U.S. Offshore Aquaculture Potential

in the Atlantic Ocean and Gulf of Mexico

INTRODUCTION

Worldwide seafood demand is on the rise and as harvests of wild fisheries reach capacity, more countries are turning to aquaculture to fulfill their needs. Despite having access to over 3.5 million square miles of coastal waters within its federal jurisdiction, also known as the Exclusive Economic Zone (EEZ), current U.S. regulations do not allow offshore aquaculture in federal waters. To meet domestic demand, the U.S. imports approximately 80-90% of the seafood consumed by value, half of which is sourced from aquaculture farms abroad. Proponents of expanding aquaculture offshore promise that the industry will counteract the seafood trade deficit, create jobs, provide access to a sustainable and healthy protein choice, and limit environmental impacts. Meanwhile, critics worry that increased aquaculture development will instead pollute the environment, negatively impact wild-caught fisheries, compromise habitats of endangered marine species, and affect human health through drug and chemical use in production.

Both finfish and bivalve shellfish can be cultivated in offshore aquaculture. Generally taking place in waters at least 25 meters deep, offshore aquaculture requires sturdy cages and anchors to withstand the impact of strong currents and storms. This suitability analysis aggregates environmental and institutional factors to identify suitable sites for offshore aquaculture in the Atlantic Ocean and Gulf of Mexico both within current state jurisdiction (up to 3 miles offshore) and given the hypothetical expansion of aquaculture into the EEZ (3 to 200 miles offshore). The analysis evaluates the cultivation potential across six marine species: Atlantic cod, Atlantic salmon, cobia, winter flounder, blue mussels, and sea scallops.

METHODS

Factors	Logic	Values	Rating
Environmental			
Bathymetry	Fuzzy linear	< -200 or > -25m	0
		-200 to -25m	0-1
Chlorophyll-*a*	Boolean		
Bivalves		> 1 mg m^{-3}	1
Current Speeds		0.1-2.0 m s^{-1}	1
Dissolved Oxygen	Boolean		
Bivalves		> 1.99 mg l^{-1}	1
Finfish		> 4.41 mg l^{-1}	1
Salinity	Boolean		
Bivalves		10-35 PSU	1
Finfish		30-35 PSU	1
SST	Boolean		
Atlantic cod		0-15 °C	1
Atlantic salmon		2-28 °C	1
Cobia		26-32 °C	1
Winter flounder		0.8-23.9 °C	1
Blue mussels		-1.4-23.4 °C	1
Sea Scallops		7.9-15.9 °C	1
Institutional			
Port Distance	Fuzzy linear	0-200 miles	0-1
Shipping Lanes	Boolean	All	0
MPAs	Boolean	V and VI	1

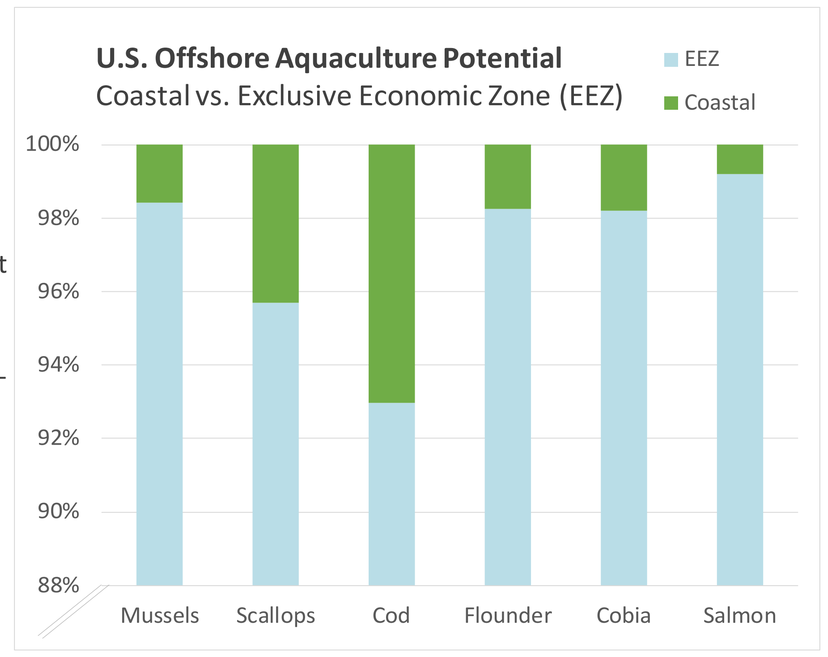
To construct the suitability analysis, a multi-criteria evaluation was conducted using fuzzy membership and Boolean constraints for environmental and institutional factors that affect offshore aquaculture potential. All data was gathered or interpolated in raster format. Depth and distance from ports were fuzzified on a 0-1 scale to account for increased cost of locating operations in deeper waters farther from coastal access points. Other factors were reclassified using Boolean logic and aggregated into a positive control through raster calculator multiplication. Zonal statistics was used to calculate suitable areas for each species where the final suitability score was 0.5 or higher.

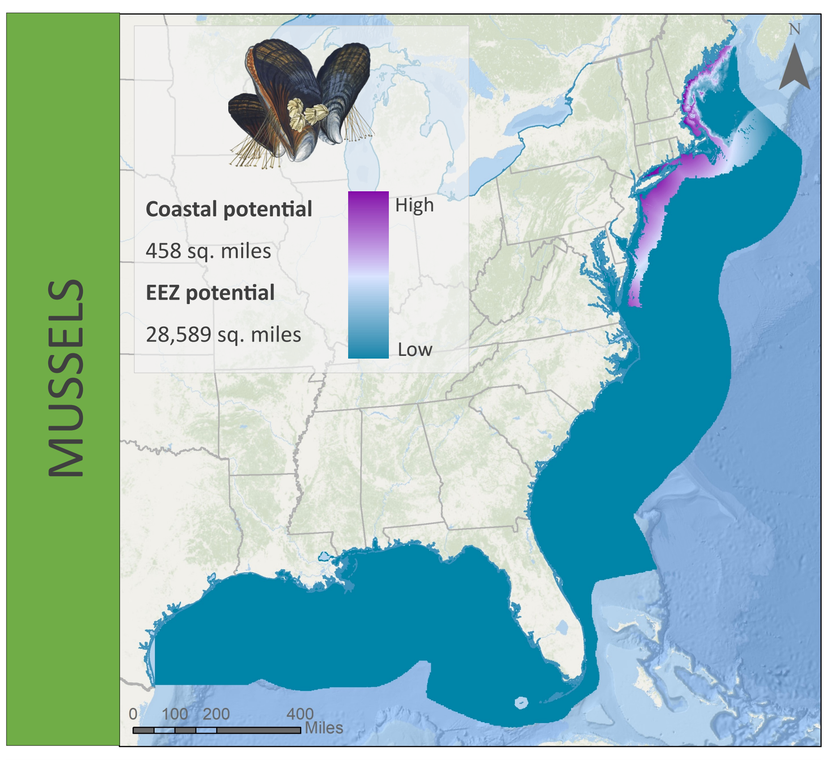
RESULTS

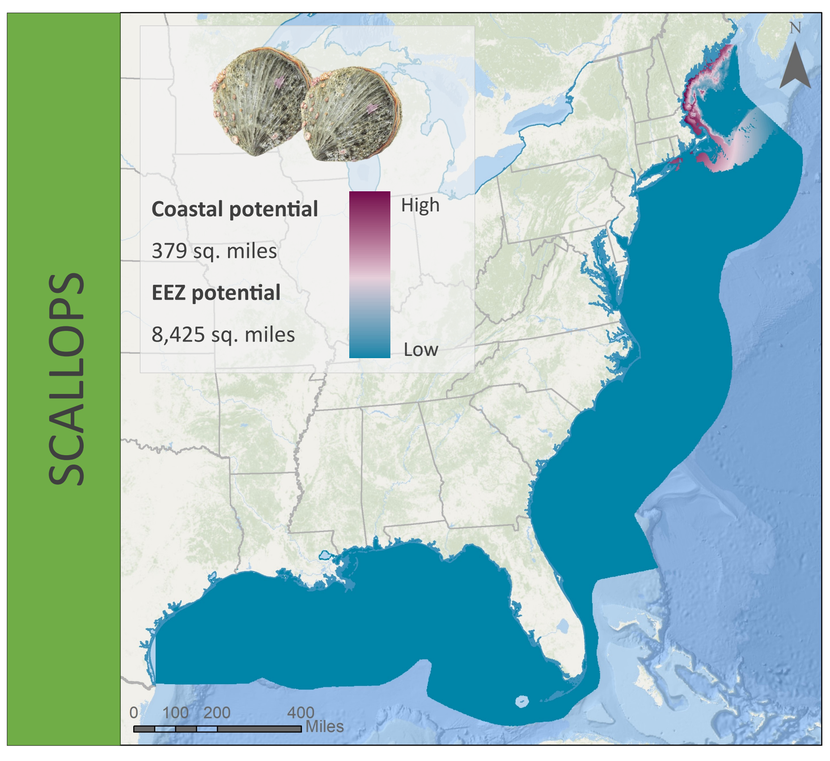
The maps below show the final 0-1 suitability score as a low-high gradient where high is the most favorable to offshore aquaculture development. Coastal potential draws attention to opportunities for offshore aquaculture within current state jurisdiction. Salmon has the highest potential for cultivation in coastal areas, followed by winter flounder, cod, mussels, and scallops. Potential in the EEZ models a hypothetical expansion of aquaculture development into federal waters. Once again, salmon has the greatest potential followed by winter flounder and mussels. Results vary geographically as some species such as mussels, scallops, and cod prefer the cooler ocean temperatures of the Northeast, meanwhile others such as salmon and winter flounder are more versatile. Mussels and scallops are additionally concentrated in the Northeast due to chlorophyll-*a* availability, which is the main source of food for bivalves.

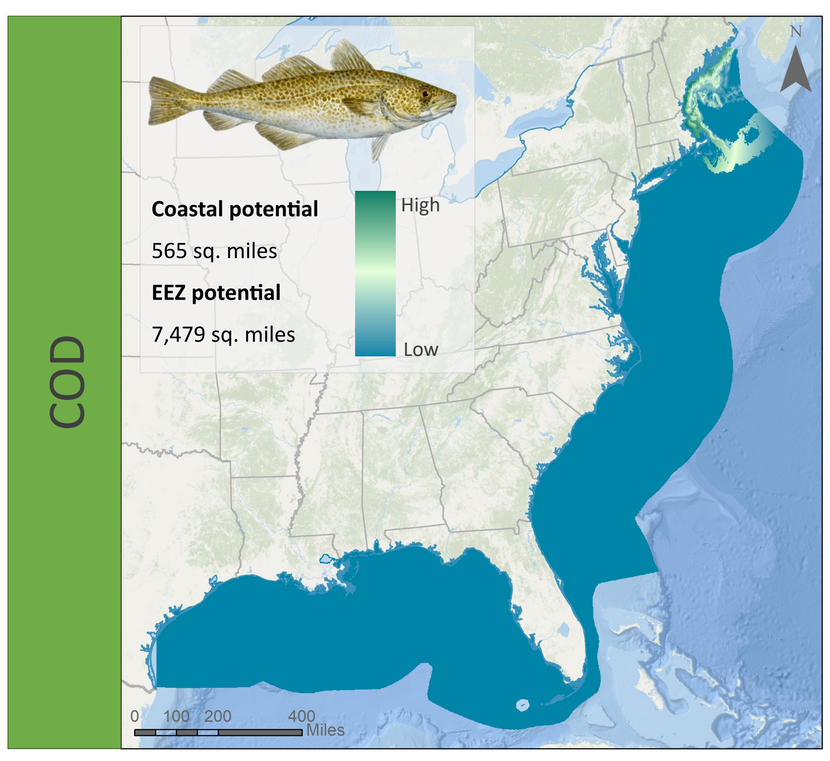
Although relatively small in area, suitable coastal sites show potential for development within the current regulatory framework as a precursor to future expansion into federal waters. A closer look at the percentage of offshore aquaculture potential attributed to costal versus EEZ areas suggests several different approaches. One option is to begin developing a network that would support the growth of a robust future offshore industry such as salmon; and another is to cultivate species that are already familiar to the region and show adequate coastal promise such as cod and scallops.

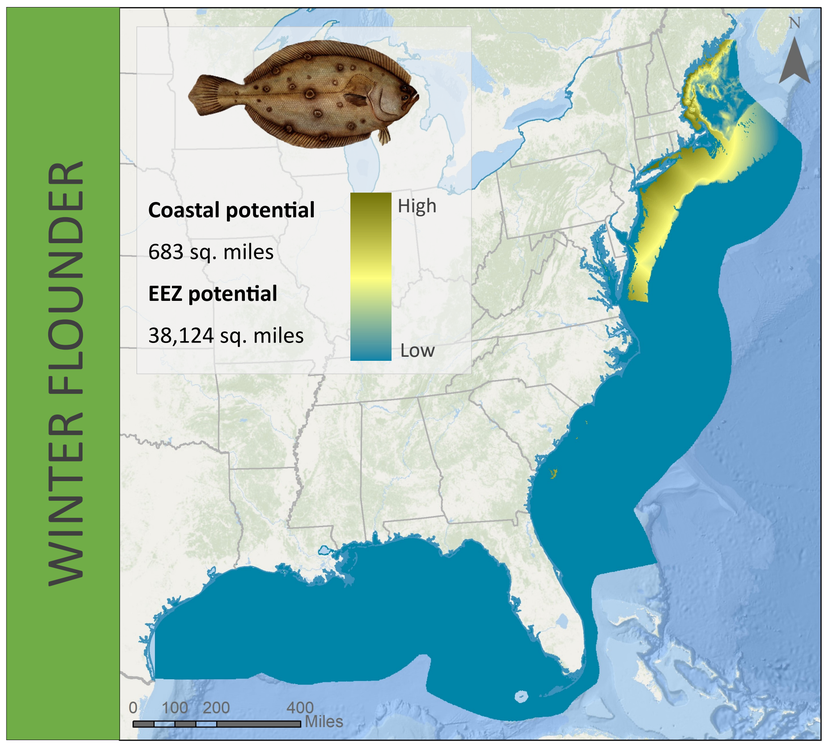
Key limitations of this suitability analysis include the assumption that state jurisdictions extend only 3 miles offshore when in practice these boundaries can vary; shipping lanes alone do not account for commercial fishing vessel density; and lack of data on overlapping wild species and the associated risks of disease transmission and predation. This suitability analysis demonstrates that geospatial analysis offers a useful way for assessing aquaculture suitability across a diversity of complex factors. This study also seeks to build on previous efforts to measure the U.S. aquaculture potential and to show that expanding development offshore may open sites that are either more suitable or will alleviate nearshore development where there are multiple competing uses.

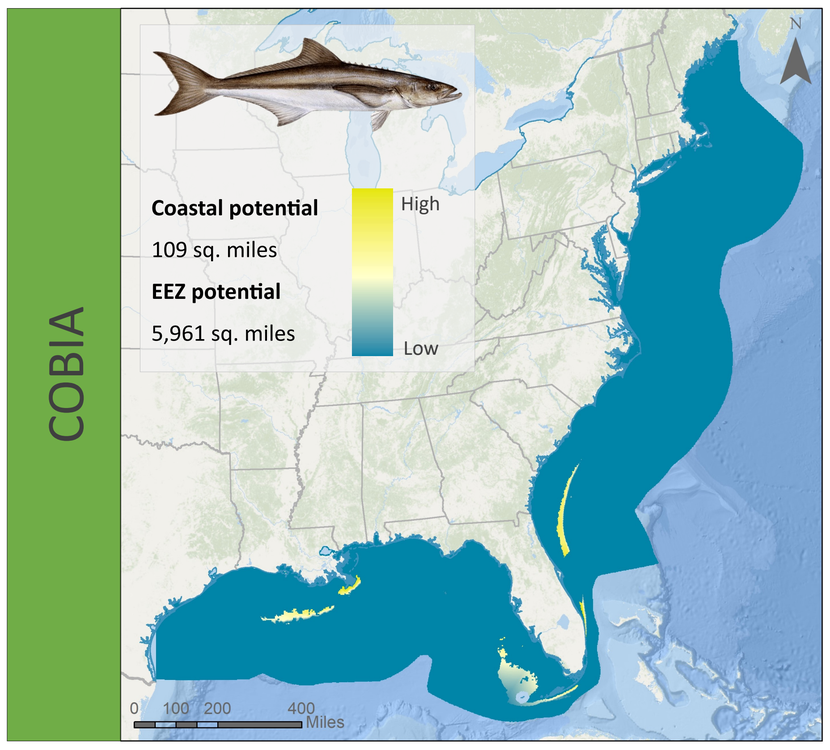


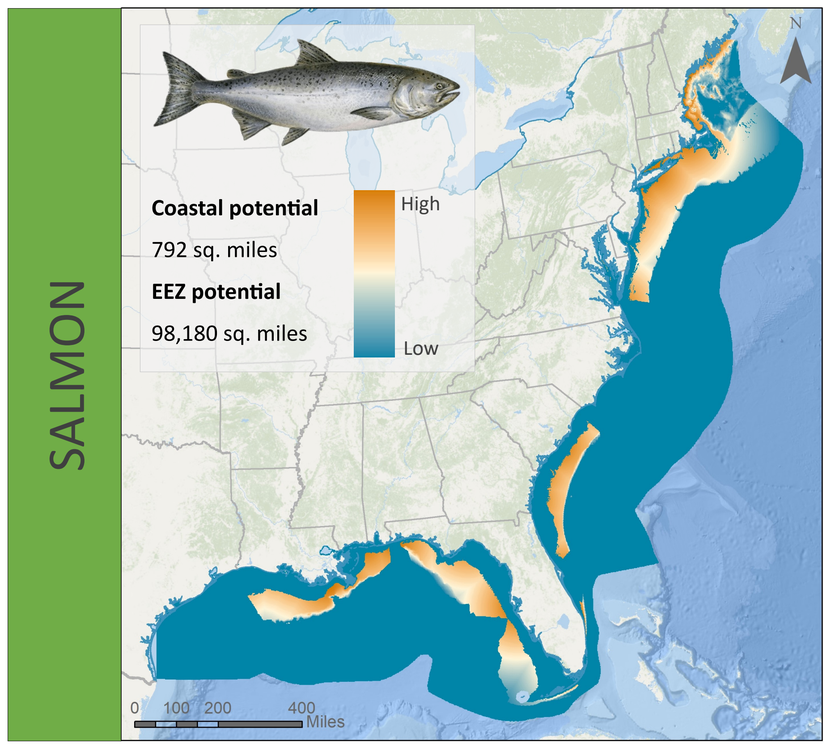












Data: U.S. Maritime limits; NOAA (ETOPO 1, MODIS, OSCAR, principal ports, WOA); and WDPA MPAs
Sources: Cicin-Sain et al. (2001); DOC, NOAA, and NMFS (2017); GAO (2008); Gentry et al. (2017); Kapetsky (2007); Knapp and Rubino (2016); Longdill et al. (2008); MBA Seafood Watch; Silva et al. (2011); and Weiss (2008)

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GCS: NAD 1983 | Projection: North America Albers Equal Area Conic
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