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Acclimatization of tuna fish to on-land facilities

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SUMMARY – The fishing activity on *Thunnus thynnus* has produced a decrease of the biomass of natural populations, and the International Commission for the Conservation of Atlantic Tunas (ICCAT) has recomended the development of studies about growth and reproduction of this specie in captivity. Due the high commercial value and high growth rates of tuna fish, these species have good possibilities for marine aquaculture. In this sense the Instituto Español de Oceanografía (IEO) has began a research project with tuna fish, with the final objective of obtaining stocks of several species and determine their capacity to reach sexual maturity and spawn under captivity conditions in on-land facilities. During the last two years several experiences have been carried out to establish the viability of maintaining stocks of different tuna fish in captivity (*Thunnus thynnus*, *T. albacares*, and *T. obesus*), in ponds located in the on-land culture facilities of the Centro Oceanográfico de Canarias in Tenerife, that allows the stocking of big size fish. This study has been carried out with three fish stocks in 1997 (July to December) and 1998-1999 (August to February) in circular tanks of 50 m^3 (7 m ∅), 250 m^3 (13 m ∅) and race way tanks of 500 m^3 (40 m length). Information has been obtained about the characteristics that the facilities should have for acclimatization and stocking of tuna, as well as to optimize manipulations of fish. Data obtained are basic for developing further studies of growth and sexual maturation in captivity.

Key words: Tuna fishes, fish culture, stock management.

RESUME – *"Acclimatation des thonidés aux installations terrestres". La pêche exercée sur* Thunnus thynnus *a causé une baisse de la biomasse des populations naturelles, et l'International Commission for the Conservation of Atlantic Tunas (ICCAT) a recommandé de mener des études concernant la croissance et la reproduction de cette espèce en captivité. En raison de la grande valeur commerciale et des forts taux de croissance des thonidés, ces espèces présentent de bonnes possibilités pour l'aquaculture marine. Dans ce sens l'Instituto Español de Oceanografía (IEO) a entamé un projet de recherche sur les thonidés, dans l'objectif final d'obtenir des stocks de plusieurs espèces et de déterminer leur capacité à atteindre la maturité sexuelle et à frayer en conditions de captivité dans des installations terrestres. Pendant ces deux dernières années, plusieurs expériences ont été menées pour déterminer s'il était viable de maintenir en captivité des stocks de différents thonidés (*Thunnus thynnus*,* T. albacares*, et* T. obesus*), dans des étangs situés au sein des installations d'élevage terrestre du Centro Oceanográfico de Canarias à Tenerife, qui permettent le peuplement avec des poissons de grande taille. Cette étude a été menée sur trois lots de poissons en 1997 (juillet à décembre) et 1998-1999 (août à février) dans des réservoirs circulaires de 50 m^3 (Ø 7 m), 250 m^3 (Ø 13 m) et des raceways de 500 m^3 (40 m de long). On a obtenu des informations sur les caractéristiques que doivent avoir les installations pour l'acclimatation et le peuplement avec des thonidés, ainsi que pour optimiser les manipulations des poissons. Les données obtenues sont fondamentales pour poursuivre les études de croissance et de maturation sexuelle en captivité.*

Mots-clés : *Thonidés, pisciculture, gestion des stocks.*

Background

For a few years the Centro Oceanográfico de Canarias (COC) in Tenerife, has been carrying out a series of projects with specimens of the tuna fish and with the aim of building up a stock of breeding specimens with which to develop the technology needed, to cultivate/farm them at larva and post-larva stage.

Working with marine species of great size and rapid growth such as tuna fish: bluefin tuna *(Tunnus thynnus*), yellowfin tuna (*T. albacares*) and bigeye tuna (*T. obesus*) is possible due to both the type of on-land facilities the COC has at its disposal, in particular the circular and "race-way" tanks with a capacity of between 250-500 m^3, and the oceanographic characteristies of the Canary Islands.

At present the COC is concentrating on the development of a method that will allow handling of the specimens during those operations needed to carry out studies on growth as well as on sexual maturity and reproduction.

Capture

Tuna fish to be used in experiments in captivity are caught using the traditional method, of the Canary fishing fleet. This fishing method is known as live bait, where small pelagic (herring, sardine) fish are used to attract the tuna and keep them near the ship whilst they are caught using bamboo canes of 3-5 m in length.

Transportation

Transportation is done aboard the same ship that catches the fish. This is done using the tanks in which the live fish used as bait during the tuna fishing were kept, and whose dimensions are 1.80 m x 2.60 m x 1.62 m, giving a capacity of approximately 7.5 m^3.

These tanks, which receive a continuous flow of water from an electric pump, allow for the transportation of 7 kg/m^3 (the equivalent of 2 fishes/m^3) over 7 days and a survival rate of 99%.

Adaptation

Experiment 1 (June 97)

Characteristics of the installations

(i) Cylindrical-conical, uncovered tank.
(ii) Dimensions: diameter = 7 m and average height = 1.5 m.
(iii) Approximate capacity: 50 m^3.
(iv) Water renewal: 6 renewals per day; (12.5 m^3/h).
(v) Water inlet in tank: through a PVC pipe hung across the tank and perforated allowing the water to fall into the tank in a curtain (Fig. 1).
(vi) Water temperature: max. = 21.7°C; min. = 20.9°C.

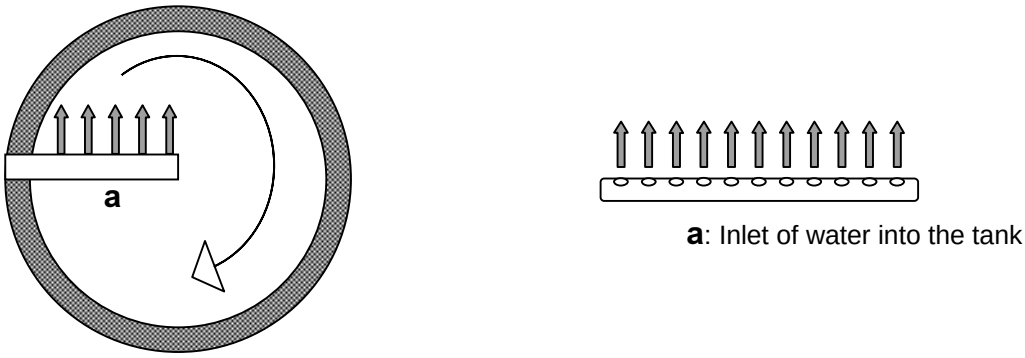

Fig. 1. Water circulation in the tank of Experiment 1.

Biomass

10 fish: 8 yellowfin tuna and 2 bigeye tuna of average weight 3.5 kg.

State of health

Some fish have lost skin on the flank as a consequence of scraping on the deck of the ship at capture.

Behaviour

Apparently calm with normal swimming habits, circular movements near the walls; however, they show signs of nervousness when near the falling water and this is further aggravated when they swim under the waterfall itself.

After the first two days they begin to rub themselves against the walls and bottom of the tank. This rubbing goes on for days and causes further injuries, leading to infection.

Nervous swimming with brusque changes of direction and speed; suddenly they swim straight across the tank into the wall, and are killed outright.

Throughout the following days the pattern is repeated until all the specimens are dead.

Experiment 2 (July '97 to September '97)

Characteristics of the installations

(i) Cylindrical-conical, uncovered tank.
(ii) Dimensions: diameter 13 m and average height 1.9 m.
(iii) Approximate capacity: 250 m^3.
(iv) Water renewal: 6 renewals per day, (62.5 m^3/h).
(v) Water inlet in tank: as in Experiment 1 (Fig. 2).
(vi) Water temperature: max. = 23.0°C; min. = 21.5°C.

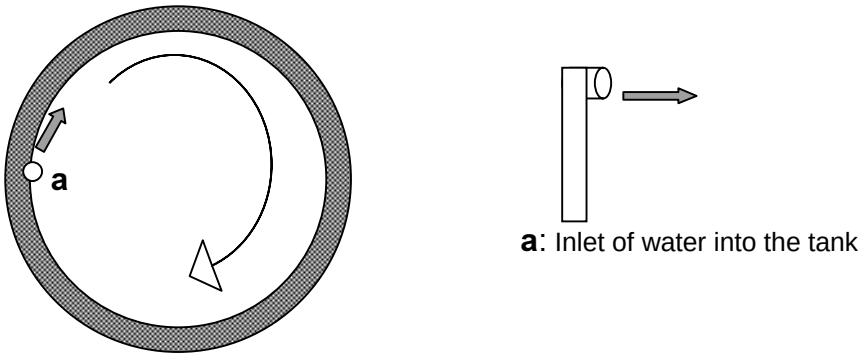

Fig. 2. Circulation of water in the tank of Experiment 2.

Biomass

16 fish: 7 yellowfin tuna, 5 bigeye tuna and 4 bluefin tuna of average weight 3.5 kg.

State of health

Some fish have lost skin on their sides due to scraping on the ship deck when they were caught; other fish have mouth injuries caused by hooks.

Two bluefin tuna and two bigeye tuna die as a result of their state upon arrival.

On the third day, in an attempt to prevent the infection of these wounds, the fish were given a prophylactic treatment, which consisted of a green solution of malachite and formol (250 cm^3 formol + 0.6 g green malachite/m^3), for one hour over three consecutive days. This treatment is applied in the holding tank, reducing the volume of water by lowering the water level to 0.5 m.

Between the fourth and fifth day 2 yellowfin tuna and 1 bigeye tuna die.

Behaviour

During the first two days, we observe the same swimming pattem as in the previous experiment and so the renewal of water in a curtain is stopped and changed to, another system consisting of a PVC pipe, 110 mm in diameter and open ended, fixed to the wall, forming a circular current.

As from this moment the fish calm down and begin swimming all over the tank. In spite of the changes, they still tend to stay near the walls, although they do not rub against them.

From the sixth day, they are fed chopped chub mackerel (*Scomber japonicus*), but they move away from the pieces without eating. After a few days, they approach the pieces, observing and watching them sink, but still do not eat.

After 15 days, 12 specimens of *Seriola* sp., of an average weight of 8 kg and fully adapted to captivity, are put into the tank. The following day 3 specimens (2 yellowfin tuna and 1 bluefin tuna) start eating the food; over the next few days the number of tuna fish feeding increases until, after 19 days, all the fish eat regularly.

The food is *ad libitum* and is supplied once a day from Monday to Friday.

Handling

(i) 60 days after their arrival, a first sampling is done for the growth study, where the weight and size of the tuna is noted. This sampling is done in the same way as with other fish of great size, such as the seriola (*Seriola* sp.) and consists of two steps:

- Reducing the level of water in the tank to 0.60 m forcing the fish into, a smaller area and making their capture casier.
- Catching the tuna using a net.

(ii) Putting 3 specimens into a tank, 1 m x 1 m x 0.6 m, with 130 cm^3/m^3 anaesthetic (300 g chlorobutanol/1000 cm^3 alcohol).

(iii) After a few minutes and once the specimens have been anaesthetised they are measured and weighed.

(iv) Once the sampling has been carried out, the specimens are transferred to a tank of similar characteristics, but fitted with an aeration system which maintains a high level of O_2 and eases the recovery of the fish.

(v) Full recovery takes a few minutes and, with the exception of one bluefin tuna which died, all the specimens are transferred to a holding tank.

During the following two days 5 fish die (1 bluefin tuna, 2 bigeye tuna and 2 yellowfin tuna), leaving only 3 specimens in the tank and which begin to show apathy towards food and to swim slowly, dying within 22 days.

Experiment 3 (August ’98 to March ’99)

Characteristics of the instalations

(i) "Race way" tank with two lateral lanes separated by a central wall; uncovered tank (Fig. 3).

(ii) Dimensions: length = 40 m, width of each side = 3.4 m, average height 1.9 m.
(iii) Approximate capacity: 500 m^3.
(iv) Water renewal: 6 renewals/day, (125 m^3/h).
(v) Water inlet in tank: using PVC pipes installed as in Fig. 4.
(vi) Water temperature: max. = 23.0°C; min. = 18.1°C.

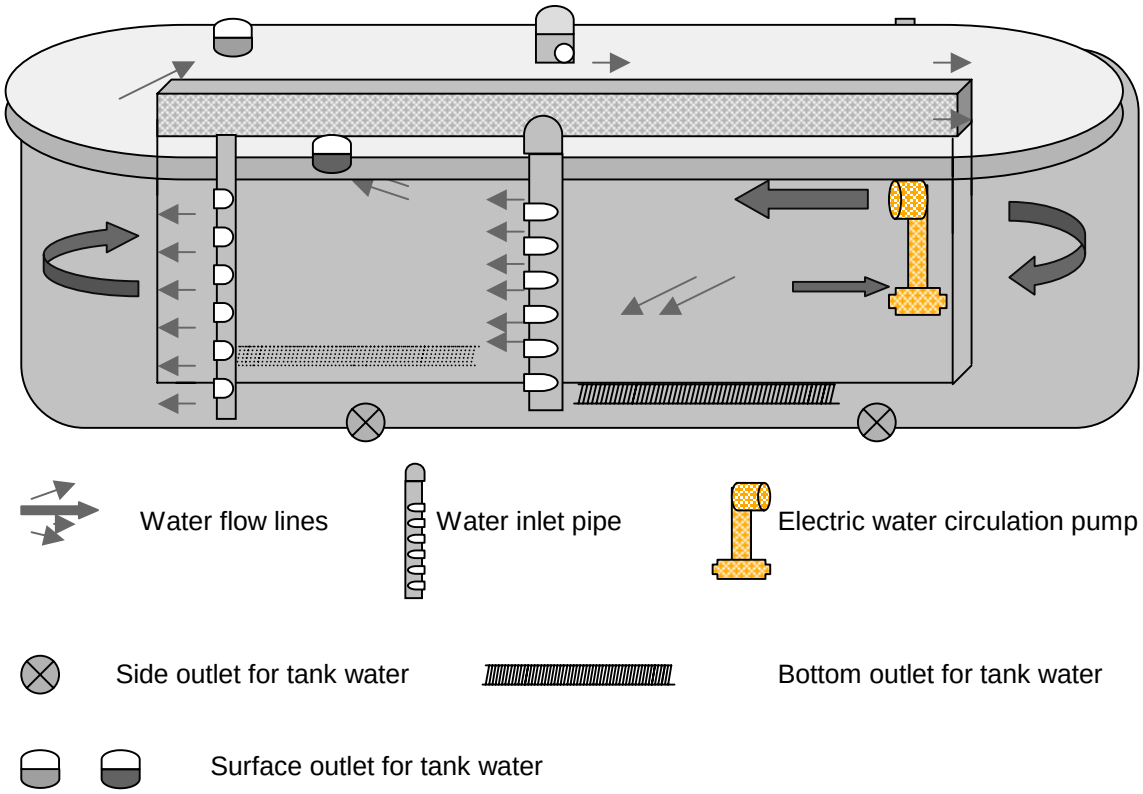

Fig. 3. Diagram of race way (Experiment 3) and water circulation.

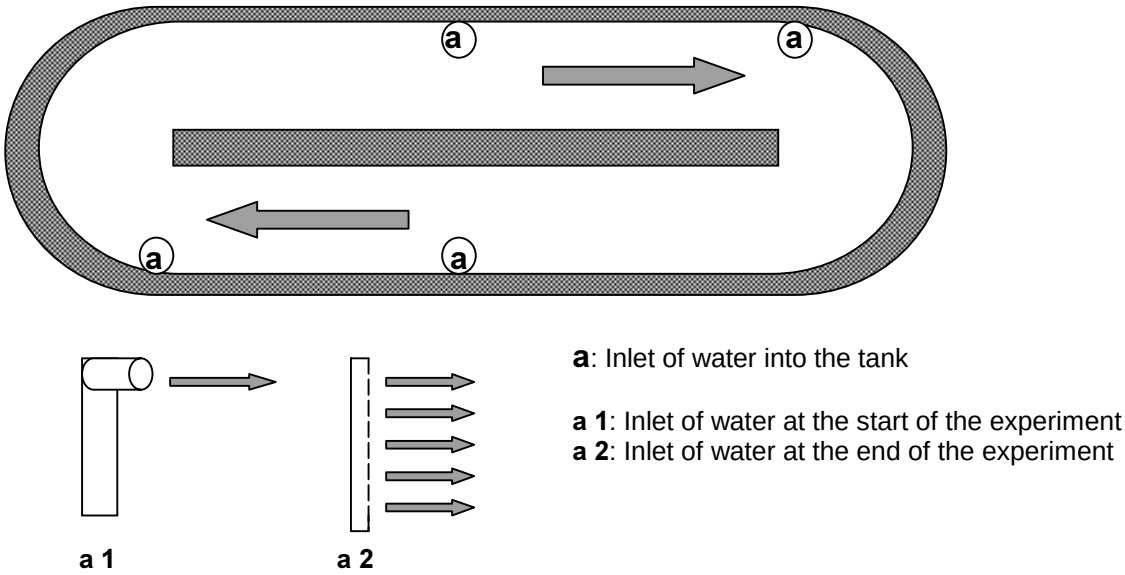

Fig. 4. Circulation of the water in the tank of Experiment 3.

During the experiment, and as a result of the behaviour of the tuna observed, the following changes were made to the holding tank:

(i) Darkening the water by covering the tank with woven plastic.
(ii) Installing an underwater electric pump (100 m^3/h) to increase the water circulation speed in the tank.
(iii) Changing the main water inlet system (a 1) to system (a 2).

Biomass

41 specimens: 22 yellowfin tuna, 10 bigeye tuna and 9 bluefin tuna of an average weight of 3.5 kg.

10 seriolas which had been in captivity for some time were added to this group of tuna in the tank.

During the first two hours 1 yellowfin tuna, which was in deteriorated state died.

State of health

The general state of health was that of skin-loss on the flanks and, in some cases, mouth injuries. Taking previous experiments into account, these conditions can be considered a normal consequence of the capture and transportation of the fish. The day after their arrival a prophylactic treatment, consisting of a solution of copper sulphate and citric acid, is applied for one hour over a period of five consecutive days to disinfect and accelerate the healing of the wounds. The results are highly satisfactory as the healing process is seen to start on the second day and is complete within the following seven days.

Behaviour

During the first days swimming behaviour is more active and content than in the previous experiments and seems to be due to not swimming in constant circles. The presence in the tank of seriolas (*Seriola* sp.) also makes behaviour calmer.

After the health treatment, they are fed, as in Experiment 2, with chopped chub mackerel. After eight days some of the specimens begin to eat the food and in the next four days all the tuna are eating.

After thirty days we start submerging with the fish to observe their behaviour more closely and note that they accept us, showing curiosity at first and, after a few days, indifference. When we start to drop the food into the area around the divers, we observe that they not only continue to show indifference towards them, but that they accept pieces of fish from the divers themselves.

Finally, it is worth pointing out that this degree of confidence is very useful when handling the fish in the water for example in carrying out those tasks necessary in the application of the prophylactic treatments.

Handling

Taking into account the results obtained in the handling of fish during Experiment 2, a series of changes were made for this experiment:

(i) Lowering the level of water.
(ii) The same anaesthetic is added to the water as in Experiment 2 and in the same concentration.
(iii) Once anaesthetised, the specimens are weighed and measured; this is done in the holding tank.
(iv) Recovery is done in another tank in 500 m^3 of water and with the same conditions as before.

This operation was carried out using only half the specimens and the result was the death of all the specimens over the next three days due to stress.

At present the following experiments are being carried out:

(i) The use of tranquillisers (instead of anaesthetics) which affect the peripheral.
(ii) Nervous system relaxing the motor plates.
(iii) Ways of applying/giving the tranquilliser.

Conclusions

Characteristics of the installations

(i) The most appropriate holding tank is the "race way" as it offers the following advantages:

- The movement of the fish in the tank is not always circular, but can be in long straight lines, which has been seen to be of great importance to the very active swimming habits of the tuna.
- The fish are evenly distributed throughout the water in the tank; this does not occur in the round tank because the fish tend to stay near the walls.
- This type of tank makes it easy to section off areas (using net partitions) to group fish to carry out the necessary health treatments or for handling fish in the growth studies.

(ii) Water dynamics in the tank:

- Dead areas (areas with little movement) of water should be avoided in the tank.
- Waterfalls at the water inlet altering the behaviour of the fish should be avoided.
- To achieve this the supply of water should not be at the surface, but along the column of water.
- The speed of the water mass should be high to ease the breathing process of the tuna fish.
- Instead of increasing the flow at the inlet, this can be achieved by installing an electric pump to recirculate the water.

(iii) It is advisable to avoid the effects of direct sunlight by darkening the water surface and thus, obtain calmer behaviour.

State of health

(i) Within 24 hours of their arrival at the centre, extemal health treatments should be applied to disinfect and heal the wounds sustained during capture and transportation.

(ii) It is recommended that the treatment be repeated every 20-30 days.

(iii) The solution used has been 210 cm^3/m^3 of 4 g copper sulphate/m^3 fresh water + 0.25 g citric acid/m^3 fresh water.

Behaviour

(i) The presence of other large, lively fish which are already adapted to captivity has a calming effect and helps to speed up the adaptation to inert food.

(ii) Being able to swim in straight lines and not always having to swim in circles seems to help them adapt to the tank.

(iii) They get used to the presence of divers amongst them, which makes their adaptation to handling easier.

Handling

(i) They can completely recover from the effects of the anaesthesia in a short period of time, but are seriously affected by the stress caused by the first symptoms of the anaesthetic.

(ii) Deaths are caused by heart attacks as a result of handling.

Transportation

We have established a density of 7 kg/m^3 over a period of 7 days giving a survival rate of 99%. However, the size of the specimens should be taken into account and so we could set an optimum density at 2 fish/m^3 for tuna fish up to 4 kg.