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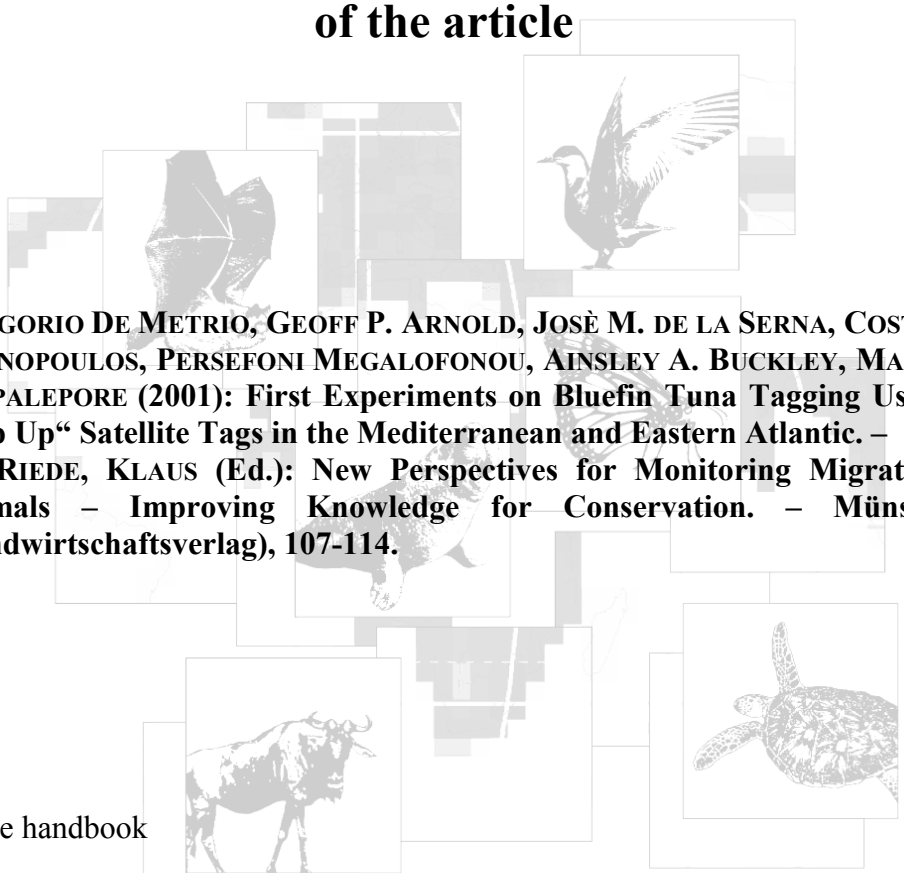

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First Experiments on Bluefin Tuna Tagging Using „Pop Up“ Satellite Tags in the Mediterranean and Eastern Atlantic

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Abstract

Bluefin tuna tagging experiments using „pop-up“ tags (EU FAIR Project N. 97/3975) were carried out between June 1998 and August 2000. The tags were programmed to detach themselves from fish and float to the surface after intervals of between 5 and 300 days, providing, by means of the Argos satellite system, 61 average hourly or daily sea temperature data and pop-up position.

Twelve fish were tagged in 1998 by divers using an underwater sport-fishing gun, in traditional tuna traps in Stintino (northern Sardinia, Italy) and Barbate (Spain).

Forty fish were tagged in 1999: twenty-three in the trap at Barbate using a hand-held harpoon; five were caught by hand lines in northern Aegean Sea and brought on board for tagging; twelve were caught by sport fishery off Bonifacio (Corsica) and tagged alongside the boat using a T-shaped tagging stick.

Seven fish were tagged in 2000 in Greece using the same methodology as in previous years and another two in Spain.

Six (50%) of the 1998 tags and six (15%) of the 1999 tags popped up successfully; no return from the tags placed in 2000 has been obtained to date. Several of the tags have shown interesting results. In fact, a tag deployed at Barbate was detected in the Greenland Sea at 75.123°N, 1.095°E, the most northerly reported position for bluefin tuna; another tag deployed in Barbate popped up at 20.269°N, 29.673°W, close to the southern limit of the eastern Atlantic stock; the results of three of the tags deployed in the area of Bocche di Bonifacio suggested that this may be a feeding area: two of them popped up in the same area after 180 and 240 days respectively, while a third tag was recovered from a fish recaptured in the same area after 65 days at liberty.

Furthermore the possible causes of the low rate of tag return are discussed.

1 Introduction

The EU FAIR project TUNASAT has been the first attempt to study migrations of bluefin tuna (*Thunnus thynnus* L.) in the Mediterranean, using electronic tags and, in particular, „pop-up“ satellite tags. It is a joint project involving scientists from four European Countries. The main objectives are: 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 elec-

tronic tags and to acquire experience for future projects with large pelagic fish. The project began in 1998 and was originally scheduled to finish by the end of December 1999.

But, as a result of several problems with the supply of „pop-up“ tags, difficulty in finding available fish and fishermen, adverse weather conditions, and low return rates, which left uncertainty about the correct working of tags, a one year extension was requested from the European Commission. The extension was agreed and the deadline postponed to the end of December 2000. The aim of this paper is to describe the work done and to present a summary of the results obtained to date.

2 Material and methods

Sixty-one bluefin tuna, several of them giants, were tagged between June 1998 and August 2000, using PTT-100 electronic pop-up tags supplied by TELEMETRY 2000 (Columbia, Maryland, USA). The fish were marked with tags programmed to detach themselves from the fish and float to the surface after intervals of between 5 and 300 days. The 61 average hourly, or daily, sea temperature recorded by each tag were recovered by radio telemetry using the Argos satellite system, which also determined the pop-up position.

The tags were attached by nylon monofilament to medical grade nylon darts (Floy Inc.) embedded in the dorsal muscles. In the Aegean Sea the fish were tagged on board the boat and the nylon darts were inserted through the base of the second dorsal fin rays.

Twelve fish were tagged in 1998. They were caught in traditional tuna traps and tagged by divers using an underwater sport-fishing gun. Three fish were tagged at Stintino (northern Sardinia) in June and nine at Barbate (southern Spain) in late July.

In 1999 a further 40 fish were tagged. Twenty-three were caught in the trap at Barbate in July and tagged by a diver using a hand-held harpoon. Five fish were caught on hand lines near Chalkidiki in the northern Aegean Sea in April (3) and December (2), and brought on board for tagging. A further 12 fish were tagged in the sport fishery off Bonifacio (Corsica) in September (11) and November (1). These last fish, which were caught on rod-hand-line, were also tagged alongside the boat using a T-shaped tagging stick, generously loaned by colleagues in the USA, and a hand-held harpoon.

In 2000 nine fish were tagged: seven of them in Greece (two in January and five in March) using the same methodology as in previous years and two in Spain. The last two fish, caught by purse seines and destined for aquaculture, were tagged at Puerto Mazaron in August.

During the last tagging operation at Puerto Mazaron, in addition to the aforementioned fish, thirteen bluefin were tagged using Pop-up Archival Tags (PAT) made by WILDLIFE COMPUTERS and supplied by B. A. Block who, together with one of her collaborators, personally took part in the tagging operation. The PATs provide a full archive of light, temperature and pressure at 2 minute intervals, in addition to the pop-up position.

The PATs were programmed to detach themselves from the fish and float to the surface after intervals of between 32 and 185 days.

3 Results

Six (50%) of the 1998 tags popped up successfully. Tags from Stintino popped up in the Tyrrhenian Sea (1 tag) and off the coast of North Africa (2 tags) after periods of 5-15 days at liberty (Tab. 1 and Fig. 1). Two tags from Barbate popped up in the Atlantic near Madeira and the Cape Verde Islands after 60 and 177 days, respectively. Data from a third tag released at Barbate were returned from the Greenland Sea in March 1999, after the fish had been at liberty for 240 days.

Only 6 tags (15%) have popped up from the 1999 releases, although 40 had been expected by now; another was recovered from a recaptured fish (Tab. 2 and Fig. 1). One of these tags, which were released off Chalkidiki, came to the surface in the southern Aegean Sea after 30 days. Three tags from Barbate popped up in the Atlantic: the first off the Strait of Gibraltar after 60 days at liberty, the second and third near the Canary Islands after 88 and 177 days, respectively. Two tags from Bocche di Bonifacio (Corsica) popped up close to the area where they were tagged after 180 and 240 days, respectively. A third tag from Corsica was recovered from a bluefin tuna (40 kg weight), which was recaptured after 65 days at liberty. Thanks to the ICCAT tag we added to the leader of the pop-up tag, it was possible to identify the tag and recovery it from the fisherman who recaptured the fish. The fisherman supplied us the co-ordinates of the recapture position. At the moment of recapture the fish was perfectly healthy. It was impossible to recovery the temperature data from the tag because it had been damaged soon after release.

No returns have been obtained from the 7 tags placed in 2000, although 4 had been expected to surface by now.

A total of 12 returns has therefore been obtained from the 56 releases, corresponding to a return rate of 21.4%. Temperature data were transmitted by all 12 tags.

Sporadic messages were received from a further 6 tags, but they were of insufficient strength or number to provide geographical location; no temperature data were received from these tags.

4 Discussion and conclusions

The returns rates obtained from the pop-up tags are poor when compared with the results from similar experiments with bluefin tuna carried out in USA. BLOCK et al. (1998) tagged both medium and giant bluefin tuna in the western Atlantic off Cape Hatteras in 1997, also using PTT-100 pop-up tags. A pop-up rate of 100% was obtained from 9 tags deployed for short periods (3-14 days). For 28 long-term (60-97 days) tags released on similar sized fish in the same area, the pop-up rate was 93%. Seventeen (85%) of 20 PTT-100 tags attached to giant bluefin in the Gulf of Maine by LUTCAVAGE et al. (1999) in 1997 popped up successfully as programmed. A lower return rate of 56% was obtained from 18 fish tagged in 1999 (Lutcavage, pers. comm.). This is close to the value of 50% we obtained from the first batch of 12 tags deployed in the traps at Stintino and Barbate in 1998. The data we have to date are insufficient to identify the most likely cause(s) of the low rate of tag return. Extensive discussion with other users of pop-up tags, as well as the manufacturer, suggest the following possibilities: a) failure of batteries, or electronic components; b) fishing mortality and non-reporting of tags; c) deep diving (as

Tab. 1: Returns from the tags released in 1998

N° TAG	9118	9119	9117	23011	23014	23328
TAGGING AREA	Stintino trap (Sardinia, Italy)	Stintino trap (Sardinia, Italy)	Barbate trap (Spain)	Barbate trap (Spain)	Barbate trap (Spain)	Barbate trap (Spain)
TAGGING DAY	07/06/1998	07/06/1998	27/07/1998	27/07/1998	27/07/1998	27/07/1998
TAGGING COOR-DINATES	40°56'00"N 8°13'00"E	40°56'00"N 8°13'00"E	36°09'02"N 5°55'08"W	36°09'02"N 5°55'08"W	36°09'02"N 5°55'08"W	36°09'02"N 5°55'08"W
POP-UP DAY EXPECTED	17/06/1998	22/06/1998	01/08/1998	25/09/1998	23/01/1999	24/03/1999
POP-UP DAY	17/06/1998	29/06/1998	01/08/1998	24/09/1998	20/01/1999	23/03/1999
POP-UP COOR-DINATES	41°10'44'N 10°39'36"E	36°59'58"N 9°01'08"E	35°37'12"N 3°46'56"W	30°41'14"N 19°03'36"W	20°16'14"N 29°40'38"W	75°07'38"N 1°06'10"W
DAYS AT LIBERTY	10	22	5	59	177	239
POP UP AREA	Tyrrhenian Sea	Off Tunisian coast	Alboran Sea	Near Madeira	Near Cape Verde Islands	Greenland Sea
DISTANCE COVERED (miles)	111	239	137	756	1604	2352

the result of behaviour, or death) leading to float failure (one of the commonest causes of failure – BLOCK, pers. comm.); d) biofouling; e) predation; f) bite damage to the radio antenna caused by other fish in the school attempting to eat the tag; g) damage to the radio antenna caused by the tag repeatedly hitting the side of the fish, as a result of inaccurate placement, or incorrect leader length; h) damage to the fish from the same causes as (g), resulting in death; i) small size of some fish. For tuna tagged with the underwater gun, there are two additional possibilities; j) heavy seas in the pop-up area after the tag has surfaced. Electronic components in the tags could have been damaged by g-forces when the bolt left the gun or entered the fish. The nylon anchor may have not have been securely embedded in the muscle of the fish because of the way in which the bolt from the gun detached itself from the fish. Additionally, it is possible that there may be systematic differences between Europe and the United States in the performance of pop-up tags with the ARGOS system (HOWEY, pers. comm.). Further work is underway to address this last question, which could have serious implications for any future work of this nature.

Despite the disappointingly low overall 'recovery' rate, several of the tags have shown interesting results. The most important, perhaps, is tag 23328, which was released at Barbate in Spain on 27 July 1998 and detected by ARGOS in the Greenland Sea (75.123°N, 1.095°W) on 23 March 1999 after 239 days at liberty. The most northerly positions reported previously for bluefin tuna are conventional tag returns from northern Norwegian waters. MATHER (1962) reported two transatlantic migrations for giant bluefin tuna tagged off the Bahamas (USA). One of these fish was tagged in July 1960 and recaptured

Tab. 2: Returns from the tags released in 1999.

N° TAG	23343	23344	23345	23327	6084	6086	7779
TAGGING AREA	Aegean Sea (Greece)	Barbate trap (Spain)	Barbate trap (Spain)	Barbate trap (Spain)	Bocche di Bonifacio	Bocche di Bonifacio	Bocche di Bonifacio
TAGGING DAY	03/04/1999	23/07/1999	23/07/1999	23/07/1999	25/09/1999	27/09/1999	27/11/1999
TAGGING COOR-DINATES	40°10'00"N 24°10'00"E	36°09'02"N 5°55'08"W	36°09'02"N 5°55'08"W	36°09'02"N 5°55'08"W	41°20'22"N 9°21'04"E	41°18'26"N 9°15'36"E	41°18'19"N 9°15'10"E
POP-UP DAY EXPECTED	03/05/1999	21/09/1999	21/10/1999	19/01/2000	23/03/2000	25/03/2000	30/07/2000
POP-UP DAY	02/05/1999	21/09/1999	19/10/1999	16/01/2000	29/11/1999 (bluefin tuna recaptured)	26/03/2000	30/07/2000
POP-UP COOR-DINATES	37°27'36"N 25°41'22"E	35°20'10"N 11°14'46"W	30°25'06"N 12°23'38"W	31°17'32"N 10°37'44"W	41°18'30"N 9°16'12"E	41°13'36"N 9°26'40"E	41°18'30"N 9°20'14"E
DAYS AT LIBERTY	29	60	88	177	65	180	246
POP UP AREA	Aegean Sea (Greece)	Eastern Atlantic Ocean	Near Canarian Islands	Near Canarian Islands	Bocche di Bonifacio	Tyrrhenian Sea	Bocche di Bonifacio
DISTANCE COVERED (miles)	143	263	474	374	0.32	19	4.10

in September 1962 at approximately 68°N, 12°E. HAMRE (1964) reported a giant bluefin tuna, which was tagged in Norway on 9 August 1960 at 60°30'N, 04°42'E and recaptured on 3 August 1961 at 66°15'N 10°30'E. Assuming the tag was released from the fish close to where it was detected by ARGOS, the position of tag 23328 is therefore the most northerly reported position for a bluefin tuna to date. The possibility that the tag might have been released from the fish before it started transmitting and then drifted further north on ocean currents needs further investigation. If validated, though, the data will suggest that bluefin can range further north into lower water temperatures than previously thought.

Tag 23014 is interesting in relation to the presumed southern limit of the bluefin tuna stocks in the eastern Atlantic. This tag, which was released on 27 July 1998, popped up at 20.269°N, 29.673°W close to the latitude considered to be the southern limit of the Eastern Atlantic Stock (POSTEL 1955). This limit may, however, not be correct, as a giant bluefin was reportedly fished in Senegal at 16°N in 1999 and bluefin have been found much further south in the western Atlantic. MATHER (1974), for example, reported two giant bluefin tuna that were tagged off the north-western Bahamas and recaptured in the South Atlantic. One fish, which was tagged in May 1963, was recaptured south-east of Recife (Brazil), at approximately at 10°S, 32°W in March 1965. The other fish, released in June 1969, was recaptured off Argentina at approximately 40°S, 52°W, in February 1973.

Tags 6084, 6086 and 7779 are also interesting. The fish were released in the area of Bocche di Bonifacio off southern Corsica in 1999, the first two in September and the third in November. The first one was recovered from a 40 kg fish in good, healthy condition, which was recaptured in the same area after 65 days at liberty. The second tag popped up just off Bocche di Bonifacio on 26 March 2000 after 180 days at liberty. The third popped up in the same area on 30 July 2000 after 246 days at liberty (Tab. 2). It seems highly likely, therefore, that the area around southern Corsica and northern Sardinia is a feeding area. On the other hand Mr. Camus, a Frenchman who regularly participates in the sport fishery for tuna, showed us some maps, obtained in February and August by sonar observations, which show the presence of large numbers of large fish (probably bluefin) on the bottom (100 m depth).

The other tags released in the Mediterranean gave some information on the movement of bluefin tuna inside Mediterranean. Two giant bluefin tagged in June on the trap of Stintino, northern Sardinia, (tags 9118 and 9119) covered minimum distances of 111 and 239 miles in 10 and 22 days at liberty, respectively. An other fish tagged in northern Aegean Sea in March covered 143 miles during 29 days at liberty.

Four of the other 5 tags released at Barbate trap (23344, 23011, 23345, 23327), showed that this bluefin tuna heade towards the Canarian Islands, wile another (9117) went to the Alboran Sea inside the Mediterranean.

The results of PATs deployed in August 2000, expected to pop-up in the current year and in the first months of 2001, could provide essential information for the study of tuna movements. These new tags are capable of recording the depth of the fish and its geographical position at frequent intervals. Whilst first generation, single point pop-up tags, of the type we have been using, are clearly appropriate for feasibility studies, they will not provide the requisite data for the large-scale fishery-independent studies of migration and distribution needed to resolve the major stock identity problems encountered in Atlantic bluefin tuna management. In addition the PAT tags may help to clarify the possible causes of the low return rate obtained by pop-up single point tags.

Fig. 1: Map of pop-up returns till July 2000.

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