

Memorandum – Coastal Engineering Review

Summary of Geologic Resources Inventory (GRI) Support Documents: Biscayne National Park (BISC)

February 2026

Review Request Summary

The Geologic Resource Inventory (GRI) is one of 12 baseline natural resource inventory efforts within the National Park Service (NPS) Inventory and Monitoring (I&M) Division. The GRI is a cooperative effort among the NPS, Colorado State University, and the University of Alaska Fairbanks. It strives to advance science-based management of natural resources in the national parks and raise awareness about geology and the role that geologic features and processes play in the environment.

The GRI team, working closely with a variety of partners, provides each of the approximately 270 parks in the I&M networks with a geologic scoping meeting, digital geologic map data and poster, and a park-specific geologic report. These products are designed to enhance stewardship of park resources by providing valuable information about geologic formations, processes, hazards, and links among geology, history, and other natural resources. The National Park Service identified 13 coastal parks that have geologic scoping meeting summaries and at least one digital geologic map, but do not have a traditional GRI report: Biscayne National Park (BISC), Cape Cod National Seashore (CACO), Canaveral National Seashore (CANA), Castillo de San Marcos National Monument (CASA), Cumberland Island National Seashore (CUIS), Fire Island National Seashore (FIIS), Fort Caroline National Memorial (FOCA), Fort Frederica National Monument (FOFR), Fort Matanzas National Monument (FOMA), Fort Pulaski National Monument (FOPU), Fort Sumter and Fort Moultrie National Historical Park (FOSU), Gateway National Recreation Area (GATE), and Timucuan Ecological and Historic Preserve (TIMU). As of spring 2024, the GRI team is transitioning to a proposal-based system, and not all parks will receive a traditional report, including all 13 of the identified coastal parks. Many of these coastal parks were originally scoped in the early 2000s and have map products approaching or now exceeding 20 years old. Therefore, to provide a status update to the coastal parks in lieu of a traditional report, the GRI team requested assistance from EA Engineering, Science, and Technology, Inc., PBC (EA), with the following:

- Prepare park-specific literature reviews focused on geologic resources to provide data resource for future work
- Prepare a literature review of service-wide and regional resources that could be useful to multiple parks
- Evaluate available digital geologic map data for each park and assess its relevance to coastal management needs

Literature Reviews

Introduction

The literature review for each park consists of an Excel spreadsheet listing all identified sources and PDF files for each source. The spreadsheet includes a link that opens the associated PDF file directly. These files for Biscayne National Park can be downloaded from the NPS DataStore at:
<https://irma.nps.gov/DataStore/Reference/Profile/2317155>.

Methodology

To ensure consistency across parks, EA followed the steps below when searching for sources:

- Checked EA servers for project files already in EA possession or previously cataloged in literature reviews, annotated bibliographies, memorandum reference lists, and related materials.
- Reviewed the GRI Product Page (NPS 2024a) to identify GRI products previously compiled by the National Park Service for each park unit.
- Conducted an advanced search of NPS DataStore using the following methods:
 - In the Text Fields section, entered:
 - *Description* contains geolog*
 - OR *Title* contains geolog*
 - OR *Keyword* contains geolog*
 - In the Content Units section, entered the four-letter park unit code or selected it from the list.
- Completed a general Google search focused on scholarly articles. When results were excessive, searches were refined by applying a publication date cutoff of 2016 or 2017.
- Reviewed the following resources relevant to multiple parks:
 - Coastal engineering inventories of select parks (NPS 2013)
 - The NPS Paleontology Library, a repository for electronic copies of geology and paleontology publications, reports, and other media, including the following paleontological resource inventory types:
 - Park-specific Paleontological Resource Inventories (NPS 2024b)
 - Service-wide Thematic Paleontological Resource Inventories (NPS 2023a)
 - I&M Network Based Paleontological Resource Inventories (NPS 2023b)
 - Shoreline change project maps for 88 ocean and Great Lake park units (NPS 2022)
- Reviewed reference lists from reports already identified, particularly those that were comprehensive, relevant, and/or recently published.
- Used the following resource topics as a starting point for search terms (this list is not exhaustive, and additional terms were added based on park-specific topics):

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- | | |
|---------------------------|--------------------------------------|
| – Surficial features | – Saltwater intrusion |
| – Hydrogeomorphic map | – Sediment transport |
| – Unconsolidated deposits | – Hydrology and hydrogeology |
| – Storm impacts | – Nearshore/seafloor/benthic habitat |
| – Erosion | – Shoreline evolution |
| – Overwash | – Paleontology/fossils |
| – Breaches | – Land disturbance |
| – Inlet formation | – Seismicity |
| – Sea level rise | – Waves, currents, and tides |
| – Marshes | – Wind |

Spreadsheet Details

Column A, File Name: Each row in this column includes a unique filename identifier corresponding to a specific PDF file stored in the park folder. Each filename begins with the park four-letter identifier, followed by GRI, and then a sequential number (for example, FIIS GRI_001).

Column B, First-level Grouping: One of the following groupings was selected from the list below to best match the document scope:

- General/natural resources
- Geology
- Coastal processes/geomorphology
- Habitat
- Engineering

Column C, Date of Publication: This is provided separately from the citation for ease of review.

Column D, Citation: These use a modified APA-style format. Examples are provided below.

Example of a journal article:

Schwab, W.C., W.E. Baldwin, C.J. Hapke, E.E. Lentz, P.T. Gayes, J.F. Denny, J.H. List, and J.C. Warner. 2013. Geologic Evidence for Onshore Sediment Transport from the Inner Continental Shelf: Fire Island, New York. *Journal of Coastal Research* Volume 29, Issue 3: pp. 526–544.

Example of an agency report:

US Army Corps of Engineers. 2007. *Atlantic Coast of Long Island, Fire Island Inlet to Montauk Point, New York Storm Damage Reduction Reformulation Study, Work Order 28, Inlet Modifications*. US Army Corps of Engineers, New York District, North Atlantic Division. 493 pp.

Column E, Short Title/Access: This includes the document title or a shortened version of the title and is linked directly to the associated PDF file.

Column F, Literature Review Summary: This includes the document abstract (if sufficiently concise) or a brief summary describing the scope and contents of the document, with a focus on relevance to geologic resources.

Column G, Keywords: This includes three to five keywords based on review of the document or keywords identified in NPS DataStore.

Column H, Notes: This is optional and is used to provide additional information, such as whether appendices are included as separate files or entries in the literature review.

BISC Literature Review Summary

BISC protects one of the most extensive coral reef systems in the world and one of the longest stretches of mangroves on the East Coast. The literature review for this park includes 35 sources published between 1950 and 2022. EA developed keywords based on relevant coastal resources addressed in each source. These are provided in column G of the spreadsheet and include the following:

- | | | |
|-----------------------------------|---------------------------|------------------------|
| ▪ Airborne electromagnetic survey | ▪ Coastal species | ▪ Drainage |
| ▪ Erosion | ▪ Growth rates | ▪ Hydrologic modeling |
| ▪ Paleoecology | ▪ Diffusion | ▪ Sulfur diagenesis |
| ▪ Aquifer | ▪ Carbon storage | ▪ Deep well injection |
| ▪ Fisheries | ▪ Holocene | ▪ Mangroves |
| ▪ Paleontology | ▪ Saltwater intrusion | ▪ Tidal currents |
| ▪ Archaeology | ▪ Climate change | ▪ Development |
| ▪ Geochemistry | ▪ Human development | ▪ Marine resources |
| ▪ Precipitation patterns | ▪ Sea level rise | ▪ Tidal inlets |
| ▪ Biodiversity | ▪ Coral | ▪ Ecology |
| ▪ Geology | ▪ Hurricane activity | ▪ Mosquito ditches |
| ▪ Recreation | ▪ Sediment transport | ▪ Water table |
| ▪ Canal management | ▪ Contamination | ▪ Ecological stress |
| ▪ Groundwater | ▪ Hydrodynamics | ▪ Natural resources |
| ▪ Salinity | ▪ Soils | ▪ Waste disposal |
| ▪ Climate groundwater flow | ▪ Density dependent model | ▪ Environmental change |
| ▪ Salt water | ▪ Hydrology | ▪ Nutrients |
| | ▪ Stratotypes | ▪ Wildlife |

In addition to park-specific literature reviews, a review was completed that includes service-wide and regional resources that may benefit multiple parks. These resources include vulnerability assessment protocols, monitoring protocols, climate change inventories/impacts, sea level rise scenarios/evaluations, coastal hazard assessments, and mapping tools that provide data for all parks, among others. Although resources are ideally provided as PDF documents, some are only useful when accessed digitally (e.g., mapping data).

Research and data are continually being published. These literature reviews may not be exhaustive; however, they provide a foundation for understanding the range of geologic resources in each park, as well as relevant internal National Park Service guidance and resources. The methodology described above may be used for future searches to update information, if desired.

Geologic Map Assessment

Introduction

Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legends, and cross sections. Bedrock, surficial, and special purpose maps, such as coastal or geologic hazard maps, may be used by the GRI to create digital geographic information systems (GIS) data that meet park needs. These GIS data allow geologic information to be easily viewed and analyzed alongside other resource management information.

The GRI team compiled digital geologic maps for each of the 13 coastal parks: BISC, CACO, CANA, CASA, CUIS, FIIS, FOCA, FOFR, FOMA, FOPU, FOSU, GATE, and TIMU. As part of, and in parallel with, the GRI literature review process, EA assessed the relevance of the GRI GIS data sets (all available on the NPS DataStore; some exceeding 20 years old) to each park's current coastal management needs. This assessment was informed in part by EA's technical expertise and familiarity with NPS management requirements.

Methodology

This work was completed without the use of GIS software and instead relied on review of the GRI Scoping Meeting Summary and the GRI Ancillary Map Information document, both available on NPS DataStore. For each park, EA's assessment focused on answering the following questions about the GRI digital geologic map(s):

1. Are the source maps (i.e., the maps that GRI digitized to create the GIS data sets) comprehensive in terms of features relevant to the coastal park? If not, what gaps are there?
2. Are the source maps recent enough (relative to extreme storms, especially) to accurately represent the park's current configuration?
3. Does an online search yield any maps that are more relevant?

In addition to park-specific literature reviews, a review was completed that includes service-wide and regional resources that may benefit multiple parks. These resources include vulnerability and monitoring protocols, climate change inventories and impacts, sea-level-rise scenarios and evaluations, coastal hazard assessments, and mapping tools that provide data for all parks. Although resources are ideally provided as PDF documents, some are only useful when accessed digitally (for example, mapping data).

Research and data are continually being published. These literature reviews may not be exhaustive; however, they provide a basis for understanding the range of geologic resources in each park, as well as internal National Park Service guidance documents and resources that may be used. The methodology described above can be followed in future searches to update information, if desired.

BISC Map Assessment

The information summarized below is based on information presented in the *Biscayne National Park Geologic Resource Management Issues Scoping Summary* (Thornberry-Ehrlich 2005), the *Biscayne National Park GRI Ancillary Map Information Document* (NPS 2021a), and the NPS DataStore page data for the three BISC GRI maps produced by GRD. Information on the BISC GRI maps is presented in table 1.

The scoping meeting summary (Thornberry-Ehrlich 2005) identified a wide range of significant geologic resource management issues in BISC (table 2). Table 2 lists each of the groups in the first column and identifies which existing GRI map products address them. Where existing maps provide incomplete information, the data-gap column is also shaded.

Table 1. Summary of GRI Map Products for BISC

GRI Map Product	Citation	Data Layers	Sources
Digital Geologic-GIS Map	NPS 2021a	– Geologic Cross Section Lines (BISCSEC) – Surficial Sediment Contacts (BISCSTURA) – Surficial Sediments (BISCSTUR) – Geologic Contacts (BISCSTLGA) – Geologic Units (BISCSTGLG)	<i>Geologic units and their related contacts were produced from:</i> Scott, Thomas M., 2001, Geologic Formations of Florida (digital): Florida Geological Survey, Open-File Report 80, scale 1:126,720 (Geologic Formations of Florida). (GRI Source Map ID 3682). <i>Surficial sediment units and their related contacts were produced from:</i> Green, Richard, Campbell, Ken, and Scott, Tom, 1996, Surficial and Bedrock Geology of the western portion of the USGS 1:100,000 scale Homestead Quadrangle: Florida Geological Survey, Open File Map Series 83/08-12, scale 1:100,000. (Homestead (western portion) 1:100,000 scale Quadrangle (Surficial and Bedrock Geology)) (GRI Source Map ID 2424). Green, Richard, Campbell, Ken, and Scott, Tom, 1995, Surficial and Bedrock Geology of the eastern portion of the USGS 1:100,000 scale Homestead Quadrangle: Florida Geological Survey, Open File Map Series 83/01-07, scale 1:100,000 (Homestead (eastern portion) 1:100,000 scale Quadrangle (Surficial and Bedrock Geology)). (GRI Source Map ID 4983). <i>Image 2 (Surficial Sediments) from each source map was used. Geologic cross section lines were produced from the following sources (listed below), as well as from the Green et al. (1995) source map listed above as a source for surficial sediment units and contacts.</i> Causaras, C.R., 1986, Geology of the Surficial Aquifer System, Dade County, Florida: U.S. Geological Survey, Water-Resources Investigations Report 86, scale 1:136,000 (Surficial Aquifer System (Dade County)). (GRI Source Map ID 3056). Reese, R.S., and Cunningham, K.J., 2000, Hydrogeology of the Gray Limestone Aquifer in southern Florida: U.S. Geological Survey, Water-Resources Investigations Report 99-4213, scale 1:675,000 (Hydrogeology of the Gray Limestone Aquifer). (GRI Source Map ID 5320). <i>Mine point features were produced from the Green et al. (1995) source map listed above with sources for geologic cross section lines.</i>

GRI Map Product	Citation	Data Layers	Sources
Digital Benthic Habitat-GIS Map	NPS 2021b	– Benthic Habitat Units (BISCBEN) – Benthic Habitat Contacts (BISCBENA)	<i>Florida (GRI MapCode BISC_benthic_habitat) Benthic habitat units and their related contacts were produced from:</i> Florida Fish and Wildlife Commission Florida Marine Research Center, 1999, Benthic Habitats of Florida Bay, Florida 1991-1995, CD-ROM: National Oceanic and Atmospheric Administration Coastal Services Center, unpublished digital data, scale 1:48,000 (Benthic Habitats of Florida Bay). (GRI Source Map ID 5046).
Digital Geohazards Habitat-GIS Map	NPS 2021c	– Hazard Area Features (BISCHZA) – Hazard Area Feature Boundaries (BISCHZAA)	<i>Hazard area features (sink holes) and their related contacts were produced from:</i> Arthur, J.D., Baker, A.E., Cichon, J.R., Wood, A.R., and Rudin, A., 2005, Florida Aquifer Vulnerability Assessment (FAVA): Contamination Potential of Florida's Principal Aquifer Systems: Florida Geological Survey, Bulletin [in review], scale 1:24,000 (Florida Aquifer Vulnerability Assessment (2005)). (GRI Source Map ID 6921).

Table 2. Geologic resource management issues addressed in existing GRI map products

Geologic resource management issues	Digital Geologic-GIS Map	Digital Benthic Habitat-GIS Map	Digital Geohazards Habitat-GIS Map	Data gap
Hydrogeologic System of Biscayne Bay	X		X	
Benthic Habitats at Biscayne National Park		X		X
Inundation history and paleoconditions				X
Sediment Transport and Erosion				X
Karst Activity	X			X
Sea level rise				X
Disturbed lands				X
Active reefs and coral mapping				X
Recreational demands and resource restoration				X
Sediment thickness	X			
Urban development concerns				X
Soil characterization	X			
Palaeontologic inventory				X

Geologic Resource Management issues are provided in scoping meeting summary (Thornberry- Ehrlich 2005)

Are the source maps (i.e., the maps that GRI digitized to create the GIS data sets) reasonably comprehensive in terms of features relevant to the coastal park? If not, what gaps are there?

Several gaps exist in the GRI GIS datasets relative to the park geologic resource management concerns listed above. Management issues fully addressed by existing maps but with remaining data gaps include the hydrogeologic system of Biscayne Bay and sediment thickness and soil characterization. Issues partially addressed include benthic habitats at Biscayne National Park and karst activity. The remaining management issues—including inundation history and paleoconditions, sediment transport and erosion, sea-level rise, disturbed lands, active reefs and coral mapping, recreational demands and resource restoration, urban development concerns, and paleontologic inventory—are not addressed by existing map products.

GRD digitized seven source maps to create three GRI GIS datasets each covering (1) surficial sediment and geologic units with cross sections (“GRI Digital Geologic-GIS Map of Biscayne National Park and Vicinity, Florida”, table 1), (2) benthic habitats (“Digital Benthic Habitat-GIS Map of the eastern portions of Florida Bay (1991-1995 Substrate), Florida”, table 2), and (3) hazard sink holes (“Digital Geohazards-GIS Map of Biscayne National Park and Vicinity (2005 Mapping), Florida”, table 3). The extents of datasets (1) and (3) are identical and include all of BISC and the surrounding southeastern Florida region. Dataset (2), however, overlaps the southeast corner of Everglades National Park in eastern Florida Bay rather than BISC; therefore, benthic mapping of BISC is not included in the GRI GIS datasets.

The surficial sediment and geologic units shown in the GRI Digital Geologic-GIS Map of Biscayne National Park and Vicinity, Florida are listed below from youngest to oldest:

- d – Disturbed by human activity
- sm – Thin soil over Miami Limestone
- sk – Thin soil over Key Largo Limestone
- ma – Marl
- mp – Marl underlain by peat
- mu – Muck
- cm – carbonate mud
- Qh – Holocene sediments
- Qm – Miami Limestone
- Qk – Key Largo Limestone

The map also includes 16 geologic cross sections that identify aquifer systems.

The benthic habitat units associated with the GRI Digital Benthic Habitat-GIS Map of the eastern portions of Florida Bay (1991-1995 Substrate), Florida include classes such as land (“l”); reef/hardbottom and seagrass (“rh”); submerged aquatic vegetation (SAV), submerged rooted vascular plants (SRV), undifferentiated (“srv”); unconsolidated sediments, mud (“usm”); and others. However, the extent of the source map does not include BISC and is limited to Florida Bay.

The Digital Geohazards-GIS Map of Biscayne National Park and Vicinity (2005 Mapping), Florida identifies areas where aquifer systems are vulnerable to surface contamination based on surface geology and lack of confinement.

Are the source maps recent enough (relative to extreme storms, especially) to accurately represent the park’s current configuration?

The source maps are dated 1986, 1995, 1996, 1999, 2000, 2001, and 2005. Hurricane Andrews in 1992 and Hurricane Irma in 2017 both significantly altered portions of Biscayne National Park (NPS 2024d). As a result, the GRI GIS datasets may not accurately represent geologic conditions following Hurricane Irma.

Does an online search yield any maps that are more relevant?

According to the Biscayne National Park GRE Scoping Meeting Summary (2005), the USGS was using spectral color imaging and LIDAR, along with hand measurements and acoustic transects, to produce high-resolution maps of coral reefs in the Biscayne area. These methods substantially improve understanding of coral production, calcification, and overall benthic ecosystem health. An online search conducted in 2023 did not identify updates to this information.

The scoping meeting summary (2005) also notes that the NOAA Coral Ecosystem Mapping Team initiated efforts to form a federal and state coral reef task force to coordinate data-rich programs. Intended products included high-resolution benthic maps to support development of a hierarchical benthic habitat and structure classification scheme. Required inputs included high-resolution imagery, LiDAR, GPS measurements, seafloor habitat characterization, and an agreed-upon minimum mapping unit. Since 2005, NOAA has mapped more than 3,000 square kilometers of coral reef ecosystem in the Florida Keys. Additional areas of the south Florida coral reef ecosystem have been mapped by the Florida Fish and Wildlife Conservation Commission, several south Florida counties, the National Park Service, and the U.S. Fish and Wildlife Service (see links below).

The geologic framework of Biscayne National Park was investigated through core drilling along a northwest to southeast transect from Black Point to Pacific Reef. Seven sites were core drilled and monitoring wells installed as part of a ground-water characterization project (Reich et al. 2006). Cores descriptions were used to extend the onshore geologic aquifer framework seaward into Biscayne Bay.

Additional online GIS resources relevant to identified geologic resource management issues include :

- Biscayne Bay (S200) Bathymetric Digital Elevation Model—NOAA/NOS Estuarine Bathymetry (NOAA NCEI 2024)
- Biscayne National Park LIDAR GeoTIFF (USGS 2006)
- Historical Atlas of Florida Keys Shallow-water Benthic Habitats and Data Download (Florida FWCC 2024a)
- Unified Florida Reef Map (Florida FWCC 2024b)
- USGS-NPS-NASA EAARL Submarine Topography, Biscayne National Park (USGS 2024)
- Digital elevation models and LiDAR data from NOAA Digital Coast, including:
 - NOAA NGS Topobathy LiDAR DEM—Hurricane Irma: Miami to Marquesas Keys, FL (NOAA NGS 2024), and Associated Point Cloud Files with Orthometric Vertical Datum NAVD88 using GEOID18 (NOAA OCM 2024a)
 - NOAA NGS Topobathy LiDAR DEM—Florida Keys Outer Reef Block 04 (NOAA OCM 2024b) and Point Cloud files with Orthometric Vertical Datum NAVD88 using GEOID18 (NOAA OCM 2024c)
 - LiDAR DEM—Miami-Dade County, FL (NOAA OCM 2024d), and Point Cloud files with Orthometric Vertical Datum NAVD88 using GEOID18 (NOAA OCM 2024e)
 - FDEM Lidar—South Florida Blocks Point Cloud files with Orthometric Vertical Datum NAVD88 using GEOID18 (NOAA OCM 2024f)
 - Continuously Updated Digital Elevation Model (CUDEM), Ninth Arc-Second Resolution Bathymetric-Topographic Tiles (NOAA 2024a)
 - Digital Coast Data Access Viewer (NOAA 2024b)
- NOAA Historical Hurricane Tracks (NOAA NOS 2024)
- NOAA Sea Level Rise Viewer, which displays projected sea-level-rise scenarios and associated impacts such as marsh migration, flooding, and community vulnerability (NOAA 2024c)

Although links to project datasets are not included in this report, USGS Science Support Strategy for Biscayne National Park and Surrounding Areas in Southeastern Florida (Wolfert-Lohmann 2008) provides summaries of past, current, and proposed USGS projects related to surface water, groundwater, coral reefs, seagrass beds, sediment quality, and coastal wetlands at BISC.

References:

Florida Fish and Wildlife Conservation Commission (FWCC)

- 2024a “Marine Resources Information System (MRGIS).” Available online: <https://ocean.floridamarine.org/integratedreefmap/unifiedreefract.htm>. Accessed March 2024.
- 2024b “Unified Reef Map” Available online: <https://myfwc.maps.arcgis.com/apps/webappviewer/index.html?id=e12fd1c0587d41c1a63eca96ec72f61a#benthic>. Accessed March 2024.

National Centers for Environmental Information

- 2018 “Biscayne Bay (S200) Bathymetric Digital Elevation Model - NOAA/NOS Estuarine Bathymetry.” National Ocean and Atmospheric Administration (NOAA). Available online: doi:10.7289/V5GM85N8. Accessed March 2024.



National Oceanic and Atmospheric Administration (NOAA)

- 2024a “Continuously Updated Digital Elevation Model (CUDEM) - 1/9 Arc-Second Resolution Bathymetric-Topographic Tiles.” Available online: <https://data.noaa.gov/metaview/page?xml=NOAA/NESDIS/NGDC/MGG/DEM//iso/xml/19919.xml&view=xml2text/xml-to-text-ISO>. Accessed March 2024.
- 2024b “Digital Coast: Data Access Viewer.” Available online: <https://coast.noaa.gov/dataviewer/#/lidar/search/where:ID=9081>. Accessed March 2024.
- 2024c “Sea Level Rise Viewer.” Available online: <https://coast.noaa.gov/slr/#/layer/slr/0/-8996744.012708599/3350374.1601295434/11/satellite/none/0.8/2050/interHigh/midAccretion>. Accessed March 2024.

National Oceanic and Atmospheric Administration National Centers for Environmental Information (NOAA NCEI)

- 2024 Biscayne Bay (S200) Bathymetric Digital Elevation Model – NOAA/NOS Estuarine Bathymetry. Available online: https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.ngdc.mgg.dem:biscayne_bay_S200_2018. Accessed March 2024.

National Oceanic and Atmospheric Administration National Geodetic Survey (NOAA NGS)

- 2024 “2018-2019 NOAA NGS Topobathy Lidar DEM Hurricane Irma: Miami to Marquesas Keys, FL.” Available online: <https://www.fisheries.noaa.gov/inport/item/63018>. Accessed March 2024.

National Oceanic and Atmospheric Administration National Ocean Service (NOAA NOS)

- 2024 “NOAA Historical Hurricane Tracks.” Available online: <https://oceanservice.noaa.gov/news/historical-hurricanes/>. Accessed March 2024.

National Oceanic and Atmospheric Administration Office for Coastal Management (NOAA OCM)

- 2024a 2018 - 2019 NOAA NGS Topobathy Lidar Hurricane Irma: Miami to Marquesas Keys, FL Point Cloud files with Vertical Datum North American Vertical Datum of 1988 (NAVD88) using GEOID18. Available online: <https://noaa-nos-coastal-lidar-pds.s3.amazonaws.com/laz/geoid18/9081/index.html>. Accessed March 2024.

- 2024b “2017 NOAA NGS Topobathy Lidar DEM: Florida Keys Outer Reef, Block 04.” Available online: <https://www.fisheries.noaa.gov/inport/item/51529>. Accessed March 2024.
- 2024c “2017 NOAA NGS Topobathy Lidar: Florida Keys Outer Reef Block 04 Point Cloud files with Vertical Datum North American Vertical Datum of 1988 (NAVD88) using GEOID18”. Available online: <https://noaa-nos-coastal-lidar-pds.s3.amazonaws.com/laz/geoid18/9081/index.html>. Accessed March 2024.
- 2024d “2015 Lidar DEM: Miami-Dade County, FL.” Available online: <https://www.fisheries.noaa.gov/inport/item/51984>. Accessed March 2024.
- 2024e “2015 Lidar: Miami-Dade County, FL Point Cloud files with Vertical Datum North American Vertical Datum of 1988 (NAVD88) using GEOID18”. Available online: <https://noaa-nos-coastal-lidar-pds.s3.amazonaws.com/laz/geoid18/5038/index.html>. Accessed March 2024.
- 2024f “2007 - 2008 Florida Division of Emergency Management (FDEM) Lidar Project: Blocks 1 - 10 (Southeast Florida and Keys).” Available online: <https://www.fisheries.noaa.gov/inport/item/49665>. Accessed March 2024.

National Park Service (NPS) Geologic Resources Inventory (GRI) program.

- 2013 “Coastal Engineering Projects Inventory.” National Park Service, Natural Resource Stewardship and Science. Available online: <https://irma.nps.gov/DataStore/Reference/Profile/2193512>. Accessed March 2024.
- 2021a “Digital Geologic-GIS Map of Biscayne National Park and Vicinity, Florida (NPS, GRD, GRI, BISC, BISC digital map) adapted from Florida Geological Survey Open File Map Series maps by Green, Campbell and Scott (1995 and 1996) and Open-File Report map by Scott (2001), and U.S. Geological Survey Water-Resources Investigations Report maps by Causaras (1986) and Reese and Cunningham (2000)”. National Park Service Geologic Resources Inventory Program. Lakewood, Colorado. Available online: <https://irma.nps.gov/DataStore/Reference/Profile/1047630>. Accessed February 2026.
- 2021b “Digital Benthic Habitat-GIS Map of Florida Bay (1991-1995 Substrate), Florida (NPS, GRD, GRI, EVER, EVER_benthic_habitat digital map) adapted from NOAA Coastal Services Center unpublished digital data (1999)”. National Park Service Geologic Resources Inventory Program. Lakewood, Colorado. Available online: <https://irma.nps.gov/DataStore/Reference/Profile/2287117>. Accessed February 2026.
- 2021c “Digital Geohazards-GIS Map of Biscayne National Park and Vicinity (2005 Mapping), Florida (NPS, GRD, GRI, BISC, BISC_geohazard digital map) adapted from a Florida Geological Survey Bulletin map by Arthur, Baker, Cichon, Wood and Rudin (2005)”. National Park Service Geologic Resources Inventory Program. Lakewood, Colorado. Available online: <https://irma.nps.gov/DataStore/Reference/Profile/2287118>. Accessed February 2026.
- 2022 “Shoreline Change Project.” National Park Service, Natural Resource Stewardship and Science. Available online: <https://irma.nps.gov/DataStore/Collection/Profile/9272>. Accessed March 2024.
- 2023a “Thematic Paleontological Resource Inventories.” Available online: <https://www.nps.gov/subjects/fossils/thematic-inventories.htm>. Accessed March 2024.
- 2023b “I&M Network Based Paleontological Resource Inventories.” Available online: <https://www.nps.gov/subjects/fossils/network-surveys.htm>. Accessed March 2024.

- 2024a “Geologic Resources Inventory—Products.” National Park Service, Geologic Resources Division. Available online: <https://www.nps.gov/subjects/geology/geologic-resources-inventory-products.htm>. Accessed March 2024.
- 2024b “Park-specific Paleontological Resource Inventory Reports.” Available online: <https://www.nps.gov/subjects/fossils/park-surveys.htm>. Accessed March 2024.
- 2024c “NPS Datastore, Integrated Resource Management Applications”. National Park Service, Natural Resource Stewardship and Science. Available online: <https://irma.nps.gov/DataStore/Search/Advanced>. Accessed July 2024.
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