Opinion

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Moving offshore for fish farming

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Opinion

Fish farm operators worldwide are moving their farms offshore due to lack of available nearshore production sites in heavily contested coastal zone, where there is increasing conflict with other usages such as shipping, fishing, tourism, conservation and recreation. Moreover, offshore sites provide much larger sea space and better water quality that are needed to increase the production of healthy fishes. As to what constitutes an offshore fish farming site, the authors opine that the offshore site has the following characteristics (i) unsheltered waters defined by the seaspace outside a straight line joining two major capes/promontories or within 25 nautical miles from the shoreline for economic feasibility[1] (ii) water depth greater than 3 times the cage height and at least 15m between the cage bottom and the seabed for better dispersion of fish wastes[2] and (iii) current speed[3] ranging from 0.5m/s to 1m/s. However, going offshore poses many challenges due to the high energy environment, inaccessibility of power supply and supporting services.

Based on a literature review on offshore fish farming, we identify the following 4 possible solutions for offshore cage designs:

(1) **Using more rigid and robust cages to withstand the high energy environment**. Examples are (i) Havfarm: 430m in length and 54m wide that has the capacity to produce 10,000 tons of salmon or over 2 million fish; (ii) Pisbarca: Hexagonal steel structure with 7 cages having a total volume of 10,000m^3 and (iii) Ocean Farm 1: Diameter of 110m and volume of 250,000m^3 that can accommodate 1.5 million salmons – see Figure 1.

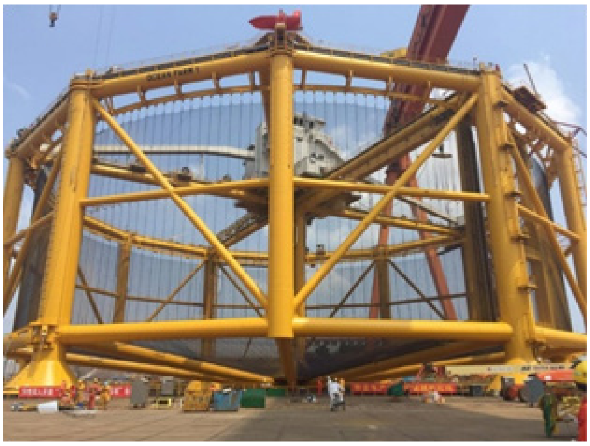

Figure 1 Ocean Farm 1.

(2) **Using submerged cages so as to move away from the strong surface waves**. Examples are (i) Farmocean: Developed in Sweden and launched in 1986, volume ranging from 2500 to 6000 m^3; Sadco: A ballasted upper steel hexagonal structure with a lower sinker tube to keep the net in shape. Volumes are available up to 2000m^3 ; (iii) AquaPod: Developed by Ocean Farm Technologies (USA), features two-point anchor for mooring with net cleaner and remover of dead fishes.

(3) **Designing closed containment tanks on large floating platforms, big barges or ships for a controlled environment.** Examples are (i) Neptun: Containment tank having an internal diameter of 40m and a gross volume of 21,000m^3; (ii) Dr. Techn. Olav Olsen tank: Cylindrical concrete tank with a 14.8m inner diameter – see Figure 2; (iii) Eco-Ark: AME2 Pte Ltd developed a closed containment, water flow-through floating fish farm equipped with solar panel for electricity supply

Figure 2 Olav Olsen Tank(photo courtesy of Tor Ole Olsen).

(4) **Creation of a sheltered sea space for fish pens by using floating breakwaters at the offshore site.** An example is the authors' HEXAGON as shown in Figures 3A & 3B. Box shaped concrete breakwaters are used to enclose 415,000m^2 sea space of a hexagonal shape. The breakwaters serve as platforms to carry offshore renewable energy converters for power supply to the farm. Also their internal spaces are used for feed storage, and to house desalination plant, waste water treatment plant and hydrogen production plant. In the middle of the sheltered sea space is a hexagonal floating concrete platform that carries the necessary facilities for a stand-alone fish farm such as control tower, admin offices, fish and fish food processing facilities, warehouses, workers quarters, pump room, power plant, and berthing facility. The central floating platform is surrounded by modular floating platforms with flexible connectors to dissipate wave energy. The modular floating platforms have 50 circular cutouts of diameter 50m for fish pens that can accommodate a total of 6.5 million fish (130,000 fish for each pen) and carries roadways for vehicles and cranes to access the fish pens.

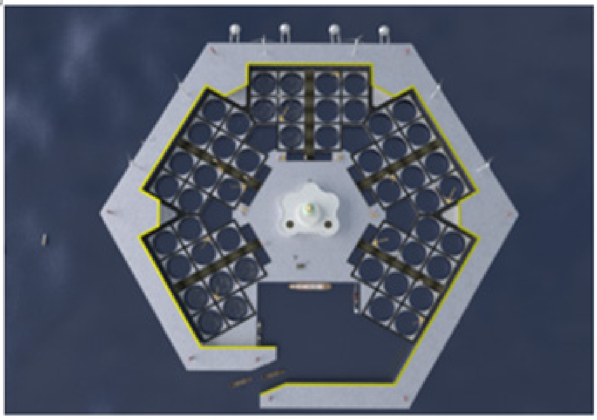

Figure 3(A) Plan view of HEXAGON

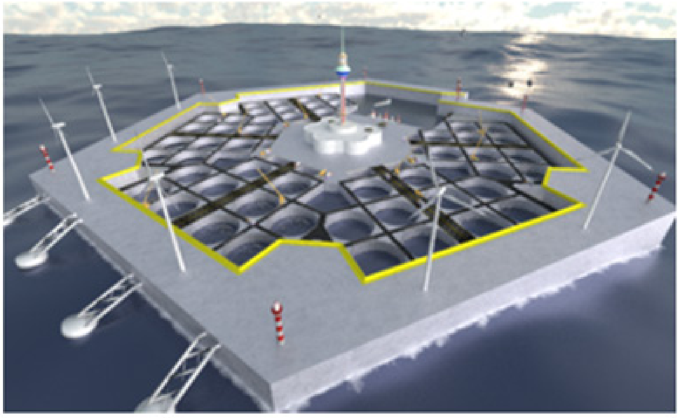

Figure 3(B) Isometric view of HEXAGON

It is clear that moving offshore for fish farming is expensive. However, it is expected that the costs for offshore farming will be reduced significantly in future by using advanced technologies in offshore engineering and materials, co-locating with offshore renewable energy systems for power supply and deploying remote technologies and drones.

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Conflicts of interest

Authors do not have any conflicts of interest.

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