Aerial survey on spawners aggregations of the Atlantic-wide research program on bluefin tuna (GBPY - 2011)
South Tyrrhenian Sea (Sub-area 2)

Final report

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Index

Summary

Aerial surveys were carried out with the aim of providing fishery-independent indices to improve the knowledge of bluefin tuna populations in the Mediterranean, particularly for what is concerning the spawners aggregations. The surveys were repeated, after the first survey in 2010 in an area comprised between Sicily and Calabria (South Tyrrhenian Sea), in a multi - year planning, since several years are necessary to detect trends in spawning stock biomass. Aerial surveys were performed and a series of sightings occurred. Data collected can contribute to the knowledge of the species in the area, and gather with other data at the same time collected for the whole Mediterranean in the framework of the general programme.

Keywords

Bluefin tuna, Thunnus thynnus, Mediterranean, South Tyrrhenian Sea, aerial survey

1. Background and objectives

The policy of conservation of Mediterranean bluefin tuna requires improved scientific knowledge regarding biology, reproductive behaviour and the broodstock status.

The programme "Aerial survey on spawning aggregations of the Atlantic-wide research programme on bluefin tuna (GBYP - 2010)" has been undertaken to develop fishery - independent indices of abundance to detect trends of the minimum spawning stock biomass. To detect these trends, surveys have to be performed for several years.

As for the first year, different Mediterranean reproductive areas have been identified, on the base of biological and traditional knowledge, and aerial surveys have been carried out to detect spawners aggregations.

The present report describes activities and results related to the South Tyrrhenian Sea (Sub-area 2).

2. Methodology and activities

The methodology followed the methodology of the general project, with some adjustments forcedly adopted to overcome operative unforeseen constraints.

According to what foreseen by ICCAT, a representative of the personnel involved in the survey participated to an "ad hoc" training course carried out in ICCAT headquarters (Madrid, 17- 18 May 2011), during which "tuning" of the methodology was carried out and some new operative standards were adopted.

Aircraft and equipment

The aircraft 1 was a Partenavia P68V used in past years for professional activities in support of bluefin tuna fishing, in which "bubble windows", as foreseen by ICCAT, were applied. Stickers with "ICCAT2" on the left side and under the right wing were applied (Figure 1 to Figure 3).

- Brand: Partenavia
- Model: P68V
- Code: D-GNIT

Figure 1 - The aircraft 1

Figure 2 - The bubble windows

Figure 3 - The wing sticker

The aircraft has upper wings, good forward visibility and capable of flying at a spotting altitude of 300 m and a speed of 100 nm. Flying autonomy is about 5-6 hours.

Because of unforeseen and unpredictable various engine problems due to totally independent origins, we were forced to use also another aircraft alternating it more than one time with the one described above. Engine problems seem to be attributed to a very negative chance, since both the aircrafts were recently serviced, and in two different maintenance centres.

The aircraft 2 has the following features:

- Brand: Partenavia
- Model: P68 Observer
- Code: I-OBSW

Figure 4 - The aircraft 2

Figure 5 - The aircraft 2 (forward and downward visibility)

In this second aircraft, the bubble windows could not be applied because different sized bubble windows should have been ordered and the time necessary was not compatible with the surveys schedule. Nevertheless the visibility, particularly from the front seats, was extremely good even downwards, as it can be seen in Figure 4 and Figure 5.

The equipment used was the following:

- GPS Garmin Map 60CSx with the statistical survey design uploaded (the same route was sent to the pilot to be transferred in the aircraft GPS as well).
- Digital photo camera Nikon® D3000 with 1600 ISO maximum sensitivity, equipped with Sigma® 70-200 zoom lens f/2.8 OS stabilised, polarised filter (77mm gauge), and Manfrotto® monopod.
- 3 Clinometers Silva® *Sight master*

Onboard there always were a professional tuna spotter and two scientific spotters. Effort and sightings were registered on the specific forms, and GPS recording of all flights and sighting positions were saved. During a survey, the GPS recorded every 5 seconds the exact position of the plane as well as all the waypoints entered by the operator. After every landing, the information were downloaded to the computer.

The survey period was comprised between the first day after the end of the fishing season for Italian purse seines (June 15th) and the 10th of July.

Weather conditions were considered adverse when they could interfere with a reliable observation of tuna schools (winds over 3 or 4 on the Beaufort scale, clouds lower than 300 m high or heavy rain, according to the terms of reference of the contract).

Survey area

The study area was the Subarea 2, comprised between Sicily and Calabria (Table 1, Figure 6) corresponding to South Tyrrhenian Sea.

A detailed map of the study area is reported in Figure 7. The area is comprised approximately between the perpendicular of Ustica island until Calabria coasts, with an approximate area of 52,461 Square kilometres.

Table 1 - Features of the Subarea 2

area (sq km)	52,461
mean length of trackline on effort (km)	1,751
expected number of surveys	5
proportion of total area	19.4%

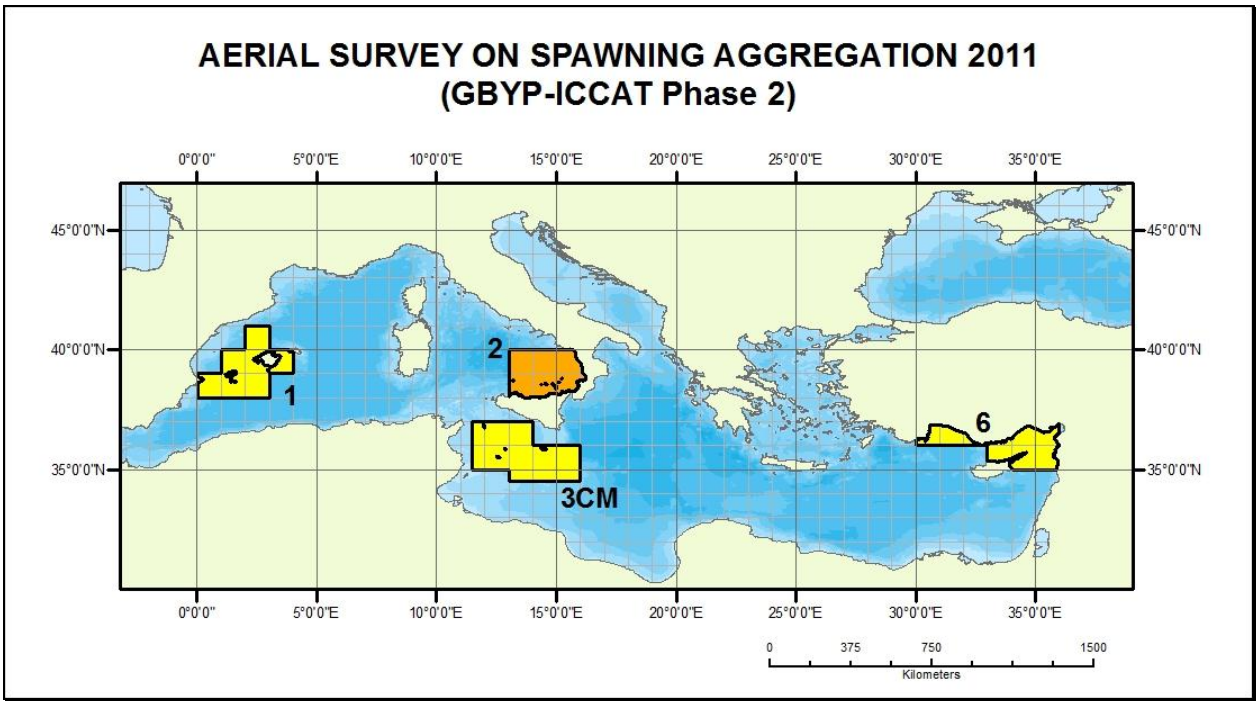

Figure 6 - Mediterranean blocks

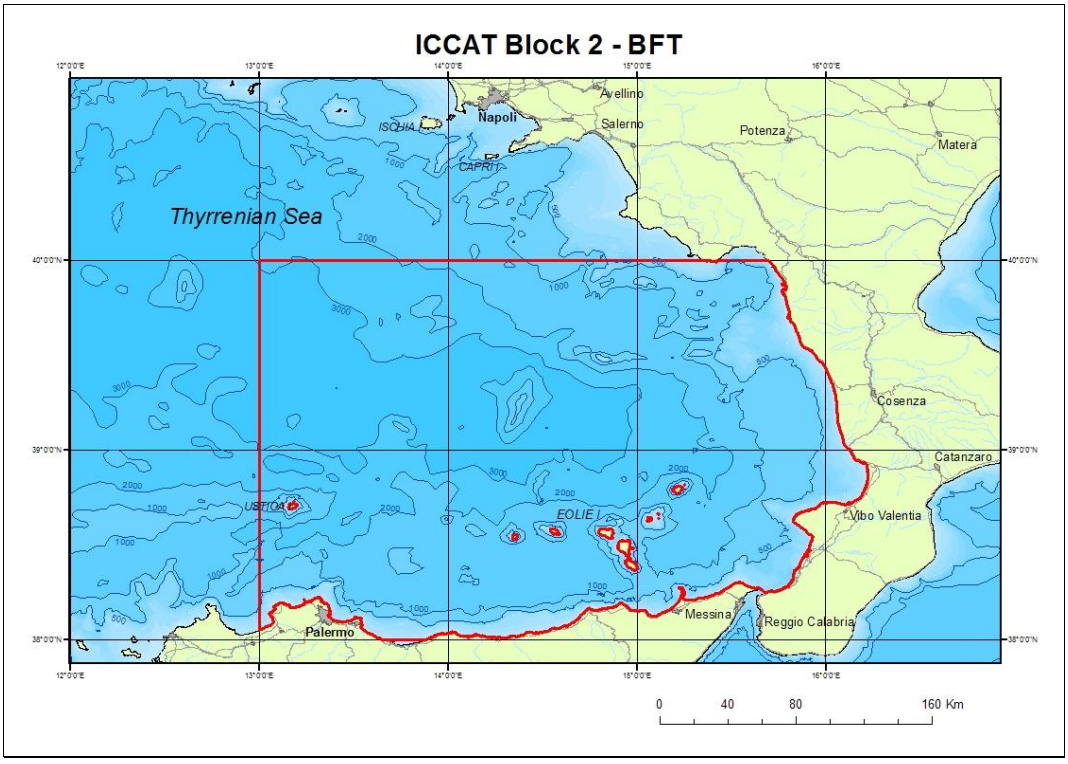

Figure 7 - Sub-area 2

For a comprehensive description of the area, we report its hydrological characterisation, as it was done in the previous year (Figure 8, from Arena, 1990).

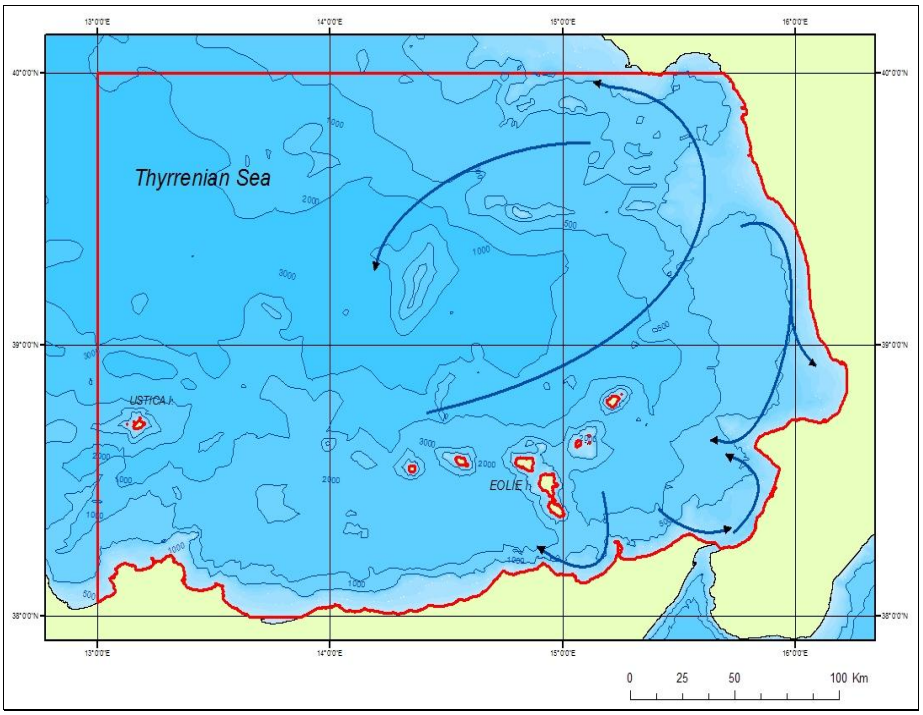

Figure 8 - Main drifts in South Tyrrhenian sea during springtime

The importance of the area for the concentration of bluefin tuna spawners is well known (Arena, P. 1978, 1982,), and constant activity of purse seine fishing has developed starting from the early Seventies (Arena, 1990). A central role was particularly played this year, since the bulk of the Italian fleet catches from purse seine were carried out in the area north of Aeolian Islands; in Figure 9, the approximate positions of catches are shown; generally, only a minor number of catches occurred south of Sicily (Unimar, 2011).

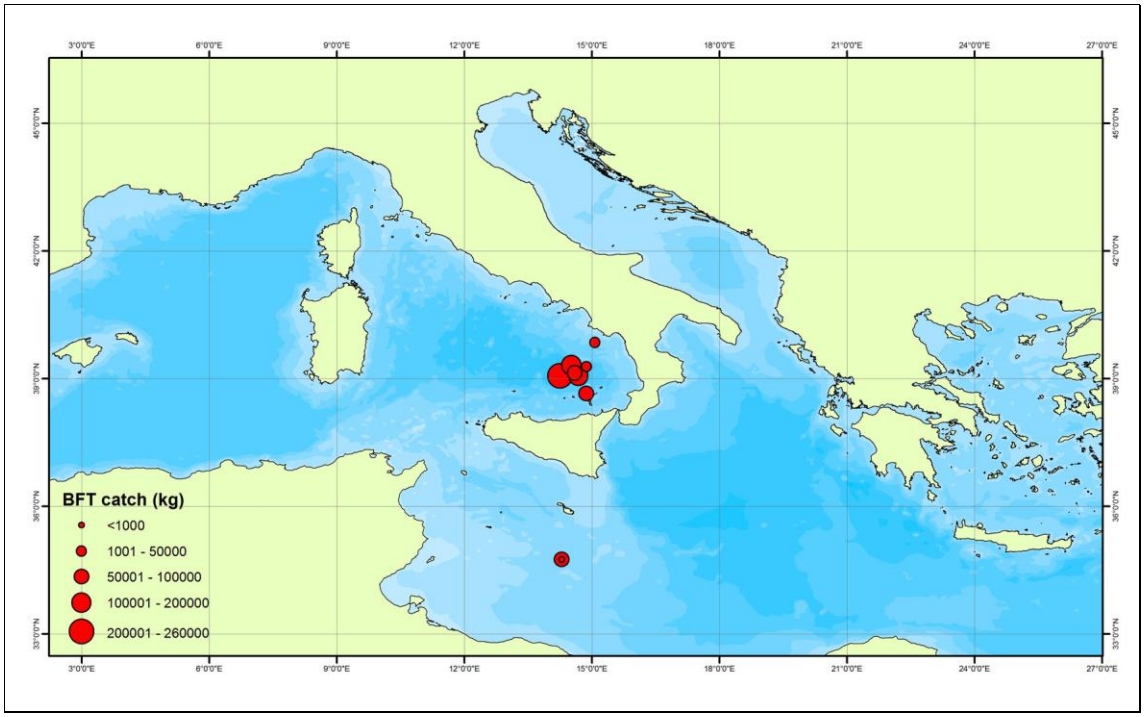

Figure 9 - Approximate position of fishing operations and catches for the Italian purse seine vessels in 2011

Survey design

Aerial surveys were designed using the "DISTANCE" program. In each block, a series of transects were created, based on the amount of flying time available and the dimensions of the area, to achieve the approximate coverage indicated. Surveys are designed as equal spaced parallel lines. Parallel line designs achieve equal coverage probability (Hammond P. et al, 2010).

Statistical design identified five possible surveys for the Sub-area 2, each one with its specific characteristics. Among this, four surveys have been chosen. Figure 10 to Figure 13 represent the transects for each survey obtained by statistical method (Table 2).

Table 2 - Features of the surveys

Data	**survey 1**	**survey 2**	**survey 3**	**survey 4**
lines generated	11	11	11	11
sampler width (km)	1	1	1	1
estimated on effort trackline length (km)	1885.047	1885.047	1885.047	1885.047
realised on effort trackline length (km)	1774.32	1750.961	1689.659	1735.521
expected sampler area coverage (sq km)	3548.64	3501.923	3379.319	3471.041
line spacing (km)	30	30	30	30
line angle (degrees)	90	90	90	90
total trackline length (km)	2081.216	2053.692	2012.649	2041.528
total cycling trackline length (km)	2420.524	2380.753	2332.155	2366.259
realised sampler area coverage (sq km)	3541.543	3498.421	3369.181	3450.215
stratum area (sq km)	52460.607	52460.607	52460.607	52460.607
proportion of stratum sampled	0.068	0.067	0.064	0.066

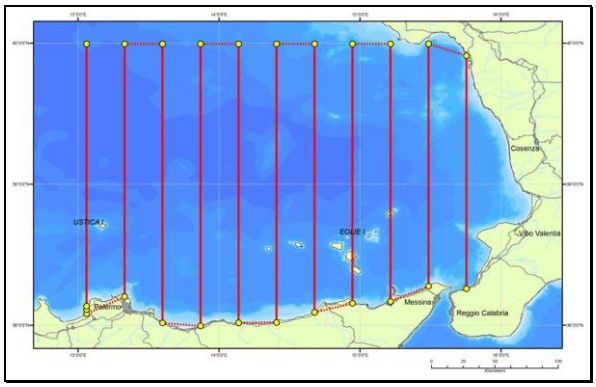

Figure 10 - Survey 1 routes

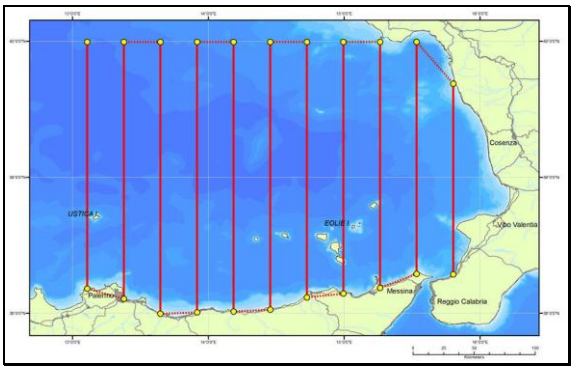

Figure 11 - Survey 2 routes

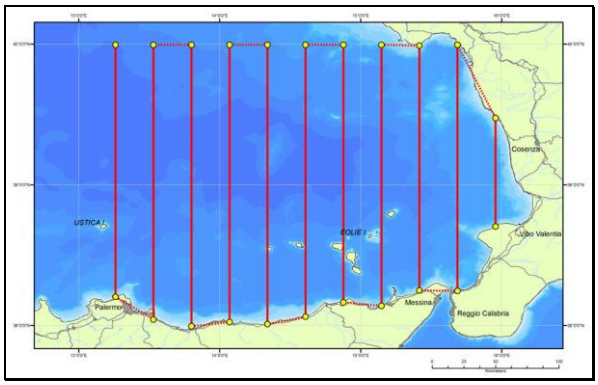

Figure 12 - Survey 3 routes

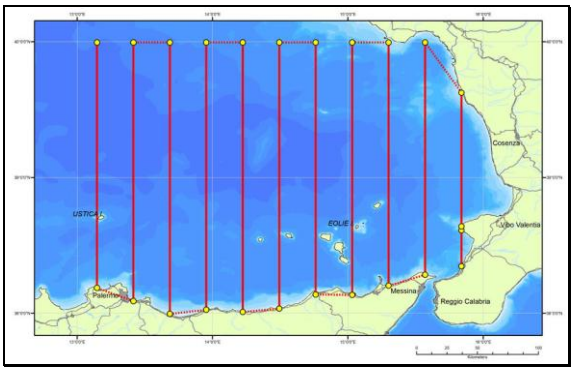

Figure 13 - Survey 4 routes

Organisation of field activities

Activities were carried out taking into account what foreseen by the ICCAT methodology and according to the behaviour of bluefin tuna in respect to the season and water temperature. This behaviour was reported in detail by Arena (Arena, P. 1979, 1982 a/b/c/d) for the South Tyrrhenian; the individuals tend to aggregate in bigger schools starting from April, with maximum aggregation when water temperature exceed 20°C and while a thermocline forms and stabilises at a depth of 15 - 30 m, inducing bluefin tuna schools to stay in the superficial layers.

Activities were organised according to the need to start after the end of the fishing season. During the 2010 survey, no fishing activities with Italian purse seine were carried out and the survey were planned only depending on the evolution of the surface temperatures, taking into account the ecological characteristics of bluefin tuna, as previously reported.

The need of avoiding any possible interference with the purse seine fishing activities forced this year to plan the survey only after the 14 of June, the last day of fishing activity.

The evolution of the surface temperatures of the South Tyrrhenian were in any case registered (Figure 14): 20°C were reached constantly approximately at the beginning of June.

Four surveys, chosen among those identified by the statistical design, have been therefore organised, starting from that date, with the deadline of July 10th, according to the meteorological conditions.

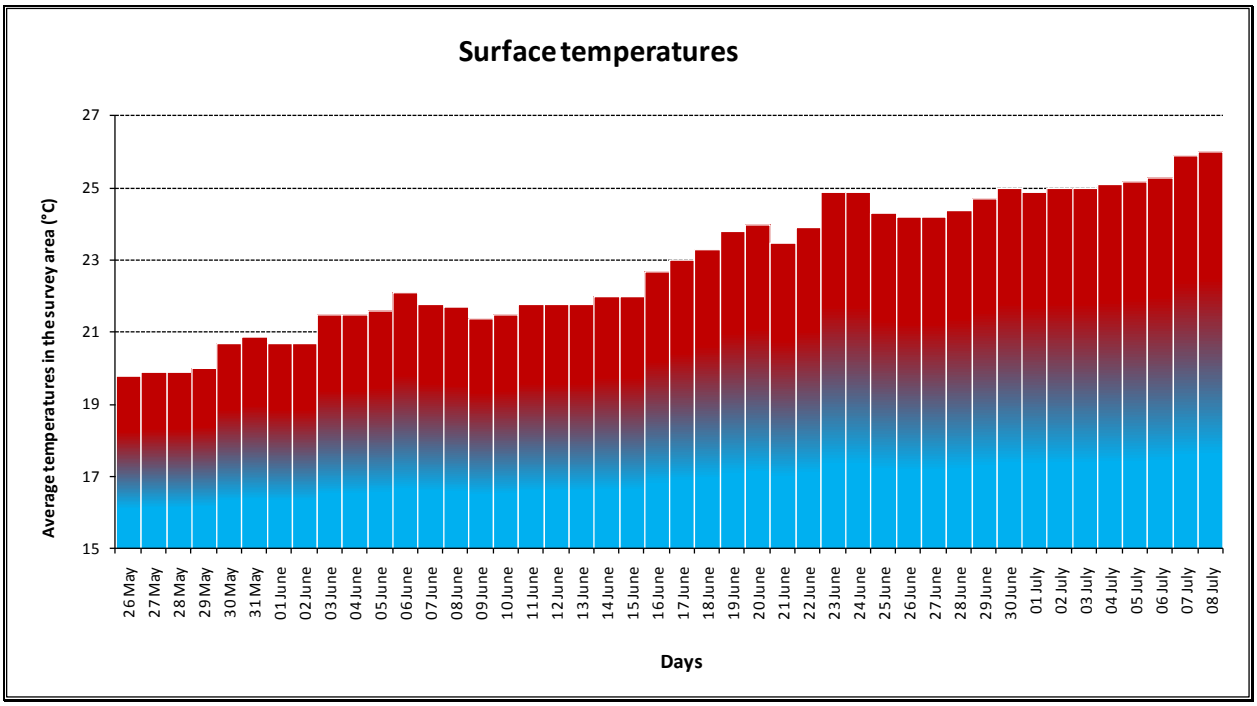

Figure 14 - Sea surface temperature
(data from National Institute of Oceanography and Experimental Geophysics http://www.ogs.trieste.it)

3. Results

The surveys started as soon as possible depending on the meteorological conditions, after the end of the purse seine fishing season, as said. The first day of stable weather, suitable for the aerial survey, was the 19th of June. The meteorological conditions are described in the local METAR and TAF bulletins already sent annexed to the Interim Report. With the stops due to mechanical problems of the aircraft or bad weather, surveys continued until the 8th of July. Four surveys were performed, according to the terms of reference of the project (Table 3). Operative base was "Salerno - Costa d'Amalfi" airport, south of Salerno. Reggio Calabria airport was also been used as intermediate landing base for refuelling.

Table 3 - Time series of the surveys

Date	Mission start	Mission end	Tot. time on effort	Tot. time on transfer	Tot. time on flight	Survey	Tracks	Scient. spotters	Prof. spotter	Aircraft	Notes
19.6	11:10	14:45	1:58	1:37	3:35	1	11, 10	Serra, Mariani	Consiglio	I-OBSW	Delay due to engine problems (D-GNIT)
20.6	8:55	10:43	0:50	0:58	1:48	1	9	Serra, Mariani	Consiglio	I-OBSW	Break for refuelling at Reggio Calabria
20.6	11:46	16:45	3:38	1:21	4:59	1	9, 8	Serra, Mariani	Consiglio	I-OBSW	
21.6	8:43	12:25	2:25	1:17	3:42	1	5, 4	Serra, Mariani	Consiglio	D-GNIT	
21.6	14:00	17:55	2:19	1:36	3:55	1	3, 2	Serra, Mariani	Consiglio	D-GNIT	
22.6	9:15	13:19	2:17	1:47	4:04	1, 2	1, 1	Serra, Valastro	Consiglio	D-GNIT	
22.6	14:07	17:05	1:47	1:11	2:58	2	11, 10	Serra, Valastro	Consiglio	D-GNIT	
23.6	8:49	12:52	2:25	1:38	4:03	2	2, 3	Serra, Valastro	Consiglio	D-GNIT	
23.6	15:04	18:05	2:10	0:51	3:01	2	9, 8	Serra, Valastro	Consiglio	I-OBSW	
24.6	8:37	11:56	2:15	1:04	3:19	2	4, 5	Serra, Valastro	Consiglio	I-OBSW	
24.6	13:01	16:01	2:08	0:52	3:00	2	6, 7	Serra, Valastro	Consiglio	I-OBSW	
27.6	-	-	-	-	-	-	-	Valastro	-	-	Weather standby
27.6	16:04	18:55	1:24	1:27	2:51	3	11, 10	Serra, Valastro	Consiglio	D-GNIT	
28.6	8:04	11:47	2:12	1:31	3:43	3	9, 8	Serra, Valastro	Consiglio	D-GNIT	
28.6	13:05	16:50	2:19	1:26	3:45	3	1, 2	Serra, Valastro	Consiglio	D-GNIT	
29.6	8:39	12:18	2:27	1:12	3:39	3	3, 4	Serra, Valastro	Consiglio	D-GNIT	
29.6	13:08	14:24	0:08	1:08	1:16	3	5	Serra, Valastro	Consiglio	D-GNIT	Landing due to engine problems
4.7	8:52	9:01	0:00	0:09	0:09	3	5	Serra, Valastro	Consiglio	I-OBSW	Landing due to engine problems
5.7	-	-	-	-	-	-	-	Serra, Valastro	Consiglio	-	Weather standby
5.7	15:01	18:16	2:10	1:05	3:15	3	5, 4	Serra, Valastro	Consiglio	I-OBSW	
6.7	8:35	12:24	2:15	1:34	3:49	4	1, 2	Serra, Valastro	Consiglio	I-OBSW	
6.7	13:37	16:24	2:05	0:42	2:47	3, 4	7, 7	Serra, Valastro	Consiglio	I-OBSW	
7.7	8:41	12:15	2:20	1:14	3:34	4	3, 4	Serra, Valastro	Consiglio	I-OBSW	
7.7	14:04	17:16	2:20	0:52	3:12	4	5, 6	Mariani, Valastro	Consiglio	I-OBSW	
8.7	9:05	12:03	2:07	0:51	2:58	4	8, 9	Mariani, Valastro	Consiglio	I-OBSW	
8.7	12:58	15:57	1:45	1:14	2:59	4	10, 11	Mariani, Valastro	Consiglio	I-OBSW	

Flights were generally performed at the altitude and speed requested (300 m, 100 nm/h); any difference were registered as well.

For all the performed flights, the tracks get by the GPS were registered and checked with aircraft GPS as well (the files of the tracks including the waypoints relevant to the sightings are sent as Annex). The forms about effort and sightings were filled (they can be find in the Annexes). Whereas taken, the pictures were identified according to the frame numbers. In some cases, during the first round on the school necessary to estimate its weight and size, the tunas went deep probably because of the aircraft presence and therefore the tunas don't appear in the pictures. A complete copy of the photos taken during the surveys can be find in the Annexes.

The maps with the tracks of each aerial survey are shown in the following 4 Figures.

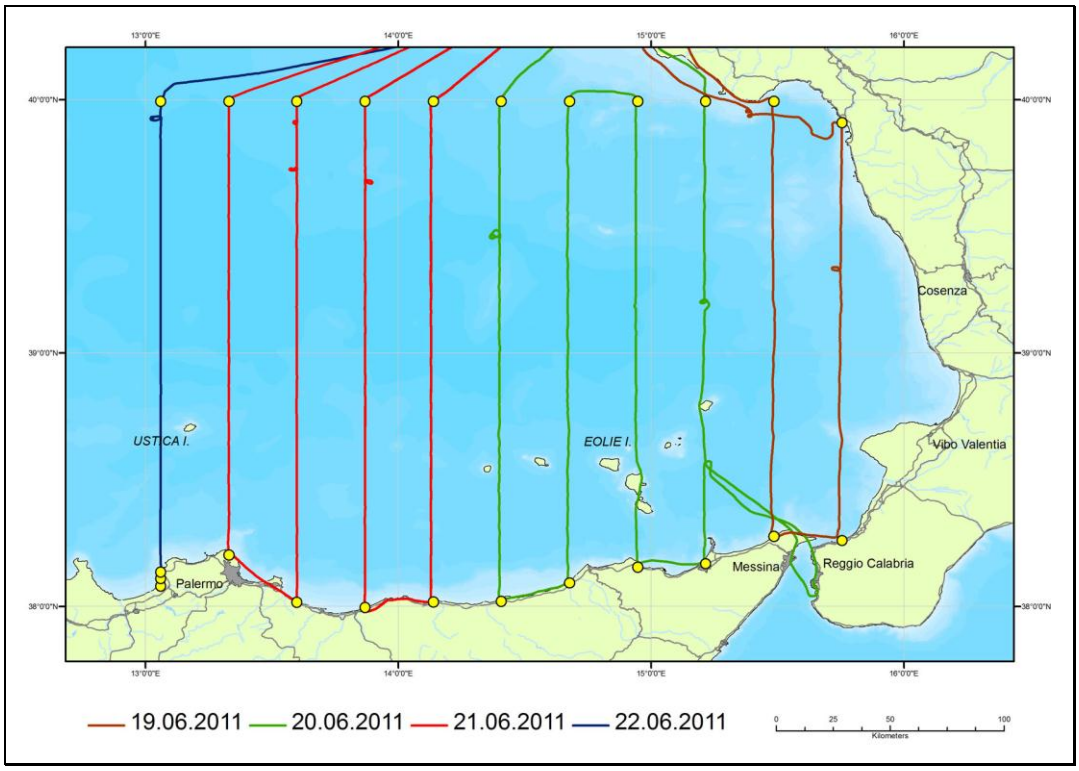

Figure 15 - Survey 1 tracks

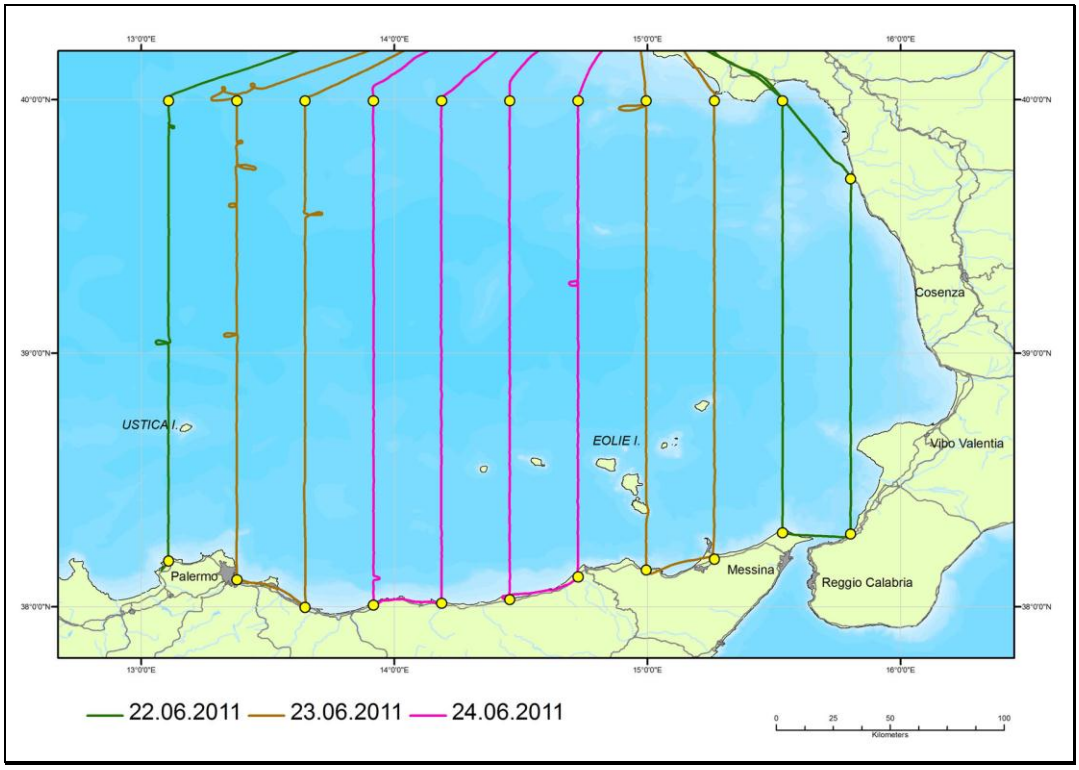

Figure 16 - Survey 2 tracks

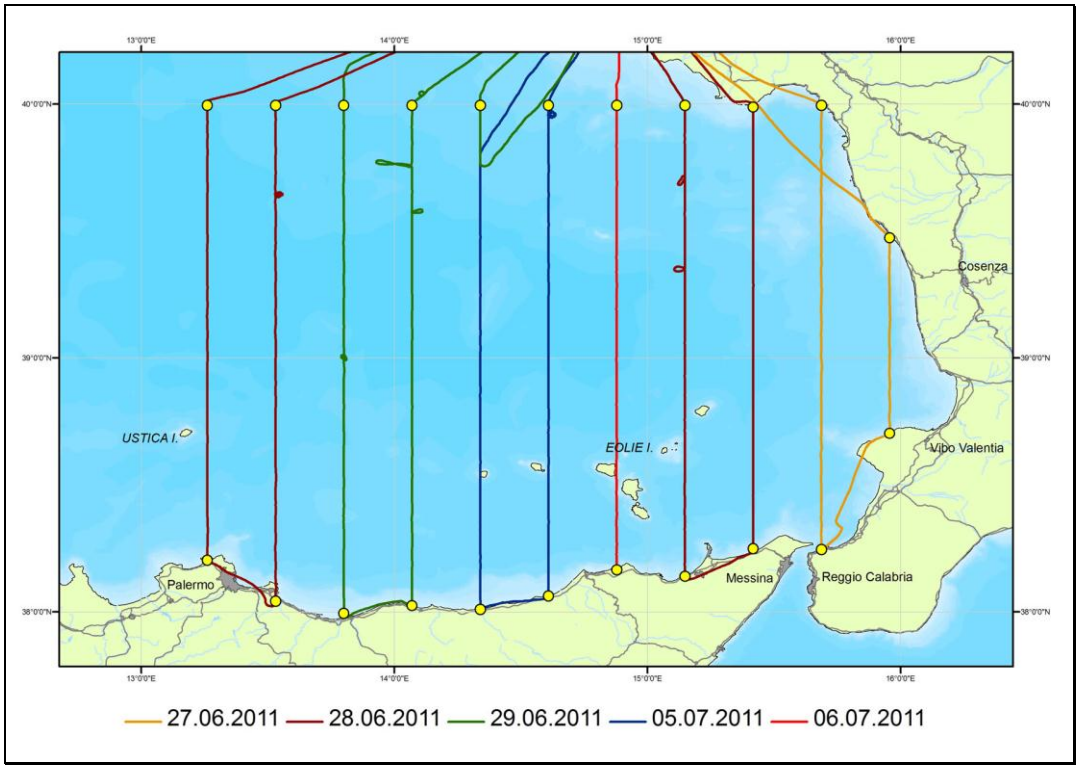

Figure 17 - Survey 3 tracks

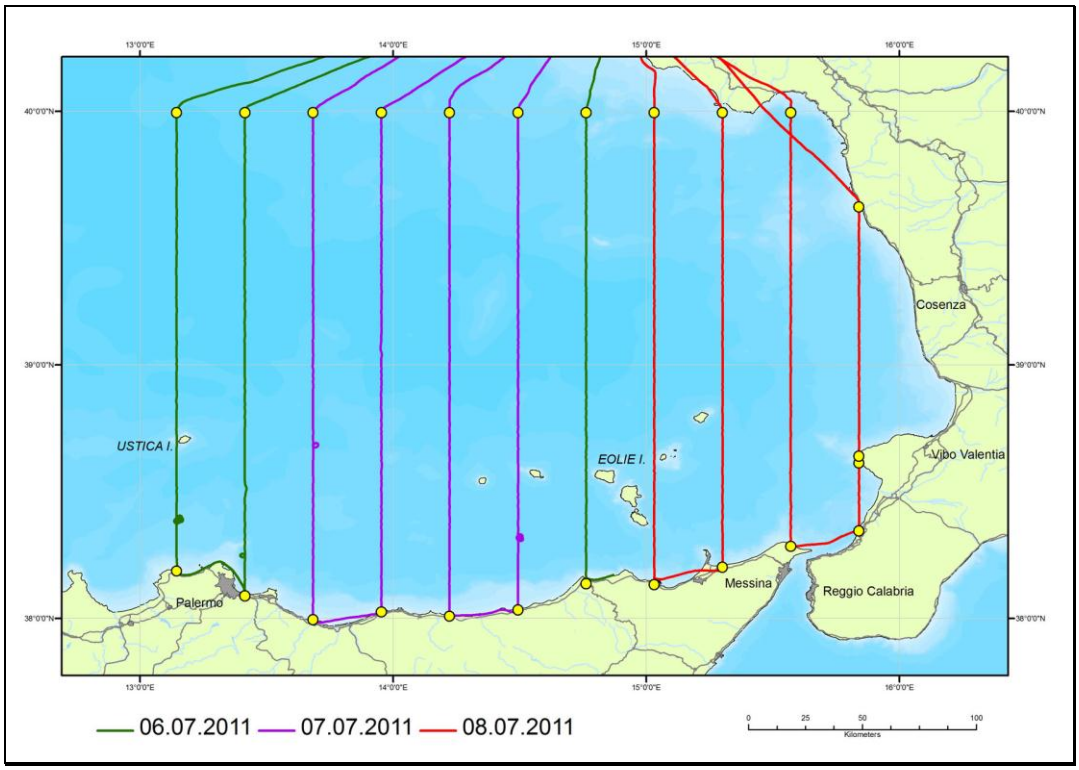

Figure 18 - Survey 4 tracks

The maps with the sightings of bluefin tuna are shown in the following 4 Figures.

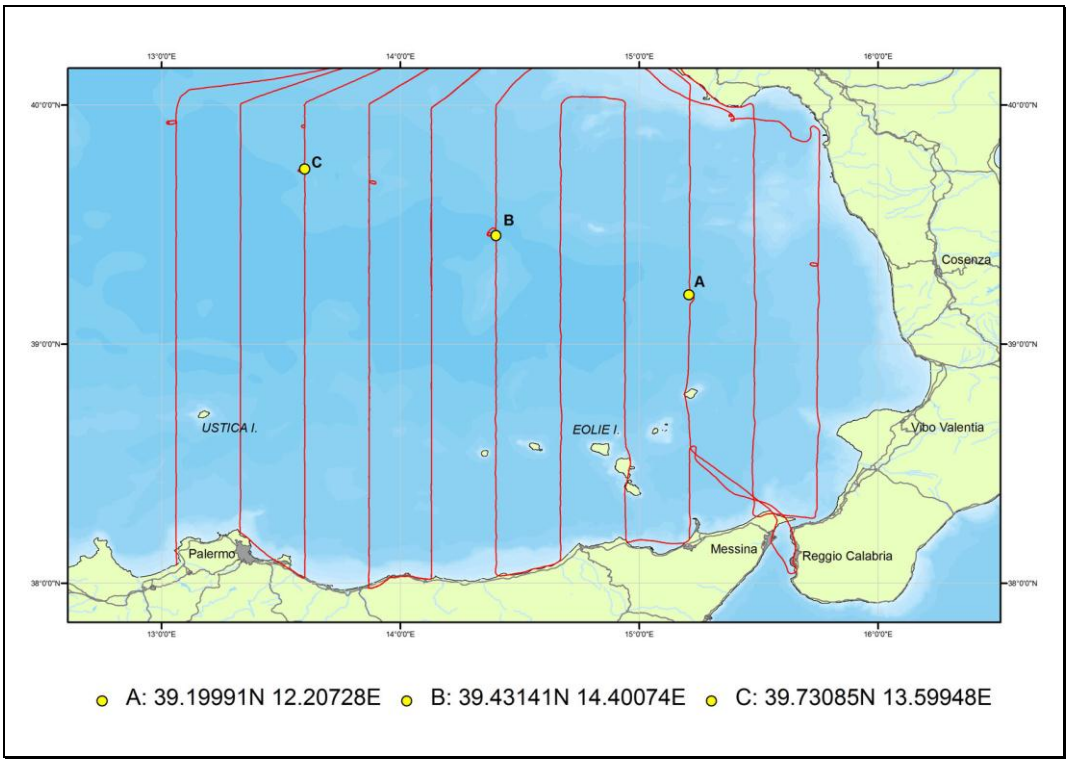

Figure 19 - Survey 1 sightings

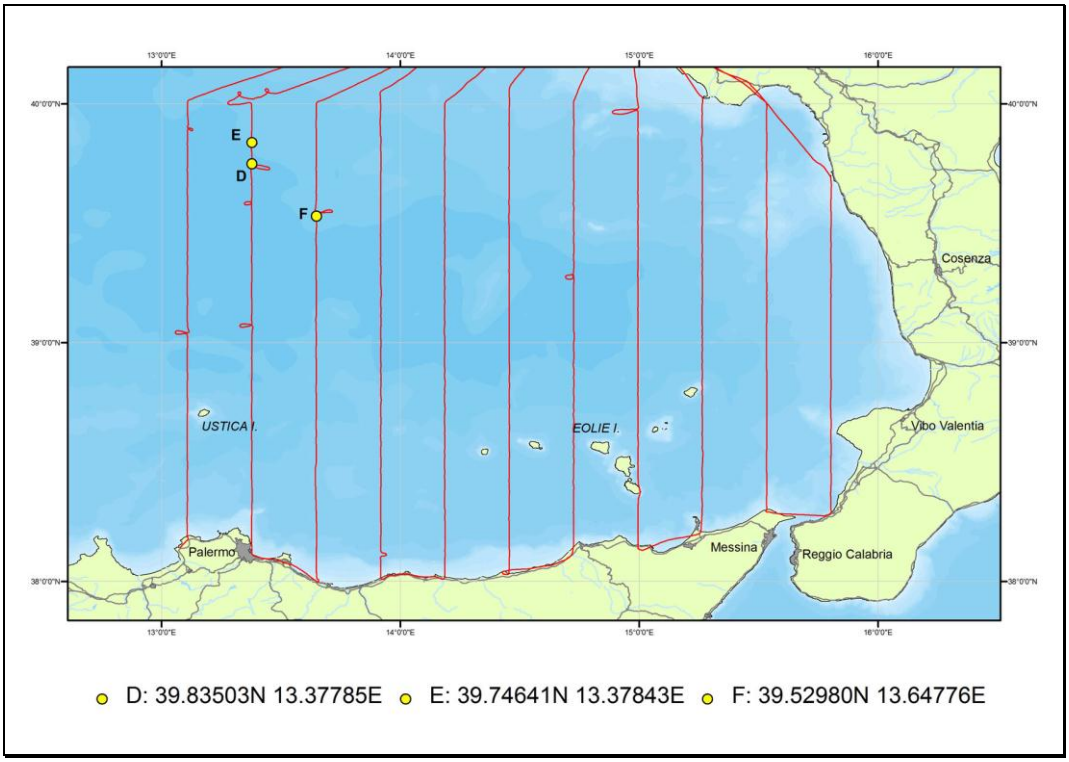

Figure 20 - Survey 2 sightings

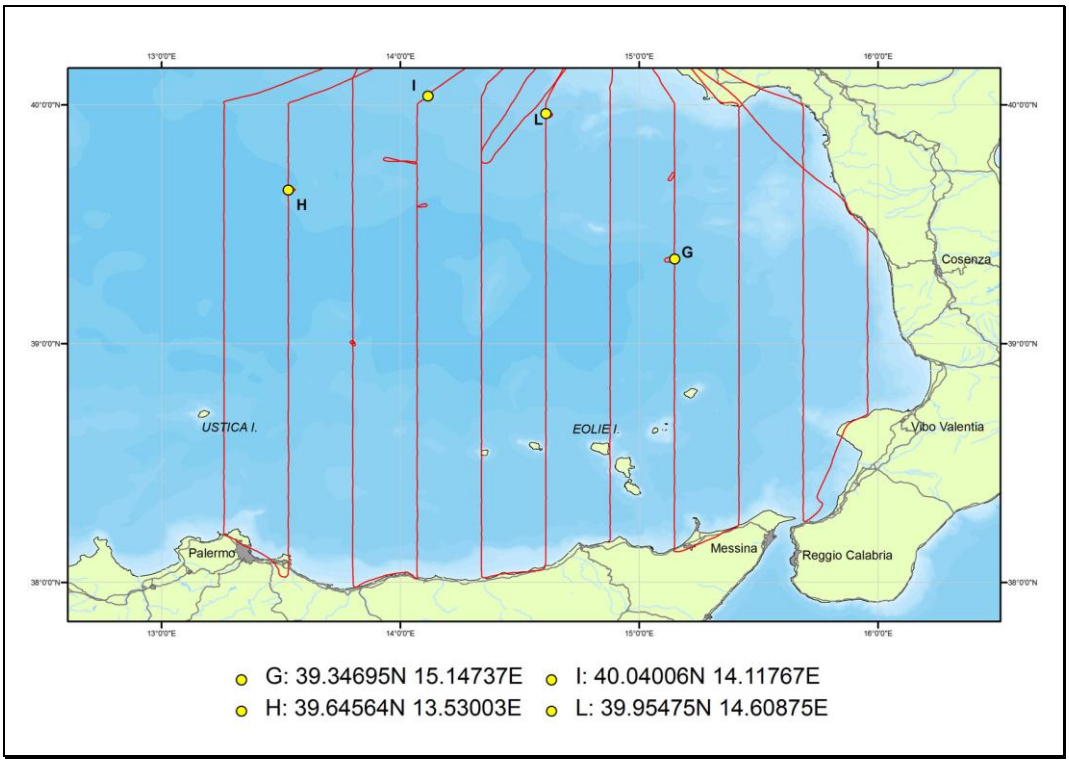

Figure 21 - Survey 3 sightings

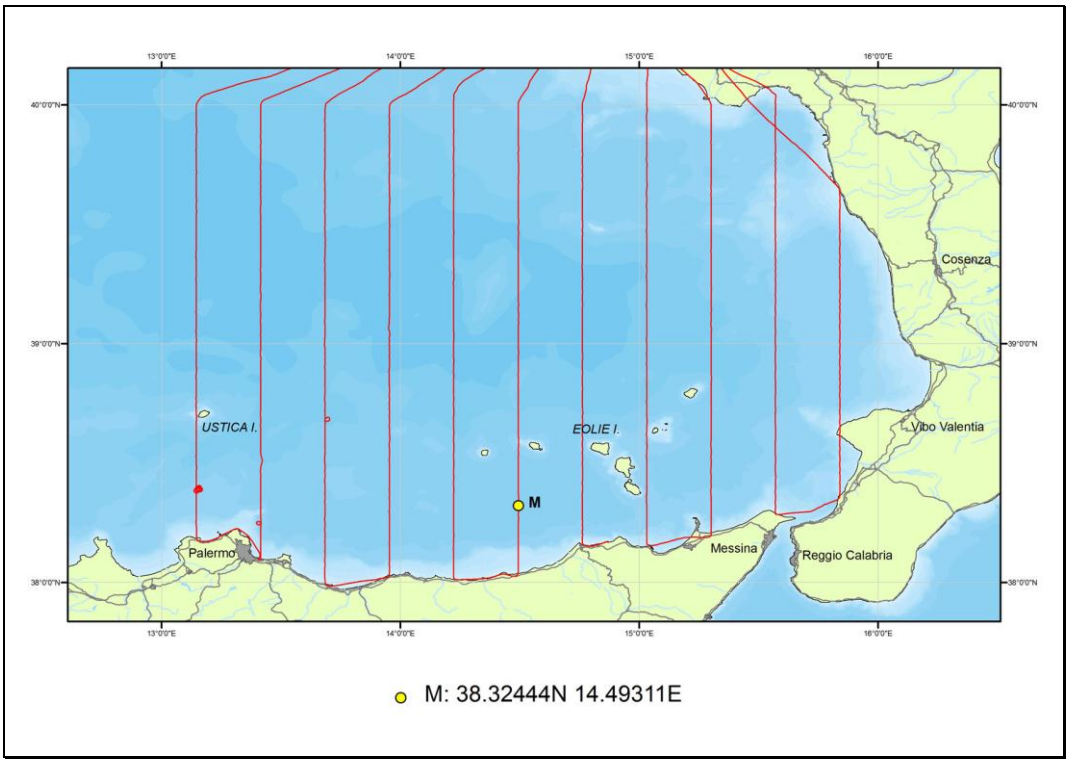

Figure 22 - Survey 4 sightings

The following 3 maps show the distribution of the sightings and the related values in terms of number of individual and weight.

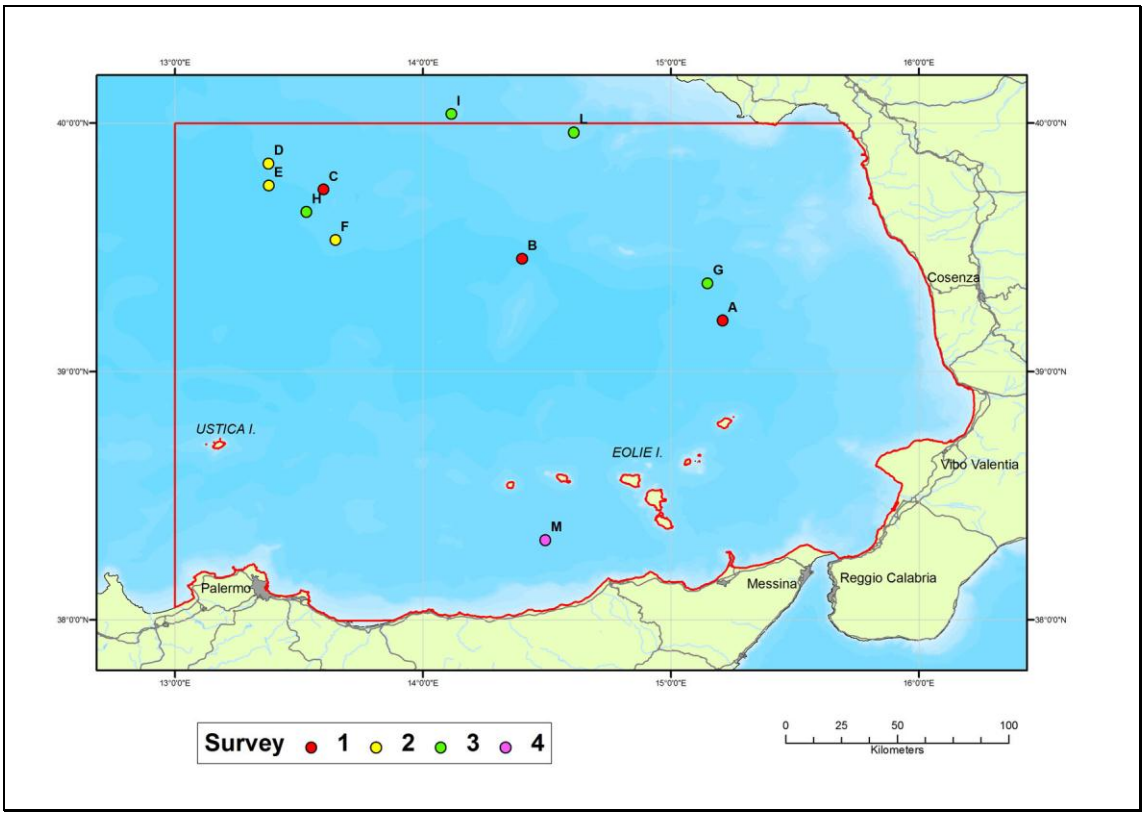

Figure 23 - Representation of the sightings positions

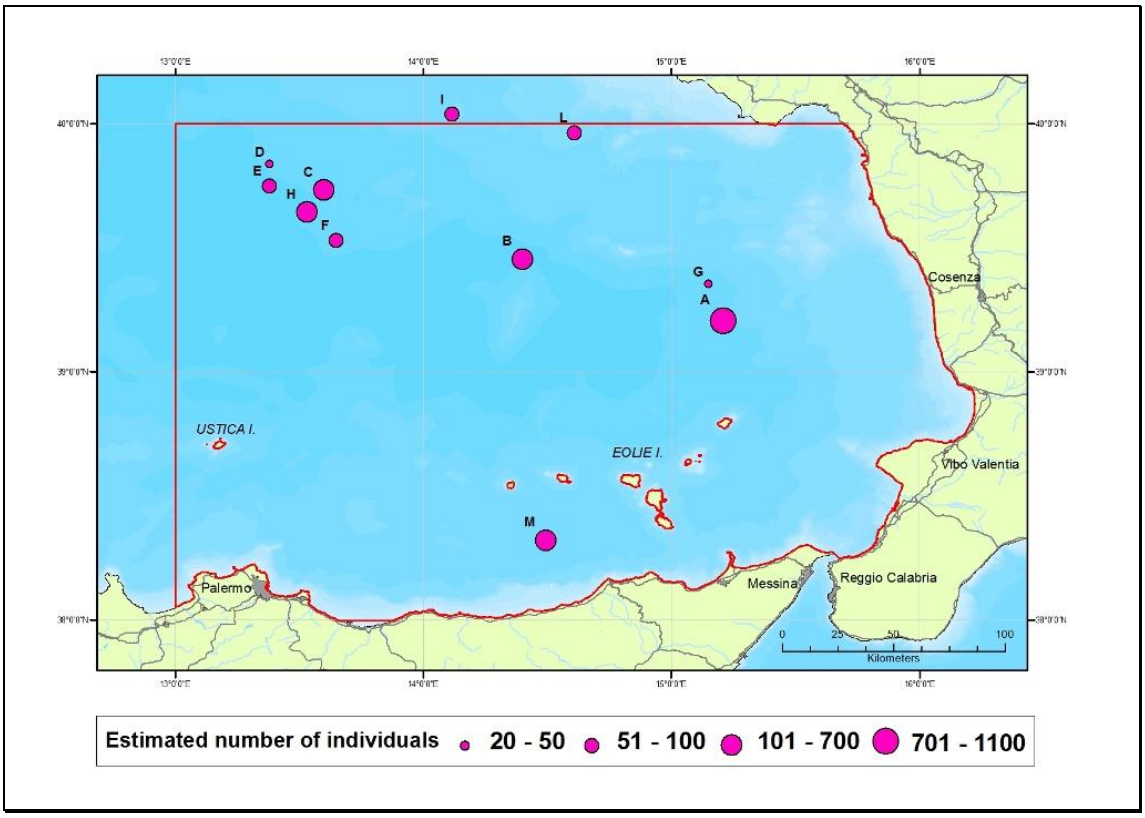

Figure 24 - Positions of the sightings with the estimated number of individuals

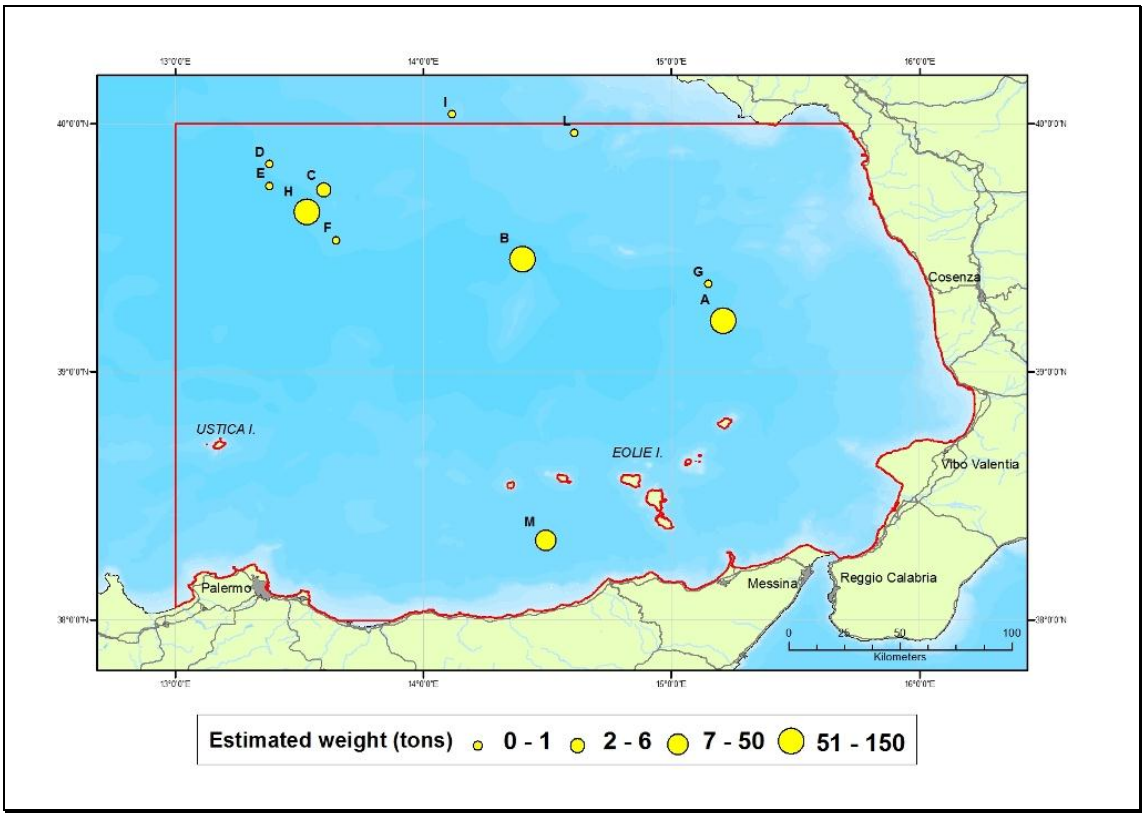

Figure 25 - Positions of the sightings with the estimated total weight of the schools

The data about the sightings of bluefin tunas are reported in Table 4.

Table 4 - Overview of the BFT sightings

ID	Survey	Transect	Date	Time	Lat	Lon	Cue	School size	Individ. Number	Estimated weight (t)	Declination angle	% small	% medium	% large	% giant
A	1	9	20/06/2011	9:50	39.19991	15.20728	ripples	LARGE	1100	150	19		40	60	
B	1	6	20/06/2011	15:58	39.43141	14.40074	ripples	LARGE	600	120	7			100	
C	1	3	21/06/2011	14:53	39.73077	13.59881	ripples	SMALL	400	6	8	100			
D	2	2	23/06/2011	9:48	39.83503	13.37785	ripples	SMALL	50	0.3	9	100			
E	2	2	23/06/2011	9:53	39.74641	13.37843	ripples	SMALL	70	0.2	10	100			
F	2	3	23/06/2011	11:58	39.52980	13.64776	ripples	SMALL	70	0.2	4	100			
G	3	8	28/06/2011	10:57	39.34695	15.14737	splash	SMALL	20	0.1	8	100			
H	3	2	28/06/2011	15:57	39.64564	13.53003	ripples	LARGE	700	100	90		100		
I	3	off effort	29/06/2011	11:51	40.04006	14.11767	splash	SMALL	100	0.4	30	100			
L	3	6	05/07/2011	17:52	39.95475	14.60875	splash	SMALL	100	0.4	12	100			
M	4	6	07/07/2011	15:53	38.32444	14.49311	splash	MEDIUM	400	50	43		50	50	

Regarding the sighting "A", being the school barely visible, we were forced to go immediately on the fish because of the high risk to lose them. In this case we had not the time to take the declination angle, and then it was calculated.

The percentage values are calculated on the number of individuals.

The exact positions of the tuna schools spotted are shown in the following Table.

Table 5 - Positions of the schools

ID	Date	Time	Lat	Lon
A	20/06/2011	9:50	39.20197	15.19995
B	20/06/2011	15:58	39.46011	14.37347
C	21/06/2011	14:53	39.72561	13.57526
D	23/06/2011	9:48	39.83287	13.39151
E	23/06/2011	9:53	39.72944	13.44352
F	23/06/2011	11:58	39.55043	13.70879
G	28/06/2011	10:57	39.35094	15.11751
H	28/06/2011	15:57	39.64577	13.53701
I	29/06/2011	11:51	40.04246	14.10710
L	05/07/2011	17:52	39.96014	14.62365
M	07/07/2011	15:53	38.32050	14.49649

4. Discussion

As concerning the results, qualitative remarks are here reported as a support for the statistical analysis to be implemented for the whole macro - area.

The importance of this area for the constant presence of spawners aggregations has been confirmed. During the 2011 fishing season, in particular, the bulk of the catches of the Italian purse - seiners came from this area and only a minor proportion from the area is south of Sicily. One sighting was between Aeolian islands and Sicily, fact that seems not to have happened since many years, according to what reported by the professional spotter.

Not many sightings occurred, particularly of schools with big specimens; only in four ones, large or medium individuals were present. Other sightings were mostly composed of small schools and small individuals, and the tunas were extremely reactive to the presence of the aircraft, rapidly moving deep.

Other sightings of small schools of other pelagic fishes (Atlantic bonitos, Little tunnies) in feeding attitude were also observed.

It is well known that many factors can influence the presence of the spawners near to the surface. Among them, biological and ecological factors such as the temperature of the superficial layers, the presence of a stabilized thermocline at a depth of 15 - 30 m and of course the degree of maturity, are the main ones.

Quite important are apparently becoming other factors, in different ways “fishery dependent” ones at least according to what reported by fishermen, such as the tendency of fishes to stay for a shorter period near to the surface to be less accessible to fishing, and also a supposed “sensitivity” to the sound of the sonar devices, also witnessed by different articulated fishing strategies of the purse - seiners adopted according with these behavioural changes.

Whichever are the causes, not many schools have been observed. The most evident peculiarity of the 2011 survey seems to be related to the period, forcedly delayed respect to the central spawning season. Excluding the first two sightings -a typical spawners aggregation both in term of composition and behaviour of the school-, the other ones appeared more to be in feeding activity, particularly the last one -with the school staying at the sub-surface, a few individuals going up to the surface and many birds around in the meanwhile-. It could seem therefore that the survey period would be actually late with respect at least to the bulk of the reproductive season.

The new methodology was applied, and some possible modifications could be proposed for a better tuning of the activities, if appropriate.

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List of the tables

List of the figures

Annexes

- Forms
- GPS tracks
- Photos