Ocean Energy Management)
9:50-10:00 EST	City of Virginia Beach, Beach Nourishment Program (Dan Adams, City of Virginia Beach)
10:00-10:40 EST	***Poll question #1***, Q&A, group discussion and short break

Session 3: Permitting and regulatory framework for marine minerals: Federal and State waters

10:40-10:50 EST Virginia – (Sarah Hamm, Virginia Energy)

10:50-11:00 EST Maryland – (Stephen Van Ryswick, Maryland Geological Survey)

11:00-11:10 EST North Carolina – (Kenneth Taylor and Kathleen Farrell, North Carolina Geological Survey)

11:10-11:20 EST South Carolina – (Barbara Neale, South Carolina Department of Health & Environmental Control)

11:20-11:45 EST ***Poll question #2***, Q&A, group discussion and short break

11:45-12:30 EST Breakout group discussion

- *Case studies: hypothetical onshore and offshore mineral separation in the context of a coastal resilience project (Additional details to be provided in Forum).*
- *Potential Questions: What are the regulatory, legal, and logistical constraints? Are there differences between States? Do we consider valuating sand & gravel resources differently than heavy mineral sand resources? Are the current regulations sufficient (i.e. handling of radioactive elements, contaminants)?*
- *Q&A, touch on questions from prior talks as needed.*

12:30-1:30 EST Lunch break (1 hour)

Afternoon Sessions

Session 4: Environmental standards, compliance, best practices applied to marine minerals

1:30-1:40 EST Federal regulatory framework and overview
(Geoffrey Wikel, U.S. Bureau of Ocean Energy Management)

1:40-1:50 EST State regulatory and permitting framework, onshore mineral beneficiation
(Rachael Peabody, Virginia Marine Resources Commission)

1:50-2:00 EST Coastal/ocean policy and planning
(Laura McKay, VA Coastal Zone Management Program)

2:00-2:30 EST ***Poll question #3***, Q&A, group discussion and short break
Hypothetical on/offshore mineral separation
What are key stakeholder issues at the local, State, and Federal level?
What are the environmental unknowns?

Session 5: Advanced technologies for heavy minerals identification, assessment, and monitoring

2:30-2:40 EST — Insights from the BOEM Atlantic Sand Assessment Project (Jaime Tomlinson, Delaware Geological Survey)

2:40-2:50 EST — Techniques in geochemistry and mineralogy (insights from mineral sand samples, Virginia, USA) (Tassos Grammatikopoulos, SGS Laboratory)

2:50-3:00 EST — Geophysical methods (Anji Shah, U.S. Geological Survey)

3:00-3:10 EST — Field methods for assessment and monitoring of heavy mineral sands: Terrestrial and offshore insights (William Lassetter and David Hawkins, Virginia Energy)

3:10-4:20 EST — ***Poll question #4***, Q&A, additional time for demos (e.g. geophysics, handheld scintillometer), open-ended discussion, next steps

- *Other questions to consider:*
- *How should we prioritize the available technologies to identify a resource?*
- *Are there ways to carry out a pilot study that leverages involvement from local municipalities, academia, and government to help lower the costs of implementation?*
- *From a mining engineering standpoint, what are the significant data needs to formulate appropriate methodologies?*
- *What are the data gaps? Needs for additional focused Forum(s).*
- *Summarize key findings from the Forum and prioritize action items*

4:20-4:30 EST — Closing remarks

4:30 EST — Forum wrap-up

Contact Information:

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BOEM: www.boem.gov

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APPENDIX B: 2022 Mid-Atlantic Marine Heavy Mineral Sands Forum Participants

2022 Mid-Atlantic Heavy Mineral Sands Forum
Sponsored by the Virginia Department of Energy and United States Bureau of Ocean Energy Management

March 31, 2022
Cisco Webex Virtual Event
Charlottesville, Virginia

List of Presenters

William Lassetter, Economic Geology Projects Manager, Virginia Department of Energy, Geology and Mineral Resources Program
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Jaime Tomlinson, P.G., Geologist, Delaware Geological Survey
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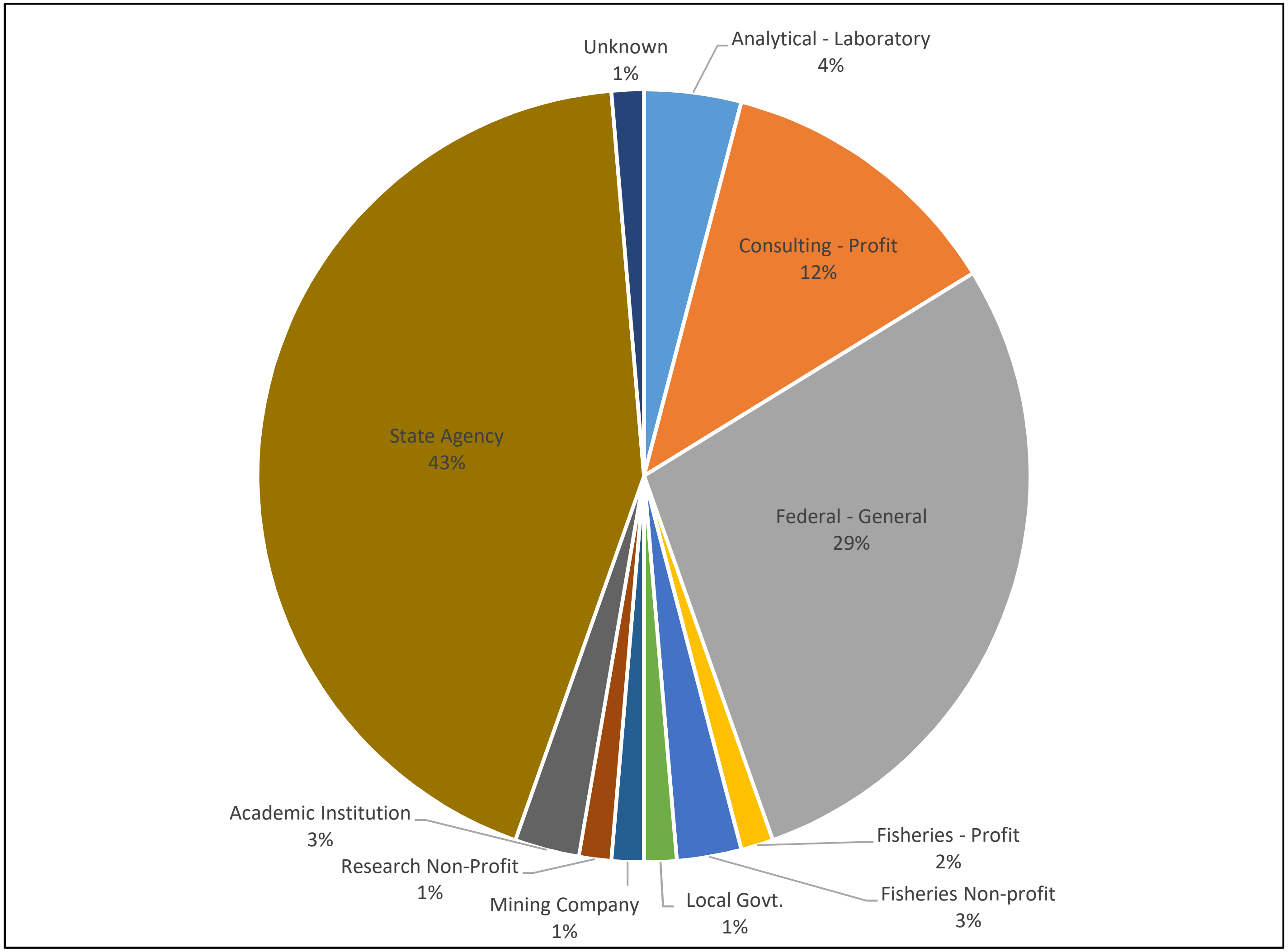
Tassos Grammatikopoulos, Ph.D., P.Geo., Senior Geoscientist, SGS Canada, Inc.
Tassos.Grammatikopoulos@sgs.com

Anjana Shah, Ph.D., Research Geophysicist, U.S. Geological Survey, Geology, Geophysics, and Geochemistry Science Center
ashah@usgs.gov

Participant by Industry (74 people):



Note: Industry type was acquired from the Webex attendance report. The report was generated when attendees signed into the meeting and recorded their organization or affiliation.

APPENDIX C: 2022 Mid-Atlantic Marine Heavy Mineral Sands Forum Presentations

Session 1: Marine mineral sands – feasibility of extracting critical mineral resources

LASSETTER, W.L. – Marine mineral sands on Virginia's outer continental shelf – The case for extracting critical minerals as part of beach restoration projects (WLassetter.pdf)

Marine mineral sands on Virginia's outer continental shelf - The case for extracting critical minerals as part of beach restoration projects

William Lassetter
Virginia Energy - Geology and Mineral Resources

Mid-Atlantic Marine Heavy Mineral Sands Forum
Charlottesville VA
31 March 2022

BOEM
Bureau of Ocean Energy Management

VIRGINIA Energy

What we have learned from recent studies

Analysis of marine data (subbottom seismic, vibracores) collected as part of BOEM-Virginia Cooperative projects indicate substantial beach-quality sand resources in two offshore regions:

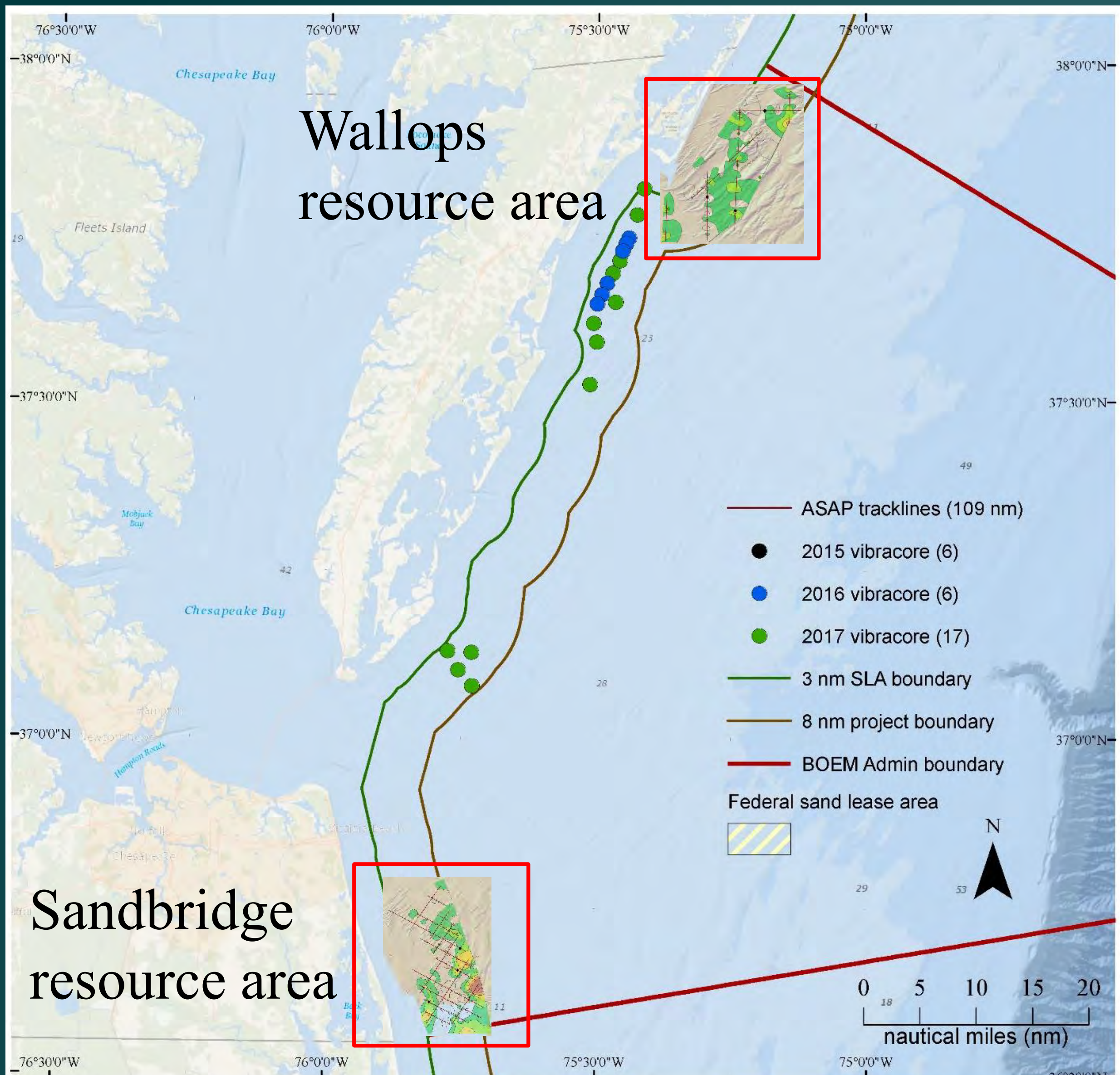
resource area	minimum 10-ft thickness	minimum 5-ft thickness
Sandbridge	271 million yd^3	333 million yd^3
Wallops	393 million yd^3	421 million yd^3

Over 600 seafloor sediment samples (grab, core) from the OCS indicate:

- THM content averaging 2.7 wt %, ranging from 0.01% up to 14.7%
- EHM minerals containing critical commodities such as Ti, Zr, REE, U, Hf, among others, make up about 41% of the THM concentrate
- based on recent commodity prices, estimated value of 1 yd^3 of dredged sand containing 2.7 wt% THM is about $10.80

There is significant potential for the recovery of economic mineral resources offshore of Virginia that could offset the costs of dredging for beach sand re-nourishment projects.

Recon estimated sand resources – seafloor to 10-ft depth

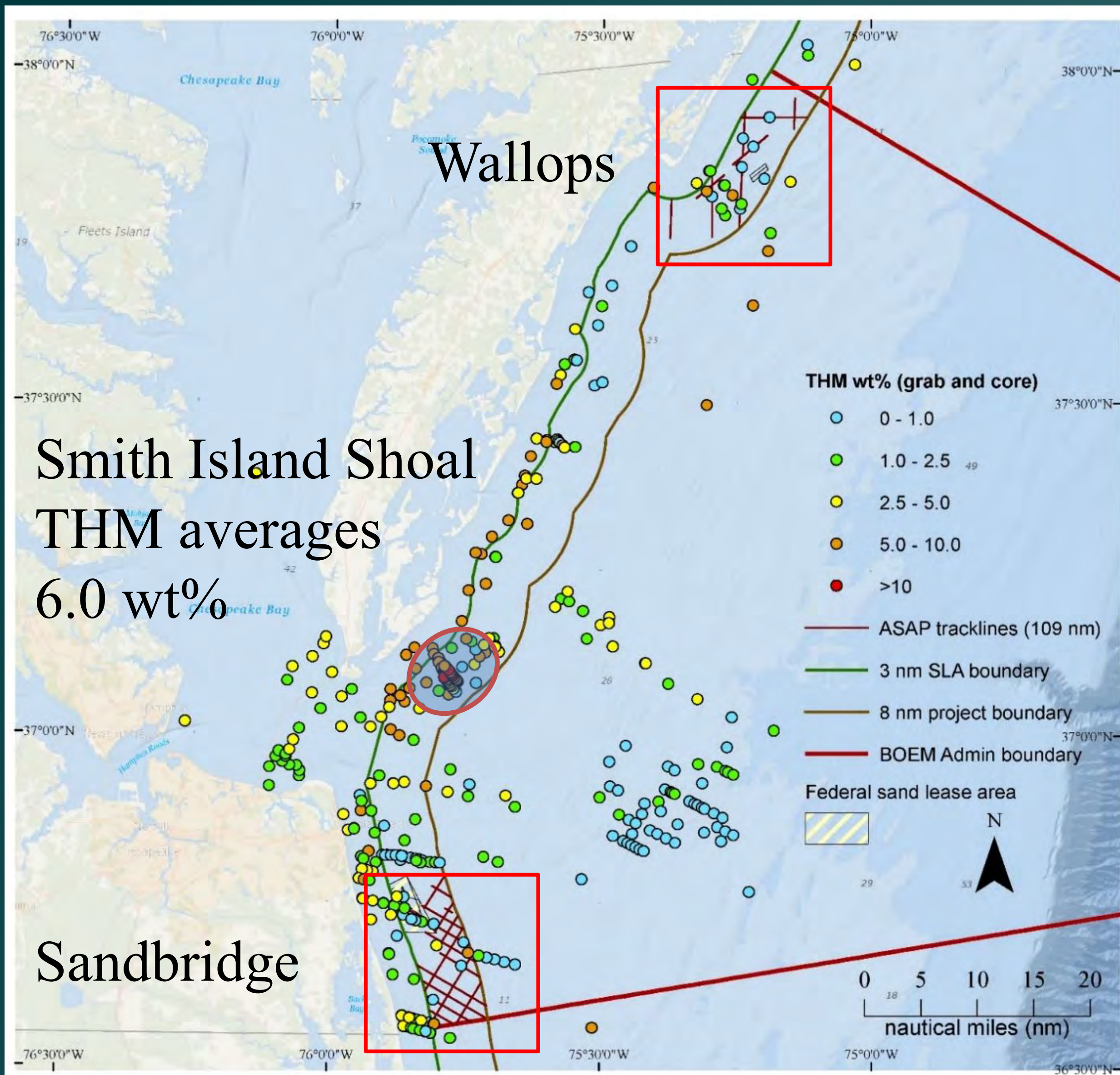


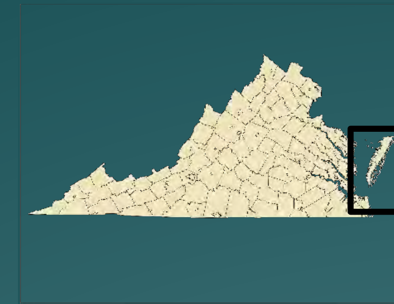
Wallops:
<u>393 million yd³</u>

OCS sand resources
ϕ mean = 2.1 (0.23 mm)
fine to medium sand

Sandbridge:
<u>271 million yd³</u>

Heavy minerals – seafloor to 10-ft depth





THM content averages 2.7 wt %, ranging from 0.01% up to 14.7%

OCS sand resources
ϕ mean = 2.1 (0.23 mm)
fine to medium sand

OCS heavy minerals
ϕ mean values

zircon	3.4 (0.10 mm)
titanite	3.9 (0.07 mm)
ilmenite	4.3 (0.05 mm)
rutile	4.8 (0.04 mm)
leucoxene	7.1 (0.01 mm)

(v. fine sand to v. fine silt)

BOEM-Virginia Cooperative Agreement 2021-23

- Examine alternative methodologies for recovering EHM from marine sand deposits (onshore-offshore)

  gravity (spiral, jig, etc.), up-flow hydroseparator, magnetic susceptibility, electrostatic, flotation, grain size classification

- Evaluate protocols for rapid field screening of critical elements.

  visual opaques, portable X-ray fluorescence (XRF), gamma scintillometer

- Assess public safety and environmental concerns, potential impacts on stakeholders (processing locations, stockpiles, etc.)

  e.g. extraction of opaque heavy minerals may result in beach sand replenishments with lighter color, affecting temperature of coastal habitat

- What permits will be required and from whom?

Economic heavy minerals in marine sands

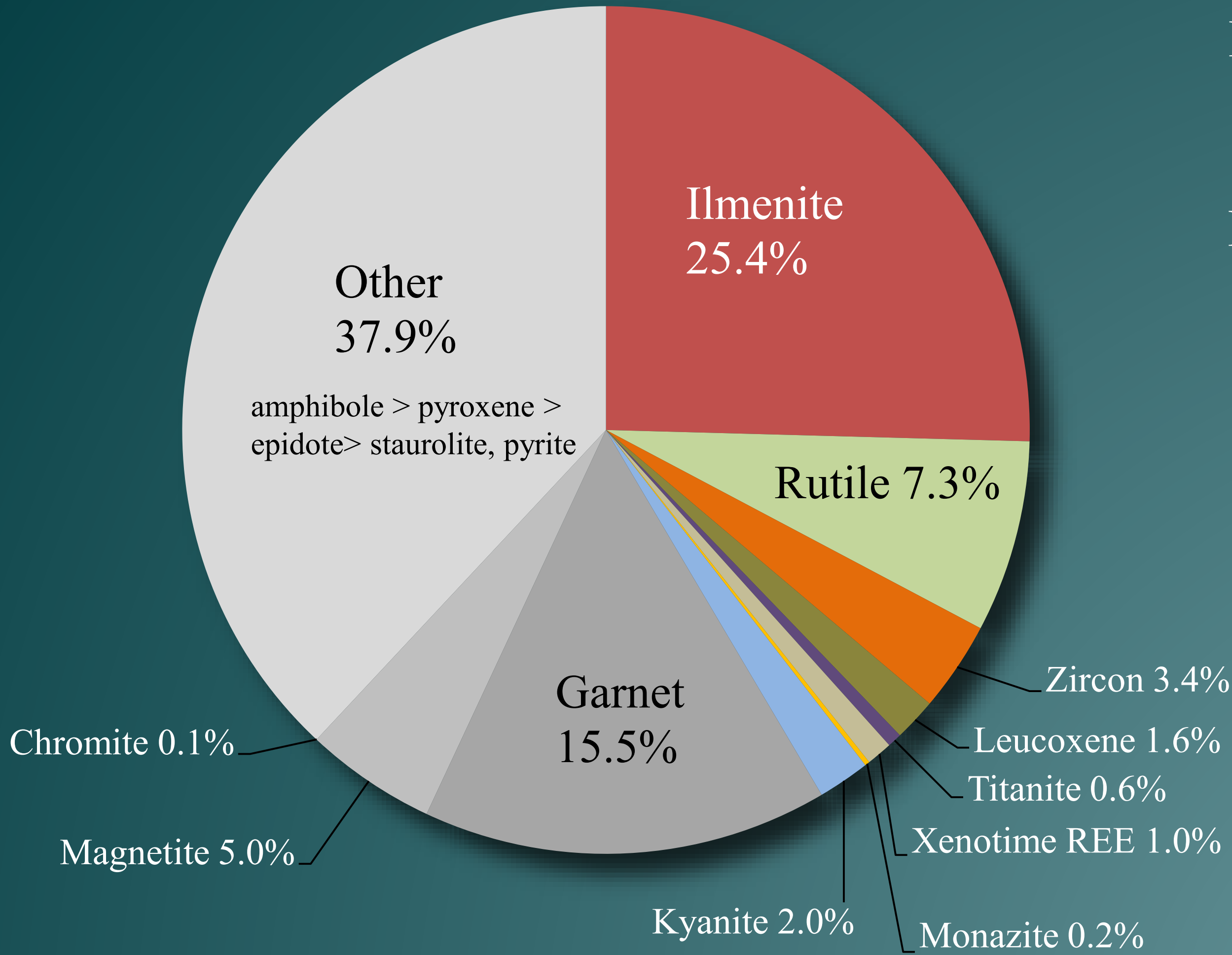
Mineral	composition	critical commodities*
Ilmenite	$FeTiO_3$	**Ti**
Leucoxene	*altered* $FeTiO_3$	**Ti**
Rutile	TiO_2	**Ti**
Titanite	$Ca(La,Ce)TiO(SiO_4)$	**Ti, REE**
Zircon	$ZrSiO_4$	**Zr, U, Th, Hf, REE**
Xenotime	$(Y,Nd,Yb)PO_4$	**Y, REE**
Monazite	$(Ce,La,Sm,Th)PO_4$	**La, Ce, Sm, Nd, Th**
Sillimanite group	Al_2SiO_5	**Al**
Chromite	$(Fe, Mg)Cr_2O_4$	**Cr**
Garnet group	$(Ca,Fe,Mg,Al)(SiO_4)_3$	**abrasive sand**

Ilmenite Leucoxene Rutile Zircon Monazite Kyanite

https://energy.virginia.gov/geology/CriticalMinerals.shtml

Sources: Garner, 1978; Van Gosen and others, 2014; Fortier and others 2018

Average composition of heavy mineral concentrates offshore Virginia, wt % of heavy mineral fraction

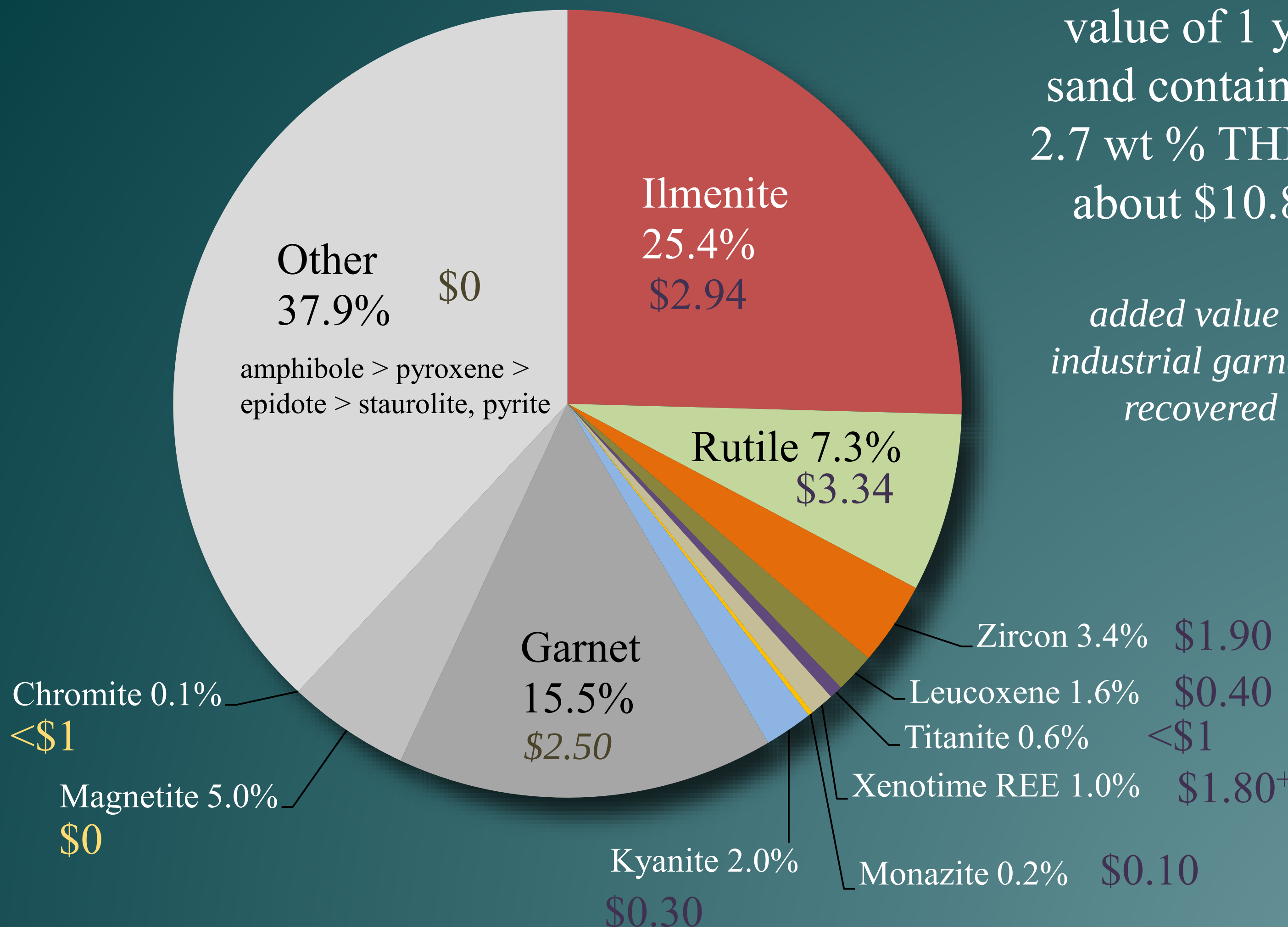


Mean THM
2.7 wt %

Mean EHM
41 wt %
of THM

Sources: Berquist and Hobbs, 1986; 1988; Berquist and others, 1990; Berquist and others, 2016; Lassetter and Blanchette, 2019

Value of commodities based on current market price ranges



value of 1 yd^3 sand containing 2.7 wt % THM is about $10.80

added value if industrial garnet is recovered

Sources: *Industrial Minerals*, 2020; US Census Bureau (export prices); SME *Mining Engineering* Industrial Minerals Review, 2021; USGS Mineral Commodity Summaries, 2021; Institute for Rare Earths and Metals AG; Bloomburg; per. comm.

Key properties of economic heavy minerals

Mineral name	Composition	Specific gravity	Hardness (Mohs)	Magnetic susceptibility[1]	Electrostatic response[2]	Weathering stability	Radioactivity[3]	Fluorescence
Monazite	$(Ce,La,Sm,Th)PO_4$	4.8 5.5	5 5.5	paramagnetic	non conductor	high	weak - strong	none
Ilmenite	$FeTiO_3$	4.7 4.8	5 5.5	paramagnetic	conductor	mod high	none	none
Zircon	$ZrSiO_4$	4.6 4.7	7.5	non magnetic	non conductor	high	mild	yes
Chromite	$(Fe,Mg)Cr_2O_4$	4.5 5.09	5.5	paramagnetic	conductor	mod high	none	none
Xenotime	$(Y,Nd,Yb)PO_4$	4.4 5.1	4 5	paramagnetic	non conductor	high	none - weak	none
Rutile	TiO_2	4.2 4.3	6 6.5	non magnetic	non conductor*	high	none	none
Leucoxene	altered $FeTiO_3$	3.6 4.3	4 4.5	paramagnetic*	conductor	high	none	none
Garnet group	$(Ca,Fe,Mg,Al)(SiO_4)_3$	3.4 4.6	7.5	non magnetic	non conductor*	mod	none	none
Allanite	$(Ce,Ca,La,Y)2(Al,Fe)_3(SiO_4)_3(OH)$	3.5 4.2	5.5	paramagnetic	non conductor	low mod	mild - weak	none
Titanite	$Ca(La,Ce)TiO(SiO_4)$	3.4 3.56	5 5.5	non magnetic	non conductor*	mod	mild	yes
Sillimanite minerals	Al_2SiO_5	3.1 3.7	4 7	non magnetic	non conductor	Mod	none	none
Quartz	SiO_2	2.6 – 2.65	7	non magnetic	non conductor*	high	none	none

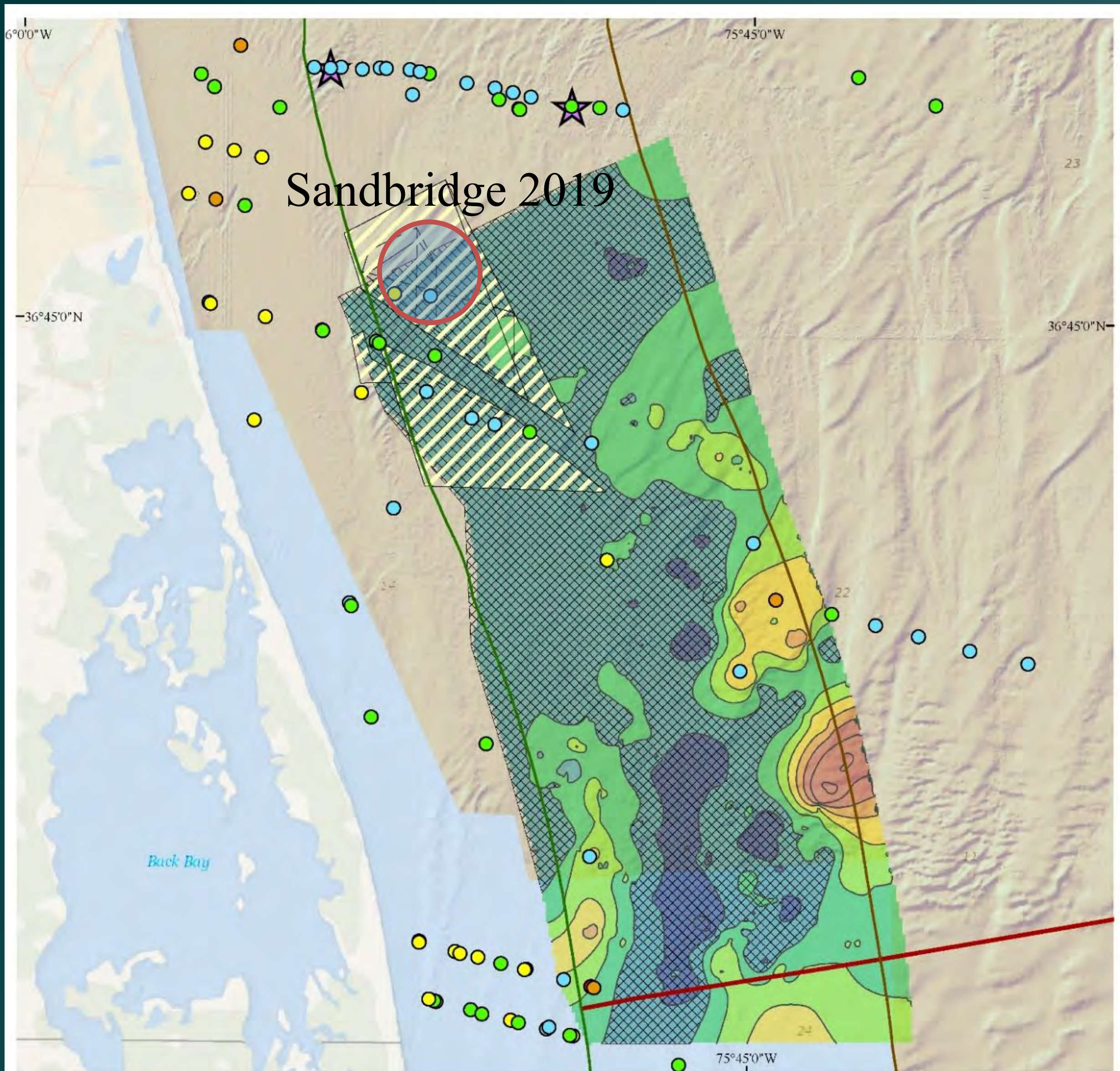
1 * variation in response based on actual mineral composition

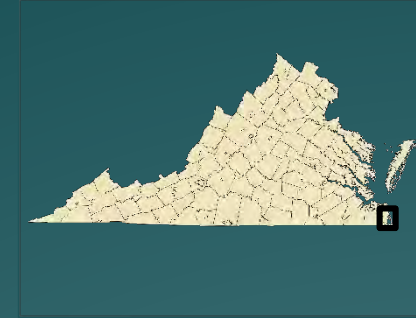
2 * mineral becomes more conductive with treatment at elevated temperatures

3 classified by API gamma units

Sources: Mindat.org; WebMinerals.com; Carpco, Inc.;

Sandbridge resource area





Sandbridge 2019 Project

1.84M yd^3 from
Sandbridge Shoal
Fed Sand Lease Area
placed on Virginia Beach,
Sandbridge Beach 2019-20

If we assume
THM ~2.7 wt %

est. value $19.91 million

https://www.boem.gov/marine minerals/requests and active leases

Contact information

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434-951-6361

Virginia Energy web site:

https://energy.virginia.gov

For more info about critical minerals, visit:

https://energy.virginia.gov/geology/CriticalMinerals.shtml

Session 1: Marine mineral sands – feasibility of extracting critical mineral resources

HAWKINS, D.W. – Overview of global coastal and nearshore mineral recovery operations (DHawkins.pdf)

Overview of global coastal and nearshore mineral recovery operations

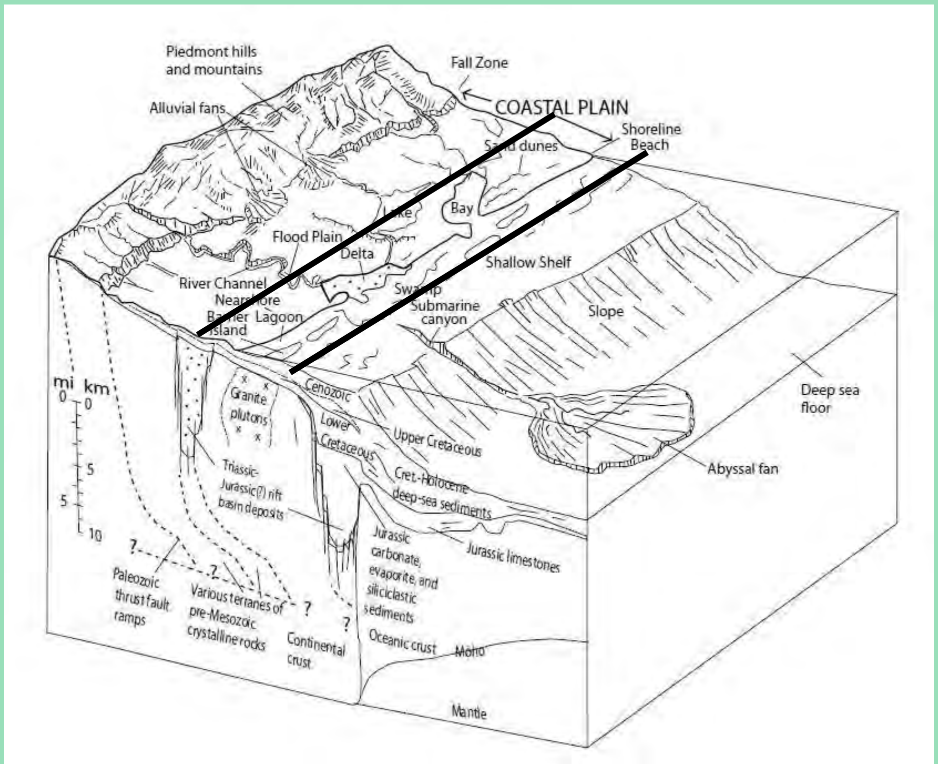
Credit: Royal IHC website

David W. Hawkins, P.G.

Virginia Department of Energy, Geology and Mineral Resources Program

VIRGINIA Energy

Geologic Context – Heavy Mineral Sands



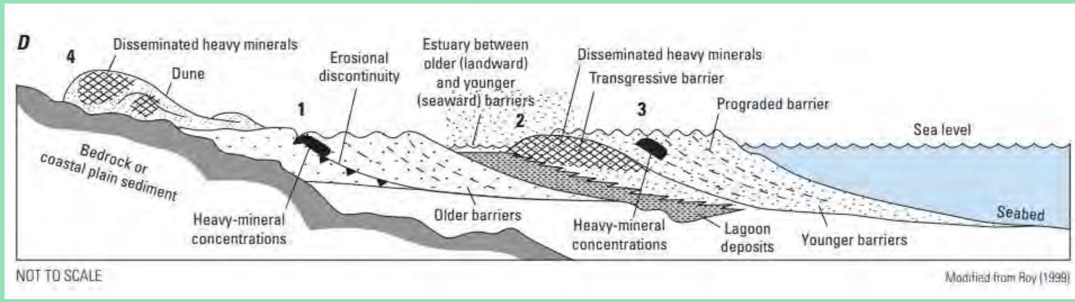
Generalized geologic cross-section (Powars et al., 2016)

Passive margin coastline backed by highly weathered high-grade metamorphic and mafic igneous rocks

Transgressive-regressive sea-level cycles

Commonly associated with placer deposits; ore deposits are typically <1 km to 4 km wide and upwards of 45 m thick

Terrestrial deposits: shallow, unconsolidated to poorly consolidated, voluminous, well-established separation techniques, >2% THM



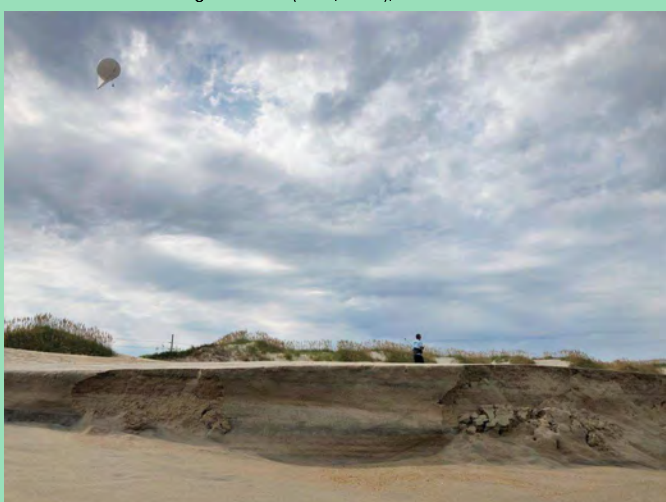
Example depositional setting for heavy minerals in the coastal zone (Schulz and others, 2017)

Surf zone at Virginia Beach (June, 2021), credit: D. Hawkins

Vibracore sections from Sandbridge Shoal (D. Hawkins)

Heavy mineral laminae in sand, credit: Dr. Rick Berquist

Time + Weathering + Burial

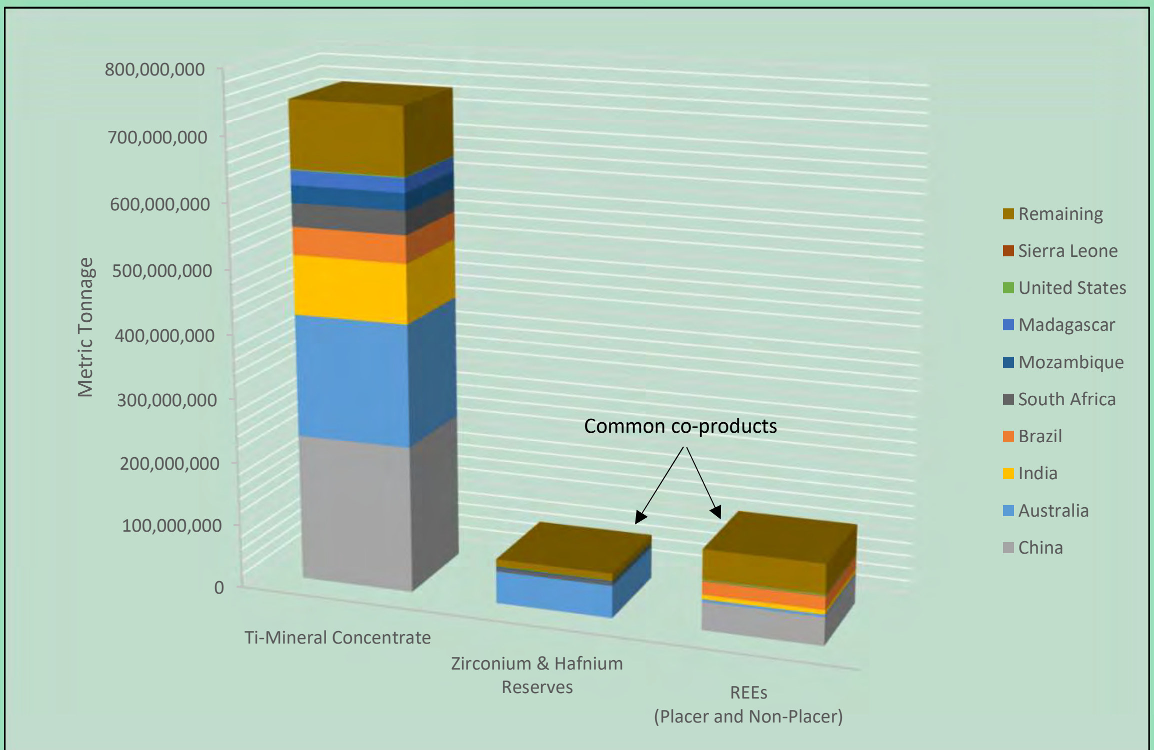


Modern beach at Pea Island, Dare County, North Carolina, credit: USGS

Drill cuttings of Pliocene sand and clay near Old Hickory (D. Hawkins)

Old Hickory Deposit excavation, credit: Dr. Rick Berquist

Commodities



Mineral Commodity Statistics for 2021 (USGS, National Minerals Information Center)

- Upwards of 1,000 Mt of HM sands ore globally[2]
- Typical suite ~up to 20% HM

Major HM Sand Commodity	Primary Producer(s) 2021 Placer deposits (does not reflect other sources)
Titanium-minerals (i.e. ilmenite, rutile)	Australia, South Africa, China, Madagascar, Mozambique, India
Zirconium	Australia, South Africa
REE placers (i.e. monazite, xenotime, apatite)	India, Brazil
Other economic minerals*	Varied

Notes:

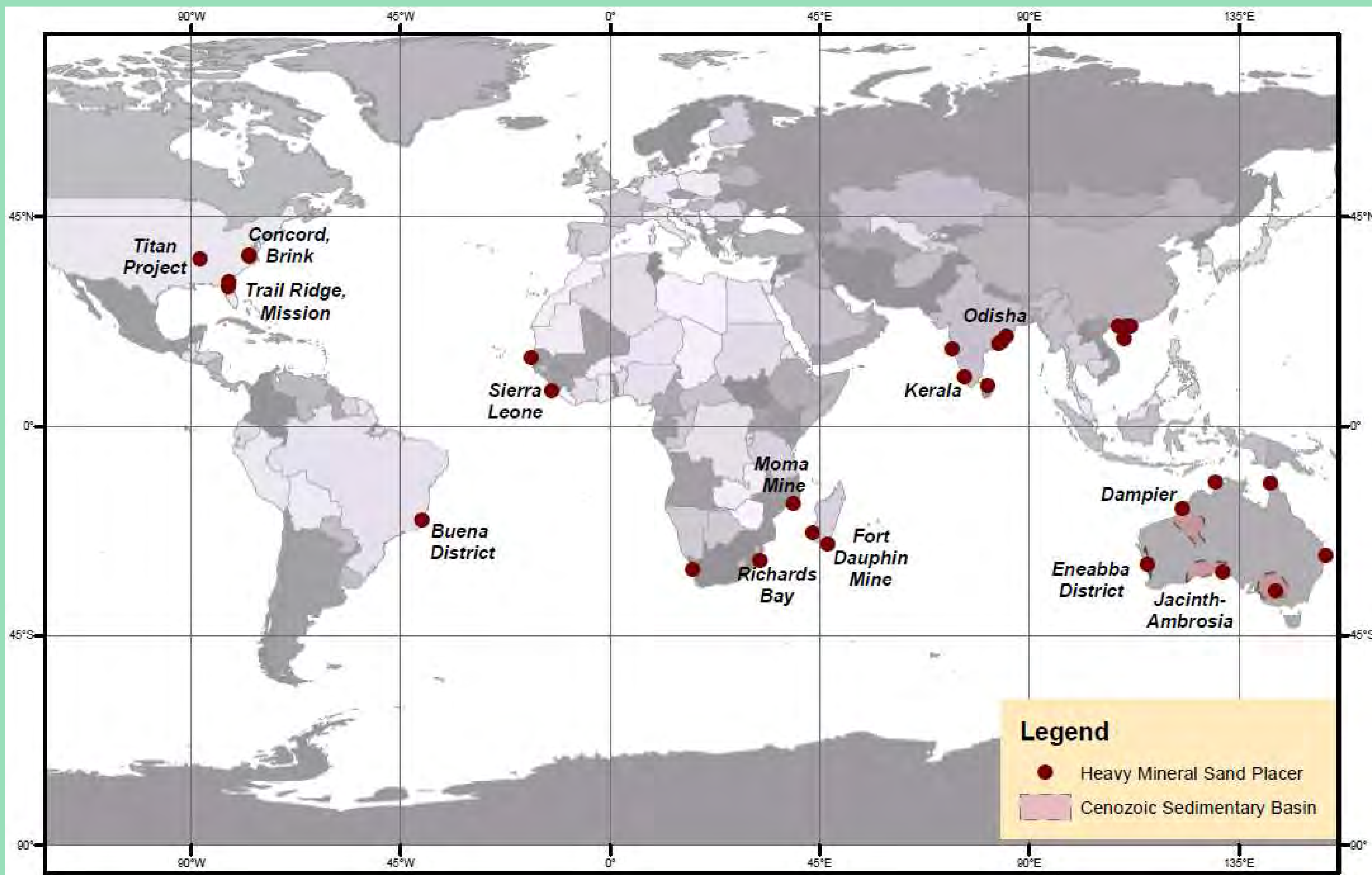
1) Other minerals historically or presently mined may include gold, tin, and diamond placers

2) Economic minerals* - refers to other accessory minerals within the typical heavy mineral (HM) sand suite (i.e. garnet, chromite, epidote, sillimanite, etc.)

Wet concentration plant and dredge, Senegal (Eramet website)

Localities

Examples of global heavy mineral sand placer deposits (note: not all known resources and/or deposits are depicted)



Localities

its (note:

Moma Plant (ArcGIS)

Concord Plant (photo from Berquist et al., 2015) SEG, Post-GSA Field Trip

Sierra Rutile (image from Iluka's website)

Moma operation (image from Kenmare Resources website)

Mineral processing (image from Kerala Minerals and Metals Ltd. Website)

Mining operations at Boonanerring (Image Resources, photo from businessnews.com.au)

Thunderbird Project (image from Sheffield's website)

Trimex Sands (Srikurman Deposit, western India)

Localities and Operations

United States (Florida, Georgia, Tennessee) – Southern Ionics, Chemours, Hyperion Metals, Iluka (reclamation)

- Titanium-minerals, zircon
- Fall zone Pliocene – Quaternary placers

Australia (Eneabba District, Jacinth-Ambrosia, Canning Basin, Murray Basin) – Iluka Resources, Sheffield Resources

- Titanium-minerals, zircon, REEs (monazite)
- Variable Cenozoic age, sedimentary basins and modern coastal strandlines

Africa (Sierra Leone, Mozambique, South Africa, Madagascar, Senegal) – Sierra Rutile, Rio Tinto, Kenmare, Eramet

- High quality rutile, titanium-minerals, zircon

India (Kerala and Odisha) – India Rare Earths Limited (IREL), Kerala Minerals and Metals Ltd – ***state-owned operations***

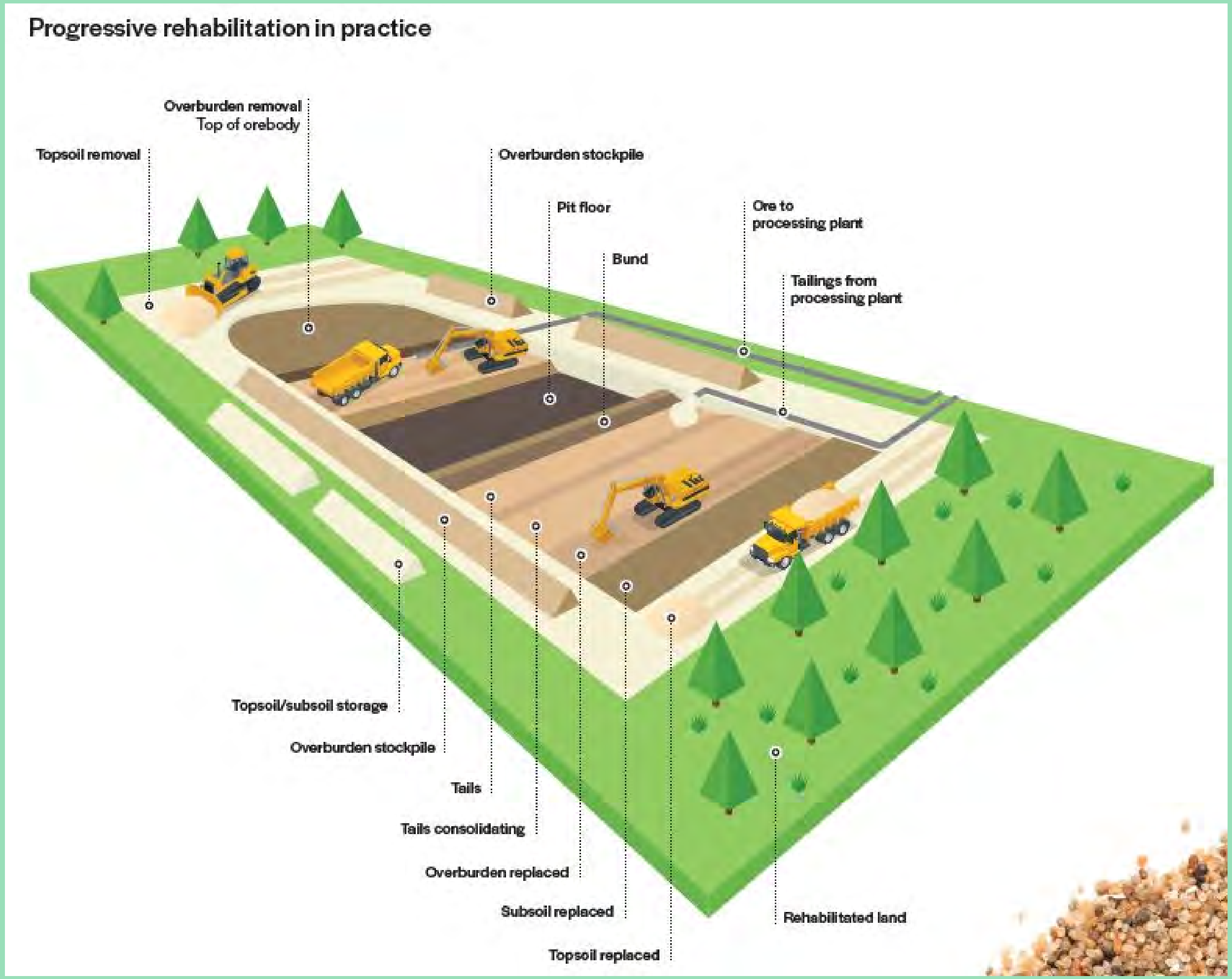
- Titanium-minerals, monazite, thorium stockpiles for nuclear power (25% of world's reserves), sillimanite
- Modern beach deposits (5 primary districts along western and eastern coasts, 15-30 km stretches up to 2 km wide)

Brazil (Buena District) – stockpile mining of monazite

- Formerly large producer of monazite from placers, 20th century

Other localities include prospects and/or current operations in SE China, Malaysia, Sri Lanka, Kenya

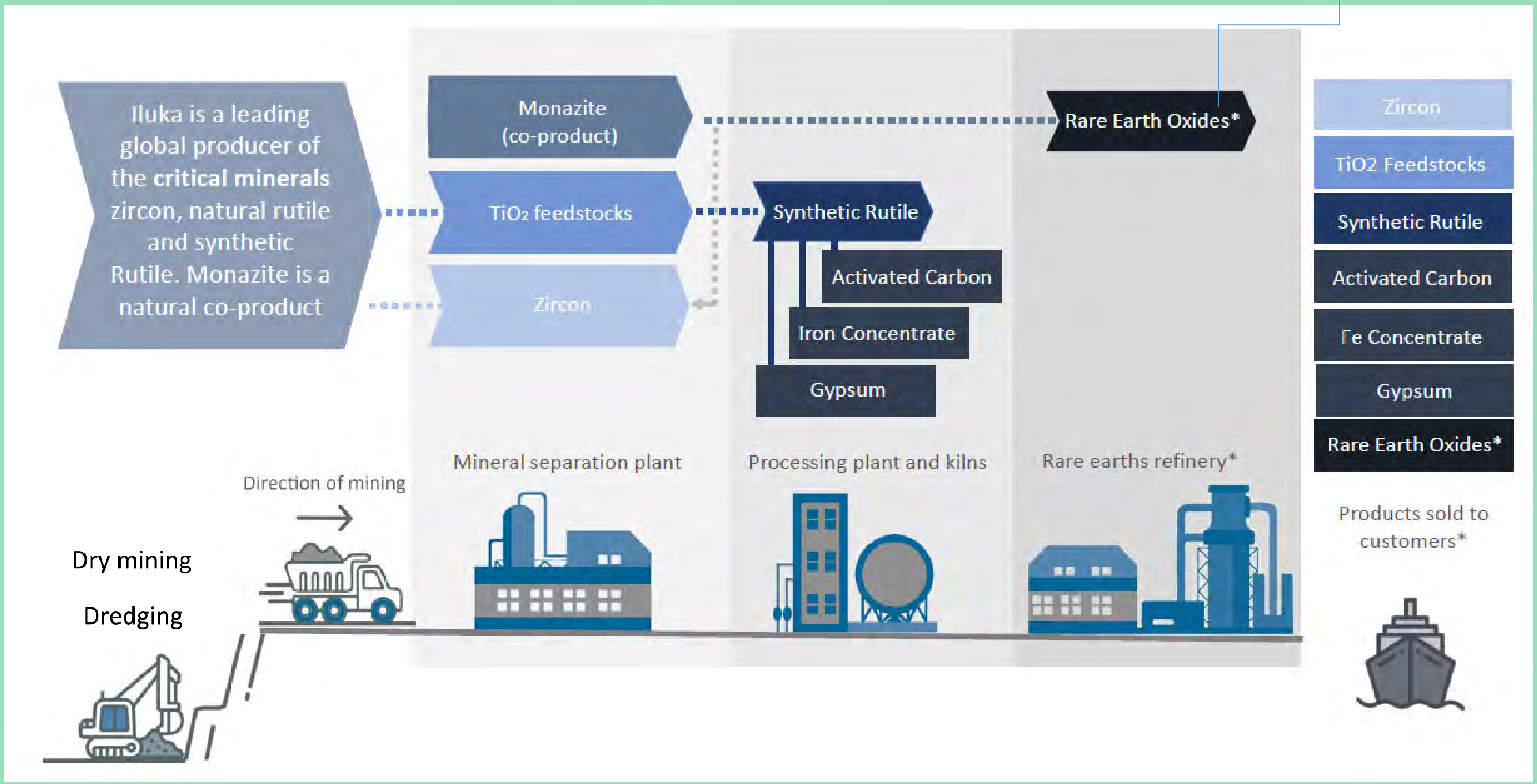
Typical Operations



Mineral sands overview (credit: minerals.org.au)

Typical Operations

Feasibility stages



Typical flow of operations (credit: Iluka Resources, Minerals Sands Conference 2021)

Offshore operations are essentially non-existent for titanium-mineral placers, aside from operations in conjunction with modern beach deposits

TABLE 3 | A summary of some seabed mining operations on continental shelves.

Contract holder (country of registration)	Description of contract holder	Location	Type of mineral	Project status (year awarded if known)
Nautilus Minerals Inc. (Canada)	Publically listed company	Bismarck Sea, PNG (Solwara 1 Project)	SMS	*Mining contract, active (2011)*
Diamond Fields International (Canada)	Limited company	Atlantis II Basin, Red Sea	SMS	*Mining contract, active (2010). Project currently on hold because of contractual issues with partnership company*
Diamond Fields (Namibia) a subsidiary of Diamond Fields International	Limited company	Namibia	Diamonds	*Mining contracts x4, active (2009, 2007 & 2007; 2000 is pending renewal; expected contract renewal as of November 2017)*
Diamond Fields (South Africa)	Limited company	Western Cape, South Africa	Phosphorites	Prospecting contract, active (2014)
Trans-Tasman Resources (New Zealand)	Limited company	South Taranaki Bight, west coast of North Island	Iron ore sands	*Three projects with an exploration permit, a mining permit and a prospecting permit*
Trans-Tasman Resources (New Zealand)	Limited company	Westland sands, Ross to Karamea, west coast of South Island	Iron ore sands	Prospecting contract, active (2016)
Chatham Rock Phosphate (New Zealand)	Limited company	Chatham Rise, east side, South Island	Phosphorites	*Mining contract, active (2013). Company refused environmental mining consent approval (2015).*
Bluewater Minerals (Solomon Islands) Ltd. (Solomon Islands)	Limited company	Temotu and Western provinces, Solomon Islands	SMS	Prospecting contract, active (2007)
Green Flash Trading 251 (South Africa)	Limited company	Green River to Cape Town, South Africa	Phosphorites	Prospecting contract, active (2014)
Green Flash Trading 257 (South Africa)	Limited company	Cape Town to Cape Infanta, South Africa	Phosphorites	Prospecting contract, active (2014)
Namibian Marine Phosphate (Pty) Ltd. (Namibia)	Limited company	Sandpiper Marine Phosphate Project, Walvis Bay, Namibia	Phosphorites	*Mining contract, active (2011). Project pending EIA approval (June 2017).*

This is not an exhaustive list and text in italics indicates exploitation (active mining) contracts, all other contracts refer to exploration. SMS, seafloor massive sulfide deposits.

Examples of shallow seabed mining operations (Miller et al., 2018)

South Taranaki Bight Project:

- Fe sand resource
- 25-60 m depth
- Mineral separation offshore
- Multiple support vessels

Status: ?

Selected References

Powars, D.S., Edwards, L.E., Johnson, G.H., and Berquist, C.R., 2016, Geology of the Virginia Coastal Plain: New insights from continuous cores and geophysical surveys, in Bailey, C.M., Sherwood, W.C., Eaton, L.S., and Powars, D.S., eds., The Geology of Virginia: Virginia Museum of Natural History Special Publication 18, pgs. 193-240.

(1) Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II, and Bradley, D.C., eds., 2017, Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply: U.S. Geological Survey Professional Paper 1802, 797 p., http://doi.org/10.3133/pp1802.

(2) Van Gosen, B.S., Fey, D.L., Shah, A.K., Verplanck, P.L., and Hoefen, T.M., 2014, Deposit model for heavy-mineral sands in coastal environments: U.S. Geological Survey Scientific Investigations Report 2010–5070–L, 51 p., http://dx.doi.org/10.3133/sir20105070L.

(3) Van Gosen, B.S, and Ellefsen, K.J., 2018, Titanium mineral resources in heavy-mineral sands in the Atlantic Coastal Plain of the southeastern United States: U.S. Geological Survey Scientific Investigations Report 2018–5045, 32 p., https://doi.org/10.3133/sir20185045.

(4) USGS, 2022, United States Geological Survey, National Minerals Information Center, Commodity Statistics and Information, https://www.usgs.gov/centers/national-minerals-information-center/commodity-statistics-and-information.

Session 1: Marine mineral sands – feasibility of extracting critical mineral resources

KARST, A.T. – Onshore heavy mineral sands: Exploration, mining, processing, and reclamation (AKarst.pdf)

Onshore heavy mineral sands

Exploration, mining, processing, and reclamation

Adam Karst, P.G.
President and Principal Geologist
Karst Geo Solutions, LLC

Exploration

Primarily looking for unconsolidated marine placer deposits of heavy minerals (HMs)

Traditional methods

- Desktop research – USGS, state surveys, academic papers, prior exploration
- Mapping and field reconassience – not as effective for buried deposits

Geophysics

- Radiometric (monazite and zircon contain U, Th)
- Magnetic (some valuable HMs are weakly magnetic)

Drilling

- Auger – low cost, good for shallow depths
- Sonic – highest cost, high-quality large-volume samples
- RC air-core – low cost, fast, only cuttings

Mining

Dredging

- Low-cost
- Requires flat-lying deposit with shallow water table (coastal areas)
- Falling out of favor due to environmental concerns (stigma)

Dry mining

- Truck and shovel – highest cost, largest equipment fleet
- Dozer trap – lowest cost, bulk mining method
- Mobile mining unit – selective, minimizes equipment
- Often involves slurry transport system – need water source

Processing

Wet concentration (Wet Concentrator Plant – WCP)

- Gravity separation – spirals
- Produces Heavy Mineral Concentrate (HMC) – all HMs that can be recovered with some silica/lights (~90% HM)
- Non-valuables (silica sand/fines/oversize) form tails stream and are retuned to the mining void
- Transport HMC to MSP

Dry separation (Mineral Separation Plant – MSP)

- Dry the HMC – energy intensive
- Electrostatic and magnetic separators
- Wet/gravity circuits
- Produces final products for sale – ilmenite, leucoxene, rutile, zircon, monazite
- Dry mill tails (DMT) – non-valuable minerals

Reclamation

- Reclamation varies based on fines content of orebody
- Sandier orebodies are easier to reclaim with quick de-watering of mine tails and stability shortly after placement
- Orebodies with higher fines content may take several years to dry/decant mine tails to support heavy equipment

Other considerations

NORM – Naturally Occurring Radioactive Material

- Some HMs (zircon, monazite) contain appreciable NORM (U and Th)
- Handling and transportation of HMC and products may require permits/licenses depending on concentrations involved
- DMT (dry mill tailings) must be managed and diluted back into the mine tailings stream (or sold)

Session 2: Current offshore sand mining operations for beach replenishment

KNORR, P.O. – Federal marine minerals leasing program in the Mid-Atlantic (PKnorr.pdf)

BOEM Bureau of Ocean Energy Management

Outer Continental Shelf Minerals Leasing

Offshore Heavy Minerals Forum

Paul O. Knorr

March 31, 2022

Overview

- Sand and Minerals
- Non-Competitive Negotiated Agreements (NNA)
- Competitive Leasing Framework
- Uncertainties

Sand and Minerals, but not Elements

- Sand -> **Sand, gravel, and shell** (OCLSA 43 USC 1301 8(k)(2)(A)(1).
- Minerals -> Oil, gas, sulphur, geopressured-geothermal and associated resources, and **all other minerals** which are authorized by an Act of Congress to be produced from ''public lands'' as defined in section 103 of the Federal Land Policy and Management Act of 1976 (OCSLA 43 USC 1301(2)(q)).
- Hard Minerals -> Any deposit or accretion on, or just below, the surface of the deep seabed of **nodules** which include one or more minerals, at least one of which contains **manganese, nickel, cobalt, or copper** (DSHMRA, 30 USC 1403(6)).
- Heavy Minerals –> Dense minerals that have a **specific gravity >2.85**, vs.quartz ~2.65 (USGS SIR 2010-5070-L).
    - E.g., contain titanium, zirconium, REE
- Critical Minerals -> A **mineral** (1) **identified *(by USGS)*** to be a nonfuel mineral or mineral material essential to the economic and national security of the United States, (2) from a supply chain that is vulnerable to disruption, and (3) that serves an essential function in the manufacturing of a product, the absence of which would have substantial consequences for the U.S. economy or national security (Executive Order 13817).
    - E.g., contain aluminum, cobalt, iridium, manganese, nickel, platinum group, REE, titanium, zinc, zirconium

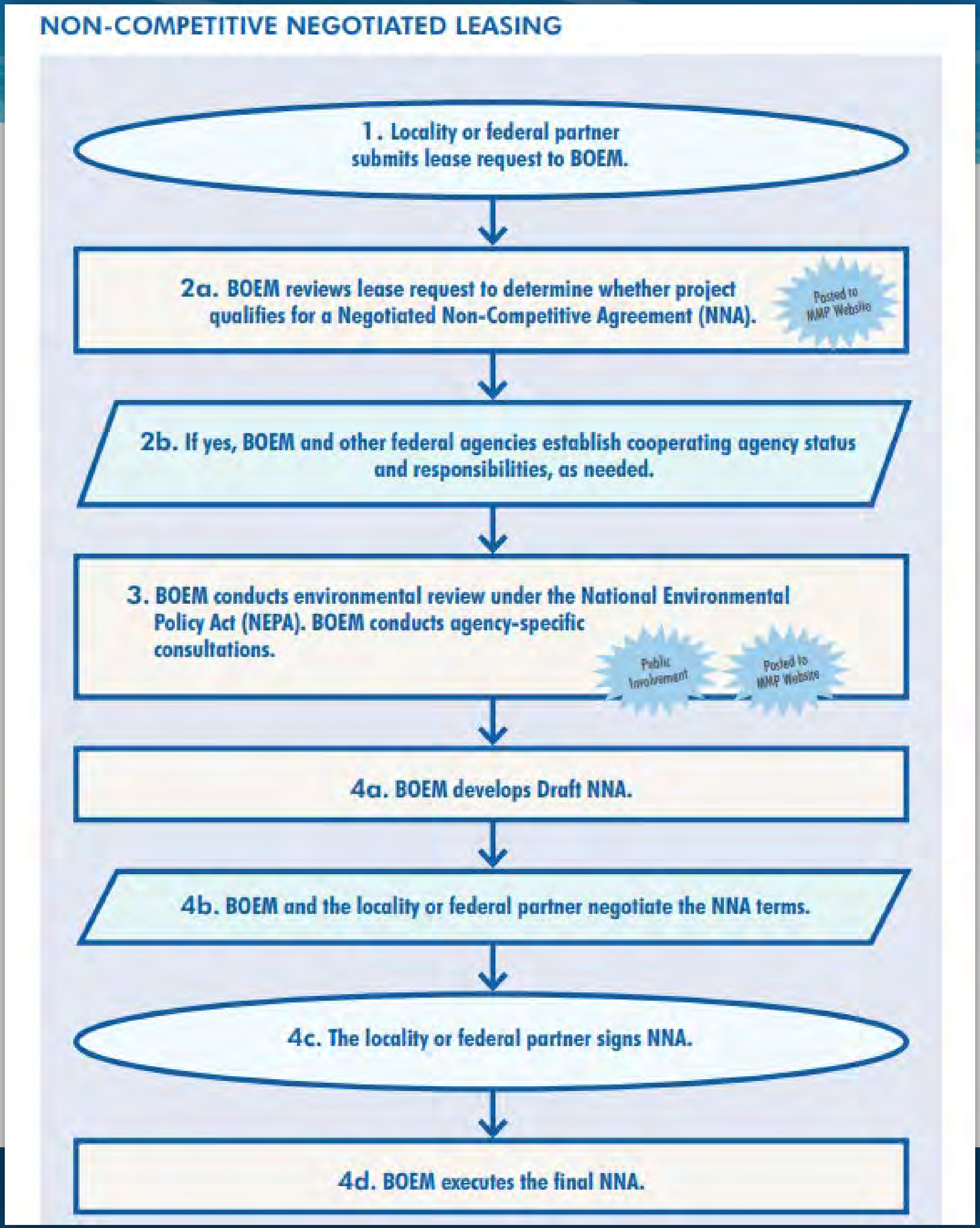
NNA Authority and Framework

- Authority
  - **Outer Continental Shelf Lands Act** (OCSLA) (43 U.S.C. 1331, et. seq.)
  - **Public Law 103-426** (43 U.S.C. 1337(k)(2)) (1994)
  - **1999 Amendment**
- Non-Competitive Negotiated Agreement (NNA)
  - For government shore protection, beach restoration, coastal wetlands restoration, or for Federal construction projects
    - **3-party MOA** – (e.g., USACE Civil Works)
    - **2-party MOA** – (e.g., BOEM / PAFB)
    - **2-party lease** – (e.g., USACE Regulatory)

Source: Charles St. Martin, Rhode Island DOT

Source: Weeks Marine

NNA Leasing Process



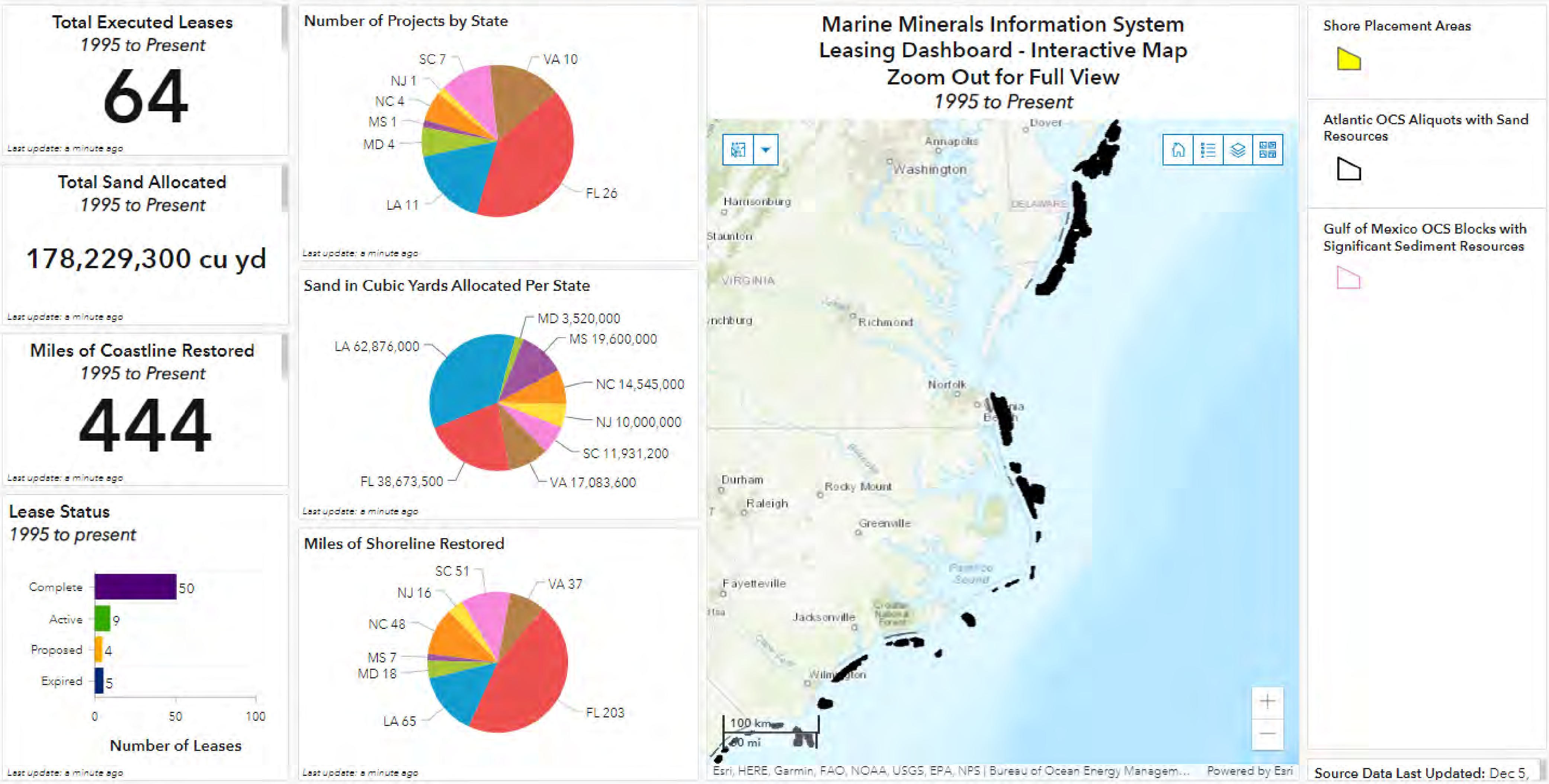
Environmental Components

NEPA

- E.O. 12898: Environmental Justice
- Magnuson Stevens Fishery Conservation and Management Act
- Federal Water Pollution Control Act
- Clean Air Act
- Coastal Zone Management Act
- Marine Mammal Protection Act
- National Historic Preservation Act
- Endangered Species Act

Current Statistics

https://mmis.doi.gov/boemmmis/



Current Statistics

Requests and Active Leases

CURRENT REQUESTS					
State	**Applicants(s)**	**Request Date**	**Project Area**	**Volume Requested (cubic yards)**	**Borrow Area Location**
N/A	N/A	N/A	N/A	N/A	N/A
ACTIVE NEGOTIATED AGREEMENTS					
State	**Lessee(s)**	**Agreement Expiration Date**	**Project Area**	**Volume (cubic Yards)**	**Construction Status**
NC	Dare County, NC Shoreline Protection Project	11/30/2024	11.7 miles of coast within Duck, Southern Shores, Kitty Hawk, and Kill Devil Hills	6,600,000	Not Begun
FL	St. Johns County, Ponte Vedra Beach	9/30/2024	8.9 miles of coastline	2,200,000	Not Begun
FL	Department of the Army/Corps of Engineers and Flagler County	3/23/2023	3 miles of Flagler County Beaches	700,000	Not Begun
FL	Flagler County	8/11/2023	Flagler County Beaches	1,800,000	Not Begun
FL	St. Lucie County and USACE	7/8/2024	3.3 miles of coast	800,000	Est. Commencement March 2022
FL	St. Johns County, FL South Ponte Vedra	4/9/2024	5 miles of St. Johns County FL beaches at South Ponte Vedra Beach	1,064,000	Not Begun
LA	East Timbalier (TE-118) and Terrebonne Basin Barrier Island and Beach Nourishment (TE-143)	6/3/2023	East Timbalier Island, extending the West Belle Headland, westward from the previously constructed West Belle Pass Headland (TE-118). Trinity East Island and Timbalier Island beach, dune, and intertidal marsh habitat (TE-143).	10,000,000	Has Begun

Domestic Competitive Leasing Framework

- **Leasing is a separate competitive process** from prospecting permit

- Current regulations
  - **30 CFR Section 580 (Prospecting)**
  - **30 CFR Section 581 (Leasing)**
  - **30 CFR Section 582 (Operations)**

30 CFR Part 580 - Prospecting for Minerals

- OCSLA requires all parties who are prospecting marine minerals for **commercial** purposes to receive authorization.
- Under BOEM regulations, **pre-lease geological and geophysical explorations** can only be performed under a **permit, authorization, or scientific research notice**.
- Interested parties are required (under 30 CFR 580.12) to submit permit application form (Form BOEM-0134) **at least 30 days before the start date**.
  - Application provides the information necessary to evaluate potential lessee's qualifications, and upon approval, a permit or authorization is issued.
  - Environmental assessment may be required as part of permitting process.

30 CFR Part 581 – Leasing of Minerals

Leasing is a separate <u>competitive</u> process from the prospecting permit

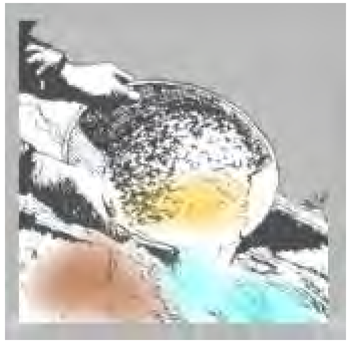
- The lease sale process can be initiated by:
    - ***An unsolicited request for a lease sale (30 CFR 581.11)***
    - On DOI's own initiative (30 CFR 581.12)
    - Followed by:
        - A request for OCS mineral information and interest (30 CFR 581.12) "RFI"
        - Joint State/Federal coordination (30 CFR 581.13).
- Lease term - not less than **20 years** (other than sand and gravel).
- BOEM has yet to issue a competitive lease under these regulations.

Source: *nih.gov*

30 CFR Part 582 – Operations

- Requirements for **Delineation, Testing, and Mining Plans** (30 CFR 582.21 – 582.24)
- Operations conducted in a manner that protects the environment and promotes orderly development of OCS minerals (30 CFR 582.12)
- Opportunities for review and comments on plans and environmental documentation (30 CFR 582.4)
- Environmental protection measures and monitoring (30 CFR 582.28)
- Reporting requirements (30 CFR 582.29)
- Noncompliance, remedies, and penalties (30 CFR 582.14)

Delineation ~ Exploration



Testing ~ Pilot Studies

Mining ~ Extraction

Image Sources: *usgs.gov, blm.gov*

Uncertainties / Food for Thought

- NNA process authorized by OCSLA 8k(2)(A)
  - No fee for use in:
    - a program of, or project for, **shore protection, beach restoration, or coastal wetlands restoration** undertaken by a Federal, State, or local government agency; or
    - a **construction project** … that is funded in whole or in part by or authorized by the Federal Government.
  - For other uses:
    - the Secretary **may** assess a fee based on an assessment of the value of the resources and the public interest served by promoting development of the resources.
- Does the location of extraction alter the status of the sediment (e.g., process at sea vs. on land)?
- Are modified or new regulations needed?
- Is a competitive lease sale required?
  - Negotiated fees? Royalties? Who benefits?

Questions?

Paul O. Knorr, PhD *paul.knorr@boem.gov*

BOEM

Bureau of Ocean Energy Management

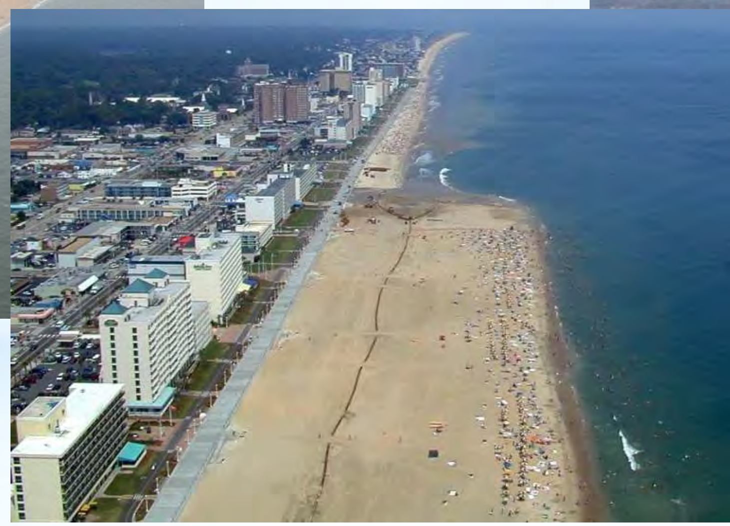
BOEM.gov

Session 2: Current offshore sand mining operations for beach replenishment

ADAMS, D.F. – City of Virginia Beach, Beach Nourishment Program (DAdams.pdf)

City of Virginia Beach
Beach Nourishment Program

Sandbridge Beach

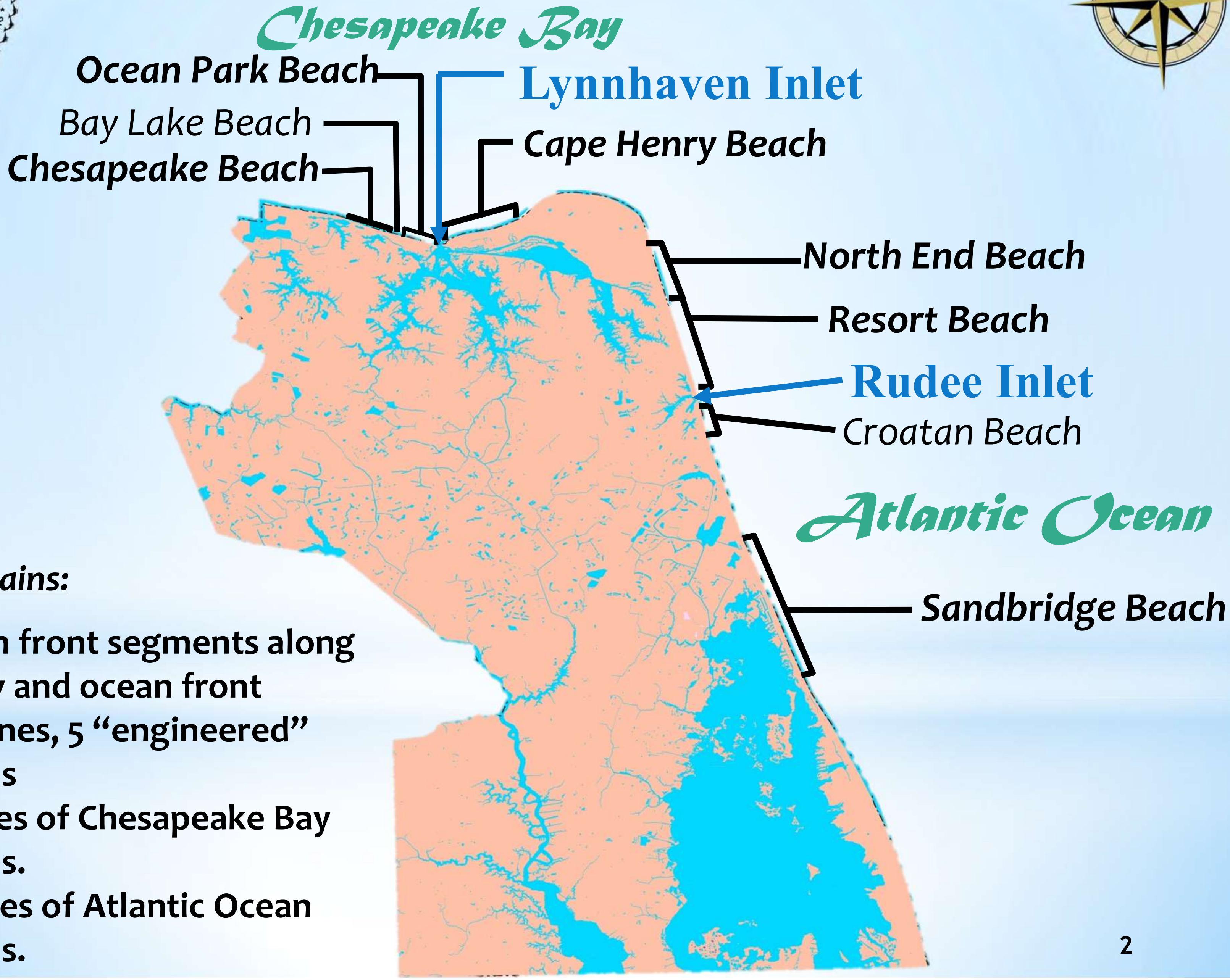


Resort Beach

Bay Beaches

Mid-Atlantic Marine Heavy Mineral Sands Forum
Virginia Department of Energy and the U.S. Bureau of Ocean Energy Management
March 31, 2022

Beach Segments

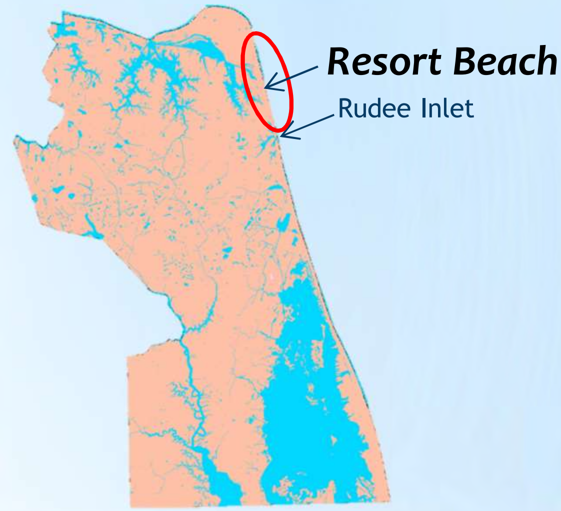


City Maintains:

- **8 beach front segments along the bay and ocean front shorelines, 5 “engineered” beaches**
- **4.6 miles of Chesapeake Bay beaches.**
- **11.8 miles of Atlantic Ocean beaches.**

Virginia Beach Erosion Control and Hurricane Protection Project

Summer 2002



- 4 Million cy of sand placed from Thimble Shoals Channel.
- Project limits between Rudee Inlet and 89th St.
- Completed in June 2002
- Nourishment cost = $22.5 Million.
- City share = $7.6 Million.

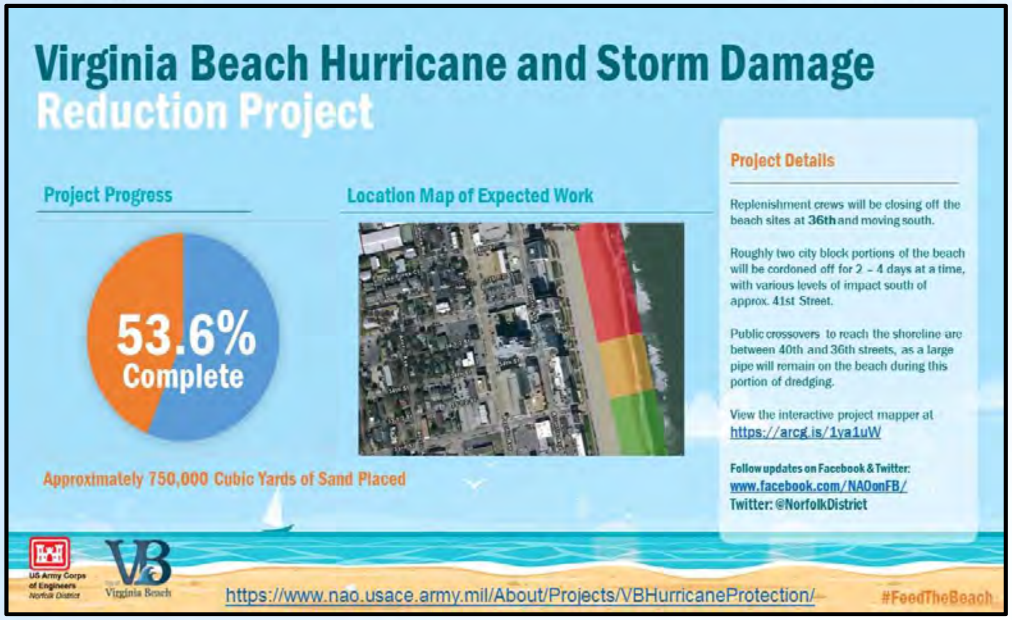
Virginia Beach Erosion Control and Hurricane Protection Project

Winter – Summer 2013

- 1.44 Million cy of sand mined from Thimble Shoals Channel & the Atlantic Ocean Channel.
- Limits of project are from 15th St. to 70th St.
- Project completed August 2013
- Construction Cost = $14.0 Million
- City Cost = $4.7 Million

Virginia Beach Erosion Control and Hurricane Protection Project

Summer 2019



- 1.4 Million cy of sand mined from Thimble Shoals Channel & the Atlantic Ocean Channel.
- Limits of project are from 15th St. to 70th St.
- Construction Cost = $22.6 Million (Base Bid + One Option).
- City Share = $7.9 Million.

Virginia Beach Erosion Control and Hurricane Protection Project

Nourishment Summary

2001 - 2002: "Big Beach"
4Million CY Nourishment
($22 Million)

Winter 2012/2013: 1.44 Million CY
Replenishment ($14 Million)

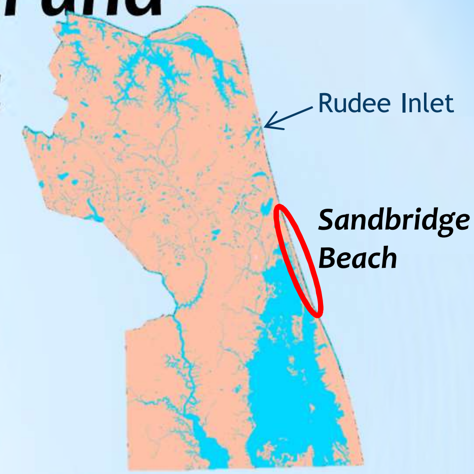
Summer 2019: 1.4 Million CY
Replenishment ($22.6 Million)

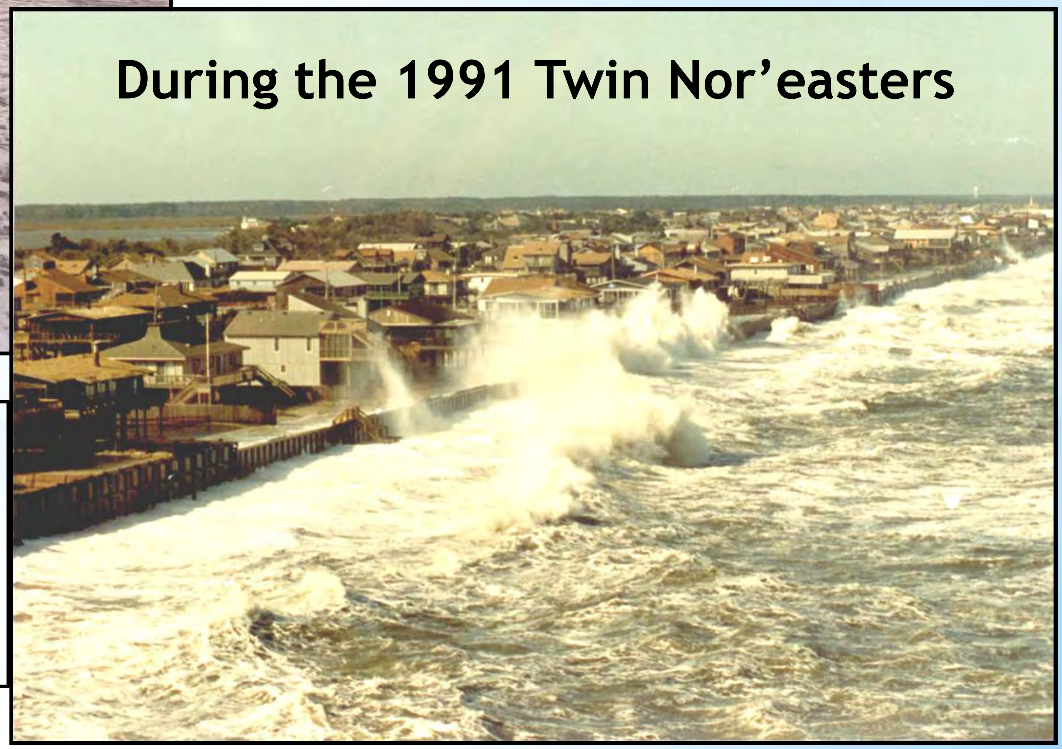
6.8 Million CY

Local Sponsor Share of Costs to Date: <u>$20.2 Million</u>

Storm Damage Aversion Since 2003 > $430 Million

Sandbridge Beach Erosion Control and Hurricane Protection Project





Historically:

- No beach nourishment program
- Segmented bulkheads built to protect against storm conditions
- Vital community that required a solution

Sandbridge Beach Restoration

Project History

- 1998 Initial replenishment - 100% City Funded
- 2003 Second cycle – 65% federal, 35% City
- 2007 Third cycle – approximately 20% federal, 80% City
- 2013 Fourth cycle – 100% City Funded
- 2019 Fifth cycle – City Funded, $3.1M federal assistance

2013 Sandbridge Beach Nourishment

Project Summary:

1. Project Duration: March 2013 to June 2013.
2. Project Limits: 5.3 miles.
3. Constructed Project Volume = 2.18MCY.
4. Berm Height : +7.0 ft. NAVD 88.
5. Berm Width: 90ft from seawalls or +7.0 ft. NAVD 88 contour.
6. Width to MHW (+1.3ft NAVD 88): 200ft from seawalls or +7.0 ft. NAVD 88 contour.
7. 1V:20H beachface slope to sea.
8. Total Project Cost = $15.9 Million.

2019 Sandbridge Beach Nourishment

Proposed Project:

1. Project Duration: Nov. 2019 to April 2020.
2. Project Limits: 5.3 miles.
3. Project Volume = 1.7MCY.
4. Berm Height : +7.0 ft. NAVD 88.
5. Berm Width: 90ft from seawalls or +7.0 ft. NAVD 88 contour.
6. Width to MHW (+1.3ft NAVD 88): 200ft from seawalls or +7.0 ft. NAVD 88 contour.
7. 1V:20H beachface slope to sea.
8. Awarded Bid Price = $20.3 Million.

Sandbridge Beach Restoration

Nourishment Summary

1998 – 1.5MCY Initial Const. ($8 Mil)

2003 – 1.7MCY Replenishment ($11 Mil)

2007 – 2.0MCY Replenishment ($10 Million)

2013 – 2.2 MCY Replenishment ($16 Million)

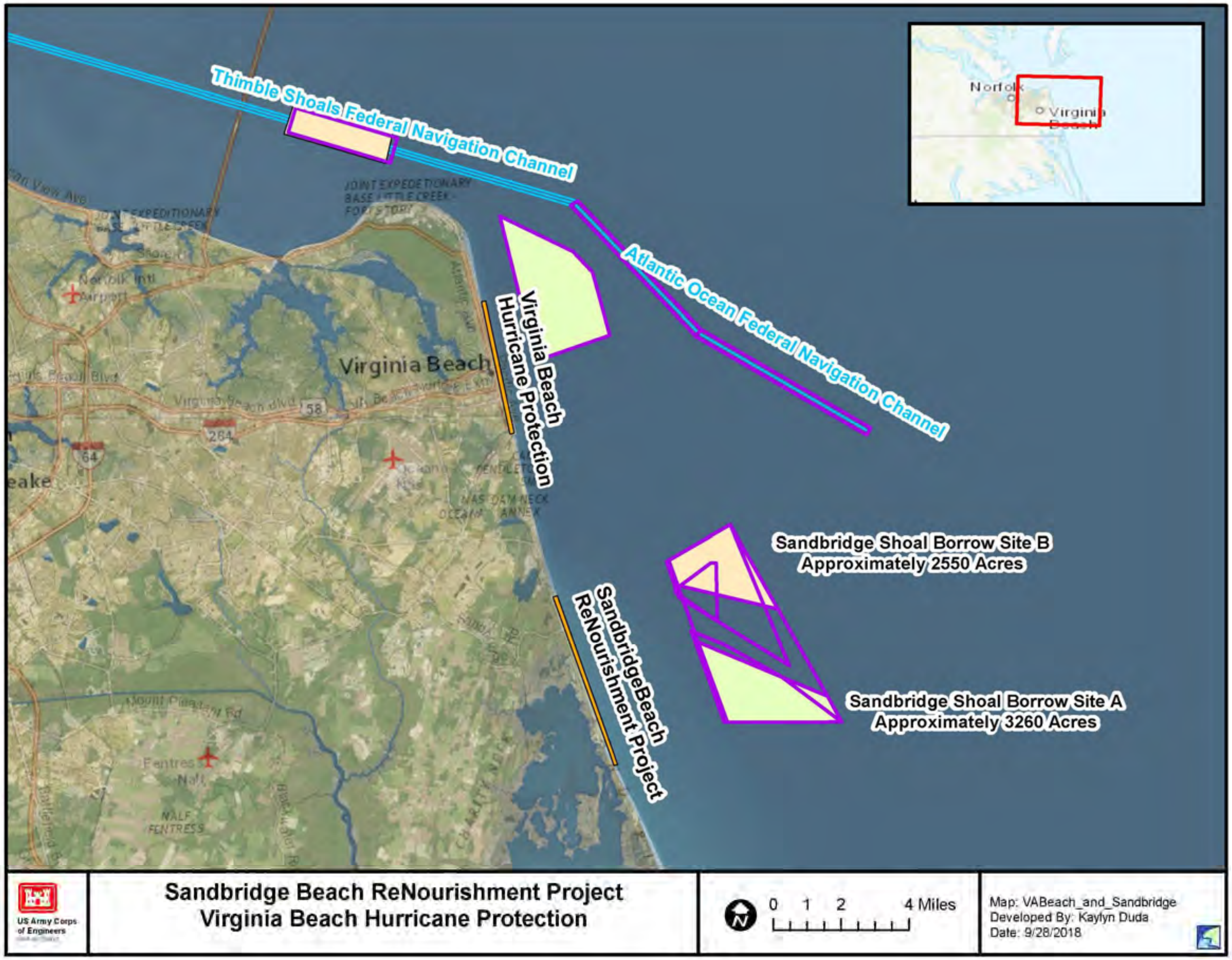
2019 – 1.70 MCY Replenishment ($20 Million)

9.1 Million CY

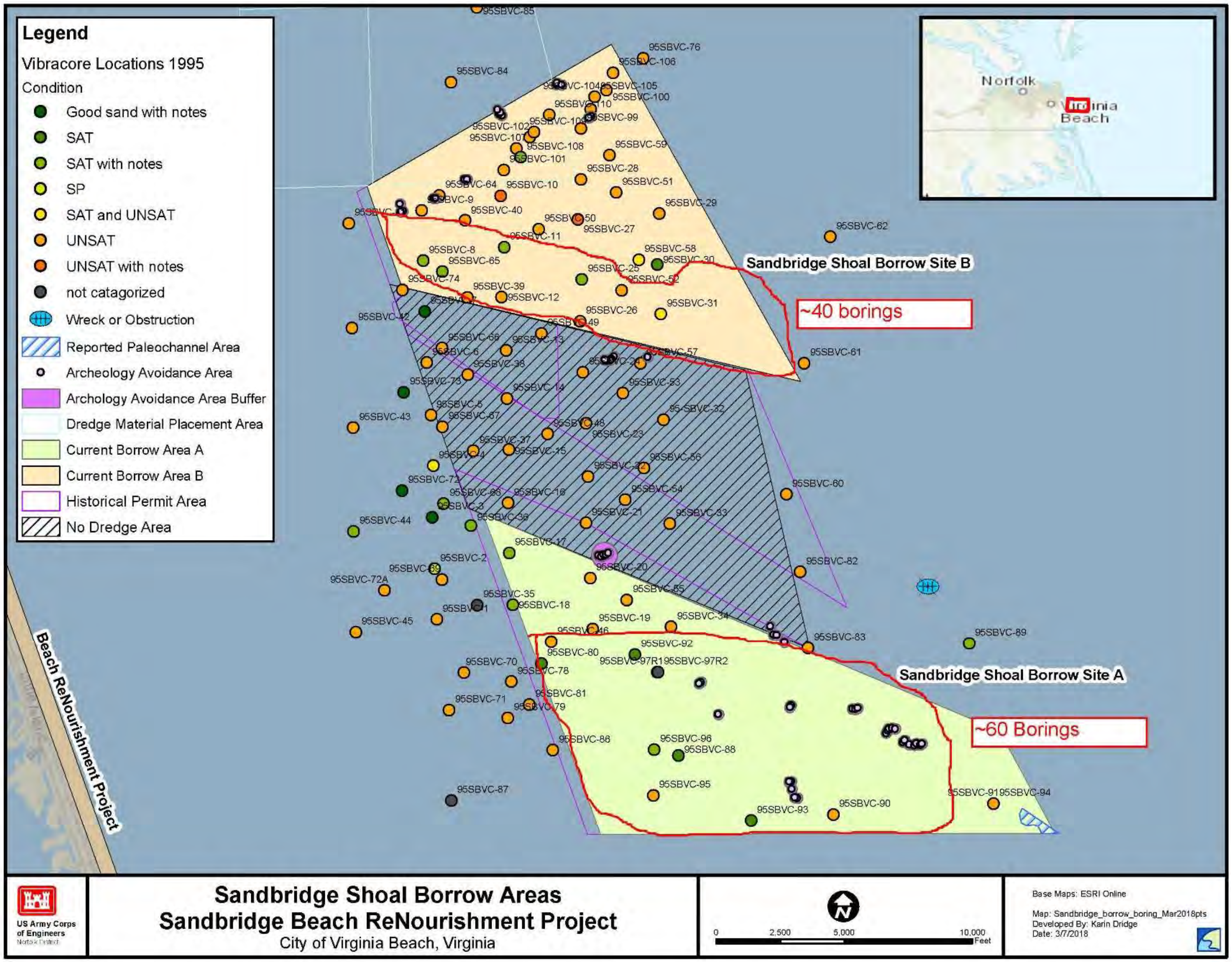
Local Sponsor Costs to Date = $55.8 Million

Storm Damage Aversion Since Hurricane Isabel (Approx. $100Mil.)

Sandridge & Virginia Beach Sand Sources



Sandbridge Shoal



The Bay Beaches

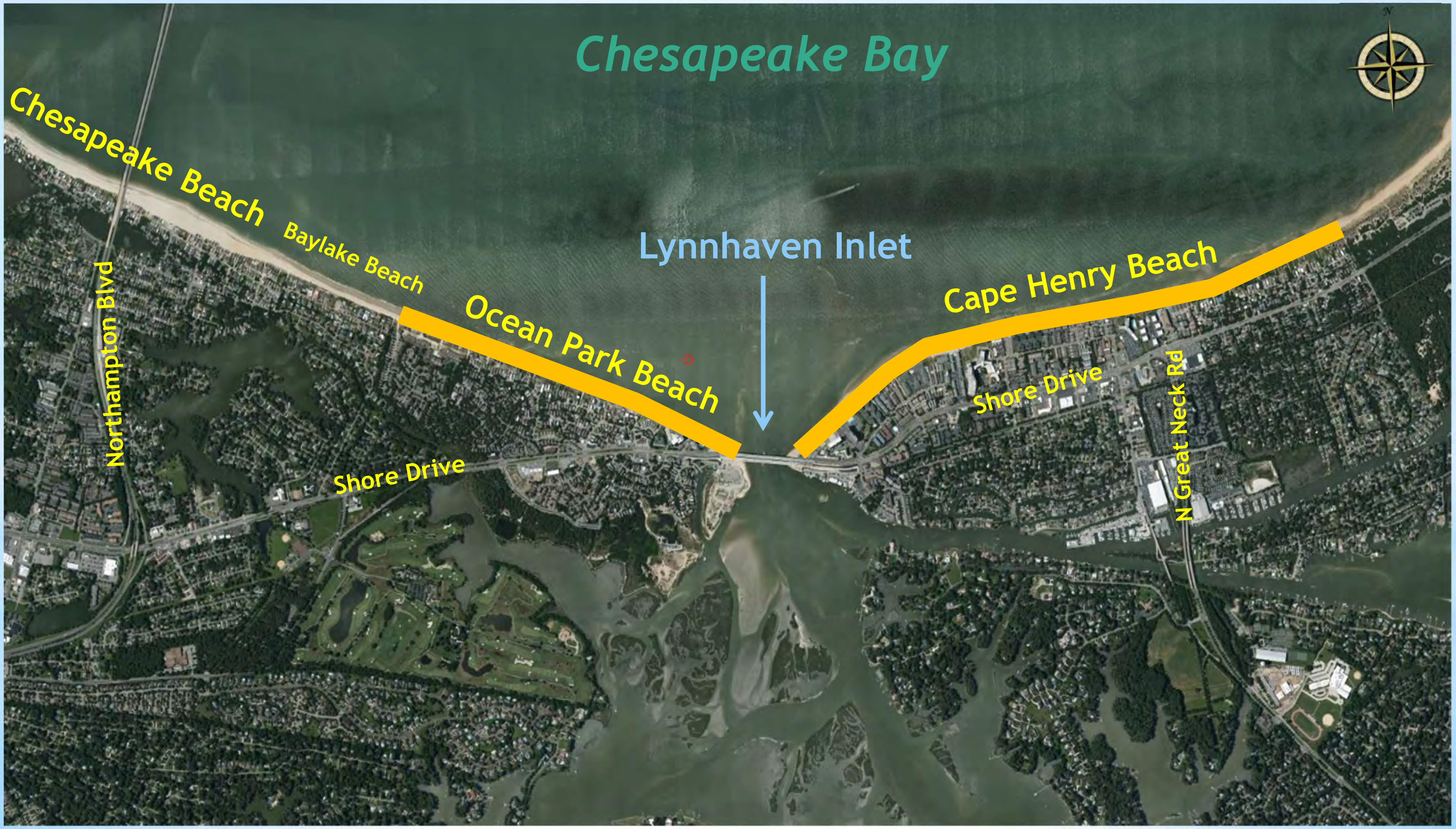
Storms of Significance

Cape Henry Beach
Superstorm Sandy 2012

Chesapeake Beach
2009 Nor'easter

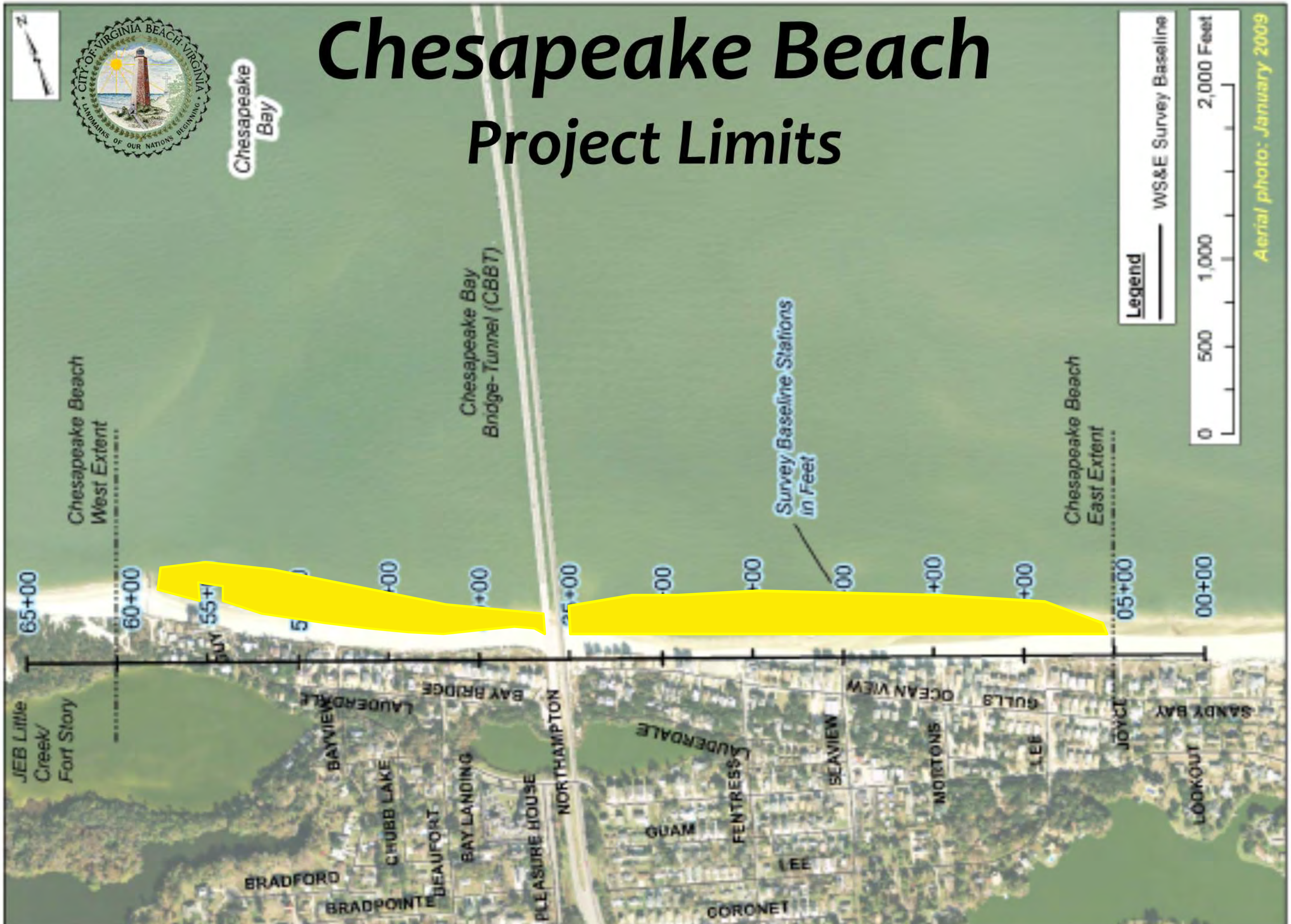
Ocean Park Beach
Hurricane Earl 2010

The Bay Beaches



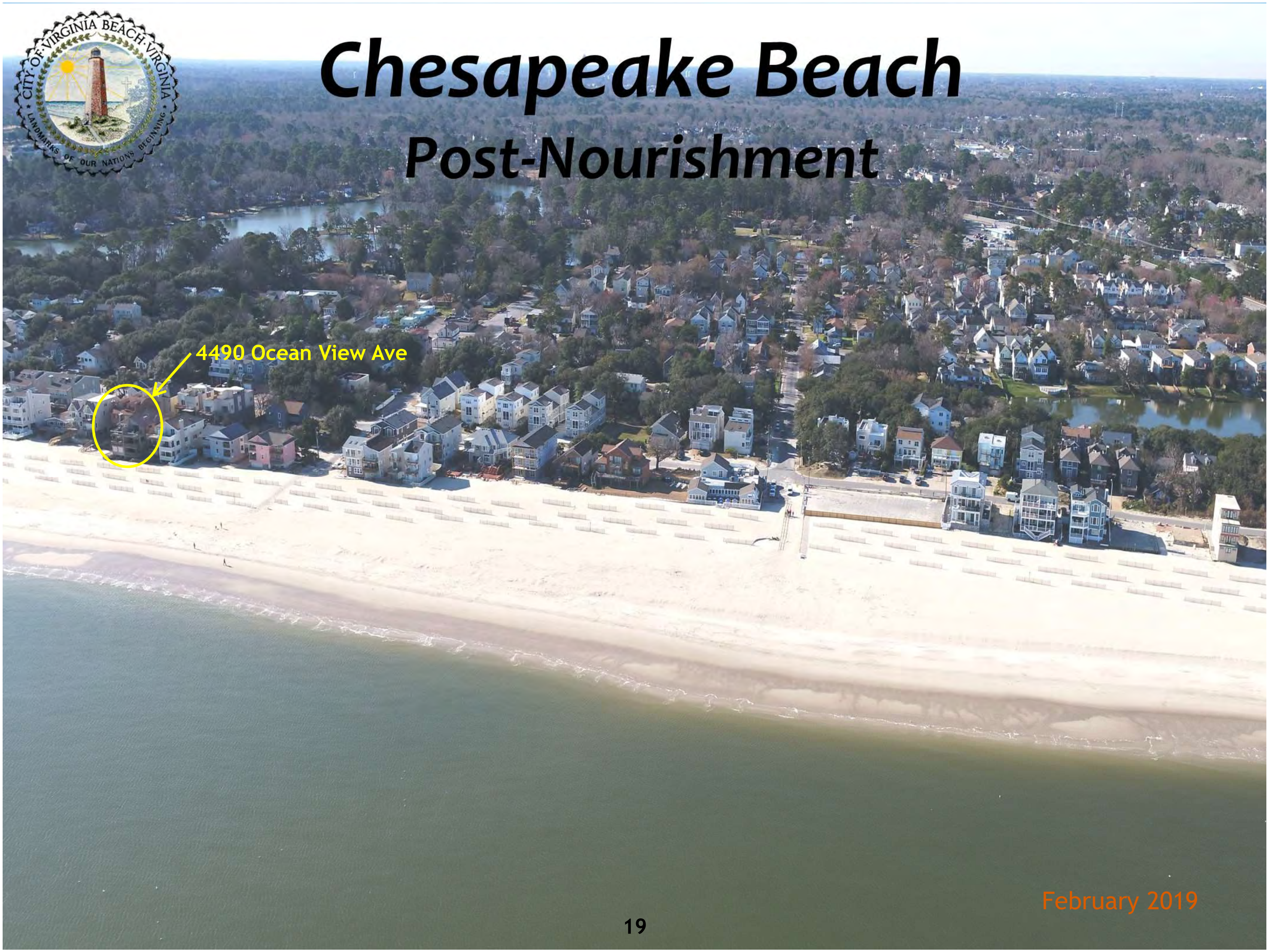
Chesapeake Beach

- 1.0 Mile beach restoration project with periodic maintenance
- Favorable court ruling that public interest in beach does exist
- Critical for coastal protection and resiliency, most erosive section of City's coastline
- 360,000 cy of sand placed to nourish the beach and restore the dunes
- Construction Completed in May 2018
- Total project costs = $5.0 Million, 100% City Funded

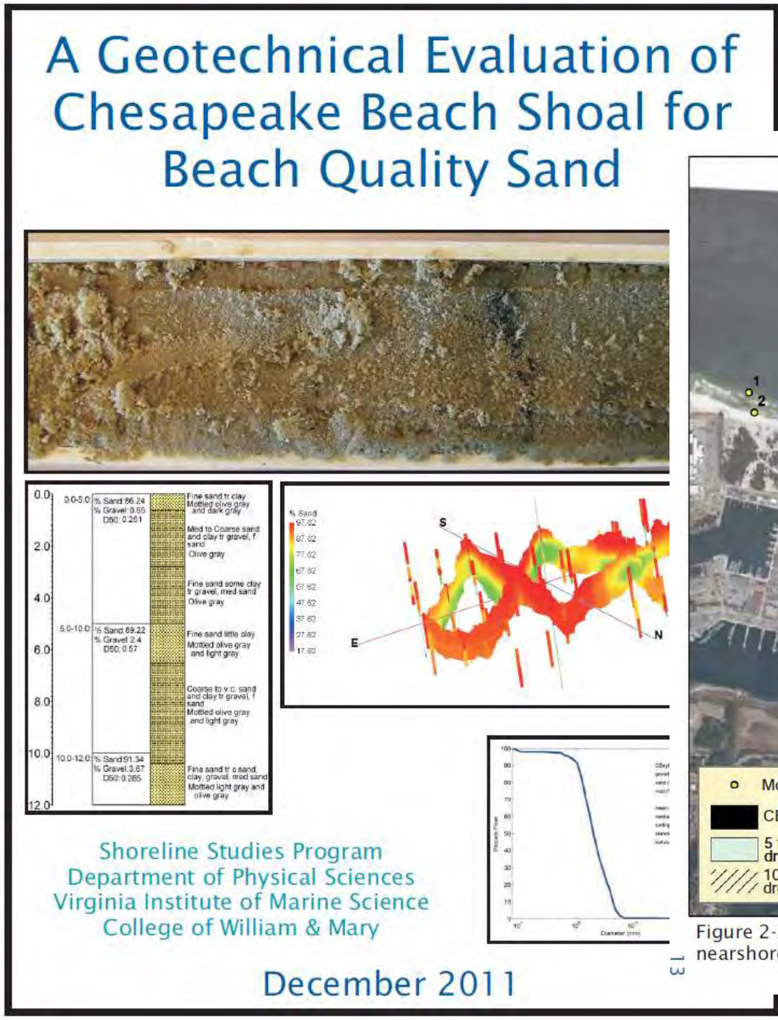

Chesapeake Beach
Project Limits
Chesapeake Bay
Chesapeake Bay Bridge-Tunnel (CBBT)
Chesapeake Beach West Extent
Chesapeake Beach East Extent
Survey Baseline Stations in Feet
Legend
WS&E Survey Baseline
0
500
1,000
2,000 Feet
Aerial photo: January 2009
65+00
60+00
55+
05+00
00+00
JEB Little Creek/ Fort Story
BAYVIEW
LAUDERDALE
BAY BRIDGE
CHUBB LAKE
BEAUFORT
BAY LANDING
PLEASURE HOUSE
NORTHAMPTON
GUAM
FENTRESS
LEE
SEAVIEW
OCEAN VIEW
MORTONS
GULLS
JOYCE
SANDY BAY
LOOKOUT
BRADFORD
BRADPOINTE
CORONET


Chesapeake Beach
Pre-Nourishment
4490 Ocean View Ave
09/08/2017

Chesapeake Beach
Post-Nourishment



Chesapeake Beach
Sand Source



A Geotechnical Evaluation of Chesapeake Beach Shoal for Beach Quality Sand

Shoreline Studies Program
Department of Physical Sciences
Virginia Institute of Marine Science
College of William & Mary

December 2011

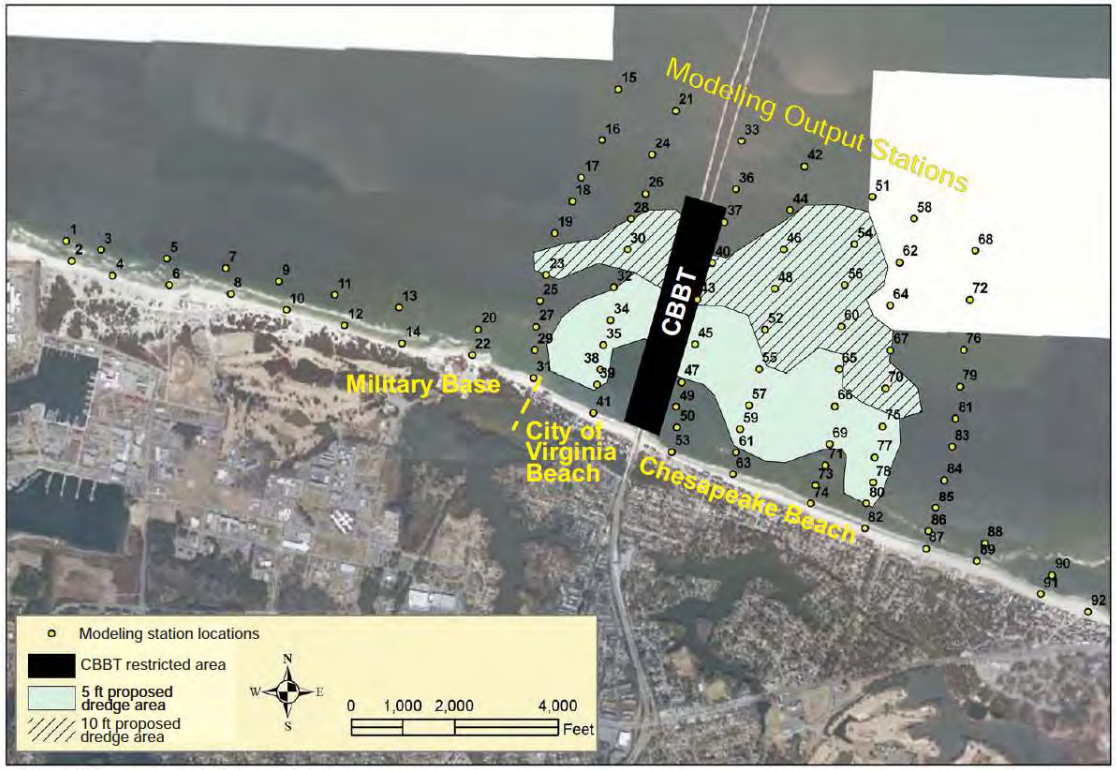
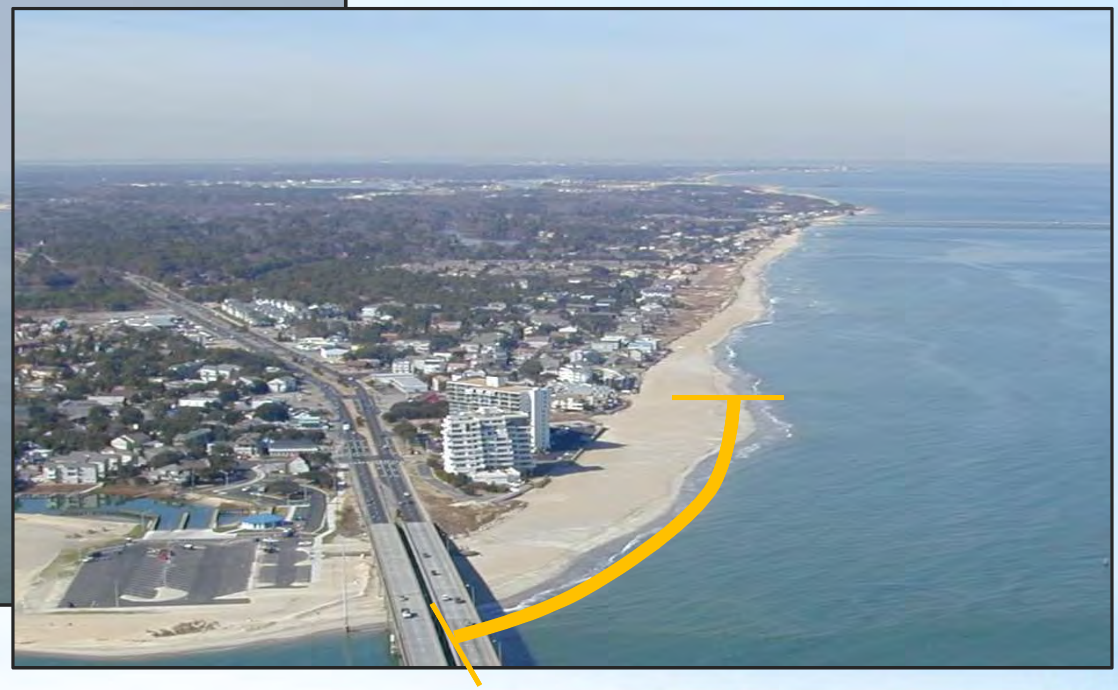


Figure 2-3. Proposed 5 ft and 10 ft dredging scenarios for modeling purposes, and output station locations for the nearshore wave modeling.

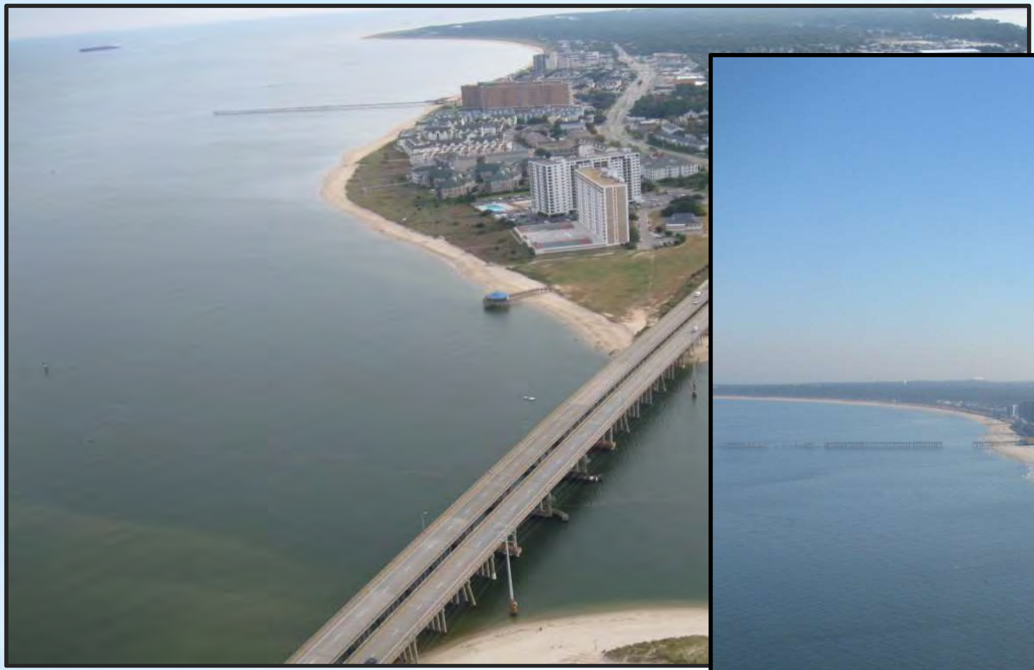
Ocean Park Beach Restoration



OPB Restoration:

- **0.5-mile project.**
- **Winter 2013 66,000 cy of sand placed on beach from the USACE's Lynnhaven Inlet dredging as a placement site**
- **May 2022 400,000 cy of sand to be placed from Norfolk Harbor Deepening Project – Thimble Shoal Channel by Port of Virginia for a full restoration based on "engineered" storm protection template**

Cape Henry Beach
Restoration

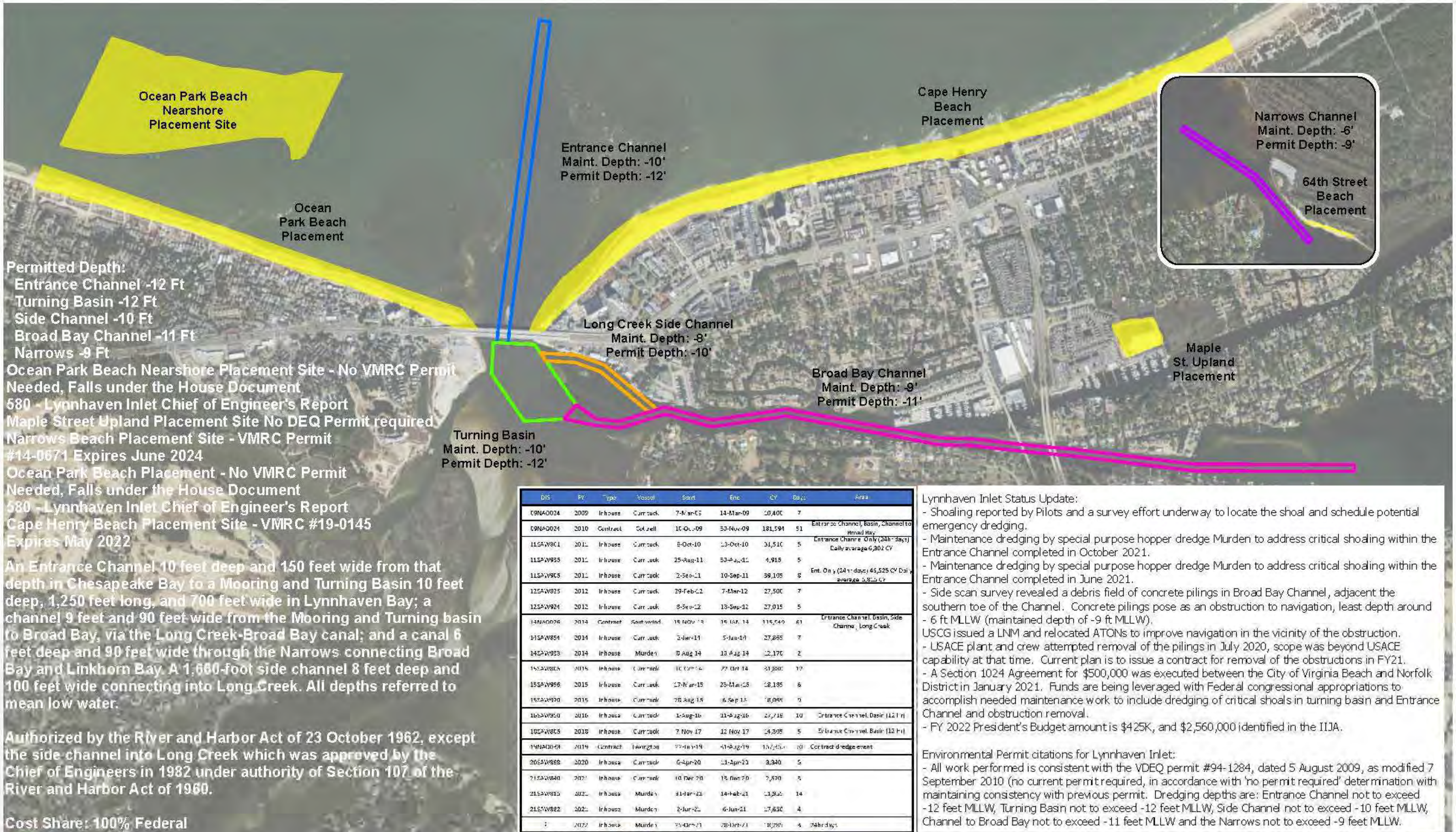


2019 Beach Nourishment Effort:

- 2 mile project length.
- 170,000 cy along CHB shoreline.
- Material mined from USACE Lynnhaven Inlet Navigation Dredging Project
- Cape Henry is now part of the Bay Beaches Resiliency effort to have a designated nourishment cycle and sand source

Ocean Park & Cape Henry

Sand Sources



Permitted Depth:
- Entrance Channel -12 Ft
- Turning Basin -12 Ft
- Side Channel -10 Ft
- Broad Bay Channel -11 Ft
- Narrows -9 Ft

Ocean Park Beach Nearshore Placement Site - No VMRC Permit Needed, Falls under the House Document 580 - Lynnhaven Inlet Chief of Engineer's Report
Maple Street Upland Placement Site No DEQ Permit required
Narrows Beach Placement Site - VMRC Permit #14-0671 Expires June 2024
Ocean Park Beach Placement - No VMRC Permit Needed, Falls under the House Document 580 - Lynnhaven Inlet Chief of Engineer's Report
Cape Henry Beach Placement Site - VMRC #19-0145 Expires May 2022

An Entrance Channel 10 feet deep and 150 feet wide from that depth in Chesapeake Bay to a Mooring and Turning Basin 10 feet deep, 1,250 feet long, and 700 feet wide in Lynnhaven Bay; a channel 9 feet and 90 feet wide from the Mooring and Turning basin to Broad Bay, via the Long Creek-Broad Bay canal; and a canal 6 feet deep and 90 feet wide through the Narrows connecting Broad Bay and Linkhorn Bay. A 1,660-foot side channel 8 feet deep and 100 feet wide connecting into Long Creek. All depths referred to mean low water.

Authorized by the River and Harbor Act of 23 October 1962, except the side channel into Long Creek which was approved by the Chief of Engineers in 1982 under authority of Section 107 of the River and Harbor Act of 1960.

Cost Share: 100% Federal

DIS	FY	Type	Vessel	Start	End	CY	Days	Area
09NAO024	2009	Inhouse	Currituck	7-Mar-09	14-Mar-09	10,400	7	
09NAO024	2010	Contract	Cotwell	10-Oct-09	30-Nov-09	181,594	51	Entrance Channel, Basin, Channel to Broad Bay
11SAW801	2011	Inhouse	Currituck	8-Oct-10	13-Oct-10	31,510	5	Entrance Channel Only (24hr days) Daily average 6,302 CY
11SAW935	2011	Inhouse	Currituck	25-Aug-11	30-Aug-11	4,915	5	
11SAW905	2011	Inhouse	Currituck	2-Sep-11	10-Sep-11	39,105	8	Ent. Only (24hr days) 46,525 CY Daily average 5,815 CY
12SAW825	2012	Inhouse	Currituck	29-Feb-12	7-Mar-12	27,500	7	
12SAW924	2012	Inhouse	Currituck	8-Sep-12	13-Sep-12	27,015	5	
14NAO026	2014	Contract	Southwind	15 NOV 13	15 JAN 14	115,549	61	Entrance Channel, Basin, Side Channel, Long Creek
14SAW854	2014	Inhouse	Currituck	2-Jan-14	5-Jan-14	27,865	7	
14SAW933	2014	Inhouse	Murden	8 Aug 14	10 Aug 14	12,170	2	
15SAW805	2015	Inhouse	Currituck	10 Oct 14	22 Oct 14	31,880	12	
15SAW956	2015	Inhouse	Currituck	17-Mar-15	23-Mar-15	18,185	6	
15SAW970	2015	Inhouse	Currituck	28 Aug 15	6 Sep 15	18,065	9	
16SAW950	2016	Inhouse	Currituck	1-Aug-16	11-Aug-16	27,715	10	Entrance Channel, Basin (12 Ft)
18SAW805	2018	Inhouse	Currituck	7 Nov 17	12 Nov 17	14,305	5	Entrance Channel, Basin (12 Ft)
19NAO049	2019	Contract	Lexington	22-Jun-19	31-Aug-19	157,45[illegible]	70	Contract dredge event
20SAW888	2020	Inhouse	Currituck	6-Apr-20	11-Apr-20	9,340	5	
21SAW840	2021	Inhouse	Currituck	10 Dec 20	15 Dec 20	7,670	5	
21SAW815	2021	Inhouse	Murden	31-Jan-21	14-Feb-21	13,9[illegible]	14	
21SAW822	2021	Inhouse	Murden	2-Jun-21	6-Jun-21	17,650	4	
?	2022	Inhouse	Murden	23-Oct-21	28-Oct-21	18,289	4	24hr days

Lynnhaven Inlet Status Update:
- Shoaling reported by Pilots and a survey effort underway to locate the shoal and schedule potential emergency dredging.
- Maintenance dredging by special purpose hopper dredge Murden to address critical shoaling within the Entrance Channel completed in October 2021.
- Maintenance dredging by special purpose hopper dredge Murden to address critical shoaling within the Entrance Channel completed in June 2021.
- Side scan survey revealed a debris field of concrete pilings in Broad Bay Channel, adjacent the southern toe of the Channel. Concrete pilings pose as an obstruction to navigation, least depth around
- 6 ft MLLW (maintained depth of -9 ft MLLW).
USCG issued a LNM and relocated ATONs to improve navigation in the vicinity of the obstruction.
- USACE plant and crew attempted removal of the pilings in July 2020, scope was beyond USACE capability at that time. Current plan is to issue a contract for removal of the obstructions in FY21.
- A Section 1024 Agreement for $500,000 was executed between the City of Virginia Beach and Norfolk District in January 2021. Funds are being leveraged with Federal congressional appropriations to accomplish needed maintenance work to include dredging of critical shoals in turning basin and Entrance Channel and obstruction removal.
- FY 2022 President's Budget amount is $425K, and $2,560,000 identified in the IIJA.

Environmental Permit citations for Lynnhaven Inlet:
- All work performed is consistent with the VDEQ permit #94-1284, dated 5 August 2009, as modified 7 September 2010 (no current permit required, in accordance with 'no permit required' determination with maintaining consistency with previous permit. Dredging depths are: Entrance Channel not to exceed -12 feet MLLW, Turning Basin not to exceed -12 feet MLLW, Side Channel not to exceed -10 feet MLLW, Channel to Broad Bay not to exceed -11 feet MLLW and the Narrows not to exceed -9 feet MLLW.

US Army Corps of Engineers Norfolk District

Lynnhaven Inlet Federal Navigation Project

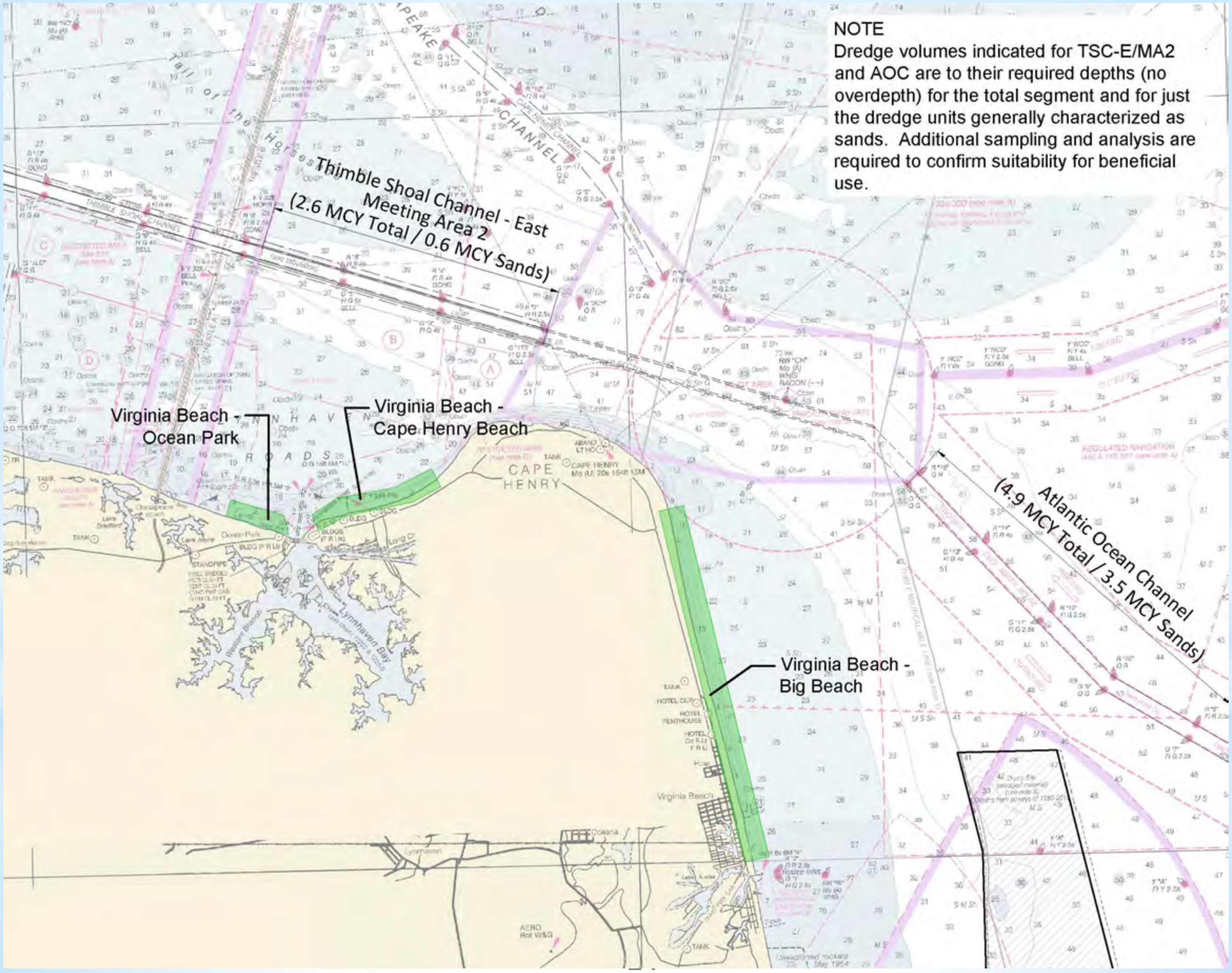
Reach Names
- Entrance Channel
- Turning Basin
- Long Creek Side Channel
- Broad Bay Channel
- Narrows
- Dredge Material Placement Area

0 500 1,000 2,000 Feet

PM: Tom Luehman
Map: LynnhavenInletProjectMap11x17_2022
Developed By: Jeff Swallow
Date of Map: 1/21/2022

Ocean Park & Cape Henry

Sand Sources



Keys to Future Success

- Maintain Federal Partnerships
- USACE & BOEM
- Beneficial Use of Dredge Material (BUD)
- Identification of new sand resources
- Regional Sediment Management (RSM)

Session 3: Permitting and regulatory framework for marine minerals: Federal and state waters

HAMM, S. – Permit requirements for mineral mines in Virginia (SHamm.pdf)

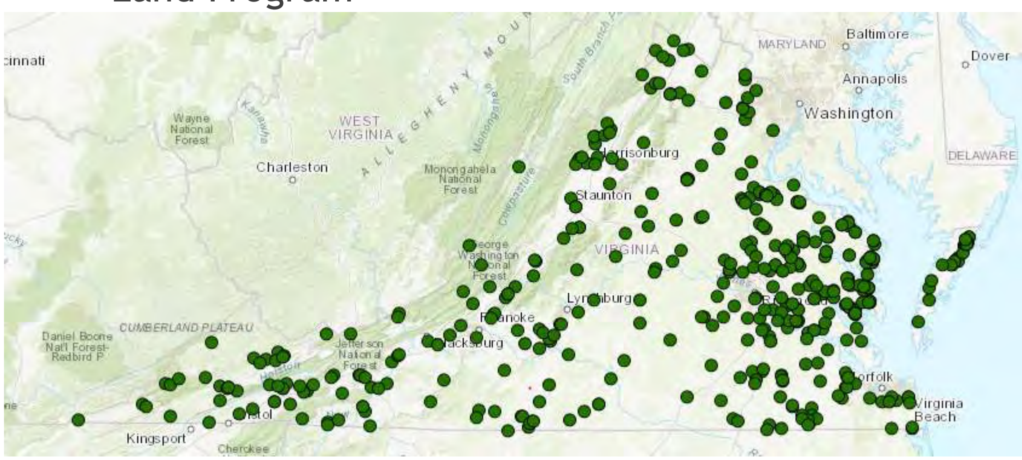
Permit Requirements for Mineral Mines in Virginia

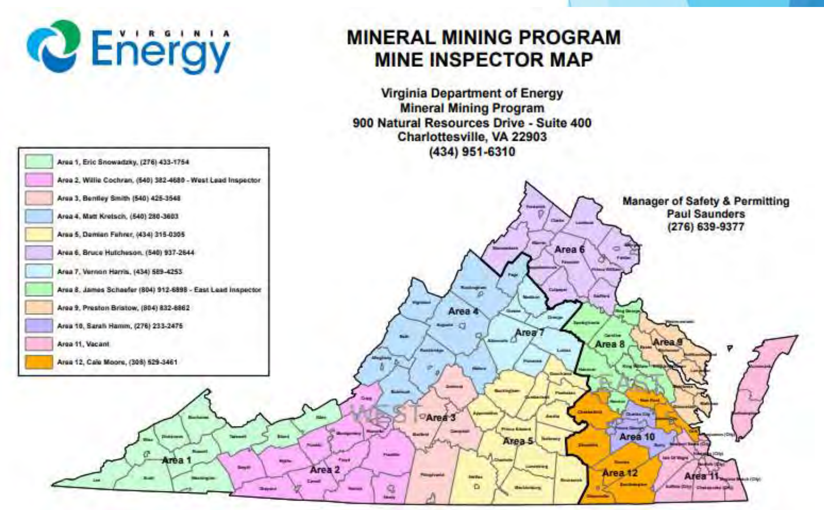
Sarah Hamm

Virginia Energy

About the Virginia Energy's Mineral Mining Program

- Over 400 permitted mineral mines in the state of Virginia
- The mineral mining program conducts reclamation and safety (non-MSHA sites only) inspections at all non-coal mineral mining operations
- In addition to regulatory activities, Mineral Mining Program also manages certification programs, offers training assistance to mine operators, sponsors mine safety and reclamation award programs, and administers the Orphaned Land Program





Permit Requirements

- General Requirements
  - Permit Map and Legend
  - Operations, Drainage, and Reclamation plan
  - Notifications
  - Right of entry
  - Permits from other state agencies

- For this project, on shore processing facilities would be permitted/licensed following normal permitting procedures
- Permitting of offshore operations would be dependent on what other permits are required from other agencies

- **NOTE: it is the operator's responsibility to also obtain any county permits required.**

Permit Map

- Permit Map and Legend - shows permitted, bonded, reclaimed areas.
  - Sensitive features map: state waters, cemeteries, oil and gas wells, underground mine workings, public utilities and utility lines, buildings, roads, schools, churches, and occupied dwellings within 500 feet
  - Property owner map within 1000 feet of the permit line

Notifications of Intent to Mine

- State law requires that land owners within 1,000 feet of a proposed new mineral mine be notified that the operator is seeking a surface mining and reclamation permit from Virginia Energy.
- The chief administrative official of the county or city in which the proposed mine shall also be notified by certified mail.
- Notifications must be sent by certified mail and proof of notification must be submitted.
- Residents may file written objections with the Director and may request a hearing.

MINERAL MINING PROGRAM
900 NATURAL RESOURCES DRIVE, STE 400
CHARLOTTESVILLE, VA 22903
(434) 951-6310

NOTICE OF APPLICATION TO MINE

NOTICE ISSUED BY ______________________________

APPLICANT'S NAME ______________________________

ADDRESS ______________________________

______________________________ TELEPHONE NO. ______________

NOTICE ISSUED TO PROPERTY OWNERS WITHIN 1000 FEET OF PERMIT BOUNDARY:

Name ______________________________

Address ______________________________

State law (Section 45.2-1210 of the Code of Virginia) requires that land owners within 1,000 feet of a proposed new mineral mine be notified that the operator is seeking a surface mining and reclamation permit from the Department of Mines, Minerals and Energy. The surface mining permit must address Department of Mines, Minerals and Energy requirements for regrading, revegetation and erosion controls of mineral mine sites.

In accordance with that requirement ______________________________ (COMPANY NAME) is hereby notifying you that it has applied/will apply for a surface mining and reclamation permit on ______________ (DATE). The mineral to be mined is ______________. The proposed mine is located ______ miles __________ (DIRECTION) of ______________ (NEAREST TOWN) on ______________ (ROAD) in ______________ (CITY/COUNTY), Tax Map ID No. ______________.

Property owners within 1,000 feet of the land proposed to be mined for minerals other than coal may specify objections in writing and request a hearing within ten (10) days of receipt of this notice to: The Department of Energy, Mineral Mining Program, 900 Natural Resources Drive, Suite 400, Charlottesville, Virginia 22903, (434) 951-6310.

Operation, Drainage, and Reclamation Plan

- The operation plan shall include a description of the proposed method of mining and processing; the location of top soil storage areas; overburden, refuse, and waste disposal areas; stockpiles, equipment storage, and maintenance areas; internal roadway information. Plans for the storage and disposal of scrap metal, scrap tires, used lubricants, coolants, and other equipment service products, batteries, process chemicals, trash, debris, and other hazardous materials should be included. All related design and construction data shall be included with the plans.
- The drainage plan describes the drainage system to be constructed before, during, and after mining. A map or overlay showing the natural drainage system and all sediment and drainage control structures to be installed along with all related design and construction data shall be included with the plans.
- The reclamation plan outlines the post mining land use, seed mixes to be used during reclamation, final grading, etc. This section tells us how the operator will reclaim the site to achieve the defined post mining land use.

Right of Entry

- On shore facilities
  - Deed
  - Deed book and page number where land transfer was recorded
  - Lease agreement
- Offshore facilities*
  - Approved dredging permit allowing the operator to dredge in state water

Other Permits/Licenses that may be needed

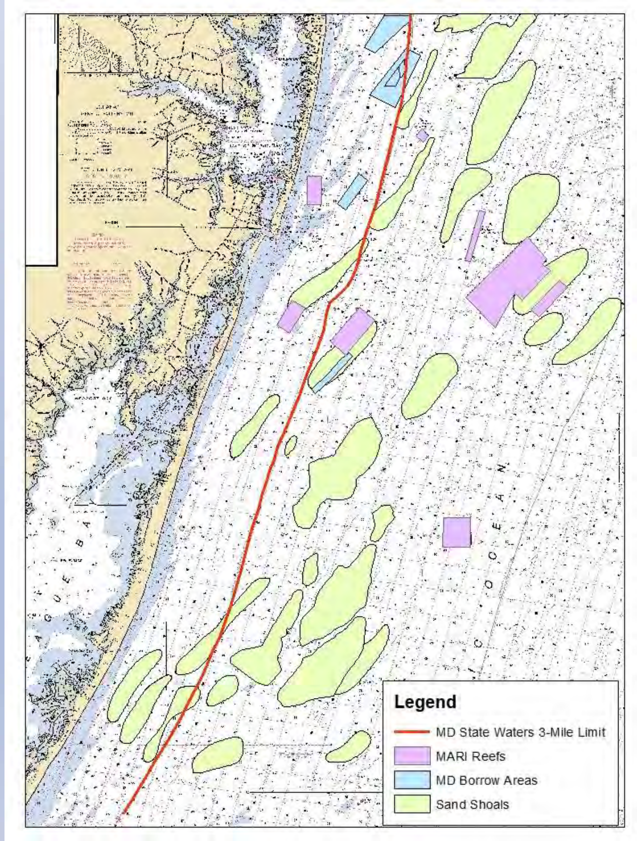
- Virginia Department of Transportation: Land Use Permit for entrance
- Virginia Department of Environmental Quality
  - Virginia Pollutant Discharge Elimination System (VPDES) General Permit for Nonmetallic Mineral Mining
  - Non metallic Mineral Processing General Permit
- Virginia Department of Health: Radioactive Materials License

Questions

Session 3: Permitting and regulatory framework for marine minerals: Federal and state waters

VAN RYSWICK, S. – Maryland permitting and regulatory framework for marine minerals (SVanRyswick.pdf)

Maryland State Waters
3-mile Extent



Maryland Regulatory Agencies

- State Authorizations
  - Maryland Department of the Environment (MDE)
    - Water Management Administration
      - Tidal Wetlands Division
      - Nontidal Wetlands and Waterways Division
      - Wetlands and Waterways Program
    - Maryland Board of Public Works (BPW)
      - Wetlands Administration
    - Maryland Department of Natural Resources (MD DNR)
      - Chesapeake and Coastal Services
        - Coastal Zone Management Act (CZMA)

- Federal Permits
  - U.S. Army Corp of Engineers
    - Baltimore District

Permitting Requirements

- Section 401 Water Quality Certification
  - Required per Section 401 of Clean Water Act when a federal license or permit is also required for a project
  - https://mde.maryland.gov/programs/Water/WetlandsandWaterways/Pages/WQC.aspx
- Coastal Zone Management Act (CZMA)
  - Consistency determination needed
  - Would be provided during the application decision process
  - If project receives federal funding, the activity will require a CZMA consistency determination
  - https://mde.maryland.gov/programs/Water/WetlandsandWaterways/Pages/CZM.aspx
- Joint Permit Application (long form)
  - Required for all work within State Tidal waters

Permitting Requirements

- Tidal Wetland License
  - Issued by the MD BPW Wetlands Administration
  - https://bpw.maryland.gov/wetlands/Pages/default.aspx
  - Based on MDE's review and recommendation of the proposed project following MDE review

- Additional Screening Requirements
  - Maryland Historical Trust
  - Rare, Threatened, Endangered Species
  - Sensitive Habitats
  - Time of Year Restrictions

Additional Considerations

- Required plans based on proposed extraction, placement of dredged material, site(s)
  - Note: Overboard disposal of dredged material is prohibited in MD unless for beneficial reuse

- Since State tidal wetlands are owned by the State, expected requirement for compensation to the BPW for the extraction of the mineral rights

- Upland disposal/processing (Minerals Separation NOT performed offshore)
  - Additional upland regulations would apply
    - Erosion and sediment control plans
    - Grading permits
    - Potentially additional nontidal wetland and waterway permit
    - Critical Area approvals
    - Possible water appropriations permit and/or National Pollutant Discharge Elimination System (NPDES) permit

Session 3: Permitting and regulatory framework for marine minerals: Federal and state waters

TAYLOR, K.B. and FARRELL, K.M. – Status report on marine offshore heavy mineral sands, North Carolina (KTaylor_KFarrell.pdf)

At the time of submission of this document, a copy of the North Carolina Geological Survey presentation had not been received.

Please contact the North Carolina Geological Survey directly for additional information.

Session 3: Permitting and regulatory framework for marine minerals: Federal and state waters

NEALE, B. – Permitting in SC waters (BNeale.pdf)

Healthy People. Healthy Communities.

Mid-Atlantic Marine Heavy Minerals Sands Forum

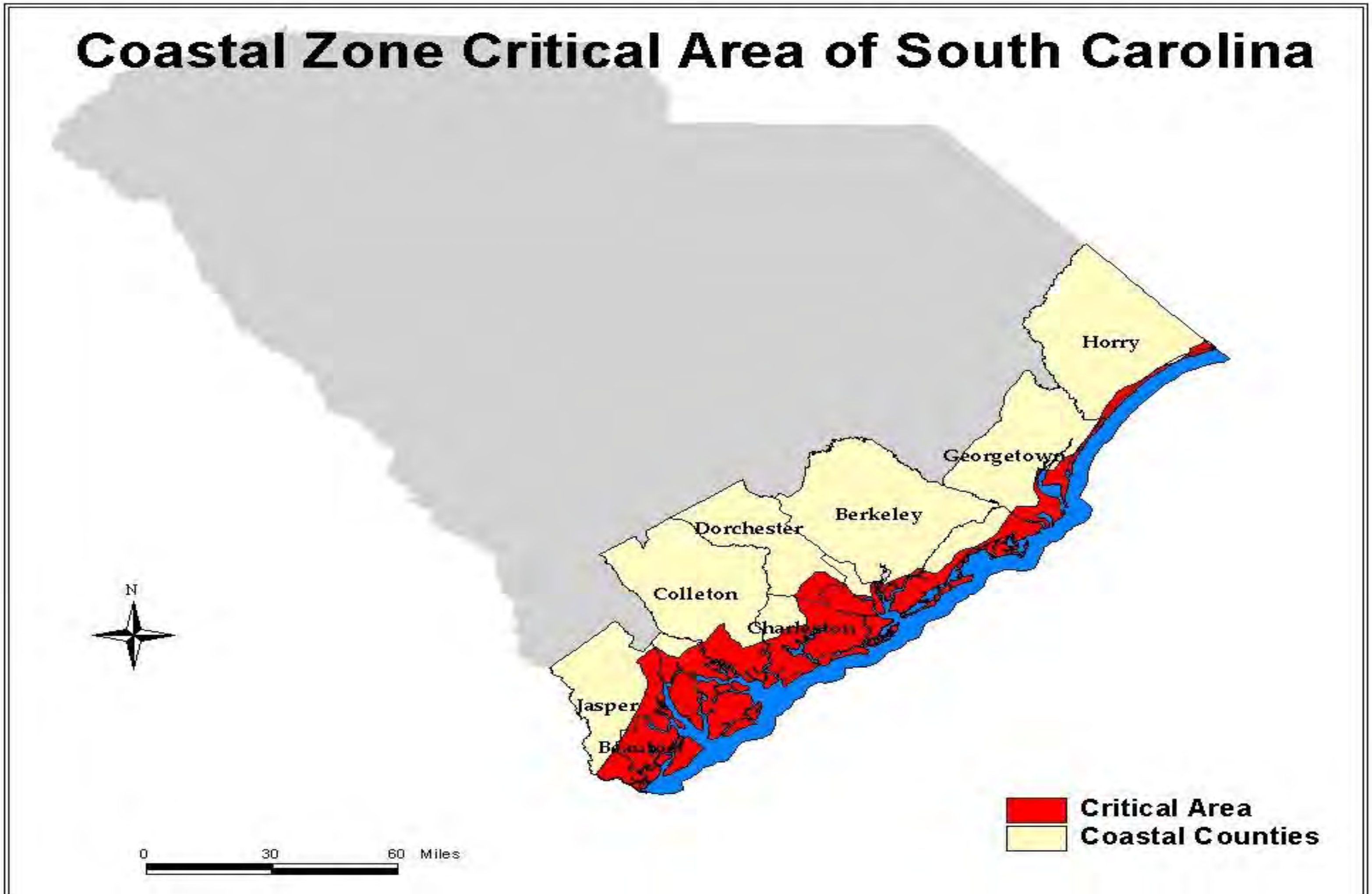
Permitting in SC Waters

Overview Coastal Program

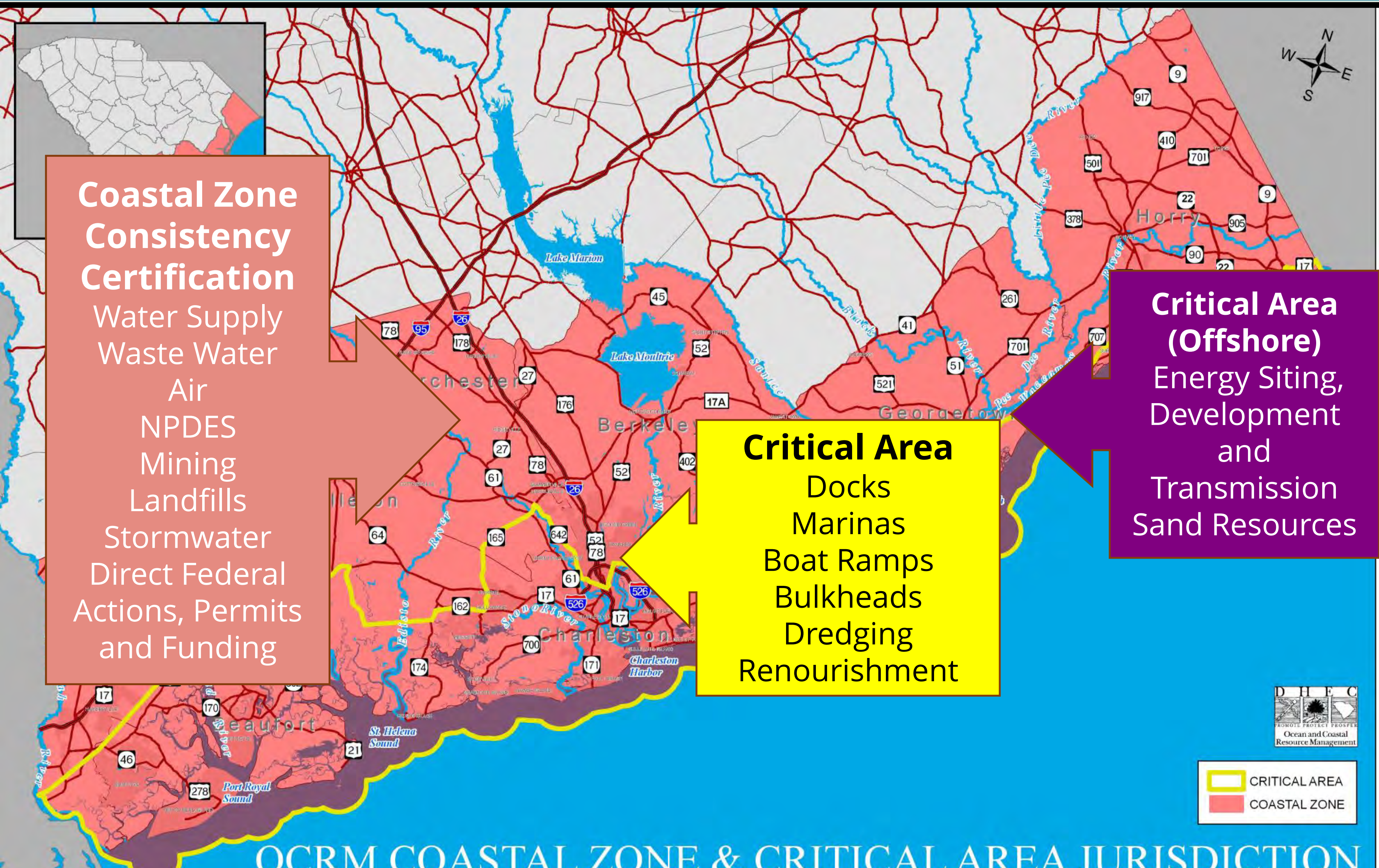
- 1972 Federal Coastal Zone Management Act
- 1977 - Coastal Tidelands and Wetlands Act, SC Code § 48-39-10 et seq.
- 1978 – Critical Area Regulations, R.30-10 et seq.
- 1979 - Coastal Management Plan
- **Direct** permitting authority for the Critical Area (tidelands, coastal waters, beaches and oceanfront sand dune system)
- **Indirect** Certification authority for state and federal activities

Value of Coastal Resources

- Over 15 million coastal tourists each year, supporting a $9 billion industry and over 200,000 jobs
- Fisheries are a $42 million industry
- Ports support 1 in 10 jobs and over $63.4 billion in economic impact annually and 1.1 billion in tax revenue in South Carolina
- Marshes and dune systems provide critical and invaluable buffer from storms and flooding


Coastal Zone Critical Area of South Carolina
Horry
Georgetown
Berkeley
Dorchester
Colleton
Charleston
Jasper
N
0
30
60 Miles
Critical Area
Coastal Counties

South Carolina Department of Health and Environmental Control
Healthy People. Healthy Communities.



Direct Permitting Authority

Critical Areas of SC Coastal Zone

- Coastal Waters
- Tidelands
- Beaches
- Beach/Dune Systems

Indirect Authority

- Federal Permits/Licenses
- Direct Federal Activities
- Federal Funds to State and Local Govts
- Outer Continental Shelf
- State Permits

Thank You!

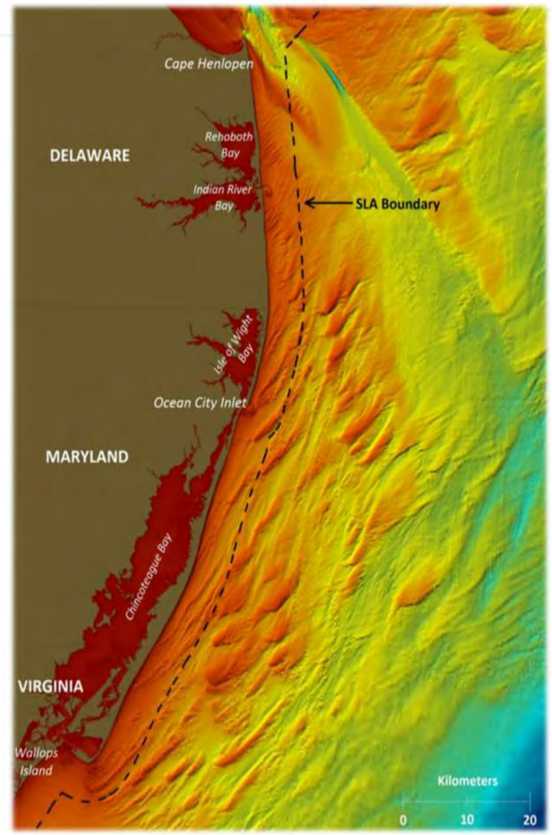
Barbara Neale
nealeb@dhec.sc.gov
(O) (843) 953-0245
(M) (843) 697-2891

Session 4: Environmental standards, compliance, best practices applied to marine minerals

WIKEL, G.L. – Synopsis of the Federal environmental review process for marine mineral extraction in the marine environment (GWikel.pdf)

Environmental Impact Assessment Objectives

- Consider environmental impacts of federal decisions
- Based on best available or high-quality scientific information
- Comply with environmental laws and regulations
- Seek meaningful approaches to assess and mitigate risk
- Clearly describe environmental risks to decision-makers, stakeholders, and public
- Are based on purposeful stakeholder engagement
- Withstand legal challenge



What Federal Agencies Evaluate and Protect

birds

marine mammals

sea turtles

fish

benthic & pelagic communities

corals

benthic ecology

ocean & physical processes

marine & coastal habitats

marine acoustics

marine archaeology

water quality

air quality

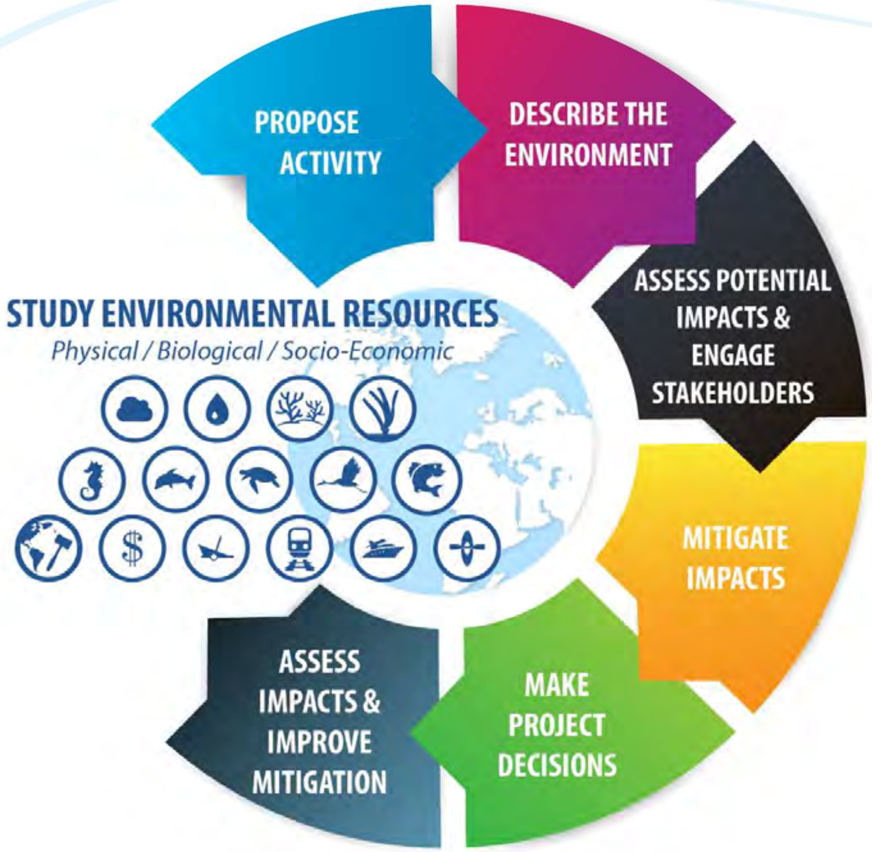
tourism & recreation

cultural & historic properties

environmental justice

fisheries & other use conflicts

Assessment and Consultation Process



Affected resources

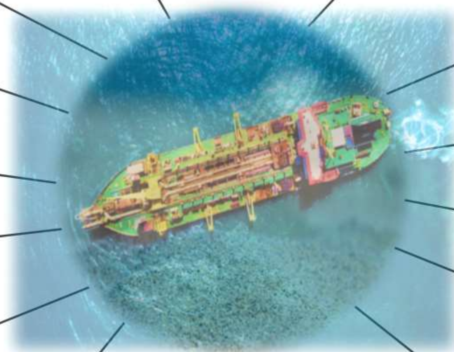
Effects of activities

Cumulative impacts

Mitigation

Compliance and monitoring

Regulations in the Ocean Environment



- Outer Continental Shelf Lands Act
- **National Environmental Policy Act**
- Coastal Zone Management Act
- Endangered Species Act
- Rivers and Harbors Act
- Marine Mammal Protection Act
- National Historic Preservation Act
- Magnuson-Stevens Fishery Conservation Management Act
- Ocean Dumping Act
- Clean Water Act
- Clean Air Act
- Executive Order 13175: Consultation with Indian Tribal Governments
- Executive Order 12898: Environmental Justice
- Migratory Bird Treaty Act

Session 4: Environmental standards, compliance, best practices applied to marine minerals

PEABODY, R. – State regulatory and permitting framework, onshore mineral beneficiation (RPeabody.pdf)

State regulatory and permitting framework, onshore mineral beneficiation

RACHAEL PEABODY, DIRECTOR OF COASTAL POLICY, VIRGINIA MARINE RESOURCES COMMISSION

VIRGINIA'S MARINE RESOURCES COMMISSION

MISSION:

WE ARE STEWARDS OF VIRGINIA'S MARINE AND AQUATIC RESOURCES FOR PRESENT AND FUTURE GENERATIONS


MARINE FISHERIES
VA 8500 YY
MARK P
Manage
Recreational & Commercial
Fisheries/Landings


MARINE HABITAT
5,000 miles tidal shoreland
1,472,000 acres bottomlands


Shellfish Management

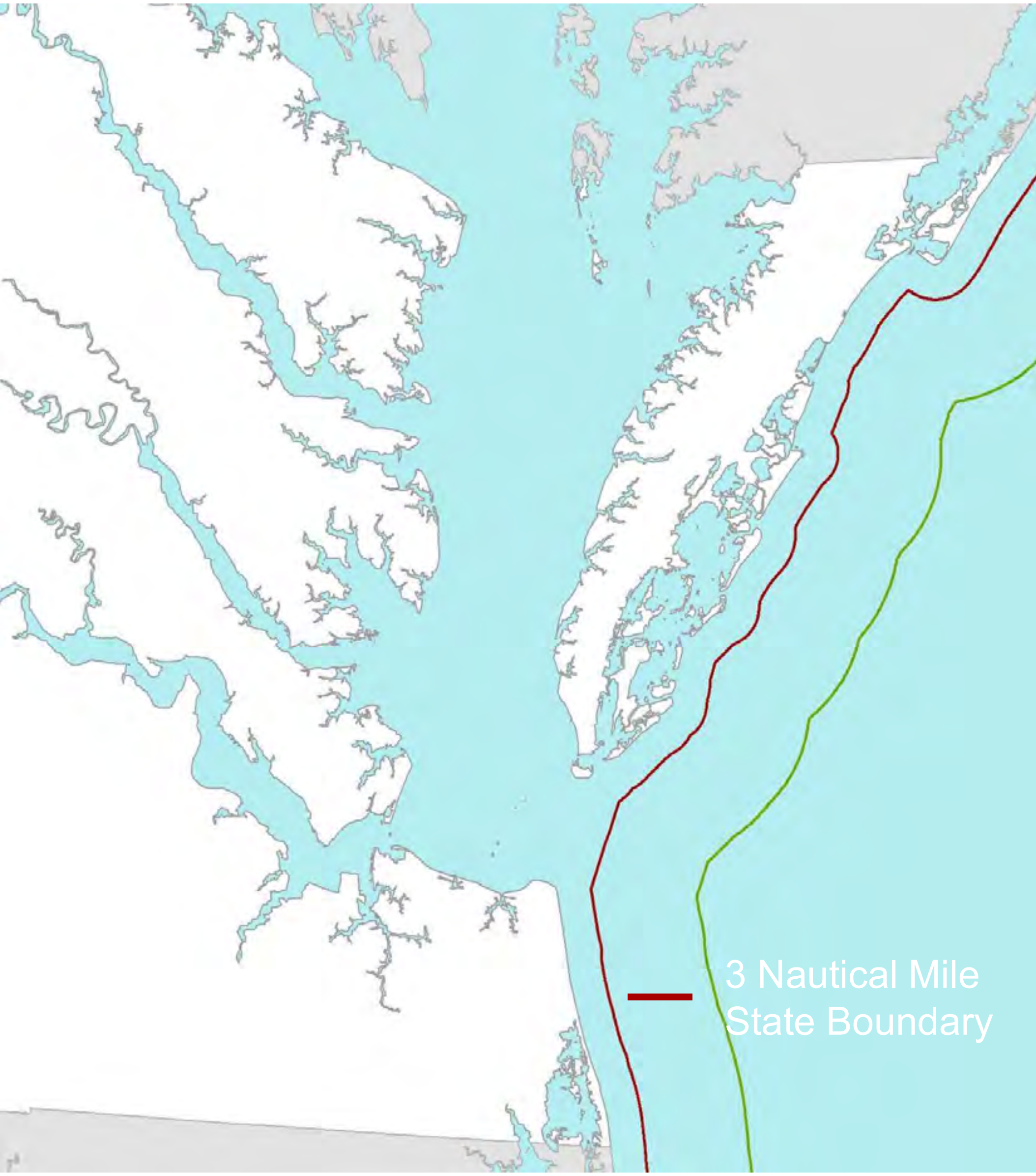
FISHERIES MANAGEMENT DIVISION

GOAL

To conserve and enhance finfish and shellfish resources, and to preserve and promote both commercial and recreational fisheries, thereby maximizing food production and recreational opportunities.

REGULATORY AUTHORITIES

- HABITAT MANAGEMENT
  - Subtitle II (Fisheries) of Title 28.2
    - Chapter 6 - Planting Grounds (1928)
  - Subtitle III (Habitat) of Title 28.2
    - Chapter 12 – State-Owned Submerged Lands (1962)
    - Chapter 13 - Wetlands (1972 & 1982)
    - Chapter 14 - Coastal Primary Sand Dunes/Beaches (1980)

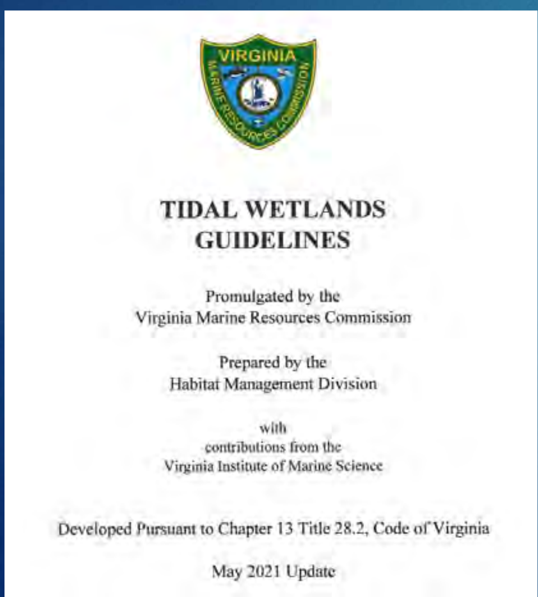


Chapter 12 – State-Owned Submerged Lands

Regulate via proprietary ownership of State bottomlands

Chapter 13 - Tidal Wetlands

- "The Commission shall preserve and prevent the despoliation and destruction of wetlands while accommodating necessary economic development in a manner consistent with wetlands preservation."
- Localities may voluntarily manage this resource through the local wetlands board process.



TIDAL WETLANDS GUIDELINES

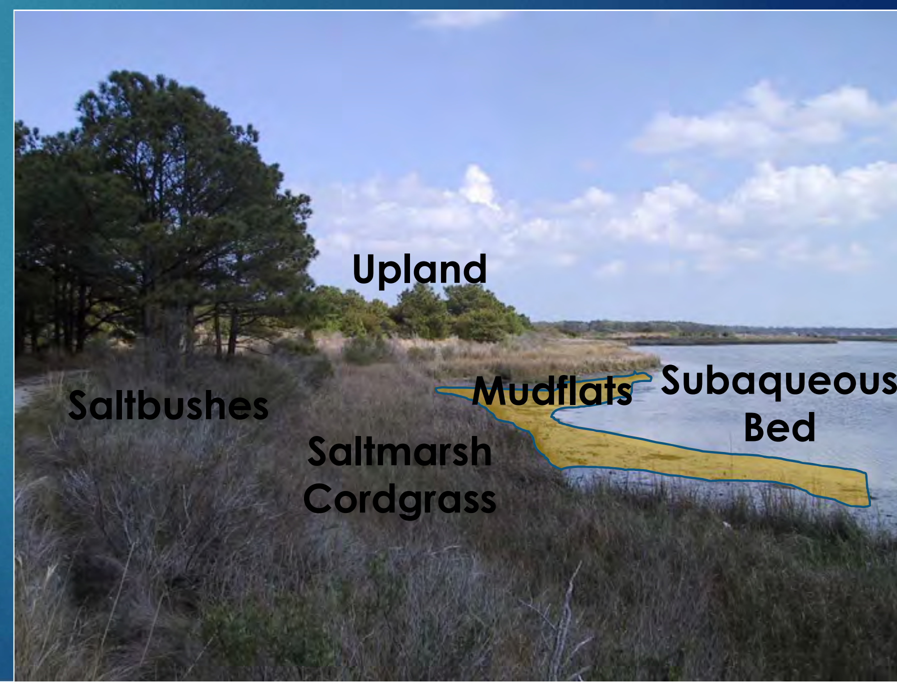
Promulgated by the
Virginia Marine Resources Commission

Prepared by the
Habitat Management Division

with
contributions from the
Virginia Institute of Marine Science

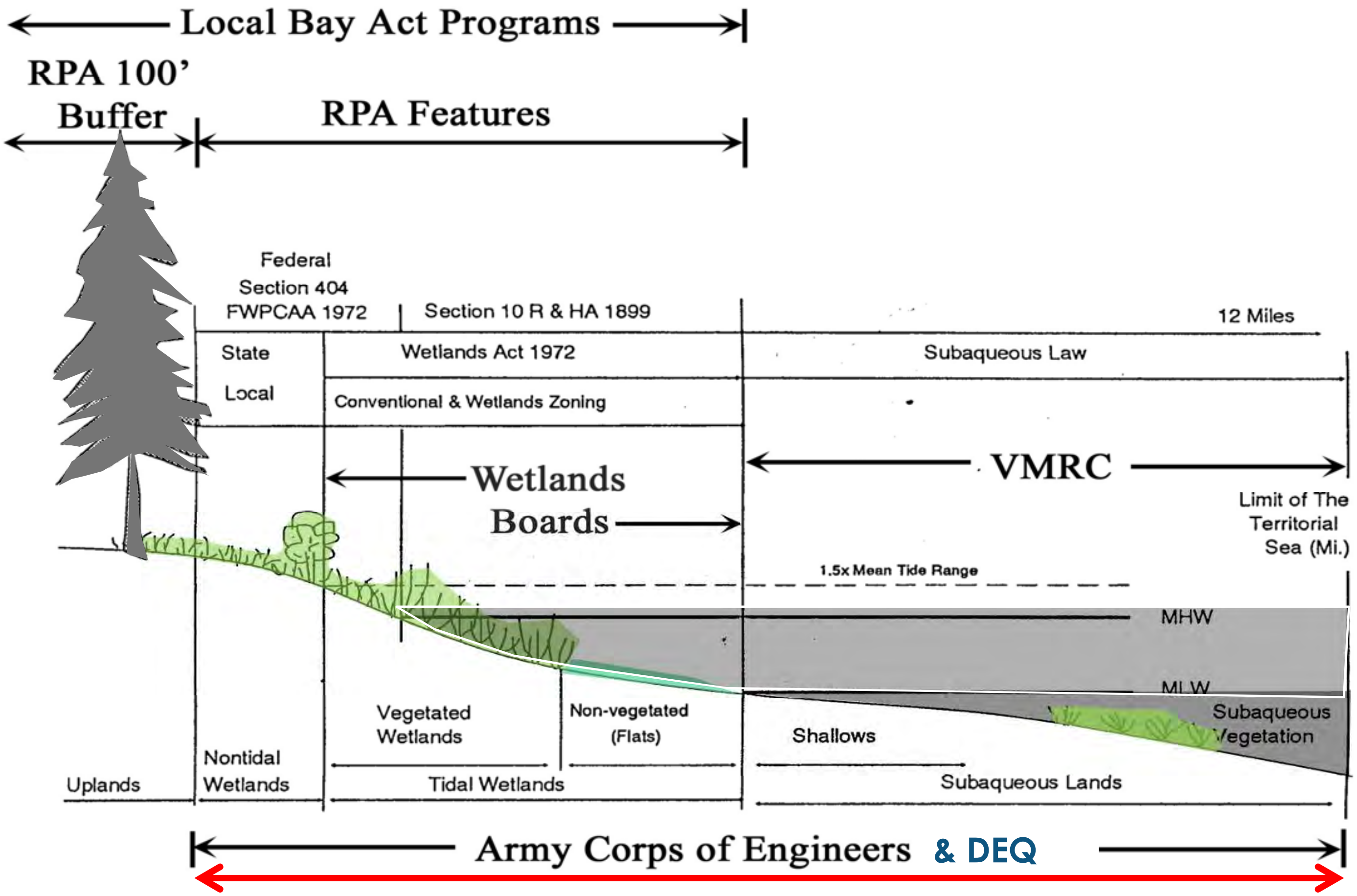
Developed Pursuant to Chapter 13 Title 28.2, Code of Virginia

May 2021 Update



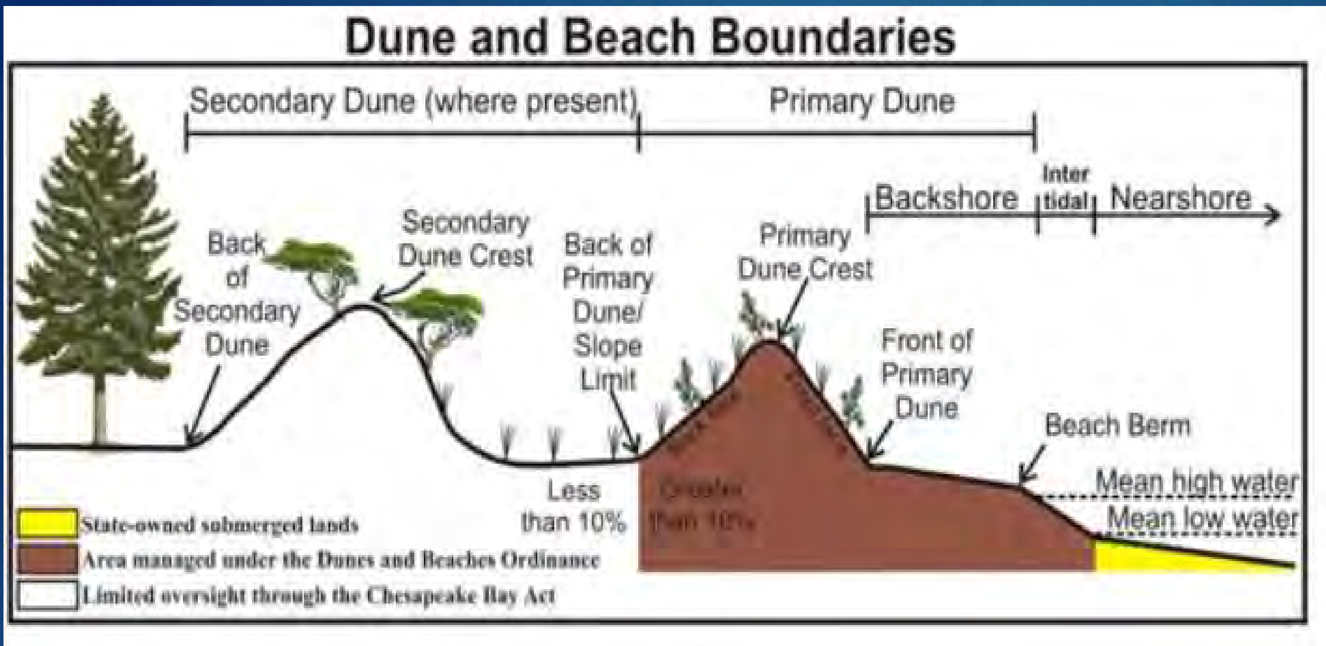
Jurisdictional Boundaries

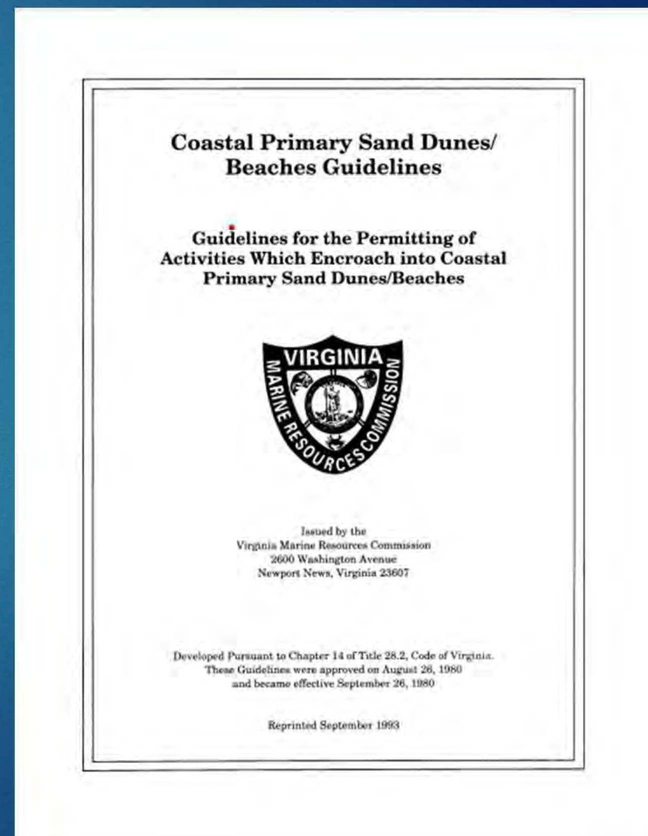
Tidal Waters



Chapter 14 - Coastal Primary Sand Dunes/Beaches

- "The Commission shall preserve and protect coastal primary sand dunes and beaches and prevent their despoliation and destruction."
  - Flood and Erosion Protection
  - Sand Replenishment
  - Habitat
- **CHAPTER 4VAC20-1340-10 ET SEQ - "REGULATION: FAST-TRACK PERMITTING PROGRAM FOR DISPOSAL OF DREDGED MATERIAL"**
  - Preference for using sandy dredged material for beach nourishment, living shorelines, wetland creation.
- **§ 10.1-704 of the Code of Virginia** directs that the beaches of the Commonwealth shall be given priority consideration as sites for the disposal of that portion of dredged material determined to be suitable for beach nourishment.





Coastal Primary Sand Dunes/ Beaches Guidelines

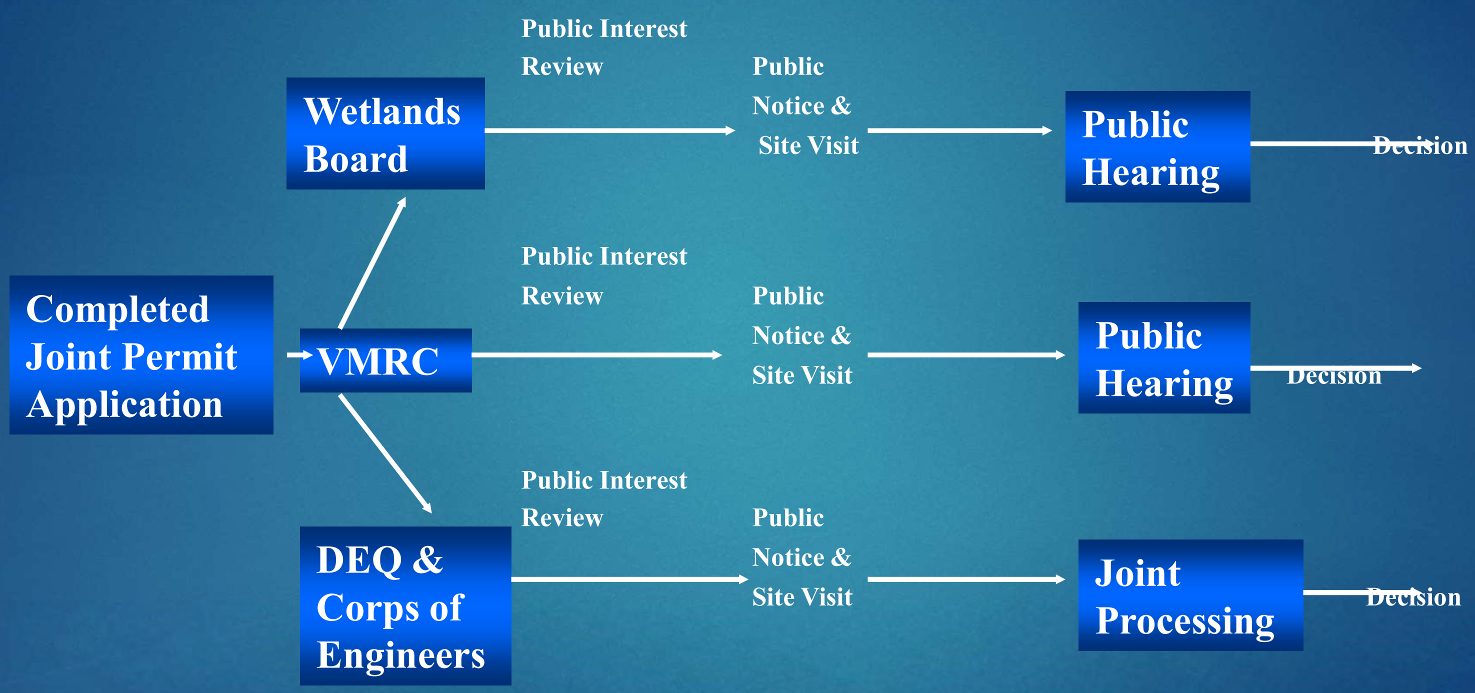
Guidelines for the Permitting of Activities Which Encroach into Coastal Primary Sand Dunes/Beaches

Issued by the
Virginia Marine Resources Commission
2600 Washington Avenue
Newport News, Virginia 23607

Developed Pursuant to Chapter 14 of Title 28.2, Code of Virginia.
These Guidelines were approved on August 26, 1980
and became effective September 26, 1980

Reprinted September 1993

Virginia's Shoreline Permit Process



MUST HAVE ALL FOUR PERMITS

CZM Consistency Review – Review Authority

NOAA
15 CFR part 930

VA DEQ
Coastal Zone Management Program

- Local Governments
  - Tidal Wetlands
  - Chesapeake Bay Preservation Act
  - Dunes and Beaches
- Marine Resources Commission
  - Marine Fisheries
  - Tidal Wetlands
  - Submerged Lands
  - Dunes and Beaches
- Dept Wildlife Resources
  - Wildlife and Inland Fisheries
- Dept Consv and Rec
  - Commonwealth lands
- Dept Health
  - Shoreline Sanitation
- Dept Environmental Quality
  - Air Pollution
  - Water Pollution
  - CBPA

VMRC Enforceable Policies

- Marine Fisheries
  - State and Federal Waters – Ecosystem and Economics
    - Spawning, TOYR, Commercial and Recreational Harvest, Fish Habitat
  - Dunes and Beaches
    - Preserve, Protect, Restore, Enhance
  - Tidal Wetlands
    - Avoid, Minimize, Mitigate, No Net Loss
  - Submerged Lands
    - - effect on other uses, fisheries resources, tidal wetlands, adjacent properties, SAV.

Session 4: Environmental standards, compliance, best practices applied to marine minerals

MCKAY, L. – Coastal/ocean policy and planning (LMcKay.pdf)

Coastal/Ocean Policy & Planning

Mid-Atlantic Marine Heavy Mineral & Sands Forum

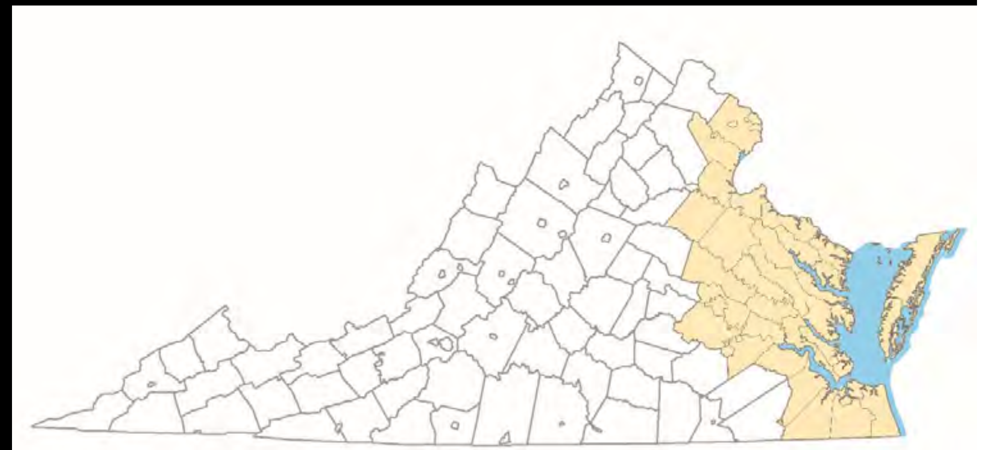
Laura McKay

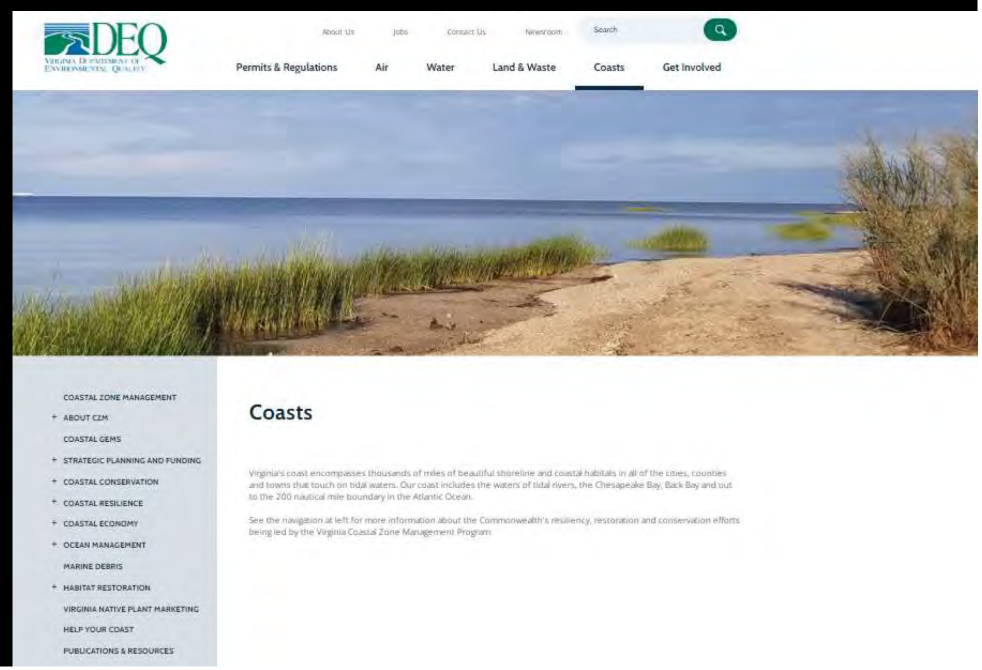
VA CZM Program Manager

Virginia Coastal Zone Management Program

What is the Virginia CZM Program?

- Network of state agencies and coastal localities
- Guided by the inter-agency Coastal Policy Team led by CZM staff at DEQ
- Virginia Energy is a member
- All the coastal laws and policies incorporated into the program and approved by NOAA
- Funded 100% by NOAA with ~ $3M per year for grants
- www.deq.virginia.gov/coasts

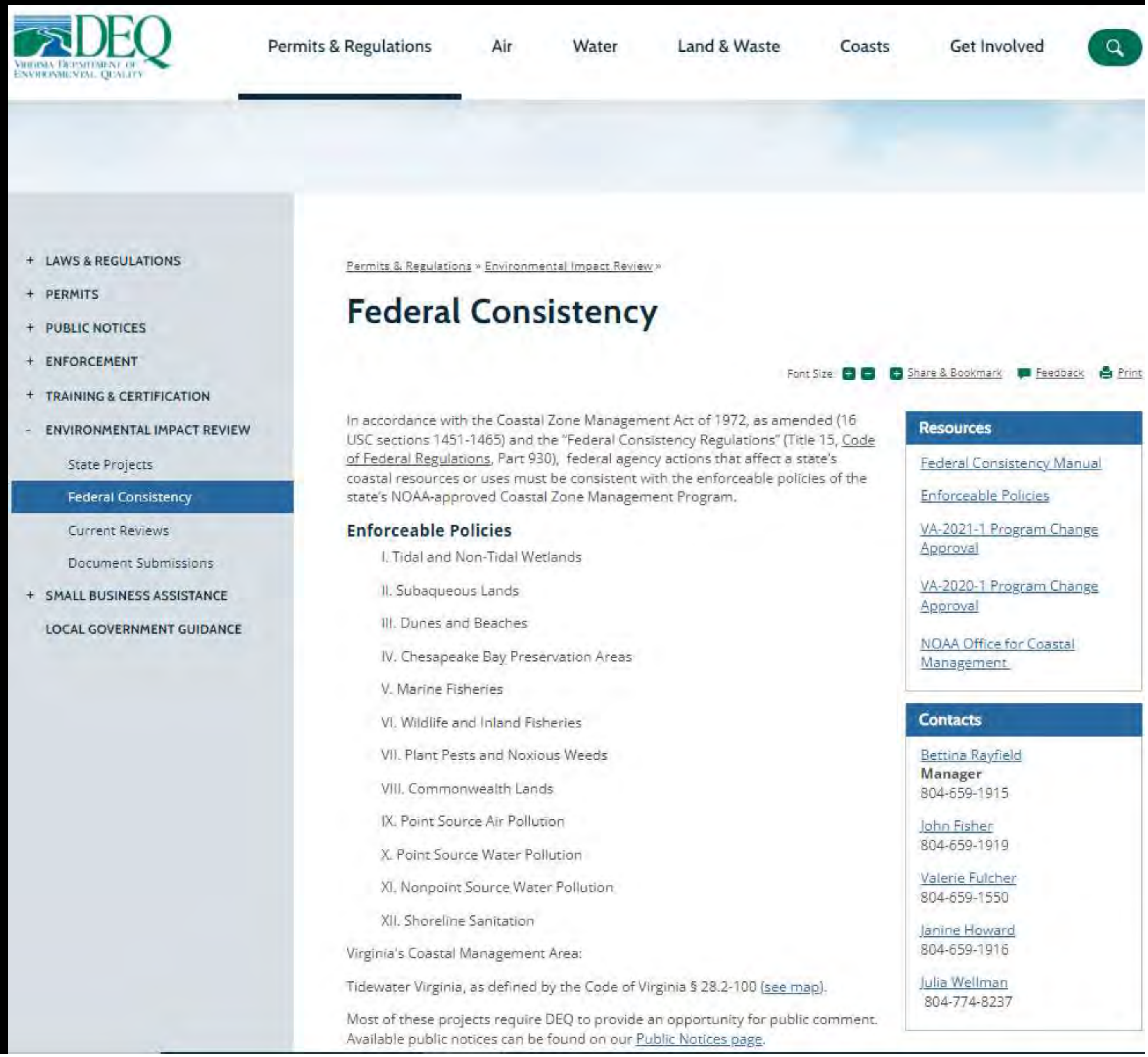





VIRGINIA
CZM
PROGRAM
(DEQ LEAD
COORDINATING
AGENCY)
AIR
POLLUTION
DEQ
SHORELINE
SANITATION
VDH
DUNES & BEACHES
MRC &
Local Wetlands
Boards
SUBAQUEOUS
LANDS
MRC
SAV
POINT SOURCE
& NONPOINT
SOURCE
WATER
POLLUTION
DEQ & Coastal
Localities
MARINE FISHERIES
MRC
TIDAL AND
NONTIDAL
WETLANDS
MRC, DEQ &
Local Wetlands
Boards
CHESAPEAKE BAY
PRESERVATION AREAS
DEQ (CBPA)
PLANT PESTS &
NOXIOUS WEEDS
VDACS
COMMONWEALTH
LANDS
DWR & DCR
WILDLIFE &
INLAND
FISHERIES
DWR

Federal Consistency

- Federal actions must be consistent with NOAA-approved Virginia laws and policies
- DEQ can review federal actions that are on our NOAA-approved "Listed Activities"



Mid-Atlantic Ocean Planning

- VA, MD, DE, NJ, NY created MARCO in 2009
  (5 state Governor's Agreement on Ocean Conservation)

- Joined the Mid-Atlantic Regional Planning Body in 2013 and produced the Mid-A Ocean Plan in 2016

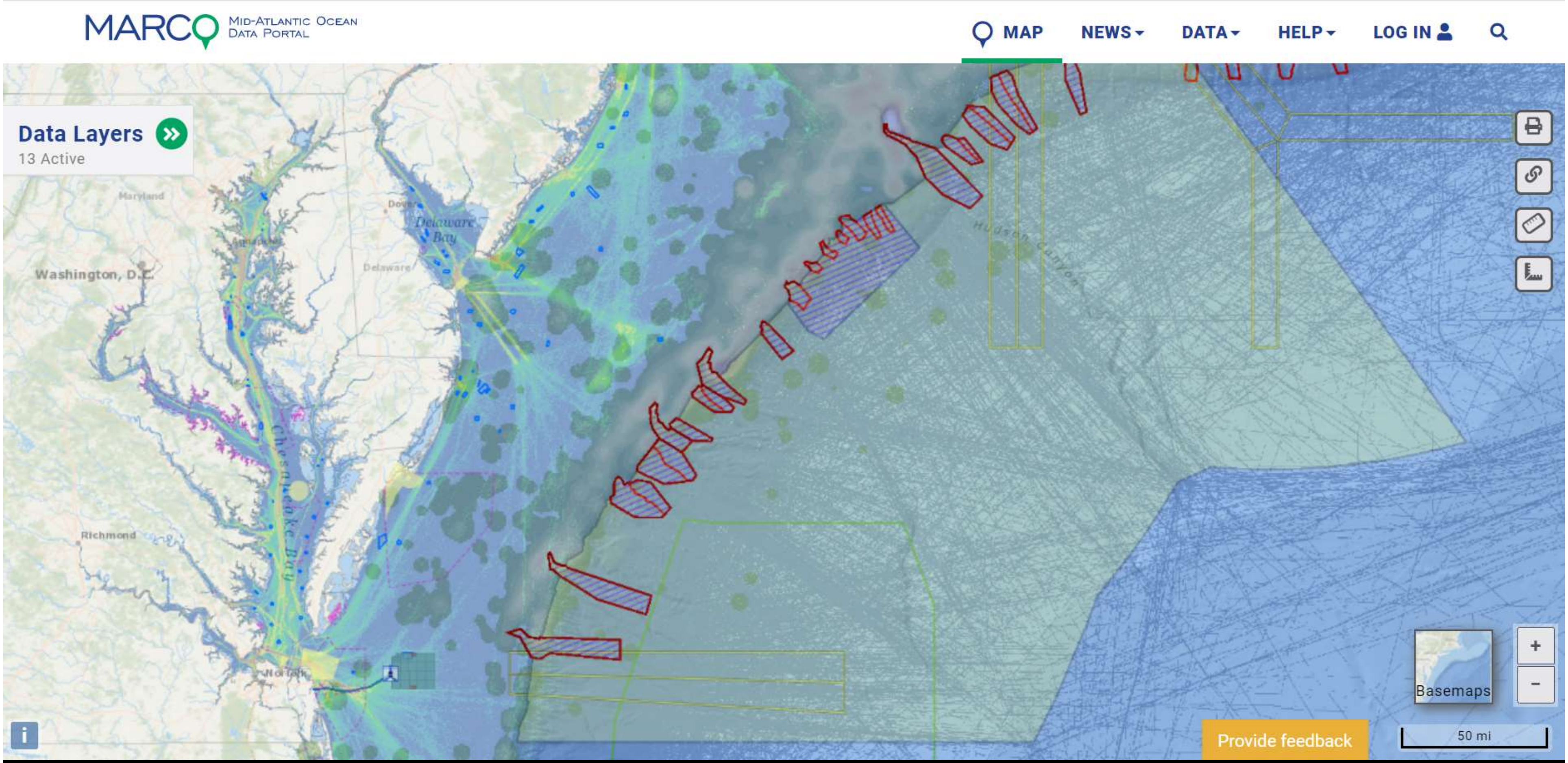
- MARCO created MACO in 2017

MARCO
MID-ATLANTIC REGIONAL COUNCIL ON THE OCEAN

MID-ATLANTIC COMMITTEE ON THE OCEAN

2010 Created MARCO Ocean Data Portal

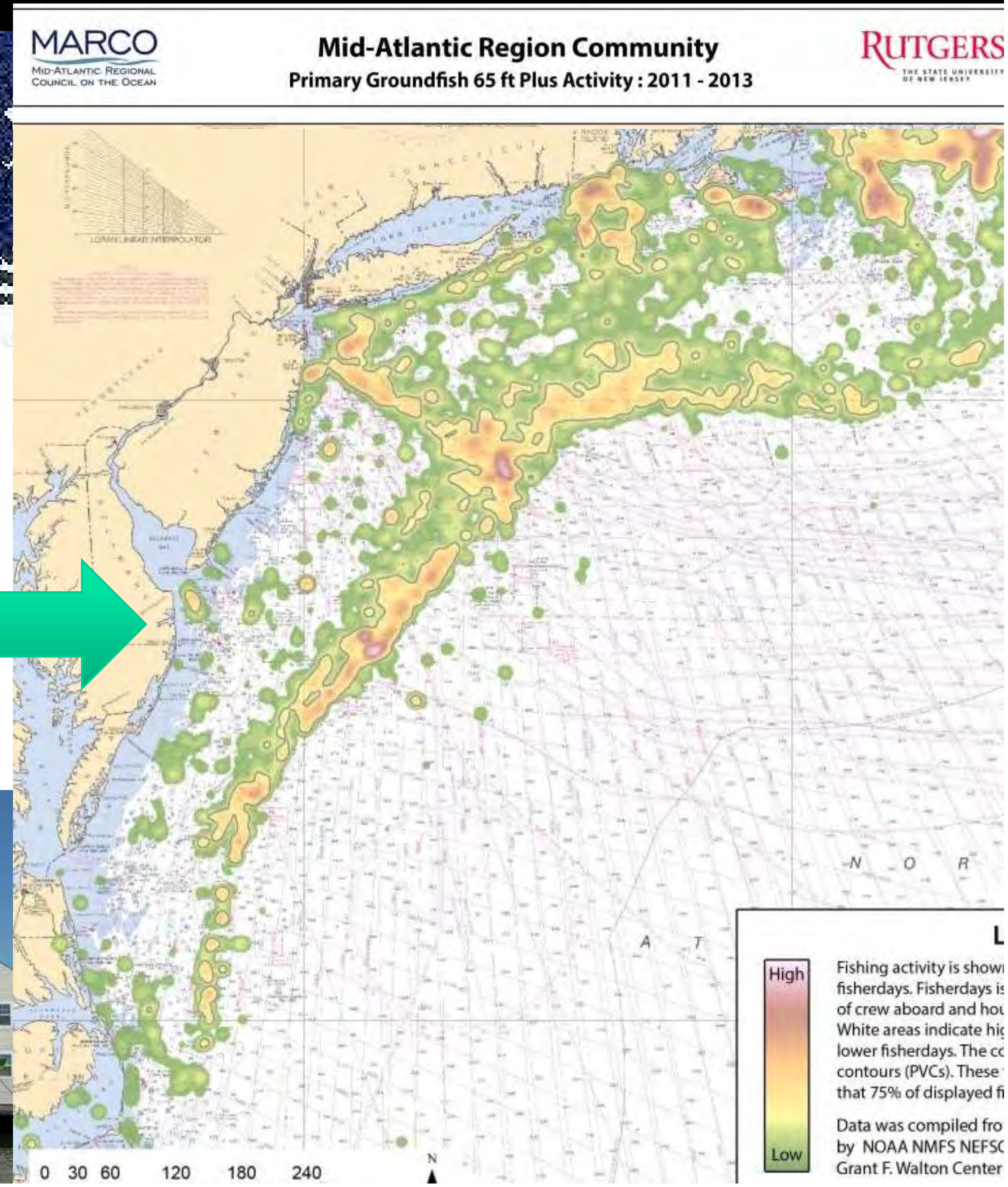
https://portal.midatlanticocean.org/



6,000+ maps in 12 themes: Administrative, Fishing, Fishing-Communities at Sea (by Port), Marine Life Library, Maritime, Oceanography, Recreation, Renewable Energy, Seafloor Habitat, Security, Socioeconomic, Water Quality

Ocean Resources of Concern

Important Fishing Areas: "Communities at Sea"



Ocean Resources of Concern

2016 Mid-A Fisheries Management Council Protects 38,000 sq. mi. of Canyon – Coral Habitat from Bottom Dredging

Ocean Resources of Concern

Marine Mammals and Other Protected Species

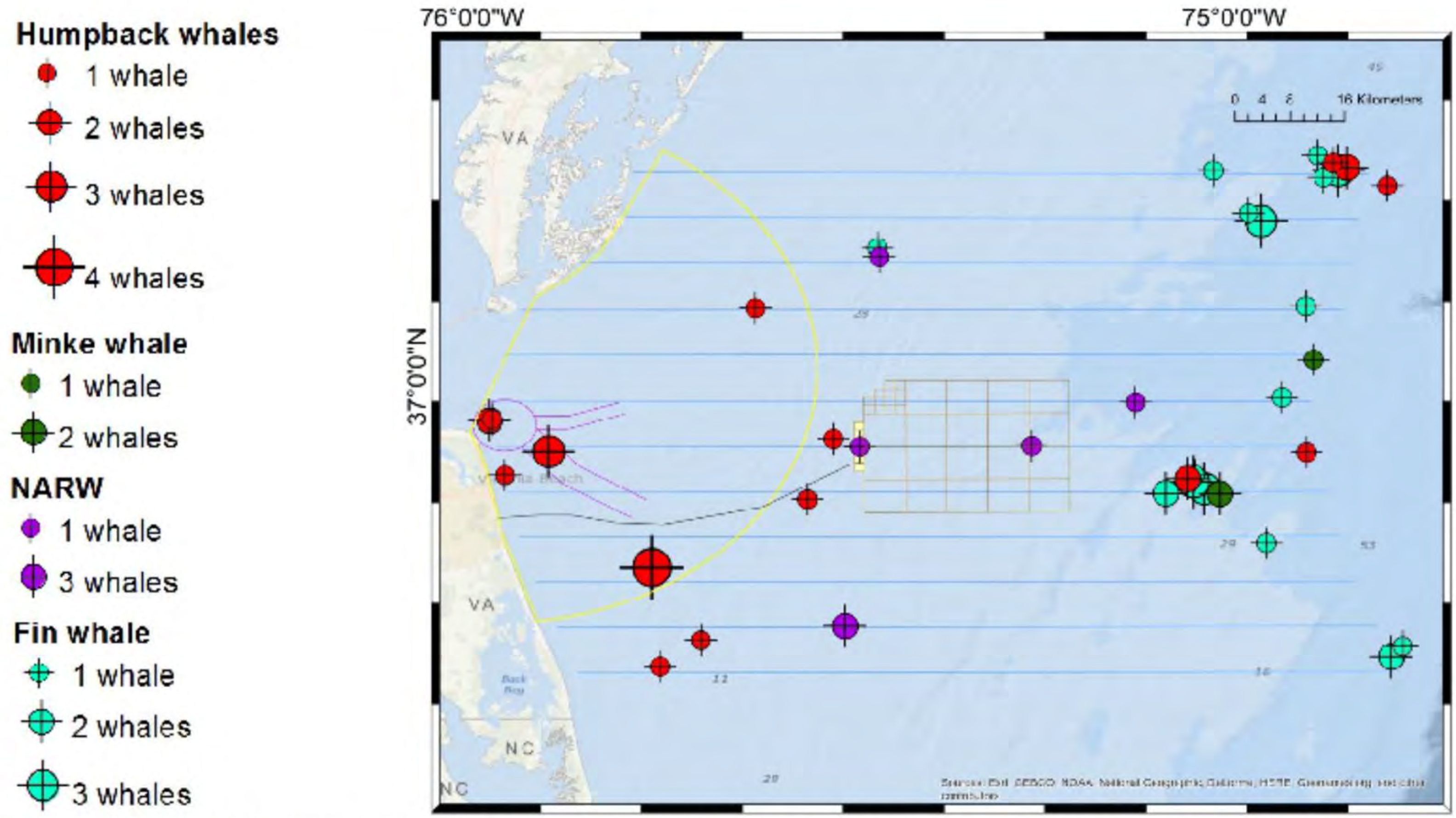
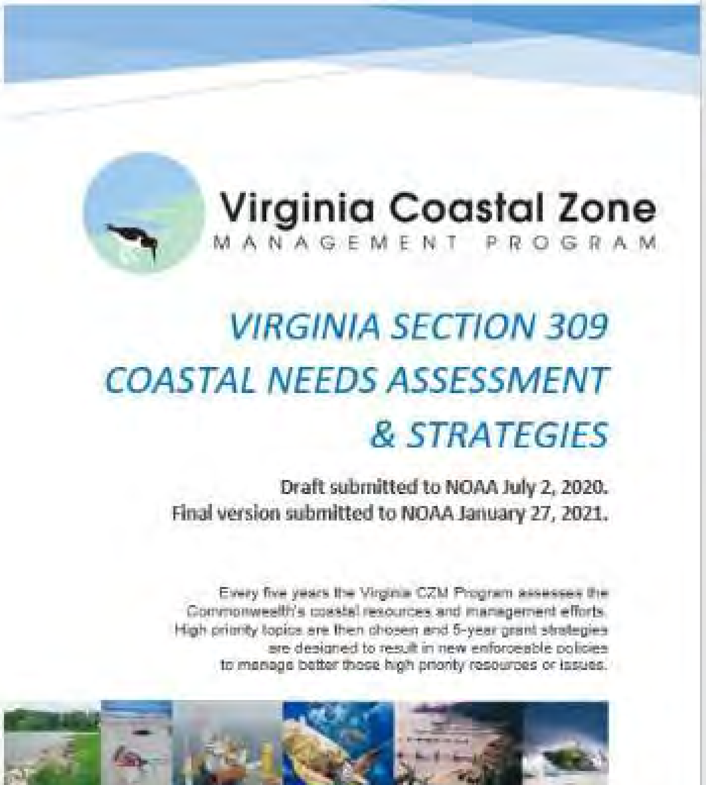


Figure 1. All large whales documented during aerial surveys in the proximity of the Virginia Wind Energy Area (VA WEA) from November 2012 through March 2015. Size of each point reflects groups size.

Aerial surveys were funded under Virginia Coastal Zone Management Grant NA14NOS4190141 Task 95.04

Virginia Coastal Zone MANAGEMENT PROGRAM

Current CZM 5-year Grant Strategies October 2021 – September 2026



VIRGINIA SECTION 309 COASTAL NEEDS ASSESSMENT & STRATEGIES

Table of Contents

5-YEAR BUDGET SUMMARY BY STRATEGY

Strategy Title	Anticipated Funding Source (309 or other)	Year 1 Funding	Year 2 Funding	Year 3 Funding	Year 4 Funding	Year 5 Funding	Total
Coastal Hazards	309	$176,000	$167,000	$167,000	$167,000	$167,000	$844,000
Ocean Resource	309	$183,000	$183,000 ~~XXXXXXX~~	$176,000	$176,000	$176,000	$894,000 ~~XXXXXXX~~
Marine Debris	309	$170,000	$160,000	$160,000	$160,000	$160,000	$810,000
Total Funding		$529,000	$503,000	$503,000	$503,000	$503,000	$2,541,000

2021-25 CZM to Create a Virginia Ocean Plan

What is Your Vision for Virginia's Ocean?

Year 1 Grants

- W&M CPC: research other state plans, develop draft plan outline and communication strategy
- VCU Fisheries Coordinator: continue to address fisheries concerns
- DWR: update marine mammal/sea turtle conservation plans

Plan to address:

- Additional offshore wind leases
- Potential offshore aquaculture
- Marine habitat & fisheries protection
- Ocean acidification
- Climate impacts
- Military & shipping needs
- *Ocean sand & heavy minerals mining?*

Session 5: Advanced technologies for heavy minerals identification, assessment, and monitoring

TOMLINSON, J. – Insights from the BOEM Atlantic Sand Assessment Project (JTomlinson.pdf)

Insights from the BOEM Atlantic Sand Assessment Project

Jaime Tomlinson

Delaware Geological Survey

C. Robin Mattheus

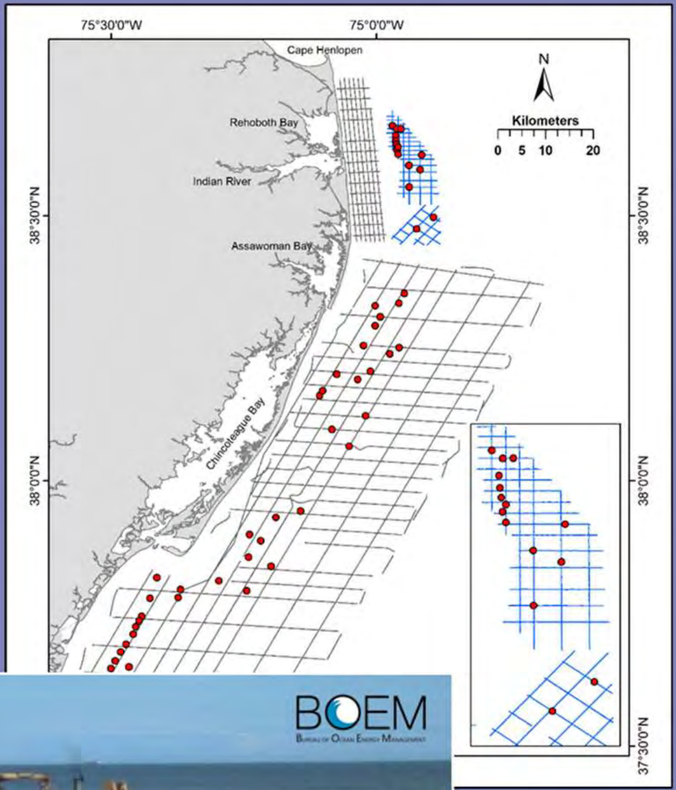
Illinois State Geological Survey

Kelvin Ramsey

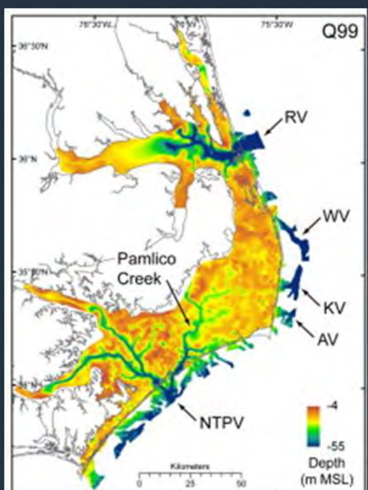
Delaware Geological Survey

Project Overview

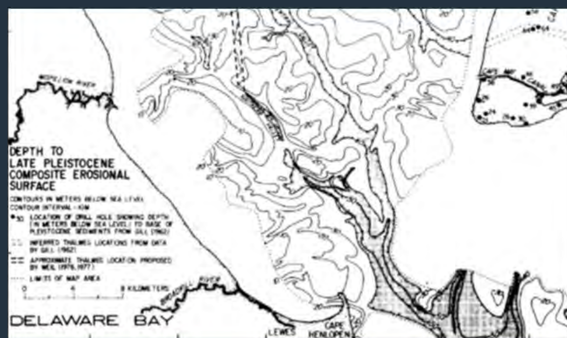
- Renewed offshore mapping activity was facilitated by the Bureau of Ocean Energy Management (BOEM) Atlantic Sand Assessment Project (ASAP)
  - Provided 100s of trackline kilometers of geophysical data
  - 60 vibracores from offshore DE, MD, and VA collected from 2015-2017
- Motivations
  - Primary
    - Hurricane Sandy response, recovery, and resiliency
    - Constraint of sand resources available in proximity to Delaware's coastal communities
  - Secondary
    - Improvement of stratigraphic framework models and mapping paleovalleys along the central to northern Delmarva



Offshore Geologic Mapping: Big Picture



Thieler et al. (2010)



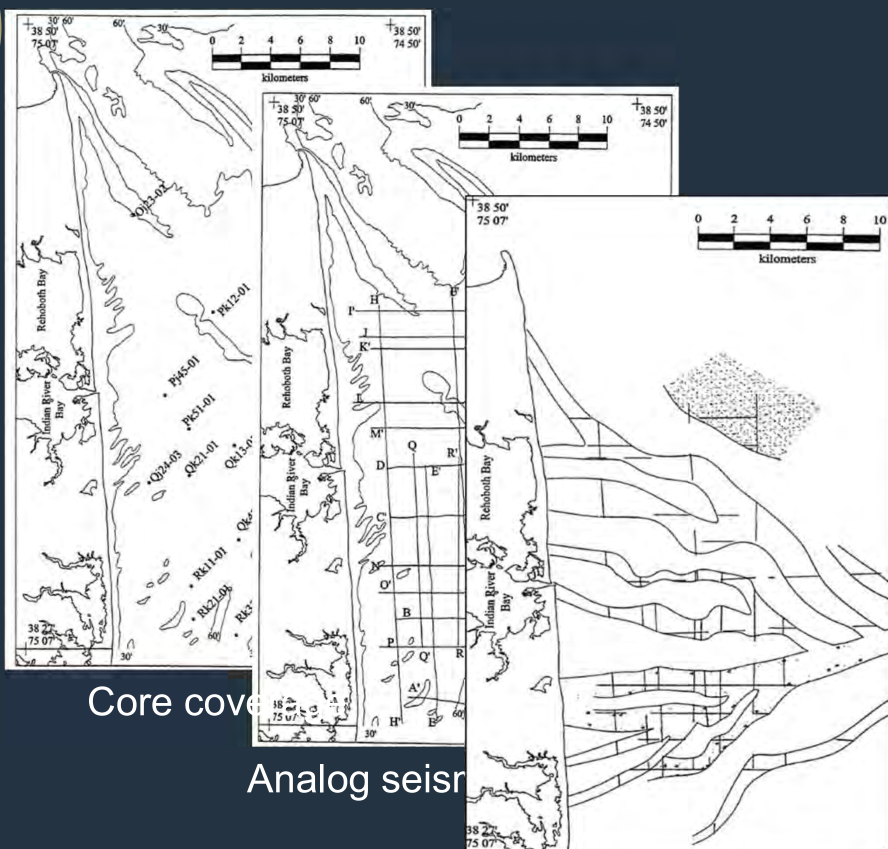
Knebel et al. (1988)

Metz, 2015

Improving stratigraphic maps and constraints of paleovalley locations is also important for:

- Offshore infrastructure design
- Characterizing groundwater flow pathways/submarine discharge
- Understanding Holocene coastal and seafloor evolution
- Parameterizing models of future change based on sea-level rise and storm-climate predictions

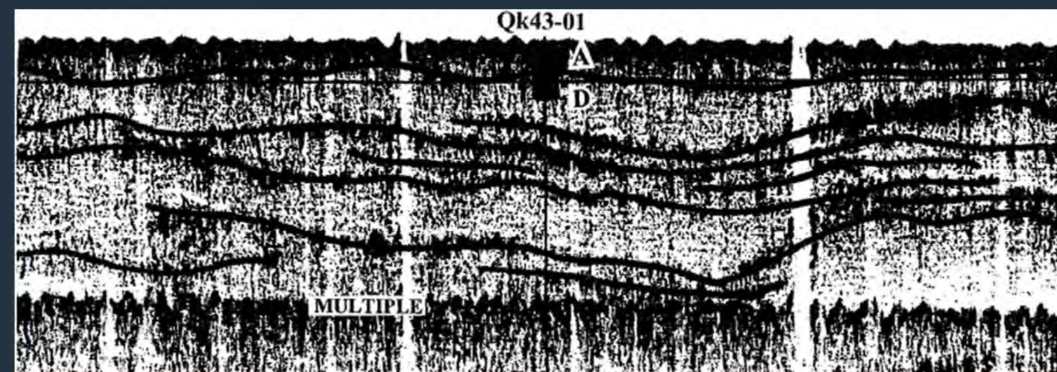
Previous Study: Williams (1999)

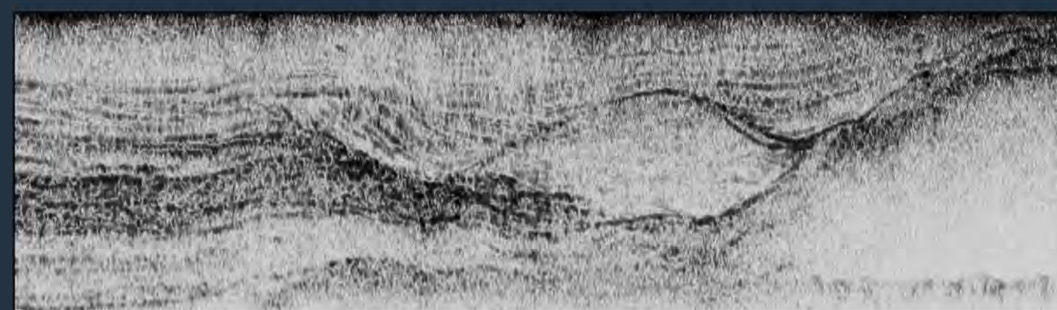


Core cove

Analog seisr

Offshore paleovalleys

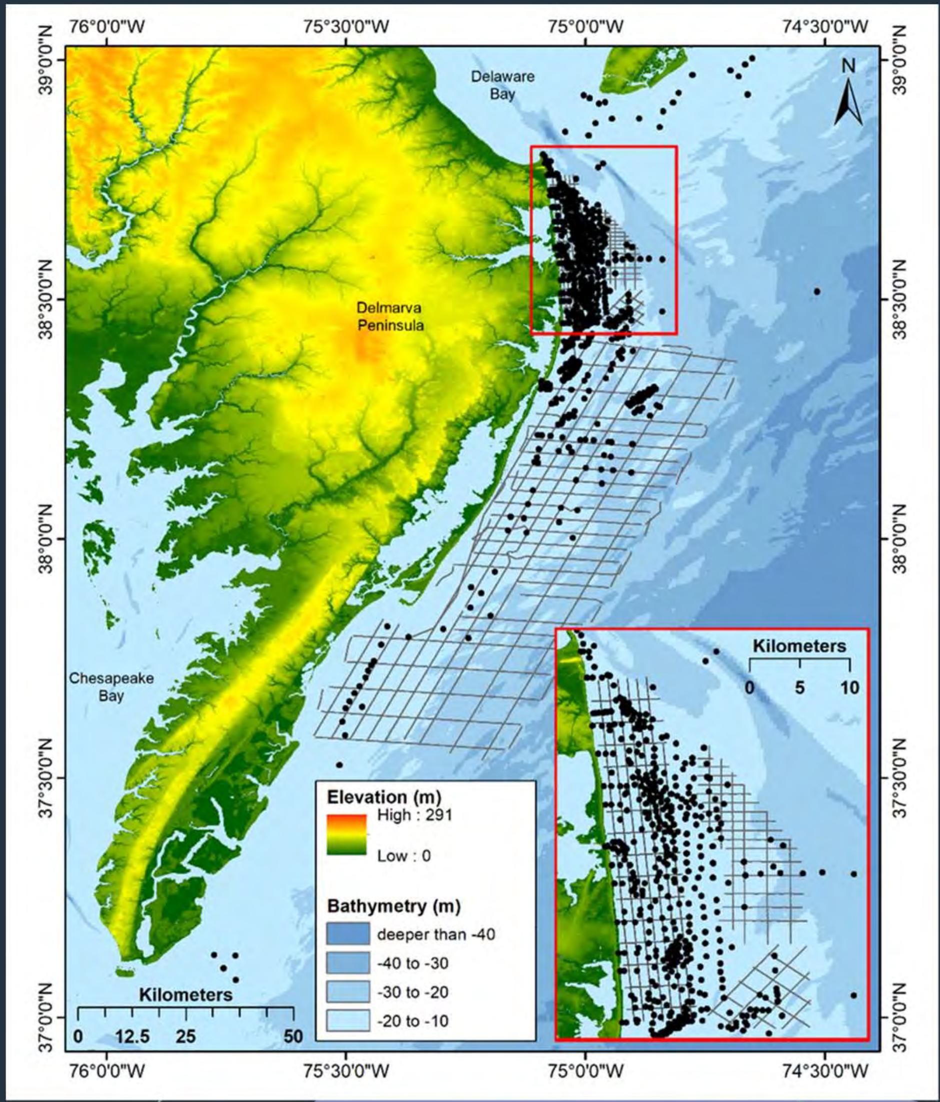


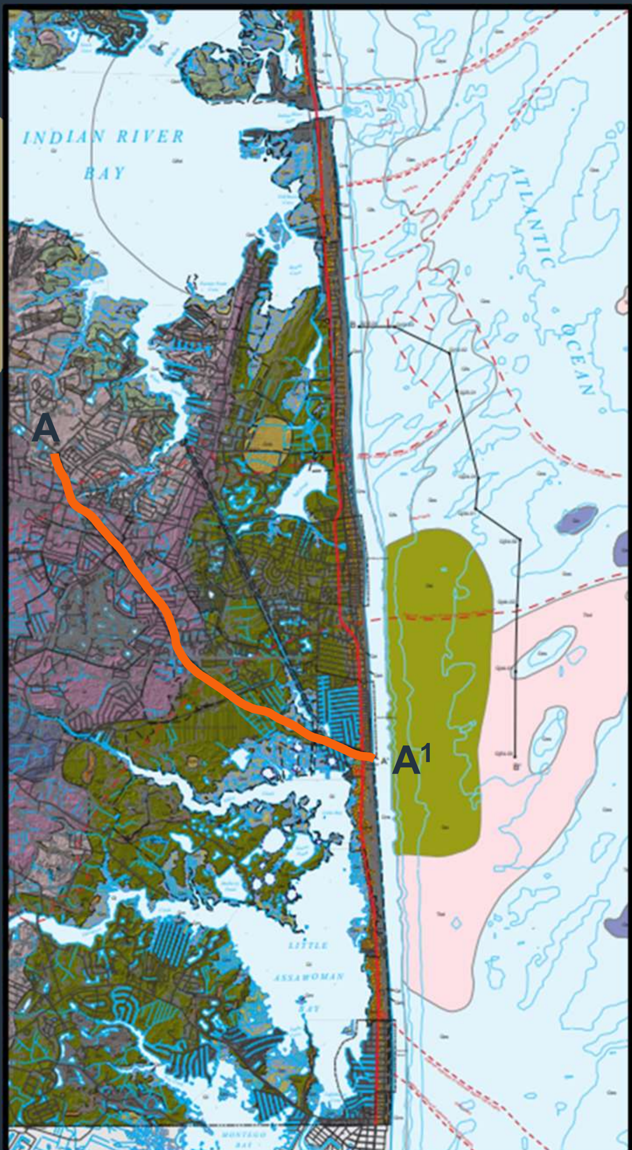


1990s Analog vs 2010s Digital

This Study

- Lithologic information (466 cores off DE; 230 cores of MD & VA)
  - DGS database information
    - Sediment texture
    - Stratigraphic picks
    - Photographs
    - Lithologic logs
    - Radiocarbon dates
    - AAR age estimates
- Marine geophysics
  - 'Chirper' seismic reflection
    - 1672 trackline km off the central Delmarva, from MD-DE state line to offshore Exmore, VA (USGS 2014 dataset)
    - ~500 trackline km in off DE (BOEM 2015 and DNREC 2013 dataset)

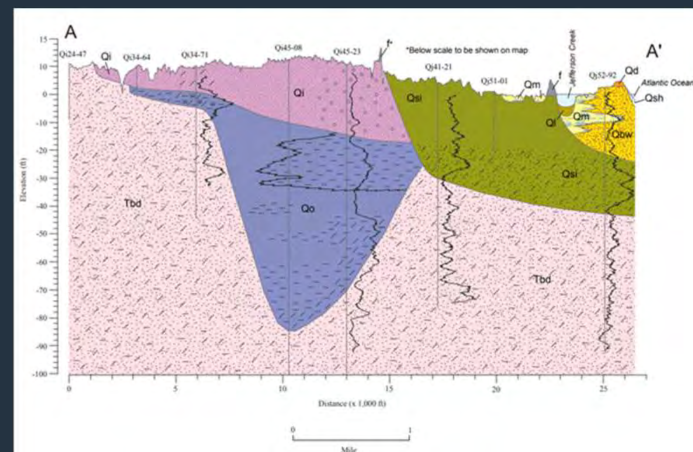




Lessons from Coastal Plain Mapping

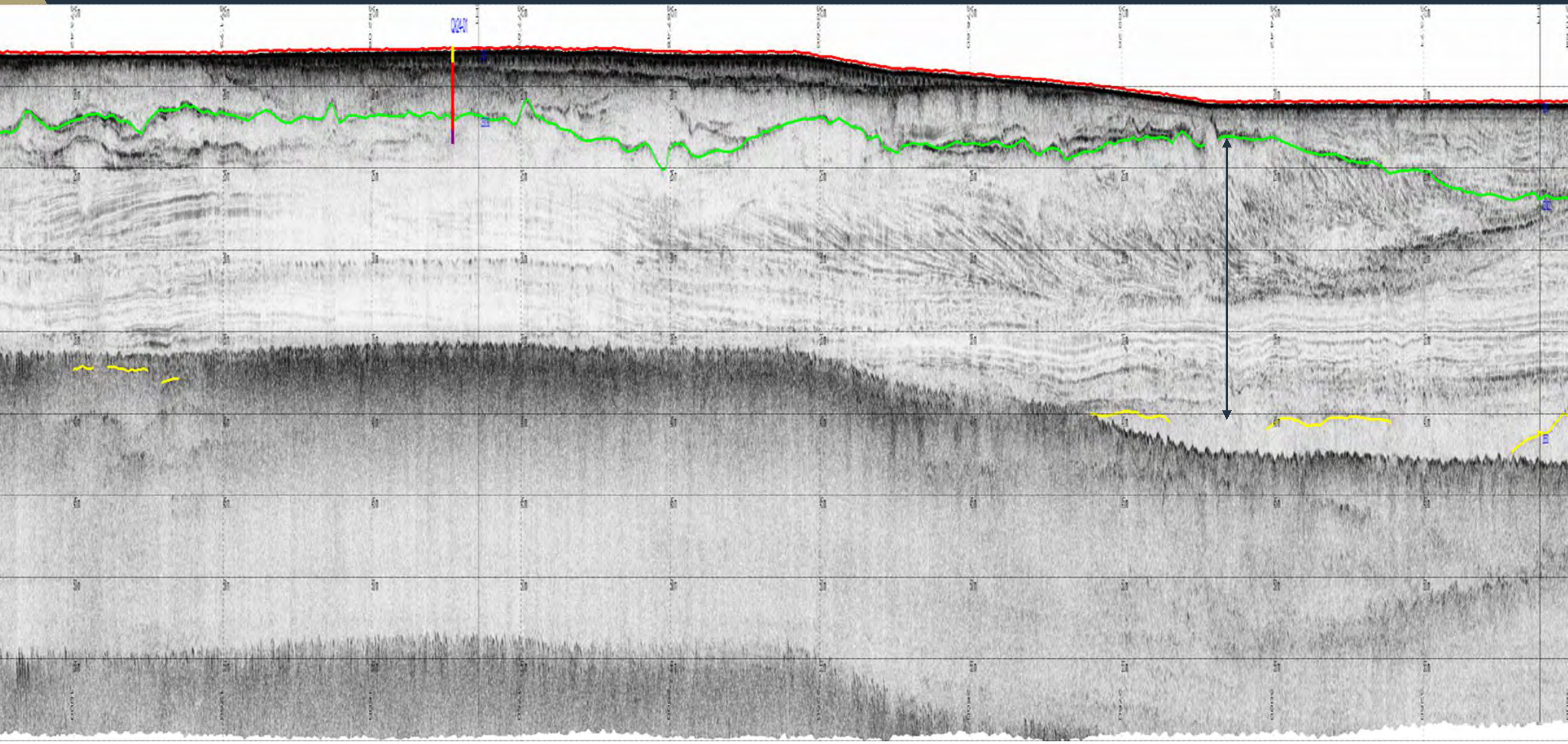
Beaverdam Formation
- Heterogeneous unit (vc sand with pebbles to silty clay)
- Laminae and beds of vc sand with pebbles to gravel common
- Absence of shells
- Sands have a white silt matrix that gives samples a milky appearance when wet

Omar Formation
- Gray clays
- Varying % of organics
- Silt and sand laminae common
- M sand beds common

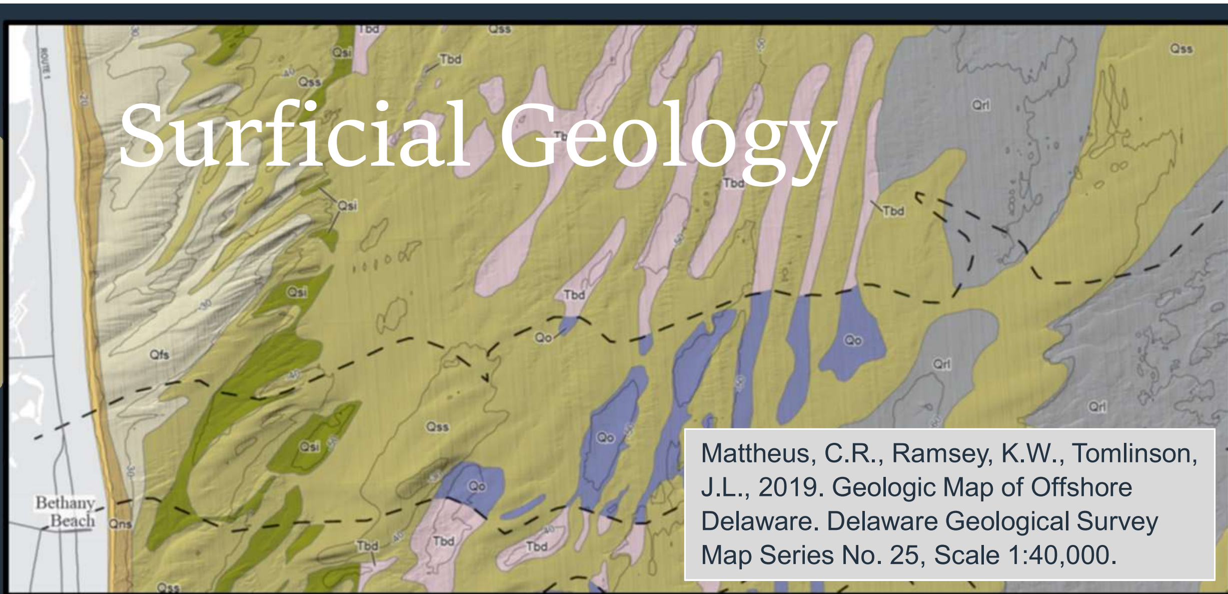


Ramsey and Tomlinson, 2012

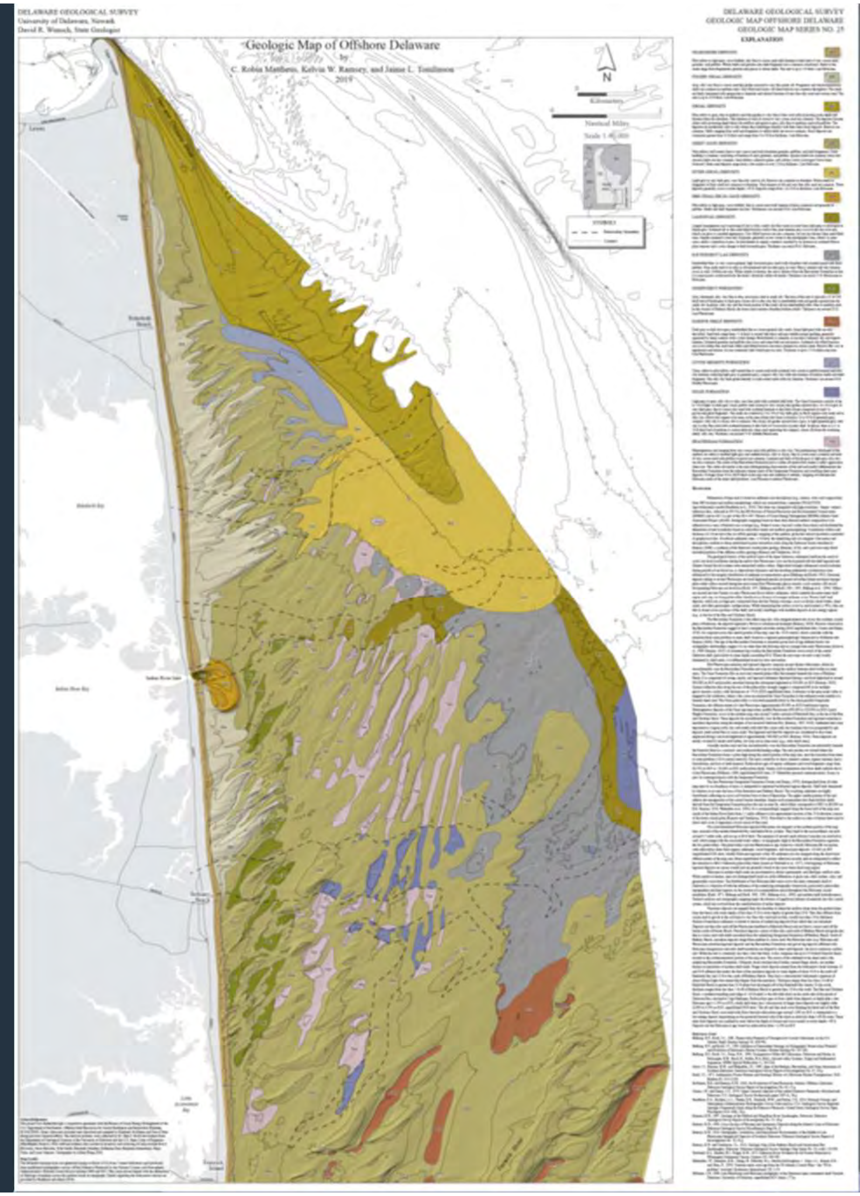
Stratigraphic Framework Offshore Delaware



Surficial Geology



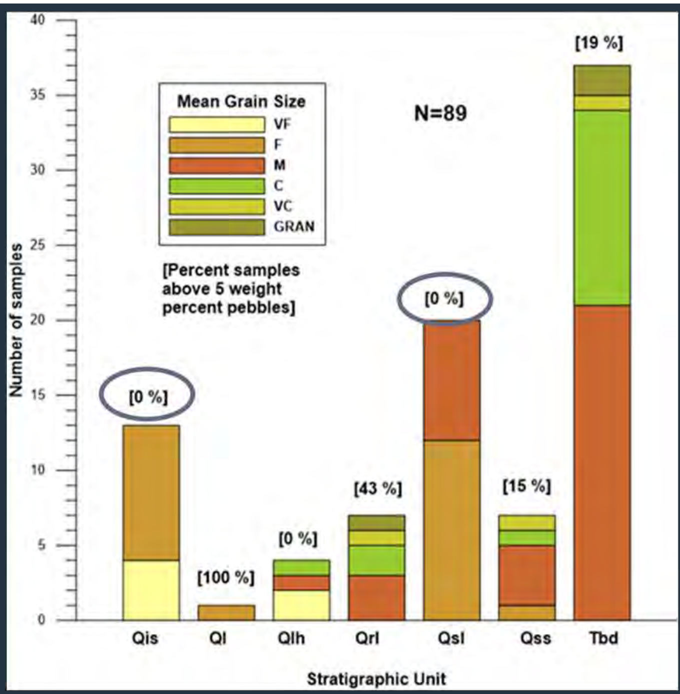
Mattheus, C.R., Ramsey, K.W., Tomlinson, J.L., 2019. Geologic Map of Offshore Delaware. Delaware Geological Survey Map Series No. 25, Scale 1:40,000.

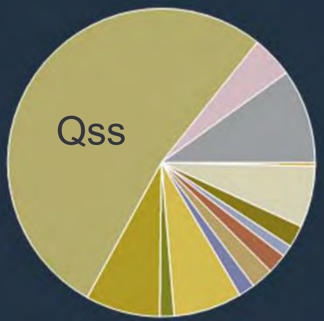


- Strongly influenced by underlying structure (e.g., paleovalleys versus interfluves)
- Sheet sands are mostly thin and discontinuous, and are sourced (at least in part) by the reworking of the Beaverdam Formation
- Textural variances of Holocene sediments dictated largely by modern hydrodynamics

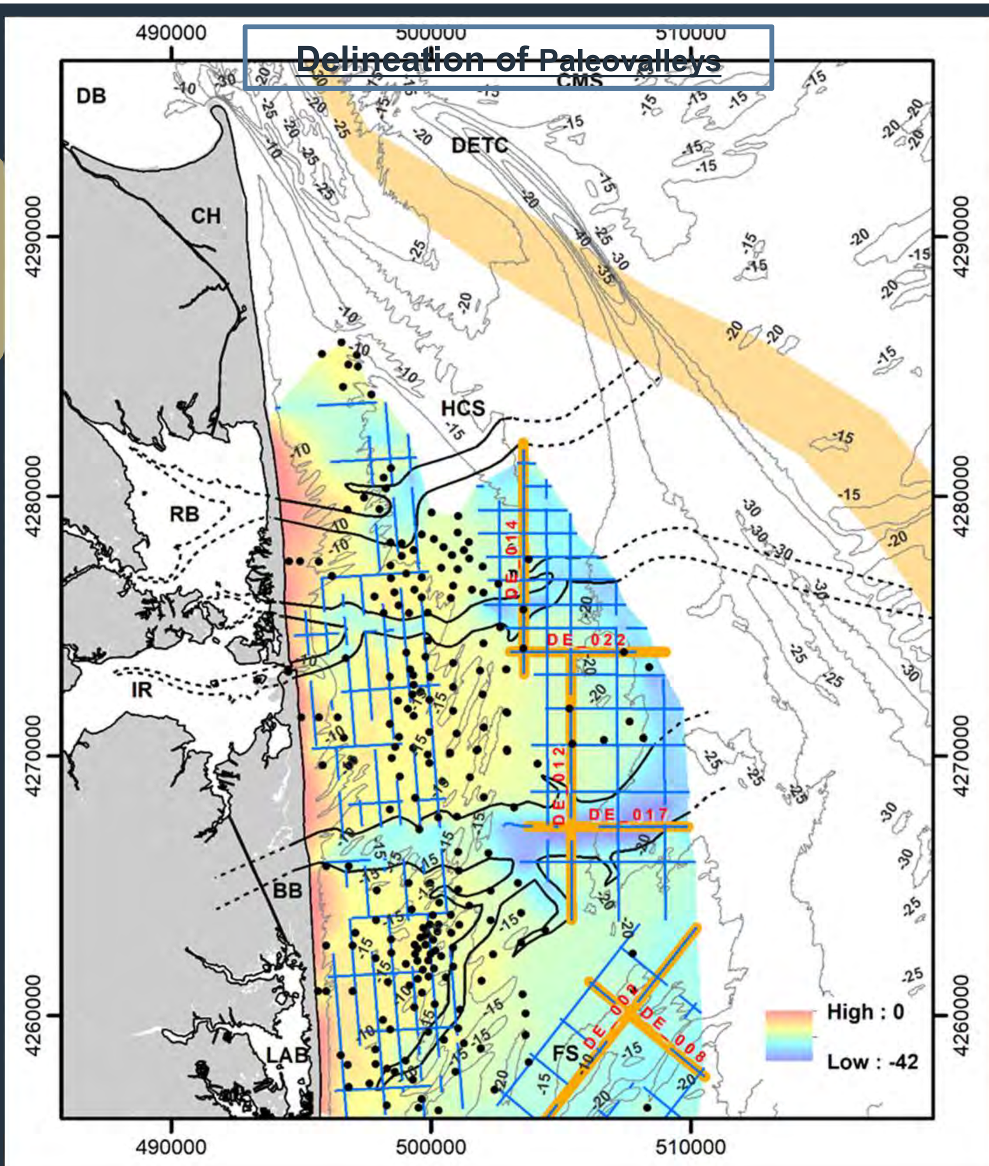
Map Unit	Defining Unit Characteristics	Unit Age	Environmental Interpretation	Formation Name	Resource Potential
Qets	White to light-gray, fine to very fine mud-laminated sand.	Holocene	Ebb-tidal delta	NA	Poor
Ql	Dark olive-gray, slightly silty clay with sandy burrows.	Holocene	Estuarine central basin	NA	None
Qo	Interbedded dark-gray silty clay and fine-medium clayey to silty sand.	Pleistocene	Estuarine central basin	Omar	None
Qrl	Gray, poorly-sorted sands and gravels.	Unknown	High-energy, shallow shelf during inundation	NA	Poor
Qss	Light yellowish-brown medium sand with scattered quartz and chert pebbles, shell fragments, and heavy minerals	Holocene	Mid-shelf shoal	NA	Excellent
Qlh	Shell-rich, mottled and slightly oxidized brown to dark gray silt and very fine sand with heavy mineral laminae.	Pleistocene	Subtidal to intertidal lagoon	Lynch Heights	None
Tbd	Light-gray, interbedded silty sands ranging from fine to very coarse with scattered Q and chert pebbles and heavy mineral laminae.	Pliocene-Pleistocene	Fluvio-deltaic braid plain	Beaverdam	Poor to Excellent
Qms	Interbedded and burrowed very dark gray to black fine silty sands, clays, and gravels.	Pleistocene	Estuarine/marine	NA	None
Qsl	Well sorted, pale yellowish-gray fine to medium sands with zones of abundant dark gray clay-lined burrows.	Holocene	Shoal	NA	Excellent
Qis	Greenish-black, bioturbated and silty, very fine to fine sand containing organic debris.	Holocene	Low-energy marine/inter-shoal	NA	Poor to good
Qfs	Tan to yellowish, well-sorted fine to medium sands, shelly, heavy minerals and few silty burrows.	Holocene	Inner shelf shoals	NA	Excellent

Some litho-units represent excellent sand resources



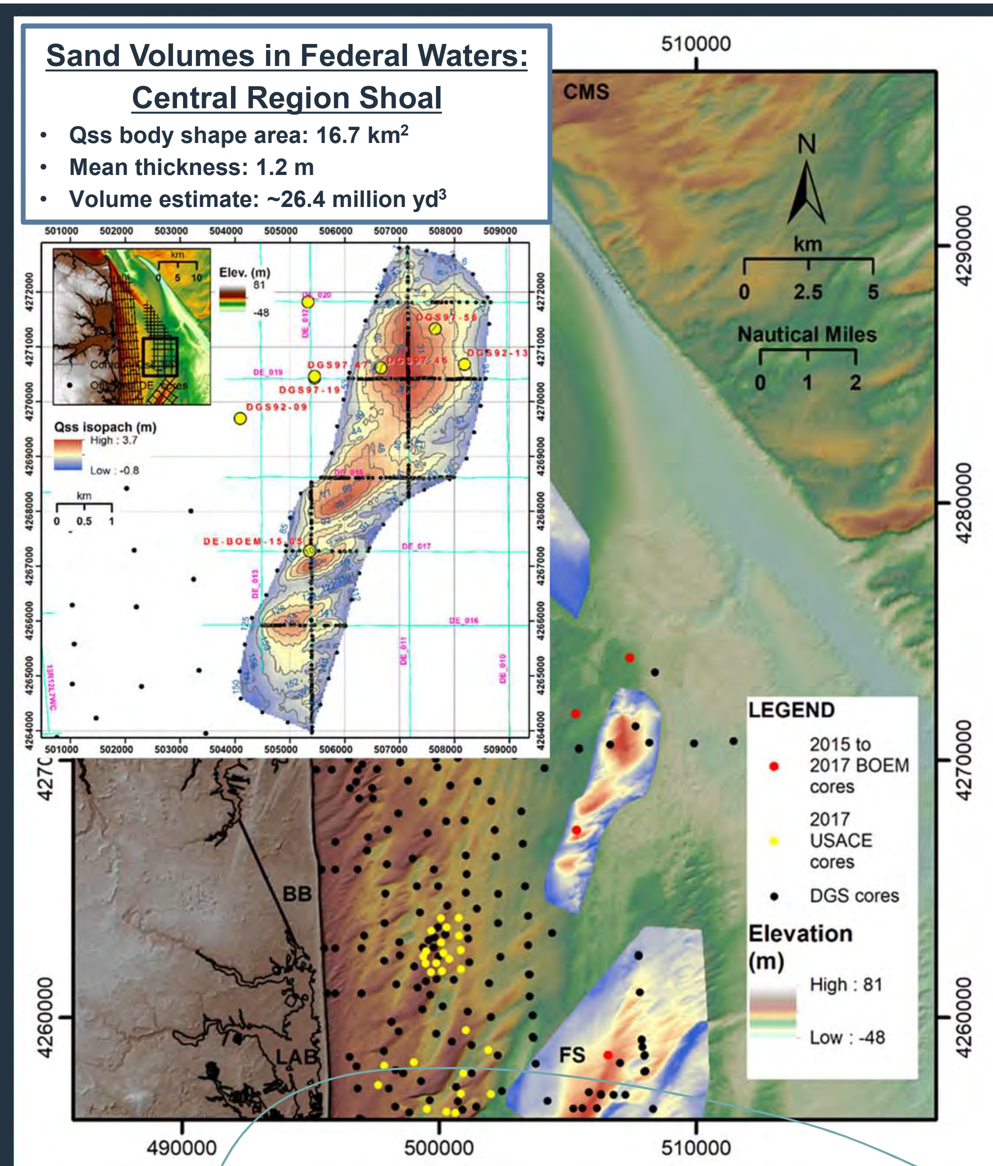


Delineation of Paleovalleys



Sand Volumes in Federal Waters: Central Region Shoal

- Qss body shape area: 16.7 km^2
- Mean thickness: 1.2 m
- Volume estimate: ~26.4 million yd^3



Session 5: Advanced technologies for heavy minerals identification, assessment, and monitoring

GRAMMATIKOPOULOS, T. – Mineralogical and geochemical investigation of REE offshore sands from Virginia, USA (TGrammatikopoulos.pdf)

Natural Resources – North America

Metallurgy & Consulting

Delivering Metallurgical Expertise Across The Entire Mining Life Cycle

Mineralogy of Mineral Sand Samples, Virginia, USA

Tassos Grammatikopoulos, SGS Canada

William L. Lassetter Virginia Department of Energy Geology and Mineral Resources Program

SGS MINERALS

AGENDA

1. ABOUT SGS – LAKEFIELD SITE
2. AUTOMATED MINERALOGY
3. HLS, GEOCHEMISTRY
4. MINERALOGICAL DELIVERABLES
5. CONCLUSIONS
6. Q & A

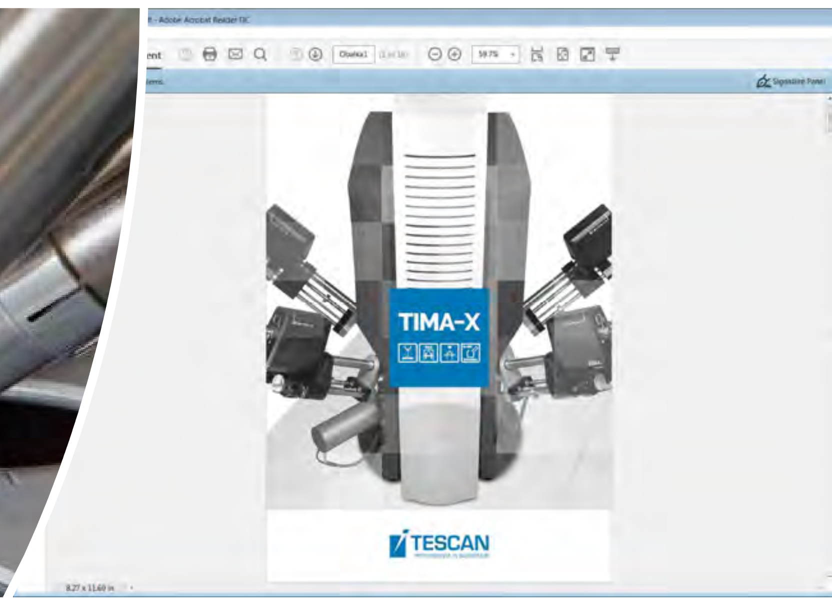
SGS Lakefield Site Capabilities

- Metallurgy
  - Mineral Processing
  - Extractive Metallurgy (Gold and Hydromet)
  - Solid-Liquid Separation and Rheology
  - Environmental Metallurgy
- Mineralogy
- Geochemistry

- 250 skilled staff
- Specialization in flowsheet development solutions for complex metallurgy and integrated processes
- Extensive piloting capabilities
- Vast experience with sulphide mineral systems and precious metals

Mineralogy

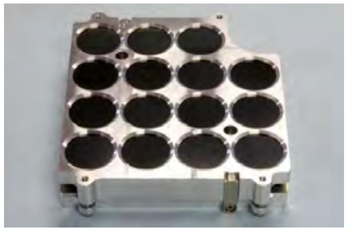
- QEMSCAN/TIMA-X Mineralogical analysis
- X-ray Diffraction Analysis
- NIR
- FTIR
- Optical microscopy
- Electron Microscopy
- Electron Microprobe Analyses
- LA-ICP-MS, ToF SIMS, D-SIMS, Raman, TEM
- Geochemistry

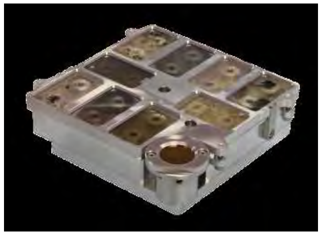


TIMA-X Hardware

- Field Emission (FEG), with GM-Chamber (*ion pumps and gun valve)*
- Typical working conditions: 25 kV, WD (working distance) 15 mm, probe current 7 nA
- 2 million counts per second
- Calibration on a Pt Faraday cup
- 15 epoxy blocks (ϕ 30 mm)
- 22 epoxy blocks (ϕ 25 mm)
- 9 thin sections (27 x 47 mm)

Active anti-vibration table

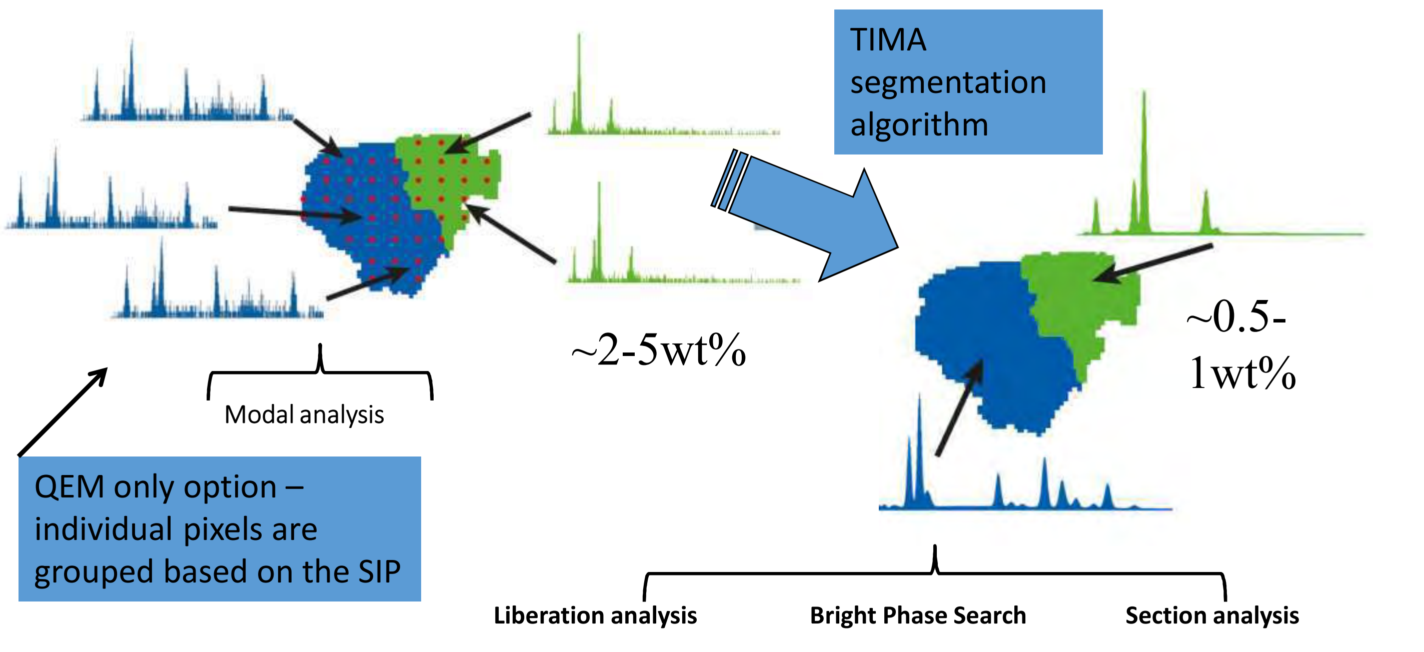




No rotation of the stage for better precision

Detection Limits in a Single Phase - Patented TESCAN Segmentation Algorithm

- TIMA Measurements (modal or segmented data):



Heavy Liquid Separation (HLS)

- HLS at 3.1 SG to concentrate the heavy minerals
- Mass balance to determine the wt% distribution
- Mass balance for elements of interest

Sample ID	Initial wt/g	wt%	Sample ID	Initial wt/g	wt%
R-11945c	299.79	100.0	R-11961c	126.35	100.0
Sink	65.81	22.0	Sink	21.00	16.6
Float	233.98	78.0	Float	105.35	83.4
R-11947c	303.05	100.0	R-11962c	221.7	100.0
Sink	46.01	15.2	Sink	134.2	60.5
Float	257.04	84.8	Float	87.5	39.5
R-11948c	54.7	100.0	R-11964c	206.3	100.0
Sink	3.27	6.0	Sink	21.65	10.5
Float	51.43	94.0	Float	184.65	89.5

Geochemistry

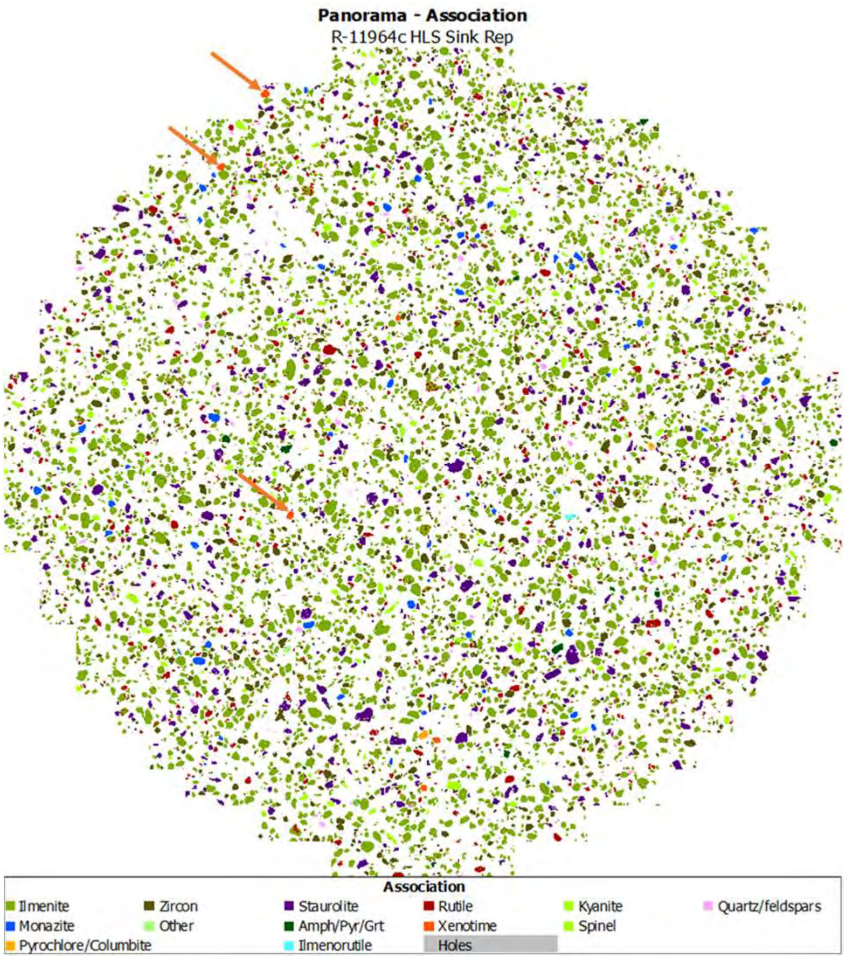
- Each sink fraction, a 2-5 g sub-sample was obtained to complete the following chemical assays
  - sodium peroxide fusion ICP-MS analysis (IMS93A) for REE, Th, U, Cs, Ga, In, Nb, Rb and Ta
  - sodium peroxide fusion ICP-AES analysis (ICP93A) for Al, Ca, Cr, Fe, K, Mg, Mn, Si, Ti and V, Sc, and Zr
  - strong acid digest / ICP-AES (ICP42C) for 30 element
  - ICM90A for As, Ge and Hf.

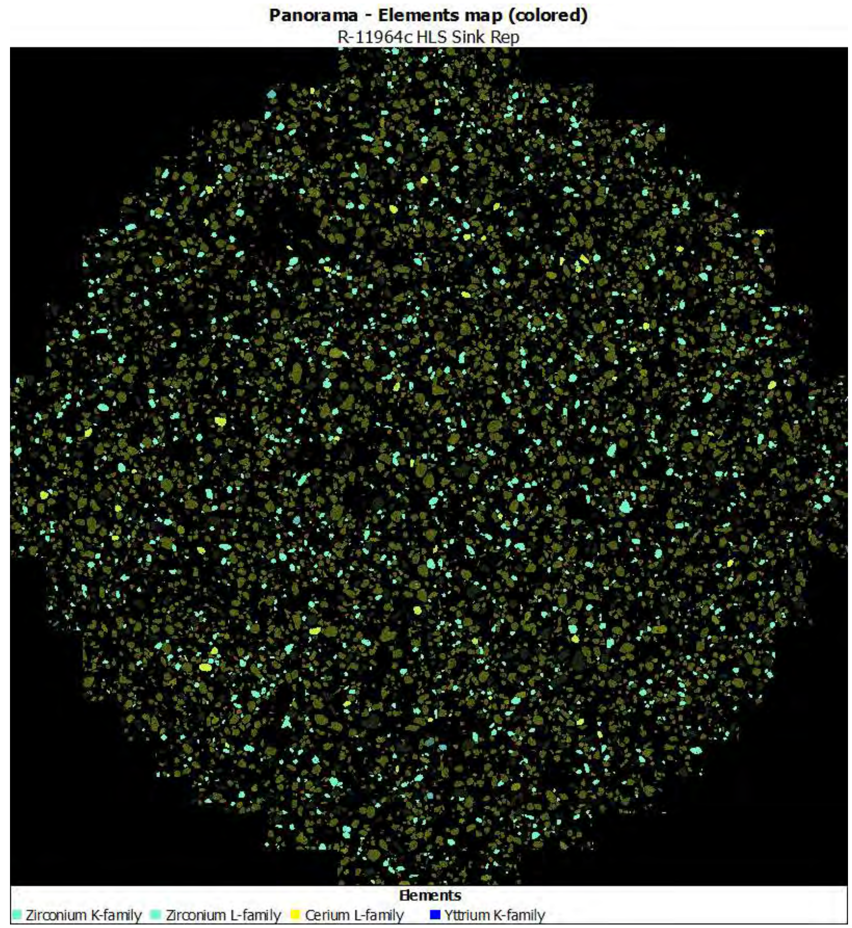
Sample ID	La g/t	Ce g/t	Pr g/t	Nd g/t	Sm g/t	Eu g/t	Gd g/t	Tb g/t	Dy g/t	Ho g/t	Er g/t	Tm g/t	Yb g/t	Lu g/t	Y g/t	Total REE+Y	LREE	HREE	LREE/HREE
R-11945c HLS Sink	139	286	32	114	19	1	16	2	11	2	8	2	11	2	15	660	591	69	8.6
R-11947c HLS Sink	344	704	79	306	56	2	35	5	24	5	17	3	24	4	41	1648	1492	156	9.6
R-11949c HLS Sink	299	638	74	267	50	3	38	4	27	5	20	3	26	5	37	1498	1331	167	8.0
R-11951c HLS Sink	225	494	57	216	38	3	32	4	25	7	23	4	33	6	35	1200	1033	167	6.2
R-11953c HLS Sink	363	763	85	326	55	3	36	4	24	5	18	3	24	5	34	1747	1594	153	10.4
R-11955c HLS Sink	242	520	59	217	40	2	27	4	22	4	16	3	20	4	31	1211	1080	131	8.3
R-11956c HLS Sink	372	779	88	317	58	3	43	5	26	5	18	3	25	5	37	1784	1617	167	9.7
R-11960c HLS Sink	111	253	29	103	17	1	15	3	24	6	26	5	45	9	15	663	514	149	3.4
R-11961c HLS Sink	112	220	27	94	16	2	19	3	26	7	33	6	47	10	16	638	471	166	2.8
R-11962c HLS Sink	94	190	22	73	16	2	17	3	34	9	43	8	59	13	17	599	397	203	2.0
R-11964c HLS Sink	817	1630	178	629	108	5	76	11	70	14	48	7	54	10	97	3754	3367	387	8.7
R-11965c HLS Sink	139	277	34	116	20	1	15	3	22	6	24	4	36	7	16	722	587	134	4.4
R-11968c HLS Sink	93	190	22	77	16	1	12	2	14	5	23	4	33	7	10	509	399	110	3.6
R-11969c HLS Sink	132	271	31	124	23	1	17	2	18	5	24	4	36	7	11	707	581	126	4.6
R-11970c HLS Sink	124	275	32	117	19	1	21	3	31	9	43	7	60	13	15	770	568	203	2.8
R-11971c HLS Sink	174	361	38	136	27	1	25	4	40	11	48	9	77	16	22	988	737	251	2.9
R-12149c HLS Sink	223	473	55	197	37	3	28	4	19	4	13	3	19	4	30	1109	987	122	8.1
R-11948c HLS Sink	315	678	77	295	50	5	50	8	56	12	49	9	67	11	72	1754	1420	334	4.3
R-11958c HLS Sink	420	898	105	399	67	7	61	8	53	12	42	7	54	10	93	2234	1895	339	5.6
R-12147c HLS Sink	1540	3200	348	1250	220	9	154	22	128	25	86	13	97	16	185	7292	6567	725	9.1

Mineralogy

- Modal mineralogy
- Grain and particle size
- Liberation/association
- Particle maps
- Element deportment
- Shape factors
- Grade-recovery

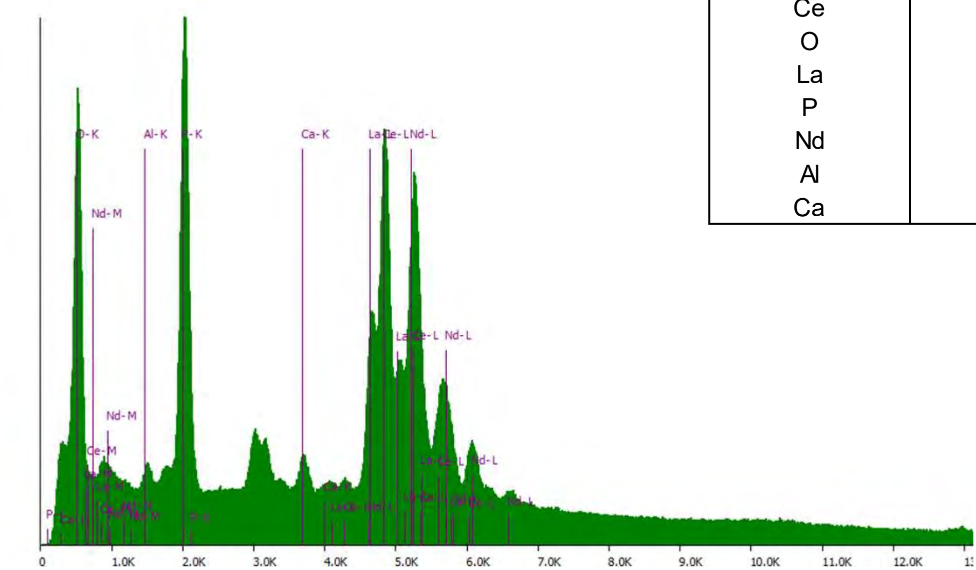
TIMA-X- Panorama – Illustrates the Entire Sample



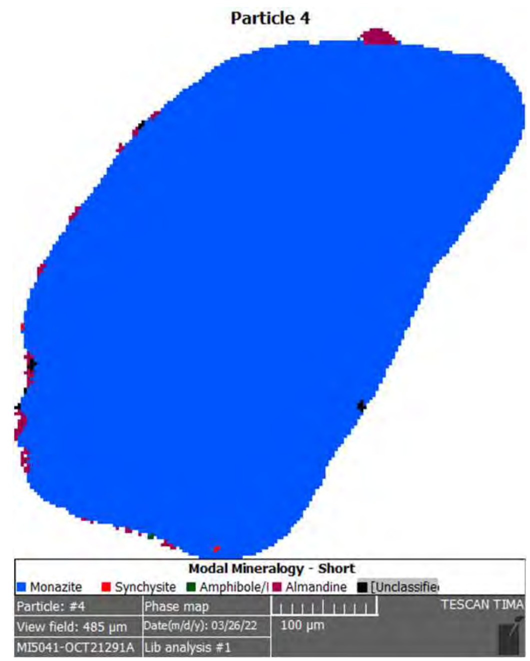


TIMA-X Analysis – Classification Scheme

- Mineral identification is based on the X-rays

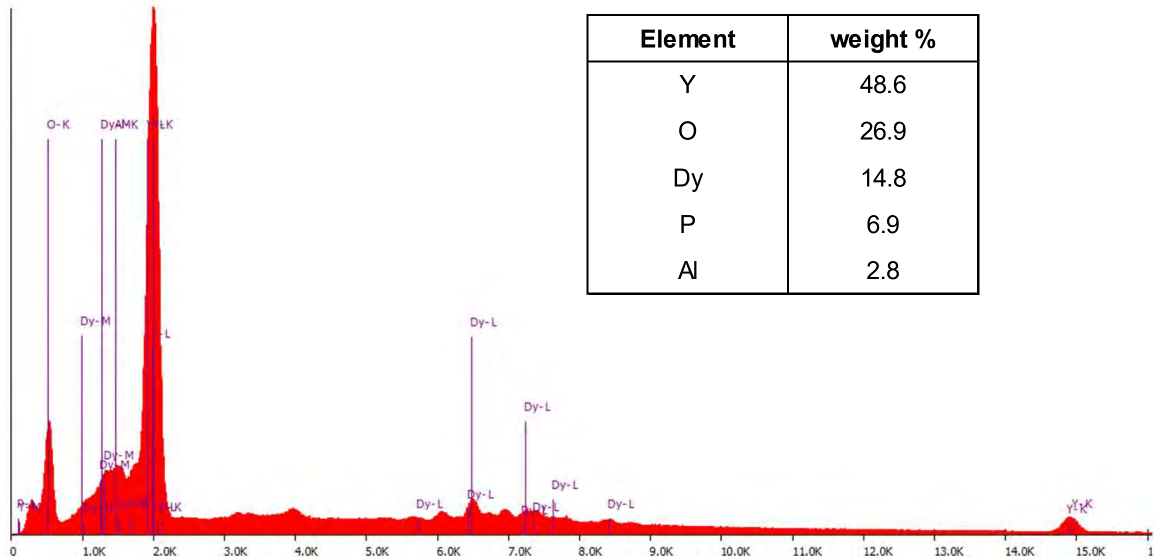


Element	weight %
Ce	30.7
O	27.1
La	14.5
P	12.9
Nd	11.7
Al	2.0
Ca	1.2

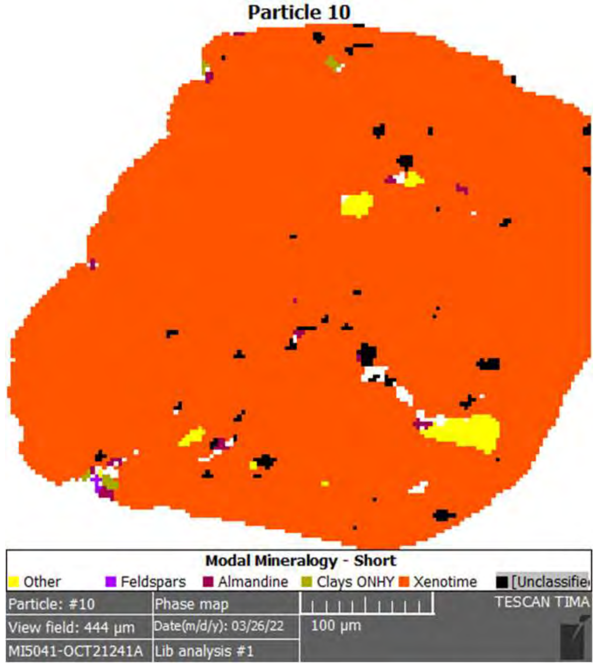


TIMA-X Analysis – Classification Scheme

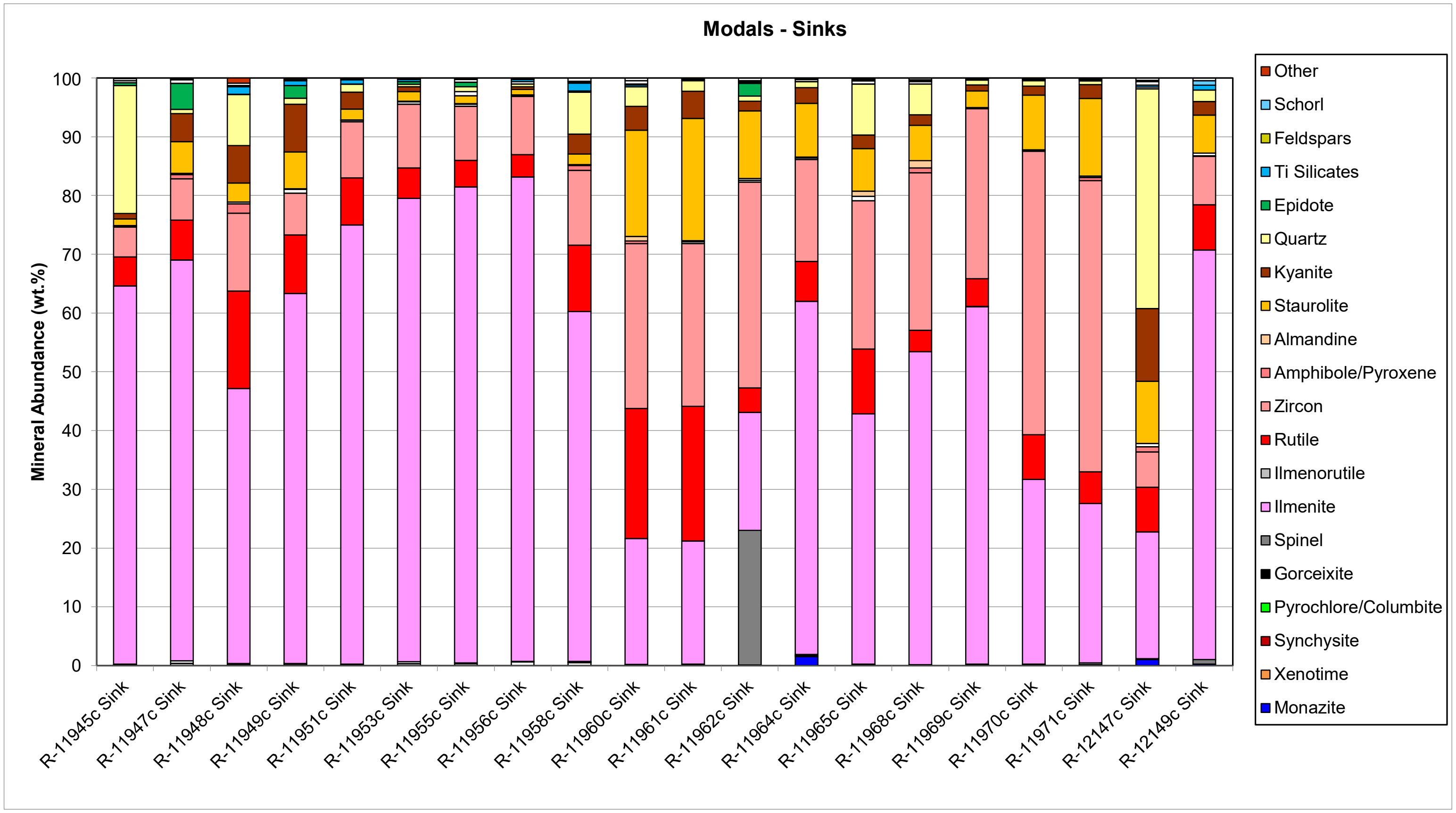
- Mineral identification is based on the X-rays



Element	weight %
Y	48.6
O	26.9
Dy	14.8
P	6.9
Al	2.8



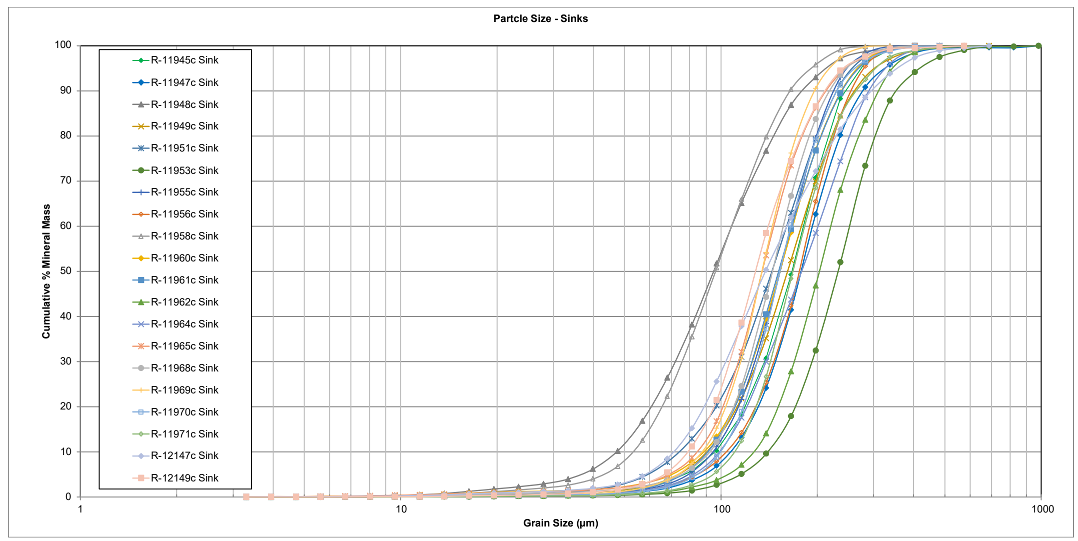
TIMA-X Analysis - Mineral mass% distribution



TIMA-X Analysis – Grain Size

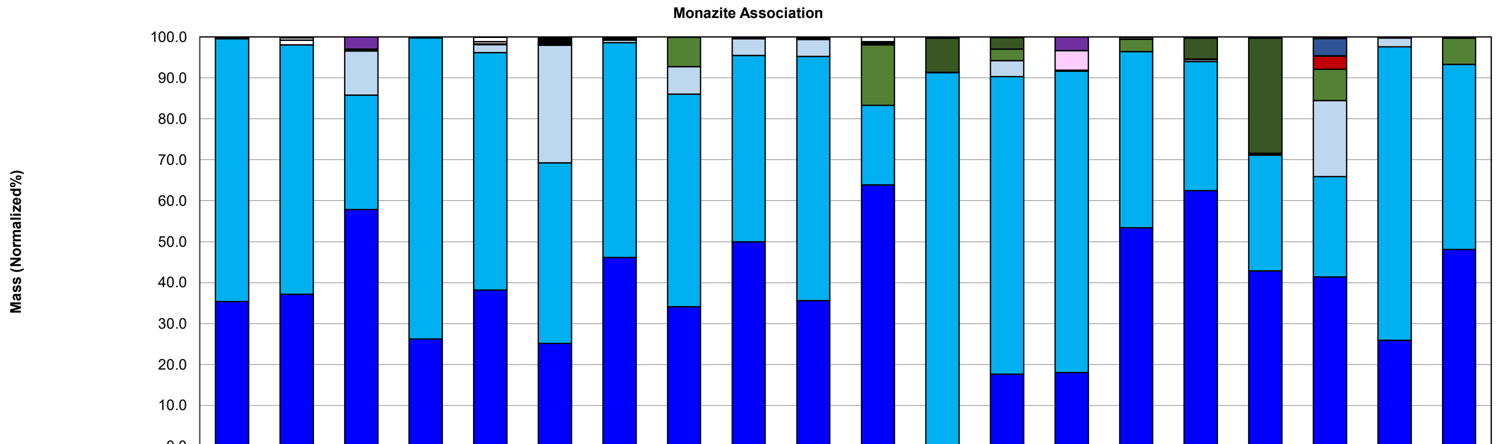
- The grain size report serves to study the distribution of the grain size of a specific phase, within the TIMA software; it is defined as equivalent circle diameter (*d*). It is the diameter of a circle that has the same area (*A*) as the particle (or grain). The diameter is defined in pixels and then multiplied by pixel spacing (*Ps*) to obtain size in micrometres. The precise definition is described in the following formula: $d = 2 \cdot \sqrt{A / \pi} \cdot Ps$.

Grain Size	Monazite	Xenotime	Pyrochlore/ Columbite	Ilmenite	Altered Ilmenite	Rutile	Pseudorutile	Zircon
R-11945c								
Median	136	7	3	169	165	145	8	160
P80	199	12	3	210	210	235	12	212
R-11947c								
Median	154	239	18	167	152	230	11	151
P80	222	239	18	212	205	230	16	202
R-11948c								
Median	62	45	8	92	83	72	12	74
P80	84	55	8	139	132	114	23	105
R-11949c								
Median	125	17	6	146	131	122	11	123
P80	144	29	6	191	180	185	16	182
R-11951c								
Median	117	69	8	134	98	93	11	116
P80	162	96	8	184	154	152	15	163
R-11953c								
Median	149	80	174	176	135	195	11	183
P80	380	80	174	226	207	303	16	246
R-11955c								
Median	127	103		145	124	115	11	139
P80	174	103		188	164	172	17	182
R-11956c								
Median	160	102	22	163	128	128	11	162
P80	204	102	22	209	183	208	16	208
R-11958c								
Median	74	59	13	96	69	70	11	82
P80	144	59	13	137	104	108	16	112
R-11960c								
Median	87	5	242	108	127	123	12	141
P80	113	5	242	154	166	162	49	181
R-11961c								
Median	107	17	7	121	131	122	10	141
P80	108	17	7	172	165	157	18	183



TIMA-X Analysis – Liberation and Association

- Indicates the liberation and association of the mineral of interest with other phases
- Data to be used for provenance and recovery potential

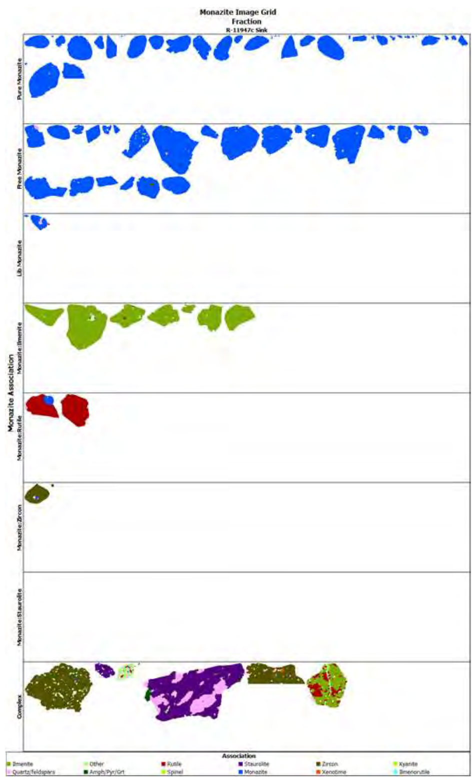


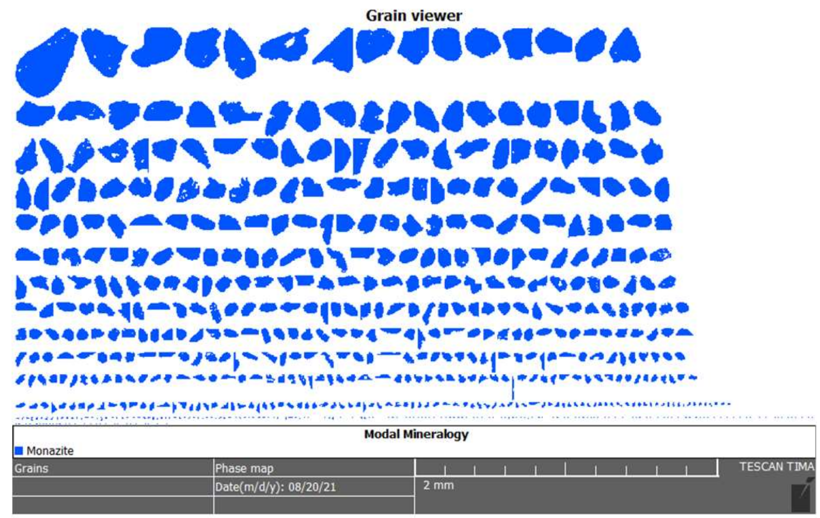
	R-11945c Sink	R-11947c Sink	R-11948c Sink	R-11949c Sink	R-11951c Sink	R-11953c Sink	R-11955c Sink	R-11956c Sink	R-11958c Sink	R-11960c Sink
Complex	0.25	0.10	2.93	0.15	0.06	0.06	0.03	0.03	0.11	0.15
Monazite:Other Minerals	0.01	0.02	0.28	0.00	1.07	0.00	0.18	0.00	0.20	0.00
Monazite:Quartz/Feldspars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monazite:Kyanite	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00
Monazite:Staurolite	0.07	0.00	0.00	0.03	0.00	1.93	0.36	0.01	0.00	0.40
Monazite:Amph/Pyr/Grt	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monazite:Zircon	0.01	0.06	0.04	0.00	0.06	0.02	0.01	0.01	0.00	0.00
Monazite:Rutile	0.00	0.55	0.00	0.02	0.00	0.00	0.01	0.01	0.00	0.03
Monazite:Ilmenorutile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monazite:Ilmenite	0.10	0.05	0.06	0.04	0.06	0.04	0.20	7.15	0.09	0.00
Monazite:Spinel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monazite:Pyrochlore/Columbite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monazite:Synchysite	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monazite:Xenotime	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Lib Monazite	0.00	1.14	10.75	0.00	2.00	28.7	0.55	6.72	4.12	4.15
Free Monazite	64.2	60.9	28.0	73.5	58.0	44.1	52.5	52.0	45.5	59.7
Pure Monazite	35.4	37.1	57.8	26.2	38.2	25.1	46.1	34.1	50.0	35.6

	R-11961c Sink	R-11962c Sink	R-11964c Sink	R-11965c Sink	R-11968c Sink	R-11969c Sink	R-11970c Sink	R-11971c Sink	R-12147c Sink	R-12149c Sink
Complex	1.19	0.10	0.05	3.29	0.09	0.01	0.10	0.00	0.19	0.12
Monazite:Other Minerals	0.04	0.00	0.00	0.00	0.39	0.00	0.06	0.00	0.02	0.00
Monazite:Quartz/Feldspars	0.00	0.00	0.00	4.77	0.00	0.00	0.00	0.00	0.00	0.00
Monazite:Kyanite	0.00	0.00	0.06	0.15	0.00	0.00	0.00	0.01	0.00	0.00
Monazite:Staurolite	0.63	0.22	0.00	0.13	0.00	0.00	0.15	0.34	0.00	0.00
Monazite:Amph/Pyr/Grt	0.00	0.00	0.00	0.00	0.00	0.26	0.00	4.21	0.00	0.00
Monazite:Zircon	0.03	8.31	2.86	0.00	0.02	5.08	28.07	0.11	0.03	0.00
Monazite:Rutile	0.00	0.02	0.00	0.00	0.04	0.00	0.00	3.22	0.00	0.16
Monazite:Ilmenorutile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monazite:Ilmenite	14.77	0.01	2.78	0.00	3.02	0.09	0.17	7.63	0.01	6.45
Monazite:Spinel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monazite:Pyrochlore/Columbite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monazite:Synchysite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monazite:Xenotime	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Lib Monazite	0.00	0.08	3.88	0.00	0.00	0.45	0.28	18.6	2.20	0.00
Free Monazite	19.5	91.2	72.7	73.7	43.0	31.6	28.3	24.6	71.7	45.2
Pure Monazite	63.9	0.1	17.6	18.0	53.4	62.4	42.8	41.4	25.9	48.1

TIMA-X Analysis – Particle Maps as a Function of Liberation and Association

- Graphical illustration of particle maps of the mineral association





- Granulated monazite grains irrespective of their occurrence

TIMA-X Analysis – Monazite Mass% as a Function of Size Class

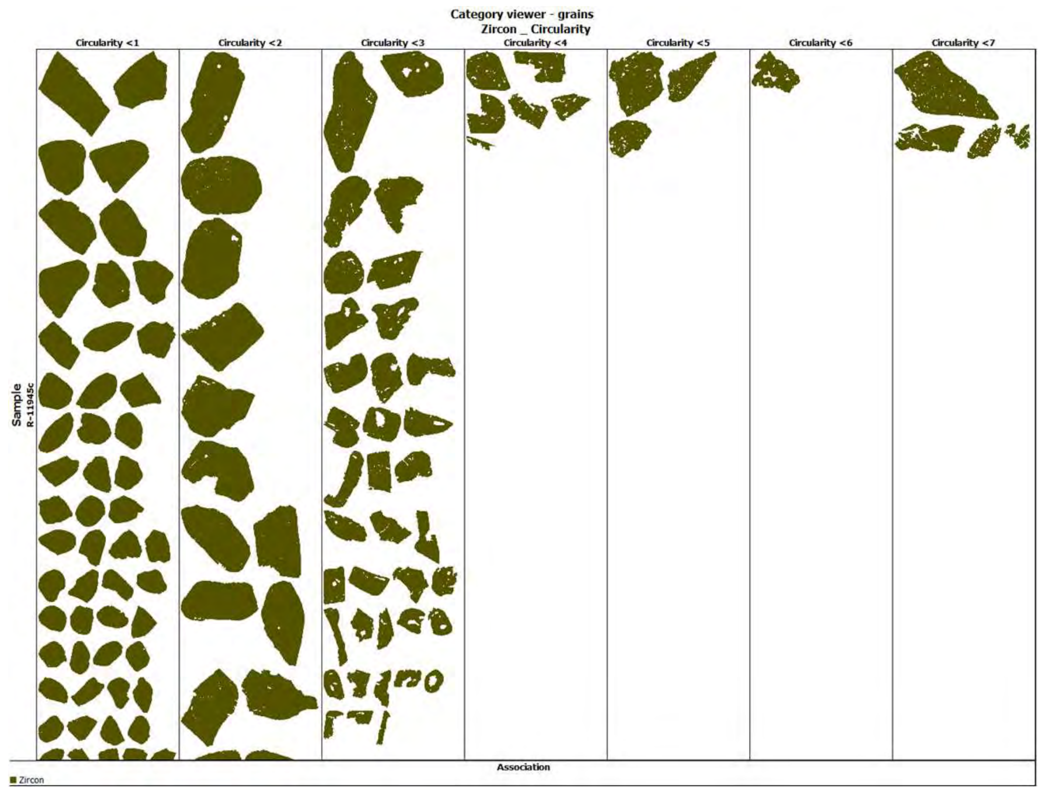
Size Monazite / Product	R-11945c Sink	R-11947c Sink	R-11948c Sink	R-11949c Sink	R-11951c Sink	R-11953c Sink	R-11955c Sink	R-11956c Sink	R-11958c Sink	R-11960c Sink	R-11961c Sink	R-11962c Sink	R-11964c Sink	R-11965c Sink	R-11968c Sink	R-11969c Sink	R-11970c Sink	R-11971c Sink	R-12147c Sink	R-12149c Sink
<=3um	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-5um	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0
5-10um	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.0	0.1
10-15um	0.1	0.1	0.7	0.0	0.1	0.1	0.1	0.0	0.2	0.2	0.6	0.1	0.0	0.0	0.3	0.2	0.0	0.4	0.1	0.1
15-20um	0.1	0.1	1.7	0.4	0.4	0.0	0.1	0.2	0.8	1.5	0.0	0.0	0.1	0.4	0.2	0.4	0.2	0.2	0.3	0.6
20-25um	0.2	0.2	4.0	0.3	0.9	0.0	0.4	0.0	1.4	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.3	0.5	0.3	0.4
25-30um	0.0	0.3	4.0	0.3	0.0	0.0	0.3	0.1	0.7	0.0	1.2	0.0	0.1	0.0	0.0	0.9	1.6	0.0	0.1	1.7
30-35um	0.0	0.1	1.7	0.0	0.3	0.0	0.0	0.0	0.6	0.0	1.4	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.3	0.0
35-40um	0.5	0.0	2.5	0.3	1.3	0.0	0.0	0.0	0.6	1.6	0.0	0.0	0.1	0.0	0.0	1.5	0.0	0.0	0.3	0.5
40-45um	0.0	0.5	6.5	0.8	0.7	0.0	0.6	0.0	3.6	2.2	0.0	0.0	0.2	0.0	0.0	1.8	0.0	0.6	0.2	1.3
45-50um	0.0	0.0	2.0	0.0	1.3	0.4	1.5	0.2	4.5	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.4	0.0
50-55um	1.2	0.4	6.8	0.6	0.8	0.0	0.9	0.4	3.8	6.8	0.0	0.0	0.1	3.4	0.0	0.0	2.2	0.0	0.3	0.9
55-60um	1.4	1.2	10.9	1.3	1.2	0.0	0.0	0.5	9.6	4.1	0.0	0.0	0.1	0.0	12.6	7.1	2.2	0.0	2.2	1.1
60-65um	0.0	0.5	6.6	0.9	3.5	0.8	0.7	0.0	1.9	5.1	0.0	0.0	0.1	0.0	10.7	0.0	6.2	0.0	3.8	1.5
65-70um	0.0	1.8	0.0	1.0	3.0	1.9	0.9	0.7	4.3	0.0	0.0	0.0	0.6	11.1	12.7	0.0	3.6	1.6	1.8	4.6
70-75um	2.0	0.7	4.7	0.0	1.7	1.0	1.0	1.7	17.5	13.3	0.0	2.7	0.8	12.4	0.0	14.0	0.0	1.8	1.5	3.7
>75um	94.5	94.2	47.6	94.0	84.6	95.8	93.5	96.1	50.6	63.0	96.5	97.1	97.7	72.7	63.2	73.7	81.0	94.0	88.4	83.3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

TIMA-X Analysis – Number of Monazite Grains as a Function of Size Class

Size Monazite / Product	R-11945c Sink	R-11947c Sink	R-11948c Sink	R-11949c Sink	R-11951c Sink	R-11953c Sink	R-11955c Sink	R-11956c Sink	R-11958c Sink	R-11960c Sink	R-11961c Sink	R-11962c Sink	R-11964c Sink	R-11965c Sink	R-11968c Sink	R-11969c Sink	R-11970c Sink	R-11971c Sink	R-12147c Sink	R-12149c Sink
<=3um	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3-5um	3	5	2	4	3	1	1	3	0	5	4	10	16	0	6	6	8	13	13	5
5-10um	1	4	4	4	3	1	0	1	2	0	2	2	4	1	4	2	0	5	7	7
10-15um	2	5	6	0	2	4	3	2	2	1	3	1	3	0	4	4	0	9	8	2
15-20um	1	3	7	6	4	0	1	7	5	4	0	0	8	1	1	3	1	2	10	5
20-25um	1	4	9	3	5	0	4	1	6	0	0	0	5	0	0	1	1	3	6	2
25-30um	0	3	6	2	0	0	3	1	2	0	1	0	3	0	0	3	3	0	1	6
30-35um	0	1	3	0	1	0	0	0	1	0	1	0	1	0	0	0	3	0	3	0
35-40um	1	0	2	1	3	0	0	0	1	1	0	0	3	0	0	2	0	0	2	1
40-45um	0	2	5	2	2	0	2	0	4	1	0	0	3	0	0	2	0	1	1	2
45-50um	0	0	1	0	2	1	4	1	6	1	0	0	0	0	0	0	0	1	2	1
50-55um	2	1	3	1	1	0	2	2	3	2	0	0	2	1	0	0	1	0	1	1
55-60um	1	3	4	2	1	0	0	2	7	1	0	1	1	0	4	4	1	0	7	1
60-65um	0	1	2	1	4	1	1	0	1	1	0	0	1	0	4	0	2	0	10	1
65-70um	0	4	0	2	3	2	1	3	2	0	0	0	5	2	3	0	1	1	4	3
70-75um	1	1	1	0	1	1	2	4	7	2	0	1	6	2	0	5	0	1	3	2
>75um	31	51	14	43	28	33	39	64	17	9	18	14	152	10	12	19	18	35	59	28
Total	**44**	**88**	**69**	**71**	**63**	**44**	**63**	**91**	**66**	**28**	**29**	**29**	**213**	**17**	**38**	**51**	**39**	**71**	**137**	**67**

TIMA-X Analysis – Particle Classification

- It is possible to construct any expression using arithmetic operators. In this example, a category containing zircon grains with circularity is defined as second power of perimeter divided by 4* π * Area
- [(perimeter() ^ 2) / (4 * 3.14159 * area_µm()) <1-7)].

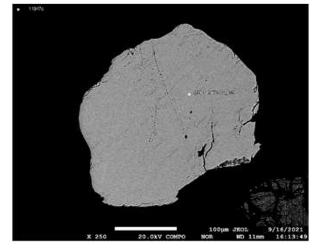


Mineral Chemistry by EPMA

- EPMA - Xenotime

SAMPLE	ThO2	UO2	P2O5	Y2O3	Ce2O3	La2O3	Pr2O3	Nd2O3	Sm2O3	SiO2	Gd2O3	Tb2O3	Er2O3	Dy2O3	CaO	TOTAL
R-11964c Xenotime_002	0.46	0.00	34.78	48.37	0.09	0.00	0.04	0.00	0.16	0.17	1.42	0.28	3.67	3.49	0.17	93.10
R-11964c Xenotime_003	0.12	0.17	32.90	41.20	0.14	0.19	0.04	0.31	0.59	0.00	2.13	0.46	4.29	3.62	0.03	86.20
R-11964c Xenotime_003	1.17	3.08	31.38	39.43	0.21	0.00	0.06	0.30	0.62	0.85	1.96	0.42	3.97	3.14	0.09	86.68
R-11964c Xenotime_004	0.50	1.01	32.59	41.35	0.00	0.00	0.10	0.34	0.40	0.21	1.68	0.49	4.31	3.44	0.05	86.48
R-11964c Xenotime_004	0.99	2.20	31.58	39.88	0.06	0.03	0.00	0.31	0.55	0.55	1.66	0.41	4.37	2.99	0.02	85.60
R-11964c Xenotime_004	1.31	2.91	30.41	38.70	0.00	0.00	0.00	0.33	0.57	0.84	1.68	0.33	4.16	2.97	0.04	84.25
R-11964c Xenotime_005	0.12	0.00	33.35	43.65	0.00	0.00	0.00	0.29	0.53	0.00	1.80	0.33	4.58	3.37	0.00	88.04
R-11964c Xenotime_005	1.34	1.99	31.98	41.13	0.09	0.00	0.00	0.29	0.48	0.73	1.98	0.42	4.23	3.65	0.02	88.34
R-11964c Xenotime_006	0.11	0.15	32.60	40.81	0.07	0.00	0.12	0.34	0.57	0.00	1.98	0.46	4.49	3.56	0.00	85.27
R-11964c Xenotime_006	0.43	2.03	31.89	39.49	0.04	0.01	0.07	0.43	0.65	0.35	2.05	0.56	4.24	3.59	0.16	85.99
R-11964c Xenotime_006	0.82	4.12	31.32	38.08	0.03	0.20	0.00	0.44	0.66	0.96	1.98	0.50	4.17	3.51	0.15	86.96
R-11964c Xenotime_007	0.09	0.00	33.69	44.71	0.07	0.06	0.03	0.07	0.10	0.05	1.05	0.36	4.40	3.49	0.00	88.18
R-11964c Xenotime_007	0.39	1.52	32.27	40.81	0.08	0.09	0.04	0.36	0.60	0.32	1.92	0.57	4.58	3.72	0.06	87.33
R-11964c Xenotime_008	0.19	0.00	33.68	43.20	0.00	0.00	0.02	0.31	0.54	0.00	1.88	0.48	4.46	4.00	0.03	88.79
R-11964c Xenotime_008	0.28	1.20	32.93	41.16	0.21	0.04	0.13	0.25	0.68	0.24	1.96	0.53	4.02	4.21	0.08	87.93
R-11964c Xenotime_009	0.66	0.91	32.90	41.86	0.00	0.10	0.06	0.28	0.58	0.29	1.73	0.43	4.36	3.46	0.03	87.66
R-11964c Xenotime_009	1.65	3.95	30.80	39.72	0.00	0.00	0.00	0.36	0.52	1.32	1.68	0.45	4.09	3.44	0.05	88.04
Average	0.63	1.49	32.42	41.39	0.06	0.04	0.04	0.29	0.52	0.40	1.80	0.44	4.26	3.51	0.06	87.34
Maximum	1.65	4.12	34.78	48.37	0.21	0.20	0.13	0.44	0.68	1.32	2.13	0.57	4.58	4.21	0.17	93.10
Minimum	0.09	0.00	30.41	38.08	0.00	0.00	0.00	0.00	0.10	0.00	1.05	0.28	3.67	2.97	0.00	84.25
Std. Dev.	0.50	1.41	1.13	2.50	0.07	0.07	0.04	0.11	0.16	0.40	0.26	0.08	0.24	0.31	0.05	1.93

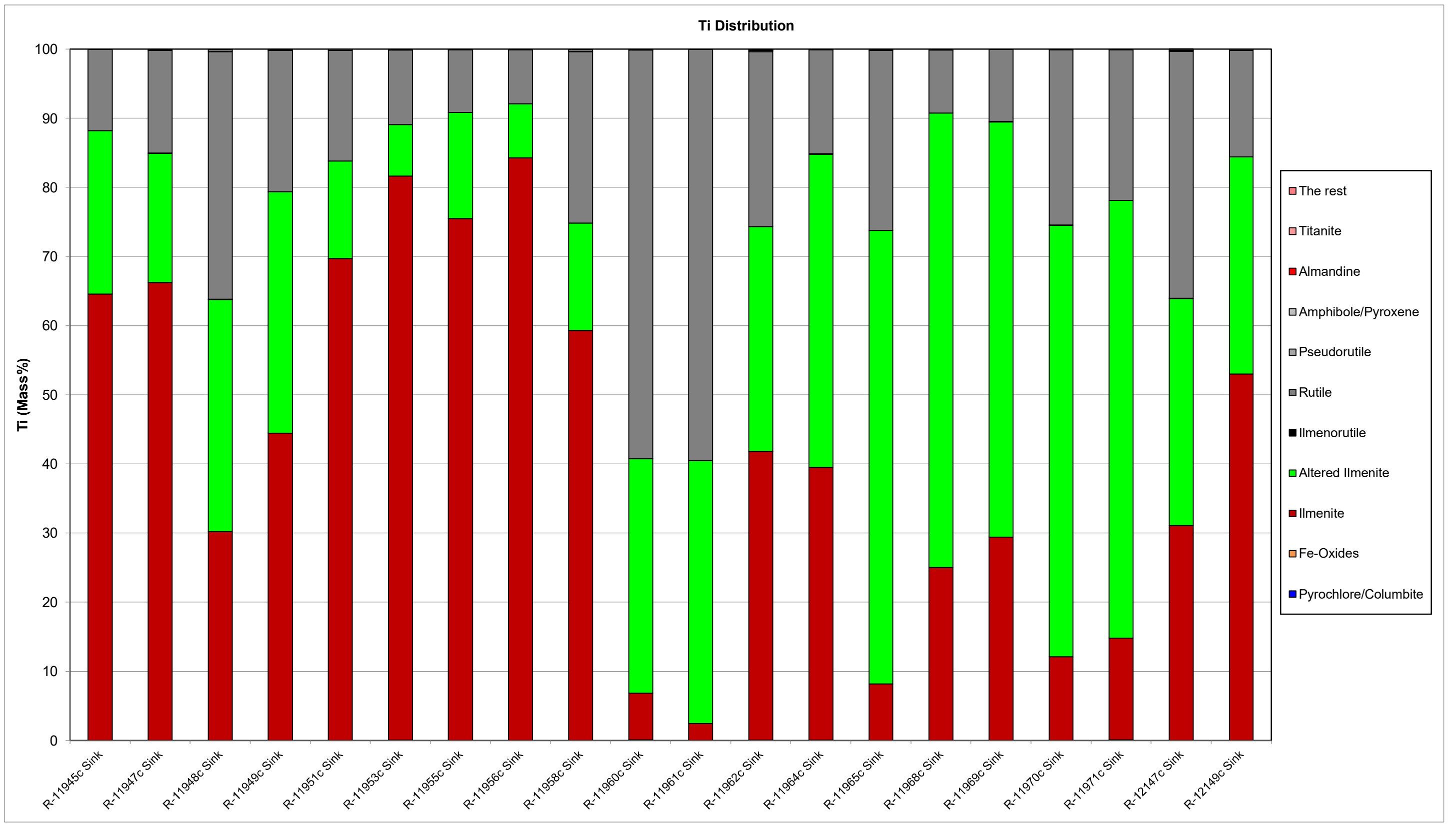
Mineral Chemistry by EPMA



- EPMA - Monazite

Sample	Oxide		ThO2	UO2	P2O5	Y2O3	Ce2O3	La2O3	Pr2O3	Nd2O3	Sm2O3	SiO2	Gd2O3	Tb2O3	Er2O3	Dy2O3	CaO
	n=172	LOD	0.119	0.170	0.043	0.059	0.147	0.177	0.145	0.083	0.079	0.029	0.098	0.102	0.069	0.132	0.020
R-11947c	n=25	Average	6.26	0.18	29.46	1.22	27.79	13.45	3.06	11.94	1.96	0.52	1.24	0.07	0.09	0.32	1.11
		Maximum	11.27	1.85	30.52	2.91	30.47	16.48	3.47	14.01	2.46	1.98	1.89	0.18	0.29	0.74	1.92
		Minimum	0.69	-	27.18	0.08	25.66	11.50	2.77	10.74	1.25	0.03	0.55	-	-	-	0.56
		Std. Dev.	2.85	0.47	0.81	0.86	1.44	1.23	0.20	0.88	0.32	0.50	0.37	0.06	0.07	0.24	0.37
R-11955c	n=27	Average	8.23	0.20	28.54	1.01	27.38	13.25	2.96	11.52	1.88	1.12	1.18	0.05	0.07	0.23	1.03
		Maximum	19.34	1.27	30.20	2.76	30.79	16.72	3.37	14.00	2.59	3.78	2.12	0.19	0.21	0.57	2.40
		Minimum	3.01	-	24.37	0.15	20.39	9.61	2.51	9.23	1.09	0.07	0.41	-	-	-	0.40
		Std. Dev.	4.73	0.32	1.72	0.67	2.56	1.91	0.25	1.31	0.45	1.10	0.42	0.05	0.05	0.17	0.43
R-11956	n=32	Average	5.67	0.06	29.39	0.85	28.72	13.57	3.16	12.54	1.93	0.56	1.12	0.06	0.06	0.22	0.86
		Maximum	12.33	0.46	30.55	3.99	34.09	16.25	3.74	15.61	2.87	2.25	1.92	0.21	0.33	0.86	1.29
		Minimum	1.78	-	26.96	-	25.60	10.11	2.88	11.09	1.16	0.12	0.45	-	-	-	0.21
		Std. Dev.	2.18	0.13	0.86	0.89	1.63	1.53	0.19	1.13	0.43	0.52	0.44	0.06	0.07	0.21	0.24
R-11958c	n=24	Average	5.92	0.32	29.01	1.64	27.36	12.59	3.11	12.44	2.26	0.77	1.56	0.09	0.10	0.46	0.84
		Maximum	16.80	1.15	30.54	3.17	31.80	16.51	3.94	16.08	3.76	4.18	3.01	0.22	0.23	0.92	1.71
		Minimum	0.49	-	23.87	0.11	21.48	9.21	2.62	9.87	1.35	0.03	0.79	-	-	0.09	0.16
		Std. Dev.	4.77	0.38	1.88	1.00	2.58	2.01	0.33	1.47	0.49	1.24	0.50	0.07	0.06	0.25	0.43
R-11964c	n=35	Average	6.75	0.17	29.17	1.83	27.93	13.71	2.89	10.90	1.77	0.82	1.16	0.07	0.13	0.42	0.91
		Maximum	12.44	1.04	30.52	3.10	31.19	16.65	3.29	12.78	2.45	2.04	2.00	0.16	0.30	0.71	1.43
		Minimum	2.67	-	27.15	0.29	24.32	10.93	2.51	9.44	1.37	0.06	0.74	0.00	-	-	0.47
		Std. Dev.	2.27	0.25	0.89	0.64	1.71	1.17	0.21	0.85	0.27	0.51	0.29	0.05	0.06	0.17	0.29
R-12147c	n=29	Average	7.98	0.18	28.97	1.57	27.06	13.58	2.84	10.76	1.85	0.93	1.17	0.07	0.11	0.39	1.10
		Maximum	19.09	0.87	30.48	3.79	30.08	15.99	3.39	13.09	2.97	3.95	2.32	0.20	0.28	1.06	1.70
		Minimum	3.55	-	24.18	0.16	23.33	10.10	2.26	7.75	1.12	0.13	0.49	-	-	-	0.52
		Std. Dev.	3.01	0.23	1.32	1.04	1.97	1.62	0.24	1.22	0.49	0.82	0.50	0.05	0.08	0.27	0.32

Elemental Deportment – a Function of the Mass and Mineral Chemistry



Why TIMA-X and Automated Mineralogy

- TIMA-X is the latest state of the art mineralogical tool in the mining industry
  - Powerful software
  - Continuous development
- Automated mineralogy can provide quantitative mineralogical parameters
  - Mineral identification - especially REE minerals to define xenotime, monazite
  - liberation, association, exposure – provide limitations to mineral processing
  - grain size, shape factors - can be used for provenance evaluations
  - elemental distribution
  - EPMA – compare the chemistry of the minerals across samples with the source rocks
  - LA-ICP-MS - additional information on trace elements for minerals, e.g., zircon
  - It can explain the geochemical trends and elemental associations (Y-Th-P-REE), and thus avoid assumptions because ores are multi element systems, especially complicated for REE.

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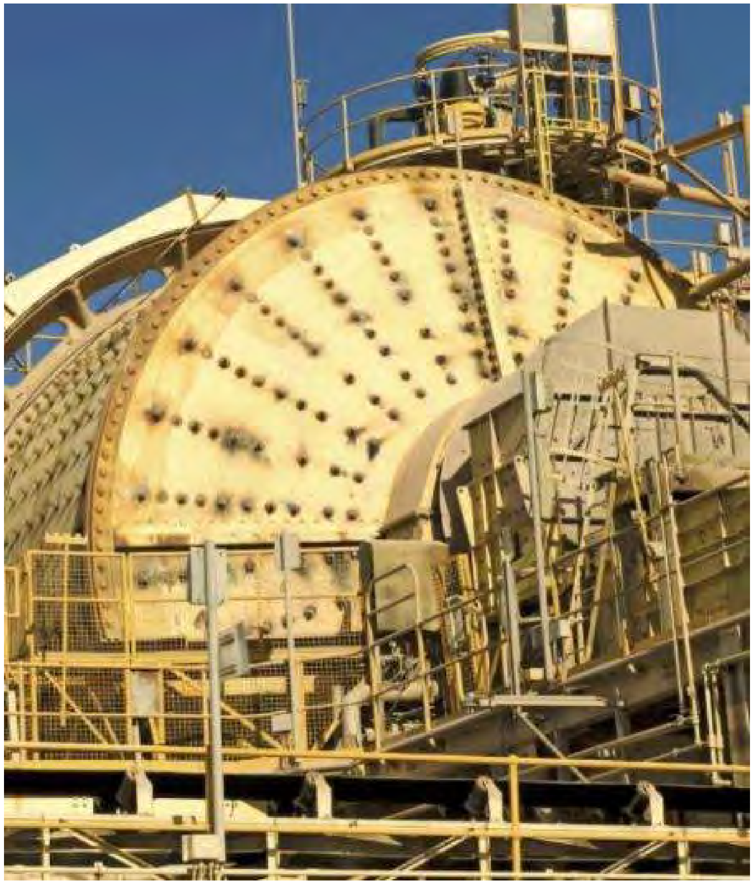

Thank you!

Do you have any questions?

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Session 5: Advanced technologies for heavy minerals identification, assessment, and monitoring

SHAH, A.K. – Geophysical approaches to imaging heavy mineral sand content in offshore environments (AShah.pdf)

Marine heavy mineral sands: Geophysical Approaches

Anji Shah, USGS

USGS
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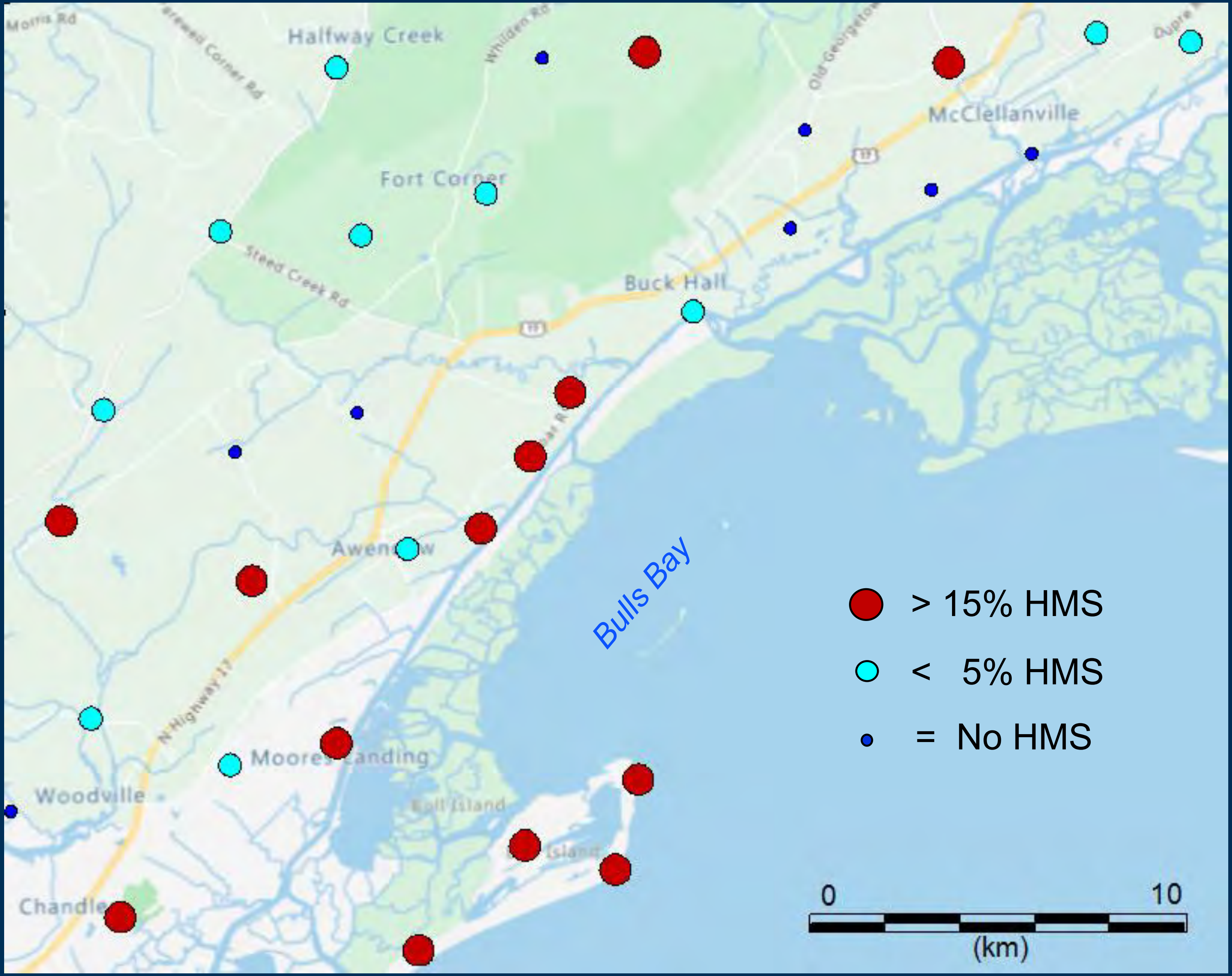
U.S. Department of the Interior
U.S. Geological Survey

Why Geophysics?

Example from onshore South Carolina

- **Auger sample data collected by R. Weems over several decades**



Preliminary information-subject to revision. Not for citation or distribution.

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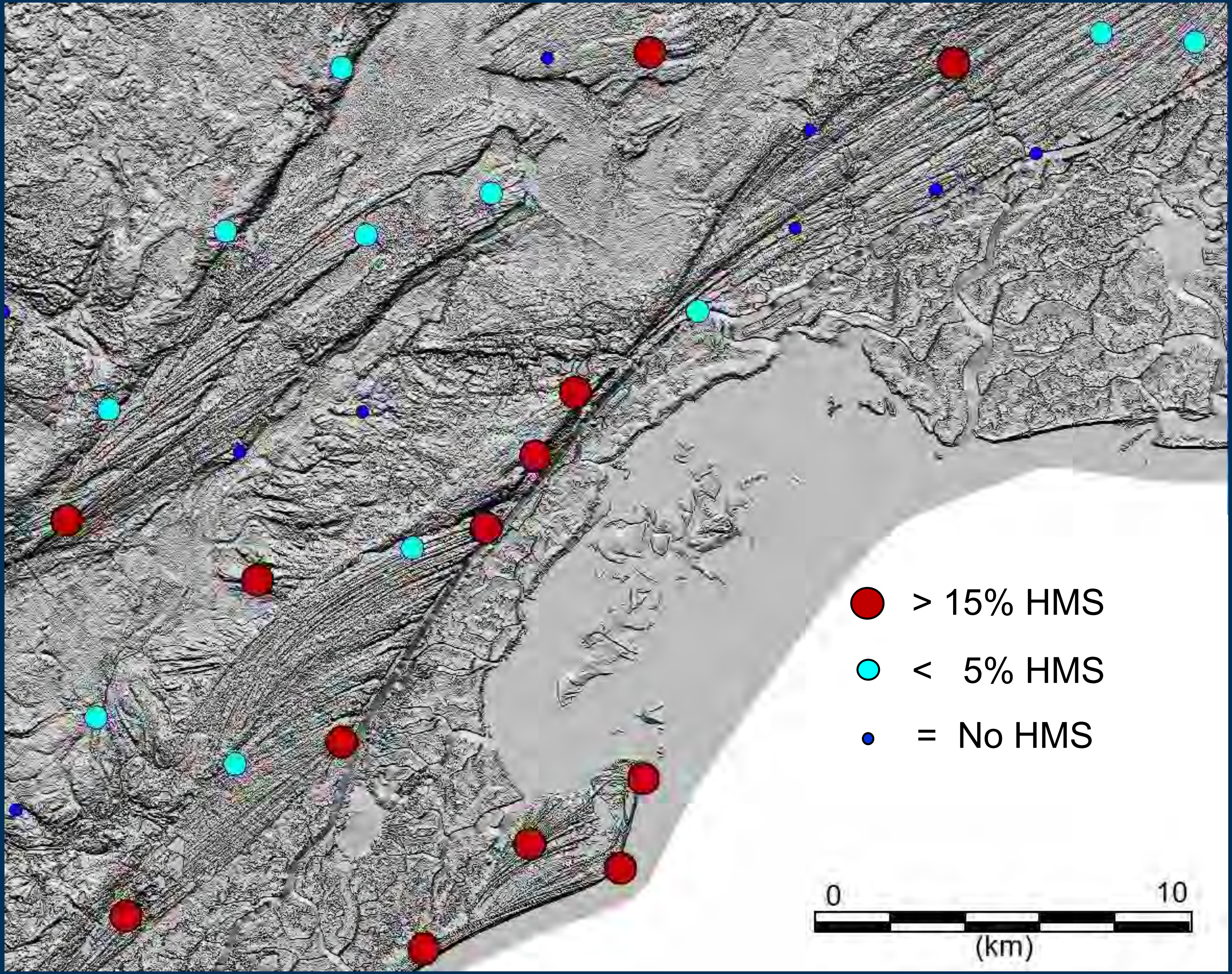
Why Geophysics?

Example from onshore South Carolina

- **Auger sample data collected by R. Weems over several decades**
- **Lidar: analogous to sidescan sonar; provides grain size information**
  HMS are in sands



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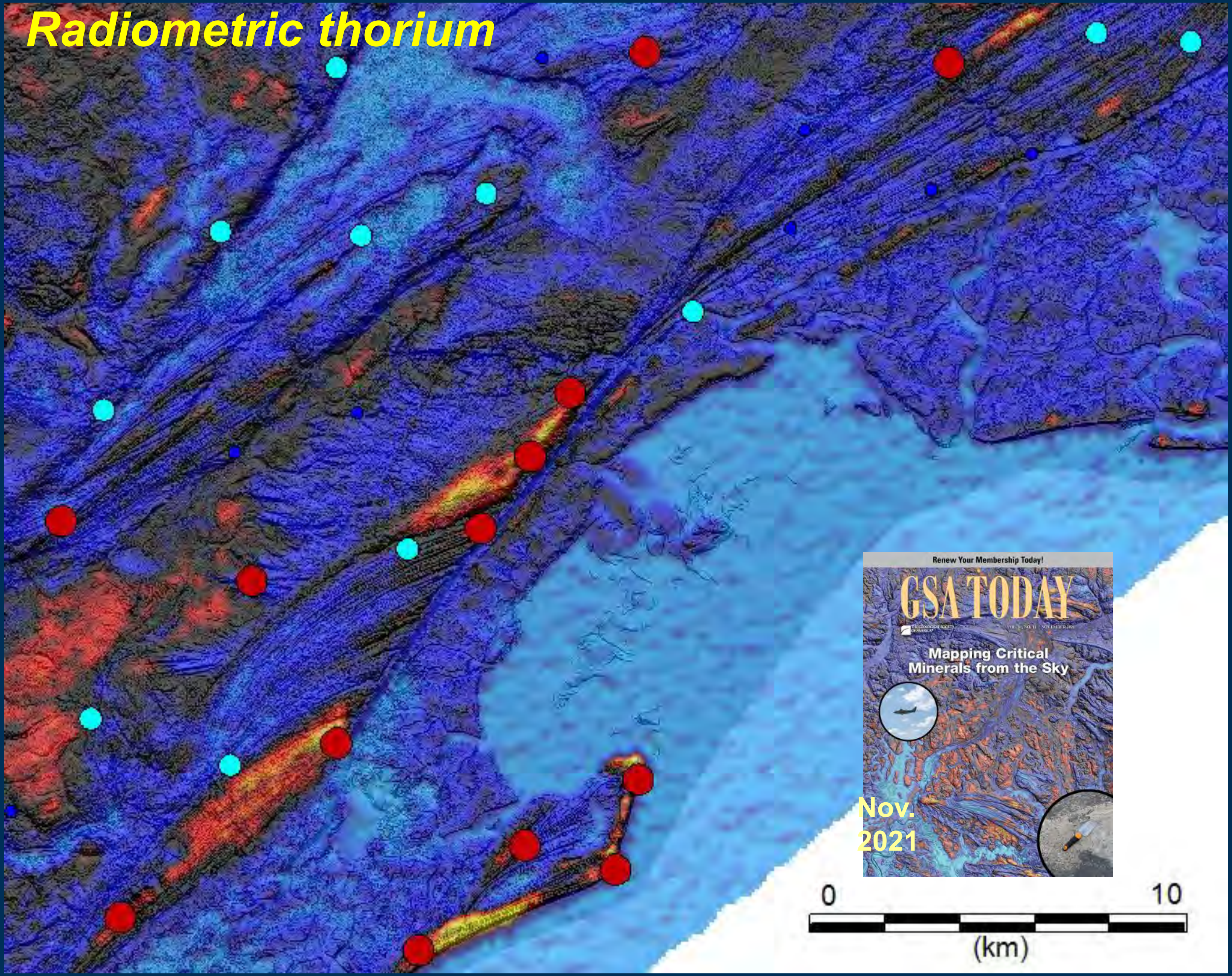
Why Geophysics?

Example from onshore South Carolina

- **Auger sample data collected by R. Weems over several decades**
- **Lidar: analogous to sidescan sonar; provides grain size information**
  HMS are in sands
- **Radiometric data: (2019 airborne survey) Th monazite reflects compositional variation**
  HMS are in areas heavily reworked



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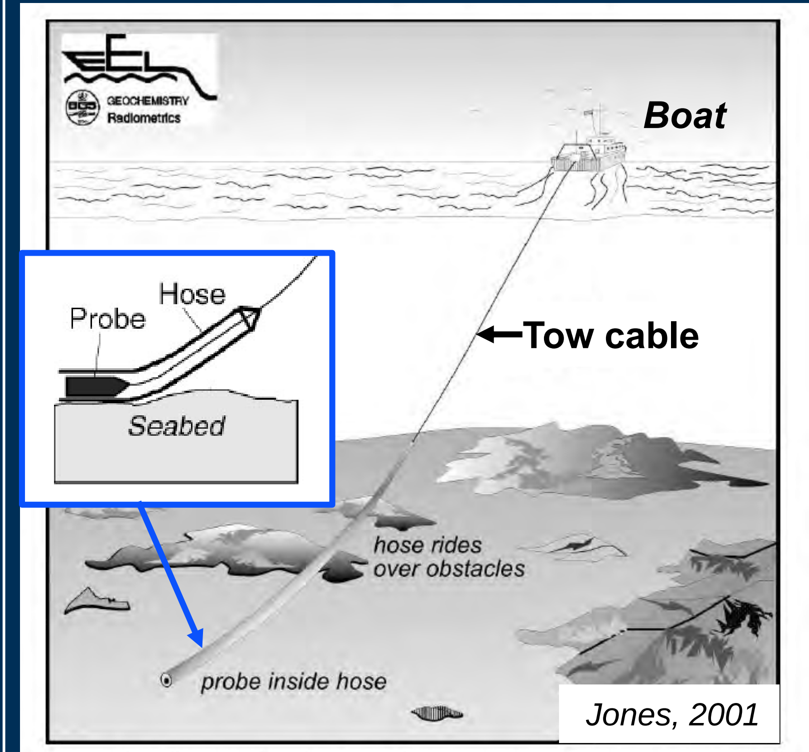
Radiometric Methods

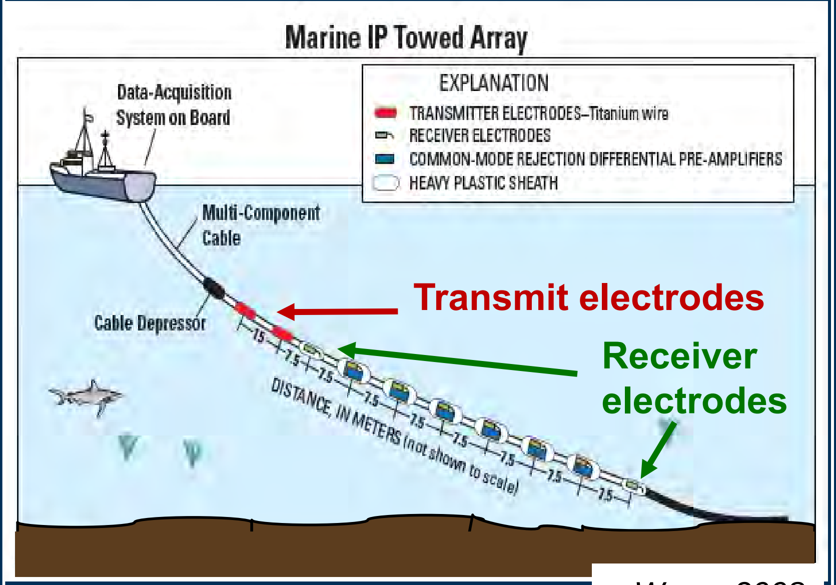
- *Gamma spec: K, U, Th*
- *Sensor must maintain contact with the seafloor*
- *Tow speed ~4 kts (up to 10 kts)*
- *Excellent likelihood of detection*
- *Operate with care*



Jones, 2001

Electrical Methods (IP)

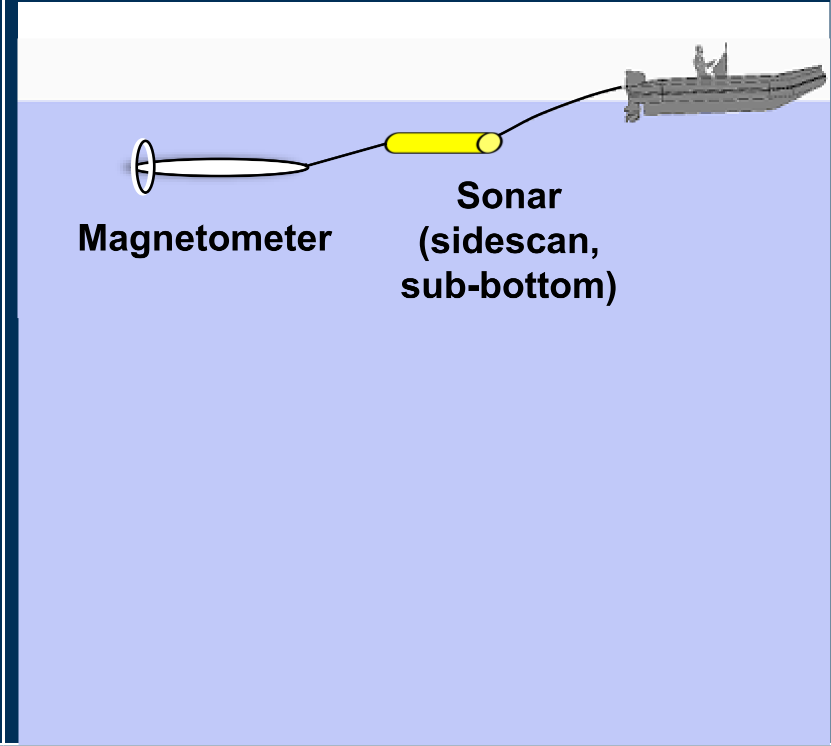
- *Electrical properties*
- *Sensor must maintain contact with the seafloor*
- *Tow speed ~3 kts*
- *Good detection, noise an issue*
- *Operate with care*



Wynn, 2008

Magnetic Methods

- *Magnetic minerals*
- *Sensor towed behind the boat; often in tandem with sonar*
- *Tow speed ~8 kts (up to 10 kts)*
- *Need to check mineralogy*
- *Need calmer waters, steady speed*



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Offshore methods

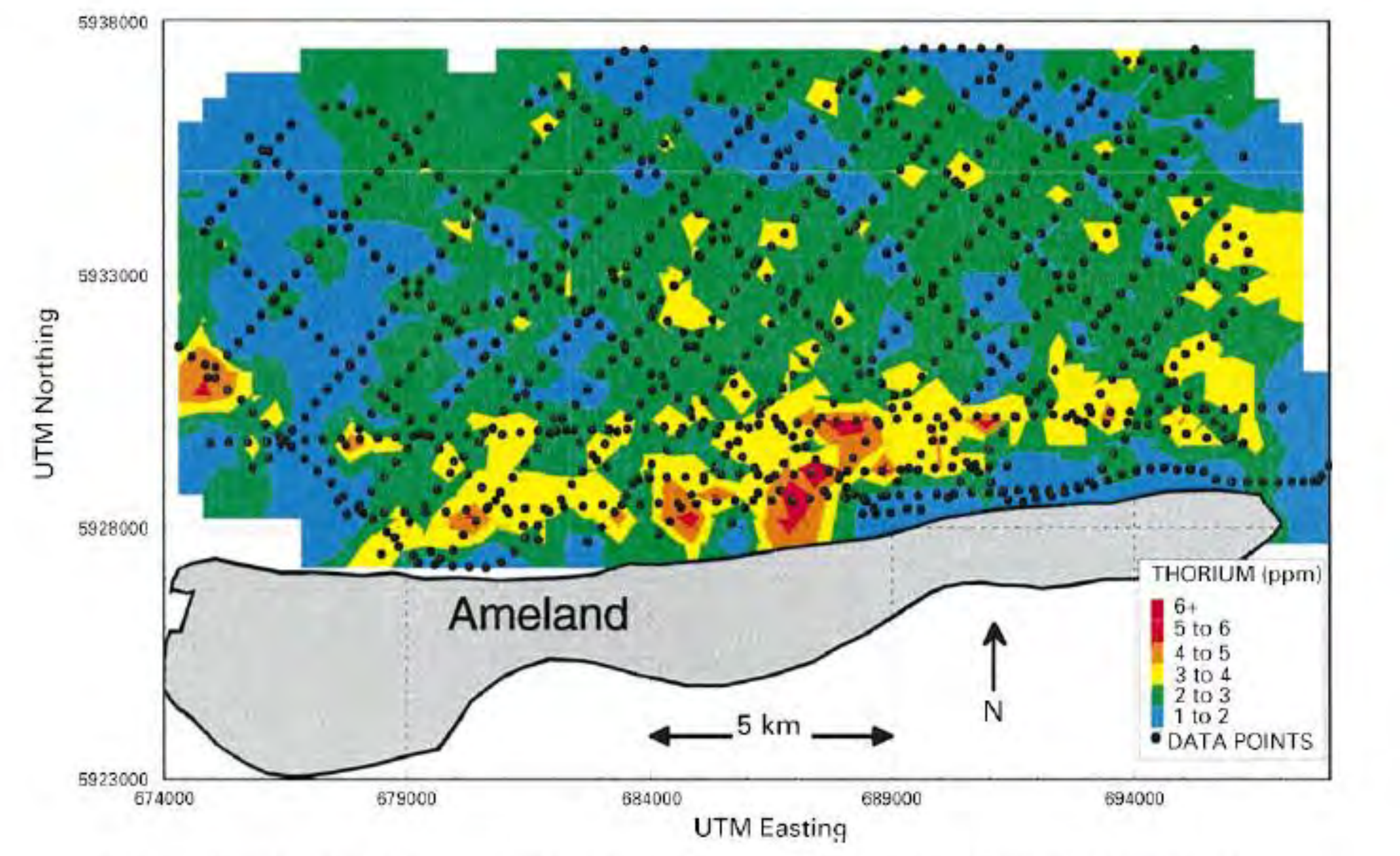
Preliminary information-subject to revision. Not for citation or distribution.

Radiometric methods

Shallow water: Small boat (to 5 m depth); winch needed for deeper areas

Surveys have been conducted in up to 1600 m depth

Thorium measured off of Ameland in the Dutch Frisian Islands; Higher Th corresponds to heavy mineral sands containing monazite. Method "sees" the upper 50 cm



Jones, J. Environ Radioactivity, 2001

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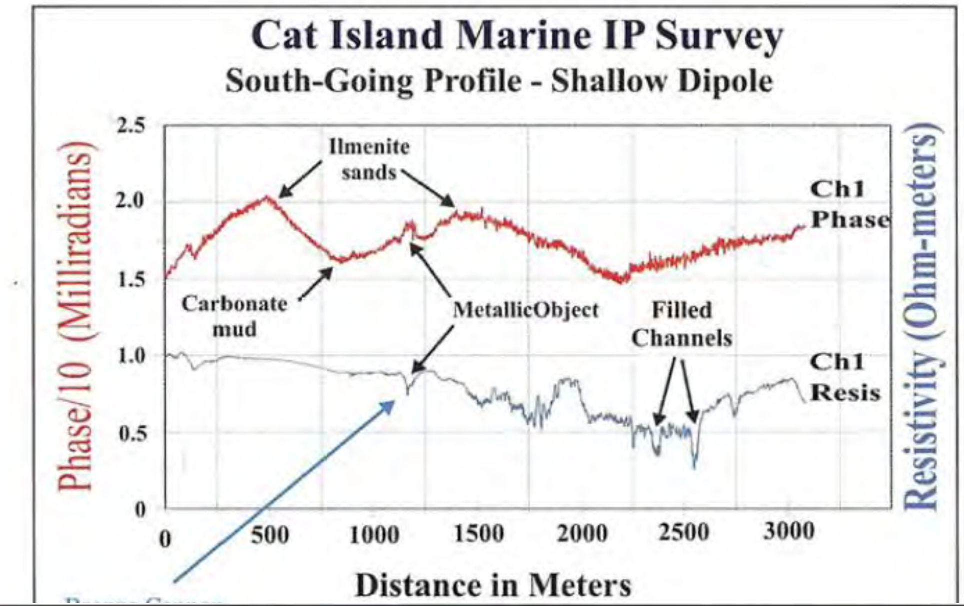
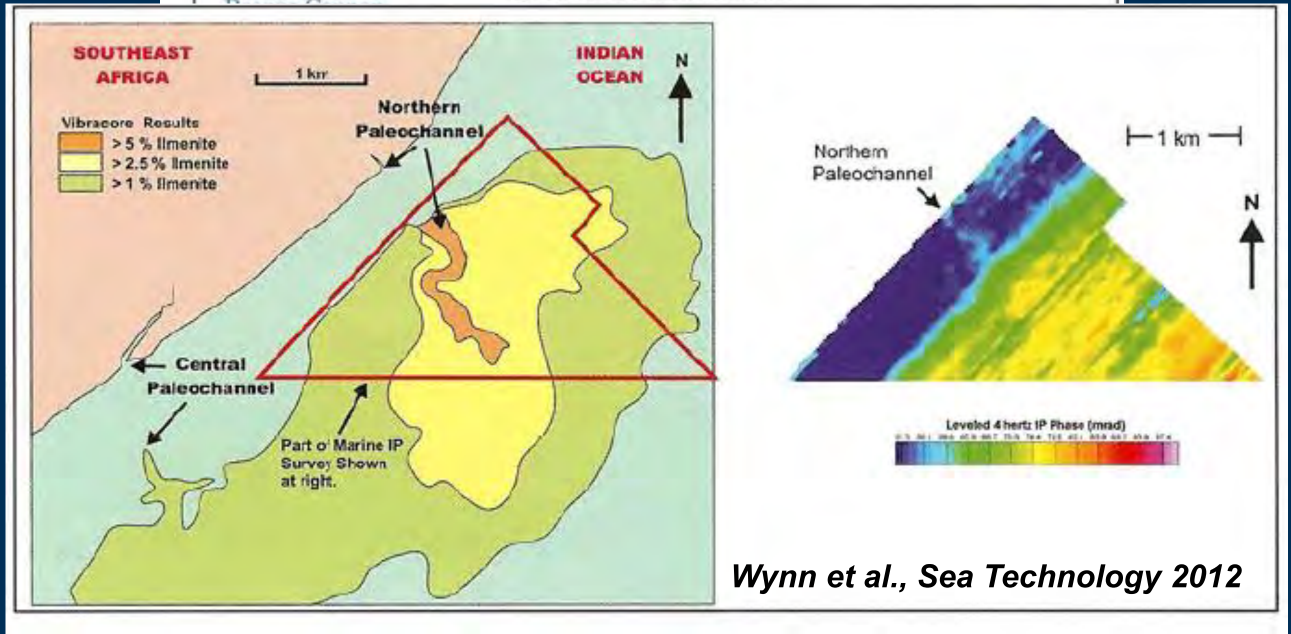
Preliminary information-subject to revision. Not for citation or distribution.

Electrical methods *(USGS)*

Phase changes (transmit vs received) respond to ilmenite. Resistivity may respond to manmade objects. Noise can be an issue.

Active signal needed. System is generally used with a larger boat to manage cables





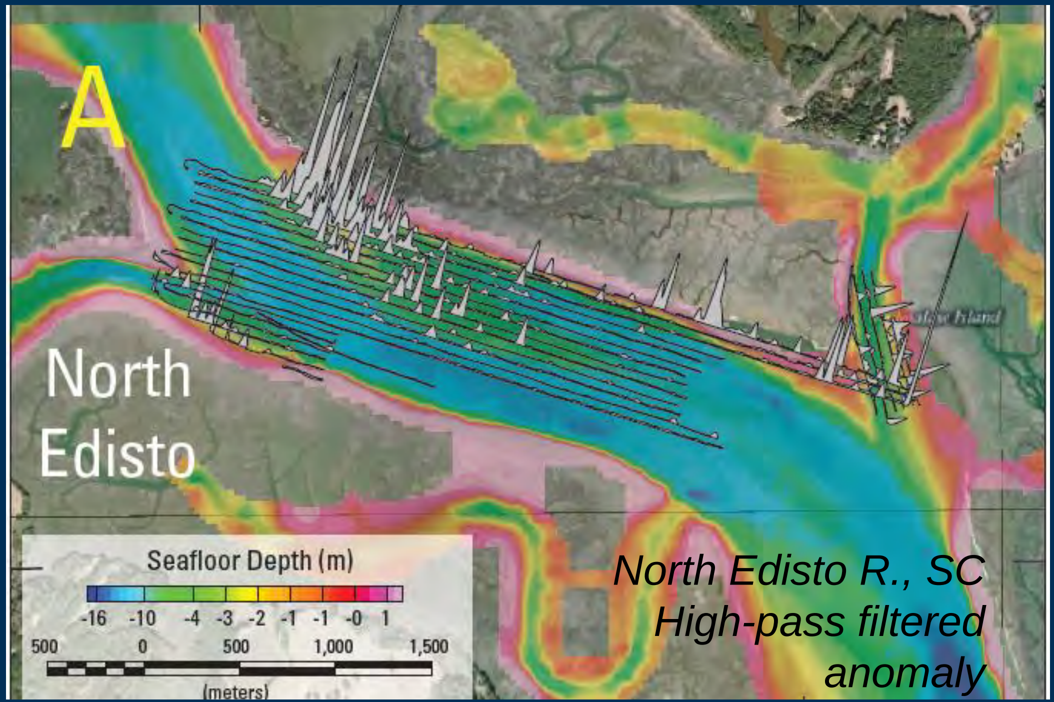
Wynn et al., Sea Technology 2012

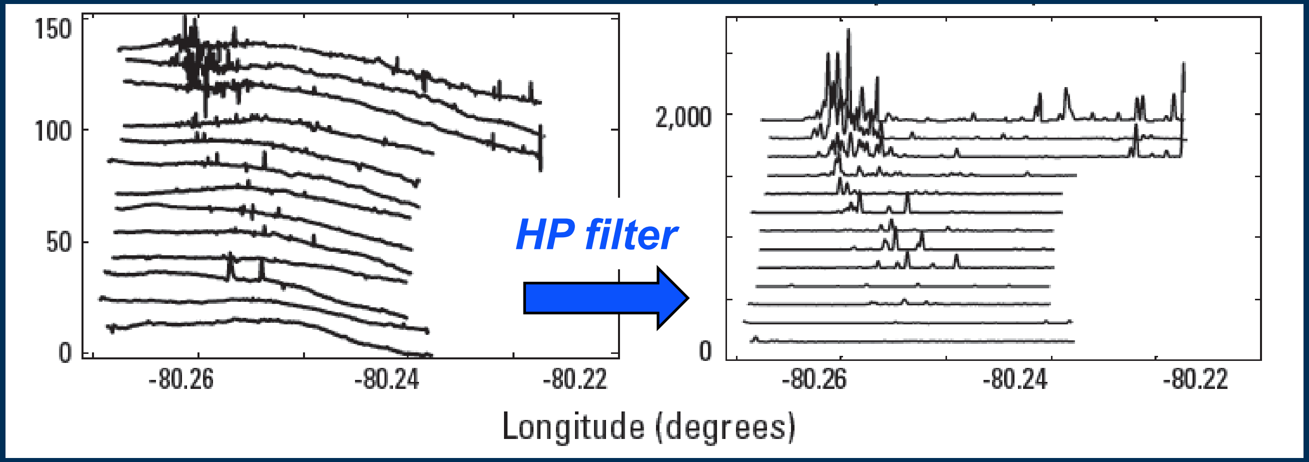
Magnetic methods *(Many systems available)*

Filtered magnetic field responds to magnetite, maghemite, hematite, but also glauconite.

Can be used at any water depth; the closer sensor is to the seafloor, the better the detection (attenuation). Sensor motion can introduce noise.

Longer wavelengths represent the basement, shorter wavelengths represent sources in sediments; filtering needed.





Shah and Harris, OFR 1112 2012;

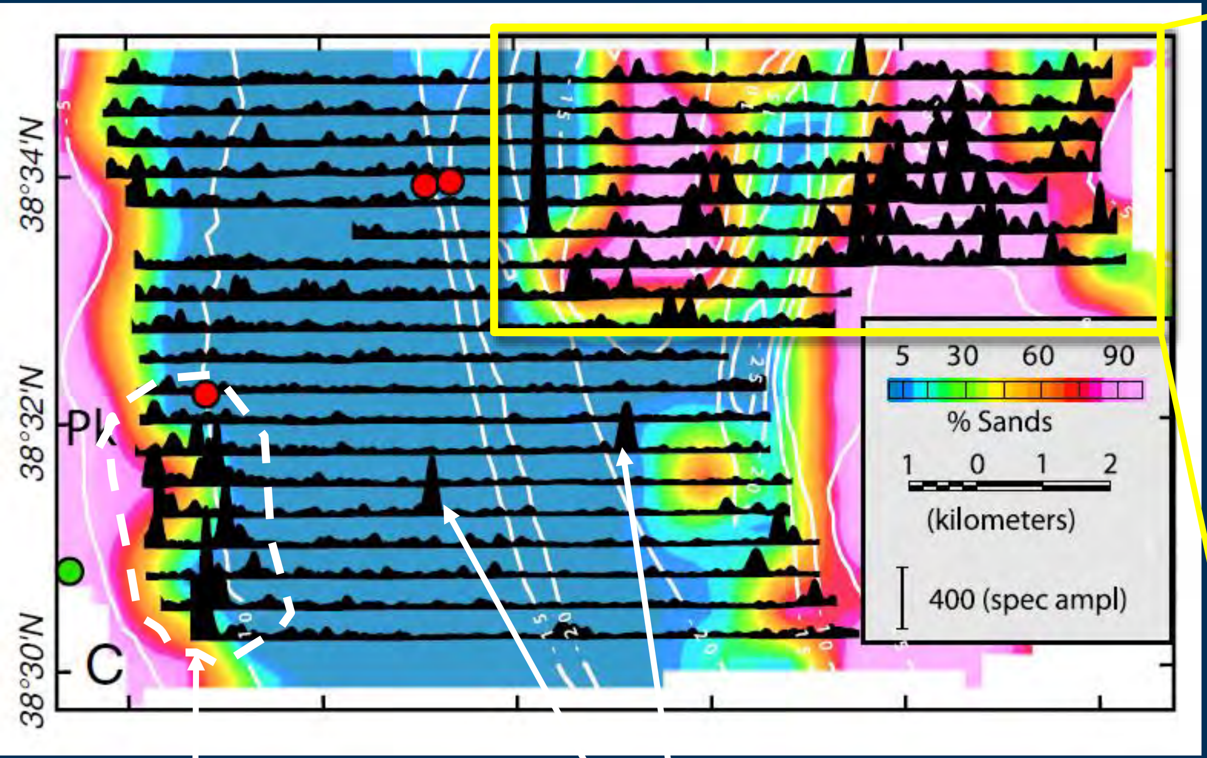
USGS

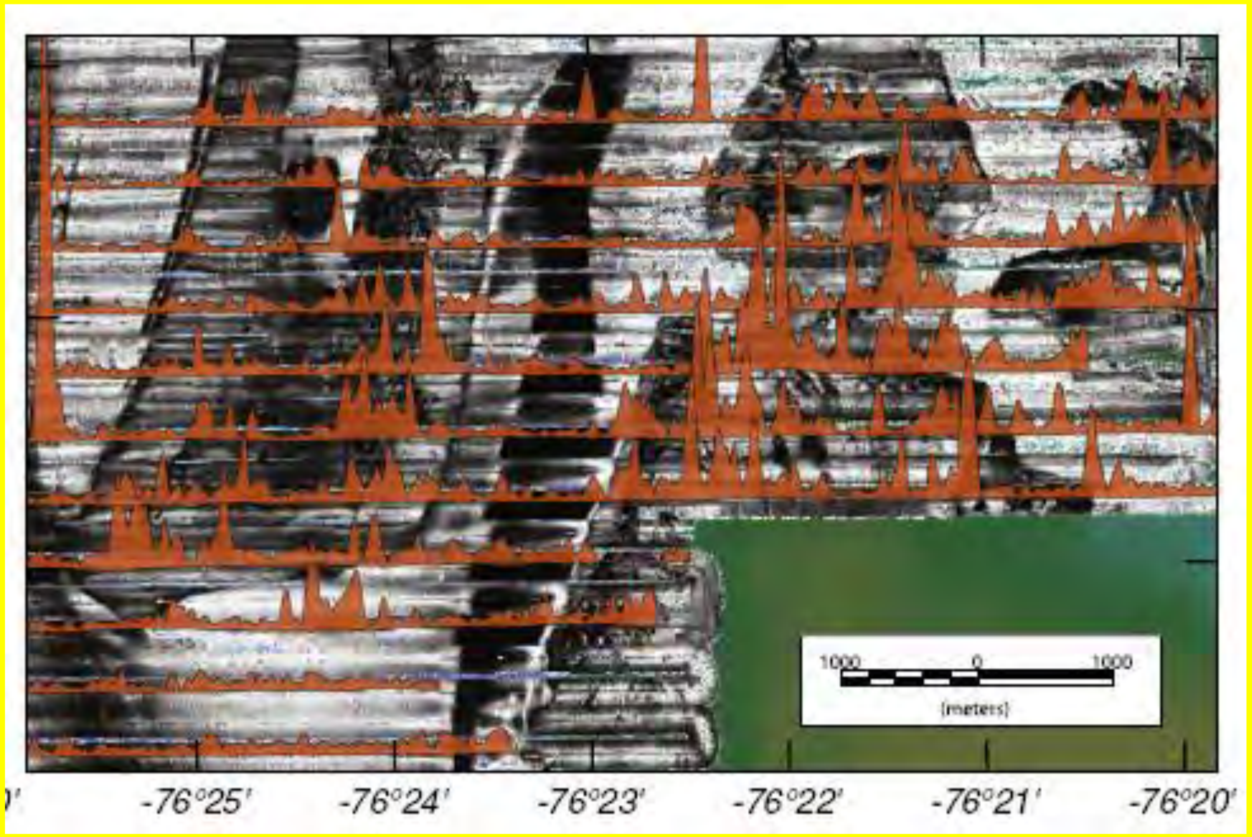
Preliminary information-subject to revision. Not for citation or distribution.

Magnetic data with sidescan sonar data: Geologic context

Example from the Chesapeake Bay, MD

Pink = % sands



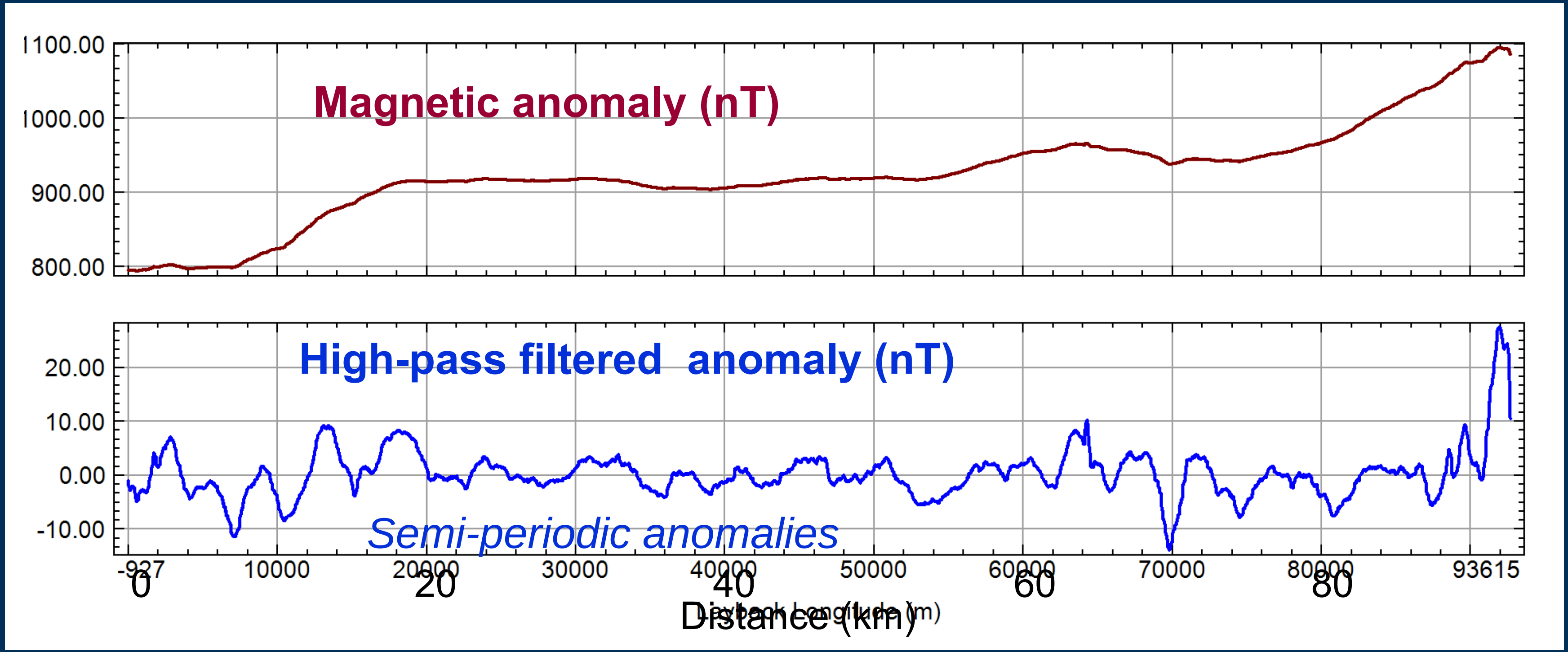


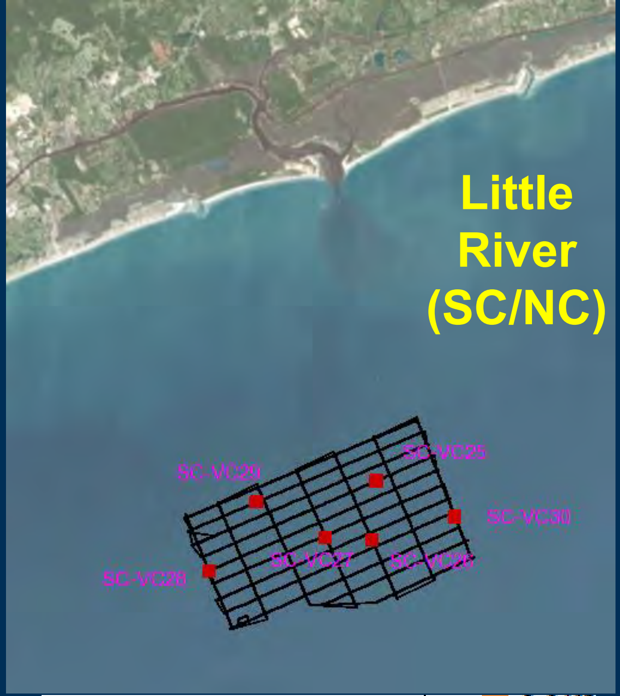
Parker's Creek

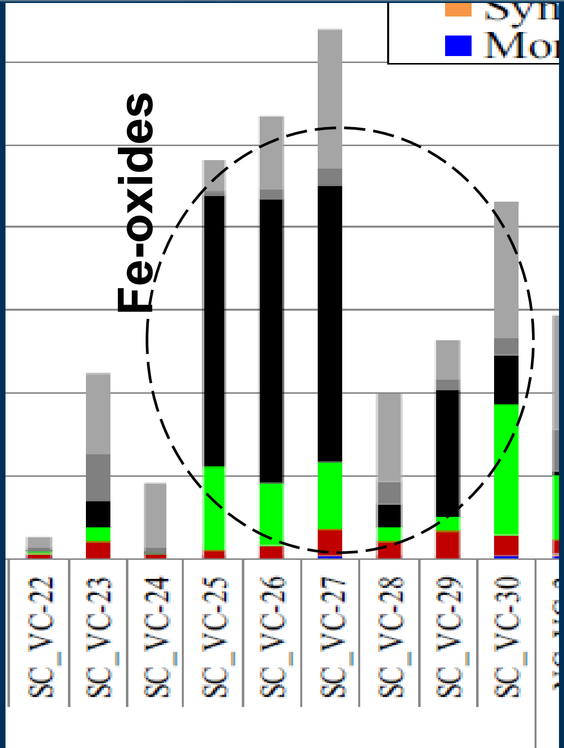
Metallic objects

Shah et al., Marine Geology, 2012

Smooth sailing…







…is important

Motion of the sensor will be reflected in the data, obscuring more subtle anomalies. Towing deeper may or may not help.

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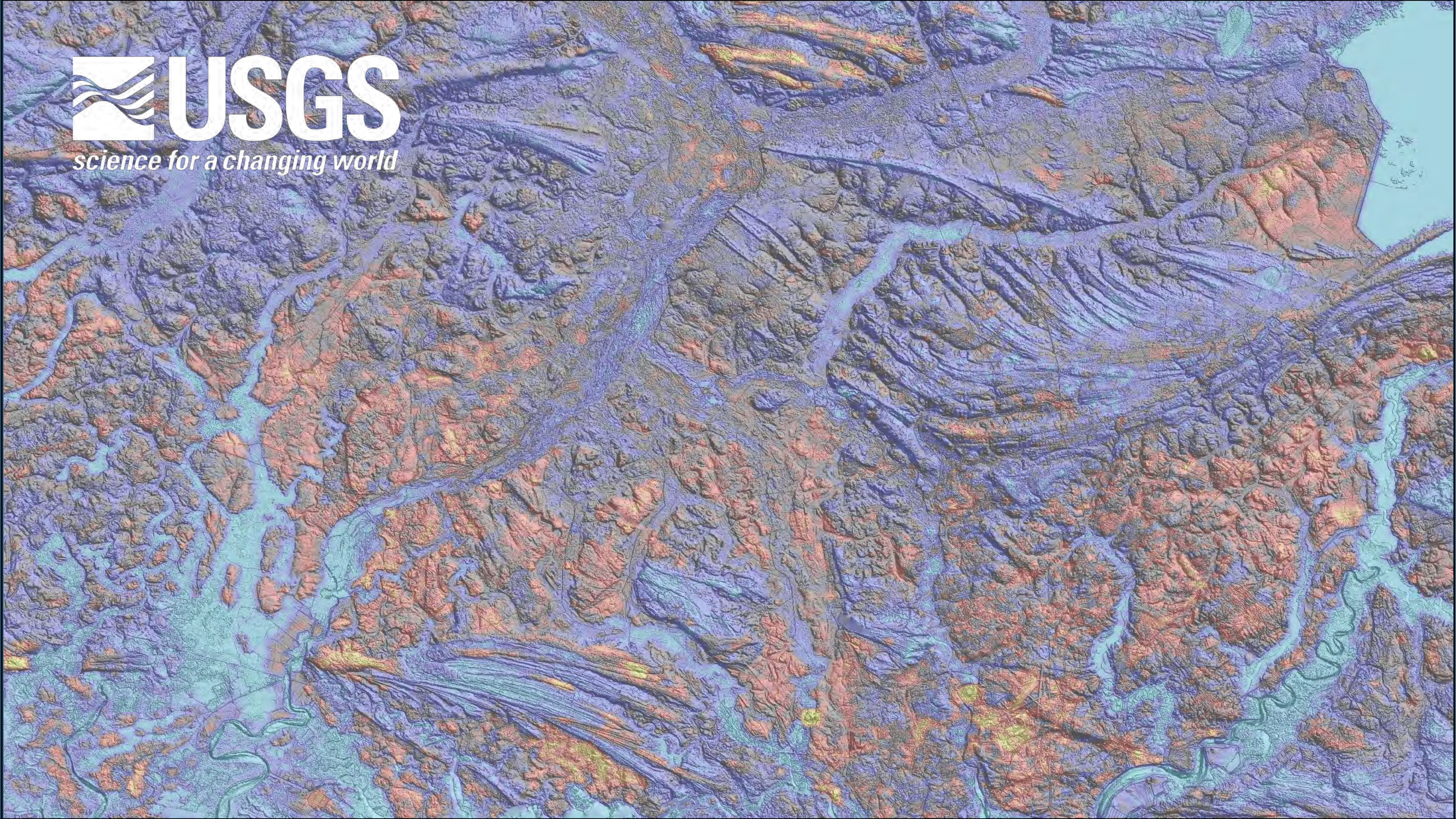
Preliminary information-subject to revision.
Not for citation or distribution.

Grammatikopoulos et al., J. Geocehm Explo., 2020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Session 5: Advanced technologies for heavy minerals identification, assessment, and monitoring

HAWKINS, D.W. and LASSETTER, W.L. – Field methods for assessment and monitoring of heavy mineral sands: Terrestrial and offshore insights (DHawkins_WLassetter.pdf)

Field Methods for Assessment and Monitoring of Heavy Mineral Sands: Terrestrial and Offshore Insights

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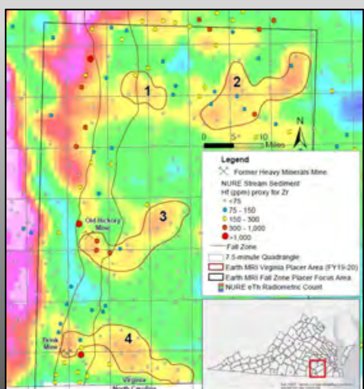
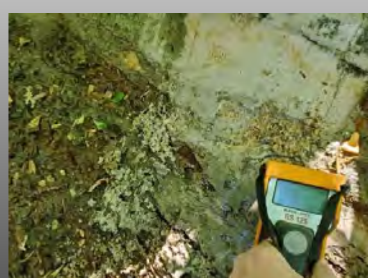
VIRGINIA Energy

Reconnaissance-level Geology



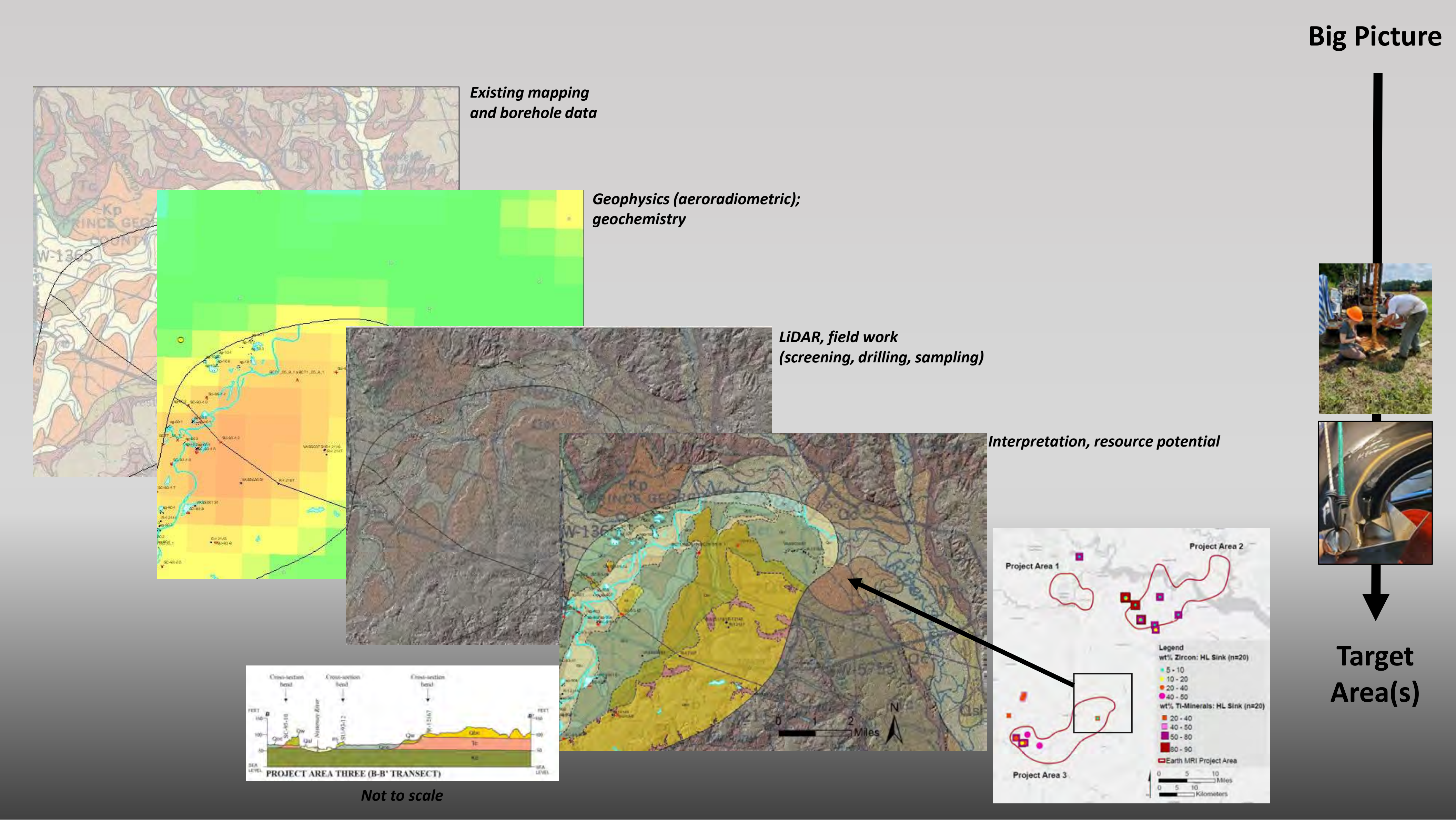
Field work



Sample processing

Analytical results

Data interpretation and refinement of methods


Big Picture
Existing mapping
and borehole data
Geophysics (aeroradiometric);
geochemistry
LiDAR, field work
(screening, drilling, sampling)
Interpretation, resource potential
Project Area 1
Project Area 2
Project Area 3
Legend
wt% Zircon: HL Sink (n=20)
5 - 10
10 - 20
20 - 40
40 - 50
wt% Ti-Minerals: HL Sink (n=20)
20 - 40
40 - 50
50 - 80
80 - 90
Earth MRI Project Area
Miles
Kilometers
PROJECT AREA THREE (B-B' TRANSECT)
Not to scale
Target
Area(s)

Regional-scale Data → Focus Areas

How can we apply land methods to the marine environment?

- Offshore geology and stratigraphy
- Seismic, other geophysics
- Lithology

→ Reconnaissance, geologic framework

- Sampling, screening, analysis

→ Field/lab applications

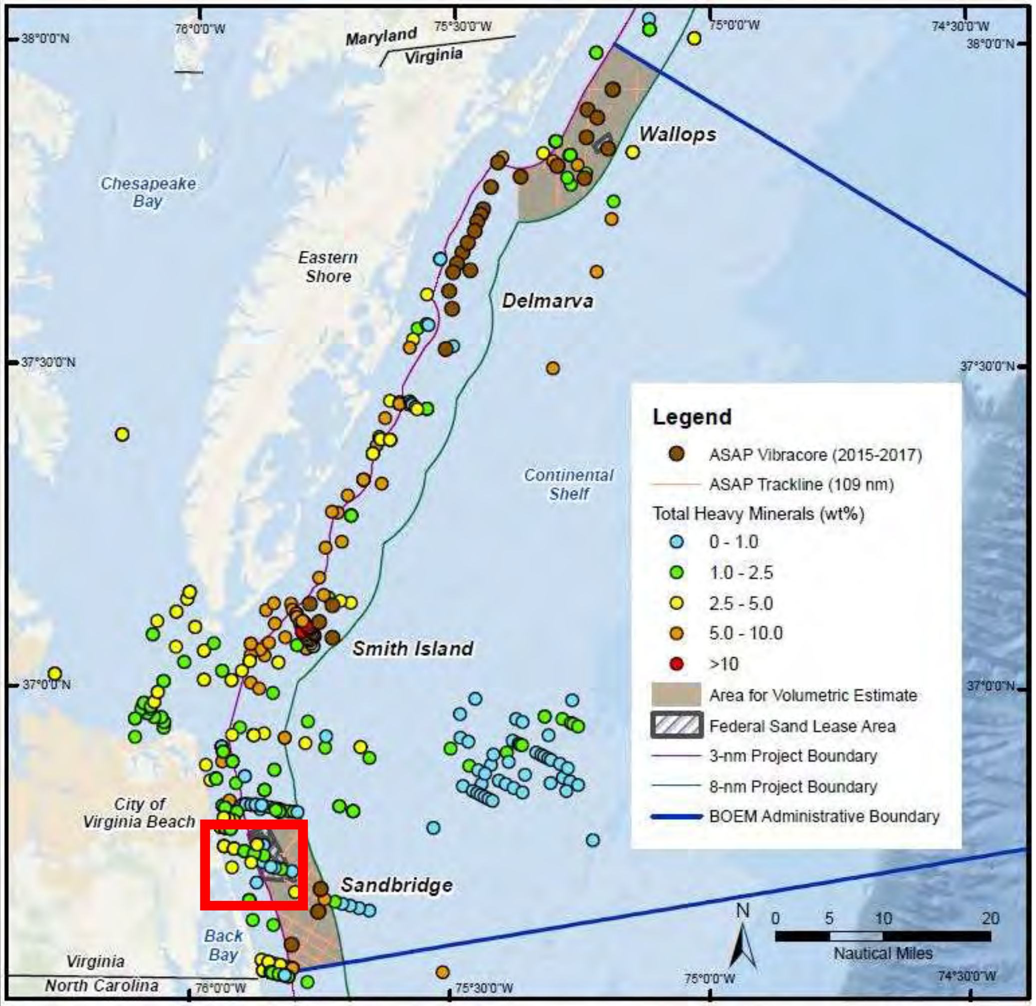
Geochemical Field/Lab Applications

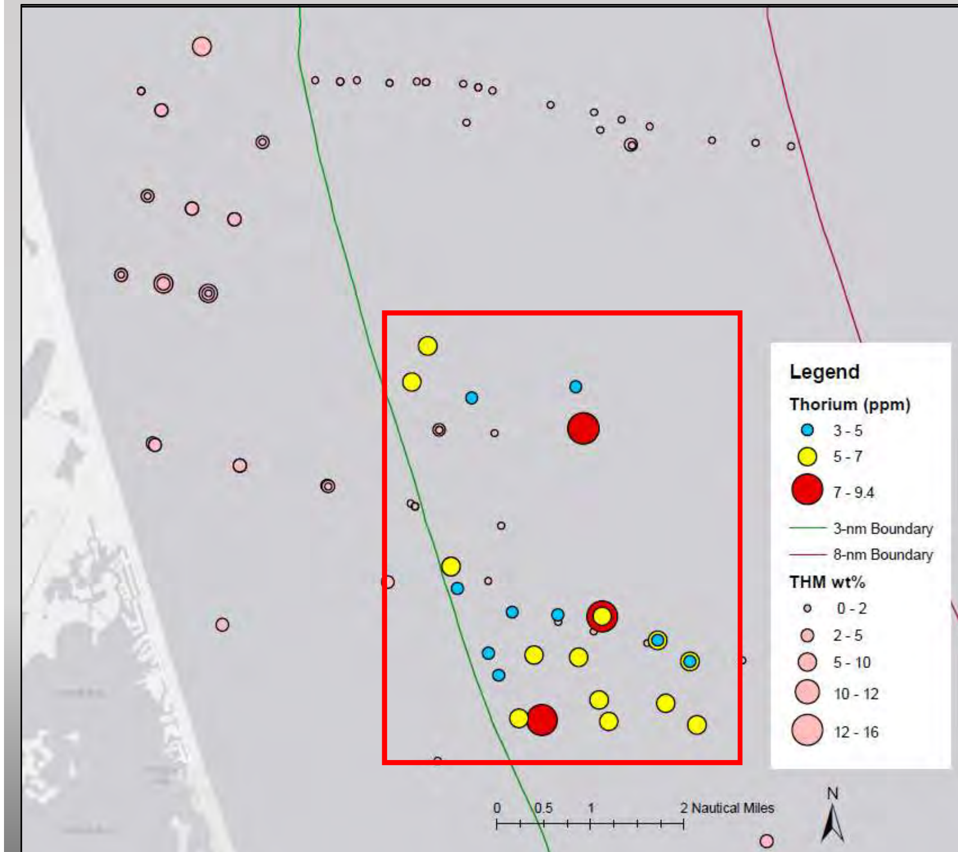
Gamma spectrometry:

- Heterogeneity (unconsolidated sediments)
- Clay content
- Error

- X-ray fluorescence
  - Heterogeneity (unconsolidated sediments)
  - Media preparation
  - Moisture content (what is the acceptable limit?)
  - Time
  - Error

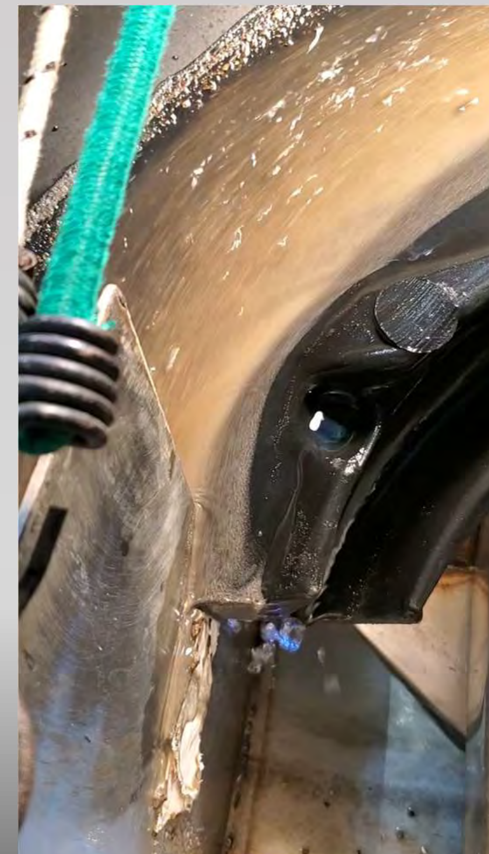
- How can we obtain a reasonable estimate for the mineralogical composition of sediment based on elemental geochemistry from screening tools?





Screening data: Thorium is a proxy for monazite and heavy minerals (note: taken from bulk sample, this is not THM mineral data for new vibracores)

Gravity Separation (Pre-concentration)



Proposed Approach

- Develop a protocol to aide in rapid field assessment of minerals and/or potential contaminants
  - **Exploration, environmental, and regulatory uses**

- Utilize laboratory setting to refine testing methods (i.e.. time, media)
  - **Variations in grain-size, porosity, moisture content, etc.**

- Thoughts from other applications?