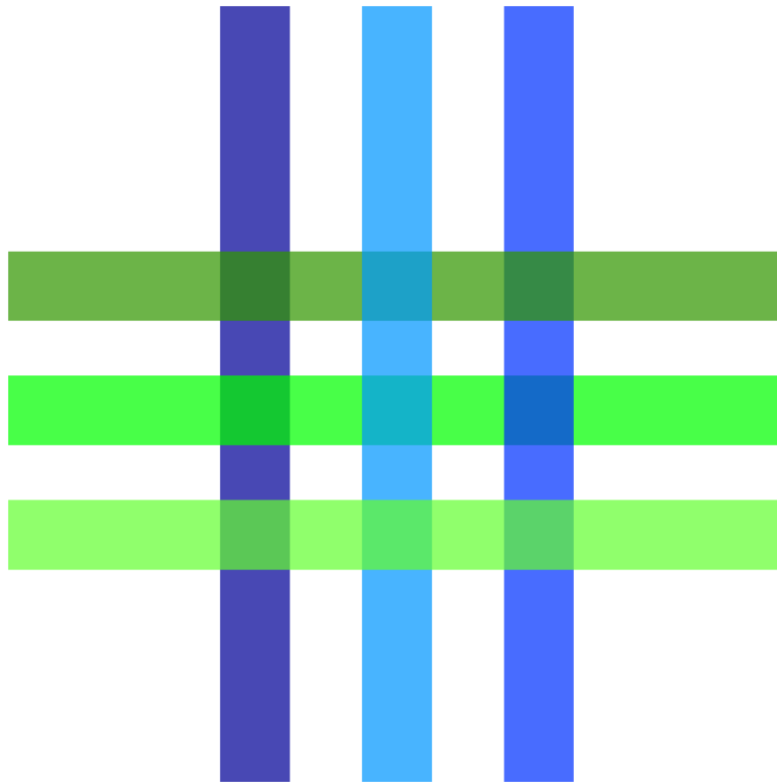


# CLEAN AND SECURE GRID INITIATIVE

A FEASIBILITY STUDY OF THE PROPOSED EAST  
COAST OFFSHORE HVDC CABLE



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## Executive Summary

The Clean and Secure Grid Initiative aims to formulate a detailed proposal for a largely underground high voltage direct current (HVDC) grid that will connect renewable energy supply areas to consumer centers in the continental U.S.

Offshore cables are necessary for connecting the northern and southern parts of the eastern seaboard because of unique soil characteristics on the East Coast. This feasibility study is an initial investigation of the possibility of using offshore cables taking biodiversity, chemo-physical, and anthropological aspects into account. Variables that were considered relevant and that were publicly available were gathered and overlapped using GIS tools. Those variables were classified as primary, secondary and supplemental concerns for the offshore grid placement. Based on that, the possible locations for the cable were set in three different scenarios. We describe and analyze variables in three scenarios of cable placement; A, B, and C, where A includes only primary variables, B includes primary and secondary variables, and C includes primary, secondary, and supplementary variables.

Bathymetry, the measurement of water depth, is the most important physical aspect to consider in the cable placement followed by seabed thickness, which must be adequate for burial throughout all the desired bathymetry. Corals are the most important biodiversity aspect to be avoided, because it is the most sensitive ecosystem to the cable and is a highly vulnerable biome and protected as a priority by federal law, e.g. the only offshore GAP (Gap Analysis Program) status 1 area in the East Coast is in Florida Keys. Lastly, among all the anthropological aspects, military installations, deepwater ports, coastal energy facilities, and oil and gas wells were considered primary concerns for the cable burial. Based solely on those variables, we drafted Scenario A regarding the way to be tracked by the submarine cable.

In addition to the primary concerns, Scenario B considers wind planning zones and other renewable energy leases, vessel density, seabed type, and particular coral habitat areas. Finally, anchorage areas, disposal sites, unexploded ordinances, and other coral essential fish habitats are the supplemental concerns that can help to lower the project risks additionally to the others mentioned previously. As a result, Scenario C could be drawn.

To join the submarine cable in the U.S. East Coast with the underground continental grid, potential locations for the onshore-offshore connections were also suggested. According to the chosen connection placement, the path tracked by the cable can be modified. The final purpose of this report is to analyze the feasibility of the offshore segment of the HVDC grid through the analysis of real world data, a step towards a nationwide underground efficient and safe power grid and towards an energy matrix mostly composed by renewable sources.

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## I. Introduction

A recent study conducted by MacDonald *et al.* and published in *Nature Climate Change* has shown that the United States has vast underutilized renewable energy sources, resulting in a 78% decrease in carbon emissions from the national energetic matrix.<sup>1</sup> To accomplish this feat in the face of intermittency concerns, the installation of an efficient power grid to transport the energy throughout the country is crucial; it is from this the context that the Clean and Secure Grid Initiative arose. The initiative calls for the creation of a nationwide underground direct current electric grid overlay that would connect consumption centers to energy production areas in the contiguous United States. Regarding the energy transfer on the Southern portion of the Eastern Seaboard, an offshore grid connection will likely be necessary because of the rocky relief and highly varying elevation in the region. This report investigates real spatial data and provides an initial assessment of the feasibility of an offshore grid connection.

Based on a previous technical study developed by Climate Institute, a set of variables crucial to the decision-making process of the cable placement was collected and plotted into maps. Thus, this investigation consists of an analysis of those variables, grouped in three main categories, in order to assess the best location for the implementation of an offshore grid: (i) Chemo-physical aspects; bathymetry, sediment thickness and seabed type; (ii) Biodiversity, which considers protected areas and habitats of marine species; and (iii) Anthropological aspects, such as pipelines, energy facilities, military-owned areas, and vessel traffic.

Based upon the analysis presented in the three sections, this report suggests a path in which an offshore HVDC cable could be buried, as well as potential locations for offshore-onshore-connections. By doing so, this study describes and analyzes the conditions surrounding the construction of the proposed offshore segment of this new nationwide HVDC grid.

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<sup>1</sup> Alexander E. MacDonald et al., "Future cost-competitive electricity systems and their impact on US CO<sub>2</sub> emissions," *Nature Climate Change* (2016): 1-6. Accessed: XXX . doi: 10.1038/NCLIMATE2921.

## II. Chemo-physical Aspects

Chemo-physical analysis refers to data concerning the physical and chemical aspects of the offshore environment in the United States East Coast. To better understand this topic area, the following variables were considered: sediment thickness, bathymetry and seabed soil composition, all of which were represented in the Figures 1, 2, and 3.

### Sediment Thickness

The first variable, sediment thickness, was collected from several nationally-run centers which collect and publish environmental data<sup>2</sup>. It consists of a raster layer<sup>3</sup> representing the sediment thickness in underwater areas worldwide. Soil thickness was needed to identify sections of shallow soil that were inadequate for HVDC cable burial. For that reason, this layer was colored in a gradient pattern, where lighter colors represented greater thickness values. It is important to highlight that no mention was made in the metadata regarding the unit adopted in this dataset, though it is reasonable to assume that “meters” was the intended unit. To check this data, it was compared to another dataset showing the existence of communications cables in areas near where HVDC cable would be buried, which might indicate the existence of appropriate conditions in the area.<sup>4</sup>

### Bathymetry

Per the definition presented by the United States Geological Survey (USGS) metadata, bathymetry is the depth (in meters) from the seabed to the surface. This information is represented by Isobath contours of equal relative depth.<sup>5</sup> Data referring to bathymetry was collected from USGS in the form of two different GIS datasets. Both were combined to provide a high-resolution view of seabed depth. Isobaths contained in similar bathymetric intervals were colored with the same shade of green. As presented by an OSPAR Commission Report, “telecommunication cables installed over the last decade have been buried [as deep] as technically feasible, but not in areas with a water depth of more than 3000 m.”<sup>6</sup> According to the same report, cables have already been placed in depths up to 1,000 and 1,200 meters. Thus, the interval considered ideal for

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<sup>2</sup> National Environmental Satellite, Data, and Information Service (NESDIS), National Oceanic and Atmospheric Administration (NOAA), and the U.S. Department of Commerce.

<sup>3</sup> A raster layer is geographically located, such as any other map layer. However, raster layers are plans which are divided in a grid of polygons and that might contain information in each of those polygons.

<sup>4</sup> This dataset will be presented later in this report. Although, other reliable sources must be consulted before the installation of the offshore cable.

<sup>5</sup> U.S. Geological Survey, Government of Canada, Natural Resources Canada, Canada Centre for Remote Sensing, The Atlas of Canada e Instituto Nacional de Estadística Geografía e Informática, 2004. *Census USGS Small-scale Dataset - North American Atlas - Bathymetry 200406 Shapefile*. (Reston, VA, 01 June 2004), distributed by U.S. Geological Survey, bathymetryenglish.txt, [http://dds.cr.usgs.gov/pub/data/nationalatlas/bathy0m\\_shp\\_nt00296.tar.gz](http://dds.cr.usgs.gov/pub/data/nationalatlas/bathy0m_shp_nt00296.tar.gz).

<sup>6</sup> Thomas Merck et al., “Assessment of the environmental impacts of cables,” *Ospar Commission Biodiversity Series* (2009), accessed September 14, 2016, [http://gsr2010.ospar.org/media/assessments/p00437\\_Cables.pdf](http://gsr2010.ospar.org/media/assessments/p00437_Cables.pdf).

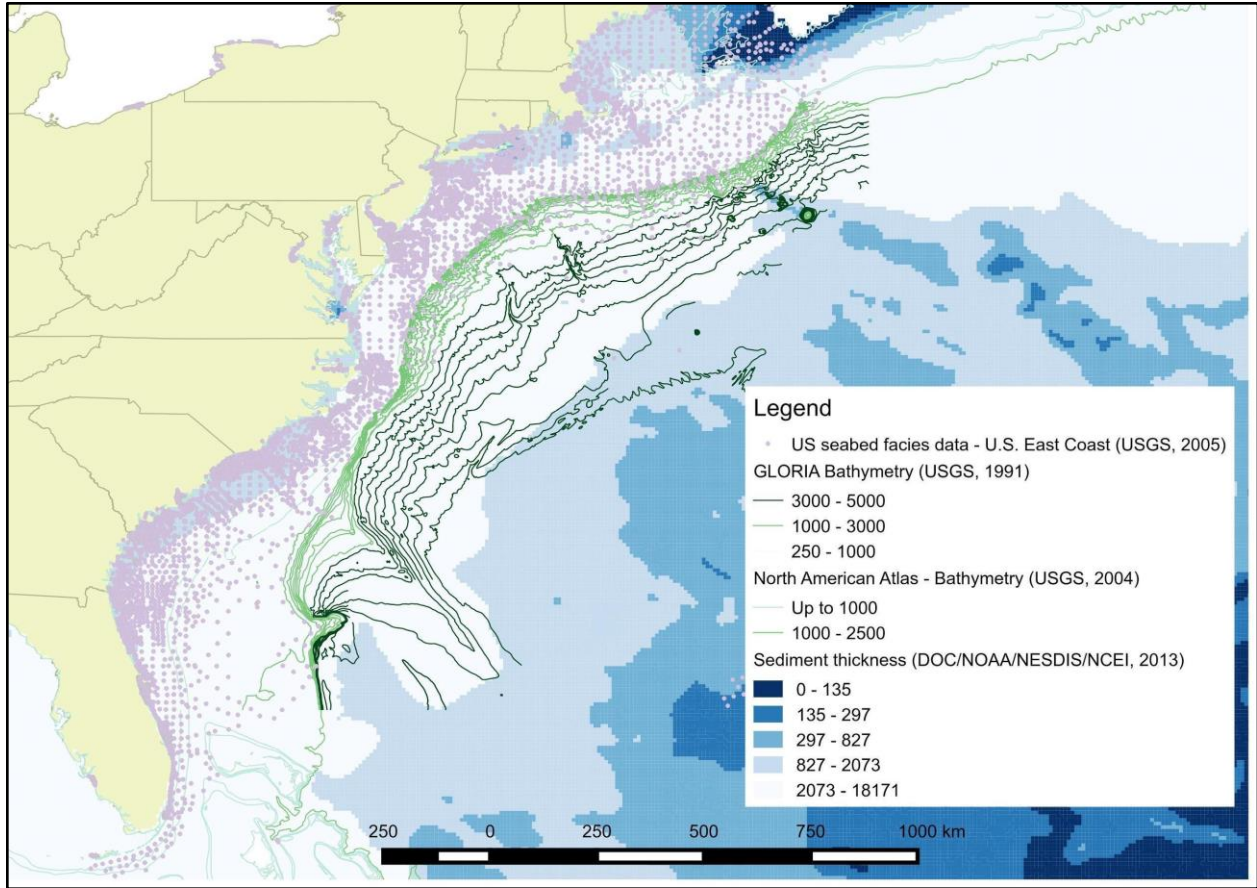
the cable burial was determined to be 1000 to 3000 meters. This interval was represented as medium green (not the lightest, nor the darkest) in the first GIS layer (named GLORIA Bathymetry (USGS, 1991)). The same shade is applied in the second GIS layer (named North American Atlas - Bathymetry (USGS, 2004)). In this case, however, the desired interval of 1000 - 2500 meters is the darkest color of the range, due to the maximum value of this dataset being 2500 meters, which is comprehended in the desired interval.

## **Seabed Type**

Finally, the last dataset applied in this analysis is the *usSEABED facies data for the entire U.S. East Coast*,<sup>7</sup> also from USGS. This data is a set of points for which a soil sample of known composition was collected. The data was published in 2005, two years after data collection occurred. This layer represents information such as the components and genesis regarding the seafloor, and was compiled from different sources that applied various methods in the collection. Figure 1 presents all the sampling spots contained in this dataset in the applicable study area.

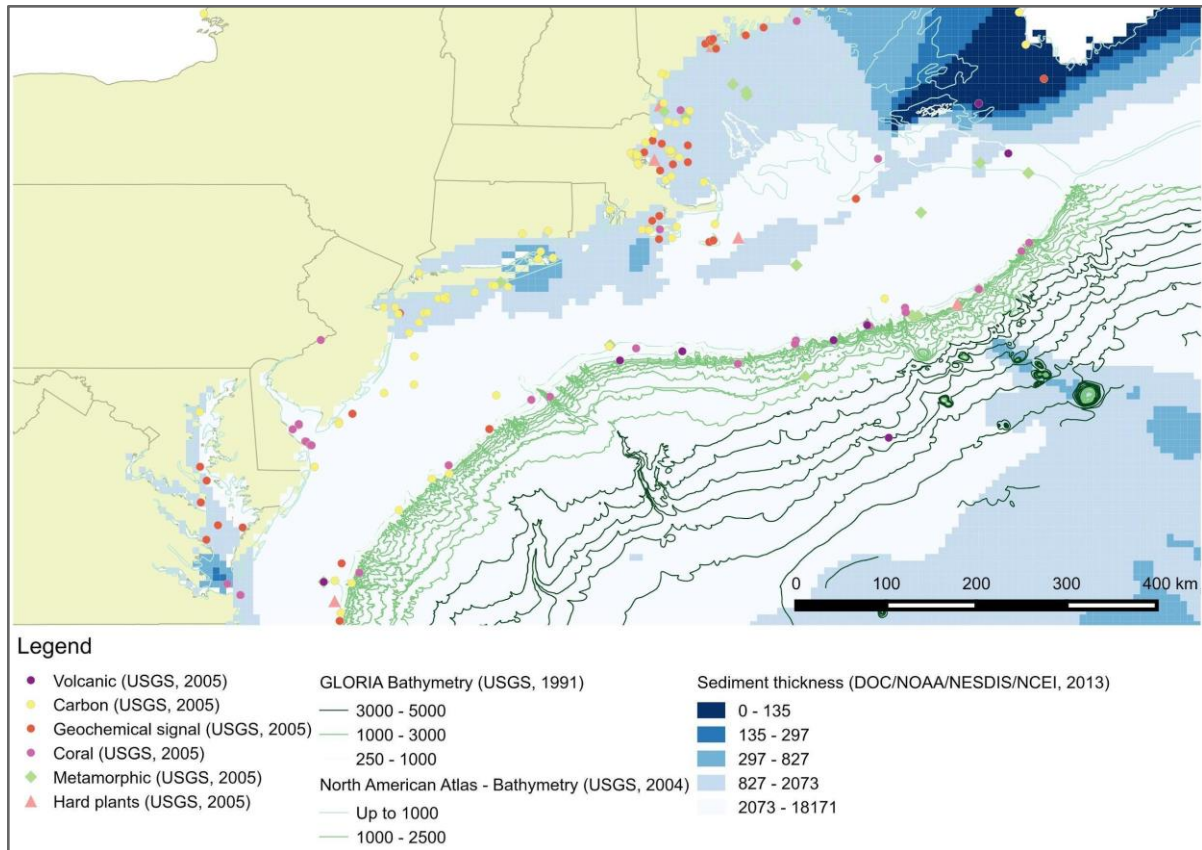
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<sup>7</sup> Multiple seabed datasets are available under USGS's coastal and marine geology program. They each present different geochemical/geophysical information, based on several investigation methods. Our selection of usSEABED facies data has taken into consideration of both seafloor feature information of our interest and research method applied. Specifically, usSEABED facies data contains numeric values for appropriately grouped content components. Examples include rocks, corals, etc. usSEABED facies data are mostly collected from presence reports, which are considered reliable sources.



**Figure 1** US Seabed Facies Data for the Eastern Seaboard

It is noticeable that the northern part of the medium green contours (denoting the desirable bathymetric interval) is covered by purple dots until the map reaches the Northern Coast of North Carolina, but the points separate from the medium green contours and reunite again only close to Florida's Eastern Coast. This means that only parsimonious conclusions or recommendations regarding soil composition in this gap interval could be made. From this dataset, points signaling in which the presence of carbon, volcanic rock, coral and/or another geochemical signal were highlighted, meaning the percentage of these components in the sample was not "null". The presence of metamorphic rock and hard plant percentages were highlighted separately. The following Figures 2 and 3 highlight each of these categories, as well as bathymetry and sediment thickness.

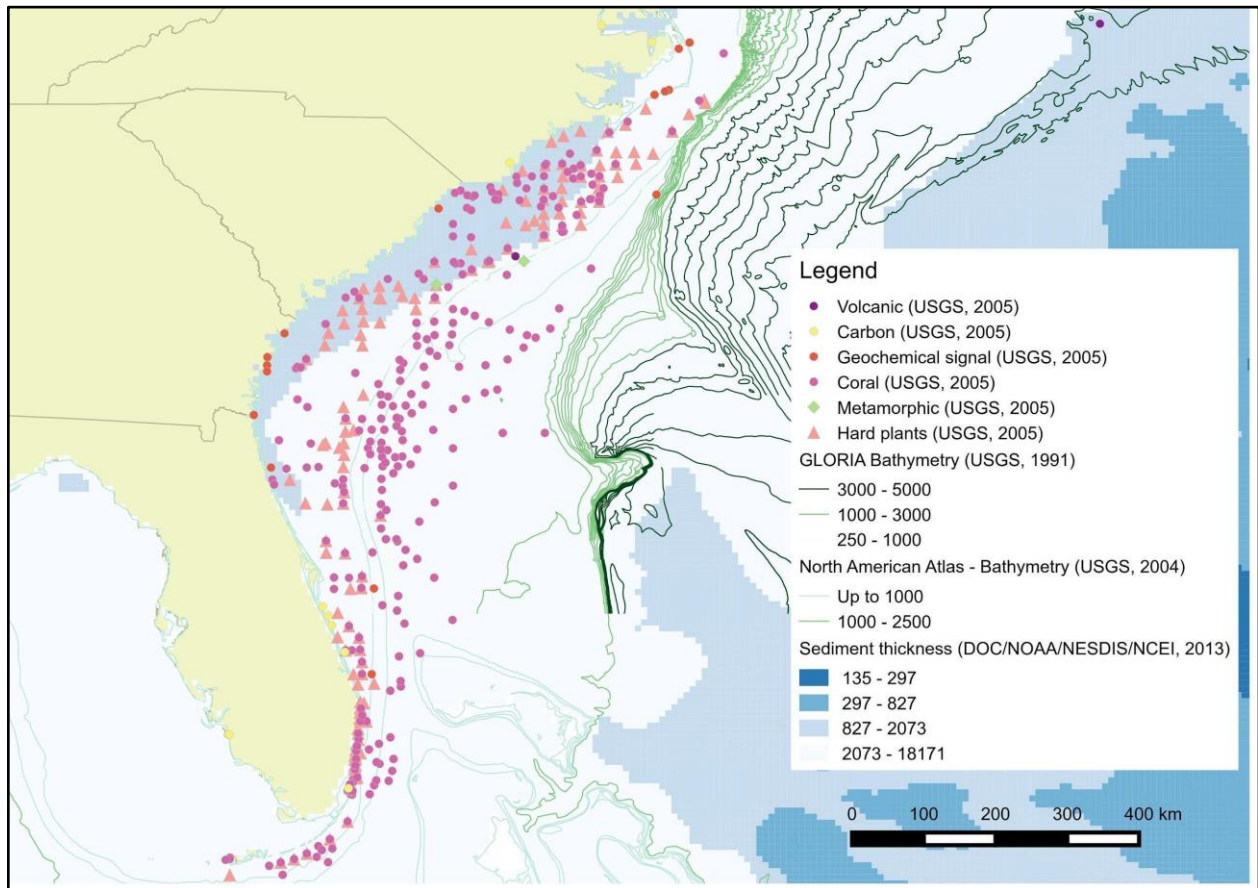


**Figure 2** Chemo-physical Aspects - Northern East Coast: Maine to Virginia.

As shown by Figure 2, the area covered by the medium-green-shaded bathymetric contours does not correspond to the shallowest sediment thickness class (the darkest blue, ranging from 0-135 [meters]). Thus, the accuracy of this dataset would signify that the depth from the seabed surface to the bedrock is enough for an appropriate cable burial in all the offshore region presented by the map. In addition, most of the points to avoid (represented by the circles, triangles, and diamonds) that are close to the medium-green area follow the contours that are the closest to the U.S. shoreline, leaving a significantly broad band of desired bathymetry further from the coastline where the cable could be placed.

The conditions along the southern East Coast represented by Figure 3 are similar to those described above. The band that is enclosed in the desired bathymetry is even farther from the colored points than those in Figure 2. However, it is important to highlight the absence of data referring to the medium-green contour area in the latitudes corresponding to South Carolina and Georgia, which enables a higher degree of certainty in the latitude ranges encompassing North Carolina and Florida. In the former case, there is a single point for representing “geochemical signals”, while in the later, there is a safe distance from the desired bathymetric interval to any of the undesirable soil composition spots, despite of the intense presence of coral components in shallower waters along the Florida shoreline.





**Figure 3** Chemo-physical Aspects - Southern East Coast: North Carolina to Florida.

### Remarks on chemo-physical data reliability

The sediment thickness and bathymetric information presented appear to be accurate and consistent. The information regarding soil composition, however, should be further verified applying other sources such as private firms, scholars, or government agencies who have worked directly in these offshore areas. Despite the broad visualization of soil composition this USGS dataset has enabled, the data collection dates vary from 1840 to 2003,<sup>8</sup> meaning that there is the possibility that some of the information has significantly changed. In addition, the absence of data from some of the points does not necessarily imply the absence of a mineral/organic soil component in the sample (this can occur due to unavailable data), which could also undermine conclusive statements regarding soil composition.

### III. Biodiversity aspects

<sup>8</sup> USGS. *FGDC Content Standards for Digital Geospatial Metadata*. 2005, accessed October 25, 2016, [http://pubs.usgs.gov/ds/2005/118/data/atli\\_facmeta.htm](http://pubs.usgs.gov/ds/2005/118/data/atli_facmeta.htm).

Another important aspect to consider when implementing a new electric grid is the impact it could have on localized biodiversity. In order to predict and mitigate negative impacts associated with offshore HVDC cables, the following variables were included in the analysis: protected areas according to the USGS Gap Analysis Program (GAP); Essential Fish Habitats (EFH) and Habitat Areas of Particular Concern (HAPC), with data generated by the Florida Fish and Wildlife Conservation Commission (FWC), and the Fish and Wildlife Research Institute (FWRI) in association with the South Atlantic Fishery Management Council (SAFMC); Migratory Behaviour - EFH Highly Migratory Species (HMS), with data generated by NOAA; and Global Distribution of Coral Reefs, with data generated by United Nations Environmental Program - World Conservation Monitoring Center, the WorldFish Centre, World Resources Institute and The Nature Conservancy).

## **GAP Analysis**

Protected areas in the United States are classified in four categories (GAP Status 1 to 4), with land use restrictions increasing as the status number decreases. The GAP Status 4 definition does not mention specific restrictions regarding land usage, meaning that there is “no known public/private institutional mandates/legally recognized easements”<sup>9</sup> in the area. Areas classified as GAP Status 3 can be subject to extractive uses, such as mining and logging. On the other hand, GAP Status 2 allows “uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.”<sup>10</sup> Finally, GAP Status 1 is defined as “an area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) [can] proceed without interference or are mimicked through management.”<sup>11</sup> Thus, GAP Status 2 to 4 allows anthropological interference to develop an area through low impact economic activity or to suppress natural disturbances.<sup>12</sup> GAP Status 1, however, should be avoided to maintain natural interaction between biotic and abiotic elements of these ecosystems.

## **Essential Fish Habitats and Habitat Areas of Concern**

According to NOAA, EFHs are “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (MSA § 3(10)). (...) ‘necessary’ means the habitat required to support a sustainable fishery and the managed species’

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<sup>9</sup> “A summary of the relationship between GAP Status Codes and IUCN Definitions,” USGS, accessed October 10, 2016, <http://gapanalysis.usgs.gov/blog/iucn-definitions/>.

<sup>10</sup> “A summary of the relationship between GAP Status Codes and IUCN Definitions,” USGS, accessed October 10, 2016, <http://gapanalysis.usgs.gov/blog/iucn-definitions/>.

<sup>11</sup> “A summary of the relationship between GAP Status Codes and IUCN Definitions,” USGS, accessed October 10, 2016, <http://gapanalysis.usgs.gov/blog/iucn-definitions/>.

<sup>12</sup> It is also corroborated by the argument presented in Climate Institute's previous report “Other Examples of HVDC Transmission Line in the US: The Neptune's Case”.

contribution to a healthy ecosystem”<sup>13</sup>. Among the EFHs, some are also classified as HAPCs. This special category is considered a conservation priority:

“Habitat Areas of Particular Concern (HAPCs), a subset of Essential Fish Habitat (EFH), are habitat types and/or geographic areas identified by the eight regional fishery management councils and NOAA Fisheries as priorities for habitat conservation, management, and research”<sup>14</sup>.

Consequently, HAPC and EFH were considered in the cable placement analysis. Furthermore, HAPC areas were differentiated from the overall EFH and deemed the most important for the HVDC cable path to avoid. EFH areas included data regarding Dolphin, Wahoo, Golden Crab, Shrimp, Spiny Lobster, Coastal Migratory Pelagics, and Snapper Grouper. Similarly, EFH-HAPC areas included data concerning Dolphin, Wahoo, Shrimp, Spiny Lobster, Coastal Migratory Pelagics, Snapper Grouper, and Tilefish. All corresponding data was publicly available from the Florida Fish and Wildlife Conservation Commission (FWC) and Fish and Wildlife Research Institute (FWRI) in association with the South Atlantic Fishery Management Council (SAFMC). A Snapper Grouper EFH<sup>15</sup> layer could not be visualized and are not included in the following map.

Figure 4 shows the areas where EFH, EFH-HAPC, and Coral Reefs were identified by the afore mentioned sources. The reef database plotted in orange was compiled by UNEP World Conservation in collaboration with Monitoring Centre (UNEP-WCMC) and the WorldFish Centre, World Resources Institute (WRI) and The Nature Conservancy (TNC). It represents the global distribution of coral reefs (data collection was held from 1999 and 2002), especially the warm-water coral reefs.<sup>16</sup> As noted in Figure 4, the Coral Reefs in orange show that the reefs close to the U.S. are concentrated in Florida’s South and Southeast Coast and near other islands South of the U.S.

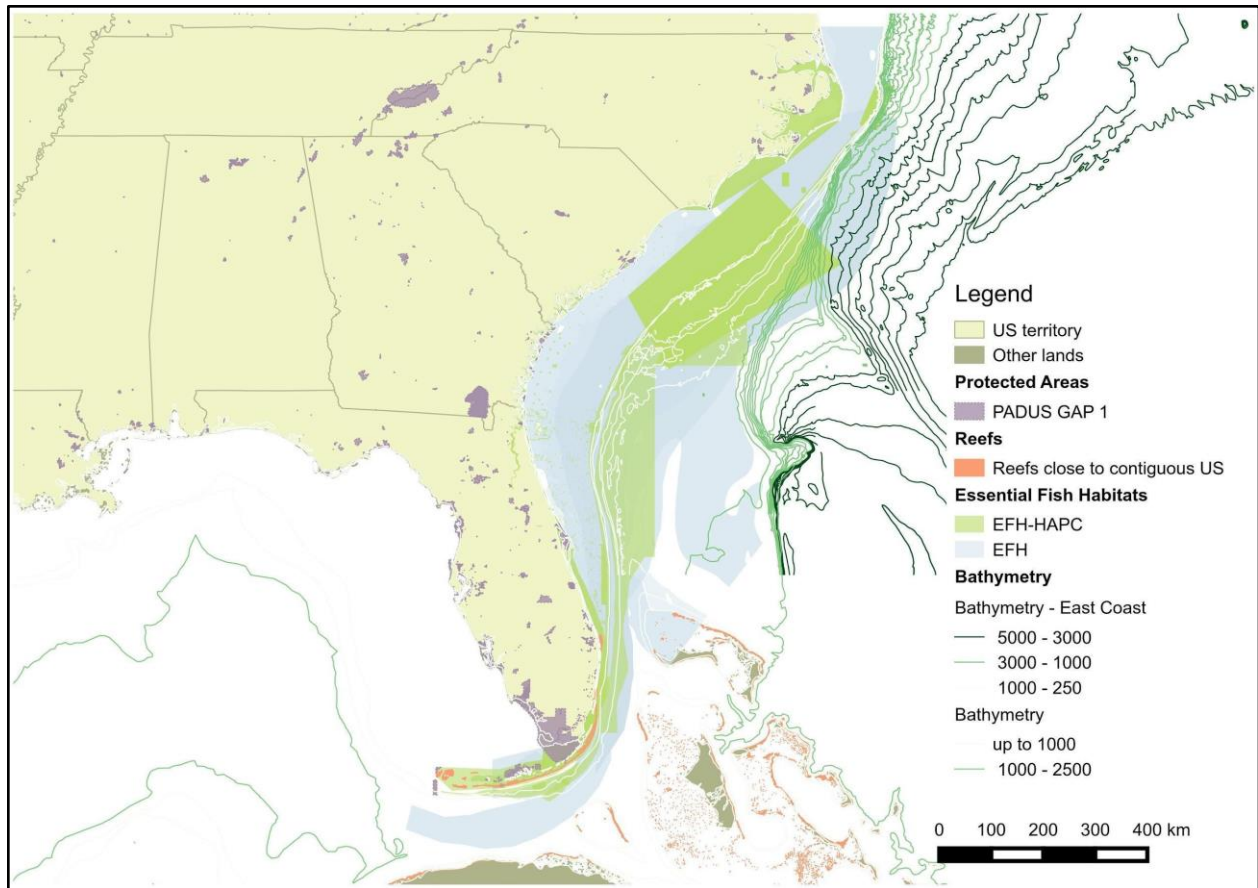
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<sup>13</sup> National Marine Fisheries Service Office of Habitat Conservation, *Essential Fish Habitat Consultation Guidance* (Silver Spring: MD, 2004), p. 3, accessed September 22, 2016, [http://www.habitat.noaa.gov/pdf/efh\\_consultation\\_guidance\\_v1\\_1.pdf](http://www.habitat.noaa.gov/pdf/efh_consultation_guidance_v1_1.pdf).

<sup>14</sup> Fisheries Leadership & Sustainability Forum for the Mid-Atlantic Fishery Management Council, *Regional Use of the Habitat Area of Particular Concern (HAPC) Designation* (2016), p. 1 accessed in September 22, 2016, <http://www.habitat.noaa.gov/pdf/Regional-HAPC-Report-May-2016.pdf>.

<sup>15</sup> The purpose of this layer was defined as: “The spatial representation of areas which for Coral, Coral Reef and Live\_Hard Bottom ranked high in terms of ecological function, sensitivity, probability of stressor introduction, and/or criteria established for designation of Essential Fish Habitat-Habitat Areas of Particular Concern (EFH-HAPC). This layer is not considered complete at this date. We anticipate enhancing this file, as more data becomes available.” FWC-FWRI (Florida Fish and Wildlife Conservation Commission-Fish and Wildlife Research Institute), “FGDC Content Standards for Digital Geospatial Metadata,” accessed September 23, 2016, [http://atoll.floridamarine.org/Data/Metadata/Custom/zzarchive/Coral.%20Coral%20Reef%20and%20Live\\_Hard%20Bottom%20EFH-HAPC.htm](http://atoll.floridamarine.org/Data/Metadata/Custom/zzarchive/Coral.%20Coral%20Reef%20and%20Live_Hard%20Bottom%20EFH-HAPC.htm).

<sup>16</sup> “Approximately 85% of this dataset originates from the Millennium Coral Reef Mapping Project, of which 35% was validated (by IMaRS-USF and IRD-Noumea) and 50% remains unvalidated (but was interpreted by UNEP-WCMC). Millennium Coral Reef Mapping Project products (validated or not) are at a consistent 30 m resolution.” (Quotes contained in the “Global Distribution of Coral Reefs (2010)” GIS data documentation).

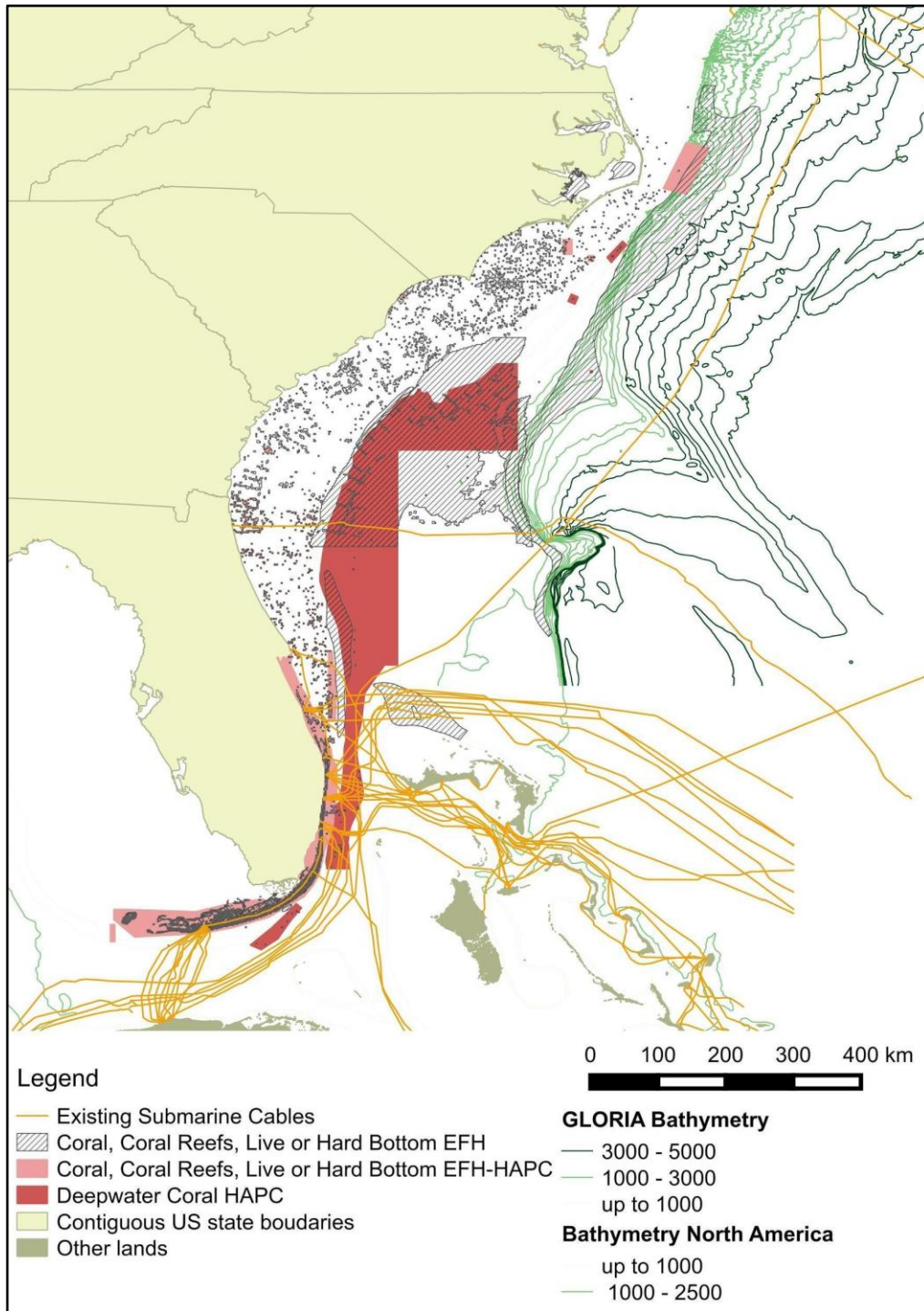


**Figure 4** Bathymetry, Reefs, Protected Areas and Essential Fish Habitats - North Carolina to Florida

As is true with coral reef locations, HAPCs are areas in which “(...) the use of all bottom damaging gear is prohibited including bottom longline, trawl (bottom and mid-water), dredge, pot or trap, or the use of an anchor, anchor and chain, or grapple and chain by all fishing vessels”<sup>17</sup>. Therefore, it is important to highlight these areas from the overall HAPCs, as well as Deepwater Coral HAPCs, that are another category defined after the establishment of HAPC areas. Scientific research pointed to the existence of high relief and hard bottom habitat areas that had not been included in the Coral HAPC boundaries. Thus, “During their October 2011 meeting, the Coral Advisory Panel recommended SAFMC revisit the boundaries of the Oculina Bank HAPC, Stetson-Miami Terrace CHAPC, and Cape Lookout CHAPC to incorporate areas of additional deep-water coral habitat.”<sup>18</sup> The following figure highlight both aforesaid categories.

<sup>17</sup> FWC-FWRI (Florida Fish and Wildlife Conservation Commission-Fish and Wildlife Research Institute). *FGDC Content Standard for Digital Geospatial Metadata*. [http://ocean.floridamarine.org/efh\\_coral/metadata/deepwater%20coral%20hapcs.htm](http://ocean.floridamarine.org/efh_coral/metadata/deepwater%20coral%20hapcs.htm)

<sup>18</sup> FWC-FWRI (Florida Fish and Wildlife Conservation Commission-Fish and Wildlife Research Institute). *FGDC Content Standard for Digital Geospatial Metadata*. [http://ocean.floridamarine.org/efh\\_coral/metadata/deepwater%20coral%20hapcs.htm](http://ocean.floridamarine.org/efh_coral/metadata/deepwater%20coral%20hapcs.htm)



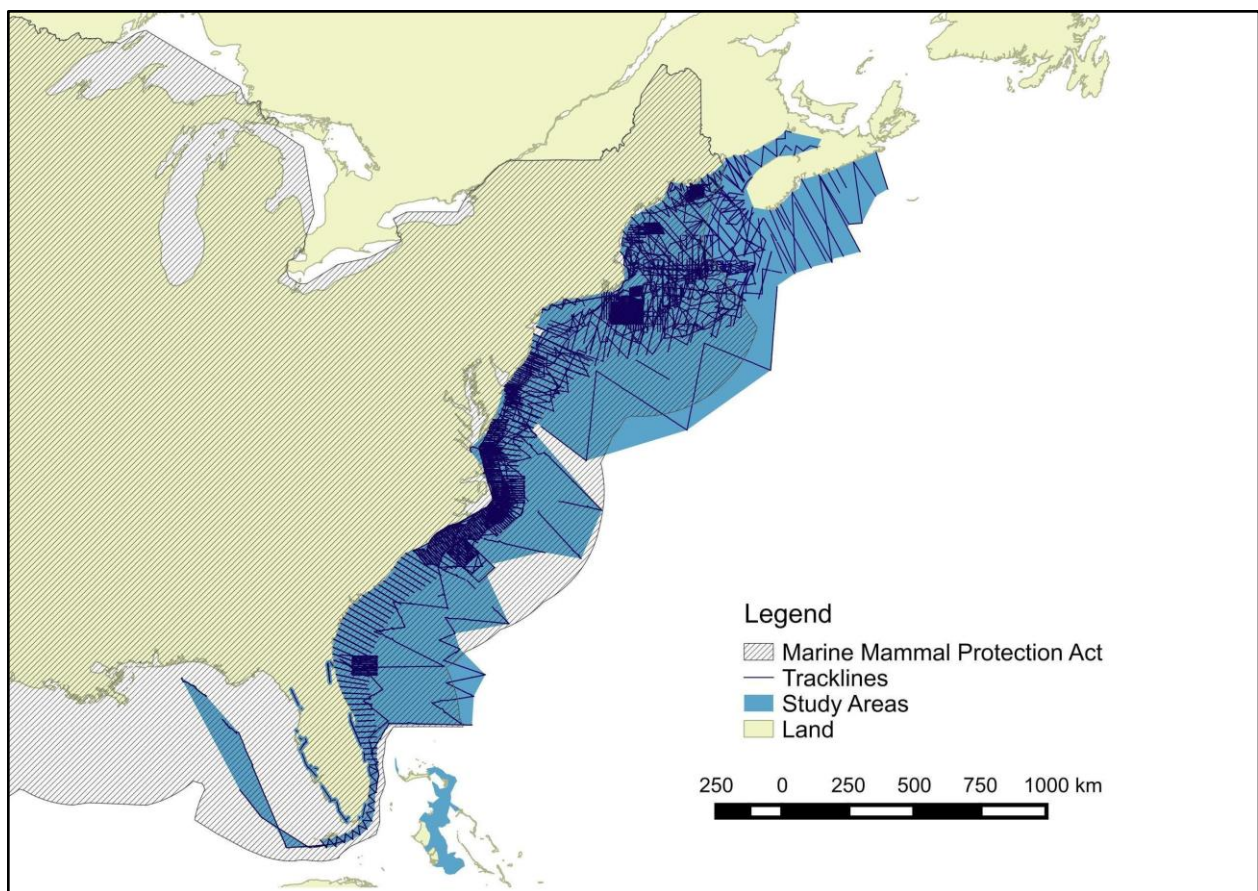
**Figure 6** Coral EFH, EFH-HAEC and Submarine Cables

The East Coast is surrounded by Essential Fish Habitats (regardless of an additional HAPC classification) are present in a considerable part of the desired bathymetric depth where the cable should be buried. This phenomenon is exemplified along the coast of North and South Carolina, as shown by Figure 6. While this leads to

environmental impact concerns, it is crucial to note that various existing submarine cables intersect the three coral layers in the map. This suggests that there is a method to burying submarine cables in Coral Habitat Areas. Nevertheless, guaranteeing the continuity of the natural lifecycle without great interferences will certainly require a deeper analysis by experts in localized marine biodiversity.

## Mammals

The habitat of some mammals was also considered as a variable to minimize the environmental impacts of the offshore HVDC cable. Their distribution through the US Atlantic Zone is presented below (Figure 7). All three layers cover the entire East Coast, which means that the cable will necessarily intercept those areas, if installed. This implies that the submarine cables presented in Figure 6 also cross those areas.



**Figure 7** Marine Mammals Study Areas and Tracklines

## Migratory Behavior

Migration is also an important phenomenon that should be considered in the analysis of the whole environmental impacts that might be caused by cable placement. This subsection highlights the existent EFHs of Highly Migratory Species in the East

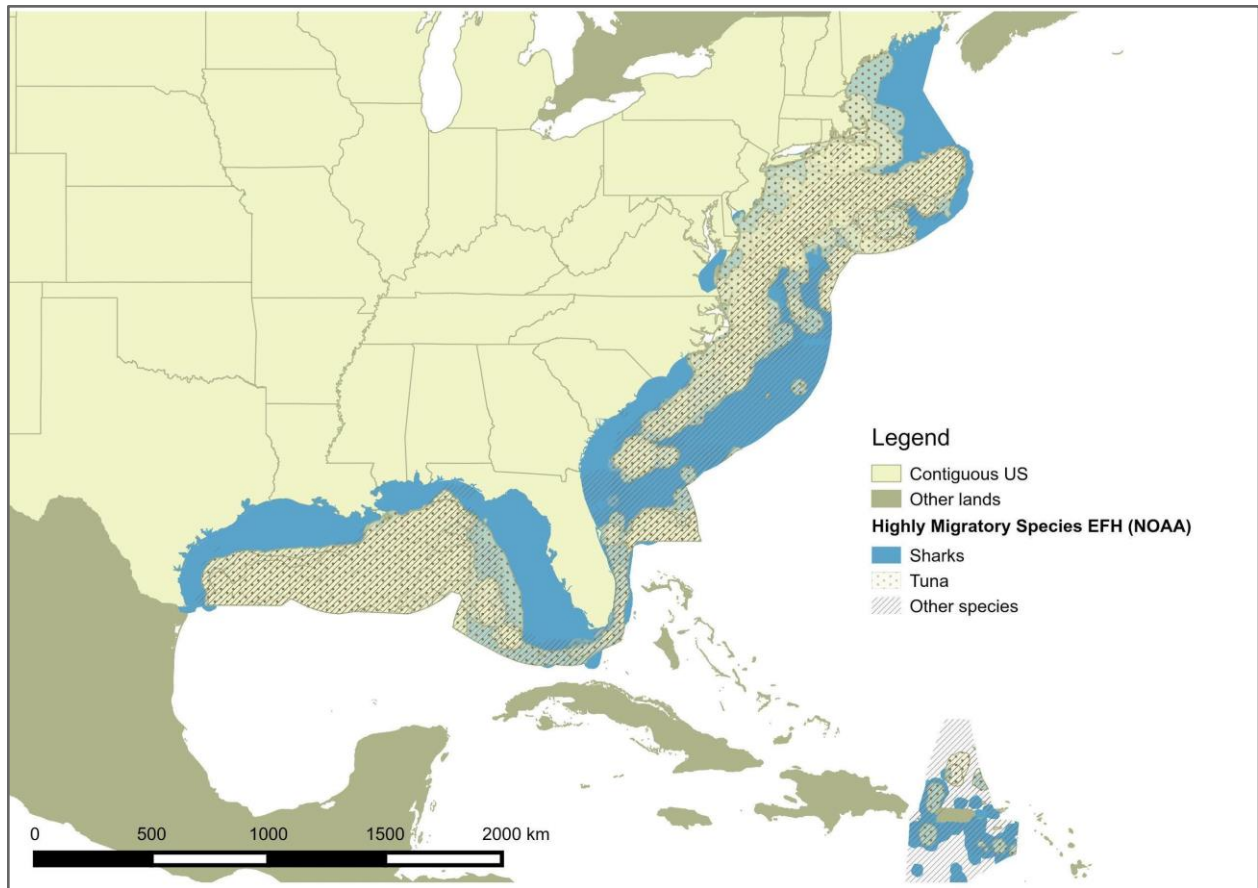
Coast of the United States, according to data available from NOAA (Figure 8). Most of these species are sharks<sup>19</sup> and tunas<sup>20</sup>; all other species were included in a third group termed “other species” and include: Longbill Spearfish, White Marlin, Sailfish, Swordfish and Blue Marlin.

All areas considered ideal for the cable burial in terms of the chemo-physical conditions is traversed by Highly Migratory Species EFH, especially by sharks. However, the fact that the circulation of those species roughly throughout the entire U.S. East Coast did not impeach the development of other offshore energy and infrastructure projects might be considered in the assessment of the feasibility of this project. What Figure 8 should tell us is an alert that the burial must take place in a careful manner, considering the seasonal routes commonly traced by those species.

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<sup>19</sup> The species of sharks included in this report are those available in NOAA GIS dataset on Highly Migratory Species: Caribbean Reef Shark, Common Thresher Shark, Dusky Shark, Finetooth Shark, Great Hammerhead Shark, Lemon Shark, Longfin Mako Shark, Oceanic Whitetip Shark, Night Shark, Nurse Shark, Porbeagle Shark, Sandbar Shark, Sand Tiger Shark, Scalloped Hammerhead Shark, Shortfin Mako Shark, Silky Shark, Spin Shark, Tiger Shark, Whale Shark, White Shark, Atlantic Sharpnose Shark, Bigeye Thresher Shark, Basking Shark, Bignose Shark, Blacknose Shark, Blacktip Shark, Angel Shark, Blue Shark, Bull Shark and Bonnethead Shark.

<sup>20</sup> The species of tuna included in this report are those available in NOAA GIS dataset on Highly Migratory Species: Skipjack Tuna, Yellowfin Tuna, Bluefin Tuna, Albacore Tuna and Bigeye Tuna.



**Figure 8** Highly Migratory Species Essential Fish Habitats - East Coast

Overlaying the Bathymetry and the information presented above, it was possible clearly identify which species were present in the potential cable path. Few species of sharks have essential habitats outside of the desired bathymetric clarification:

1. Caribbean Reef Shark
2. Finetooth Shark
3. Lemon Shark
4. Nurse Shark
5. Whale Shark
6. Sandbar Shark<sup>21</sup>
7. Spinner Shark
8. White Shark
9. Atlantic Sharpnose Shark
10. Blacknose Shark
11. Blacktip Shark
12. Bull Shark
13. Bonnethead Shark

<sup>21</sup> Note in Appendix I that there is another layer referring to the same species and whose habitat also crosses the desired bathymetric area.



The aforementioned sharks only circulate through the Gulf of Mexico or in shallow waters near the coast. All other species inhabit or migrate through the area where the cable may be buried. The complete set of maps for each of the affected species can be found in Appendix I.

#### **IV. Anthropological aspects**

Aside from Biodiversity and Chemo-physical aspects, it is important to observe the anthropological structures and activities that are present in the proposed placement area. This can include sea traffic, fisheries, and infrastructure. All of which are described below.

##### *Traffic*

Cables are usually buried under a safe depth in the seabed. However, seabed erosion and movements in the water can gradually expose the buried cable. Human activity can further accelerate this process through anchorage and trawling. Exposed cables can be dangerous in specific situations, e.g. they could possibly snag a ship's hook and cause it to capsize. Therefore, identifying areas of high shipping traffic is important to proactively plan safer routes for the cable placement. The following subsections describe in detail each of the variables that were considered in the identification of critical areas regarding sea traffic.

##### *Shipping lanes*

The shipping lanes are defined as routes regularly adopted by ships, and are classified in the following seven categories. (1) Precautionary Areas are those in which is important to navigate with caution; (2) Speed Restriction Areas are areas in which the speed is seasonally reduced because of endangered species; (3) Particular Sensitive Areas are those endangered by international maritime traffic; (4) Shipping Safety Fairways are areas in which artificial structures are prohibited; (5) Areas to be Avoided, which are characterized as such because of hazardous navigation; (6) Recommended Routes should be chosen by ship for safety reasons; (7) Traffic Separation Schemes/Traffic Lanes define specific traffic flow or assist opposing streams of marine traffic.<sup>22</sup>

Recommended routes are only found close to Long Island and along the coast of Maine coast, yet Speed Restriction Areas are the predominant shipping lane category in the Eastern Atlantic. States in which this category can be found include: Georgia, South Carolina, parts of North Carolina Coast, the Northern Coast of Florida, specific points in

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<sup>22</sup> Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Office of Coast Survey (OCS). *FGDC Content Standard for Digital Geospatial Metadata*. 2015. [http://gis.charttools.noaa.gov/ocs\\_metadata/public/fgdc/ship\\_fways\\_lanes\\_zones\\_us\\_waters.xml](http://gis.charttools.noaa.gov/ocs_metadata/public/fgdc/ship_fways_lanes_zones_us_waters.xml)

Long Island (NY), Virginia, Delaware, New Jersey, Connecticut, and Massachusetts. All shipping lanes are to be avoided by cables to the greatest extent possible.

### *Ports and Deepwater Ports*

Ports were georeferenced using newly created methodology,<sup>23</sup> while similar information for deep-water ports was found in a premade GIS dataset<sup>24</sup>. Deepwater ports are those located farther from the shoreline, in contrast to conventional ports. They are used to load and unload large ships, which often carry liquefied natural gas and oil. Ports are spread in a non-equidistant manner along the East Coast while Deepwater ports can only be found West of California and East of Massachusetts. Consequently, deep-water ports should be avoided by the cable burial path, which might be located with a significant distance from the coastline, while conventional ports should be avoided by the offshore-onshore connections that will join the offshore cable with the underground grid in the continent.

### *Anchorage Areas*

According to what is described by NOAA in the Metadata document, “An anchorage area is a place where boats and ships can safely drop anchor.”<sup>25</sup> Those areas are created if required to improve safe and responsible navigation. Additionally, there is a high potential for ship crowding in areas specifically created for anchorages, and as such must be avoided by the offshore grid and by the connections in order to prevent accidents involving ships and vessels. Figure 9 represents the information described above, and proves that the areas and structures described above are very close to the coast (except for the region between New Jersey and Massachusetts), where they might represent an obstacle for cable burial.

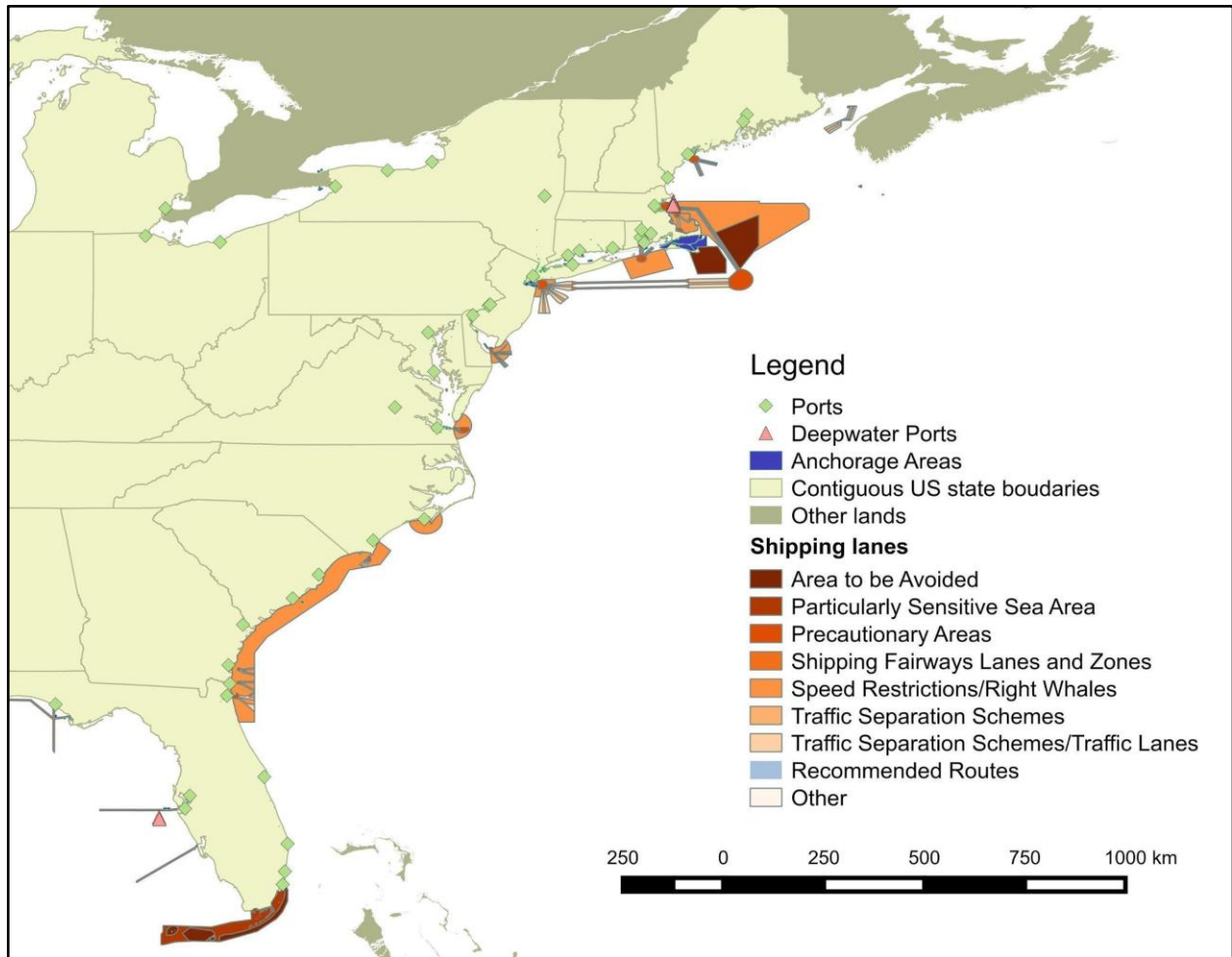
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<sup>23</sup> Ports Methodology is presented in Appendix II..

<sup>24</sup> NOAA (See GIS Data Bibliography for details).

<sup>25</sup>

<https://coast.noaa.gov/dataservices/Metadata/TransformMetadata?u=https://coast.noaa.gov/data/Documents/Metadata/harvest/MarineCadastre/AnchorageAreas.xml&f=html>

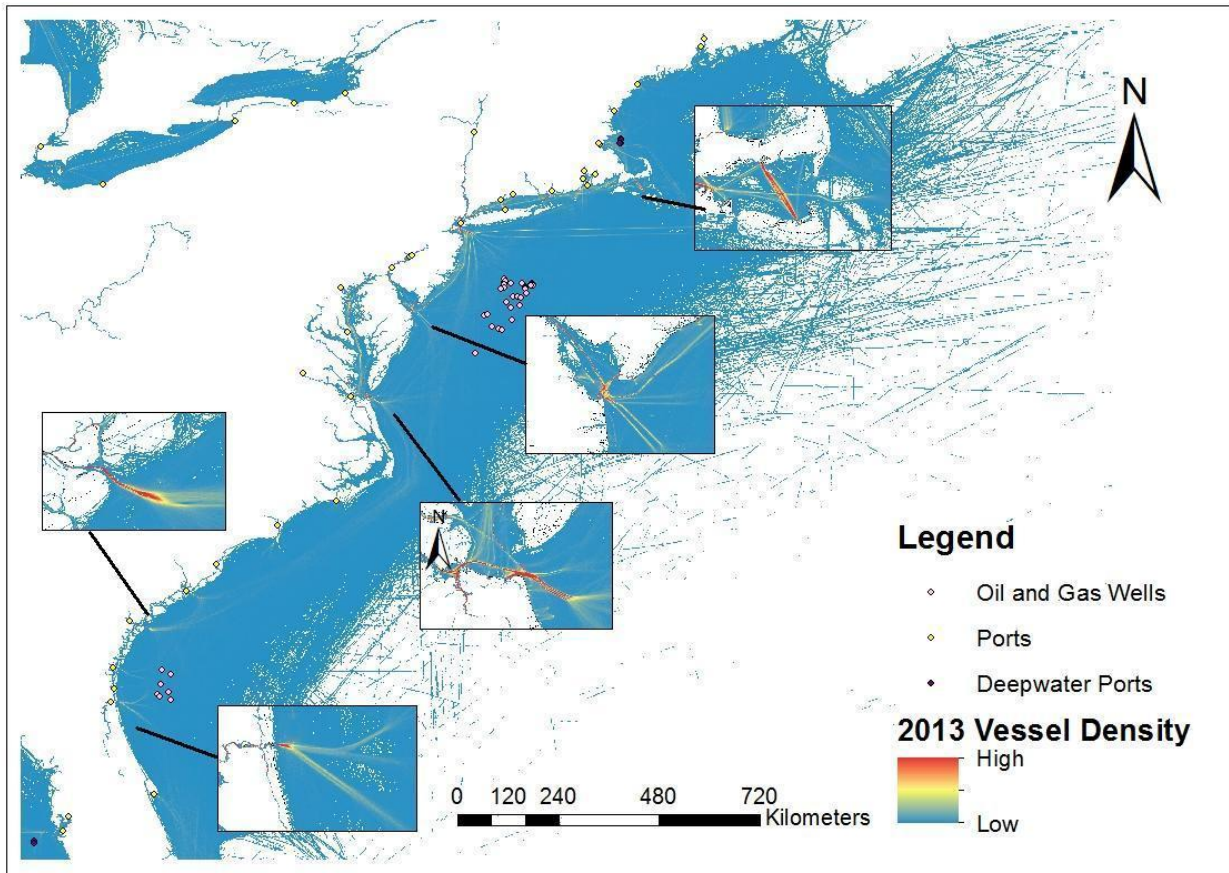


**Figure 9** Shipping Lanes, Ports and Deepwater Ports and Anchorage Sites

### *Vessel Density*

Vessel Density along the East Coast was also included in the analysis. This dataset represents 2013 annual vessel traffic density for the contiguous United States offshore waters based on Automatic Identification System (AIS) monitoring.<sup>26</sup> This comprehensive density map that includes all types: cargo, fishing, passenger, etc. The high to low density scale in the following figure shows the traffic concentration, but not actual vessel counts. It can be observed that high vessel density is likely to occur around ports and narrow channels. Cable placement should purposely avoid high vessel density areas to prevent the cable from external vessel damage and ensure a safe installation.

<sup>26</sup> NOAA Office for Coastal Management. *FGDC Content Standard for Digital Geospatial Metadata*. Charleston, SC: NOAA, 2015. <https://coast.noaa.gov/dataservices/Metadata/TransformMetadata?u=https://coast.noaa.gov/data/Documents/Metadata/harvest/MarineCadastre/VesselDensity2013.xml&f=html>.



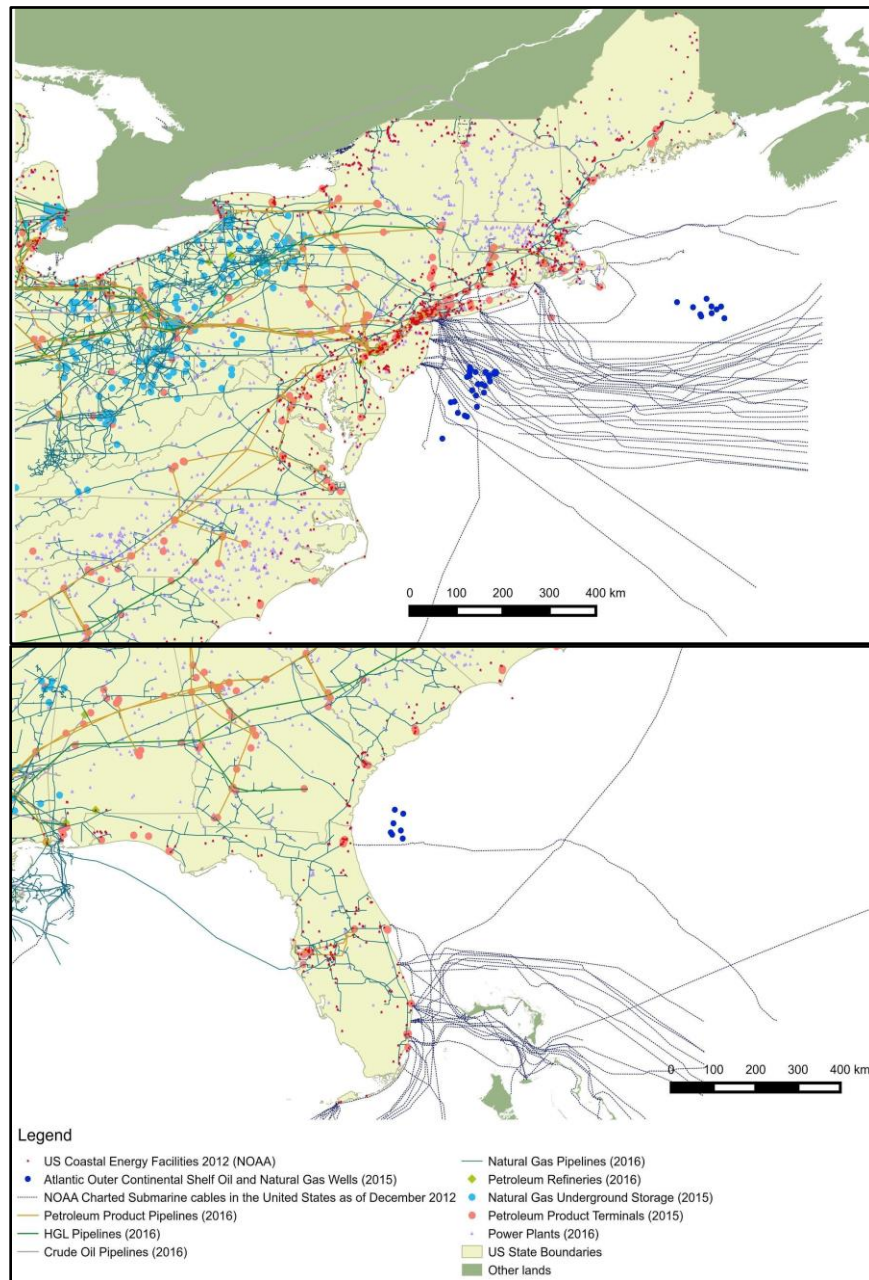
**Figure 10** Vessel density for the year 2013

### Electrical and other energy-related infrastructure

Oil and gas wells were considered in this section, which data was published in 2015 but data collection happened from 1975 to 1984. Data regarding petroleum product pipelines, product terminals, refineries, power plants and points of underground storage were collected for EIA. Finally, Coastal Energy Facilities (data collected from Bureau of Ocean Energy Management NOAA) and preexisting submarine cables (pictured in Figure 6) were also accounted for in this sub-section. Figure 11 presents these components in the same map and will be considered in the final suggested route for cable burial.

An obvious component of Figure 11 Firstly is that cables seem to intersect each other. Thus, the cables are not a primary concern, but it is still important to know where other cables are placed, what type of cables they are, as well as the party(ies) responsible for them. Secondly, wells are an important obstacle for the burial because their structure is built to extract material from the ground, obstructing the underground area where the cable should be placed. Finally, the locations of power plants and coastal energy facilities are an important issue due to the thermoelectric cooling procedures often applied during energy production. Water returned to the system is

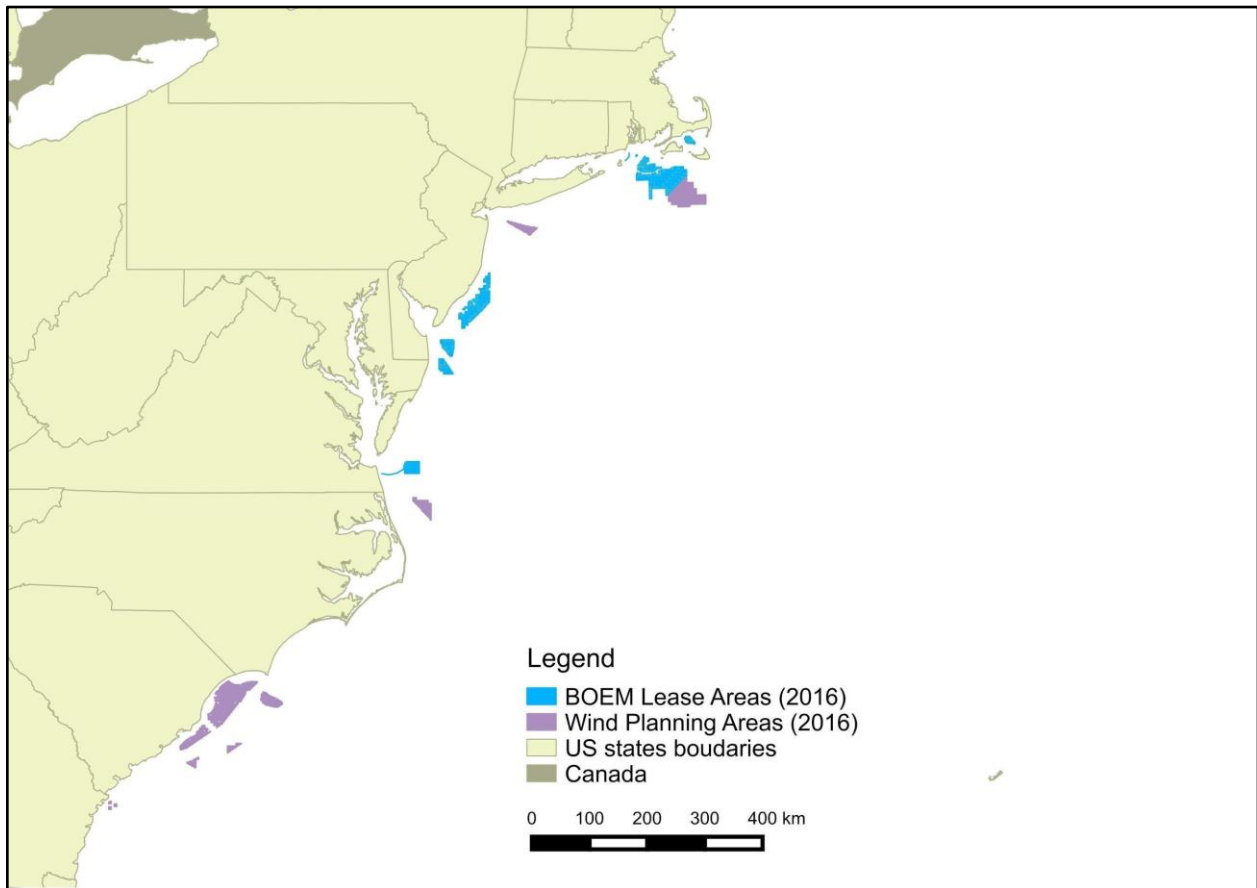
often much warmer than the ambient environment. This could represent a risk to heat dissipation during cable operation, depending on how quickly water temperature drops once again as depth increases.



**Figure 11** Coastal Energy Facilities, Oil and Gas Wells, Pipelines, Power Plants, Petroleum Product Terminals and Petroleum Refineries and Natural Gas Underground Storage

*Renewable Energy infrastructure*

Another important issue to consider is existing renewable energy infrastructure. Wind planning zones and renewable energy leases, published by Bureau of Ocean Energy Management (BOEM), are presented in the map below (Figure 12). Wind planning areas are those for which there are announcements made within the US Federal Register, meaning those areas “are being considered for wind power development,”<sup>27</sup> while renewable energy leasing areas includes the current leases and grants regarding renewable sources<sup>28</sup>. These renewable energy production areas are supposed to be connected to the grid, however, cables may not yet pass through them. Nevertheless, such variables are supplemental in nature and must be evaluated at the time of construction.



**Figure 12** Wind Planning Areas and Active renewable energy leasing areas on the Atlantic OCS

<sup>27</sup> “Wind Planning Areas Shapefile”, Bureau of Ocean Energy Management (BOEM), Accessed October 31, 2016, <http://www.boem.gov/Wind-Planning-Areas/>.

<sup>28</sup> “BOEM Lease Areas Shapefile”, Bureau of Ocean Energy Management (BOEM), Accessed October 31, 2016, <http://www.boem.gov/BOEM-Lease-Areas-Metadata/>.

Finally, disposal sites, military installations, unexploded ordnates and wreck, and obstruction were also analyzed regarding the scenarios presented in the following section. Although these areas were not visualized in their own respective maps, it is important to state that many of them are already crossed by existing submarine cables, which decreases the relevance of those elements as a real concern for the cable burial.

## V. Offshore grid placement

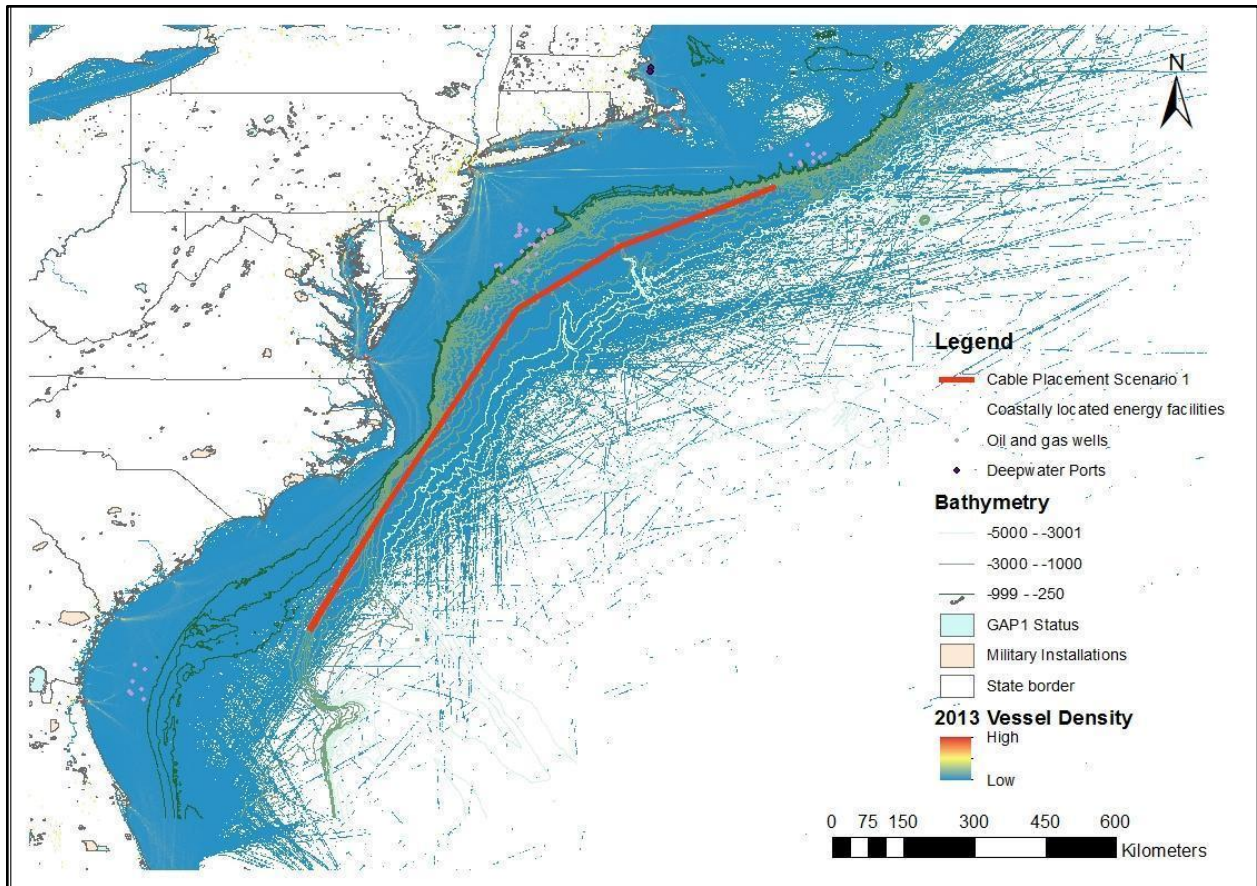
To map potential zones for cable placement, determining factors from chemo-physical, biodiversity, and anthropological aspects were classified into three categories: primary concerns, secondary concerns, and supplementary concerns. Primary concerns are defined as factors that the cable placement must comply with exception. Secondary concerns are factors that the cable placement should avoid if possible. Supplementary concerns are factors that the project developer can choose to avoid to lower the risk. Subsequently, three scenarios were built based on this classification. The final decision on the cable placement will likely to be a compromise between results from this feasibility analysis and financial evaluation.

### Scenario A: Primary considerations

**Table 1** Primary concerns for cable placement

Bathymetry	Optimal water depth to place is between 1000~3000m
Sediment thickness	Optimal seabed depth to bury is at least 1m.
Deepwater ports	Must avoid existing construction.
Military installations	Must avoid existing construction.
Oil and gas well	Must avoid existing construction.
Coastal energy facilities	Must avoid existing construction.
GAP status 1	Permanent protection from land cover conversion.

There are 7 determining factors that fall under primary concerns (Table 1). The optimal water depth for cable placement is between 1000~3000m. This region is delineated by medium green in Figure 13. Since the sediment is consistently thick (>135m) along the East Coast, potential cable placement zone will automatically satisfy the optimal bury depth requirement. Main constructions the cable must avoid are deep-water ports, military installations, oil and gas wells, and coastal energy facilities. Meanwhile, it is also essential for the cable to keep away from GAP status 1 protected areas. A potential cable placement route is drawn in Figure 13 for Scenario A. Note that it only shows a portion of the entire route. Depending on the exact location of offshore-onshore connections, this cable placement line is supposed to be modified to link to the land.



**Figure 13** Scenario A: Primary considerations cable placement

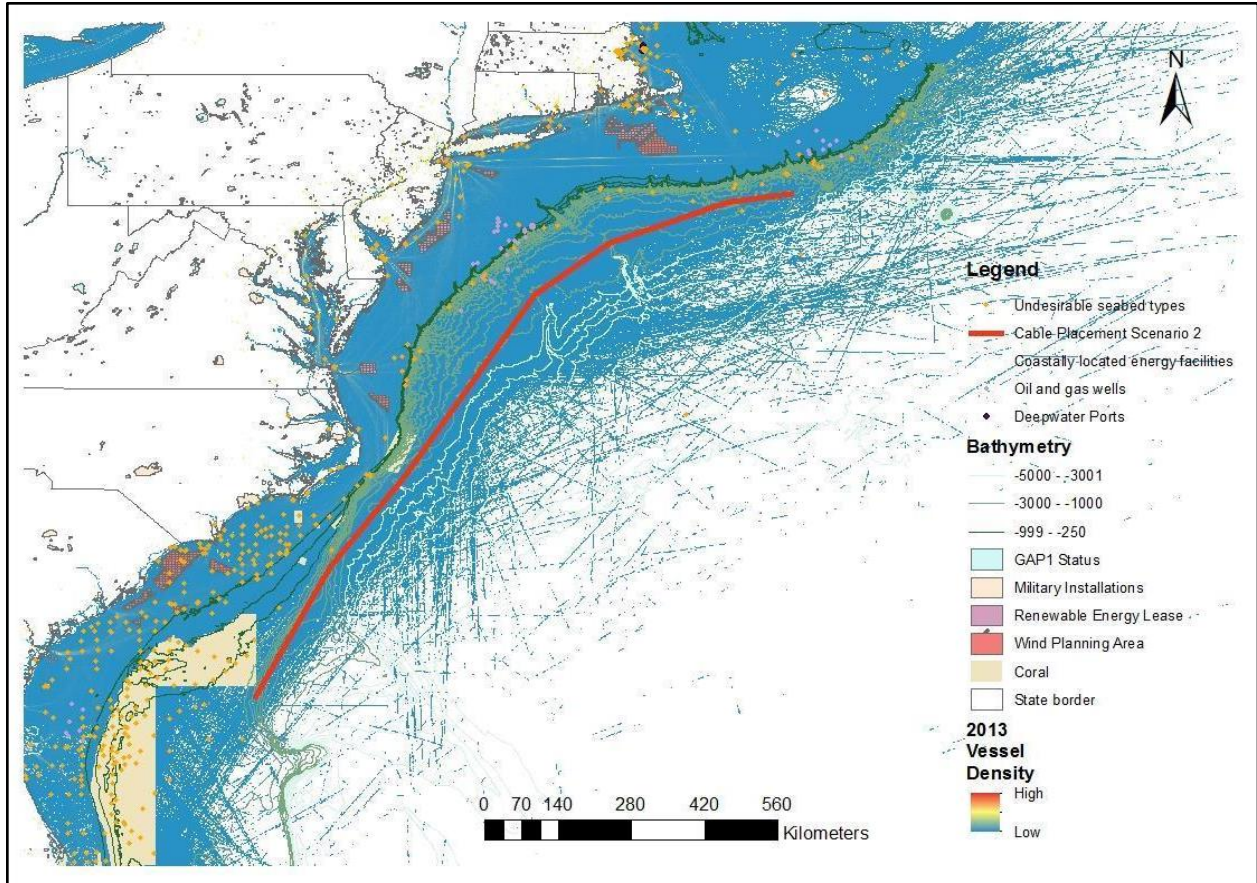
**Scenario B: Primary and Secondary considerations**

**Table 2** Secondary concerns for cable placement

Seabed type	Avoid hard seabed bottom if possible.
Vessel density	Avoid high vessel density area if possible.
Wind planning zone	Avoid planning zone if possible.
Renewable energy lease	Avoid lease zone if possible.
Coral	Avoid deep-water HAPC Coral zone if possible.

Five determining factors fall under secondary concerns (Table 2). It will be optimal if the project developer can find a route that avoid high vessel density, wind planning zone, renewable energy lease, hard seabed bottom, and deep-water HAPC coral zone, additionally to primary concerns. As can be seen in Figure 14, the new cable placement route is farther away from the shoreline compared to that in Scenario A mostly due to protected coral zone and undesirable seabed area.





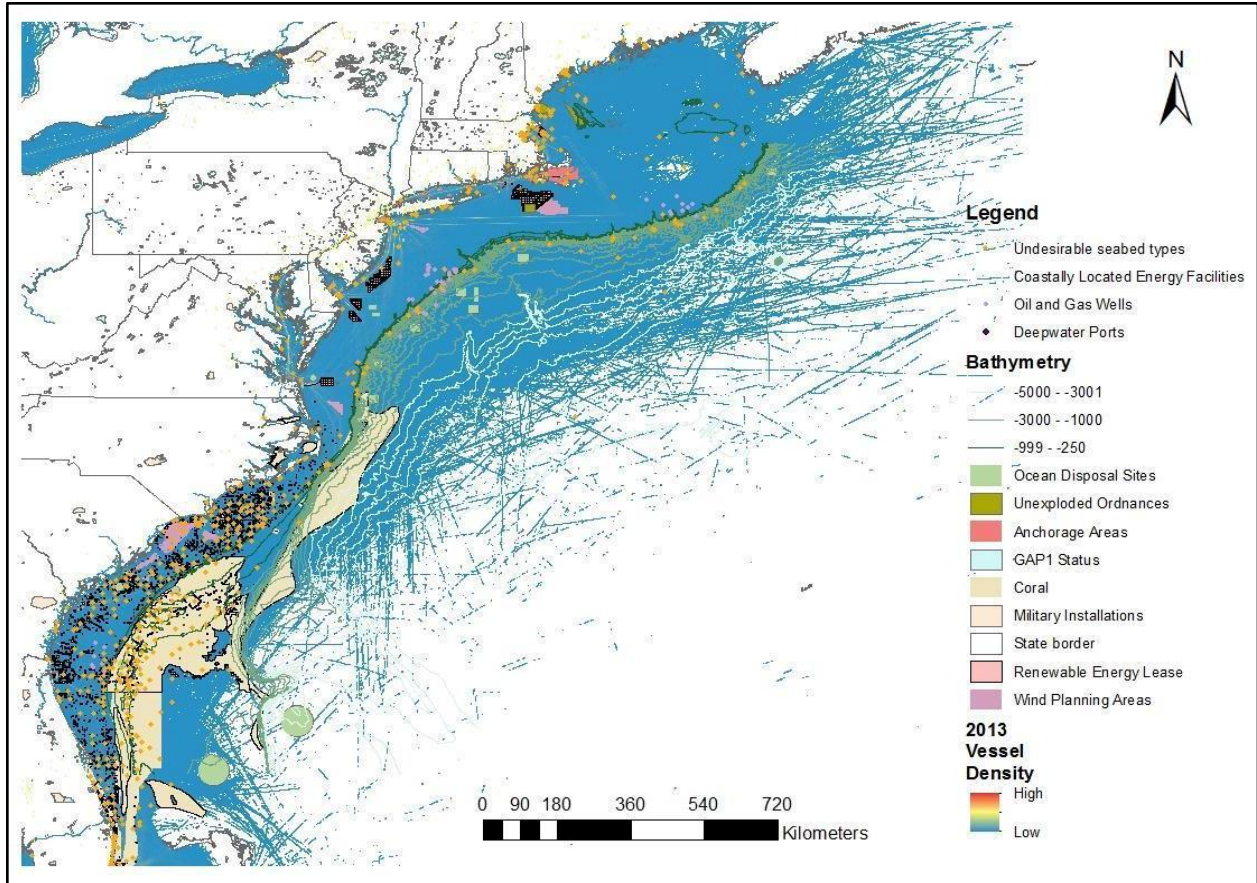
**Figure 14** Scenario B: Primary and Secondary considerations cable placement

**Scenario C: Supplemental factors**

**Table 3** Supplementary concerns for cable placement

Expanded coral	Choose to avoid coral EFH and EFH HAPC.
Anchorage Area	Choose to avoid anchorage area.
Disposal Sites	Choose to avoid disposal sites.
Unexploded ordnance	Choose to avoid unexploded ordnance.

Four determining factors are considered supplementary concerns (Table 3). Whenever possible, the project developer might choose to avoid anchorage area, disposal site, unexploded ordnance zone, and coral EFH/EFH HAPC zone to lower the risk of cable damage and reduce project environmental impacts. Figure 15 depicts the plus supplementary scenario with all determining factors included.



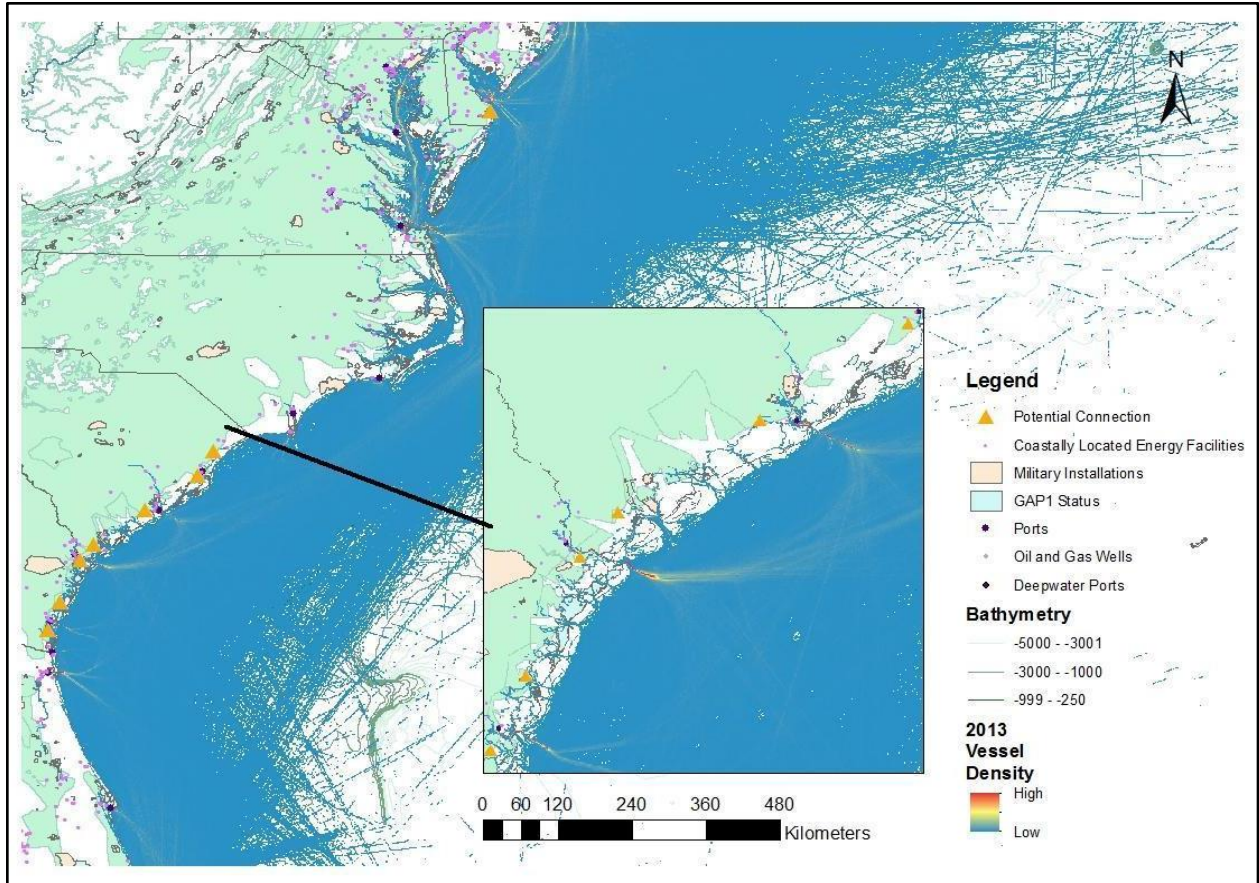
**Figure 15 Scenario C: Supplementary considerations**

## VI. Potential spots for offshore-onshore connection

Having set the possible paths that could be tracked by the cable, another important matter that must be verified is the feasibility of building connections between the offshore cable and the onshore underground grid. To assess the environmental conditions, military installations, coastal energy facilities, oil and gas wells, ports and deep-water ports, high vessel density<sup>29</sup>, as well as GAP status 1 protected areas<sup>30</sup> were avoided. The area in light green symbolizing usable soils with at least a four-foot depth to the bedrock were considered priority as a favorable aspect to the offshore-onshore connection placement. Based on that, some spots are suggested as potential locations. The following images present the most favorable location in the Southeast and Northeast Coast respectively.

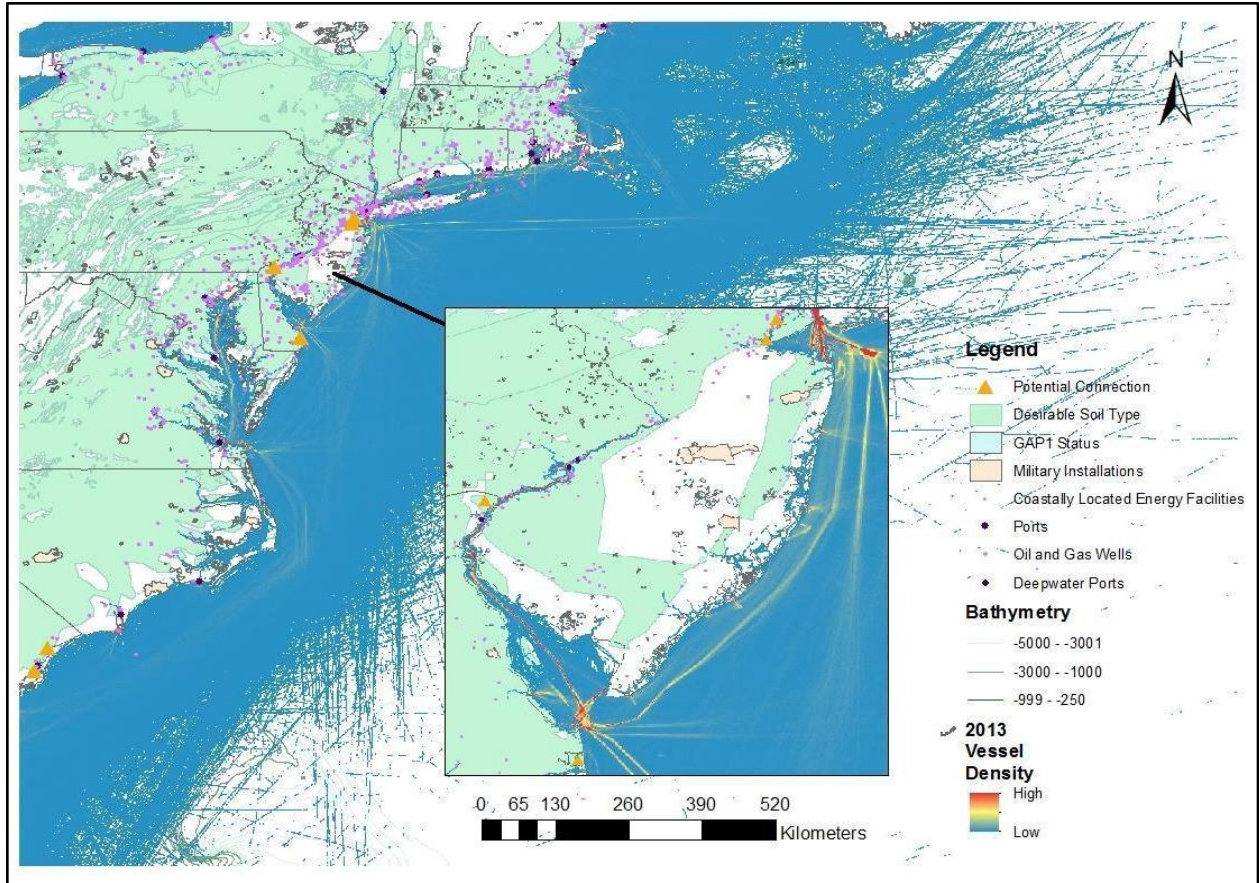
<sup>29</sup> This variable as well as all the previously mentioned were discussed in the section "Anthropological Aspects".

<sup>30</sup> Previously discussed in the section "Biodiversity Aspects".



**Figure 16** Offshore-onshore Connections - Potential Spots in the Southeast Coast

Regarding the three southernmost points, located in the state of Georgia, it is also important to highlight they are placed in an area that seems to be a wetland and thus should be further carefully analyzed. The following image shows the satellite image of Georgia's Coast. A large area in brown close to the coast might indicate the presence of this wetland. Finally, the three spots that are suggested for the Northeast Coast are in Delaware and New Jersey and presented in orange below.



**Figure 17** Offshore-onshore Connections - Potential Spots in the Northeast Coast

## VII. Conclusion

This report describes and analyses the feasibility of an offshore portion of the HVDC grid in the East Coast of the United States. By collecting all the publicly available data and analyzing the distribution of those variables in a geo-referred manner, and considering the way existing cables interact with those that were considered relevant variables, this study pinpoints a technically feasible path for the placement of the proposed cable. In this respect, the inshore-offshore connections are an important element that corroborates the feasibility of the Clean and Secure Grid.

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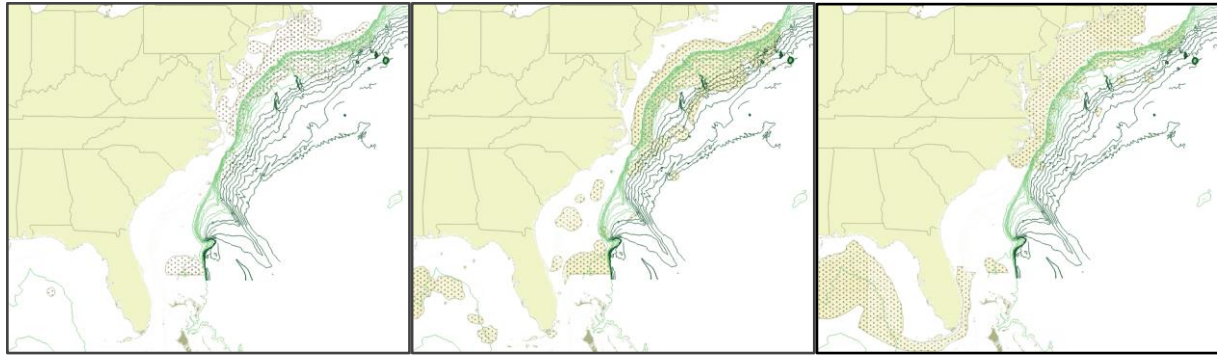
Global Soil Regions [GIS] Paul Reich, USDA-NRCS & FAO-UNESCO,  
[http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/?cid=nrcs142p2\\_054013](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/?cid=nrcs142p2_054013)  
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## **Appendix I: Highly Migratory Species Potentially Affected by HVDC Cables**

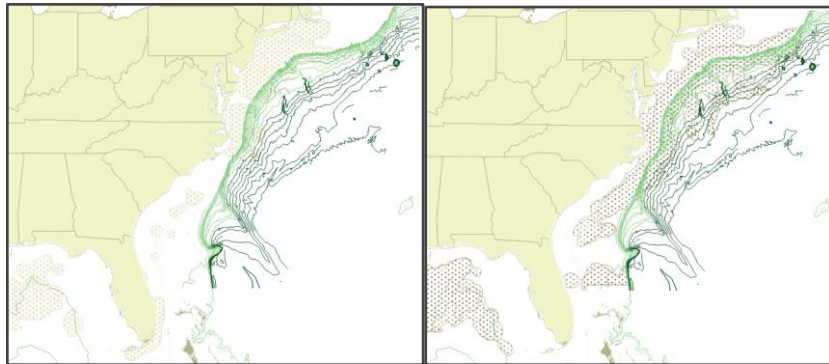
### **A. Tunas HMS**



Albacore Tuna

Bigeye Tuna

Bluefin Tuna



Skipjack Tuna

Yellowfin Tuna

**Legend**

Contiguous US

Other lands

**Highly Migratory Species EFH (NOAA)**

Sharks

Tuna

Other species

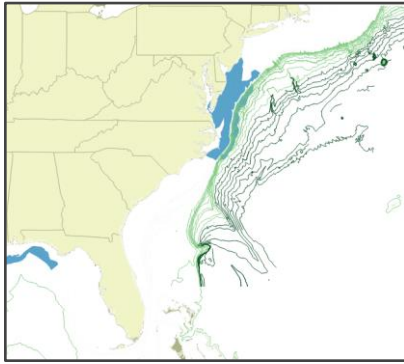
**Bathymetry**

more than 3000

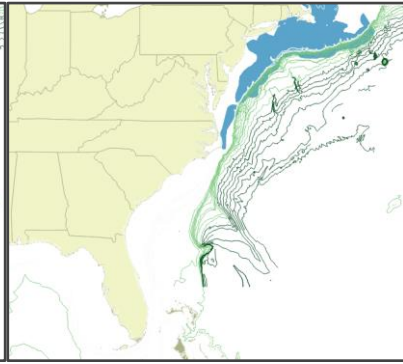
1000 - 3000

up to 1000

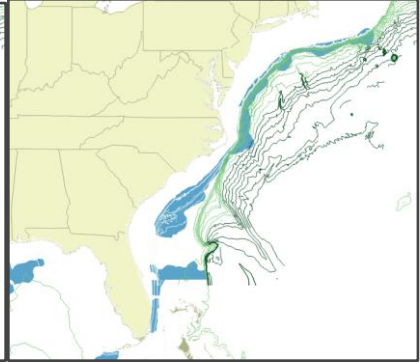
**B. Sharks HMS**



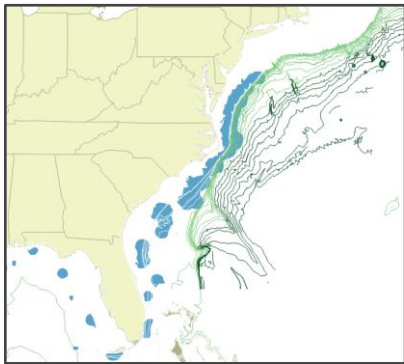
Angel Shark



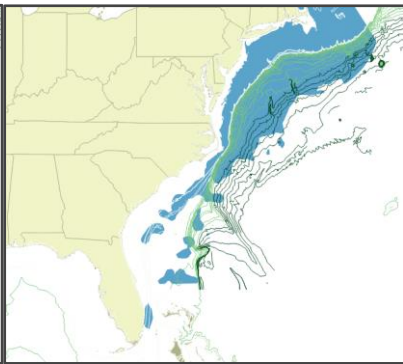
Basking Shark



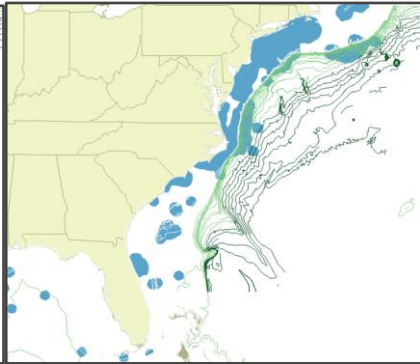
Bigeye Thresher Shark



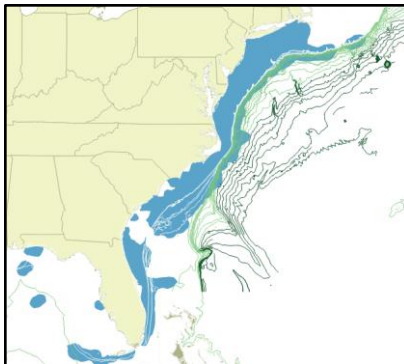
Bignose Shark



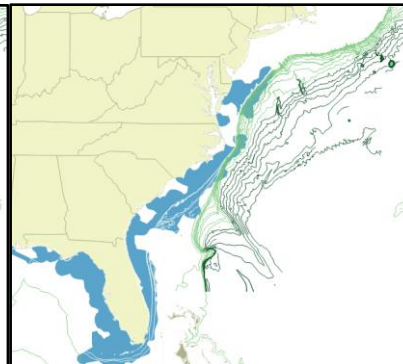
Blue Shark



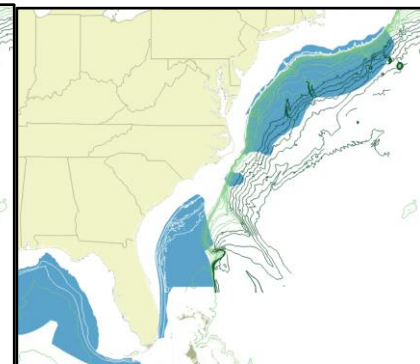
Common Thresher Shark



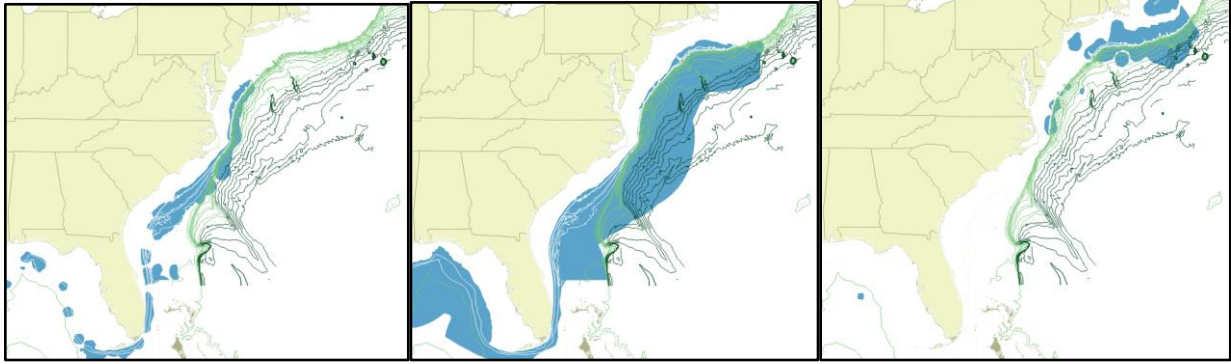
Dusky Shark



Great Hammerhead Shark



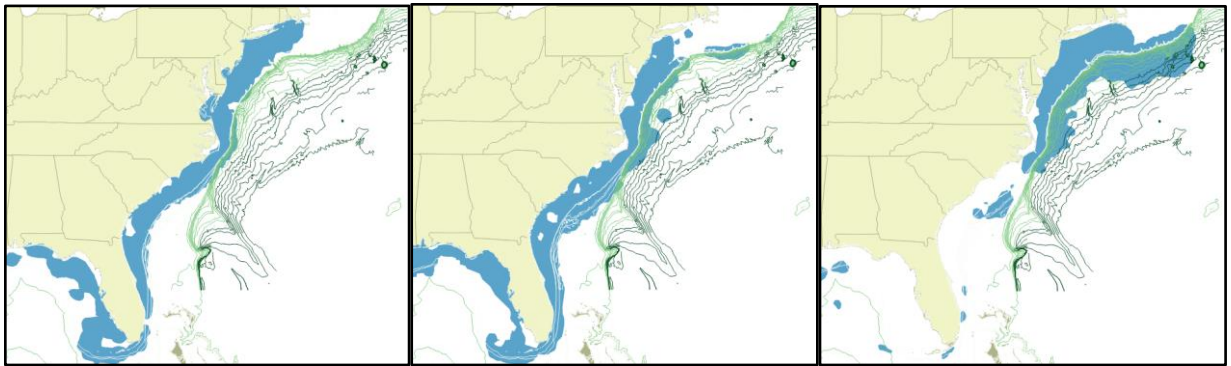
Longfin Mako Shark



Night Shark

Oceanic Whitetip Shark

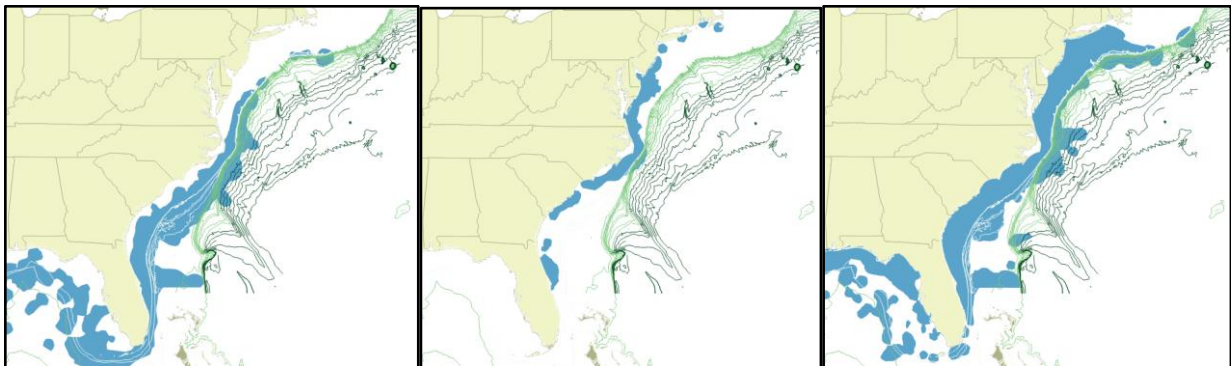
Porbeagle Shark



Sandbar Shark

Scalloped Hammerhead Shark

Shortfin Mako Shark



Silky Shark

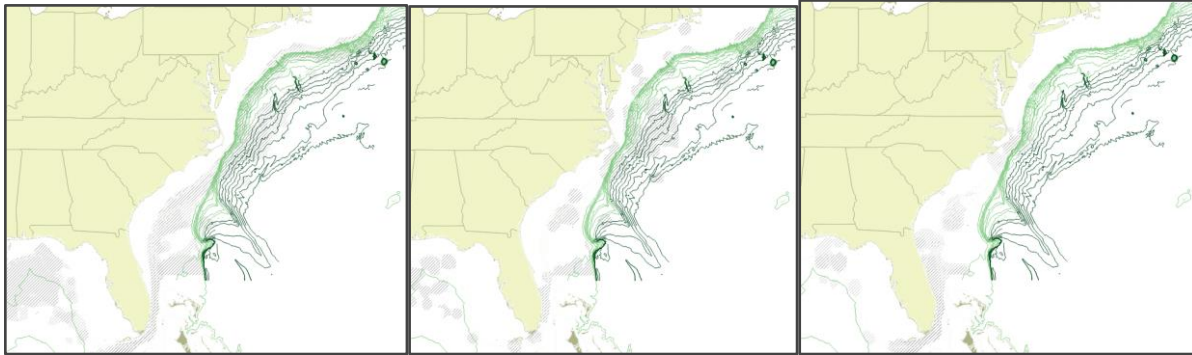
Tiger Shark

Tiger Shark

**Legend**

- Contiguous US
- Other lands
- Highly Migratory Species EFH (NOAA)**
- Sharks
- Tuna
- Other species
- Bathymetry**
- more than 3000
- 1000 - 3000
- up to 1000

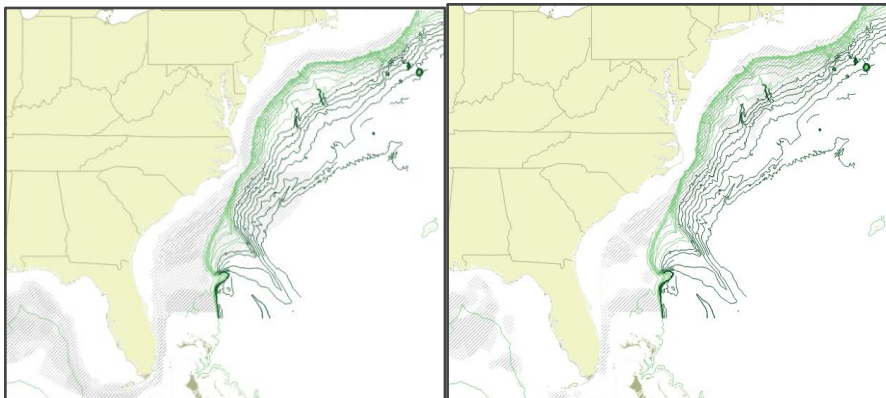
### C. Other HMS Species



Blue Marlin

Longbill Spearfish

Sailfish



Swordfish

White Marlin

#### Legend

Contiguous US

Other lands

#### Highly Migratory Species EFH (NOAA)

Sharks

Tuna

Other species

#### Bathymetry

more than 3000

1000 - 3000

up to 1000



## **Appendix II: Ports Methodology**

The ports were georeferenced using the database “2013 - 2015 Vessel Calls in U.S. Ports and Terminals” from the US Department of Transportation. The data contained “a calculation of vessel calls for privately-owned, oceangoing merchant vessels of all flags of registries over 1,000 gross tons (GT) calling at ports and selected ports/terminals within the contiguous United States, Hawaii, Alaska, Guam and Puerto Rico.” Based on the list of ports in the database, each of those ports were manually searched on Google Maps using the name. The location found was verified using the state in which the port is located, to avoid gathering information from homonyms. Then, latitude and longitude were collected for 108 ports out of 110: the ports of El Segundo Offshore Oil Terminal (CA) and Yabucoa (PR) could not be found. The coordinates then was used in order to plot the respective points into the map.