# Gulf Coral & Hardbottom

This indicator predicts the presence of coral and hardbottom in the Gulf of Mexico based on direct observations, acoustic surveys, and known locations of human-created structures like artificial reefs. It combines data from multiple sources, including Bureau of Ocean Energy Management seismic water bottom anomalies, usSEABED sediment data, several National Oceanic and Atmospheric Administration datasets, and more.

## Reason for Selection

Hardbottom provides an anchor for important seafloor habitats such as deep-sea corals, plants, and sponges. Hardbottom is also sometimes associated with chemosynthetic communities around cold seeps or deep-sea hydrothermal vents where bacteria convert chemicals into energy and form the base of complex food webs (Love et al. 2013). Hardbottom and associated species provide important habitat structure for many fish and invertebrates (NOAA 2018). Hardbottom areas serve as fish nursery, spawning, and foraging grounds, supporting commercially valuable fisheries like snapper and grouper (NCDEQ 2016). According to Dunn and Halpin (2009), "hardbottom habitats support high levels of biodiversity and are frequently used as a surrogate for it in marine spatial planning." Human-created hardbottom (e.g., artificial reefs) is also known to provide additional habitat that is quickly colonized to provide a suite of ecosystem services commonly associated with naturally occurring hardbottom (Wu et al. 2019, Schulze et al. 2020).

## Input Data

- Southeast Blueprint 2024 extent
- Southeast Blueprint 2024 subregions: Gulf of Mexico and South Florida Marine
- usSEABED Gulf of Mexico sediments, accessed 12-14-2023; download the data; view and read more about the data on the National Oceanic and Atmospheric Administration (NOAA) Gulf of Mexico Atlas (select Physical --> Marine geology --> 1. Dominant bottom types and habitats)
- Bureau of Ocean Energy Management (BOEM) Gulf of Mexico seismic water bottom anomalies, accessed 12-20-2023
- NOAA deep-sea coral and sponge locations, accessed 12-20-2023 on the NOAA Deep-Sea Coral & Sponge Map Portal
- Florida coral and hardbottom habitats, accessed 12-19-2023
- NOAA Electronic Navigational Chart (ENC) Wrecks, accessed 12-14-2023; download the data
- State artificial reef datasets
    - Louisiana Department of Wildlife and Fisheries (LDWF) Artificial Reefs: Inshore Artificial Reefs, Nearshore Artificial Reefs, Offshore and Deepwater Artificial Reefs (Google Earth/KML files), accessed 12-19-2023
    - Texas Parks and Wildlife Department (TPWD) Artificial Reefs, accessed 12-19-2023; download the data from The Artificial Reefs Interactive Mapping Application (direct download from interactive mapping application)
    - Mississippi Department of Marine Resources (MDMR) Artificial Reef Bureau: Inshore Reefs, Offshore Reefs, Rigs to Reef (lat/long coordinates), accessed 12-19-2023

- Alabama Department of Conservation and Natural Resources (ADCNR) Artificial Reefs: Master Alabama Public Reefs v2023 (.xls), accessed 12-19-2023
  - Florida Fish and Wildlife Conservation Commission (FWC): Artificial Reefs in Florida (.xlsx), accessed 12-19-2023
- Standing oil and gas platforms in Federal waters
  - Bureau of Safety and Environmental Enforcement (BSEE) Data Center oil and gas platforms geodatabase (Platforms.gdb), accessed 12-12-2023 (to download, click the black “Mapping” button at the top to open the mapping widget and scroll down to “Geodatabase Downloads”)
- Oil and gas structures in State waters (note: Mississippi and Florida do not have active wells or platforms in state waters)
  - State of Alabama Oil and Gas Board Platforms, accessed 12-19-2023
  - Louisiana Strategic Online Natural Resources Information System (SONRIS) Oil/Gas Wells, accessed 12-19-2023 (to download, visit the interactive mapper, select Oil/Gas Wells, zoom in, and choose “extract features”)
  - Texas offshore oil and gas structures from the Texas General Land Office GIS Maps and Data, accessed 12-19-2023

### Mapping Steps

Note: Most of the mapping steps were accomplished using the graphical modeler in QGIS 3.28. Individual models were created to combine data sources and assign ranked values. These models were combined in a single model to assemble all the data sources and create a summary raster.

- From the BOEM seismic water bottom anomaly data, extract the following shapefiles: anomaly_confirmed_relic_patchreefs.shp, anomaly_Cretaceous.shp, anomaly_relic_patchreefs.shp, seep_anomaly_confirmed_buried_carbonate.shp, seep_anomaly_confirmed_carbonate.shp, seep_anomaly_confirmed_organisms.shp, seep_anomaly_positives.shp, seep_anomaly_positives_confirmed_gas.shp, seep_anomaly_positives_confirmed_oil.shp, seep_anomaly_positives_possible_oil.shp, seep_anomaly_confirmed_corals.shp, seep_anomaly_confirmed_hydrate.shp.
- To create a class of confirmed BOEM features, merge anomaly_confirmed_relic_patchreefs.shp, seep_anomaly_confirmed_organisms.shp, seep_anomaly_confirmed_corals.shp, and seep_anomaly_confirmed_hydrate.shp and assign a value of 6.
- To create a class of predicted BOEM features, merge the remaining extracted shapefiles and assign a value of 3.
- From usSEABED sediments data, use the field “gom_domnc” to extract polygons: rock (dominant and-subdominant) receives a value of 2 and gravel (dominant and subdominant) receives a value of 1.
- From the wrecks database, extract locations having "high” and “medium” confidence (positionQuality = "high” and positionQuality = “medium”). Buffer these locations by 150 m and assign a value of 4.

- Merge artificial reef point locations from FL, AL, MS and TX. Buffer these locations by 150 m. Merge this file with the three LA artificial reef polygons and assign a value of 4.
- Extract Federal standing platforms from BSEE platform locations using “Standing” =1. Extract only “Active” oil and gas wells from the LA database using “LEGEND_DES” contains “ACTIVE”. Merge the AL oil well and structure datasets. Merge all of the above well and structure datasets together with the TX offshore structures. Buffer these points by 150 m and assign a value of GCHBValue= 4. The buffer distance used here, and later for coral locations, follows guidance from the Army Corps of Engineers for setbacks around artificial reefs and fish havens (Riley et al. 2021).
- From the NOAA deep-sea coral and sponge point locations, select all points. Buffer the point locations by 150 m and assign a value of 6.
- From the FWC coral and hardbottom dataset polygon locations, assign coral reefs a value of 6, hardbottom a value of 5, hardbottom with seagrass a value of 5, and probable hardbottom a value of 3.
- Union all of the above datasets together and assign final indicator values. For overlapping polygons, this value will represent the maximum value at a given location.
- Buffer the Southeast Blueprint 2024 Gulf of Mexico and South Florida Marine subregions inland by 100 km to make a continuous buffer along the coast, with no gaps. This buffer distance matches the one used in the Atlantic version of this indicator, which attempts to capture how far upstream brackish water typically extends along the Atlantic coast and is informed by a 1978 water quality study of the estuarine James River in Virginia (Neilson and Ferry 1978).
- Clip the unioned polygon dataset to the buffered marine subregions.
- Convert the polygon dataset to raster using GDAL “rasterize”.
- Fill NoData cells with zeroes and mask the resulting raster with the buffered Gulf of Mexico and South FL marine subregions. Adding zero values helps users better understand the extent of this indicator and to make this indicator layer perform better in online tools.
- Export the final dataset as an unsigned 8-bit integer raster to ArcPro. Create the raster attribute table using the legend values below.
- As a final step, clip to the spatial extent of Southeast Blueprint 2024.

### *Final indicator values*

Indicator values are assigned as follows:

6 = Confirmed hardbottom-associated species (corals, patch reef, chemosynthetic communities, or other organisms)
5 = Confirmed natural hardbottom
4 = Confirmed human-created hardbottom (shipwrecks, artificial reefs, oil and gas structures)
3 = Predicted hardbottom (fine resolution)
2 = Rock (coarse resolution)
1 = Gravel (coarse resolution)
0 = Not identified as hardbottom

### Known Issues

- While active oil and gas platforms provide artificial hardbottom habitat that supports diverse marine life (Claisse et al. 2014), oil and gas extraction in the marine environment also has negative impacts, including the risk of spills (Daley 2019). In addition, climate change due to fossil fuel combustion is contributing to coral bleaching and ocean acidification, which harms marine life (NOAA 2023). We recognize the tradeoffs inherent in this indicator and will continue working to find the right balance through feedback from Blueprint users and subject matter experts.
- The confirmed human-created hardbottom class does not account for variation in the condition of artificial habitat structures, such as harmful leaks from capped oil and gas wells or “black reef” phenomena caused by pollution and invasive species growth around contaminated shipwrecks (Degnarain 2020).
- Due to the extent of the BOEM seismic anomalies dataset, this indicator may underprioritize confirmed hardbottom-associated species and predicted fine-resolution hardbottom) in state and federal waters around Florida, and in state waters across the Gulf of Mexico. The BOEM data is limited to the central and western planning areas in the Gulf of Mexico.

### Literature Cited


Dunn DC, Halpin PN (2009) Rugosity-based regional modeling of hard-bottom habitat. Marine Ecology Progress Series 377:1-11. [https://doi.org/10.3354/meps07839].

Claisse JT, Pondella DJ, Love M, Zahn LA, Williams CM, Williams JP, Bull AS (2014) Oil platforms off California are among the most productive marine fish habitats globally. Proc Natl Acad Sci USA 111: 15462–15467 [https://www.pnas.org/doi/10.1073/pnas.1411477111].

Daley, Jason. Deepwater Horizon Site is Now a Sticky Wasteland Populated by Sickly Crabs. September 19, 2019. Smithsonian Magazine. [https://www.smithsonianmag.com/smart-news/deepwater-horizon-site-wasteland-populated-sickly-crabs-180973181/].

Degnarain, Nashan. Black Reef Risk: How Sunken Metal Shipwrecks Attract Coral-Destroying Invasive Species. August 20, 2020. Forbes. [https://www.forbes.com/sites/nishandegnarain/2020/08/20/black-reef-risk-how-sunken-metal-shipwrecks-attract-coral-destroying-invasive-species/?sh=55ae49c4129d].

Jenkins C. Dominant Bottom Types and Habitats In Gulf of Mexico Data Atlas [Internet]. Stennis Space Center (MS): National Centers for Environmental Information; 2011. [5 screens]. [https://gulfatlas.noaa.gov].

National Oceanographic and Atmospheric Administration. Deep Sea Coral Research and Technology Program 2018 Report to Congress. December 2018. [https://www.ncei.noaa.gov/data/oceans/coris/library/NOAA/DSCRTP/Other/Reports_To_Congress/2018/DSCRTP2018_Report_to_Congress.pdf].

National Oceanographic and Atmospheric Administration. Flower Garden Banks National Marine Sanctuary. Mesophotic Habitats. Accessed August 3, 2023. [https://flowergarden.noaa.gov/about/mesophotic.html].

National Oceanographic and Atmospheric Administration. How does climate change affect coral reefs? National Ocean Service website. Last updated January 20, 2023. Accessed August 9, 2023. [https://oceanservice.noaa.gov/facts/coralreef-climate.html].

NCDEQ (North Carolina Department of Environmental Quality) 2016. North Carolina Coastal Habitat Protection Plan Source Document. Morehead City, NC. Division of Marine Fisheries. 475 p. [https://deq.nc.gov/media/26813/open].

Neilson, B. J., & Ferry, P. S. (1978) A Water Quality Study of the Estuarine James River. Special Reports in Applied Marine Science and Ocean Engineering (SRAMSOE) No.131. Virginia Institute of Marine Science, College of William and Mary. [https://doi.org/10.21220/V52157].

Love, M., Baldera, A., Yeung, C. & Robbins C. (2013). The Gulf of Mexico Ecosystem: A Coastal and Marine Atlas. New Orleans, LA: Ocean Conservancy, Gulf Restoration Center. [https://oceanconservancy.org/wp-content/uploads/2017/05/gulf-atlas.pdf].

Riley, K.L., Wickliffe, L.C., Jossart, J.A., MacKay, J.K., Randall, A.L., Bath, G.E., Balling, M.B., Jensen, B.M., and Morris, J.A. Jr. 2021. An Aquaculture Opportunity Area Atlas for the U.S. Gulf of Mexico. NOAA Technical Memorandum NOS NCCOS 299. Beaufort, NC. 545 pp. [https://doi.org/10.25923/8cb3-3r66].

Schulze A, Erdner DL, Grimes CJ, et al (2020) Artificial Reefs in the Northern Gulf of Mexico: Community Ecology Amid the “Ocean Sprawl.” Front Mar Sci 7:447. [https://doi.org/10.3389/fmars.2020.00447].

Wu, Zhongin, James R. Tweedley, Neil R. Loneragan, Xiumei Zhang. 2019. Artificial reefs can mimic natural habitats for fish and macroinvertebrates in temperate coastal waters of the Yellow Sea. Ecological Engineering, vol 139. [https://doi.org/10.1016/j.ecoleng.2019.08.009].