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Quantifying the potential impacts of oil and gas infrastructures on cold-water corals and sponges in the northern Gulf of Mexico

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The northern Gulf of Mexico is home to structure-forming cold-water corals and sponges (CWCS) that provide a wide range of ecosystem services to other organisms. Oil and gas infrastructure, such as platforms and pipelines, form an extensive network throughout the northern Gulf of Mexico. Since the construction of the first structures in the early 1930s, detrimental impacts of oil and gas exploration and extraction have been recorded at depths where corals and sponges are found. Given the vulnerability of CWCS to long-term impacts, it is necessary to implement conservation and management measures to protect these fragile ecosystems. This work aimed to identify areas of CWCS habitat that are the most vulnerable to impacts from oil and gas infrastructure, and in parallel, to identify areas that would be suitable for the establishment of conservation sites.

Techniques from geomorphometry were used to derive quantitative seafloor characteristics from bathymetric data provided by the United States Bureau of Ocean and Energy Management. This bathymetric data, which cover about 233,000 km^2, represents the current highest-resolution bathymetric grid for the northern Gulf of Mexico, with a cell size of about 12 m. Slope, the orientation of the slope, rugosity, and general, planar, and profile curvatures were derived from the bathymetry in a GIS. These environmental variables were combined with CWCS occurrence data retrieved from the National Oceanic and Atmospheric Administration Deep-Sea Coral Data Portal to produce eleven species distribution models (SDMs) based on principles of maximum entropy (MaxEnt). The SDMs were combined with data on the location of active and proposed oil and gas infrastructures to identify potential hotspots of CWCS and analyze their distribution relative to oil and gas infrastructures.

In general, depth and slope were the two primary abiotic drivers of CWCS distribution. However, specific orders of CWCS had different environmental preferences. For example, the curvature of the seafloor was found to contribute to explaining the distribution of the Gorgonacea and Lyssacinosida orders. A summary SDM produced using all available data identified 7,355 km^2 (3.5% of the entire study area) as suitable habitat to sustain CWCS ecosystems. Assuming that oil and gas infrastructures can impact ecologically or biologically significant areas within 2 km of distance, active oil and gas infrastructure could impact up to 69,896.6 km^2 of seafloor across the entire Gulf of Mexico. The construction of proposed pipelines would add impacts on an additional 279 km^2.

Within the sole extent of our SDM, 1,496 km^2 of suitable CWCS habitat would be impacted by oil and gas infrastructure, which corresponds to 20.34% of all predicted suitable habitat. By comparing predicted CWCS hotspots to the distribution oil and gas infrastructure, we identified nine areas greater than 100 km^2 that hold potential for successful conservation and could help create a network of connected protected areas in the northern Gulf of Mexico. Our maps can inform discussions among stakeholders to reach the best conservation and management planning outcomes while considering other ecological, social, economic, and governance factors.