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Engineering general aspects of BFT farming

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SUMMARY – From the first phases of the DOTT (reproduction, genetics, etc.) to the final stages in the processing plant, a number of tasks should, at least, be considered and studied from the engineering point of view. These include handling methods and techniques to keep the alive fish in good shape during catching, towing, farming, harvesting and post-harvesting operations; transport and offshore cages; mooring designs and monitoring methods for these systems; feeding controls; non-invasive fish size assessment methods; the removal of dead fish and feeding waste; killing cages and killing methods; systems to collect fertilized eggs; the use of land base facilities and processing methods together with installation, instrumentation and control systems.

Key words: Offshore, cage, control systems.

RESUME – *"Ingénierie des aspects généraux de l'élevage du thon rouge". Depuis les premières étapes de domestication des thonidés (reproduction, génétique, etc.) jusqu'aux derniers stades d'une usine de transformation, il faudrait considérer et étudier au moins un certain nombre de tâches du point de vue de l'ingénierie. Ceci comprendrait les méthodes et techniques de manipulation pour que les poissons vivants soient maintenus en bonnes conditions pendant les opérations de capture, remorquage, élevage, récolte et post-récolte ; le transport et les cages offshore ; les dispositifs d'ancrage et les méthodes de suivi pour ces systèmes ; le contrôle de l'alimentation ; les méthodes non invasives d'évaluation de la taille des poissons ; l'élimination des poissons morts et des résidus d'aliments ; les cages et les méthodes d'abattage ; les systèmes de collecte des oeufs fertilisés ; l'utilisation d'installations sur terre et les méthodes de transformation de même que des systèmes d'installation, d'instrumentation et de contrôle.*

Mots-clés : *Offshore, cage, systèmes de contrôle.*

Generic areas

A summary of the generic areas to be covered by the engineering field in the domestication of the BFT is as follows:

(i) Cages.
- The design of new cages should be considered together with the upgrading of existing ones.
- New designs should be verified before being put into use.
- Mooring systems should be developed and modified.
- Hydrodynamic channels and towing tanks should be used for laboratory testing.

(ii) Materials. Metallic and non-metallic materials (PA, PES, PE, PP, NETLON, rubbers, nylon) should be designed and tested, covering all cage components: structures, floating systems, nets, chains and ropes.

(iii) Auxiliary equipment. The design, qualification and tests should be made for such diverse areas such as cranes, pumps, filters, valves, heat exchangers, compressors, heaters, tanks, etc. that are used within the industry.

(iv) Auxiliary ships, barges and platforms.
- New design and upgrading.
- Manufacturing follow.
- Hydrodynamic channel tests ... Towing tank.

(v) Instrumentation and control. New designs are required for testing.

(vi) Support structures. Design and calculations considering vibrations, corrosive environment, stress corrosion and cracking will be required in the future.

(vii) Welding. New designs are required with “coupons tests”, of destructive and non-destructive methods.

(viii) Economic feasibility studies.

Upgrading specific areas

In meetings with tuna grow-out private companies and R&D Institutions, the following considerations and possible upgrading areas have been identified.

Considerations

Offshore culture

The BFT culture should be performed in deep water, far from shore, due to the life conditions, fish behaviour and also due to environmental requirements, therefore the grow-out facilities will have to withstand the high energy (waves, currents, winds, etc.) of open sea. Accordingly the facilities should be designed for such conditions. These harsh conditions should be considered in the feeding equipment, fish handling, sampling and the safety problems associated to operation conditions.

Towing and transfer

The procedure that begins after capturing the fish with pure seine nets, and follows when transferred into transportation cages, is found unsatisfactory. The towing of the alive fish after capture to final destination and the transfer to moored cages should be improved. The connections between cages for moving the fishes from cage to cage, without touching them, is an important aspect to be considered.

Cage design

The cage design should resolve the concerns of the fish grow-out farmers:

(i) The depth of the cages in relation to the tuna behaviour.

(ii) To avoid stress and mortality caused by lighting during storms.

(iii) To consider how much this fish depends upon light for food. The research has shown that tuna see best in shaded or diffused light, and that strong summer light has a blinding effect on tuna fish as their eyes have no protection and their pupil can not expand or contract. For these reasons it seems that shaded cage may be advantageous to allow fish see well.

Handling

The beginning of the research itself will be in cages, therefore the question of how to handle this giant fish is a major issue.

An extensive alive fish research work must be done to include taking blood samples, biopsy of their gonads, how to put them to sleep, as well as to make sure that we do not harm them at any time. Further on, work must be done on marking techniques to study the daily and seasonal growth patterns.

There is an urgent need to have a device (i.e. special hammock or cradle) to put the fish while working on it them in the water, or to move the fish out the water onto a dry platform and keep them in good shape while performing needed work. We must ensure the recover and the survival of fish when transferred back into the cage. The design of this device should consider how to reduce the stress and injury to the big tuna. This is the first priority item of the technological needs that will allow to collect

information for better understanding of how tuna respond to the external (environmental) and the internal (physiological) events.

Land facilities

One important area is the land based facilities in which we would like to keep brood stocks in order to study them and get them to spawn in captivity, including transportation methods from cages to land facilities.

The design of the tanks should consider the following parameters and controls: (i) size, form and depth; (ii) temperature, salinity and light controls; (iii) prevention from harming themselves by bumping into the walls; and (iv) indoors or outdoors.

Improved quality

The technology area must also include harvesting and post-harvesting (processing) techniques. The aim of these points can be joined under improved quality of BFT aiming to upgrade and/or develop handling, harvesting and post-harvesting methods and techniques to maximise the colour and flesh characteristics (freshness, texture, avoid tissue damages, improve organoleptics, etc.) as required by the export market.

The project may also try to develop methods and techniques to process whole fish for export in which the flesh colour remains stable in spite of long transport duration while reaching consumers.

Regarding this technology area we must understand the Japanese market and to accurately evaluate existing "Killing and Handling Guidelines" as was suggested by Japanese tuna buyers. The standards and criteria should be considered in terms of their use and relevance in sushy and sashimi dishes.

Possible upgrading areas

(i) Methods and techniques on how to handle the alive fish and keep them in good shape during catching, towing, farming, harvesting and post-harvesting.

(ii) Transport cage design upgrading including connection between cages.

(iii) Offshore cage design with special attention to the ring materials, the depth of the cages and the light shade or diffuse systems.

(iv) Mooring designs and monitoring methods for these systems in the offshore cages.

(v) Feeding control.

(vi) Non-invasive fish size assessment methods.

(vii) Dead fish and feeding waste removal systems.

(viii) Sacrify cage designs.

(ix) Sacrify methods: ultrasonic, laser, submarine magnetic chamber, etc.?

(x) System to collect fertilized eggs from the cages.

(xi) Land based facilities design that should include the transportation methods from cages to land, the tanks and the fish moving and handling systems.

(xii) Processing method upgrade to improve the fish quality.

Description of engineering areas

The DOTT activities to be performed in the engineering field should be performed by the following work areas with the facilities identified here below.

Design of structural solutions for experimental facilities

The scope in the area of structures includes: (i) analysis and evaluation of design alternatives; (ii) design of feasible structural arrangements; (iii) selection of materials; (iv) design of structural elements for the farm and equipment; (v) design of mooring, anchoring and movable elements; (vi) design of elements for operating the farm; and (vii) design of personal devices and vehicles.

The members of this group should accumulate real life experience design of complex and novel marine structures (materials, loadings and responses), mooring and anchoring systems and hydrodynamics of floating submerged and semi-submerged structures in moving waters.

The labs and computer facilities should be well equipped for research, simulation and fabrication of prototype models, to evaluate design alternatives. Special interest will focus on the analysis of animal-friendly structural arrangements and the use of environmental safe solutions materials for structural members and coatings.

Towing tank laboratory

The towing tank should have a carriage with variable speed and a regular wave generator for waves. It should also incorporate equipment for testing anti rolling tanks, and equipment for making the scaled physical models, in wood or plastic.

Other facilities are those about computational calculations, with own codes developed through years in the laboratory: (i) power prediction of floating bodies (still water and waves); (ii) pressure and velocity distributions around a vessel; (iii) seakeeping in irregular seas; and (iv) controllability.

Another fields in which the laboratory should work are: (i) instrumentation; and (ii) sea keeping tests in real ships.

Underwater acoustics laboratory

The laboratory should be opened to all the fields of application of the underwater acoustics and is oriented fundamentally toward the development, evaluation and commission of systems, without discarding the transducers and subsystems tests and trials.

With the purpose of using to the maximum the resources, this laboratory could be located in the electrotechnics, electronics and systems laboratory, by the importance that has the electronic transducer systems and signal process.

Materials group

The materials group should have experience in subjects related with the welding and joining technologies and also in inspection (NDT) and testing of welding joining.

A very important research line should be related with environmental degradation of adhesive joints in seawater. For this purpose, the laboratory should be equipped with light and scanning electron microscopy, mechanical testing (tensile, hardness, impact, etc.).

On the other hand, using non destructive testing (ultrasounds, magnetic particles, liquid penetrants, eddy currents, radioscopy) a line of research could be established on defects of metallic and plastic materials.

Conclusions

Considering these engineering general aspects, the objectives defined during the Engineering Workshop should permit to the participants in each cluster to establish the specific working packages to prepare a proposal for BFT husbandry research.