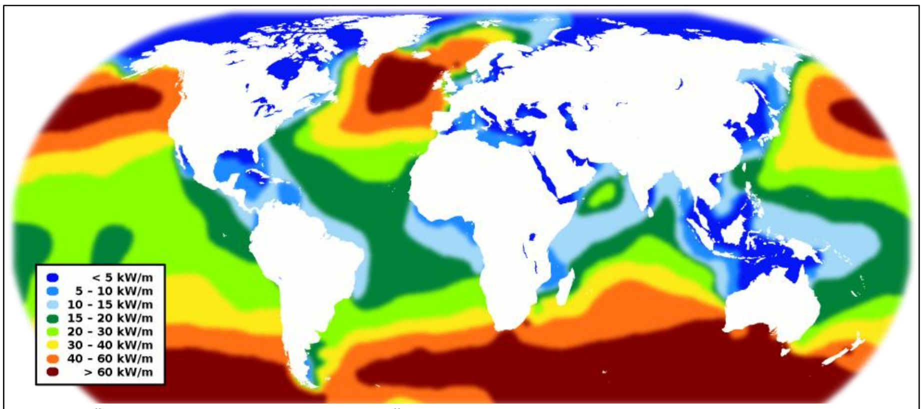
C7 Aquaculture and Wave Combination for the Caribbean Basin – Strategic Report

1 – Introduction

The Caribbean region includes nearly 30 nations, both continental and insular, with a wide range of economic and social characteristics. The Caribbean Basin has already developed aquaculture production for several commodities, such as tilapia and shrimp. Given the geographic location, it has strong potential for further expansion of production. It must be considered that further development of the sector will rely on the use of marine facilities, given the competition for the use of land. This is particularly relevant for island nations, where land resources are limited, and in many cases, production presents a logistics challenge. In some countries of the Caribbean, offshore finfish production, mainly cobia, is already taking place, presenting an opportunity to seize the lessons learnt on production. Reinforcing the importance of the aquaculture sector, it must be taken into consideration that the growing demand for fishery products implies that future expansion of supplies will rely on aquaculture. The development of marine facilities for aquaculture production poses the challenge of supplying those facilities with power.

The combination proposed of marine energy generation devices with aquaculture production facilities would present a solution to the energy supply issue, providing a clean energy solution, reducing the dependence on oil subproducts, therefore reducing the carbon footprint of fish production, and additionally, improving national food security through the contribution to higher food supply and employment and revenue generation. This would be a multiple use of space (MUS) initiative, allowing certain advantages in terms of management and transportation costs, as well as an improvement in installed capacity usage (for example, sharing boats for operations and maintenance). In a further stage, possible energy surpluses, or technological penetration, could supply energy to other on-shore facilities.



Source: "World wave energy resource map" by Ingvald Straume - Own work. Licensed under CC0 via Commons - https://commons.wikimedia.org/wiki/File:World_wave_energy_resource_map.png#/media/File:World_wave_energy_resource_map.png

Currently, some initiatives are being carried out in European countries both to develop wave energy generation, and furthermore, to combine this technology with aquaculture production. At a first stage, the strategy would refer to large scale nets and pods, used for finfish or molluscs production, while the wave energy generation would be through point absorber devices. An example of an initiative similar to the proposed intervention, is the announcement in 2015 that, in Scotland, a marine energy generation company would associate with one of the largest fish farming companies in order to combine technologies to power offshore aquaculture. In addition, the contribution to the development and consolidation of marine energy generation would allow aquaculture technology to reach a higher scale, reducing costs and improving profitability and technological development. The figures below reveal that the average wave energy climate in the Caribbean is modest compared to other regions. Also, the potential within the different areas of the Caribbean is uneven. Given the climate particularities

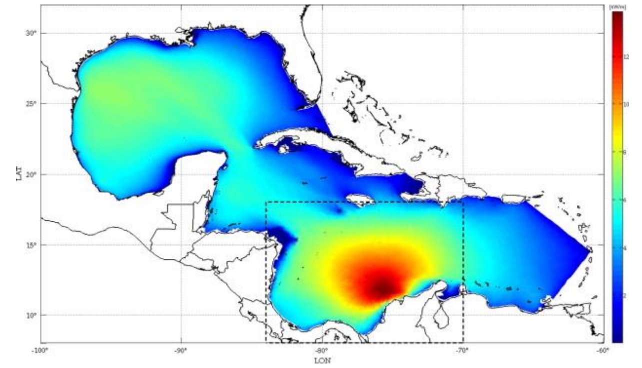


Fig Annual mean waver power (kW/m) in the Gulf of Mexico and Caribbean Sea, showing maximum mean wind speeds in the area influenced by the CLLJ (1979–2008 . (Christian M. Appendini, et al 2015) of the Caribbean region, (extreme weather conditions usual in the region -namely, hurricanes and tropical storms-) further analysis will need to be carried out in order to determine the areas with higher potential for wave energy generation, as well as the risks associated to marine, climate, etc.

2 – Products

2.1 Product Offering 1:

The product analysed in this document is aquaculture production facilities that rely on wave energy generation for functioning. The proposed combination will allow facilities to increase the autonomy of functionality reducing the dependence on other energy sources and providing a clean energy alternative, also contributing to the reduction of the carbon footprint of aquaculture production. The expansion of marine aquaculture in the long term will necessarily require to expand operations offshore, to avoid overcrowding of coastal areas, and adequate spatial use considering other economic activities (mainly, transportation, small-scale fisheries and tourism). The expansion of aquaculture towards offshore areas presents further challenges in terms of provision of required inputs. In the case of wave energy generation, the technology varies according to the distance from the shore. In addition, the energetic demands of facilities depend on the size of the technological level of production. Electricity, depending of the level of technology selected, is required for: illumination of platforms; automatic feeders; automatic counters; fish collection with suction pumps; and aeration. The proposed combination considers small autonomous wave energy device of 20 kW capacity as a base. In case of higher demands of energy, more devices can be added to the facility. Considering the variability of energetic supply and demand, storage equipment should be added.

2.2 Product Offering 2:

The main output of the proposed combination would be seafood products for human consumption produced in a sustainable way through a technological combination that reduces carbon emissions and promotes the use of renewal energy sources. The species and output volume would depend on the location, the regulation in force in terms of species and concentration of aquaculture. At a preliminary stage, some species to be considered are cobia, shrimp and bivalves. These species present different technological requirements, and total production will depend on the size of the facility besides the legal regulations in force. As mentioned above, some countries such as Colombia and Panama, are already producing cobia, therefore there is acquired knowledge in the region to further develop production, and in addition, regulations have already been adjusted to regulate the species exploitation.

3 – Market Analysis

3.1 Development Driver: Demand for fishery and aquaculture products is on a clear upward trend, driven not only by population growth, but also by economic development and change in dietary habits. Besides the continuous growth on international trade, increasing volumes are being kept in domestic markets, adding pressure on prices and countries to increase production to supply their own and export markets. Additionally, the Caribbean Basin presents a strong market potential for aquaculture products, given by the strong tourism sector, which, in the first half of 2015 implied the arrival of 14.5 million tourists, according to the Caribbean Council and the Caribbean Tourism Organization.

3.2 Market size: According the OECD-FAO Agricultural Outlook projections for the fisheries sector, by 2024 fisheries production worldwide will have grown 19% from the levels reached in 2012-2014, driven mainly by a 38% increase in aquaculture production. Per capita consumption of fish in 2024 is estimated to reach 21.5 kg, a 9% increase from the base year estimates for the projection. Some of the key factors to determine the variations in growth rates in aquaculture will be land and water availability, and technological improvements. In fact, the constraints related to availability and quality of water, competition for production locations and need for investments on infrastructure are among the causes of the slowdown in growth rates of aquaculture production.

According to FAO-FishStatJ figures, the Caribbean Basin marine aquaculture production in 2013 totalled 12 116 tonnes, of which 70% was accounted by shrimp production. These figures are relatively low compared to total aquaculture production in the region (479 875 tonnes in 2013), but considering that production peaked in 2006 at 26 659 tonnes, it shows that there is clear margin for the expansion of production. Although production is led by continental nations, the development of near-shore and offshore aquaculture presents strong opportunities for the island nations.

Given the brief outline above of seafood consumption and production trends, the expansion of marine aquaculture presents a wide range of possibilities and opportunities for island and coastal nations that are part of the Caribbean Basin.

In addition, being a clean energy alternative, it would contribute to reduce the effects of production on climate change, reduce its carbon footprint, as well as allow the development of new economic activities, associated to the operations and maintenance of facilities. By reducing the dependence on other energy sources, mostly from diesel and oil, it would reduce the volatility of costs linked to the variations of the price of oil. In the long term, for those energy generation facilities located close to the shore, there could be the possibility of providing energy to operations inland, if a surplus could be achieved and the grid connection costs and technology allowed it.

One of the key elements for the future development of marine aquaculture is the adequate spatial planning and environmental impact assessment and mitigation. Consequently, the location of future projects will require adequate planning of the use of waters, and adequate regulation if the proposed economic activities imply the introduction of foreign species. This becomes particularly important given the richness of biodiversity and ecosystems in the Caribbean region, as well as the coexistence of other economic activities. It must be taken into consideration not only the impact of aquaculture production (such as residues, possible contamination from feed and medication to avoid fish diseases, stock escapes, pollution from operations, etc.) but also the impact of the installation of facilities and devices (residues, damage to the ecosystems, changes in fish stocks behaviour, etc.).

4 – Customers

The key customer for this type of technology would be aquaculture companies investing in marine aquaculture. Several initiatives are taking place for the development of new aquaculture activities, such as cobia production, which takes place offshore. Given the fact that in many cases, technology is at an early stage of development, therefore costs of implementation can become significant. This implies that early stage of implementation would require strong capital investment, that probably could be faced by consolidated companies, special promotion projects and programmes, or initiatives supported by the government. However, once technology is consolidated and has reached a certain level of standardization, it might be more affordable for organizations of producers and smaller companies.

A secondary customer are those stakeholders that purchase the output of the enterprise, namely wholesalers of seafood products, and if the connectivity conditions allow it, other producers that could buy energy surpluses in case there is exceeding energy production capacity.

5 – Competition

The main source of competition comes from other energy sources. The key differentiation aspects are linked to availability, technological development, and environmental impact. The table below presents a summary of the different technologies analysed.

Table 1 - Competitors to Concept

Competitor	Key Differentiations	Rating (1-10; 10 is most competitive/desirable)
Diesel power	Available, reliable supply. Environmentally poor, price fluctuations associated to oil price variability	8
Power from Grid	Distance to connection can become a difficulty. In some countries, grid supply also relies on oil and diesel.	6
Tidal energy	Still at a development stage, depends on the location and environmental impact is not yet fully assessed.	2
Wind power	Operations are fully functional in several countries. Facilities are affect the landscape, and the installation of devices can affect the sea floor and its resources. Extreme weather conditions such as hurricanes can have a severe impact on windmills.	5

Solar power	Capability of technology is proven, although the generation capacity can be tight in some cases. If installed in the same facility than production, would facilitate the autonomy of the site, and depending on the design, might be less vulnerable to extreme weather conditions (e.g.: hurricanes)	7

6 – Revenue

The main source of income for the proposed combination would come from the sales of aquaculture production. Another source of income could come from the sale of energy to other production facilities nearby, or to the power grid. This would be conditioned by available connections to transport energy.

Also, given that seafood is a commodity for which prices tend to be determined at an international level, the modification in the cost structure can have an impact on the profitability of the business.

Given that the concept proposed is an autonomous production facility in terms of energy supply, no tariffs would be directly associated to the production of energy. This would result in a reduction of operation costs as energy would be provided by the wave generation device. Although higher initial investment could be required considering the need to include the investment in the energy generation devices. However, some other tariffs and prices should considered from a cost perspective:

- Diesel prices will remain an input cost, since it is needed for the operations of boats to transport products, inputs and people to and from the facilities. However, a reduction in requirements would allow a change in the energetic matrix of the sector, reducing the exposure to oil price volatility, as already mentioned.
- Possible payments for spatial use and production licenses should be expected. In addition, following the environmental impact assessment, some taxes to internalize environmental costs are also a possibility.

In terms of operations, one of the difficulties for the development of wave energy production facilities listed by the European Commission Ocean Energy Technology Information Sheet is the need of rental of boats for operations, since the wave energy sector has not achieved a critical size yet, having a strong impact on costs. This constraint could be overcame since boats would already be available for regular aquaculture operations.

As a clean energy alternative, these initiatives could benefit from subsidies and grants to promote clean energy, carbon emission reductions, and those initiatives that are oriented towards climate change mitigations. These programmes are usually implemented at a national level, but regional initiatives could be designed in order to promote technological innovation, tailoring of existing technology and implementation. Aquaculture production itself could benefit from possible development plans that consider tax exemptions or special regimes in order to promote the sector.

The required investments could be high at an early stage, considering the technological status and the need for R&D to adjust existing technologies to the region and the aquaculture sector. This narrows the spectrum of possible investors. However, this also presents a wide spectrum for public intervention, through either national initiatives or funding from international cooperation agencies and programmes.

7 – Strategic Roadmap

Given the early stage of development of marine energy generation, and more in particular, its combination with aquaculture, the first stage would be the design and testing of adequate technology, taking into consideration the advances already done in other regions of the world. This should take in consideration the singularities of the Caribbean region, as well as the differentiation of requirements and potential of generation depending on the location (shoreline, near-shore, offshore). Afterwards, once the technology has been validated and tested, and further information on operational requirements and costs has been collected, an economical evaluation of viability must be carried out. For this stage, financial support from promotion agencies could be needed, given the uncertainty of the future viability of the proposal. In light of the economic assessment, the investment needs will be quantifiable, and therefore, this should allow allocating possible investors, and assessing the requirements of support from other stakeholders (namely, governments, international funding organizations, etc.).

Table 2 – 5 year Strategic Roadmap

2016	2017	2018	2019	2020
TRL 3-4		*TRL 5*		*TRL 6*
Design and testing of combined facilities. Assessment of possible geographic locations.		Installation of facilities. Collection of baseline information for environmental impact assessment. Collection of installation and initial operations costs. Operations of the facilities and follow up.		Validation of vulnerability of the prototype to external factors. Collection of data for economic and environmental evaluation.
H2020 funding		IADB/EU funding		
IRL 4		*IRL 5*		

8 – Conclusions

The analysis presented proposes an outline for the development of the combination of marine aquaculture and wave energy generation technology, in the context of the MARIBE initiative. This would present a solution to the issue of energy supply for marine production facilities, as well as reduce the reliance of other energy sources, providing a clean energy alternative through a multi-use of space proposal. However, given the early stage of development of the proposed technology proposed, further assessments will be required regarding economic and environmental feasibility, as well as the environmental impact on the Caribbean ecosystems, and the challenges presented by the region in terms of operations potential and possible impact from climate and geographical conditions. Further assessment is needed to determine the species to be produced, the location of the facilities, the size, and subsequently, the technological requirements and potential energy demand. This would be once the specific implementation plans are outlined, and will also set the initial investment needs. On the other hand, the further development of the proposed combination, would contribute to develop the use a low carbon energy generation technology, and through its combination to sustain aquaculture production, it would contribute to food security through the production of food and employment generation, as well as to mitigate climate change by reducing the carbon emissions in the region.

9 – References

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