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BLUEFIN TUNA TAGGING USING "POP-UP TAGS": FIRST EXPERIMENTS IN THE MEDITERRANEAN AND EASTERN ATLANTIC

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SUMMARY

Bluefin tuna tagging experiments using "pop-up" tags (EU FAIR Project N. 97/3975) began in June, 1998, at the Stintino in northern Sardinia using the tuna trap called "Saline". The tagging operations took place on June 7, 1998, and three bluefin tuna, weighing about 150 kg each, were tagged. The tags, inserted by an under-water fishing gun, were anchored on the fish in the area close to the base of the second dorsal fin.

The tags were programmed to pop up at the following times: 1 after 10 days, 1 after 15 days and 1 after 25 days. The first two tags popped up at the expected time, while no information was obtained from the third tag.

The tagging operations continued on July 27, 1998, in the eastern Atlantic where nine bluefin tuna were tagged, using the same methodology, in the trap at Barbate in Spain. The tags were programmed to pop up at the following times: one after five days, one after 20 days, two after 60 days, two after 120 days, one after 180 days, one after 240 days and one after 300 days. The first tag popped up at the expected time, while the third, which was expected to pop up on August 16-17, has not yet transmitted. The remaining tags are programmed to pop up between November, 1998, and May, 1999.

RÉSUMÉ

Le marquage expérimental de thon rouge avec marques pop-up (UE Projet FAIR 97/3975) a commencé en juin 1998 à Stintino, au nord de la Sardaigne, en utilisant la madrague "Saline". Le 7 juin, le marquage a porté sur 3 thons rouges, pesant chacun environ 150 kg ; les marques ont été apposées à proximité de la base de la deuxième dorsale au moyen d'un fusil de chasse sous-marine. Il était prévu qu'elles se détachent, l'une au bout de 10 jours, la deuxième au bout de 15 jours, et la dernière au bout de 25 jours. Les deux premières marques se sont détachées comme prévu, mais on est resté sans nouvelles de la troisième.

Le marquage s'est poursuivi selon la même méthode le 27 juillet dans l'Atlantique Est, et a porté sur 9 thons rouges dans la madrague de Barbate, en Espagne. Il était prévu que les marques se détachent comme suit : 1 au bout de 5 jours, 1 au bout de 20 jours, 2 au bout de 60 jours, 2 au bout de 120 jours, 1 au bout de 180 jours, 1 au bout de 240 jours et 1 au bout de 300 jours. La première marque s'est détachée comme prévu, mais on ne sait rien de la troisième, qui devait se détacher les 16-17 août. Il est prévu que le reste des marques se détachent entre novembre 1998 et mai 1999.

RESUMEN

Los experimentos de marcado de túnidos con marcas "pop-up" (EU FAIR Project N.97/3975) se iniciaron en junio de 1998 en Stintino, al norte de Cerdeña, empleando la almadraba para túnidos denominada "Saline". Las operaciones se realizaron el 7 de junio de 1998 y se marcaron 3 atunes rojos de unos 150 kg de peso cada uno. Las marcas fueron colocadas en los peces cerca de la base de la segunda aleta dorsal, con un fusil de pesca submarina.

Las marcas fueron programadas para surgir con los siguientes intervalos: 1 a los 20 días, 1 a los 10 días y 1 a los 25 días. Las dos primeras marcas surgieron cuando se esperaban, pero no se obtuvo información alguna de las tercera marca.

Las operaciones prosiguieron el 27 de julio de 1998 en el Atlántico este, marcándose 9 atunes rojos con el mismo métodos en la almadraba de Barbate (España). Las marcas se programaron como sigue: 1 surgiría a los 5 días, 2 a los 20 días, 2 a los 60 días, 2 a los 120 días, 1 a los 180 días, 1 a los 240 días y 1 a los 300 días. La primera actuó en el momento esperado, pero la tercera, que debía aparecer entre el 16 y 17 de agosto, todavía no ha trasmitido. Las restantes marcas deberán actuar entre noviembre de 1998 y mayo de 1999.

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Introduction

As is known, ICCAT has been assessing Atlantic bluefin tuna stocks for many years now. This assessment is based on the hypothesis that two separate stocks exist with limited rates of exchange between them: the Eastern-Atlantic stock, which includes the Mediterranean, and the Western-Atlantic stock.

In order to study interchange between the Western and the Eastern Atlantic and to understand the bluefin tuna migration, ICCAT has for sometime proposed an increase in tagging campaigns and the use of "intelligent" tags (ICCAT-SCRS, 1993; 1994).

A EU project has been proposed in order to test the hypothesis put forward by ICCAT and to verify whether bluefin tuna from the Eastern Mediterranean mix with bluefin tuna from the Middle-Western Mediterranean and Eastern Atlantic, or whether it represents a local sub-population with little interchange with the remaining bluefin from the other areas of the Mediterranean (ICCAT-SCRS, 1996; Akiuz e Artuz, 1957; Artuz, 1959; Ben Tuvia, 1957; Devedjian, 1926; Le Danois, 1949; Sara 1971).

The objectives of the above projects are as follows:

a) to identify and describe migration and dispersion patterns of bluefin tuna in the Atlantic and the Mediterranean with reference to the spawning and nursery areas;

b) to assess the advantage of using electronic tags and to acquire experience for future projects with large pelagic fish;

c) to identify biological mechanisms of migration;

d) to gain a better understanding of the interaction between environmental factors and fish behaviour.

The project involves electronic tags that pop-up after a pre-programmed interval and transmit their geographical position and a limited amount of environmental data by Argos satellite (Block, 1996).

The experiment aims to overcome both the severe limitation of acoustic tracking, which requires a research vessel, is very expensive and only provides a short period of observation (Arnold et al. 1990), and the limitation due to the necessity to recapture archival and/or traditional tags.

This paper describes the tagging experience acquired in the initial stages of the above project and its first results.

Materials and Methods

The plan involves the tagging and release of a total of 120 bluefin tuna: 40 in the Tyrrhenian Sea, 40 in the area of the Straits of Gibraltar and 40 in the Aegean Sea.

During the first co-ordinating meeting held in Athens (March 1998) it was decided to evaluate tagging procedures carrying out field trials in the Mediterranean to test whether the tags could be reliably detected by Argos before embarking on a full-scale release. This decision was made in consideration of difficulties encountered by the tag producer in detecting PTTs on eagles in Spain some years ago (Howey, pers. comm.). In addition, in view of the high cost of the tags and of the fish, it was decided to test the tags both under field conditions in the Mediterranean and in the laboratory at Lowestoft, before releasing batches of 30-40 tags. Therefore some preliminary trials were planned, which were to be performed in Sardinia or Sicily, to test fish handling and tag attachment methods, as well as the pop-up mechanism and satellite detection under field conditions. Five PTT 100 pop-up tags (Telemetry 2000 Inc., Columbia, MD, USA) with 400 mW radio transmitters were ordered for the preliminary trial. Each tag consists of a streamlined carbon / epoxy pressure housing (160 mm total length), a corrosive release mechanism at the leading end, and a flotation collar that allows the antenna to float upright when the tag jettisons from the fish. The release mechanism incorporates a small bobbin, through which a monofilament leader can be passed. Each tag is positively buoyant (density 0.96), weighs 65-68 g in air and will withstand pressures up to 1000 psi. A microprocessor, which controls the release mechanism and the Argos satellite transmitter, also records up to 61 average daily water temperatures. Temperatures, which are sampled hourly, are recorded for the first 60 days after deployment. The 61st measurement is made on the last day before the tag is programmed to pop up. Once at the surface, the recorded temperatures and real time sea surface temperatures are transmitted for 30 days. The geographical position of the tag is determined by the Argos satellite. The five PTT 100 tags for the preliminary trial were set to detach themselves from the fish at interval of 5, 10, 15, 20 and 25 days after the date of attachment to the fish. The tags were connected to medical grade nylon darts (Floy Inc.) by means of 25 cm monofilament fishing line (100 lb. test grade). To anchor the tags to the fish a short hand-hold stick supplied by Molly Lutcavage (New England Aquarium) was used. It, however, proved to be inappropriate to tag the fish whilst they are swimming freely in the trap. Accordingly an underwater fishing gun was employed, which turned out to be more suitable. The arrow of the gun was modified to shoot the dart tags and a regulating device (a small plastic disk which stops the run of the arrow) was attached to it at 10 cm from the arrowhead to avoid an excessively deep penetration into the flesh.

The dart tags were carefully disinfected and covered with a cicatrizing salve before being used.

Two trials were carried out in the trap at Stintino in northern Sardinia (Italy). The first attempt took place on 23 May 1998 without success. On this occasion 14 bluefin tuna were in the trap. It was decided to tag 5 specimens and, after tagging, to kill the remaining bluefin tuna before releasing the tagged ones. Unfortunately, due to lack of experience of the skin diver and to the presence of giant bluefin tuna in a small area, some difficulties arose in the course of tagging. As a result, only 3 specimens were tagged, but they died before being released when the fisherman killed the other fish using electricity. Afterwards the tags were recovered from the dead tuna.

Because of the great problems encountered during the first trial and the difficulty in getting close enough to the fish to tag them with a short stick, it was decided to use a modified version of the underwater fishing gun.

The second trial took place on 7 June 1998; on this occasion 4 bluefin tuna were in the trap. Three specimens of about 100 kg each were tagged, while the other of about 300 kg, died during the tagging operation after becoming trapped in the meshes of the net.

The tags programmed to pop up 10, 15 and 25 days after the date of insertion were applied to the fish by J.L. Cort using the underwater fishing gun. The experiment was conducted in the trap at a depth of 8 - 10 m; the area of the trap was about 600 m^2.

The results were satisfactory, although this trial showed that it would probably be better to use a more powerful underwater fishing gun.

Results in Stintino were sufficiently encouraging to persuade us to carry out the first tagging experiment at Barbate (Spain) near the Straits of Gibraltar. PTT 100 tags with 400 mW radio transmitters were also used for this experiment. The tagging was carried out on 27 July 1998, taking in to consideration the suggestions made by J.L. Cort during the previous experiment, and using a more powerful underwater fishing gun (made by *Sporasub*, mod. *Viper élite 90*, power: 10 m) than the one used in the Sardinian trial (made by *Imersion*, short model, power: 3 m). Nine of the twelve fish present in the trap were tagged and 8 of the tags appeared to be securely attached to the fish. The whole job went very smoothly and was completed in a couple of hours.

A video was made of the tagging and the results look good with the fish swimming calmly around the trap before attachment of the tags but they accelerated for a short period of time after the arrowhead hit them. Once the tagging operations were completed, all 12 bluefin tuna were released.
The 9 tags were programmed to pop from the tuna up according to the following scheme:

Tagging day:27/07/98	*Coordinates: 35.49 N; 3.9 W*
Tag number	**Pop-up time (days)**
9117	5
9120	20
23010	60
23011	60
23012	120
23013	120
23014	180
23328	240
23330	300

The tasks of collecting pop-up information from satellite Argos and environmental parameters were respectively assigned to CEFAS Lowestoft Laboratory and Planetek Italia.

Preliminary results and discussion
The first trial was unsuccessful for several reasons: a) the hand-hold tagging stick was too short and the divers did not insert the darts far enough; b) the divers had limited experience of tagging and excited the tuna by having to repeatedly approach them with the short tagging stick; c) the decision to kill the nontagged fish using electricity turned out to be disastrous because conduction of the electricity in the water also killed the tagged fish. The tags recovered from these latter showed that the darts were not in far enough even if a knife was necessary to extract them from the flesh.
The first two tags used in the Stintino trap during the second trial popped up on schedule. The first one, number 9118, started transmitting at 03:10 h on 17 June and gave its first position fix at 12:40 h on 18 June. The transmitted position, 41.17 N 10.66 E, which was in the Tyrrhenian Sea to the east of Sardinia and Corsica, implies that the fish had travelled about 100 miles to the east through the Straits of Bonifacio.
The second tag, number 9119, started transmitting on 24 June giving a position fix only on 29 June at 36.968 N 8.664 E but the data had a very poor accuracy. The hypothetical movements of the two fish are shown in Fig.1.
Tag number 9138, expected to pop up on 2-3 July, did not send any messages.
The third message came from tag number 9117 applied in the trap at Barbate (Spain) to a bluefin tuna on 27 July. This tag transmitted at the expected time popping up at 14:38 h on 1 August and giving a good position fix at 35.49 N 3.9 W. Fig.2 shows the hypothetical movements of this fish.
The fourth tag 9120, also used in the trap of Barbate, which was expected to pop up on 16 - 17 August has not yet transmitted.
In addition to their position, which was determined by the satellite, tags 9117, 9118 and 9119 transmitted the average temperature for each day between release and pop-up. This data are shown in Figs. 3, 4 and 5.

A first analysis of satellite derived Sea Surface Temperature maps and a comparison with tag records has been carried out by Planetek Italia.
The satellite data were obtained from the AVHRR (Advanced Very High Resolution Radiometer) sensor on board NOAA (National Oceanic and Atmospheric Administration) NASA satellite. They give information about sea temperature from the very upper water layers (up to a few centimetres depth).
The first map included in this article (Fig. 6) is a sample of AVHRR images for the entire Mediterranean.
The three maps showing waters around Sardinia (Fig. 7) represent Sea Surface Temperatures averaged over one week, for weeks beginning on 8, 15 and 22 June.
The two maps centred on the Straits of Gibraltar (Fig. 8) show daily temperature values for 27 July and 1 August, deployment and pop-up dates for tag 9117.
Considering the reduced thickness of the thermocline in June, it can be expected a good agreement between tags output temperatures and satellite data. These considerations strengthen the reliability of hypotheses about tuna paths: actually, the tuna found, after 10 days, not far from the Sardinia coast (tag 9118) travelled in colder waters (at about 20 °C) then the one retrieved over Tunisia after 15 days (tag 9119), as evidenced in satellite images too.
The third fish was released in late July, when the thermocline has deepened, in an area, the Gibraltar strait, were cold currents permanently reside. This matter of fact clearly appears in the first half of tag acquired temperatures, characterised by sudden and rapid oscillations, and in the satellite maps, which show a particularly cold area near Gibraltar when compared to the Mediterranean.
All these considerations are purely preliminary and need further analysis and more data to acquire some reliability.
Future plans include the analysis of satellite Ocean Colour maps, giving information about the phytoplankton concentration in the areas of interest.

Conclusion
The trials carried out in the trap "Saline" at Stintino (Northern Sardinia) have turned out to be very useful in determining the most appropriate method of tagging the fish while they are swimming freely in the "chamber of death" of the trap.
The results indicate that an underwater fishing gun is an effective way of attaching pop-up tags to large bluefins in tuna traps. The gun allows a diver to attach the tag in the selected place without exciting the fish by repeated attempts to approach it closely with a short hand-hold tagging stick. Five tags released in Sardinia and Spain have been programmed to pop-up to date. Three of these tags have transmitted position and temperature data and the current success rate is therefore 60 %. This is not as good as success rates of 95 % (Block et al., 1996) and 85 % (Lutcavage et al., pers. comm.) reported for pop-up tags attached to bluefin tuna in the western North Atlantic but our sample size is smaller (12 tags c.v. 37 and 20 tags, respectively).
Possible reasons for tags failing to report their positions include electronic failure, antenna damage, float failure, fouling (which could prevent the antenna from floating vertically), natural mortality of the fish, mortality due to capture and release, and the possibility that the fish was captured and the tag discarded.
Although we would expect most post-spawning bluefin tuna to move out into the Atlantic, the movement of tag 9117 into the Mediterranean is not necessarily unusual because the same behaviour was observed some years ago in a bluefin tagged with a conventional tag (de la Serna, pers. comm.).

Thanks

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References

Akiuz E.F., Artuz I. 1957 - Some observation on their Biology of tuna caught in Turkish waters. *FAO , CGPM* 4, 14:93-99.

Arnold G.P., Greer Walker, and Holford B. H 1990 - Fish behaviour: achievements and potential of high-resolution sector-scanning sonar. *Rapports et Proces-verbaux de Reunion du Conseil International pour l'exploration de la Mer*. 189:112-122.

Artuz I. 1959 - Fluctuations in the catches of some pelagic fishes in the Marmara Sea. *FAO, CGPM* 5, 41:303-311.

Ben Tuvia A. 1957 - Pelagic fishery in Israel. *FAO, CGPM* 4, 45:383-391.

Block B. 1996 - Satellite and Archival Tagging of Highly Migratory Fish in the Atlantic *ICCAT Tuna Symposium*, Ponta Delgada, Sao Miguel, Azores 10-18 June 1996.

Devedjian R. 1926 - Peche et Pecheries en Turquie. *Costantinopoli Ed.* pag. 124.

ICCAT-SCRS 1993 - *Rapport de la periode biennale* 1992-93, I partie: 162-171. Madrid.

ICCAT-SCRS 1994 - *Commission Report SCRS*. Nov. 1994 Madrid.

ICCAT-SCRS 1996 - *Report for biennal period* 1994-95 Part II Vol. 2. Madrid.

Le Danois E 1949 - Vie et moeurs des poissons *Ed. Payot* Paris pag. 335.

Sarà R. 1971 - Pour un repeuplement actif de thons rouges en Mediterranee. Project FAO (CGPM), UNESCO, CIESMM *Bull. Etude Comm. Mediterranee* 2, 13.

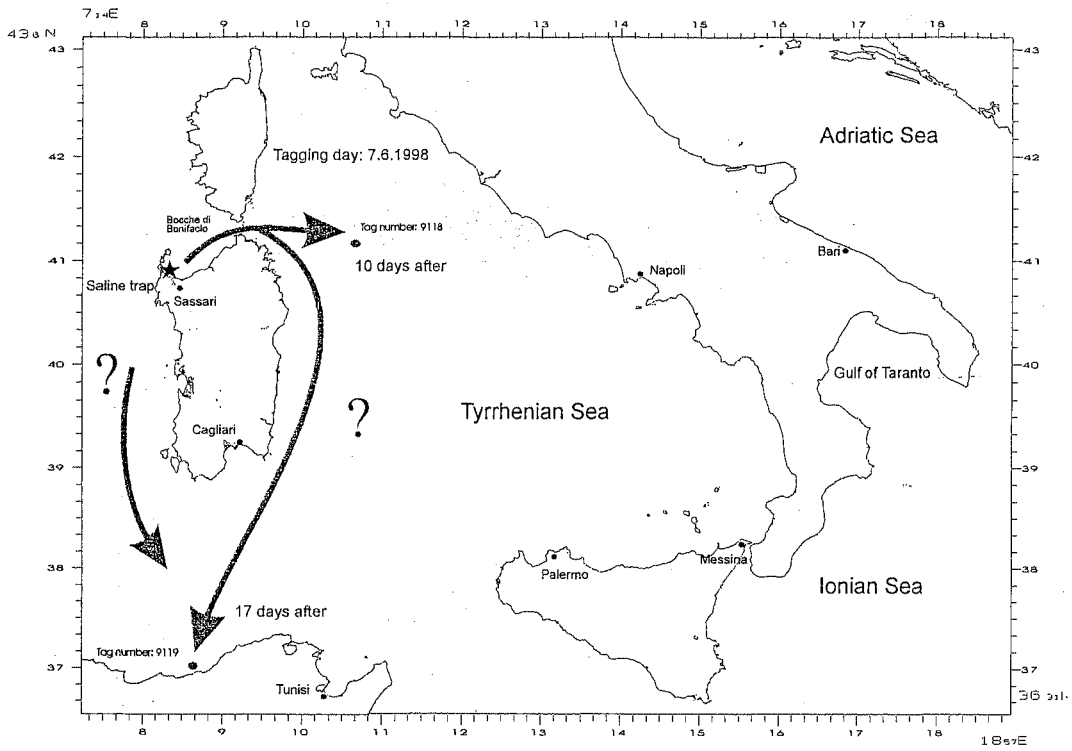

Fig. 1 - Hypothetical movements of the two bluefin tunas tagged at Stintino trap (Sardinia) in June 1998 (tags 9118 and 9119).

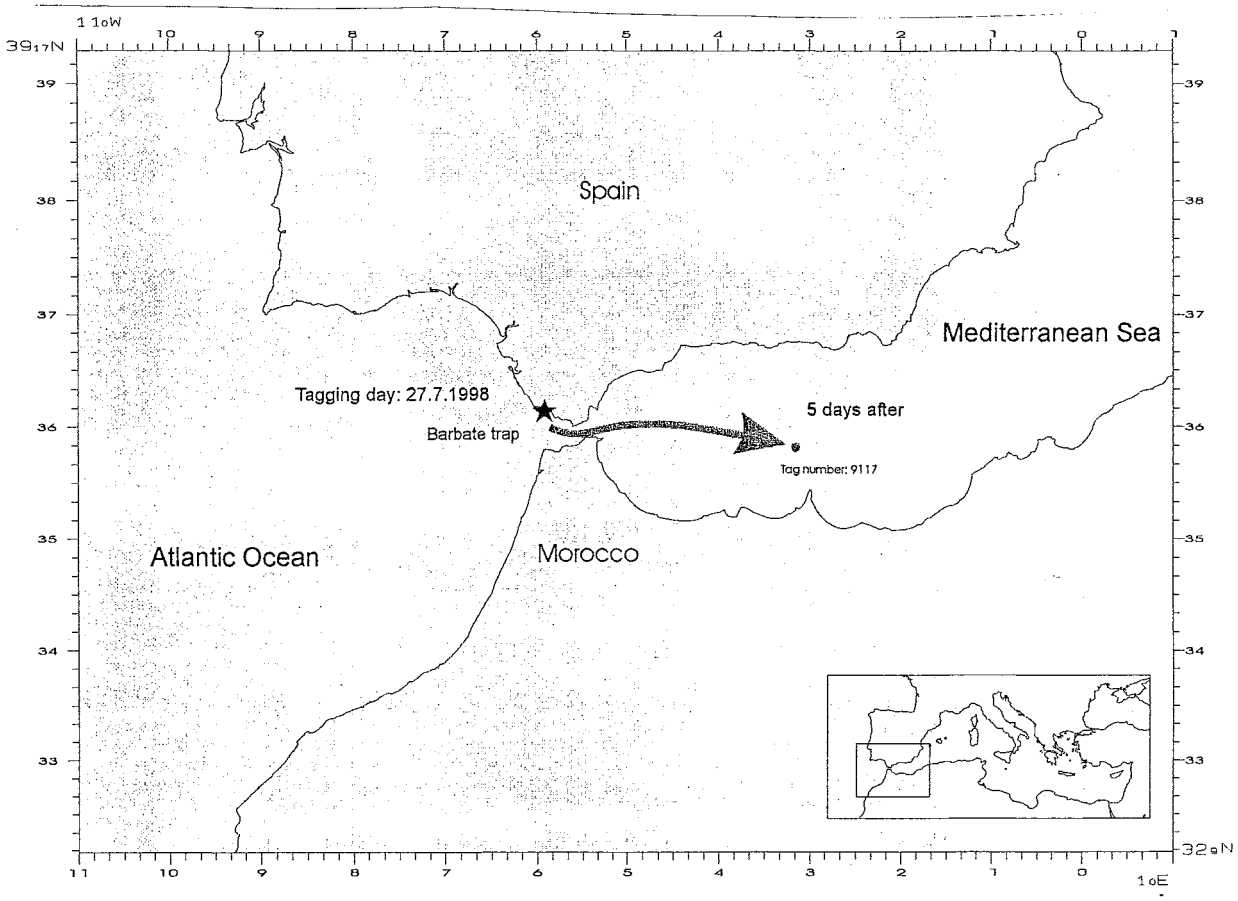

Fig. 2 - Hypothetical movements of the first bluefin tuna tagged at Barbate trap (Spain) in July 1998 (tag 9117).

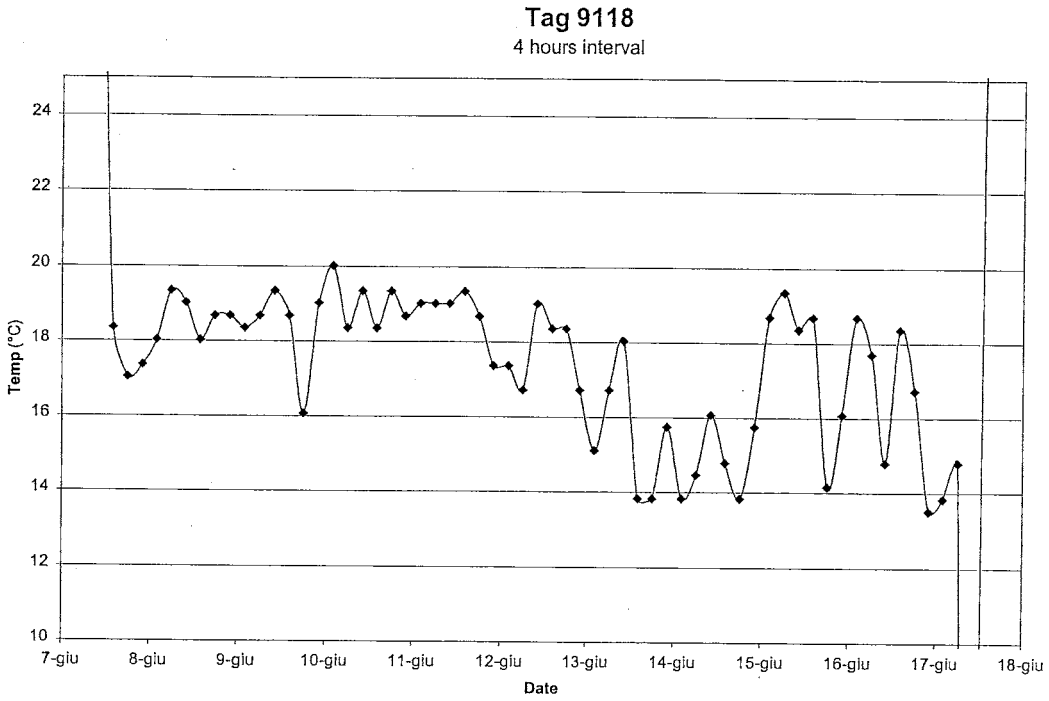

Fig. 3 Average temperatures recorded by tag 9118, which was released at Stintino (Sardinia) on 7 June 1998 and started transmitting from the Tirrenian Sea on 17 June. The data are average temperatures calculated every 4 hours.

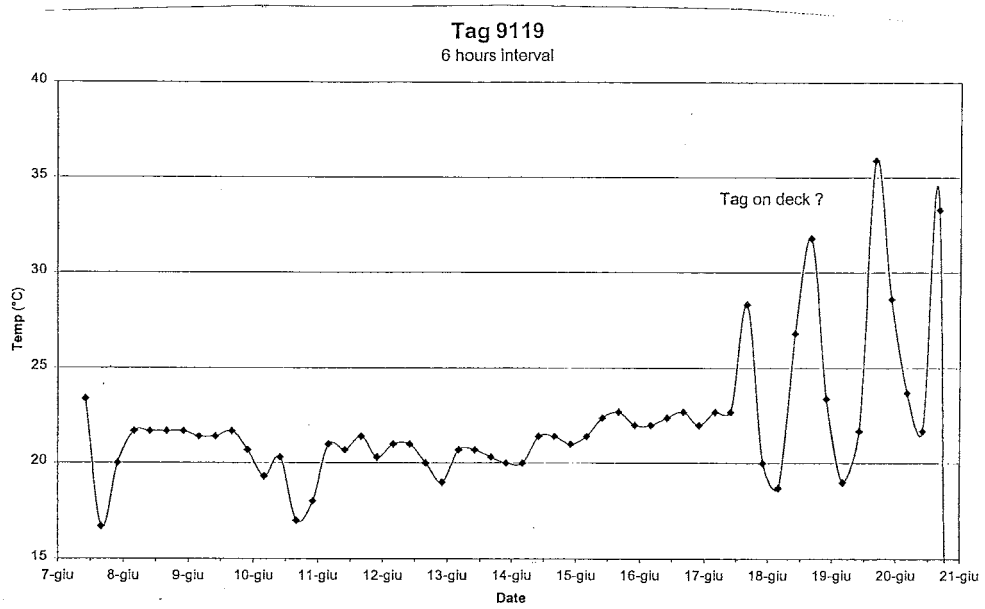

Fig. 4 Average temperatures recorded by tag 9119, which was released at Stintino (Sardinia) on 7 June 1998 and started transmitting on 20 June. The data are average temperatures calculated every 6 hours.

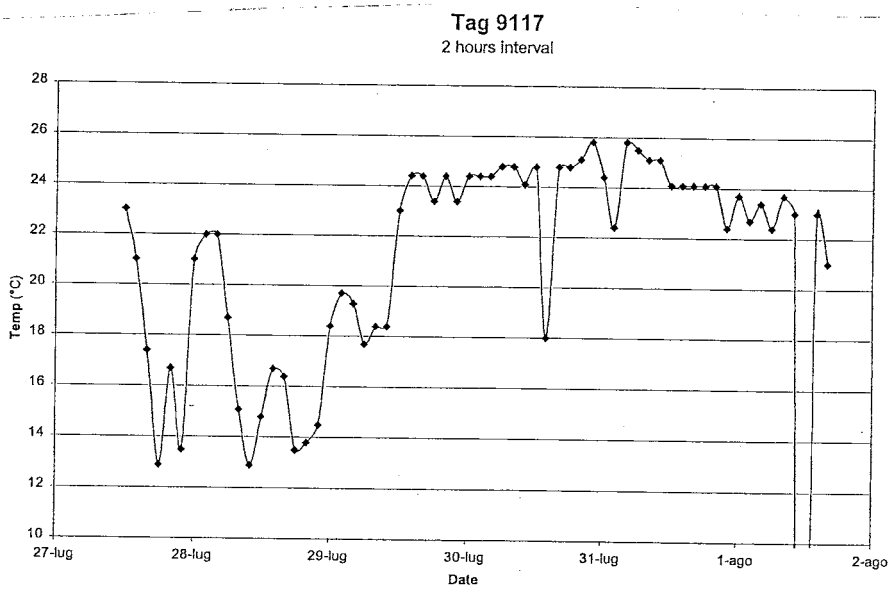

Fig. 5 Average temperatures recorded by tag 9117, which was released at Barbate (Spain) on 27 July 1998 and started transmitting on 1 August. The data are average temperatures calculated every 2 hours.

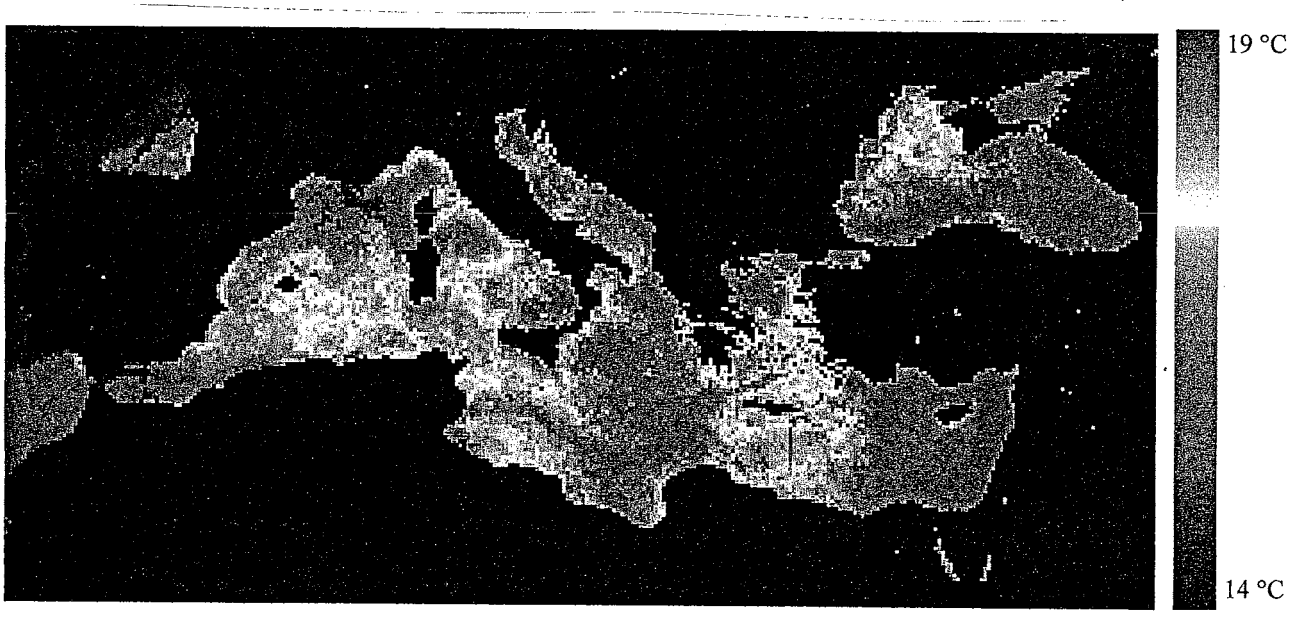

Fig. 6 Sea Surface Temperature (SST) image obtained from AVHRR sensor. The image shows maximum temperatures for 8th June 1998 week.

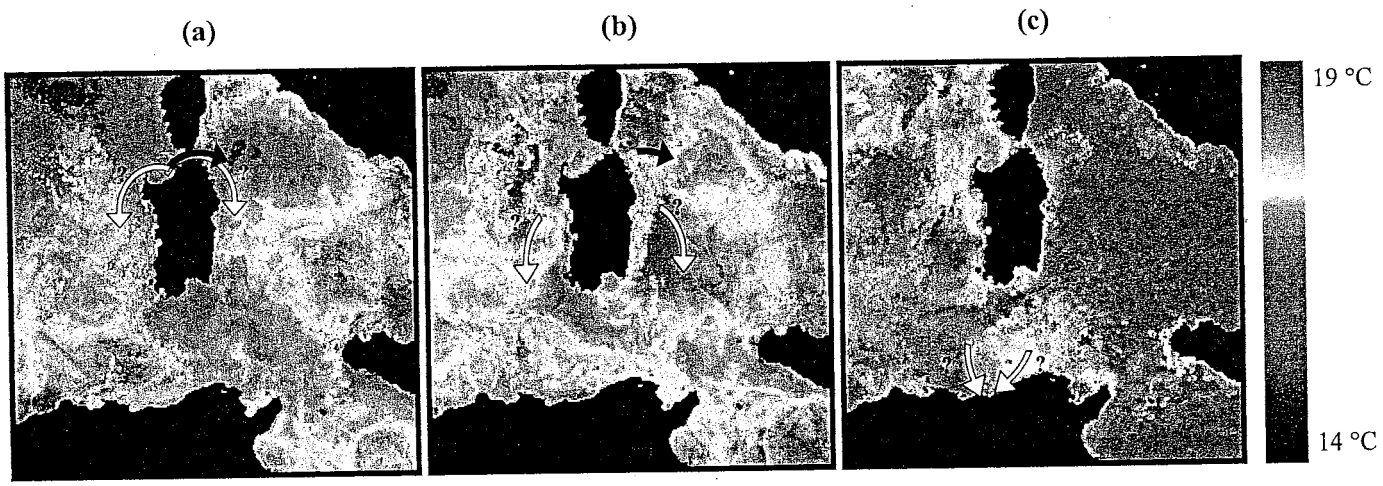

Fig. 7 Sea Surface Temperature (SST) images obtained from AVHRR sensor. The images show week maximum temperatures for three weeks in June 1998 (from left to right 8th, 15th, 22nd). The arrows indicate the hypothetical tracks for tuna with tags 9118 (black) and 9119 (white). In the second case, there are not enough elements to choose one of the two possible tracks.

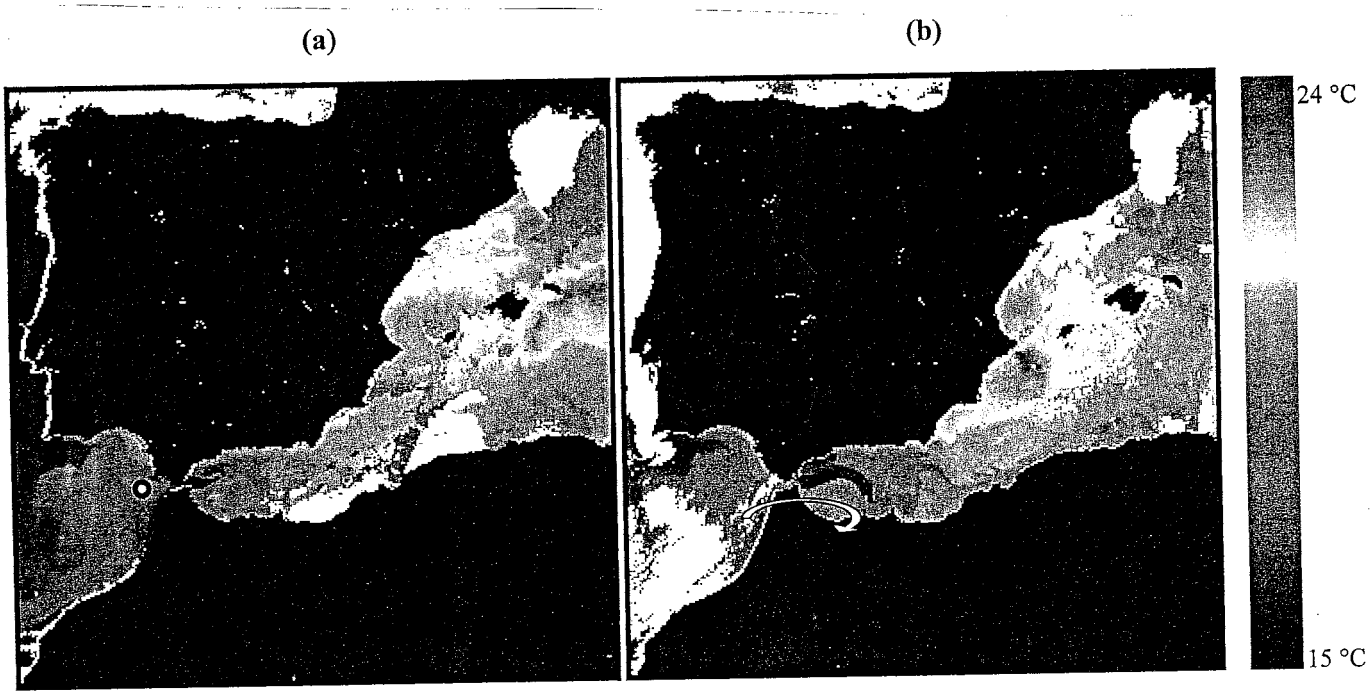

Fig. 8 Sea Surface Temperature (SST) image of the Mediterranean Sea obtained from AVHRR sensor on 27 July (left) and 1 August 1998. The point and arrow indicate the hypothetical displacement of tuna with tag 9117.