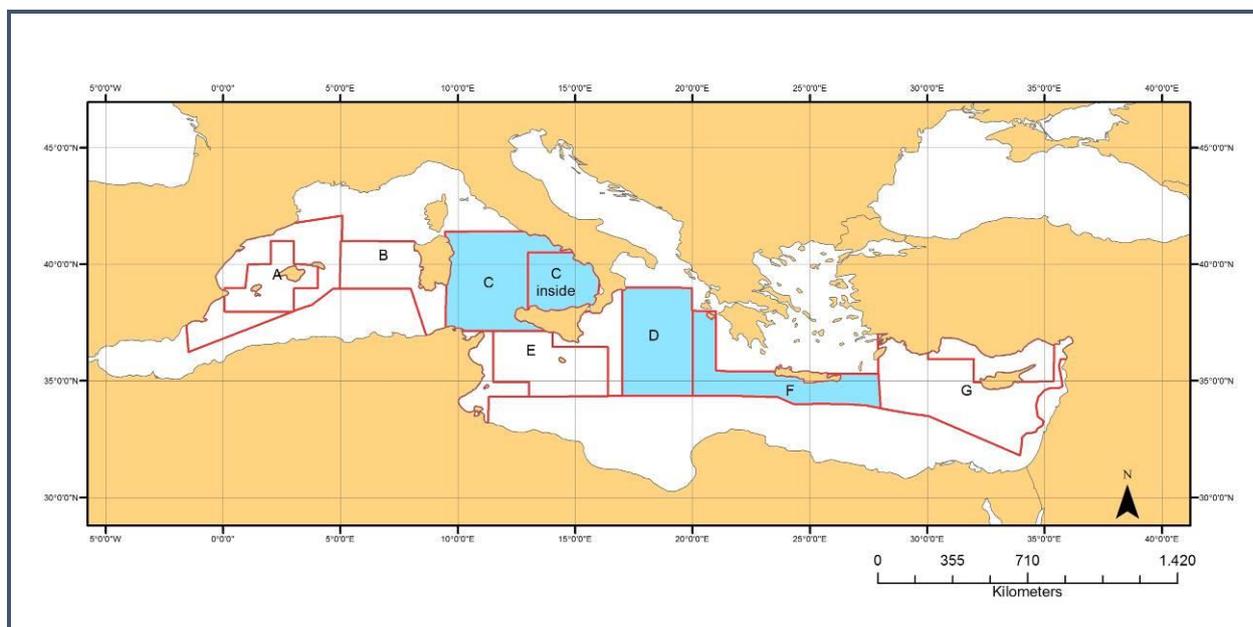




**AERIAL SURVEY ON SPAWNERS AGGREGATIONS
OF THE ATLANTIC-WIDE RESEARCH PROGRAMME ON BLUEFIN TUNA
(ICCAT-GBYP 03/2015)
SUB-AREAS C, D and F**



Final Report

27 July 2015



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Index

Summary.....	4
1. BACKGROUND AND OBJECTIVES.....	5
2. MEANS AND METHODS.....	5
2.1 Aircrafts and equipment.....	5
2.2 The Survey design and the Survey areas.....	8
3. RESULTS.....	13
3.1 Preparatory tasks.....	13
3.2 Field activities.....	14
3.3 Sightings overview.....	27
3.4 Methodological remarks.....	34
4. DISCUSSION.....	35
5. REFERENCES.....	36
6. ANNEXES.....	38



Summary

Within the ICCAT GBYP program, 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. After the 2010 and 2011 surveys, which were carried out in four Mediterranean spawning areas, in 2013 the survey was extended to the whole Mediterranean Sea. The same choice was adopted for 2015 survey, which this report is about. In particular, Unimar 2015 survey was carried out in the sub-areas C, D and F, which include respectively the Tyrrhenian Sea, the Ionian Sea and the Crete-Libyan Sea. While some bluefin tuna schools were spotted in the sub-area C (Tyrrhenian Sea), no significant sightings took place in other two sub-areas.

Keywords

Abundance, Geographical distribution, Migrations, Spawning grounds, Tuna fisheries, Statistical sampling, Bluefin tuna, Thunnus thynnus, Mediterranean, Aerial survey



1. BACKGROUND AND OBJECTIVES

The improvement of the knowledge of the Atlantic bluefin tuna key biological and ecological processes is essential for developing management policy which can provide long term sustainable exploitation of this resource.

The comprehensive ICCAT Atlantic Wide Research Programme on Bluefin Tuna (GBYP) was initiated with the aim to improve basic data collection, the understanding of key biological and ecological processes, assessment models and management. Among the other activities, aerial surveys were planned to be performed for several years.

In 2010 and 2011, aerial surveys on spawning aggregations were carried on 4 areas in the Mediterranean Sea, which were, identified as spawning areas on the base of biological and traditional knowledge, as well as recent fishery data. In 2013, following the GBYP Steering committee recommendation, the area of the survey was extended to the whole Mediterranean basin and therefore more sub-areas than in the previous years were identified.

The present report describes the activities and the results related to the 2015 Unimar survey, covering the sub-areas C, D and F (comprising the Tyrrhenian sea, Ionian sea and Crete-Lybian area).

2. MEANS AND METHODS

The activities were carried out following the terms of reference of the ICCAT Call for Tenders and the Technical specifications annexed to the contract. The spawning behaviour of Bluefin tuna 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 late 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.

Most of the personnel involved in the survey participated to the training course held in the ICCAT headquarters (Madrid, 26th May 2015), during which the details of the methodology and operative standards were explained and previous field experiences were shared.

2.1 Aircrafts and equipment

In order to conduct the survey in all three sub-areas within the available time frame, as in the 2013, two aircrafts were involved, both with upper wings, good forward visibility, bubble windows on both sides and capable of flying at a spotting altitude of 300 m and a speed of 100 nm, as foreseen by ICCAT GBYP. The aircrafts type was "Partenavia P68", the same as the one used in the 2013 campaign.

In detail, one model was a Partenavia P68 V (I-GNIT registration number), planned to work in the sub-area C. Stickers with "ICCAT 3" on the right side and under the left wing of the aircraft

were attached. It had about 4-5 hours flight range. The aircraft is shown in Figure 1 and Figure 2.

- Brand: Partenavia
- Model: P68 V
- Code: I-GNIT



Figure 1 - The I-GNIT aircraft and team



Figure 2 - I-GNIT aircraft, a bubble window

The second aircraft model was a Partenavia P68 C-TC (I-AGSD registration number) planned to be used in sub-areas D and F. Stickers with “ICCAT 4” on the right side and under the left wing of the aircraft were attached. It has about 5-6 hours flight range. Because of its long range tanks, it was chosen to operate in sub-areas with the longer transects and flights. The aircraft is shown in Figure 3 and Figure 4.

- Brand: Partenavia
- Model: P68 C-TC
- Code: I-AGSD



Figure 3 - The I-AGSD aircraft and team



Figure 4 - The I-AGSD aircraft, a bubble window



The equipment used by the spotters was the following:

- 2 GPS: *Garmin*[®] Map 60CSx and 62st, with the statistical survey design uploaded (the same route files were provided to the pilot);
- 2 GPS external antennas which were applied on a top window in order to enhance the satellite signal reception
- 2 Digital *Nikon*[®] photo camera: D3200 with 6400 ISO maximum sensitivity, equipped with *Sigma*[®] 70-200 zoom lens f/2.8 OS and 62st, polarised filter (77mm gauge); D3000 with 1600 ISO maximum sensitivity, equipped with *Nikkor*[®] 55-200 zoom lens f/5.6 VR, polarised filter (52mm gauge).
- *Silva Sight Master*[®] clinometers

Onboard each aircraft there were always a pilot (who was also a professional spotter), a professional tuna spotter and two scientific spotters. Effort and sightings were recorded on the specific forms and the GPS recording of all the flights and sighting positions were saved. During the flights, the GPS recorded (with a 3 seconds frequency) the exact position of the aircraft as well as all the waypoints entered by the spotters in order to mark the significant events to be transcribed to the forms. After every landing, the information was saved into the laptop and sent to the central office as soon as possible.

The survey period was comprised between June 1st and 30th, 2015.

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

Esri ArcMap[®] GIS software was used for data mapping. Garmin BaseCamp[®] and Garmin MapSource[®] were used for track designing, analysis, saving and editing,

2.2 The Survey design and the Survey areas

Aerial surveys were designed using the "DISTANCE" program and were provided by ICCAT GBYP. In each block, a series of transects were created, based on the dimensions of the area, in a manner to achieve the approximate statistical coverage. Surveys were designed as equal spaced parallel lines since it provides equal coverage probability (Hammond P. et al, 2010).

According to the statistical design, each one of the sub-areas C, D and F had its specific characteristics.

A general map of the study areas is provided in

Figure 5. The sub-areas are represented in Figure 6 to Figure 9 and are described as follows.

Sub-area C: the Central Mediterranean area approximately located between Sardinia and the Western Italian coast, with Sicily and Tunisia in the South. As in the 2013 survey, the sub-area C was divided in a wider area called "C outside" and a smaller area named "C inside", the



second one similar to the area surveyed in the past campaigns and located in the southern Tyrrhenian Sea. The importance of the sub-area "C inside" for the Bluefin tuna spawners is well known (Arena, P. 1978, 1982): for this reason, constant activity of purse seine fishing has been carried out there since the early Seventies (Arena, 1990).

Table 1 - Features of Sub-area C "inside"

Total area (km ²)	64,610
On effort track (km)	1,735

Table 2 - Features of Sub-area C "outside"

Total area (km ²)	149,607
On effort track (km)	2,038

Area D: the Ionian Sea from Calabria to Greece and down to the Tripoli FIR border.

Table 3 - Features of Sub-area D

Total area (km ²)	147,666
On effort track (km)	2,307

Area F: a strip from the Ionian Sea to the East until the perpendicular under Rhodes island, down to the Libyan and Egyptian FIR border, up to Crete and Zakynthos islands.

Table 4 - Features of Sub-area F

Total area (km ²)	130,585
On effort track (km)	1,824

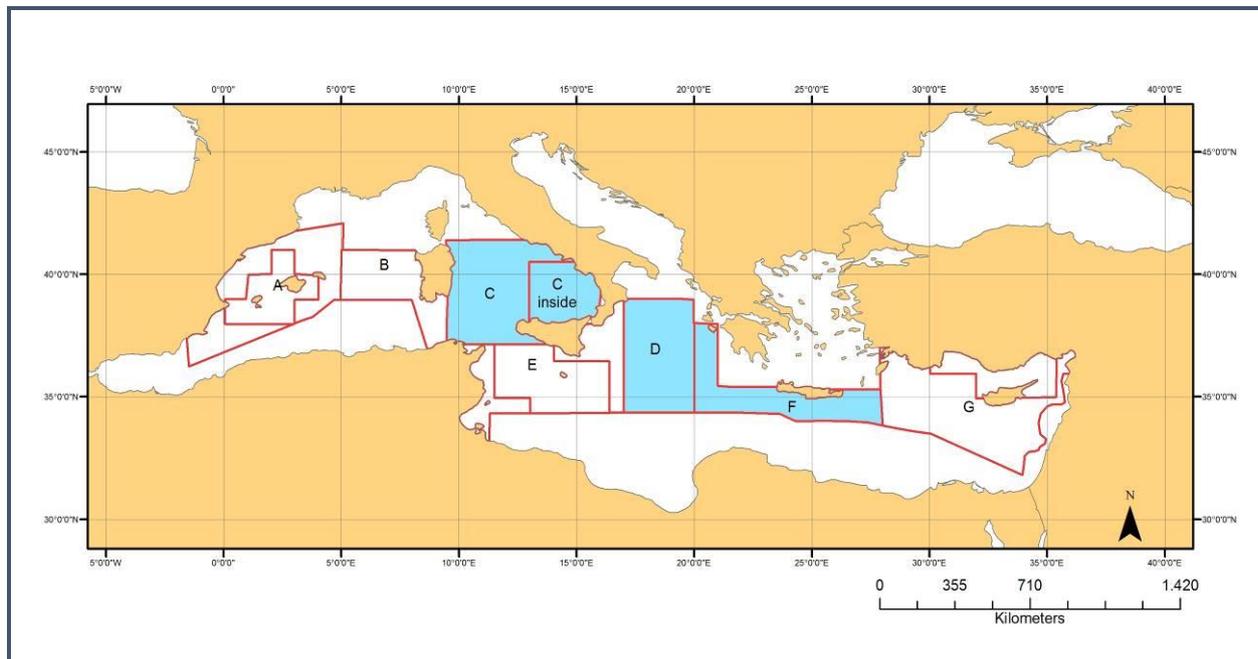


Figure 5 - Aerial Survey 2015: UNIMAR Survey area (blue colored)

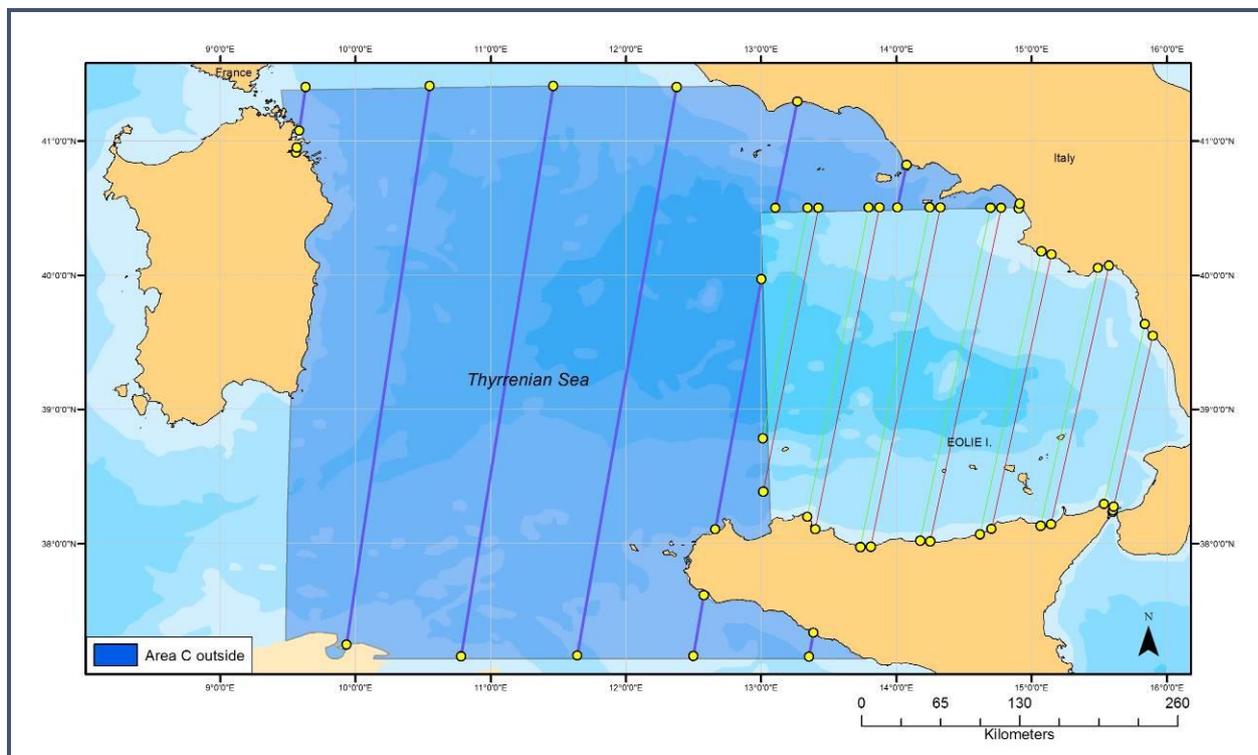


Figure 6 - Area and sampler routes: Sub-area C "outside"

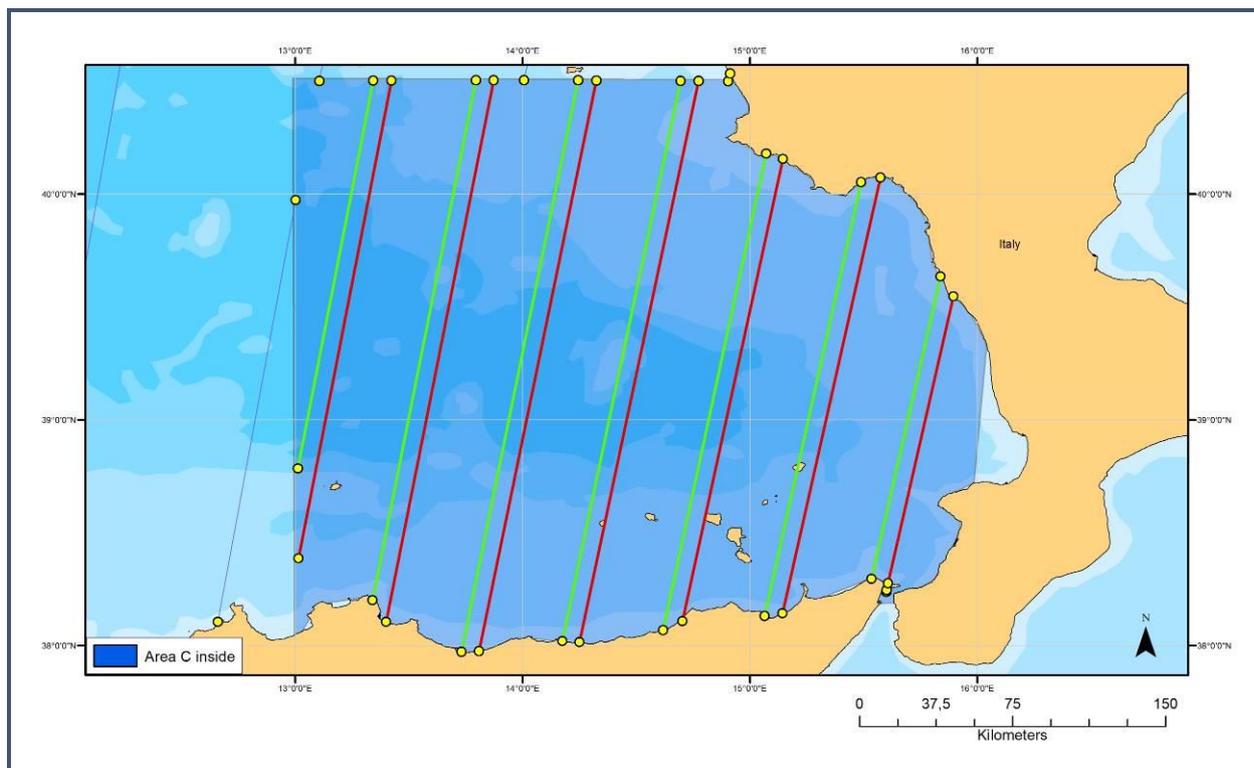


Figure 7 - Area and sampler routes: Sub-area C "inside"

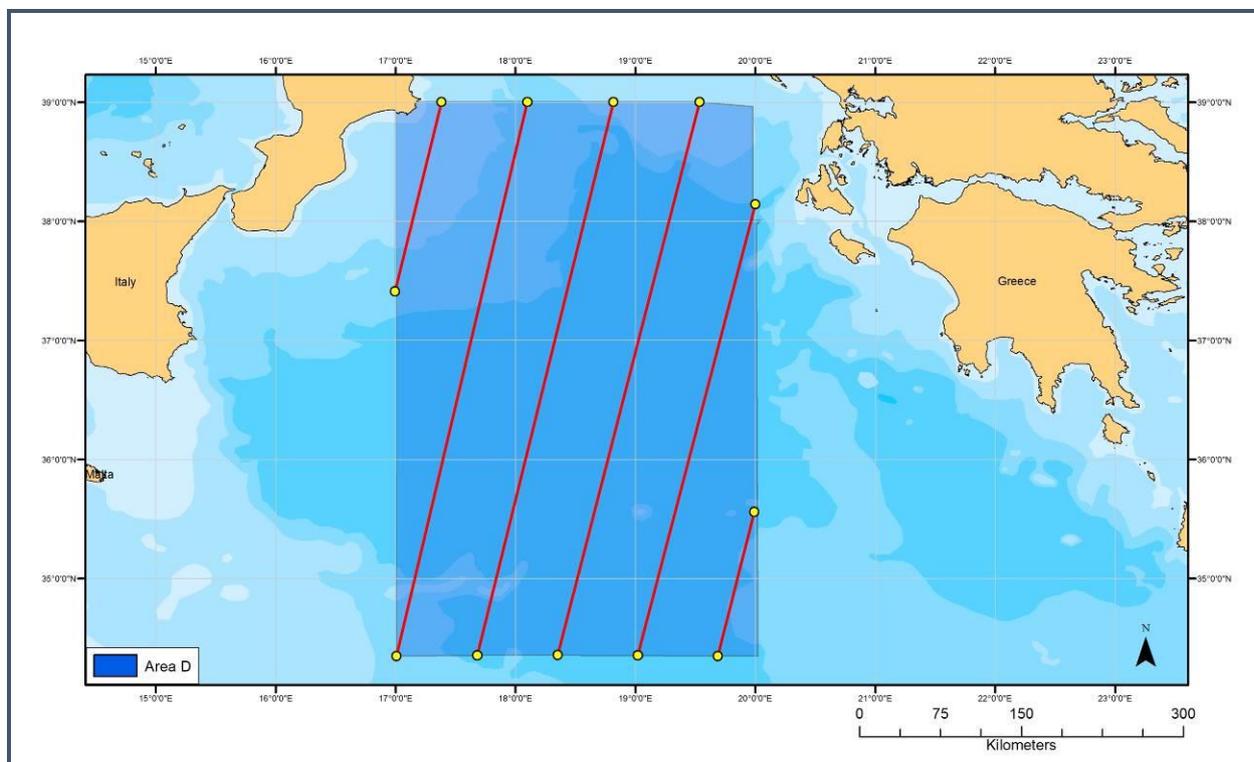


Figure 8 - Area and sampler routes: Sub-area D

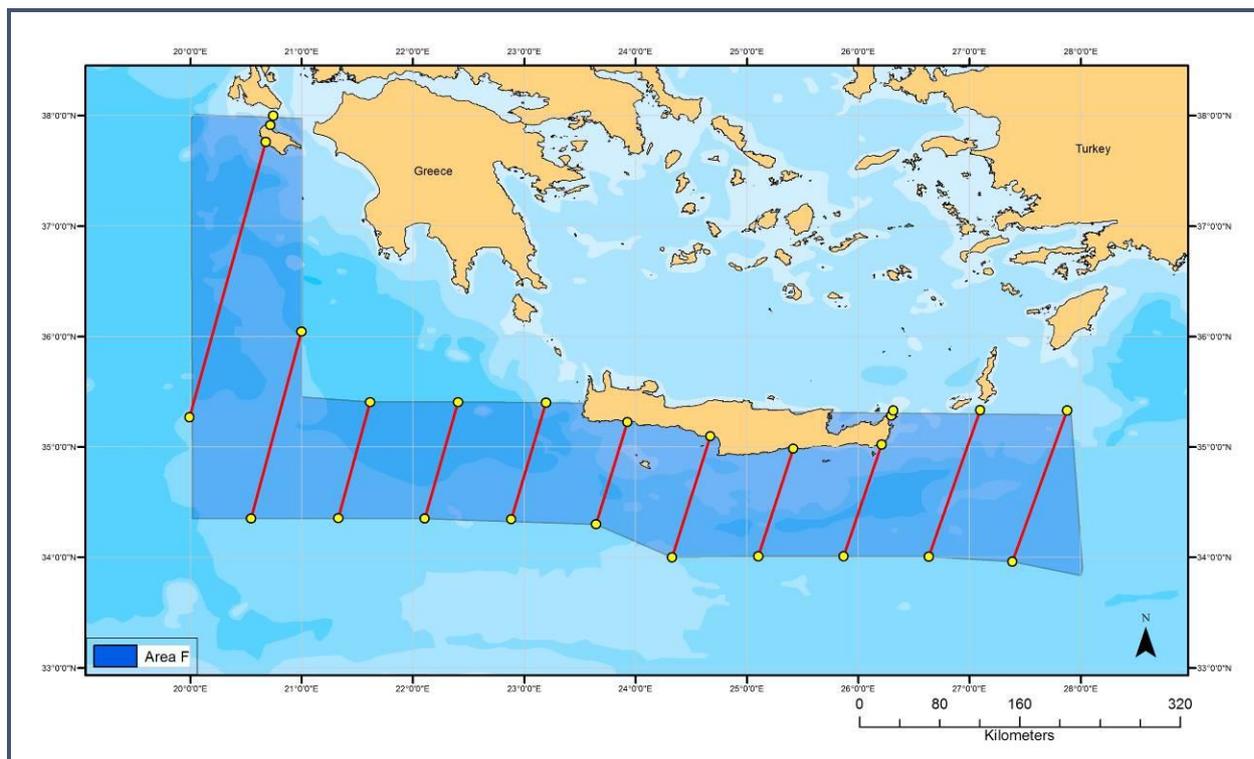


Figure 9 - Area and sampler routes: Sub-area F



3. RESULTS

3.1 Preparatory tasks

First of all, the team was set up. The coordination staff made contact with the subcontractors (the two companies providing the aircrafts) and the spotters, that were chosen on the basis of the expertise requested for the aerial survey: years of experience in aerial tuna spotting for the professional spotters, years of experience in tuna fisheries and biology, aerial surveys and/or census of marine populations for the scientific spotters, past participation in aerial tuna spotting or aerial survey campaigns for the pilots. A data analyst with experience in data mapping was involved as well. All scientific observers were already involved in one or more campaigns in the previous years.

In addition to the ICCAT course in Madrid, some meetings were held at Unimar headquarters in order to share the methodology among the scientific spotters and to organise the field activities. Other meetings with the pilots were organised before the surveys.

Three countries were contacted in order to avoid any problem of flying through the foreign airspaces: Malta, Greece and Tunisia. This effort was supported by ICCAT GBYP representatives, who provided a strong aid in obtaining the permits, when it was necessary.

Based on the communications from 2013 with the Greek Civil Aviation Authority and Italian Embassy in Athens (Col. Venanzi), Greece assured that no special permit was needed for flights in the Greek FIR. It was only required to submit flight plans to the Civil Aviation, every day prior to the flights.

In Tunisia Unimar faced problems in obtaining the permits: after the direct intervention of ICCAT GBYP representatives, the Tunisian Ministry of fisheries answered on June 24th, 2015 stating that, in order to enter the Tunis FIR, Ministry of Defence requested to have a Tunisian observer on board and that it was needed to board at a Tunisian airport. Therefore, due to all the difficulties that this would have entailed, ICCAT GBYP proposed to cut the transects included in the Tunisian FIR and allowed to carry out the survey without entering the Tunisian FIR. This has only slightly affected the survey of sub-area C outside, because only two relatively short segments of two sub-area C transects (30 and 50 nm each) were cut off in order to avoid entering the Tunisian FIR. The segments lost were replaced doing an extra replica of equivalent length in the sub-area C.

During the flight planning, it was noticed that 6 out of 7 transects in the sub-area F provided in the Survey Design finished right on the Libyan and Egyptian FIR boundaries. As already communicated before the survey, because of the extremely delicate situation ongoing in the Northern African countries and considering as well the very long distance of some of these points from the nearest airport, the pilots strongly recommended to keep a safety margin from the boundary, leaving the transects some miles before their southern end.



3.2 Field activities

According to ICCAT schedule and the meteorological conditions, the surveys started on the first day available (June 1st, 2015) and ended on the June 30th, 2015. The diary report of the surveys carried out is provided in the Table 5 and Table 6. As in the past years, the operative base for both aircrafts was "Salerno - Costa d'Amalfi" airport, near Pontecagnano, south of Salerno. As shown in the annexed tables and on the maps, other airports were also used as further bases, both in the Tyrrhenian and the other surveyed areas.



Table 5 - Diary report of the surveys: Area C

Date	Flight start time*	Flight end time*	Tot. time on effort	Tot. time off effort	Tot. time on duty	Area	Transects	Aircraft	Scient. spotters	Prof. spotter	Take off airport	Landing airport
01/06	9:04	12:09	01:36	01:29	03:05	C-in	C-in r1, leg07 C-in r2, leg07	I-GNIT	Fusari, Lombardo	Severino	Pontecagnano	Pontecagnano
01/06	13:25	16:57	02:31	01:01	03:32	C-in	C-in r1, leg05 C-in r1, leg06	I-GNIT	Fusari, Lombardo	Severino	Pontecagnano	Pontecagnano
02/06	7:10	10:55	02:59	00:46	03:45	C-in	C-in r1, leg03 C-in r1, leg04	I-GNIT	Fusari, Lombardo	Severino	Pontecagnano	Pontecagnano
02/06	12:22	16:20	02:25	01:33	03:58	C-in	C-in r1, leg01 C-in r1, leg02	I-GNIT	Fusari, Lombardo	Severino	Pontecagnano	Pontecagnano
03/06	11:10	14:41	02:24	01:07	03:31	C-in	C-in r2, leg06 C-in r2, leg05	I-GNIT	Fusari, Lombardo	Severino	Pontecagnano	Pontecagnano
04/06	9:28	13:10	02:58	00:44	03:42	C-in	C-in r2, leg03 C-in r2, leg04	I-GNIT	Fusari, Lombardo	Paolillo	Pontecagnano	Pontecagnano
05/06	7:30	10:50	01:02	02:18	03:20	C-out	C-out, leg 04 C-out, leg 05 C-out, leg 06	I-GNIT	Fusari, Lombardo	Paolillo	Pontecagnano	Pontecagnano
06/06	8:05	12:03	02:46	01:12	03:58	C-in	C-in r2, leg01 C-in r2, leg02	I-GNIT	Fusari, Valastro	Paolillo	Pontecagnano	Palermo-Boccadifalco
08/06	9:20	11:50	01:10	01:20	02:30	C-out	C-out, leg 05	I-GNIT	Fusari, Valastro	Paolillo	Palermo-Boccadifalco	Pontecagnano
08/06	12:40	15:55	00:27	02:48	03:15	C-out	C-out, leg 05 C-out, leg 06	I-GNIT	Fusari, Valastro	Paolillo	Pontecagnano	Palermo-Boccadifalco
09/06	7:47	11:02	00:51	02:24	03:15	C-out	C-out, leg 04	I-GNIT	Fusari, Valastro	Paolillo	Palermo-Boccadifalco	Pontecagnano
26/06	5:56	09:52	00:54	03:02	03:56	C-out	C-out, leg 04 (repl)	I-AGSD	Serra, Mariani	De Martino	Reggio Calabria	Pontecagnano
28/06	8:15	12:05	00:47	03:03	03:50	C-out	C-out, leg 03 C-out, leg 02 C-out, leg 01	I-GNIT	Fusari, Lombardo	Severino	Pontecagnano	Figari
28/06	13:02	16:42	01:41	01:59	03:40	C-out	C-out, leg 02	I-GNIT	Fusari, Lombardo	Severino	Figari	Palermo-Boccadifalco
29/06	7:55	11:00	00:51	02:14	03:05	C-out	C-out, leg 03	I-GNIT	Fusari, Lombardo	Severino	Palermo-Boccadifalco	Palermo-Boccadifalco
29/06	13:16	16:22	01:19	01:47	03:06	C-out	C-out, leg 04	I-GNIT	Fusari, Lombardo	Severino	Palermo-Boccadifalco	Palermo-Boccadifalco
30/06	7:55	11:22	02:46	00:41	03:27	C-out	C-out, leg 03	I-GNIT	Fusari, Lombardo	Severino	Palermo-Boccadifalco	Pontecagnano

(* GMT)



Table 6 - Diary report of the surveys: Area D and F

Date	Flight start time*	Flight end time*	Tot. time on effort	Tot. Time off effort	Tot. time on duty	Area	Transects	Scient. spotters	Prof. spotter	Aircraft	Take off airport	Landing airport
04/06	15:30	17:10	-	-	01:40	transf	-	-	-	I-AGSD	Reggio Calabria	Malta
06/06	10:05	13:45	-	03:40	03:40	transf	-	Serra, Poggi	De Martino	I-AGSD	Malta	Corfu
07/06	05:45	09:02	01:17	02:00	03:17	D	D3	Serra, Poggi	De Martino	I-AGSD	Corfu	Reggio Calabria
07/06	11:17	15:03	01:35	02:11	03:46	D	D4	Serra, Poggi	De Martino	I-AGSD	Reggio Calabria	Corfu
08/06	05:44	10:09	02:09	02:16	04:25	D-F	D5-F1	Serra, Poggi	De Martino	I-AGSD	Corfu	Corfu
09/06	08:13	09:32	-	01:19	01:19	transf	-	Serra, Poggi	De Martino	I-AGSD	Corfu	Messolonghi
10/06	06:34	11:15	01:33	03:08	04:41	F-D	F1-D6-F2	Serra, Poggi	De Martino	I-AGSD	Messolonghi	Messolonghi
11/06	07:09	07:46	-	00:37	00:37	transf	-	Serra, Poggi	De Martino	I-AGSD	Messolonghi	Cephalonia
11/06	09:33	13:43	00:51	03:19	04:10	D	D5	Serra, Poggi	De Martino	I-AGSD	Cephalonia	Cephalonia
11/06	14:39	15:14	-	00:35	00:35	transf	-	Serra, Poggi	De Martino	I-AGSD	Cephalonia	Messolonghi
12/06	10:29	12:50	-	02:21	02:21	transf	-	Serra, Poggi	De Martino	I-AGSD	Messolonghi	Heraklion
13/06	07:14	12:08	01:16	03:38	04:54	F	F3-F4-F5	Serra, Poggi	De Martino	I-AGSD	Heraklion	Heraklion
14/06	05:47	09:44	01:34	02:23	03:57	F	F9-F8-F7-F6	Serra, Poggi	De Martino	I-AGSD	Heraklion	Heraklion
14/06	12:31	16:26	01:12	02:43	03:55	F	F10-F11	Serra, Poggi	De Martino	I-AGSD	Heraklion	Heraklion
15/06	06:20	09:47	-	03:27	03:27	transf	-	Serra, Poggi	De Martino	I-AGSD	Heraklion	Corfu
15/06	11:19	15:03	-	03:44	03:44	transf	-	Serra, Poggi	De Martino	I-AGSD	Corfu	Malta
16/06	06:20	10:47	01:06	03:21	04:27	D	D3	Serra, Poggi	De Martino	I-AGSD	Malta	Malta
17/06	06:02	10:20	01:17	03:01	04:18	D	D2	Serra, Poggi	De Martino	I-AGSD	Malta	Malta
24/06	12:45	17:40	01:06	03:49	04:55	D	D4	Serra, Mariani	De Martino	I-AGSD	Malta	Malta
25/06	08:10	09:43	-	01:33	01:33	transf	-	Serra, Mariani	De Martino	I-AGSD	Malta	Reggio Calabria
25/06	12:59	17:36	02:09	02:28	04:37	D	D1-D2	Serra, Mariani	De Martino	I-AGSD	Reggio Calabria	Reggio Calabria

(* GMT)



The times are calculated by the time the engines were switched on.

The time format is GMT.

Although the flights were generally performed at the altitude and speed requested (300 m, 100 nm/h); there are some differences and fluctuations due to environmental and technical factors.

For all performed flights, the tracks were registered by the observers' GPS (the .gpx files of the tracks are sent in the Annexes). The effort and sightings forms can be found in the Annexes, as well. Two categories of waypoints were requested by the protocols, but no name was specified: 1. The change of weather and general spotting conditions, 2. The position of the centre of the school. So, it was decided to identify the points respectively with the letter "W" and "S", in order to allow to distinguish them from the other waypoints. The "S" points were calculated later in the office, using GPS tracks where available or information reported by the observers. The pictures can be identified according to the frame numbers. A complete set of the relevant photos taken during the surveys can be found in the Annexes. The photos were taken following the methodologies tested in the previous campaigns. In order to overcome the problems in photography, especially the ones linked to aircraft bouncing, high shutter speeds were used, but in many cases this wasn't enough for getting sharp photos. This specially refers to taking photos of other species, which were sighted while flying on the transect without break. The very short time from the sighting to the disappearing on the back of the aircraft made impossible to take pictures. We estimated that only 6-7 seconds were available from the sighting to the disappearing of the animals, if they were sighted on the front of the view field from the bubble window and even less, if they were sighted on the centre or on the back. During this short time, in almost all the cases, it is possible only to identify the species and to measure the angle.

All the photos are provided in non compressed RAW (.NEF) formats: the more relevant ones were adjusted with photo editing programs in order to enhance the visibility of the images. The edited photos were saved in compressed high quality format (.jpg).

Regarding aerial photos, some problems were encountered in foreign airports: both the Maltese and Greek Civil Aviation personnel asked almost before every flight if we would take photographs, saying it was not allowed.



Description of the surveys

Sub-area C

On 31/5/2015, the spotters arrived at Pontecagnano and a briefing at the airport was organised.

The sub-area was entirely surveyed with I-GNIT aircraft (Aerial Banners Srl), except a 90 nm segment done a second time by I-AGSD due to the bad weather conditions.

I-GNIT Team ("ICCAT 3")

Pilots: Francesco Orrico, Francesco Ruggiero

Professional spotters: Vincenzo Severino, Pietro Paolillo

Scientific spotters: Andrea Fusari, Sergio Lombardo, Massimiliano Valastro

The 2015 campaign was the fourth survey in the C-inside area, already surveyed in 2010, 2011 and 2013. While in 2010 and 2011 about eleven transects per replica were followed, in 2013 and 2015 the transects number per replica was 7, so the distance between the lines was higher. The C outside area was surveyed for the first time in 2013.

Flight history

Day 1 - 1/6/2015

N. 2 Pontecagnano-Pontecagnano flights. Morning: **C-inside Replica 1, Transect 7** and **C-inside Replica 2, Transect 7**. Afternoon: **C-inside Replica 1, Transect 5** and **C-inside Replica 1, Transect 6**.

Day 2 - 2/6/2015

N. 2 Pontecagnano-Pontecagnano flights. Morning: **C-inside Replica 1, Transects 3** and **4**. Afternoon: **C-inside Replica 1, Transects 1** and **2**.

Day 3 - 3/6/2015

N. 1 Pontecagnano-Pontecagnano flight: **C-inside Replica 2, Transects 5** and **6**.

Day 4 - 4/6/2015

N. 1 Pontecagnano-Pontecagnano flight: **C-inside Replica 2, Transects 3** and **4**.

Day 5 - 5/6/2015

N. 1 Pontecagnano-Pontecagnano flight: **C-outside**, northern segments of **Transects 4, 5** and **6**.



Day 6 - 6/6/2015

N. 1 Pontecagnano-Palermo flight: **C-inside Replica 2, Transects 1 and 2.**

Day 7 - 7/6/2015

Standby for maintenance.

Day 8 - 8/6/2015

N. 1 Palermo-Pontecagnano flight in the morning: **C-outside, Transect 5** (central segment).

N. 1 Pontecagnano-Palermo flight in the afternoon: **C-outside**, southern segment of **Transects 5 and 6.**

Day 9 - 9/6/2015

N. 1 Palermo-Pontecagnano flight: **C-outside**, central segment of **Transect 4.**

Because of the adverse weather conditions the survey was suspended. It was decided to do a replica of this segment, if possible, because of the very uncertain conditions affecting the spotting.

Day 10 - 26/6/2015

N. 1 Reggio Calabria-Pontecagnano flight: **C-outside**, central segment of **Transect 4.**

The I-AGSD team, in the last day of the survey, during the transfer flight from Reggio Calabria to Pontecagnano decided to do the replica of the segment over described. The sea state was not perfect, but within the limits set by the ICCAT GBYP protocol.

Day 11 - 28/6/2015

N. 1 Pontecagnano-Figari flight in the morning: **C-outside, Transects 1, 2 and 3.**

N. 1 Figari-Palermo flight in the afternoon: **C-outside, Transect 2.**

After waiting good sea conditions and the permit from Tunisia, the survey with I-GNIT restarted without entering the Tunisian FIR, as approved by ICCAT GBYP.

Day 12 - 29/6/2015

N. 2 Palermo-Palermo flights. Morning: **C-outside**, southern segment of **Transects 3.**
Afternoon: **C-outside**, southern segment of **Transects 4.**

Day 13 - 30/6/2015

N. 1 Palermo-Pontecagnano flight: **C-outside**, central segment of **Transect 3.**



Sub-areas D and F

Entirely surveyed with I-AGSD aircraft (Aviopesca Srl).

I-AGSD Team ("ICCAT 4")

Pilot: Marco-Fitz Seung

Professional spotter: Salvatore De Martino

Scientific spotters: Simone Serra, Andrea Poggi, Adriano Mariani

Besides the problems related to the international coverage of the survey, Unimar faced other problems in sub-area F, some of which were already encountered within the previous missions in the Tyrrhenian Sea. One was related to the flight permissions "on flight": despite no special authorisation was requested for flying in Greek (UE) airspace and despite flight plans were regularly registered prior to every flight, different problems occurred, sometimes with radio contacts because some transects passed through inaccessible military zones (the detailed effects of this are described below in the flight history). In almost all the cases, the pilot was allowed to proceed with the regular flight. In an area in the Ionian Sea, west to Zakynthos, it was impossible to fly: this made the flights longer than what was planned.

The second problem was crew's luggage on board, which increased the total weight for about 100 kg. For safety reasons, the flight schedule was modified in a way that the transfer flights never included surveys, except in the case from Reggio Calabria to Pontecagnano, because that time the luggage were lighter and the flight was not particularly long and remote.

The third problem was non-availability of suitable airports: very few of them had necessary fuel type available (Avgas 100LL). Some had only small quantities for touristic flights and the other ones didn't have it at all because they had mostly civilian traffic and large aircrafts with their own type of fuel or other types, like JetA for jet engines. This problem forced the pilots to modify the flight schedule and limit it to a small number of airports only. Initially, the following suitable airports were identified: Reggio Calabria, Malta, Corfu, Heraklion (Crete). On the last days before starting the survey, the Messolonghi local airport was identified as a fifth Greek base available for the Ionian transects. It had a limited quantity of Avgas fuel stocked and made it available for the flights by the owner. The availability of this airport allowed Unimar to complete the southern segments of some Ionian transects, otherwise it would have been very difficult and it would have taken much longer to do the same from the other three airports. Nevertheless, the use of this airport created a new and unpredictable problem linked to customs issues, as explained below in the "flight history" paragraph.

Malta airport was used as a base for the western transects of sub-area D, although the airport personnel couldn't assure more than 200 lt of Avgas 100LL fuel per day, which was not enough for doing long flights. Fortunately, we had only three flights planned from Malta and we found the way to obtain few more litres, but this problem created a lot of uncertainty every day and should be considered for planning future programs. In the Malta airport, furthermore, we



were always forced to wait a lot for refuelling (up to 3 hours in some case), because they had a limited number of operators engaged for all the flights of the airport: in some cases, this forced us to change the plans and delay the flights to the following day. Corfu airport was the one used as the base for the northern segments of some Ionian transects, as well as Reggio Calabria, and as a refuelling stop for the transfer flight from Malta to Crete and back. Heraklion (Crete) was chosen as the base for all the transects in the sub-area F, except for the western ones.

As in 2013, because of the deeply unstable wind conditions in the sub-areas D and F, the team was forced to plan the flights day by day, constantly checking the forecasts more than once a day to avoid bad sea conditions. During the survey period, the wind direction and strength both changed drastically from one day to another and also from the morning to the afternoon. Several websites (see in the references) were regularly checked in order to avoid vain flights and to waste flight hours. Despite this, it was impossible to know precisely the actual weather conditions along all the flight course, especially in the case of the transects which were far away from the airport: in many cases, the conditions could drastically change from one moment to the other. At the same time, the team had to deal with the total amount of available days and flight hours, the final deadline of the survey, and the upcoming stable bad weather conditions shown by the forecasts. Despite all these problems, it was possible to cover the surveys within the deadline.

Flight history

Day 1 - Thursday 4/6/2015

Transfer of the aircraft and the observers to Malta.

Day 2 - Friday 5/6/2015

The day was dedicated to fulfil the requests of the Maltese Civil Aviation and to prepare the necessary documents for obtaining the permit for aerial work. It was necessary to deal with the permits issue on site, because although the authorities assured we would get the permits (according to the contacts from Italy), at the moment of the taking off the tower stopped us. After fulfilling all the requests and sending all the documents, the Maltese authorities assured to grant the permit in 2-3 working days. This work took almost the whole day.

Day 3 - Saturday 6/6/2015

Malta-Corfu transfer flight.

While waiting the Malta permit, we were forced to change the plans and do the "Greek" surveys first.



Day 4 - Sunday 7/6/2015

N. 1 Corfu-Reggio Calabria flight: **Transect D3.**

N. 1 Reggio Calabria-Corfu flight: **Transect D4.**

The first Ionian transects were done, surveying their northern segments without entering the Malta FIR because of the permits problems.

Day 5 - Monday 8/6/2015

N. 1 Corfu-Corfu flight: **Transects D5 and F1.**

Two more Ionian transects were done from Corfu, surveying their northern parts without entering the Malta FIR.

Day 6 - 9/6/2015

Corfu-Messolonghi transfer flight.

During the planned transfer flight to Crete, the right engine showed a slight loss of power, probably due to the ice that was created in high altitudes. In order to avoid any risk, it was decided to land at Messolonghi, one of the airports already planned to be used after the Crete flights. Therefore, in the afternoon the engine was checked by the airport mechanics and all problems were fixed: at the same time, due to the help of the ICCAT GBYP representatives, the permit from the Malta authorities was granted and therefore the flight schedule was changed: having the possibility to enter the Malta FIR, it was decided to do the transects from Messolonghi before moving to Crete.

Day 7- 10/6/2015

N. 1 Messolonghi-Messolonghi flight: **Transects F1, D6 and F2.**

A long flight was performed from Messolonghi, including the F1, F2 and D6 transects.

Day 8 - 11/6/2015

N. 1 Messolonghi-Messolonghi flight, landing at Cephalonia for customs reasons: **Transect D5.**

A very long and difficult mission was done: for customs reasons, in order to cross the Athens-Malta FIRs boundaries, it was necessary to depart from an international airport. Despite that the day before no problem was created by the authorities, on that day, the offices didn't grant the permit for leaving the Greek FIR if departing from Messolonghi (a small airport used for local flights), since the Greek law doesn't allow to go outside the Greek FIR departing from a non-international airport. Therefore, it was decided to land at an airport along the way to the transect, only to do the police and documents controls: Zakynthos had no space left that day, but Cephalonia was available. Consequently, two transfer flights from Messolonghi to Cephalonia (and two landings and take-offs) were necessary, without refuelling because



Cephalonia was one of the airports unsuitable as a base because they didn't have Avgas 100LL fuel.

Considering the presence of “no-flight” military zones in the area, that forced Unimar to do a track longer than the one planned on the map, the final total duration of the flight was around 5h30', which was very close to the safety limit of the aircraft range.

Day 9 - 12/6/2015

N. 1 Messolonghi-Heraklion transfer flight

In the morning, it was decided to perform more accurate check of the engine before moving to Crete at mid-day. The fuel that the owner of the airport made available to us was barely sufficient to finish the transects and move to Crete.

Day 10 - 13/6/2015

N. 1 Heraklion-Heraklion flight: **Transects F3, F4 and F5.**

In the day 10, one 5-hours flight was performed, covering the three western transects from Heraklion.

Day 11 - 14/6/2015

N. 2 Heraklion-Heraklion flights: **Transects F6, F7, F8, F9, F10, F11.**

The strong wind, which occurred on the following days, forced us to perform two flights per day, so in the morning the four central transects south of Crete were surveyed and in the afternoon the **Transect F10 and F11**, which are easternmost ones of the Unimar Survey.

Day 12 - 15/6/2015

2 transfer flights: Heraklion-Corfu and Corfu-Malta.

In order to move to Malta, it was necessary to go to Corfu for refuelling. A direct flight from Crete to Malta was too long and too far from the mainland. The transfer flights were more difficult because of the luggage weight.

Day 13 - 16/6/2015

1 Malta-Malta flight: **Transect D3.**

A long flight was performed (around 4h30') including the southern segment of the D3 Transect.

Day 14 - 17/6/2015

1 Malta-Malta flight: **Transect D2.**

In the morning, a flight including the southern part of Transect D2 was performed. Just one Transect was left from Malta and two from Reggio Calabria, but after checking the weather



forecast, it was decided to stop the survey and come back until better weather conditions arise. The aircraft was left in the Malta airport and the staff came back home.

Day 15 - 24/6/2015

In the morning, transfer back of the staff to Malta.

In the afternoon, 1 Malta-Malta flight: **Transect D4.**

A 5-hours flight was performed, covering the southern segment of the farthest Transect from the mainland.

Day 16 - 25/6/2015

In the morning, Malta-Reggio Calabria transfer flight.

In the afternoon, 1 Reggio Calabria-Reggio Calabria flight: **Transects D1 and D2.**

The whole transect D1 and the northern part of the D2 were surveyed.

Day 16 - 25/6/2015

1 Reggio Calabria-Pontecagnano flight: **Transect C4.**

During the transfer from Reggio Calabria to Pontecagnano, it was decided to do a replica of a segment of the C4 Transect, because it was done under very unstable weather conditions by the I-GNIT aircraft: a sudden and unforeseen thunderstorm occurred during the flights, affecting the spotting possibilities.

Figure 10 to Figure 13 show the GPS tracks of the surveys in the three sub-areas. Each colour corresponds to a different day. In the sub-areas C "outside", D and F, the primary replicas were performed. In the sub-area "C inside", the two primary replicas were performed.

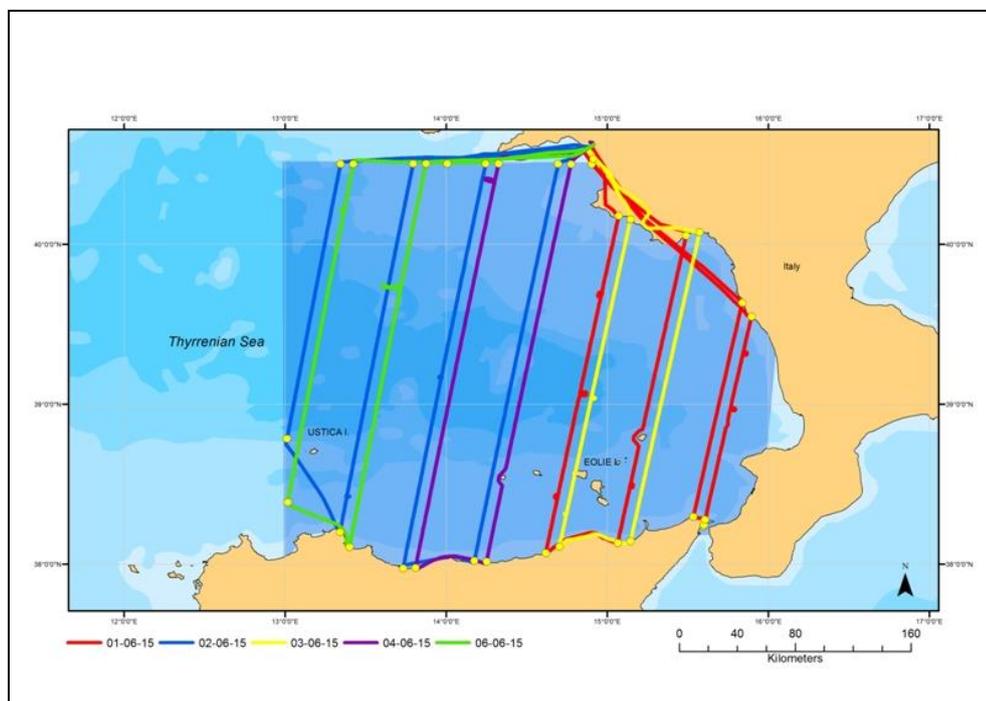


Figure 10 - GPS tracks: Sub-area C "inside", replica 1 and 2

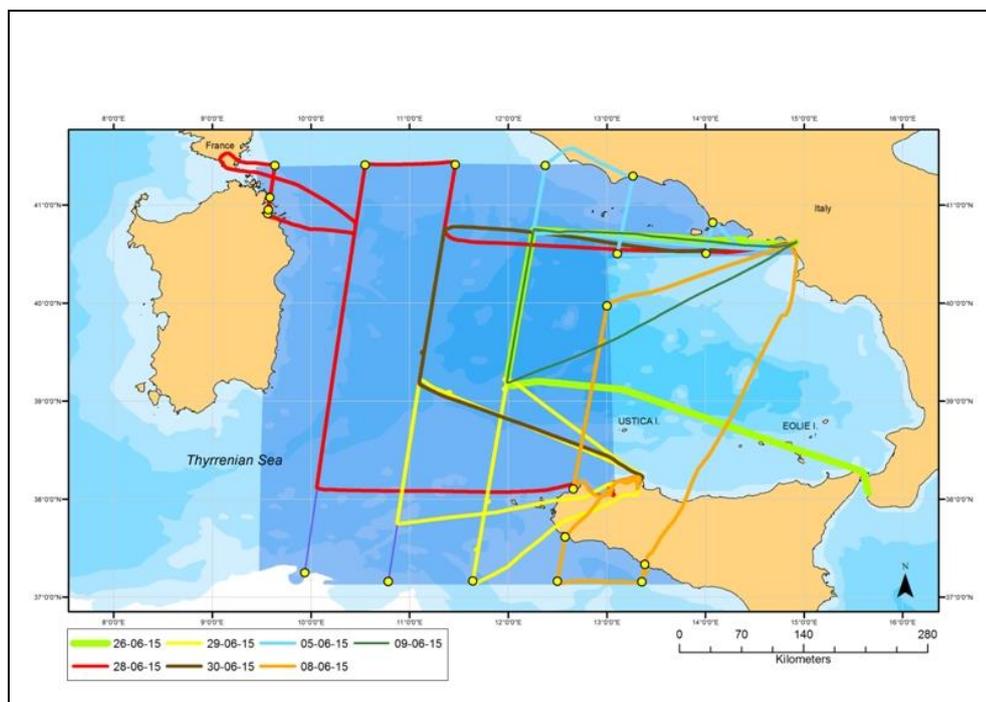


Figure 11 - GPS tracks: Sub-area C "outside"

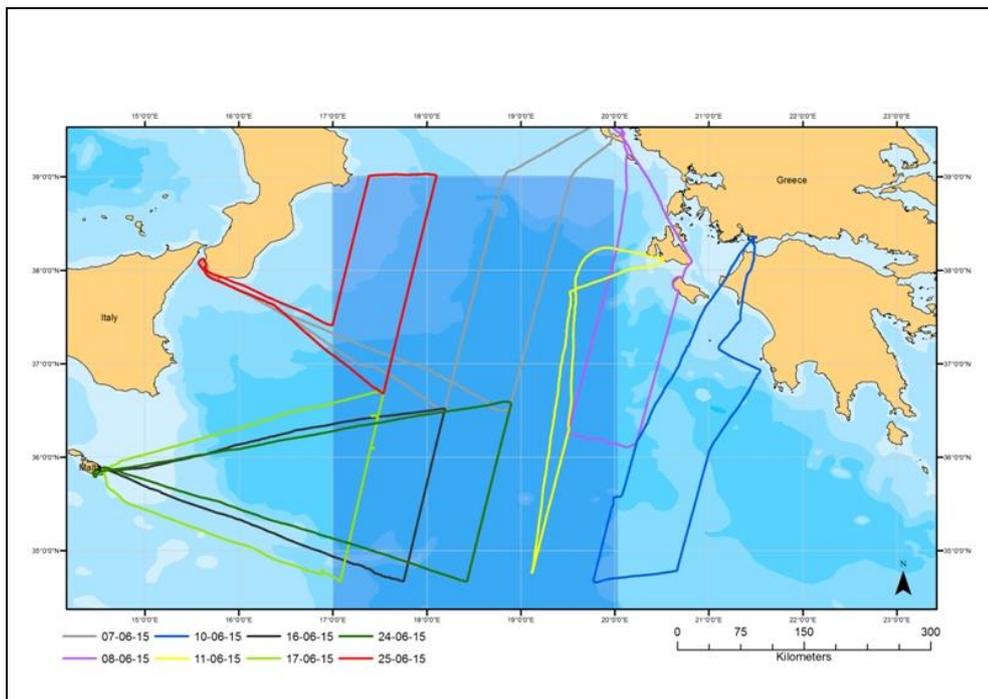


Figure 12 - GPS tracks: Sub-area D

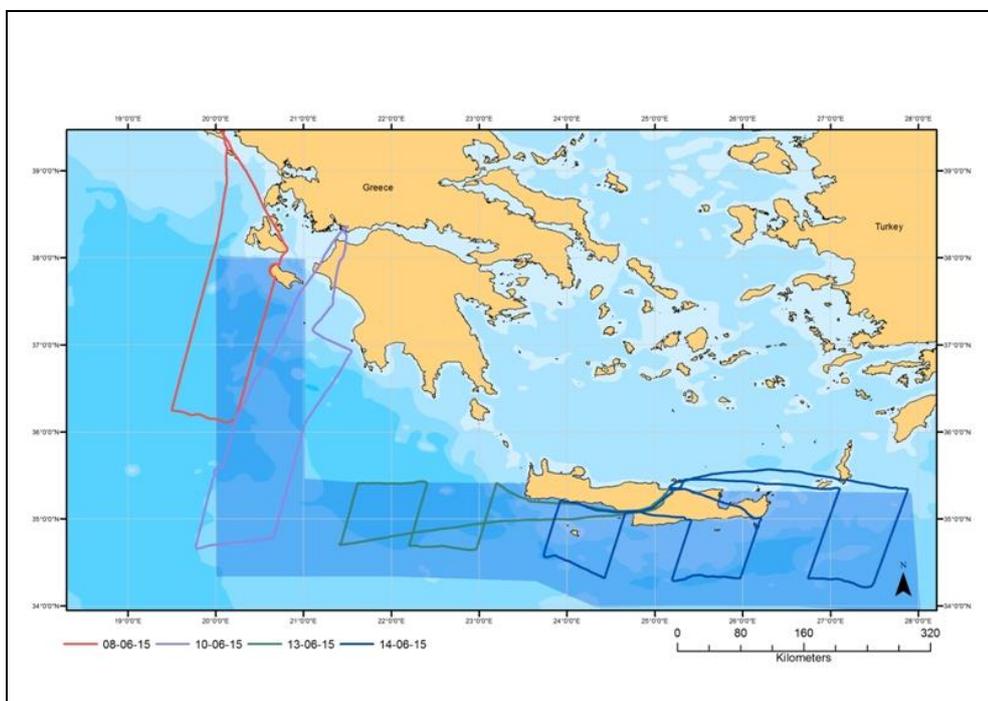


Figure 13 - GPS tracks: Sub-area F



3.3 Sightings overview

The maps representing the sightings of Bluefin tuna are shown in Figure 14 and Figure 15. The maps show the distribution of the sightings and the related values in terms of number of individuals and weight. All the details are available in the Table 7 and in the annexed forms.

Almost all the sightings occurred in the sub-area C and in particular "C inside": 5 adult schools on effort (3 of them in the C-inside sub-area) and 2 off effort were sighted. In the sub-area D, two BFT off effort sightings occurred: one of small individuals within the Corfu bay (as well as in the 2013) and one large school of adult individuals in the southern Ionian Sea. In the sub-area F, only one on-effort sighting was made: a school of small individuals in feeding behaviour very close to a small island in the south-west of Crete (Koufonisi). Like in the past campaigns, no clear pictures of small individuals are available: only some splash and birds are visible in the images. It was possible to have clear photos of only one adult school during one of the last survey days. According to the professional spotters' opinions, it is probable that in the first part of the survey the fish were deeper and less visible. In respect to the former campaigns, the campaign in this year started earlier (for example in 2013, the survey started on the June 18th). Three more schools were sighted in the first days in the sub-area C, but they were lost during the attempt to approach them, probably because they moved to the deeper layers. One more sighting of a school of small individuals occurred in sub-area D (northern Ionian Sea very close to Corfu, outside the bay), but it was lost as well.

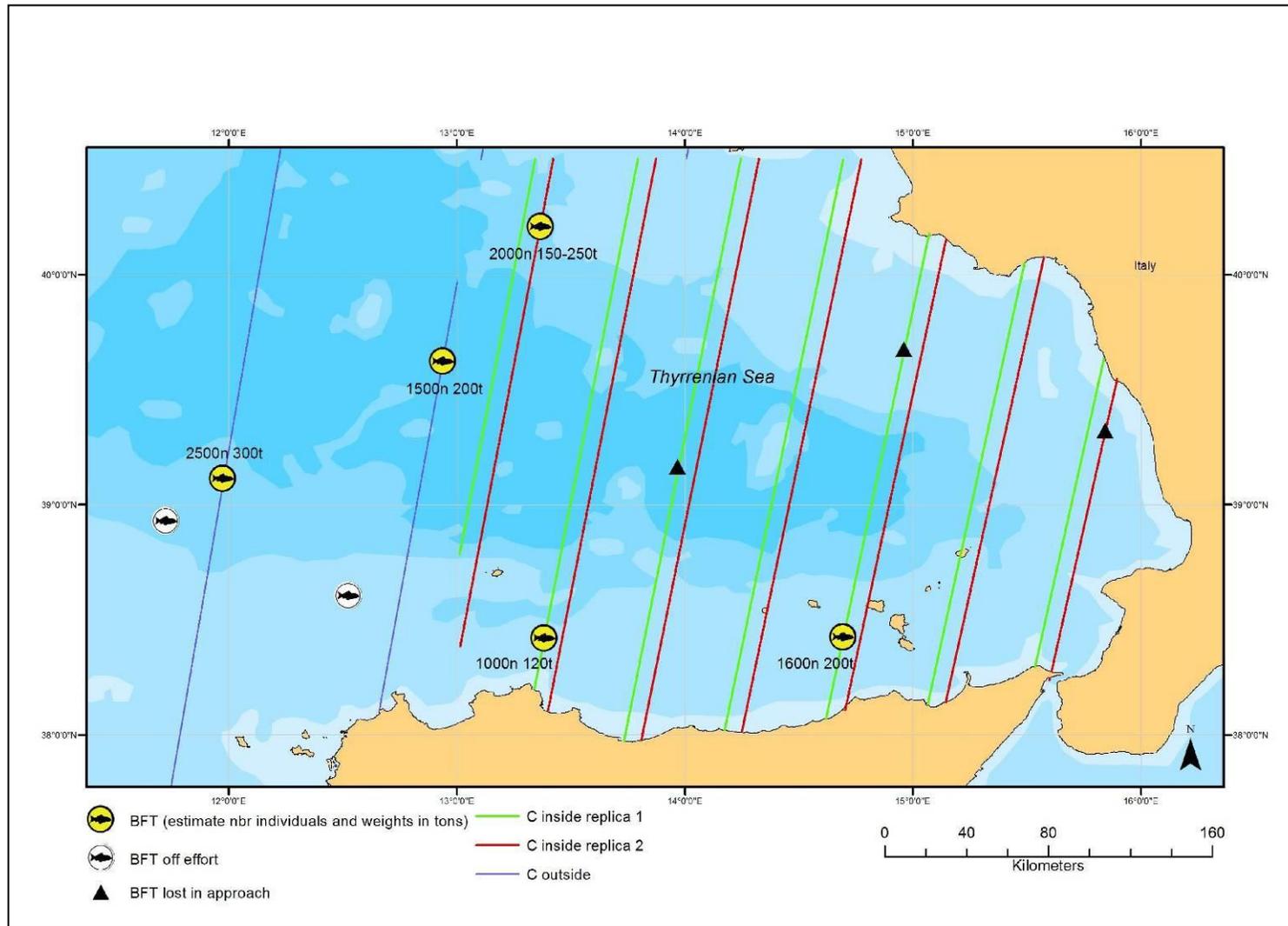


Figure 14 - Map of the BFT sightings (number of individuals and total weight): Sub-area C

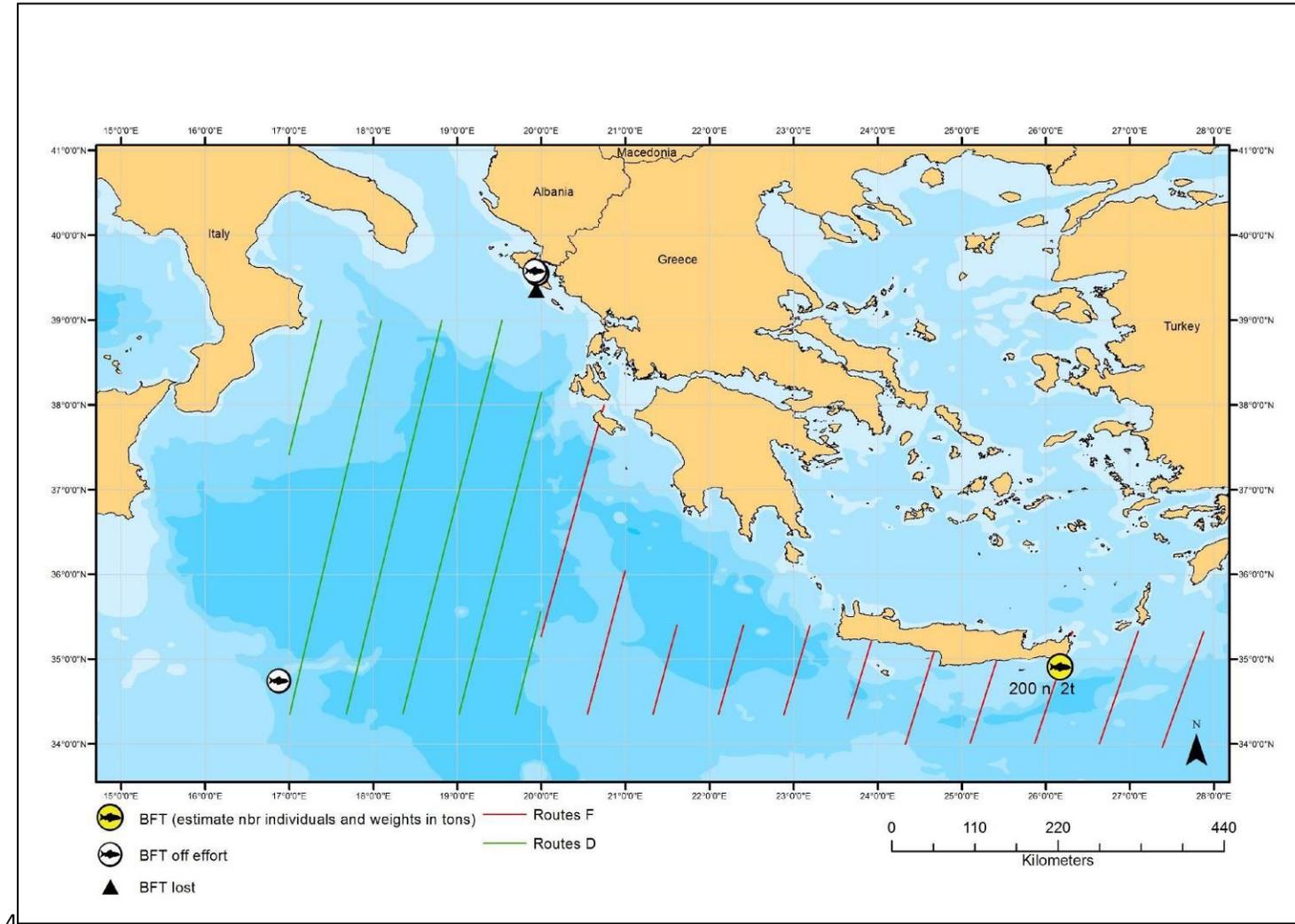
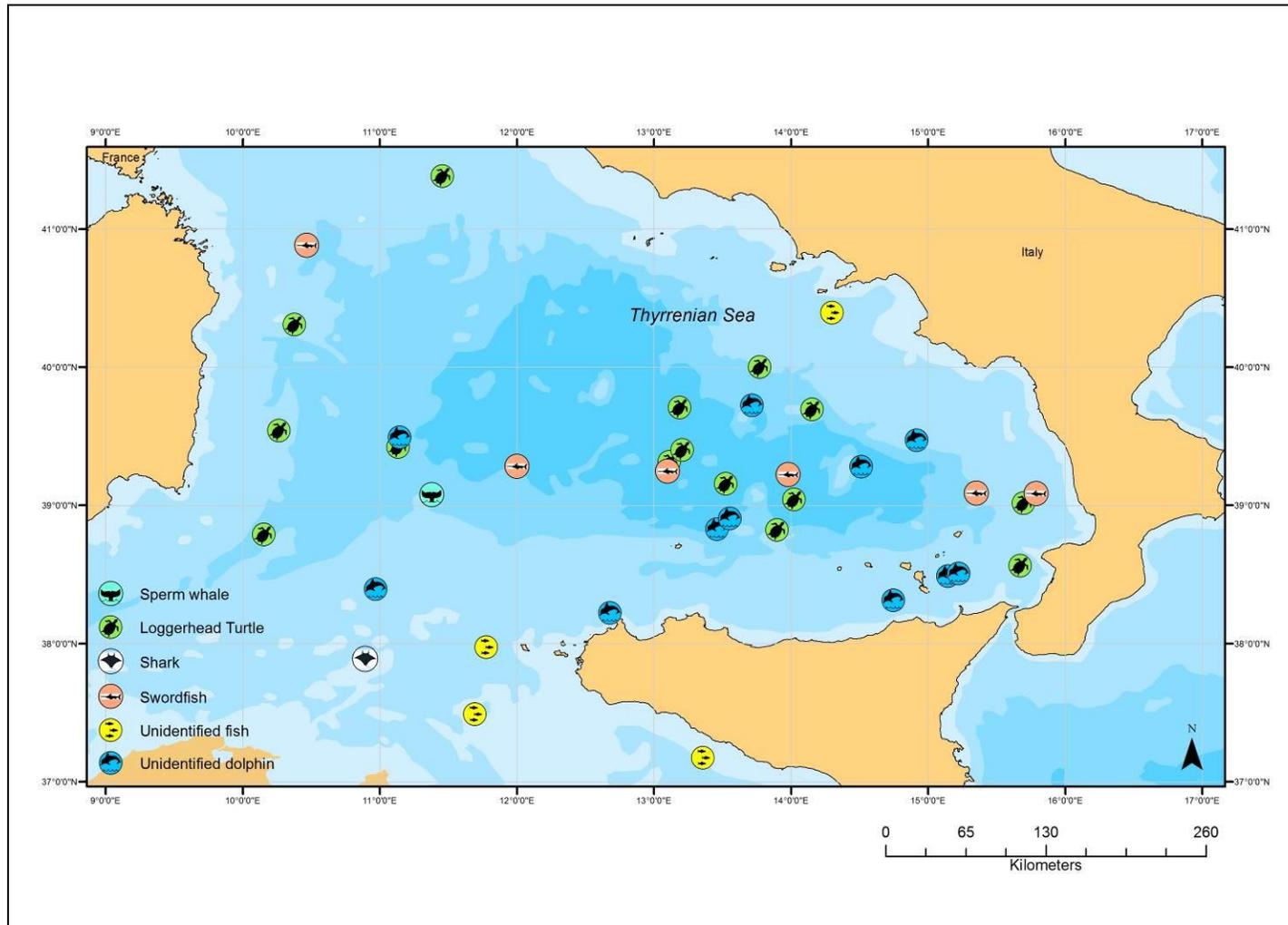


Figure 15 - Map of the BFT sightings (number of individuals and total weight): Sub-areas D-F



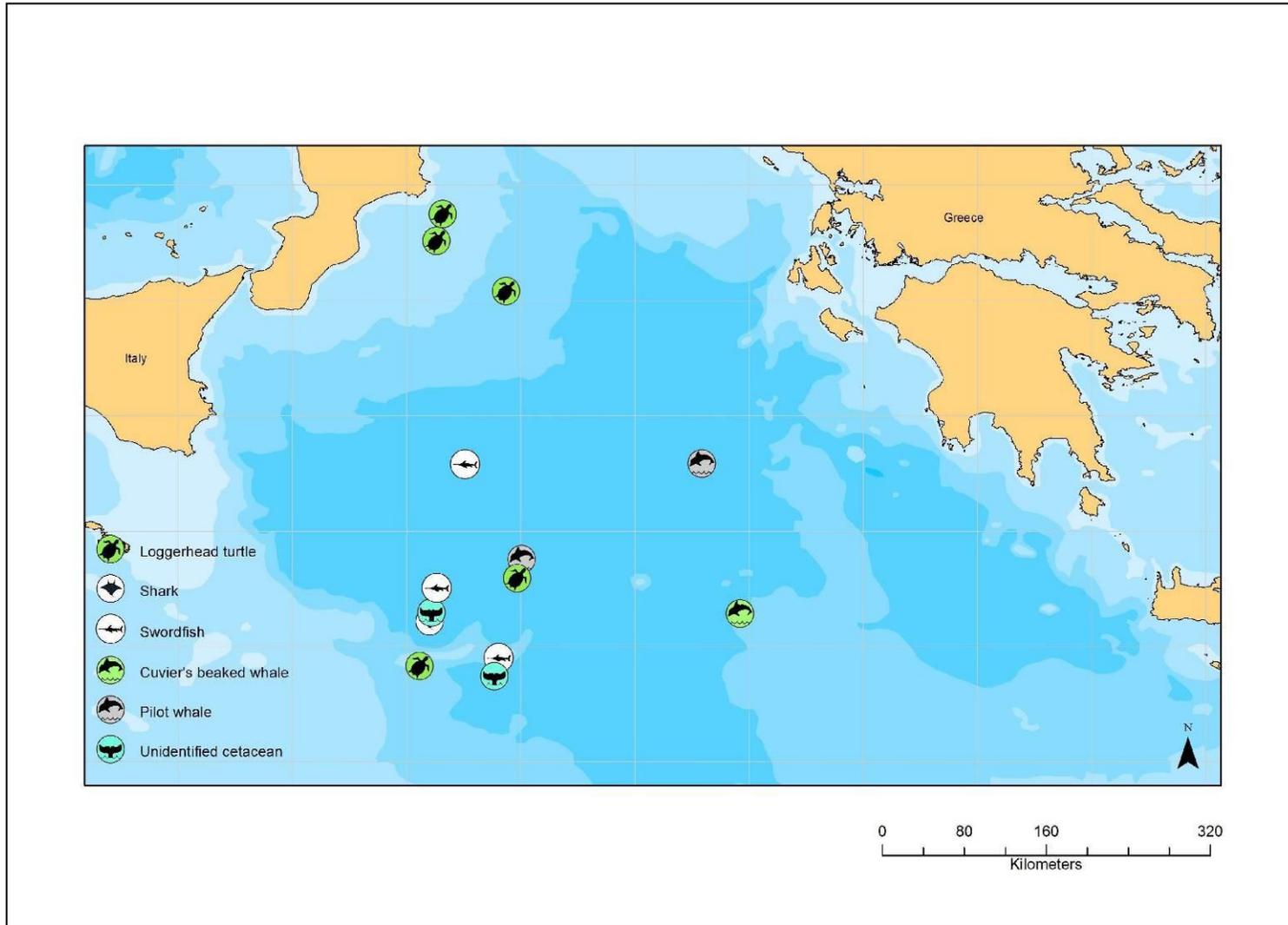


Figure 17 - Map of the other species sightings: Sub-areas D and F



Table 7 - Overview of the BFT sightings

ID	Block	Date	Time of first sighting	Time abeam	Decl. angle	Lat first sighting	Lon first sighting	Cue	School size	Est. weight (t)	% small	% med	% large
11	C-in	1/6	15:51	15:51	16	38,41929	14,69074	Surface	1600	200		100	
20	C-in	2/6	15:30	15:30	19	38,42214	13,3819	Surface	1000	120		100	
31	C-in	6/6	9:49	9:49	14	40,20987	13,36466	Underwater	2000	150-250		40	60
36	C-out	8/6	11:23	11:23	-*	39,62537	12,93705	Ripples	1500	200		30	70
45	C-off eff.	29/6	09:19	09:19	45	38,60659	12,52372	Ripples	300	60		50	50
46	C-off eff.	29/6	09:39	09:39	40	38,93134	11,72295	Ripples	200	40		50	50
50	C-out	29/6	15:07	15:07	16	39,11668	11,97184	Ripples	2500	300		20	80
6	F	13/6	06:27	06:27	13	34,91123	26,17010	Ripples	200	2	100		
11	D-off eff.	17/6	07:20	07:20	4	34,74381	16,87289	Splash	1000	200			100

* direct break at first sighting, no abeam point



The exact positions of the tuna schools are shown in the Table 8.

Table 8 - Positions of the sightings

ID	Block	Date	Time of first sighting	Lat of the "C" point	Lon of the "C" point	Lat of the center of the school ("S")	Lon of the center of the school ("S")
11	C-in	01/06/2015	15:51	38,42561	14,67411	38,42105	14,67784
20	C-in	02/06/2015	15:30	38,42631	13,39124	38,42178	13,39147
31	C-in	06/06/2015	9:49	40,21119	13,34883	40,21446	13,35274
36	C-out	08/06/2015	11:23	39,60783	12,95701	39,61453	12,95670
45	C-off eff.	29/06/2015	09:19	*	*	*	*
46	C-off eff.	29/06/2015	09:39	*	*	*	*
50	C-out	29/06/2015	15:07	39,12746	11,95320	39,12763	11,96115
6	F	13/06/2015	06:27	34,91181	26,15911	34,91547	26,15505
11	D-off eff.	17/06/2015	07:20	34,78808	16,87927	34,78593	16,88290

* very close, estimated without circling



3.4 Methodological remarks

The main difficulties were related to the available time for the preparatory phase: since in the 2013 it was longer, it allowed us to learn the procedures for obtaining the flight permits and to find out where they were and where they were not necessary. But, having to use new airports, once being on site, we encountered new problems. If we have had more time available in the preparatory phase, these problems could have been avoided. In any case, in order to be more efficient, this point might be taken into account for future surveys.

Regarding the methodological aspects of the sightings, no significant difference from the past campaigns is worthy of notice. It is confirmed that the bubble windows are comfortable for vertical spotting, but at the same time they create some disturbance for long distance spotting and taking photographs because of the strong light reflection and visual distortion. Even if the camera was set with the highest shutter speeds, sometimes the photographs were "blurry" or distorted: this seems to be the result of the window interference.

Some difficulties were also encountered for marking the point C (arriving at the position for circling), which was the new task established by the ICCAT GBYP protocol for this year campaign. While going from the transect to the school, it was almost impossible to understand when to mark the point C. Therefore, different points were recorded while flying in circle around the school. We still believe that the best way to mark the position of the school (and calculate the distance from the track as well) is to calculate it from the GPS tracks when back to the office, creating a point on the centre of the estimation circles.

Prior to the first flight, an external GPS antenna with a long cable was connected. We suggest to fix it over the aircraft instrument panel or on the upper part of the front window in order to overcome some GPS signal reception problem, already noticed in the former campaigns, especially during circling.

Sunglasses with polarised lenses are useful for searching under the sea surface, but we noted that through the bubble windows they increase the sun reflection on the glass and disturb the long distance spotting.



4. DISCUSSION

Comparing to the 2013 survey, 2015 program was wider and more complex, especially regarding the management, coordination and setting-up aspects. The multi-national dimension of the survey entailed several problems and a great number of variables and unknown aspects to deal with.

Furthermore, despite the former experiences - in particular the 2013 ones which provided us a lot of useful elements to take into consideration for the organisation and the management of the field activities, this year we faced some new unpredictable issues.

Regarding the results of the surveys, a preliminary screening shows less bluefin tuna school sightings in the southern Tyrrhenian Sea compared to the 2013 campaign. We believe that it could be the result of the fact that the survey period started earlier this year (it started on the 18th June for both 2011 and 2013 and 1st June in 2015). Furthermore, a suitable thermocline was available later in the season. Anyway, the importance of southern Tyrrhenian Sea as a bluefin tuna spawning area has been confirmed, with 5 on-effort and 2 off-effort sightings of adult spawners aggregations. In the other two sub-areas, only one adult school was observed (off-effort) in the south-western Ionian, 135 nm South-East of Malta. 3-4 small schools of juveniles in feeding behaviour were sighted near Corfu and Crete. Even in those areas, we should take into account the oceanographic situation in 2015.



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Weather forecast websites

Mediterranean Wave Forecast	http://isramar.ocean.org.il
Aeronautica Militare Italiana	http://www.meteoam.it
Consorzio Lamma	http://www.lamma.rete.toscana.it
Windfinder	http://it.windfinder.com
Hellenic National Meteorological Service	http://www.hnms.gr



Index of the tables

Table 1 - Features of Sub-area C "inside"9
Table 2 - Features of Sub-area C "outside"9
Table 3 - Features of Sub-area D9
Table 4 - Features of Sub-area F.....9
Table 5 - Diary report of the surveys: Area C15
Table 6 - Diary report of the surveys: Area D and F16
Table 7 - Overview of the BFT sightings32
Table 8 - Positions of the sightings33

Index of the figures

Figure 1 - The I-GNIT aircraft and team6
Figure 2 - I-GNIT aircraft, a bubble window6
Figure 3 - The I-AGSD aircraft and team.....7
Figure 4 - The I-AGSD aircraft, a bubble window7
Figure 5 - Aerial Survey 2015: UNIMAR Survey area (blue colored)10
Figure 6 - Area and sampler routes: Sub-area C "outside"10
Figure 7 - Area and sampler routes: Sub-area C "inside"11
Figure 8 - Area and sampler routes: Sub-area D11
Figure 9 - Area and sampler routes: Sub-area F.....12
Figure 10 - GPS tracks: Sub-area C "inside", replica 1 and 225
Figure 11 - GPS tracks: Sub-area C "outside"25
Figure 12 - GPS tracks: Sub-area D26
Figure 13 - GPS tracks: Sub-area F.....26
Figure 14 - Map of the BFT sightings (number of individuals and total weight): Sub-area C ..28
Figure 15 - Map of the BFT sightings (number of individuals and total weight): Sub-areas D-F
.....29
Figure 16 - Map of the other species sightings: Sub-area C.....30
Figure 17 - Map of the other species sightings: Sub-areas D and F31



6. ANNEXES

1. Forms
2. GPS tracks
3. Photos
4. High quality maps images
5. Power Point presentation