Exploring Co-Location Opportunities of OTEC and Offshore Fish Farms to Support the Blue Economy in the Southeast U.S

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Co-locating OTEC systems with Kanpachi fish farms can optimize ocean space use and support sustainable energy and food production.

INTRODUCTION

- As global demand for food and energy increases, there is growing interest in co-locating offshore renewable energy systems with aquaculture.
- Co-location seeks to optimize the use of ocean resources by simultaneously supporting renewable power generation and fish production, as it reduces lifecycle costs and minimizes spatial conflicts.
- Co-location research has primarily focused on wave and wind energy, with OTEC remaining relatively underexplored.
- Recent techno-economic studies on OTEC-supported aquaculture indicate that while small-scale systems (in the hundreds of kW) are not cost-competitive with conventional diesel generators, larger OTEC systems (≥1 MW) can achieve a levelized cost of energy (LCOE) comparable to or lower than diesel, making them viable for integration [1].
- This study aims to explore the potential for co-locating OTEC systems with offshore aquaculture, addressing a research gap by incorporating OTEC-specific spatial, technical, and environmental criteria into site selection.

METHODS

- This study focuses on two regions: the Gulf of America and Florida Straits, as well as Puerto Rico and the U.S. Virgin Islands.
- Each region exhibits temperature gradients suitable for OTEC applications, with potential sites for Fish Farm co-location found through a three-step evaluation process: each region was assessed based on 1) power production potential, 2) the feasibility of cultivating Kanpachi in offshore cages, and 3) overlapping zones for dual use.
- Spatial datasets for dissolved oxygen, salinity, and temperature were acquired and imported into QGIS for processing reclassification based on the suitability ranges.
- These reclassified layers were then overlaid to generate a composite suitability map for Kanpachi aquaculture, identifying optimal locations across the study regions.
- Feasibility analysis incorporated regulatory, spatial, and logistical constraints, including marine protected areas, military zones, bathymetry, proximity to ports, vessel traffic, and maritime boundaries [2, 3, 4].

Figure 1. Kanpachi aquaculture farm.

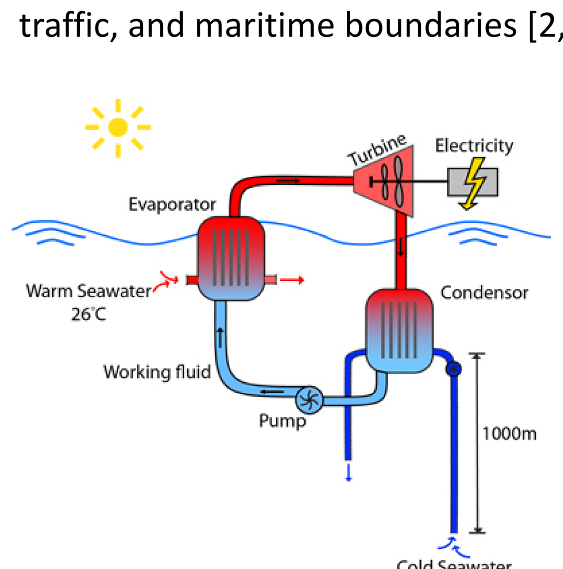

Figure 2. OTEC diagram

Table 1. Constraints for a sample offshore Kanpachi farm

Variables [5,6]	Suitability Score		
	0	1	2
Dissolved Oxygen (ppm)	DO < 5	-	DO ≥ 5
Salinity (ppt)	S < 25, S > 40	35 < S < 40	25 ≤ S ≤ 35
Temperature (°C)	T < 17, T ≥ 30	17 ≤ T < 23	23 ≤ T < 30
Ocean Current Speed (m/s)	U < 0.05, U > 0.5	0.05 ≤ U ≤ 0.5	-

RESULTS

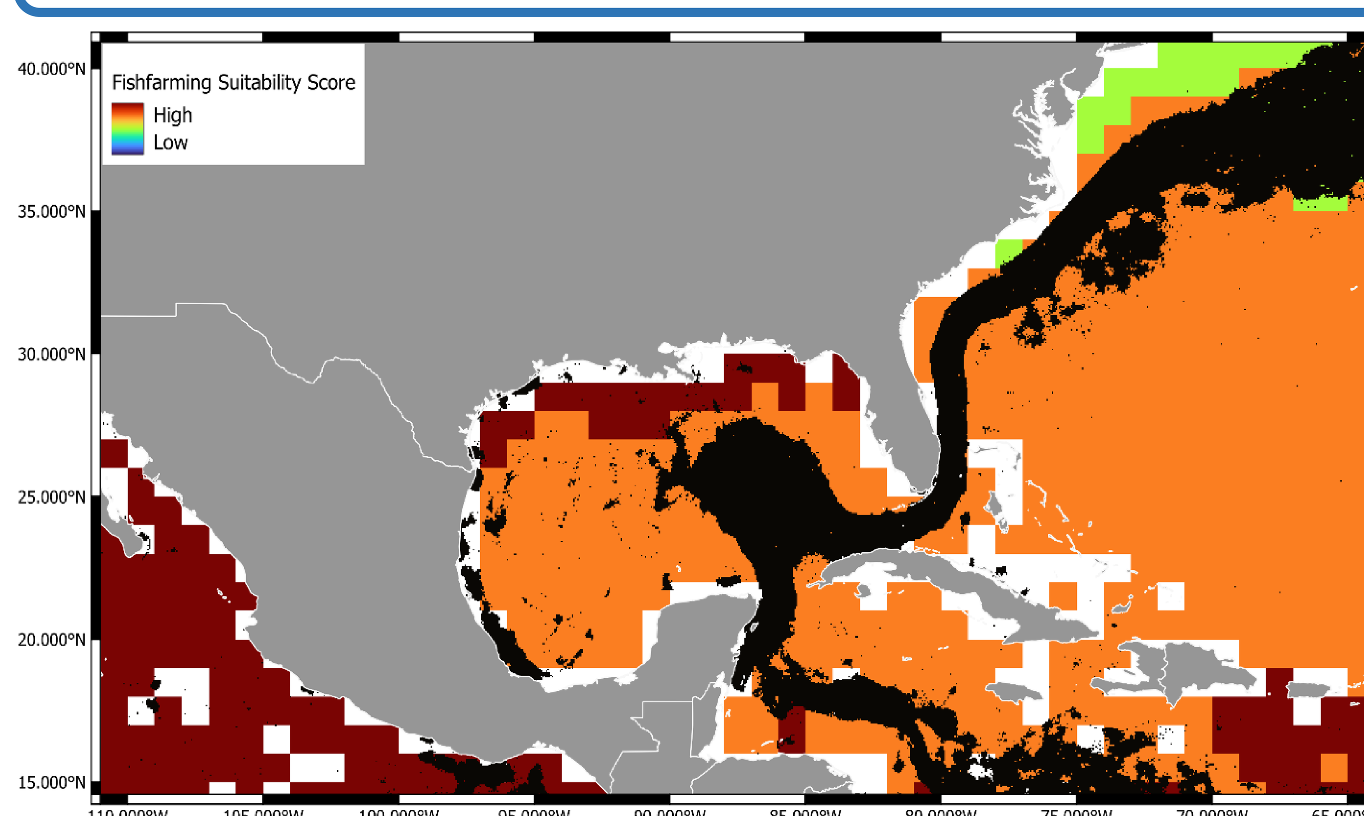

Figure 3. Fish farming suitability map for the study region

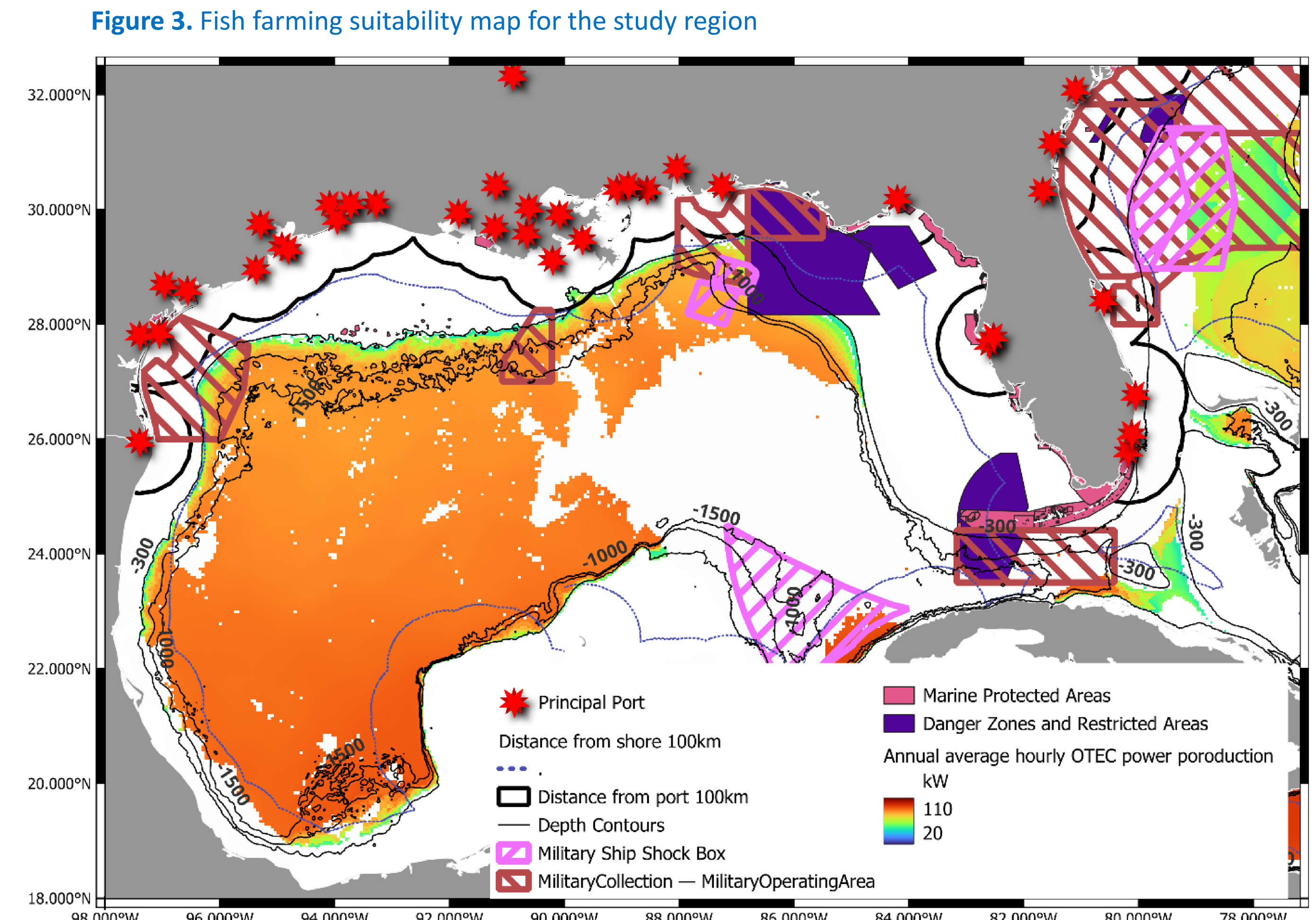

Figure 4. OTEC power potential in the Gulf of America and Florida Straits, excluding unsuitable areas based on regulatory, oceanographic, and logistical constraints.

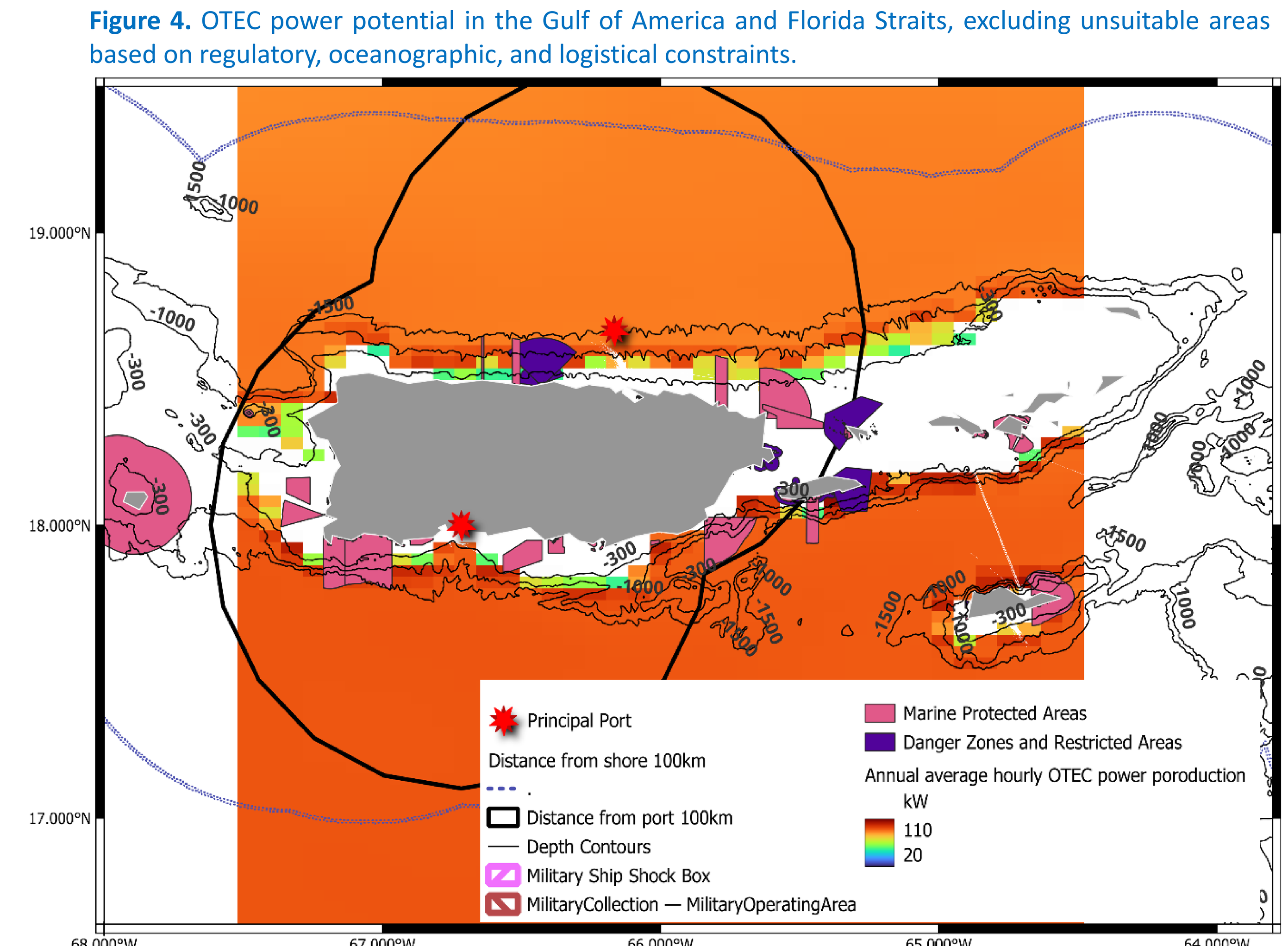

Figure 5. OTEC power potential Puerto Rico and the U.S. Virgin Islands, excluding unsuitable areas based on regulatory, oceanographic, and logistical constraints.

Figure 3 shows the Kanpachi suitability map. While study sites are not in the absolute highest-scoring zones, they are located in highly favorable areas, especially around Puerto Rico and parts of the Gulf, indicating strong potential for offshore aquaculture.

Figure 4 and 5 present the spatial distribution of average OTEC net output power across the study regions, overlaid with key regulatory and logistical constraints.

- The Florida Straits exhibit the lowest OTEC co-location index. This area poses significant challenges for co-location due to high ocean current speeds driven by the Gulf Stream surpassing the upper limit considered suitable for Kanpachi aquaculture.
- The Gulf of America displays a similar pattern, where most high-potential OTEC zones are also located far from shore. However, a small area near the coast of Louisiana falls within 100 km of a major port and meets both the energy and logistical criteria, making it a promising candidate for co-location and further development efforts.
- Puerto Rico presents particularly favorable conditions for the integration of OTEC systems with offshore aquaculture. Most high-potential OTEC areas lie within 100km of the island's two major ports, supporting feasible logistics for construction, operation, and maintenance. Areas of high OTEC power density were identified along both the northern and southern coasts, particularly between the 1000m -1500m depth contours.
- The U.S. Virgin Islands lack a major port facility, numerous suitable co-location sites were identified within 100km of the shoreline. While this improves logistical feasibility in terms of distance to shore, it also introduces greater engineering challenges for deploying and securing mooring systems in deep water.

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