Installation, operation and evaluation of a submersible cage at 55 m depth in Crete for the rearing of red porgy *Pagrus pagrus*

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- Exist limitations for the rearing location of net-pen sea cages due to
  - socio-economic factors related to the management of the coastal zone (site limitation in sheltered areas, competition with other activities)
  - biological parameters related to species specific requirements for husbandry conditions

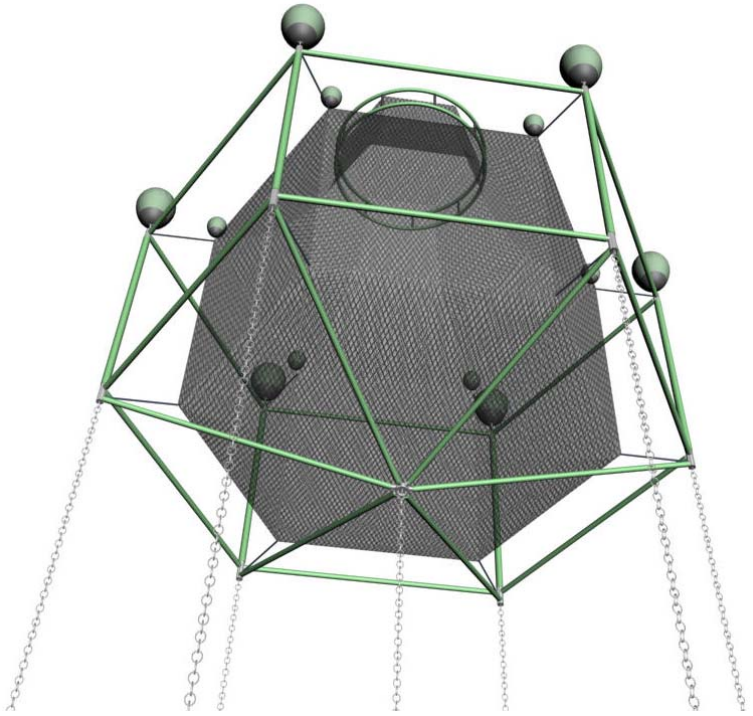
- The red porgy (*Pagrus pagrus*) require
  - narrow temperature range for optimum growth (17 - 19°)
  - low light intensity to avoid hypermelanosis

- Stenothermic species (black spot sea bream, *Pagellus bogaraveo*; wreckfish, *Polyprion americanus*) can not be reared in Mediterranean due to high surface temperatures during summer

- A solution to this may be the rearing in submersible cages at depths below thermocline (> 35-40 m)
- However, available cages are submerged only 10 to 15 m from the surface, and the fish are subjected to high submersion & lift-up velocity
- We have designed and installed a cage at 55 m depth based on the REFA TLC technology at the pilot cage facility of HCMR in Crete
- The system was evaluated during rearing of red porgy studying the effect of the technology on the growth and performance of red porgy

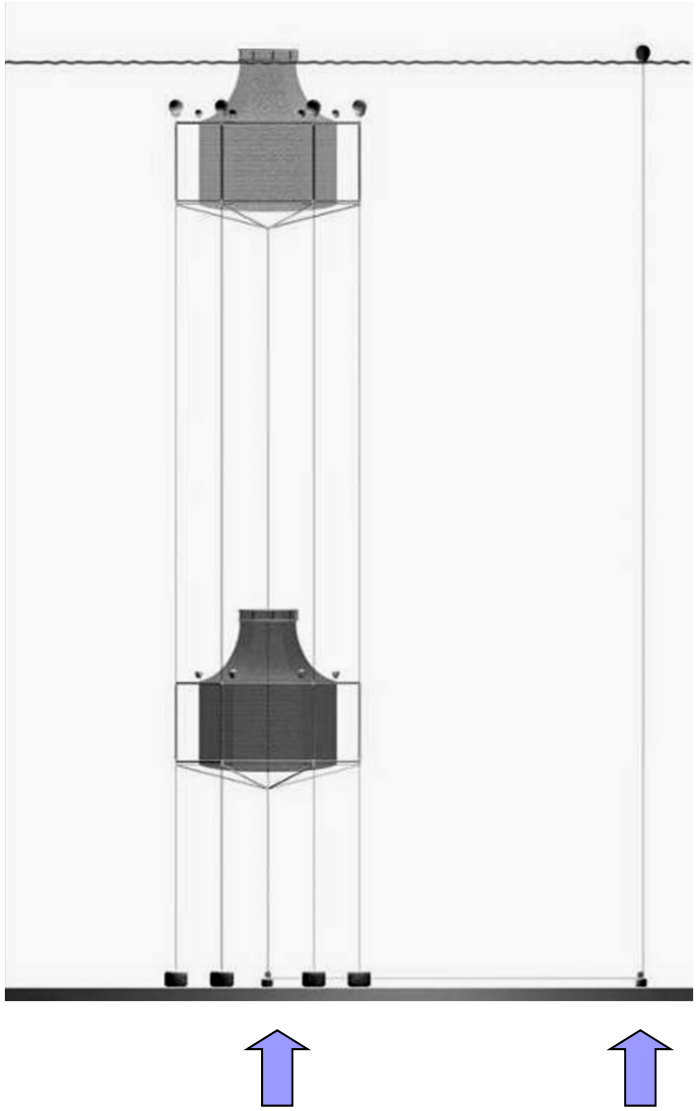
The cage

- The cage-net module consists of a nylon net-pen contained within a hexagonal rigid frame to maintain the shape of the net
- Vertical beams of the frame glide over 6 tension legs placed in a circle
- Tension legs consist of mooring block, chain and flotation buoy, permanently installed



- The controlled submersion of the cage, and its raising back to the surface, is performed with an electric winch and rope – pulley system

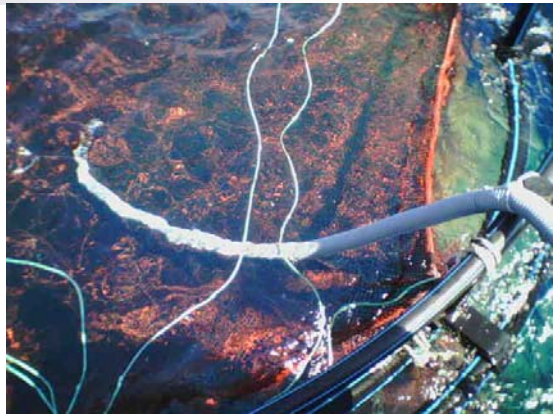
- The pulleys are installed on 2 concrete blocks, one positioned below the cage centre and the other outside



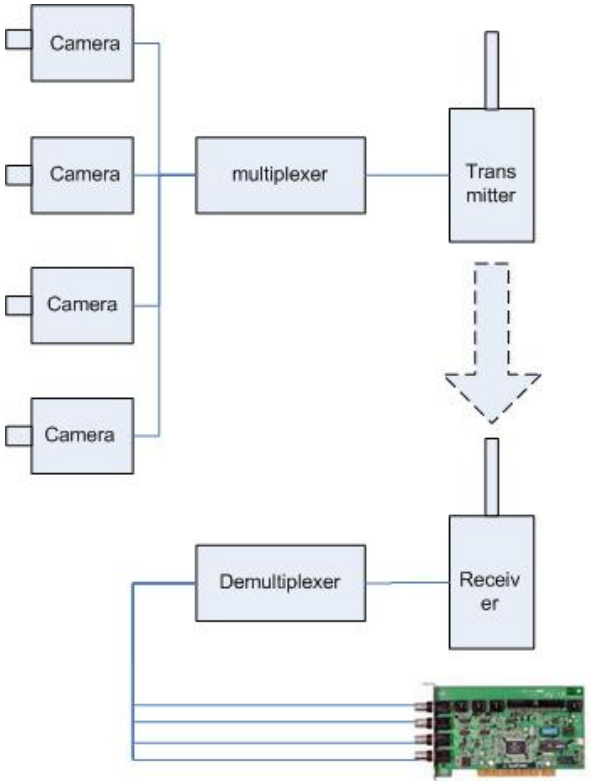
operation

- The cage is submerged to 40 m at the installation site. The hauling up of the cage is done with a velocity below 1m min-1
  - 1st day: 2 hauling up 8m each with an interval of 3 hours
  - 2nd day: 2 hauling up 8m each with an interval of 3 hours
  - 3rd day: 1 final hauling up of 8m
- The operation of the cage is supported by a floating platform
- Solar panels provide power (320 W) connected to batteries that can supply almost 50Ah over 4 days (max period without sun during February)

Feeding



- is performed by transferring feed together with water through a flexible tube from the surface
- An electric pump located on the platform pumps water into the cage, while an electric dosing mechanism delivers prescribed feed amounts
- The feeding pipe is installed at the upper part of the cage to ensure even distribution
- For the monitor of the populations a camera was used. The video signal could be directly recorded on site or transmitted by a wireless analogue video to a receiver



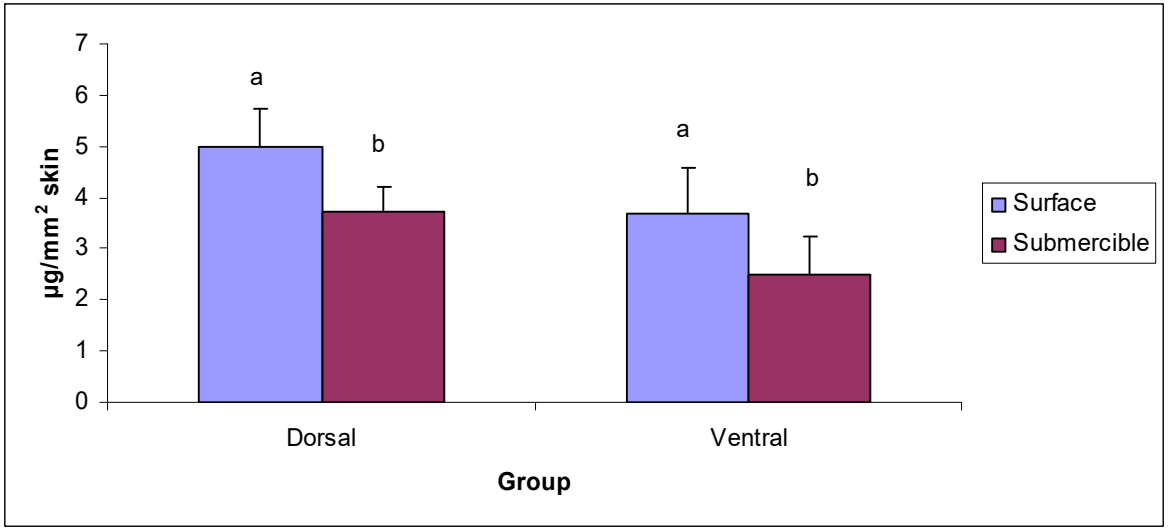
- The operation of the cage was evaluated using a population of red porgy (*Pagrus pagrus*), at an initial stocking density of 5 kg m^{-3}, and for a rearing period of 5 months
- A second group of red porgies reared in a surface net-pen cage served as control
- Fish were fed carotenoid-supplemented feed
- At the end of the trial 12 to 15 fish were sampled from each group to evaluate the effect of rearing system on fish performance (including skin color and melanin content)

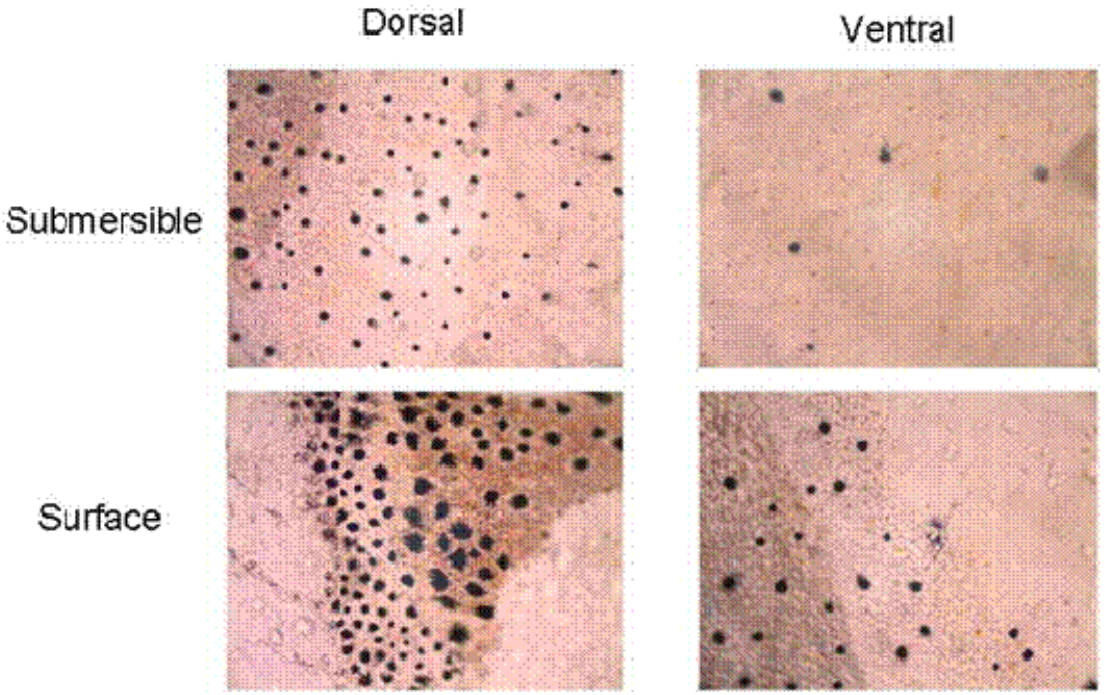
results

- The operation of the cage was without any relevant difficulty
- The solar system provided energy without shortages and the feeding system operated properly
- The only difficulties that arose were related to the inability for inspection and sampling without disturbing fish
- Growth performance was similar between the two experimental groups;
  - individuals grew in weight from 683.6±94.6 to 770.5±85.3 g
  - FCR ranged from 2.3 to 2.5.

The rearing method affected fish skin pigmentation

- Individuals reared at the submersible cage had
  - brighter skin color
    - Submersible (L^*_{dorsal}=60.78±3.95; $L^*_{ventral}$=78.19±9.15)
    - Surface (L^*_{dorsal}=49.35±5.08; $L^*_{ventral}$=69.43±3.90)
  - lower melatonin content in the skin





Melanophores at the dorsal and ventral area of reared red porgies in submersible and surface cages

- Red porgy reared with carotenoids rich diet in the submersible cage
- Red porgy reared with carotenoids rich diet in a surface cage

- Aquaculture is one of the fastest growing food industries worldwide
- There exist a considerable interest in developing open sea aquaculture
- Among other possible solutions submersible cages offer a feasible alternative

- Our results showed that the tested submersible cage was operational for 2 years without significant problems
- Its everyday husbandry was rather easy although better feeding and monitoring systems can further improve its functionality
- Rearing of red porgy in submersible cages allowed the exposure of the individuals to lower light intensity and radiation levels and to a constant temperature for optimum growth,
- This resulted in improved performance in terms of increased skin brightness and lower melanin content, improving thus the commercial value of the species

- This submersible cage can provide a feasible alternative for rearing of fish in exposed areas and especially for species with specific biological requirements for optimum growth and performance, such as narrow temperature ranges and low light intensity