Tagging programme 2013

Conventional tagging of juvenile and/or adult BFT by purse-seiners in the *Tyrrhenian Sea*

ICCAT/GBYP Phase 4 – 2013

Final Report

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Summary

The scientific tagging campaign was carried out in the Tyrrhenian Sea with the aim to address several important biological and ecological topics regarding Atlantic Bluefin tuna as well as to possibly provide independent estimates of abundance and/or fishing mortality rates.

This was the first attempt for this kind of activity in the Tyrrhenian sea during spawners aggregation and the general approach was to define a tagging methodology for adult BFT by divers in the purse seine, getting at the same time reliable size estimates and keeping the research-related mortality very low.

Keywords

Bluefin tuna, Thunnus thynnus, Mediterranean, Southern Tyrrhenian Sea, tagging, purse seine, image analysis

1. Background and objectives

The main objectives of the ICCAT Atlantic-Wide Bluefin Tuna Research Programme (GBYP) are to improve: (a) the understanding of key biological and ecological processes, (b) the current assessment methodology, (c) the management procedures, and (d) advice.

Key tasks are to reduce uncertainty in stock assessment and to provide robust management advice. This requires improved knowledge of key biological processes and parameters. However, currently almost all the data used in s tock assessments are obtained from the fisheries-dependent data. It is therefore important to obtain data from alternative sources, such as tagging studies, in order to verify the assumptions made when conducting the assessments.

The specific objectives of the tagging activity in the medium term (according to the ICCAT/GBYP Tagging Design) are:

a) validation of the current stock status definitions for populations of BFT in the Atlantic and Mediterranean Sea;
b) estimation of biological parameters such as growth, natural mortality rates (M) of BFT populations by age or age-groups;
c) estimation of tagging reporting rates for conventional tags, by major fishery and area, also using the observer programs currently deployed in the Mediterranean fisheries (ICCAT ROP-BFT);
d) evaluation of habitat utilization and large-scale movement patterns (spatio-temporal) of both juveniles and spawners;
e) estimation of the retention rate of various tag types, due to contrasting experiences in various oceans;
f) estimation of the feasibility of tagging BFT in traps and purse-seiners by divers getting at the same time reliable size estimates.

2. Methodology required

This report refers to the activities carried out in the Tyrrhenian Sea according to the ToRs of the Call for Tenders GBYP 01/2013.

The methodology provided for the Conventional tagging of juvenile and/or adult Bluefin tunas by purse-seiners in t he western Mediterranean Sea - including the Tyrrhenian Sea - set among others, the following specific tasks:

a) conventionally tagged Bluefin tuna should be in a range between 1,000 and 2,000 individuals, possibly with 40% double tagging; The age range should be between ages 1 and 3 for the juveniles while adults should be over age 3;

b) the time-frame for tagging shall be mid-May 2013 to mid-October 2013;

c) the area shall be the western Mediterranean, with two possible options: the Balearic Sea and the Tyrrhenian Sea;

d) purse-seiners shall be the type of vessel to be used for tagging; the total number of vessels by area shall be sufficient for reaching the final objective, with a minimum of one vessel. The vessel time available for this tagging activity by vessel shall be set at a minimum of two weeks;

e) juvenile Bluefin tuna shall be tagged on board a small vessel, catching them from the seine with handlines, equipped by hooks having no barbs; they shall be measured individually, according to the standard protocols; tagging data shall be recorded on the ICCAT form;

f) adult tunas shall be tagged by divers directly underwater; fish can be kept in the seine or moved into a cage, according to the best choice for the offering institution; each fish shall be tagged by a diver using a pole; a second diver shall be equipped with an underwater stereoscopic camera having a laser system able to more precisely estimate the length of each individual tagged fish; the sequence of tags, pictures and laser estimates shall be properly recorded for future uses and controls, while the number of each tag and the length estimate shall be properly recorded on the ICCAT forms;

g) carry out biological sampling during the tagging activities; a minimum of 60 biological samples by area shall be collected according to the protocols adopted by the Contractor(s) in c harge of the biological and genetic sampling and analyses; the samples shall be shipped to the laboratory in charge.

3. Materials and methods

The preparatory activities started with a series of meetings with the experts participating to the project, the fishermen and the divers, to discuss about the practical possibility of adapting the methodology suggested by Iccat to operational conditions, considering that this pilot tagging activity, as it was reminded by the GBYP Steering Committee, may present high risks of failure or/and high fish mortality, as well as several field practical difficulties in high sea.

Preliminary meeting

For all these reasons, it was decided to hold a preliminary operational meeting, to discuss and take advantage of the best available knowledge and experienced people, about all practical aspects and possibly identify all risks and act for minimizing them. Here following, we report the results of the discussions according to the two main groups of target Bluefin tuna to be tagged: adults and/or juveniles.

Tagging adults

As for the adults, great concern was expressed about the viability of the methodology proposed, mostly for the possible high rate of mortality and the possibility of carrying out the tagging on a considerable number of specimens. Concerns were focused on the possible reactions of adult specimens to the shot, the tendency of going deeper and deeper and therefore on the possibility of tagging many individuals in this way, besides the danger that the behavior of some stressed entangled specimen could compromise the stretch of the net, causing a fast and potentially deadly reduction of water for the fish to school or inducing a frenzy reaction.

In addition, in case of any change of the sea state, the risk of having a Bluefin tuna school of adults restricted inside a purse seine in high sea could create unacceptable risks for both the net and the vessel and, as a consequence, the net should be opened and the fish should be released into the wild.

Tagging juveniles

Tagging juveniles, according to the TORs of the project, should be carried out by fishing the young BFT (bait boat style), while the fish are restrained in the purse seine. According to fishermen and to the diver, the fishes just caught, even in a wide net, won't eat for some days. Maybe there could be more chances by fishing "bait boat style" on free school BFT feeding aggregation. Unfortunately, our purse seiners are not equipped for this purpose, and by the way, similar trials attempted in the Mediterranean in the recent past have failed.

Considering the different constraints, it was suggested to concentrate the trials during September; in that season it is possible to find specimens of the size 3 – 25 kg quite close to the coast.

Once caught the specimens with a purse seine, the fish would be transferred into a cage and dragged to a sheltered place, feeding them during the transport until they start to get accustomed and reactive to feeding.

Once in the place, it would have been possible to fish tunas by the edge of the cage, with pole and line, with good possibility of success, and avoiding the risk of important mortality during tagging operations.

This remarks were submitted to ICCAT – GBYP. It was estimated that carrying out the tagging of juveniles could determine the risk of "domesticated" induced behavior on the juveniles, and that a similar trial was in any case foreseen in the Adriatic Sea, while tagging adults in this way would have in any case an important meaning of applying and tuning a new methodology, having in mind the fundamental imperative to avoid in any way important mortalities due to tagging operations.

Therefore all the activities went on following this guidelines.

Geographic area

The area of the scientific tagging campaign was the Tyrrhenian sea. The importance of this area for the concentration of BFT spawners is well known (Arena, P. 1978, 1982,), and constant activity of purse seine fishing has developed starting from the early Seventies (Arena, 1990).

According to ICCAT indications, the scientific campaign started only after the end of the BFT fishing season for the operating vessel and in particular following the transfer operations of the total allowable catch for the vessel which was 133 tons for 2013.

Equipment for tagging was prepared before starting the scientific campaign.

Vessel

The vessel used for the scientific tagging campaign in the Tyrrhenian sea was selected among the purse seiners fleet actually operating in Italy (Figure 1).

An agreement was signed on 23/05/2013 with "La Tonnara" cooperative which was responsible for providing the fishing vessel and crew for 14 days of scientific activity.

The selection of the vessel was made taking into account both the technical features and the comfort/safety on board for the tagging team.

The crew also included two professional divers for the achievement of the planned activities.

The main technical features of the vessel are reported in annex 2 and also included the following electronic equipment:

- Radar Furuno FR-1525 MK3
- Colour echo sounder Furuno FCV-292
- Satellite phone
- GPS Furuno GP-90
- Satellite compass Furuno SC-50
- Plotter Fish T59-08 colour
- Sonar Furuno FSV-24 multi beam

Tagging

UNIMAR received the following technical equipment which was selected and used according to the best choice on field:

1. Conventional tags:
    a. 1500 spaghetti tags (BYP023351-BYP024850)
    b. 250 small billfish (BYP059276-BYP059525)
    c. 250 large billfish (BYP072151-BYP072400)
2. Applicators as follows:
    a. 75 for conventional spaghetti tags
    b. 25 small billfish tags
    c. 25 large billfish tags
3. 10 units of wooden handles for applicators + additional 10 small billfish applicators.
4. 5 electronic miniPATs tags (Argos ID n° 130573 to 130577) + 1 miniPAT applicator.

Spearguns

- N° 4 spear guns (length 120 cm, 100 cm and 95 cm);

- Power band Dynatex Ø 14 mm
- Shaft (Ø 6,5 mm, length 135 cm and 160 cm)

Spearguns shafts were duly modified so that applicators could be sticked on the top of the shafts.

For the purpose, we set the four spear guns, a 120cm, a 100cm and a 95cm custom wooden made (Figure 3) and a OMER Cayman 95cm “Arbaletes”. All the weapons were equipped with a single or coupled circular power band in Dynatex.

Three hand rods were prepared: two in aluminium 3 m long and a stainless steel one, 2.5 m long, all with a diameter of 2.5 cm, at the end of which was acquitted a threaded stainless steel dice, which can hold a series of short harmonic steel (17-4 PH) 30 cm long spear, 7 mm in d iameter. The lengths were proportioned to the spear guns, ranging between 150 cm and 135 cm.

The tip of these shaft, was appropriately drilled or splined for the insertion of the 4 different models of applicators provided by ICCAT (Figure 4).

For the applicator models "Bill fish", it was decided to drill into the 6,25 mm Ø and 6,50 mm Ø harmonic steal (17-4 PH) spearheads a hole, in which the applicators were firmly glued with epoxy glue.

To prevent an excessive subcutaneous penetration of the applicator, each shaft was equipped with a semi-rigid rubber stopper, obtained by a modified tube caps, large 2 cm Ø and 3 cm long.

To avoid the sliding of the stopper during shooting and penetration of the tag, it was decided to lock it on the shaft, through a thickness obtained by several wraps of glued Dynema bride.

The slimness and the frusto-conical shape of the rubber annexe, turned to be fundamental for a correct ballistics of the compound, ensuring a fair compromise between a good hydrodynamics and the relative accuracy of the shot, with a good stopping power during the phase of penetration of the applicator into the flesh of the marked fish

Posteriorly to the stopper, a small rubber o-ring, proceeded to maintain the tag in place during the phases of firing

The tags, arranged in series of 20, were sewn onto a tape that was applied to the leg of the operator through a velcro, ensuring an easy access to the tags between the shooting phases.

All the tags were sterilized with a water resistant disinfectant spray, just before the deployment.

For the deployment of the pop up tags, two shafts 7mm Ø and 160cm long were arranged to be mounted on the longest wooden spear gun.

On the spearhead, in a hole 3cm deep an harmonic steel pin, 3mmØ and 8cm long, was inserted and glued, designed to accommodate the large pop up darts.

In the assumption then discarded of a manual applications of the tags, the set included a large floating cradle for cetaceans and a couple of inflatable mattresses.

Recording system

- video camera GoPro Black edition + underwater case
- video camera Canon + underwater case
- photo camera Nikon D80

The videos of the tagging were recorded using a Gopro video camera installed on the side of the speargun using a specific mounting bracket (Figure 5). The video camera was set up with the following parameters:

- video resolution 1440p
- PAL system 48 frame per second
- Field of View (FOV) Ultra-wide
- Screen Resolution/ Aspect Ratio 1920x1440 4:3

Analysis of video images

The estimate of tuna size were determined from the analysis of images coming from the video-camera mounted on the spear guns, defining an algorithm that compares images of tunas with a series of images of a graduated pole, taken from a known distance. This trials were carried out during the fishing campaign.

4. Detailed activities

The vessel was based in Salerno, where on the 12th of June all the crew, scientific team and equipment was boarded. In the same day the vessel left the harbour, starting officially with the research. The BFT fishing season for 2013 started on the 26th of May and catches were reported to be abundant and fairy quick so that the research was able to be started before the official closure of the fishing season planned on the 25th of June.

Activities started on the 12th of June 2013 when the vessel left the harbour in Salerno. The first night was spent in the bay just out of Marina di Camerota, ready to the early leave the next morning to reach the spot.

The conditions of the sea in the morning of 13th of June were good enough to catch a school of adult BFT (39,2033333 N; 15,6470834 E) and start tagging operations. The school was then released (39,1833334 N; 15,6833333 E) about 5 hours later due to sudden adverse weather conditions.

The research went on the following day, searching another school of adult BFT to be tagged, however no sightings occurred on 14th of June despite about 150 miles covered.

On the 15th of June, although a school of BFT has been sighted, the team decided to refrain from starting catching operations. The majority of specimens ranged between 15-30 kg and adult BFT were about the 5% of the school.

The condition of the sea was stable over the week and on the 16th of June several sightings occurred (see Table 2). A b ig school of BFT was located (39,4794229 N; 15,2225326 E) and catching operation started. The team did not succeeded in the catch and the school escaped before the closure of the net.

On the 17th of June, the condition of the sea which was extremely calm, permitted to undergo continuous sightings of BFT schools. In many cases the vessel succeeded in approaching the school and started to feed it with sardines. Although tunas were often attracted by the fish and came right overboard, the small size of individuals never permitted to start catching operations

With the aim to concentrate the effort of the team to approach a school of adult BFT, on the 18th of June, taking advantage on the spatial overlap of the tagging and aerial surveys GBYP campaigns, it was decided, in accordance with the ICCAT – GBYP Coordinator, to establish a contact with the aircraft which could communicate to the vessel the coordinates of eventual sightings during its planned track.

The aircraft communicated a good sighting at 39,04878925 N; 15,50958065 E , which was about 30 miles away from where the vessel was. Unfortunately by the time the vessel moved to the waypoint of the sighting, the school was not there anymore. On the other hand the aircraft could not be used for an eye-contact on the school as it was carrying out the activity for the GBYP aerial survey campaign.

On the following days weather conditions kept on being very good, and sightings of juveniles BFT were very frequent. However no adult BFT schools have been sighted anymore.

The last two days of the research have been carried out near the cape of Punta Campanella since information on sightings of adult BFT in that area have been gained, and weather forecasts called for a possible quick change of sea conditions, advising against to undergo an offshore navigation.

5. Results

The search of the schools of adult BFT to be tagged, was carried out according to the experience of the fishermen and their best knowledge on the major spots in the Tyrrhenian sea.

According to the information gained by the fishermen and their recent experience of BFT catch, the research for adult BFT focused in the Southern Tyrrhenian. At this regard the amount and distribution of 2011 catches in the Tyrrhenian sea, is shown in Figure 2. This information confirmed the trend of the previous years regarding the major spots where catches have been traditionally carried out.

Differently from the usual habits of the fishing campaigns, the screening of the spots was carried out without any support from other fishing vessels of the same fleet which is normally a key factor for the success of the fishing campaign.

The total amount of NM covered over the 14 days of activity was about 1455 NM and the average cruise speed of the vessel was approximately 9.5 knots, with an average of 12 hours/day spotting covering approximately 10.000 square miles.

Taking in due consideration the fact that during the research of adult BFT schools for tagging, the observation of juveniles was very frequent, it was decided to take notice of the sightings regardless of the size of individuals (Table 2, Figure 6).

In any case, over the campaign, two different schools of adult BFT were found and one of these was successfully caught by the purse seine on the 13th of June.

Catch and tagging operations

The round weight range of individuals was 30-200 kg and the estimation of the total weight of the school was about 50 tons.

Because of the bad sea state and the strong current we decided to leave the tunas in a very large portion of the purse seine (about 300 m in c ircumference, corresponding to 100 m in diameter and about 50 m deep) with the purpose to minimize the risk of inducing any frantic behaviour in the fish school, avoiding as much as possible to increase the mortality rate for accidental entanglement. This thicker and stiffer portion of the net called "pezzale", was kept open by a tender, even under rough seas and strong currents, as occurred during all operations (Figure 7). In the meantime , a second tender kept on pulling the main fishing boat to avoid it to overcome the net.

After a first dive in which it was observed the quiet behaviour of the school, estimated on an average of 600 adult specimens, we started the tagging trials using a minimally invasive approach, trough slow and silent free-diving descent (Figure 8), armed with spear guns properly studied and developed.

Beyond all expectations, the school of fish turned to be more than just collaborative, small groups continued to approach curious to operators who through silent glide dive could easily direct the shot on the back of the tuna, which in turn reacted almost with indifference to the penetration of the tags.

The ductility of the setting, allowed to quickly modulate the ballistics of the guns during the trial and the optimal compound was achieved by coupling a single circular, regardless of the length of the spear gun used.

This arrangement has enabled us to significantly speed up the replacement of the applicators, whenever was recorded the bending or breaking of the applicator's needle.

This problem occurred mainly with the applicators "Bill fish small" whose thin needle turned to be too weak for the application of the tags using the spear gun.

The strategy planned by the team shortly before the start was guided by the primary need of a very conservative and "precautionary" approach in o rder to avoid any possible risk of frenzying reactions and eventual massive mortalities. Because of this reason it was planned to apply pop-up tags at the end of tagging operations, considering that their bigger size could possibly determine reactions of the tunas and increase the possibility of the equipment to be entangled in the net.

The shoots were placed at depths ranging from 6 to 15 meters from the surface. The setting of the spear gun chosen for the operations turned out to be optimal, allowing to place accurate shot at a distance between 1 and 2 meters, estimated from the tip of the applicator to the back of the fish. The cameras mounted on rifles due to their small size, did not affect in any way the efficiency of the spear gun.

Unfortunately, after about six hours of tagging (around 17.00 pm.) a sudden further increase of bad sea conditions, particularly of the current, did not facilitate the action of the tender and whenever the purse seine lost its optimum circularity, the school began to swim frantically, causing the fatal entanglement of some specimens (Figure 10). It was very difficult to keep the net opened and, it was decided to release all the catch, including the tagged individuals, to avoid possible massive mortality but compromising the strategy planned by the team shortly before the start, to deploy the satellite tags only at the end of operations in order to avoid any risk of loss or damage for such valuable equipment. Fortunately in this way the losses were very limited (5 samples on estimated 600 samples of the school).

Despite of the difficult environmental conditions, it was possible to successfully tag and record 70 Bluefin tuna with conventional tags:

- 7 small billfish
- 63 large billfish

Underwater video of the tagging has been recorded. Every single tag has been associated with a single video of the tagging (Figure 9). A specific system to evaluate the tuna size by the video has being setting up.

On the 15th of June, although a school of BFT has been sighted, the estimation of the size of individuals suggested to refrain from starting the catch operations. The total biomass was estimated to be around 30 tons, but the majority of individuals ranged from 15 to 30 kg. The bigger tunas were a small portion of the school (around 5%) ranging between 50 and 80 kg.

Taking in d ue consideration ICCAT recommendations to avoid high mortality rates arising from tagging/catch operations, we considered that shooting in the purse seine to individuals of such a school could possibly induce a frantic behaviour to smaller fish, exposing tagging operations to the undesired risks of increasing the mortality rate for accidental entanglement.

On the 16th of June a second school of adult BFT has been found and catching operations have been started immediately. Unfortunately the fish did not keep the surface while the vessel was encircling the school and it suddenly reversed the swim escaping from the net.

Analysis of video images

Methods

While evaluating fish size from a dual-camera system is a relatively straightforward task, achieving the same goal from a single camera is not trivial, except in the case all the targets are identical in shape and their aspect and orientation does not vary. Needless to say, this is not a common situation, and it is absolutely unlikely to happen when length assessment in tuna fish schools is involved.

However, if a suitable method can be developed to assess fish size from a single image, then acquiring images of tuna fish specimens that are about to be tagged can be a very interesting opportunity, because it could allow to assess the size of those specimens with no additional effort (Figure 9).

In order to achieve this goal, we adapted a “Machine Learning” approach that has been already applied to dual camera systems to the analysis of single images captured right before firing a tagging spear. Obviously, some assumptions must be met, as accurately as possible, to obtain accurate size estimates based on such a simplified set-up. Basically, we assume that:

1. all the tuna fish are exactly identical in shape, while their size may vary;
2. the firing distance of tagging spears is constant and equal to the distance from a known target used for calibration;
3. tagging spears are always aimed at the center of mass of the target tuna fish.

As the apparent shape of tuna fish that are about to be tagged may vary, we used the apparent length and the maximum apparent width (Figure 12) as predictive variables for actual length. Obviously, the apparent length varies depending on fish aspect, whereas the maximum apparent width is more strictly related to the actual size.

While the role these predictive variables may play is clear, the way they are related to the actual length of tuna fish may be captured by several types of models. The advantage of a Machine Learning approach and in particular of an Artificial Neural Network (ANN) is that the model structure is not to be specified in advance. In fact, an ANN learns from the examples that are passed to it and when fully “trained” it is able to behave according to what it learned. For instance, it might learn to assess tuna fish size on the basis of only two predictive variables.

In order to provide examples that an ANN may learn, not only the values of predictive variables must be known, but also the value of the target variable. In the tuna fish case, the target variable was the actual length. As the length of tuna fish specimens in the available images was obviously unknown, we had to use other images, containing tuna fish of known size, to train the ANN.

The only way to associate known lengths to images from which apparent size could be measured relied upon the generation of a 3D tuna fish model (Figure 13), which was shaped using available images as a template (Figure 14). This satisfied assumption 1, while assumption 2 was met by using the image of a pole of known length (2.5 m), captured from a distance that we assumed was equal to the usual distance from which tagging spears were fired (2 m) (Figure 15).

The reference pole image was then used to scale 3D tuna fish models (Figure 16), setting the virtual lenses to the same focal length as the underwater camera mounted on the speargun (equivalent to 12 mm for a 35 mm film). 3D models were scaled to 7 different known lengths, namely equivalent to 135, 150, 155, 160, 165, 175 and 200 cm FL, and rotated in order to change their orientation and aspect several times in small increments. The outcome of this procedure was a set of 356 images, in which each one of the seven above-mentioned lengths of the 3D tuna fish model was the basis for about 50 different images.

While 267 of the available images were assigned to ANN training, the remaining 89 were used as validation set. The ANN we trained was a multilayer perceptron with a 2-11-1 architecture and sigmoid activation functions both in the hidden and in the output layer. The training procedure was stopped as soon as the validation error began to increase and repeated several times up to 107 epochs. The best ANN was then selected according to its Mean Square Error (MSE).

Result

The ANN we trained allowed to explain as much as 83% of the variance of tuna fish length in the validation set, while MSE was 70.09 (fig. 7). Errors in length estimates ranged from -19.97 cm to +17.59 cm, but 90% of them fell in the [-12.37 cm, +14.43 cm] interval and 50% of them in the [-4.93 cm, +5.76 cm] interval.

The ANN optimization procedure is driven by the MSE, which obviously depends on the distribution of the available data. Sometimes this may lead to solutions that, although optimized in terms of MSE, are systematically biased in the extreme values. Our ANN showed this problem when predicted lengths were plotted against observed (i.e. known) ones: estimates for the 135 cm long 3D model were consistently overestimated, while those for the 200 cm one were mostly underestimated, independently of the optimization of the MSE.

To solve this problem we fitted a linear model to our ANN estimates using a least squares regression. The resulting linear model equation is shown in Figure 18and we used this equation to remove the systematic bias from the ANN model. In short, if Y is the uncorrected predicted tuna fish length, then the corrected length is Y'= (Y-40.5211)/0.7474.

After the linear correction, the MSE in length estimates was about 10% larger (MSE=78.21, fig. 9), but systematic errors were completely removed. The errors in the length estimates from the corrected model ranged from -18.66 cm to +20.22 cm, but as much as 88% of the errors fell within the [-10 cm, +10 cm] interval, and about 50% of the errors fell within the [-5 cm, +5 cm] interval.

The distribution of errors in c orrected (red) and uncorrected (blue) length estimates is shown in Figure 20. While no histogram can provide a fully reliable image of the true error distribution because of the discretization of the errors into classes, and while the number of cases in the validation set is limited (n=89), the linear corrections certainly helped to regularize the ANN outputs at the cost of a small increase in MSE.

Remarks

The ANN based approach for assessing tuna fish length from images captured during tagging seems a very promising solution, and certainly more accurate than those based on visual assessment.

While ANNs are usually more effective than other computational methods in solving regressive problems, other tools can be tested in the future, and more data (i.e. more 3D model images) can be used. Moreover, a third predictive variable may prove useful, i.e. the angle between Y axis and longitudinal axis of the fish whose length is to be assessed.

Further tests will allow to check whether these changes may really improve the accuracy of length estimates, but in the meantime good results can be already obtained from two simple measures derived from images captured by a speargun mounted camera, thus adding significant value to tuna fish tagging with almost no additional effort.

6. Conclusion

The application of a method never tried before, in such an extreme operational context as the one found on the field, has implied a discrete organizational effort, especially when, in order not to leave anything to chance, various series of tagging tools have been designed and customized.

As can be imagined, most of these equipment have never been used during the operations, since the single attempt carried out, was the only operational scenario which confirmed their inadequacy. Among these were discarded all those that provided the setting by hand of the tag, such as poles or manual applicators, witch for their use, would have implied a considerable water restrictions for the fish swim, with potentially fatal consequences.

The trials were also successful to answer all the concerns about the behaviour of the tunas in the purse seine and after the tag application.

The school of BFT in the purse seine was quite calm, keeping the typical round swim at about 10-15 m depth. Divers preferred to shoot without any scuba equipment, believing that free movements and reduced noise could be the best choice for a successful tagging so avoiding any source of additional stress to the fish.

The operations permitted to test several methods of tagging using different spear guns and tags. In particular the best tag applicator in r elation to the shooting power and the best assembly of the cameras on the guns.

Finally, the method set up to estimate tuna size from video images has proved to be quite satisfactory.

From the technical point of view, therefore, both equipment as it was modified, and tagging strategy, turned to be suitable for the purpose of the project.

6.1. Recommendations and proposals for an amended methodology

During the tagging campaign we experienced several approaches and methodologies that are now a good basis to provide recommendations for any future trial.

1) "small" tags applicators were not strong enough and turned out to brake easily. We therefore used the "Large" ones which never broke and, at the same time, caused no harm to tunas.

2) we started using a speargun armed with two power bands. This approach turned to be over dimensioned, it is therefore enough to use a single power band. Taking into consideration the behaviour of BFT in the seine, also air spearguns could be tested or other type of simpler settings of spear guns with bands. This kind of equipment could be interesting as it is much easier to handle during tagging operations.
3) taking into account the quantity of juveniles BFT which have been sighted during the campaign, the possibility to use the same equipment to tag juveniles, could be considered. Nevertheless it should be considered very carefully that the reactions of small specimens to the approach of divers and shooting could be different respect to large individuals.
4) the higher risk of entanglement for BFT in the seine is connected with the effects on the net of strong currents, which are very difficult to fight with tenders. Working in a n open sea situation, the environmental conditions remain the more unpredictable factor for the success of the operations.
5) the use of a stereo camera seems to be very difficult considering the big size of the equipment which represent an obstruction for the movements in the seine (Figure 11), having in mind that two divers were used for shooting (four divers in case of a stereo-camera). It could also be difficult to follow the fast movements of the diver before shooting. The setting of video recording chosen, with the results of the images analysis achieved seems satisfactory, being a good compromise to adopt in this specific operative conditions.

<u>Proposals for an amended methodology</u>

Despite the total number of fishes tagged was largely less then foreseen, we judge in a positive way the trial, having in mind that this number has been reached in the only day dedicated to tagging.

From the technical point of view, as said before, a good setting of equipment and tagging operations was achieved. Modifications and improvements can be applied quite easily, and they were explained in details in the previous sections.

The strategy of fishing campaign is the focus point to be modified for the success of operations. Working with no reference point, i.e. information from other fishing boats operating at the same time in the same area means to have no possibilities to search for tunas other than continuing to turn around in the areas traditionally known, as we did. Nevertheless in this situation uncertainty is too high and, as a matter of fact, only one day was devoted to fishing and tagging in 14 days of campaign, with a huge waste of time and money.

According to the experience gained in this trial, the use of an aircraft, flying for a few hours in the same area of the boat seems to be crucial to reduce drastically the screening time. Once the school location is transmitted by the aircraft, the vessel can reach that point, saving time and reducing fuel and navigation costs. To avoid any possible problem, the campaign would start after the end of the official fishing campaign, and the aircraft would be duly identified by Iccat.

In this way, the time of the fishing boat would be devoted only to fishing and tagging activity. Taking as a reference the number of fishes tagged in one day, the total time at sea could be reduced to 7 – 10 days.

7. References

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- Arena, P. 1978 Le thon rouge en Méditerranée. Biologie et aquaculture. Sète, 9-12 May 1978. Act.coll.CNEXO, 8; 53-57
- National Institute of Oceanography and Experimental Geophysics website http://www.ogs.trieste.it

List of the tables

Table 1: features of the tagging area.

Area (miles)	10.000
Total length of trackline(nm)	1455
Days on effort	14

Table 2: sightings.

N	date	Lat_N	Long_E	Activity	Tons	Size range	N. tags	Death	Weather condition	Note
1	13/06/2013 11:00	39,2033333	15,6470834	catch	50	30-200	70	5	smooth	strong current
	13/06/2013 17:00	39,1833334	15,6833333	release	50	30-200	70	5	smooth	strong current
3	15/06/2013 10:57	39,3434446	15,0719453	sighting	30	15-80	0	0	calm	
4	16/06/2013 08:15	39,4277672	15,6644529	sighting	20	15-50	0	0	calm	
5	16/06/2013 11:42	39,4794229	15,2225326	sighting, missed capture	10	30->100	0	0	calm	
6	17/06/2013 08:02	39,2509822	15,3652727	sighting	30	10-15	0	0	calm	continuous sightings
7	18/06/2013 13:05	39,04878925	15,50958065	no sighting	0		0	0	calm	sighting indication from ICCAT aerial survey
8	20/06/2013 10:10	39,47531667	15,28320062	sighting	20	10-15	0	0	calm	
9	20/06/2013 11:10	39,56044215	15,22235955	sighting	10	10-15	0	0	calm	
10	20/06/2013 11:38	39,6582403	15,1859091	sighting	30	10-20	0	0	calm	
11	20/06/2013 13:50	39,74481445	15,19148605	sighting	10	10-20	0	0	calm	
12	21/06/2013 14:56	40,0676423	13,3956528	sighting	40	10-20	0	0	calm	

List of the figures

Figure 1 purse seine "Vergine del Rosario"

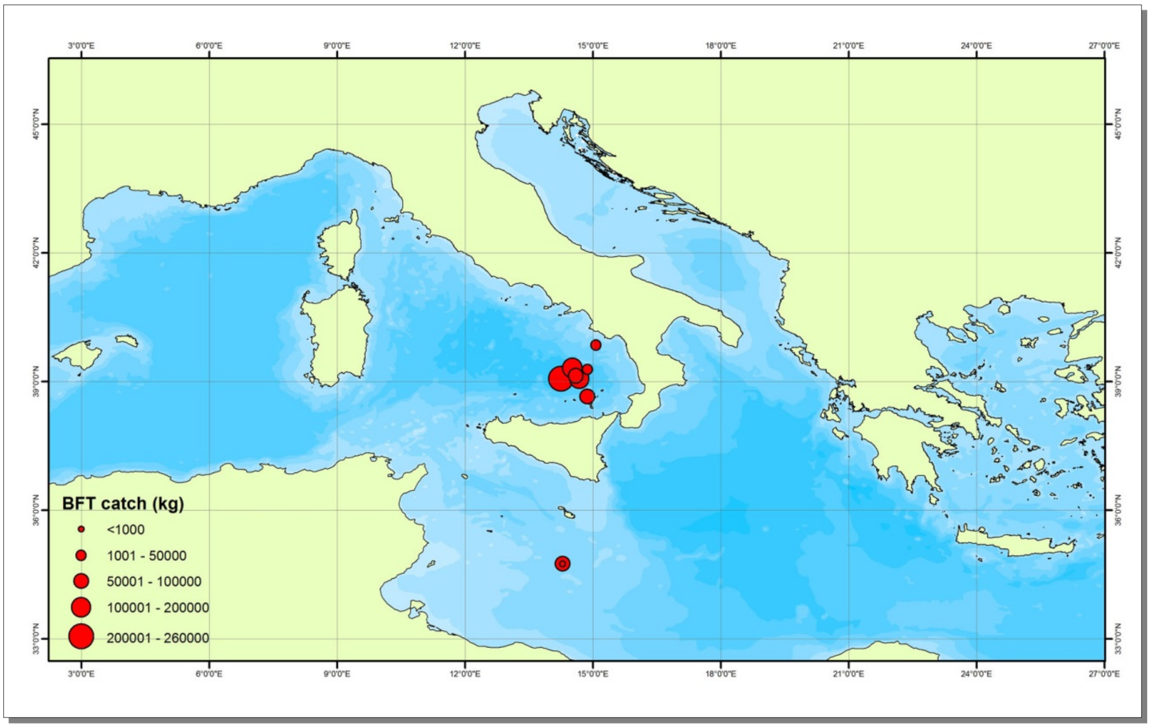

Figure 2 Approximate position of fishing operations and catches for the Italian purse seine vessels in 2011

Figure 3: spearguns used during the trial (wooden and carbon fiber).

Figure 4: tags and hand rods.

Figure 5: video camera with mounting bracket

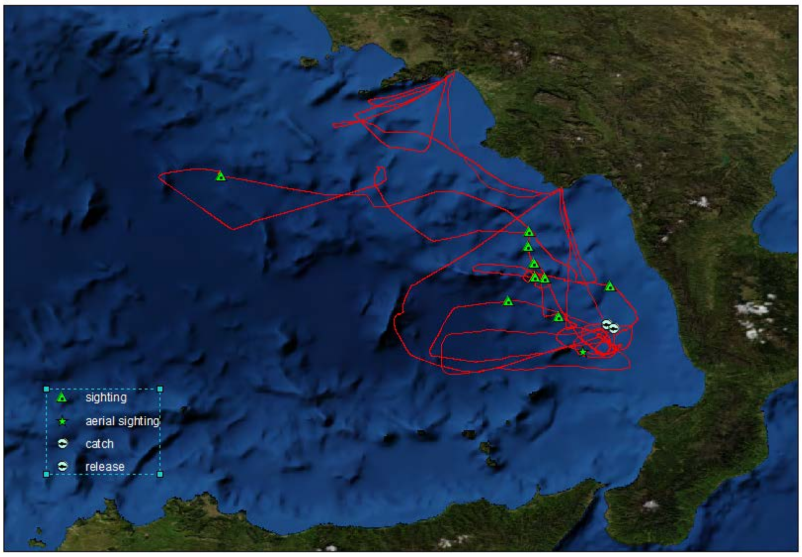

Figure 6 Vessel track and sightings.

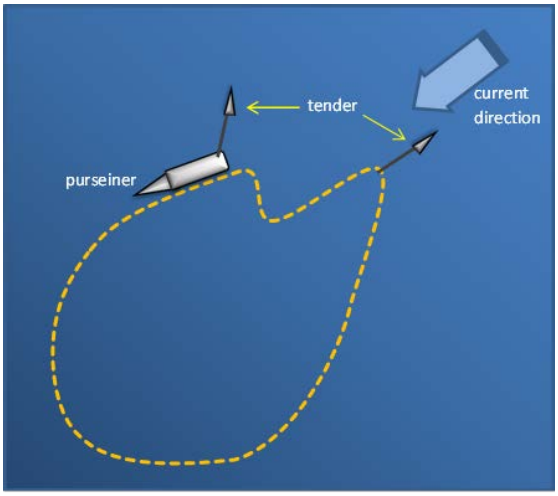

Figure 7: position of the purseiner during the tagging activity and direction of the sea current.

Figure 8: freediver during a tag operation.

Figure 9: example of tagging.

Figure 10: effects of the strong current.

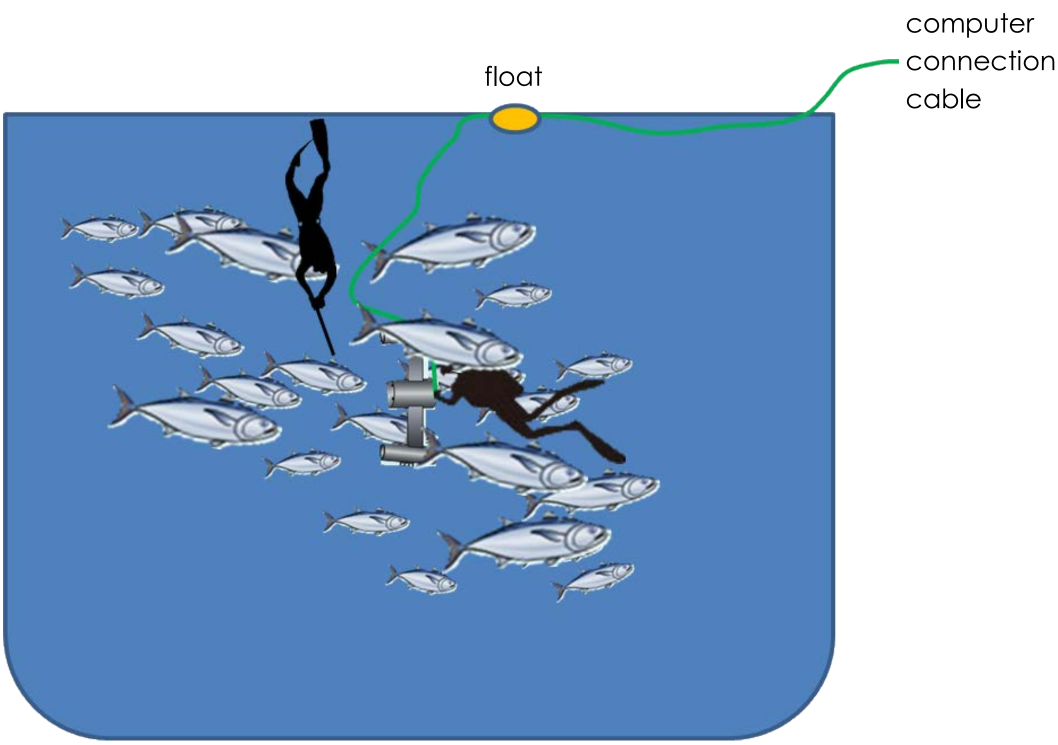

Figure 11: example of the use of a stereocamera during tagging.

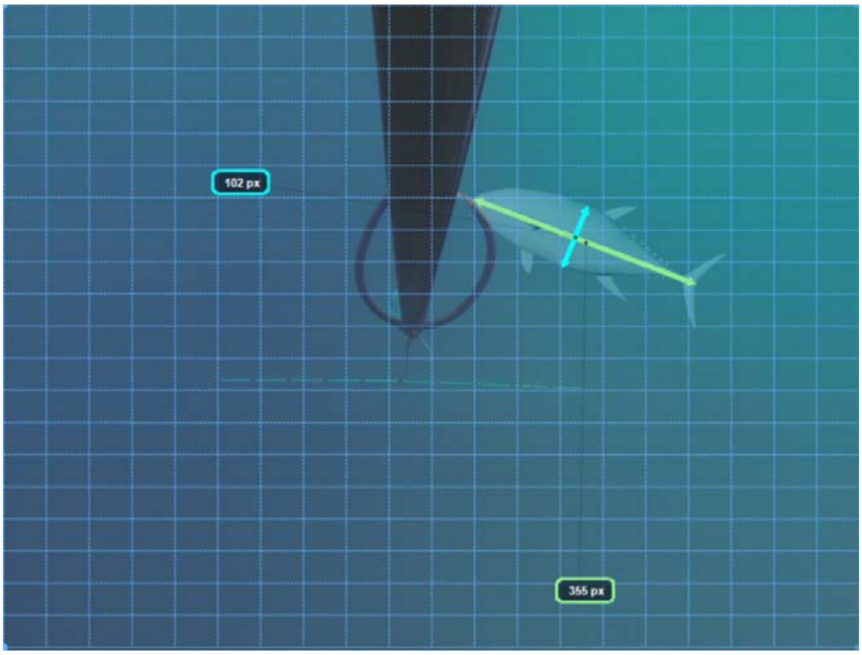

Figure 12 - apparent length and the maximum apparent width.

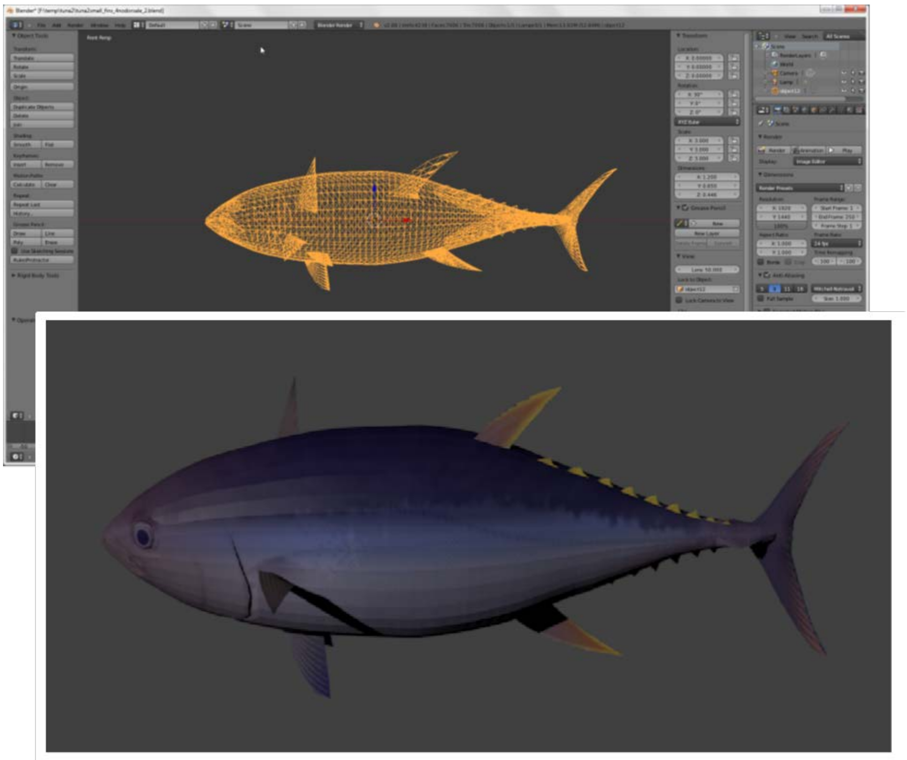

Figure 13 - 3D Tuna fish model.

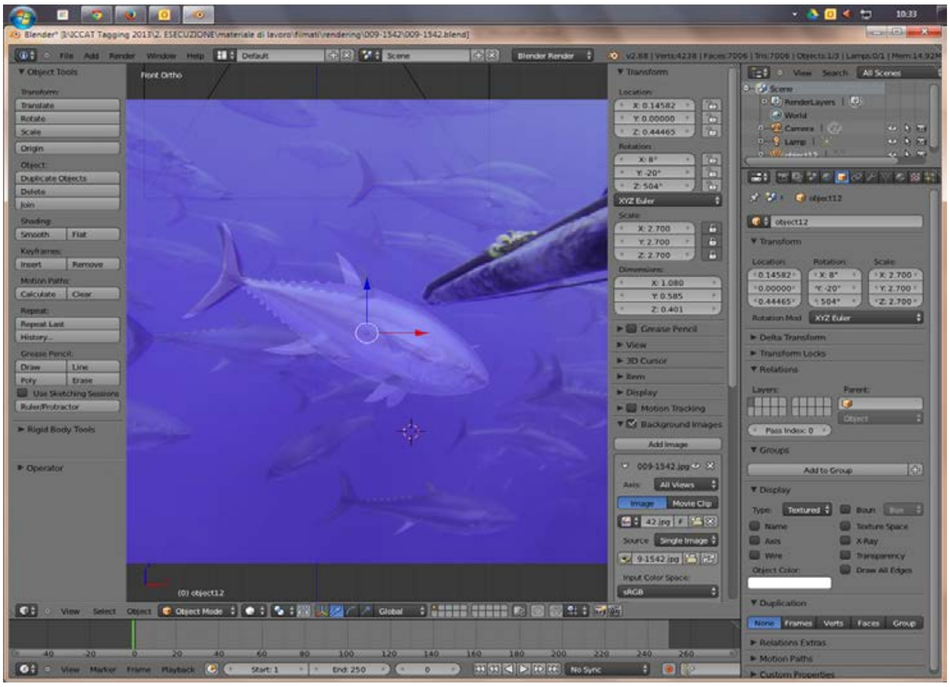

Figure 14 – imaged used to create the 3D tuna fish model.

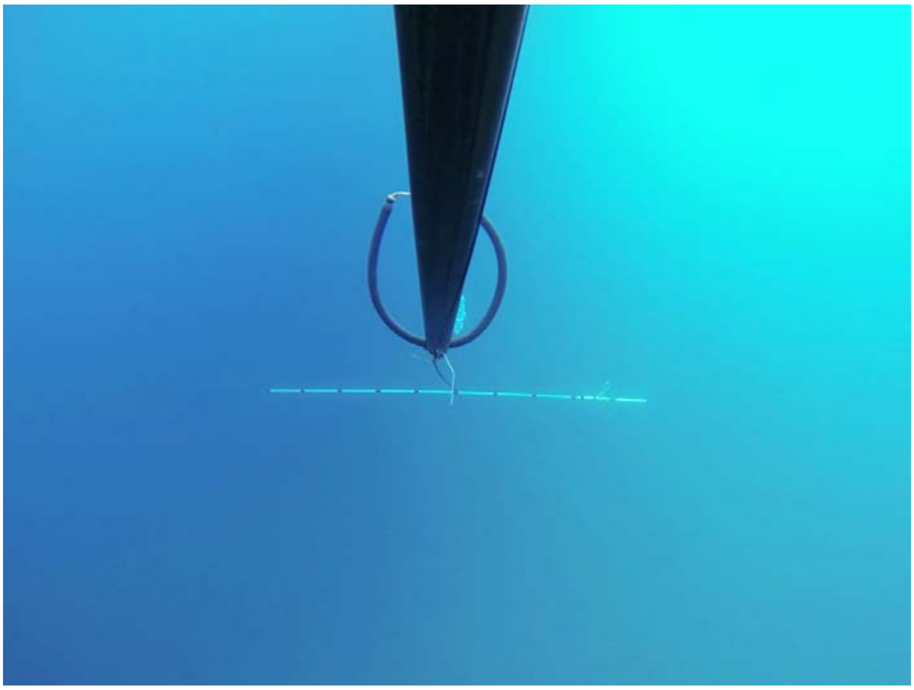

Figure 15 - usual distance from which tagging spears were fired (2m).

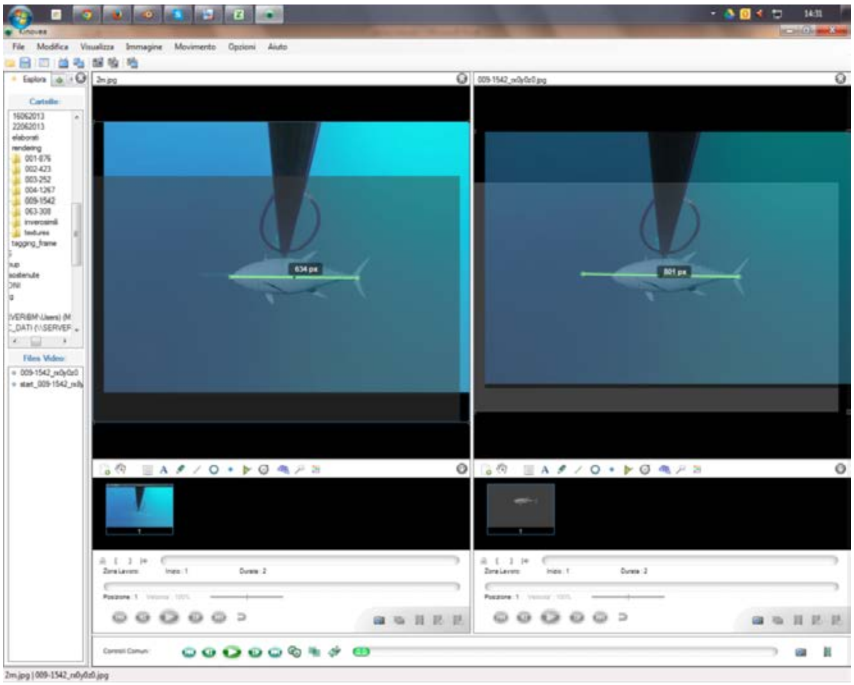

Figure 16 - reference pole image used to scale 3D tuna fish models.

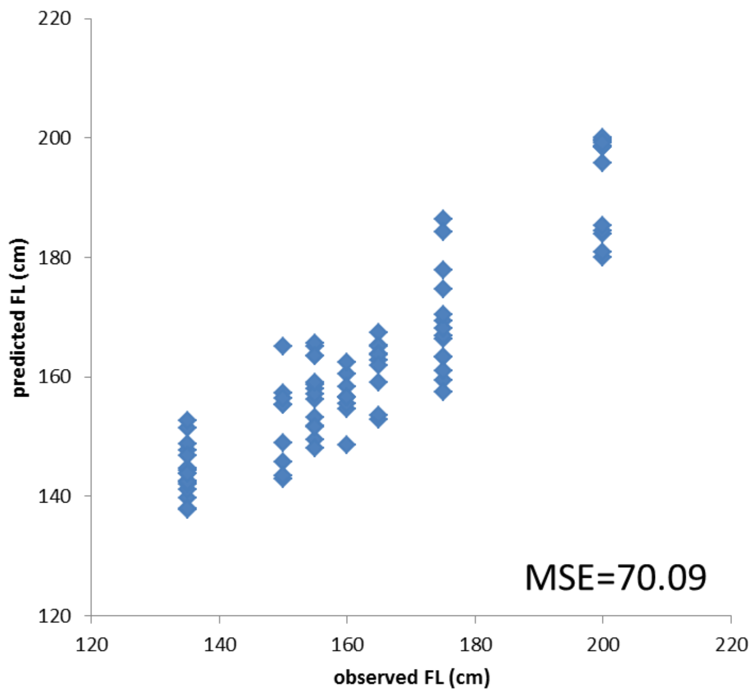

Figure 17 - Mean Square Error.

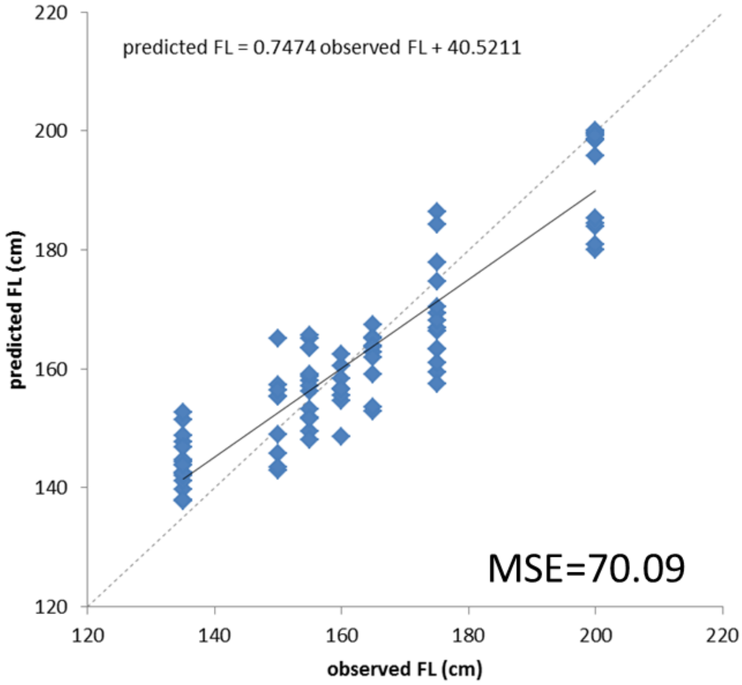

Figure 18 - Mean Square Error with the linear model equation.

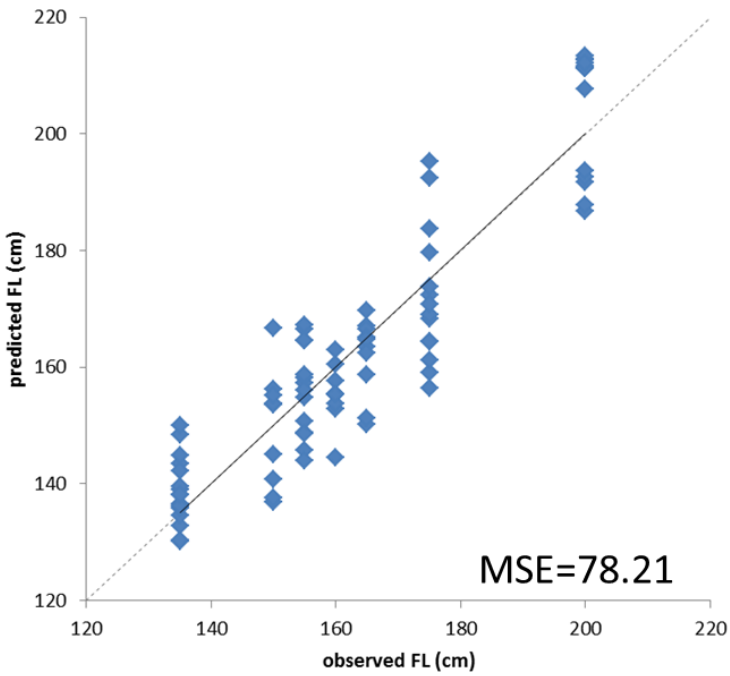

Figure 19 - Mean Square Error after the linear correction.

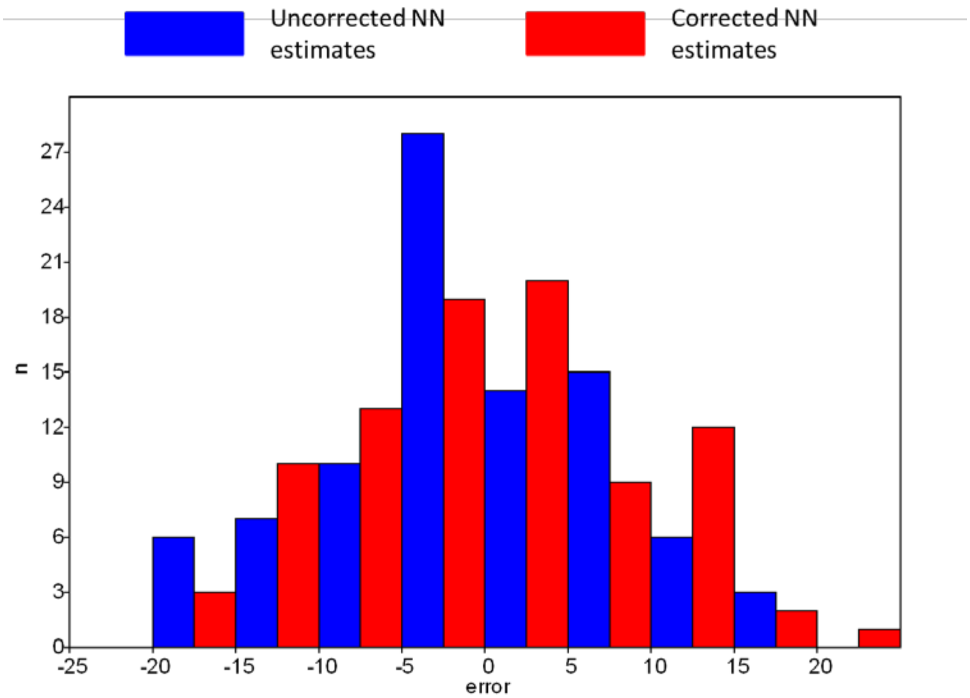

Figure 20 - distribution of errors.