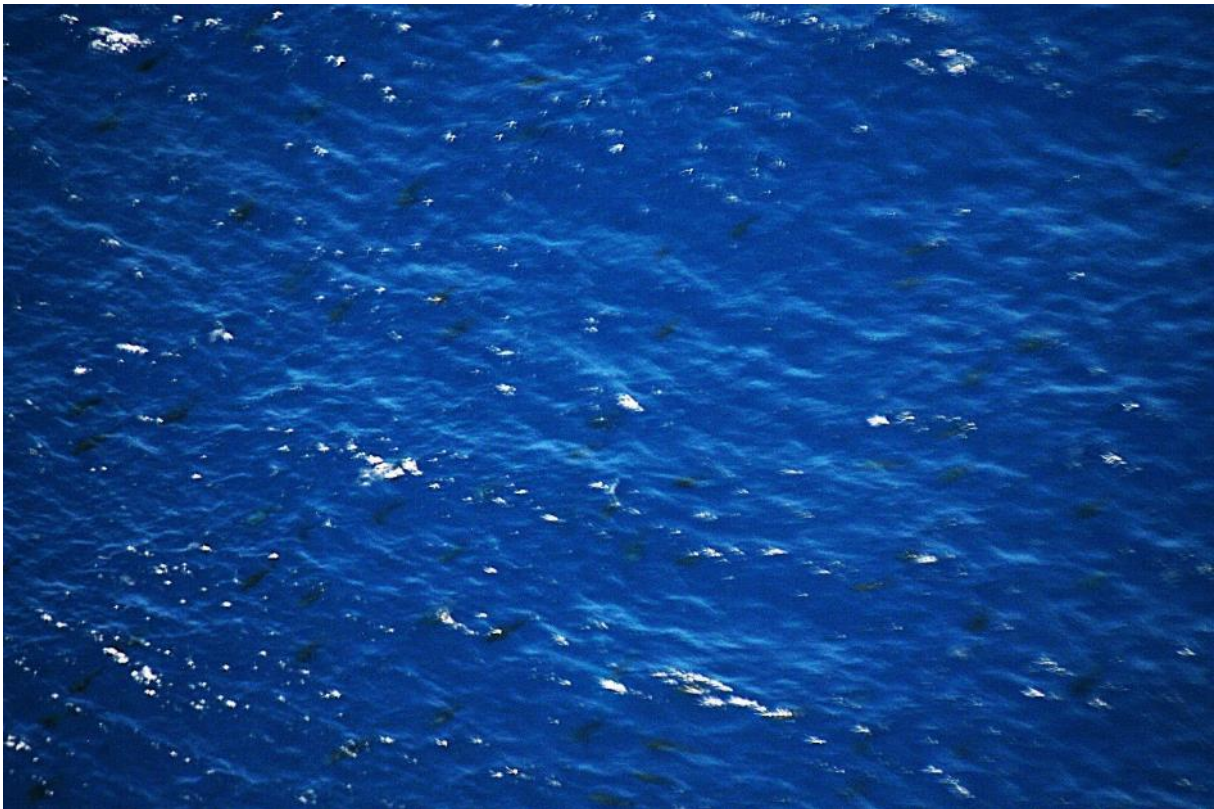




AERIAL SURVEY FOR THE MONITORING OF BLUEFIN TUNA SPAWNING AGGREGATIONS IN THE MEDITERRANEAN SEA

ICCAT GBYP Phase 14

Balearic Sea – Area A



This project is co-funded
by the European Union

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This work was carried out under the provision of the ICCAT. The contents of this document do not necessarily reflect the point of view of ICCAT, which has no responsibility over them, and in no ways anticipate the Commission's future policy in this area.

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ABSTRACT

Atlantic bluefin tuna (*Thunnus thynnus*) is a shared fishery resource with high market value exploited by more than twenty countries. In this context, ICCAT through its research program on Bluefin tuna GBYP, has been conducting aerial surveys in the Mediterranean Sea since 2010. Its main aims are to improve the knowledge of key biological processes of this species and develop independent indices of the fisheries, to define international management policies for a sustainable use of this resource. This report presents the aerial survey carried out by the company Air Périgord in area A - Balearic Sea in 2024. The survey area is located from the west of Ibiza island to the east of Menorca island. The survey included 4 replicas with 30 transects situated from north to south. CESSNA 337 aircraft equipped with bubble windows was used, flying at an altitude of 1,000 feet and a speed of 100 knots. The survey took place from 4 to 24 June 2024. In total 485 sightings were recorded including 12 of Atlantic bluefin tuna. The most numerous were sightings of Loggerhead turtles – 261.

Keywords: Thunnus thynnus, aerial survey, Mediterranean, abundance.

INTRODUCTION

The Atlantic bluefin tuna (*Thunnus thynnus*) is distributed throughout the Atlantic and the Mediterranean Sea (Figure 1). That makes it a shared fishery resource, with high market value which is exploited by more than twenty countries. The improvement of knowledge of the biological processes of bluefin tuna is essential in order to develop an international stock management policy for the sustainable exploitation of this resource.

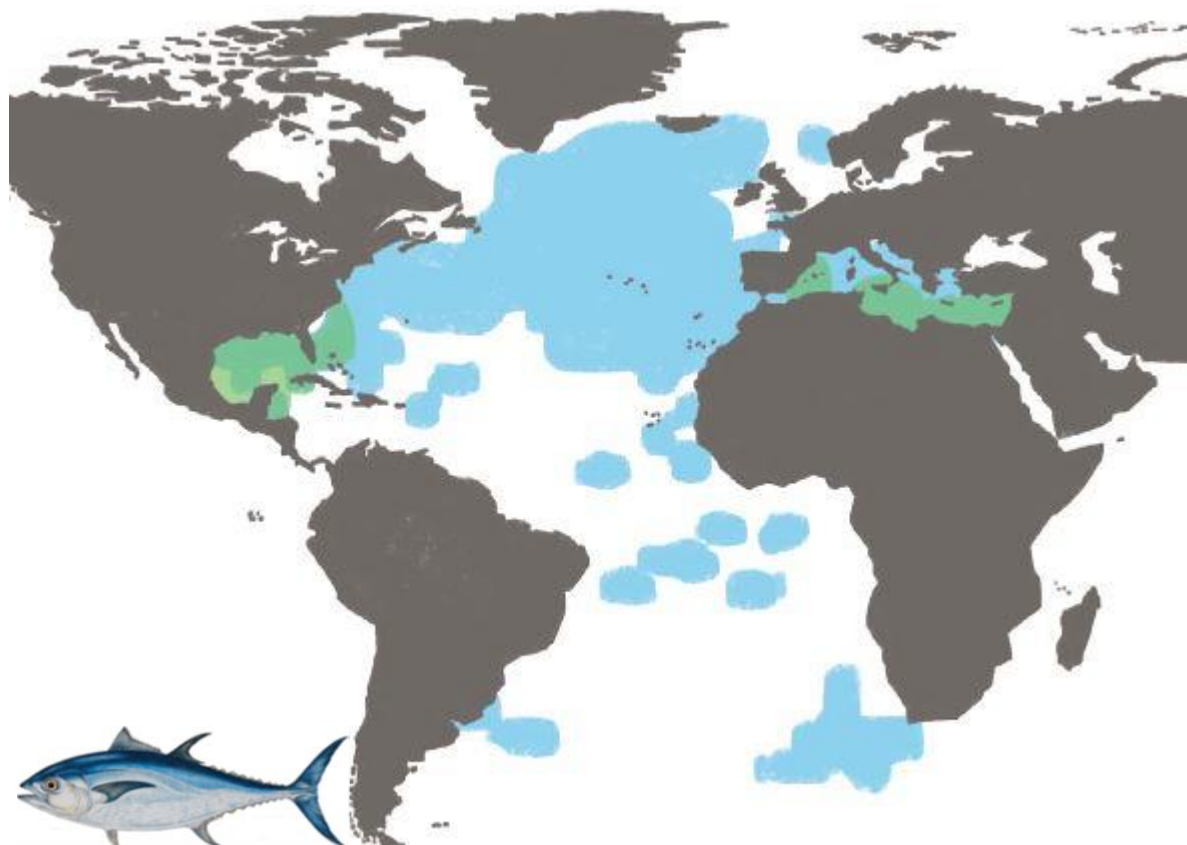


Figure 1: Atlantic bluefin tuna (*Thunnus thynnus*) distribution range (blue: adult range, green: spawning areas). Source: ETN.

The main objectives of the International Commission on the Conservation of Tunas in the Atlantic (ICCAT), Atlantic-Wide Bluefin Tuna Research Programme (GBYP) are to improve:

- a) the understanding of key biological and ecological processes,
- b) current assessment methodology,
- c) the management procedures, and

d) advice.

Key tasks are to reduce uncertainty in stock assessment and to provide robust management advice. This requires improved knowledge of key biological processes and parameters. Currently, almost all the data used in stock assessments are obtained from fisheries-dependent data, which can be affected by changes in exploitation patterns and TACs. It is therefore important to obtain data from alternative sources, such as fishery-independent indices, in order to verify the assumptions made when conducting the assessments or to improve the current data sets used in OM or MSE.

The comprehensive ICCAT GBYP was initiated 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 out in 4 areas in the Mediterranean Sea, which were, identified as spawning areas based on biological and traditional knowledge, as well as recent fishery data. In 2013 and 2015, 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. In 2017, ICCAT decided to restrict the survey to the 4 initial areas and so was done in 2017, 2018, and 2019. From the 2022 campaign, ICCAT decided to exclude Area G and cover only the following three ones (Figure 2):

A - Balears

C - Southern Tyrrhenian Sea

E - Sicily Channel

This report describes the activities and the results from the 2024 survey, covering Area A conducted by Air Perigord company.

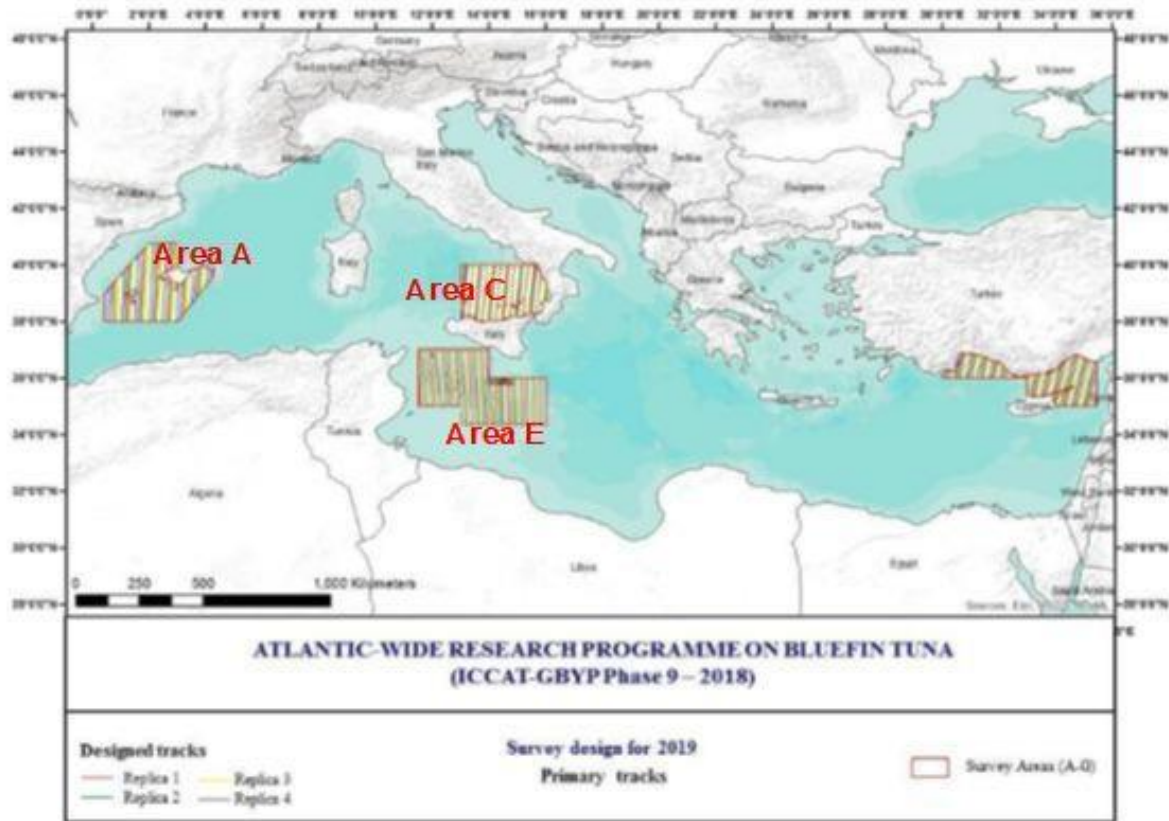


Figure 2: Areas A, C, and E surveyed in 2024.

MATERIALS AND METHODS

The activities were carried out following the mandate of the ICCAT tender and the technical specifications annexed to the contract. The reproductive behavior of bluefin tuna in the Mediterranean, detailed by *Fromentin & Powers (2005)*, *Ravier and Fromentin (2001)*, and *Mather et al. (1995)*, explains that individuals tend to accumulate in schools from late May to early July, with maximum aggregation when water temperatures exceed 20°C. This mission was carried out in June 2024. It began on 4 June and ended on 24 June 2024.

PLANE AND TEAM

The company AIR Périgord specializes in aerial surveillance of natural resources. It was tasked by ICCAT to lead the 2024 aerial surveillance campaign for area A.

The aircraft used during this mission was a CESSNA 337 Skymaster “push-pull” registered F-GMBE. This type of aircraft is designed for maritime air surveillance. It has great autonomy, high wings, and two in-line engines at the front and rear of the fuselage, which ensures high security. This aircraft was equipped, on the recommendations of ICCAT with “bubble windows” (Figure 3). These were situated on both sides of the rear seats to improve observations and data collection in flight.



Figure 3: Bubble window

During the observations, the plane flew at 1,000 feet altitude and a constant speed of 100 knots (nautical mile/h).

The crew was made up of four members (Figures 4 and 5):

- Professional pilot (P): Patrick Féron
- Professional spotter (PS): Charles Sauvaire
- Scientific spotter (SS) and cruise leader (CL): Dimitar Popov
- Scientific spotter (SS): Lea David (3-6 June 2024), Pascal Hacquebart (7-16 June 2024) and Pierre Andre Farque (17-24 June 2024).

The positioning of the crew in the aircraft is essential for the proper data collection. The pilot is positioned at the front left of the aircraft. The professional observer is at the front right to have maximum visibility to the front and sides. Both scientific observers are at the rear scanning the surveyed strip through the bubble windows changing places each flight (Figure 6).



Figure 4: AIR Perigord team at the start of the mission (left to right): Patrick Féron (pilot), Charles Sauvaire (PS), Lea David (SS), and Dimitar Popov (SS, CL).



Figure 5: AIR Perigord team at the end of the mission (left to right): Dimitar Popov (SS, CL) Charles Sauvaire (PS), Pierre Andre Farque (SS), and Patrick Féron (pilot).

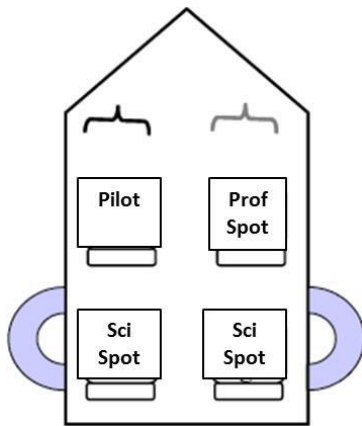


Figure 6: Position of crew in the aircraft during the survey flights.

EQUIPMENT

The plane was equipped with a Garmin GPS on the front of the aircraft for the pilot. In order to facilitate data collection by scientific observers, a second handheld GPS device (Garmin 78s, Figure 7a) was used by the scientific observers. Altitudes were downloaded by the pilot's GPS device which was more precise than the scientists' handheld GPS. Despite of that it should be considered that GPS altitude data in airplanes is rarely precise.



Figure 7: Equipment used – a) GPS Garmin 78s, b) SUUNTO PM 5/360PC inclinometer

Each of the scientific observers at the rear used a SUUNTO PM 5/360PC inclinometer (Figure 7b), to measure the declination angle between the aircraft and the recorded sighting (schools of fish or another marine megafauna). This measurement allows by a simple trigonometry calculation of perpendicular distance between the transect line and the observed object which is the basis of the distance sampling method. To facilitate searching effort that according to field protocol must have concentrated closer

to the line (90% of effort between 90° and 40°), marks were on the bars supporting the wings indicating 60°, 40°, 20° and 10° were used. In order to photograph the schools of tuna and other species observed during the mission, a digital SLR camera Canon EOS 350D with an 18-200 mm zoom lens with a 62 mm polarizing filter was used. After testing several settings, we opted for taking pictures at shutter speed priority mode (S) with a speed of 1/1250 and ISO 400 or 200. Scientific observers used a portable computer to fill the Effort and Sightings Excel forms during the flight.

STUDY AREA

Study area A is located in the Balearic Sea. It extends from the west of the island of Ibiza to the east of the island of Menorca. The area is divided into 4 straight replicas oriented from North to South (Figure 8).

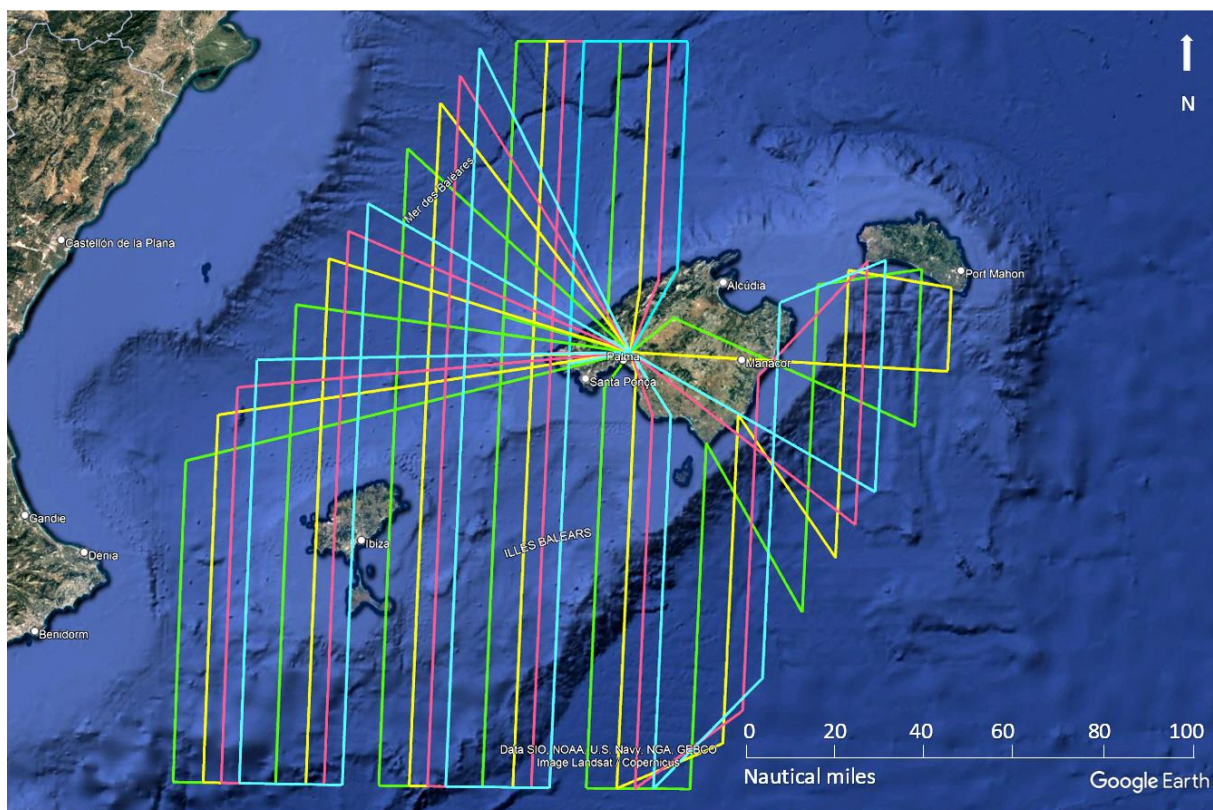


Figure 8: 4 Replicas of area A: Replica 1 (yellow) – 8 transects; Replica 2 (pink) – 7 transects; Replica 3 (blue) – 7 transects; Replica 4 (green) – 8 transects

Each replica included 7 or 8 transects. The theoretical total length of transects was 3,189 nm (Table 1). Realized effort was shorter due to constraints related to terminal areas of airports as well as a short part of transect 6 of replica 2 that was within Cabrera NP before authorization was granted.

Transect	1	2	3	4	5N	5S	6	7	8	Total (nm)
Replica 1 (nm)	75	116	150	164	55	92	72	63	18	805
Replica 2 (nm)	87	122	156	163	53	82	73	58		794
Replica 3 (nm)	93	109	162	158	50	82	75	51		780
Replica 4 (nm)	71	105	134	164	61	92	76	72	35	810
Total	326	452	602	649	219	348	296	244	53	3189

Table 1: Transect lengths and replicas of Area A.

All flights have been carried out from Son Bonet Airport at Palma on the island of Mallorca.

The environmental conditions were the main factors limiting observation, and more particularly the force of the wind which affects the sea state. In order to carry out the mission in optimum conditions for observing schools of bluefin tuna, the ICCAT GBYP Aerial Survey Field Protocol has set certain limits for environmental factors. The protocol recommended survey flights to be performed during wind of maximum Beaufort 3, no low cloud, no rain, and a minimum visibility of 3.5 km. The weather forecast was regularly checked using mainly the website windy.com that is providing 5 forecast models (ECMWF, GFS, ICON-EU, and ICON). It was known from the previous year's survey that low clouds may pose a challenge and those were checked together with wind speed.

FLIGHTS AUTHORISATION

After several preparatory email exchanges with ENAIRE, the competent body of Spanish Civil Aviation, in particular, to ensure that there would not be any major military exercises in the working area as in 2023, we applied on 17 May 2024 to

ENNAIRE for flight authorizations to carry out the ICCAT campaign in area A. We received the authorization on 27 May 2024.

As in previous years, it specified, among other things, instructions to penetrate the permanent military dangerous area D 26. Regarding the restricted area surrounding the Cabrera Island National Park, it was agreed as in previous years that it would be ICCAT which would request authorization given its relations with the Directorate of National Parks.

No particular problem appeared during the flights, air traffic control has always been cooperative and professional. Apart from a few miles in the vicinity of the terminal areas of Ibiza and Palma airports (18 miles in total, see details on flight report), all the transects could be flown.

Authorization to enter Cabrera National Park came late due to internet connection difficulties and a change of address. During replica 1, 19 miles of transect 6 could not be flown, but this missing segment was covered during the flight for replica 3. During replica 2, 10 miles of transect 6 were not covered.

Regarding the military dangerous area D 26, it was always free at the time of the eight flights which required penetration of this area. On one occasion we had to delay the flight so that we reach the area after the activation period.

In conclusion, only 18 nm near the airports and 10 nm in Cabrera National Park were not covered out of a total of 3,189 miles planned transects.

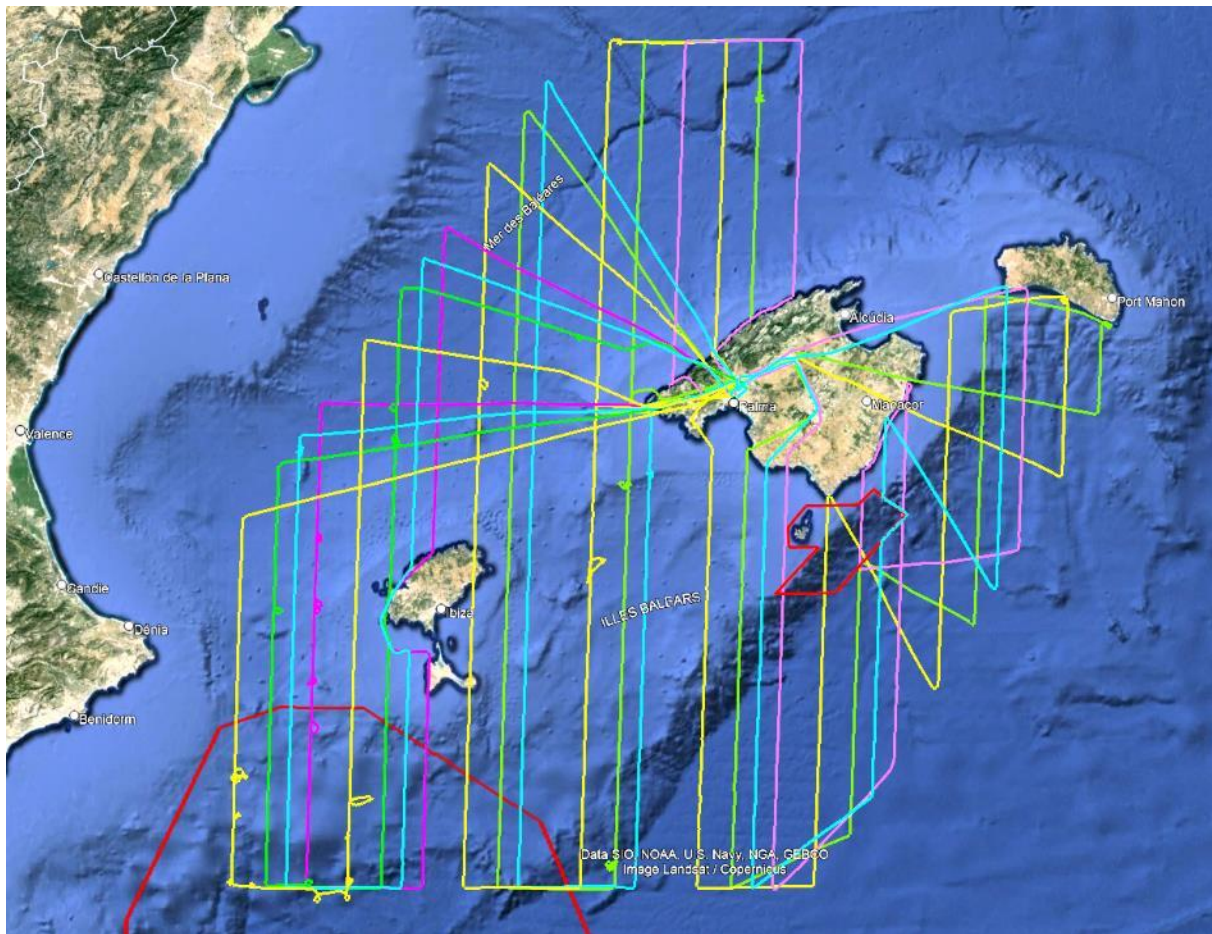


Figure 9: Realized flights and overlap with restricted areas – Cabrera NP and D26

FIELD PROTOCOL

The day before each flight, the pilot prepared the flight plans and checked the compatibility of planned transect distances with aircraft capabilities. He and the cruise leader checked together the transects to be done, and the weather forecasts. Once agreed those were good and flight can be conducted, the pilot checked flight authorizations, as well as NOTAMs. He was also responsible for programming the plane GPS for better teamwork during the flight.

During the flight, observations were carried out along transects, and on some occasions during transit flights. When the aircraft is on transect the whole team is in search effort mode: this event is recorded in effort forms as "ON EFFORT". Between the lines and during transit flights, the team was usually at rest: this was recorded as "OFF EFFORT". Two data sheets were completed throughout the flight, one for the general data of the

flight and the weather (effort form) and one for observations (sightings form): Appendices 1&2.

When a school of tuna was spotted, the first GPS point was marked by the scientist on the side opposite the school of fish: we call this point the 1st observation (F). The pilot remained on the transect and continued along the transect until the school was perpendicular to the scientific observer who then measured the declination angle. At the same time, the other scientific spotter marked a new GPS point: we call this point Abeam(A). Once this data was recorded, the pilot left the transect, guided by the professional observer who tracked the detected tuna school. The pilot circled over the tuna school, always in a clockwise direction, so that the PS could observe better and determine the species, school size, and weights of each fish. The scientific observer on the right side also made an estimation and when possible was taking as many photos as possible. In the same time, the other scientific observer marked GPS points for leaving the transect (LE) and circling over the school (C). He also recorded the estimates and remarks of the two observers on the right. Once the data had been recorded, the team decided to return to the transect to continue surveying it a new GPS point was recorded (RE). The scheme of the followed field protocol during sightings is shown (Figure 10). Weather conditions were recorded at the start of each transect and when a change of conditions (sea state, glare, etc.) occurred a new GPS point was marked and recorded in the Effort form.

At the end of each flight, the GPS tracks are extracted, recorded, and transferred to BaseCamp 4.7.5 and QGIS 3.16.5 to review and validate data and produce maps for better readability of the results.

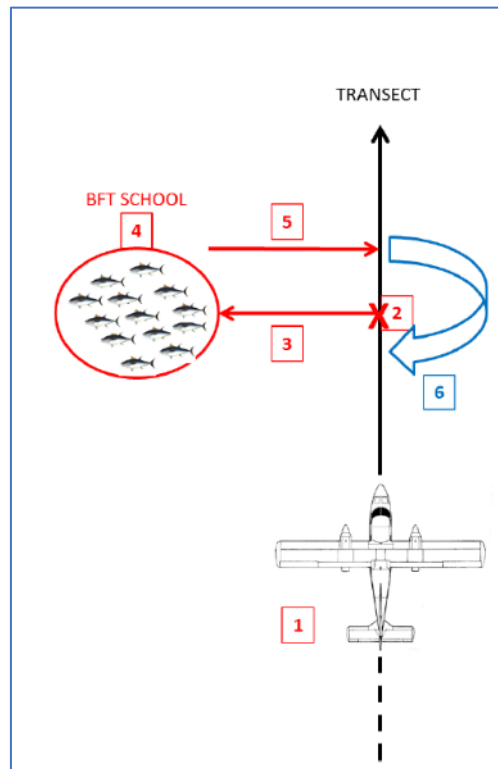


Figure 10: Scheme of the survey protocol during a sighting of BFT. 1 = F, 2 = A, 3 = LE, 4 = C, 5 = RE.

RESULTS

A total of 16 survey flights (Figure 11) were carried out during the mission. Seven (8, 9, 11, 14, 19, 20, 23 June) flight days were canceled before takeoff due to poor weather forecast: winds above 3 Beaufort or low clouds. On two of the days (13 and 21 June) two flights were performed and thus missed days due to bad weather were to large extent compensated. Details for all conducted flights are presented in table 2.

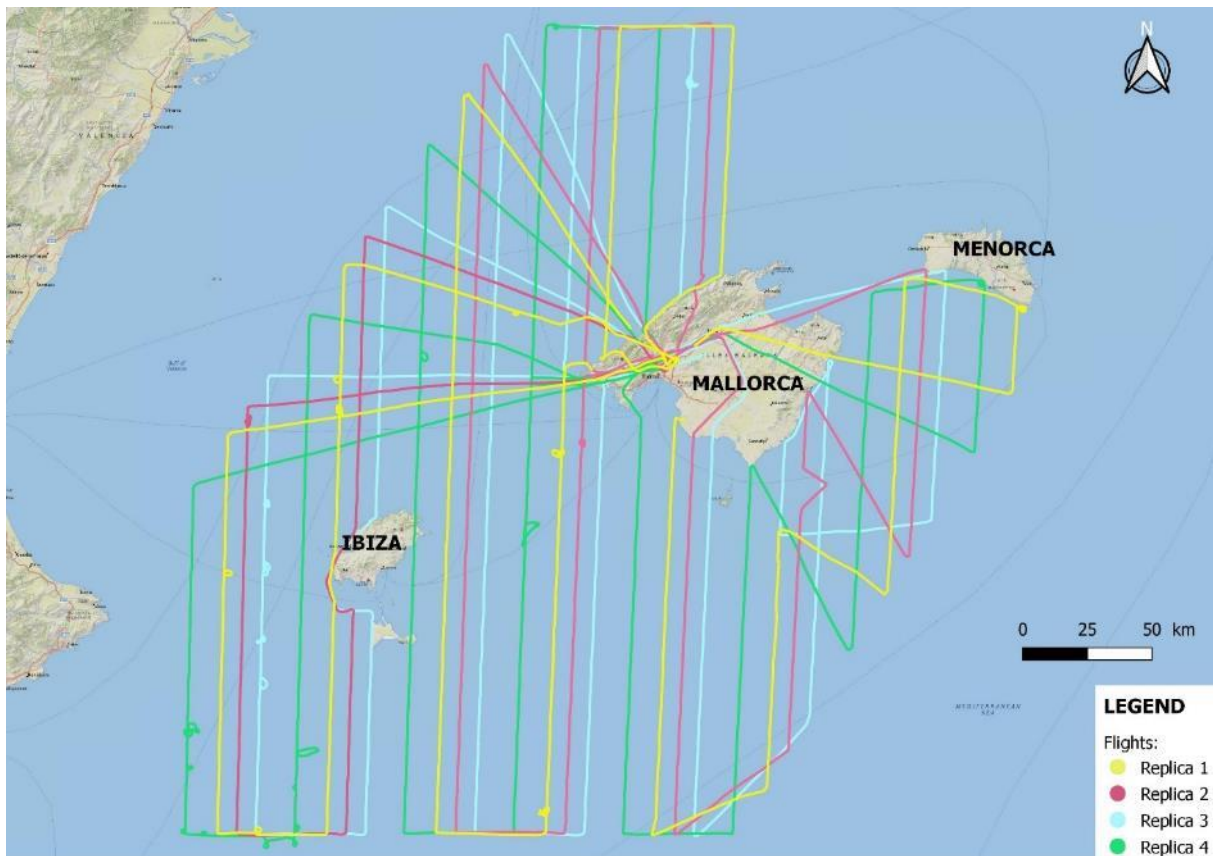


Figure 11: Realized survey flights (GPS tracks)

ICCAT 2024 Area A - Flight report

Dates		Airports		UTC		Flight duration	Flights	Transects	Comments
		Take off	Landing	Depart.	Arrival				
Monday	03 June 2024	LFIB	LFNG	9:05	10:25	1:20		Ferry	
Monday	03 June 2024	LFNG	LESB	12:00	14:10	2:10		Ferry	
Tuesday	04 June 2024	LESB	LESB	12:55	15:00	2:05	1	Replica 1 transects 4N, 5N	
Wednesday	05 June 2024	LESB	LESB	7:20	11:20	4:00	2	Replica 1 transects 5S, 6, 7, 8	19 miles north of transect 6 not flown: no permit for Cabrera park
Thursday	06 June 2024	LESB	LESB	9:50	13:45	3:55	3	Replica 1 transects 3, 4S	
Friday	07 June 2024	LESB	LESB	8:10	10:05	1:55	4	Replica 2 transects 4N, 5N	
Saturday	08 June 2024								No flight because of weather
Sunday	09 June 2024								No flight because of weather
Monday	10 June 2024	LESB	LESB	9:00	12:40	3:40	5	Replica 2 transects 5S, 6, 7	10 miles of transect 6 not flown: no permit for Cabrera park
Tuesday	11 June 2024								No flight because of weather
Wednesday	12 June 2024	LESB	LESB	11:50	15:25	3:35	6	Replica 2 transects 3, 4S	
Thursday	13 June 2024	LESB	LESB	7:55	11:45	3:50	7	Replica 1 transects 1, 2	3 miles not flown in the vicinity of Ibiza airport
Thursday	13 June 2024	LESB	LESB	13:45	15:35	1:50	8	Replica 3 transects 4N, 5N	
Friday	14 June 2024								No flight because of weather
Saturday	15 June 2024	LESB	LESB	6:45	10:40	3:55	9	Replica 3 transects 5S, 6, 7	Segment of 19 miles of replica 1 transect 6 not flown during flight 2 flown during this flight
Sunday	16 June 2024	LESB	LESB	9:55	13:45	3:50	10	Replica 2 transects 1, 2	5 miles not flown in the vicinity of Ibiza airport

Area A

Monday	17 June 2024	LESB	LESB	7:30	11:05	3:35	11	Replica 3 transects 3, 4S		
Tuesday	18 June 2024	LESB	LESB	10:10	14:20	4:10	12	Replica 3 transects 1, 2	4 miles not flown in the vicinity of Ibiza airport	
Wednesday	19 June 2024								No flight because of weather	
Thursday	20 June 2024								No flight because of weather	
Friday	21 June 2024	LESB	LESB	7:05	11:25	4:20	13	Replica 4 transects 5S, 6, 7, 8	6 miles not flown in the vicinity of Palma airport	
Friday	21 June 2024	LESB	LESB	13:40	15:40	2:00	14	Replica 4 transects 4N, 5N		
Saturday	22 June 2024	LESB	LESB	7:30	11:30	4:00	15	Replica 4 transects 1, 2		
Sunday	23 June 2024								No flight because of weather	
Monday	24 June 2024	LESB	LESB	7:10	10:45	3:35	16	Replica 4 transects 3, 4S		
Tuesday	25 June 2024	LESB	LFNG	8:30	10:30	2:00		Ferry		
Tuesday	25 June 2024	LFNG	LFIB	11:55	13:05	1:10		Ferry		
						60:55	Total flight time			
						54:15	Survey flight time			
						6:40	Ferry flight time			

Table 2: Details on all flights conducted in Area A by AIR Perigord

DETAILS FOR EACH FLIGHT

The results for each flight are presented through two tables summarizing the duration of each flight including time spent on, off effort, and circling above (potential) sightings. All times are in UTC. A map showing the track recorded by the pilot's GPS together with recorded sightings (including off-effort) is included.

Flight 1: 4 June 2024, Replica 1: Transects 4N and 5N

SURVEY DATA SUMMARY	
Date	4.6.2024
Survey	1
Departure Time (UTC)	12:55:03
Landing Time (UTC)	15:00:28
Total Time	2:05:25
On effort time	1:18:59
Circle time	0:08:24
Off effort time	0:46:26

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	1
BFT	1	SWO	2
FIN	0	MOB	6
UDO	7	SDO	0
RIS	0	MIN	0
PIL	0	CUV	0
UNF	0	BOT	0
SHA	1	CAR	0
TOTAL			18



Figure 12: GPS track and recorded sightings in flight 1

Flight 2: 5 June 2024, Replica 1: Transects 5S, 6, 7, 8

SURVEY DATA SUMMARY	
Date	5.6.2024
Survey	2
Departure Time (UTC)	7:20:32
Landing Time (UTC)	11:20:28
Total Time	3:59:56
On effort time	2:09:11
Circle time	0:00:00
Off effort time	1:50:45

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	0	SWO	0
FIN	1	MOB	0
UDO	1	SDO	0
RIS	0	MIN	0
PIL	0	CUV	0
UNF	1	BOT	0
SHA	1	CAR	37
TOTAL			41



Figure 13: GPS track and recorded sightings in flight 2

Flight 3: 6 June 2024, Replica 1: Transects 3, 4S

SURVEY DATA SUMMARY	
Date	6.6.2024
Survey	3
Departure Time (UTC)	9:50:32
Landing Time (UTC)	13:45:18
Total Time	3:54:46
On effort time	2:42:33
Circle time	0:15:27
Off effort time	1:12:13

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	2	SWO	0
FIN	0	MOB	1
UDO	3	SDO	0
RIS	0	MIN	0
PIL	0	CUV	1
UNF	0	BOT	1
SHA	0	CAR	8
TOTAL			16

1 MOB – OFF EFFORT

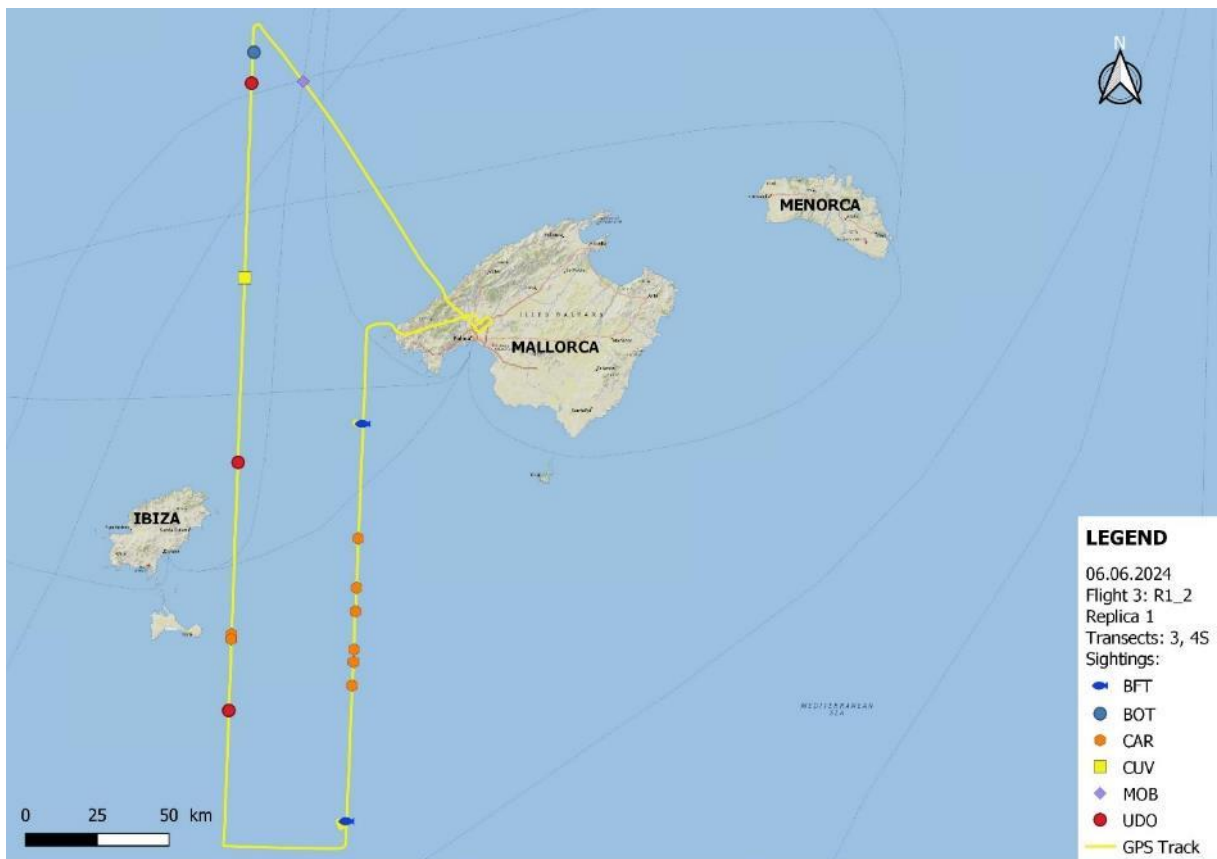


Figure 14: GPS track and recorded sightings in flight 3

Flight 4: 7 June 2024, Replica 2: Transects 4N, 5N

SURVEY DATA SUMMARY	
Date	7.6.2024
Survey	4
Departure Time (UTC)	8:10:11
Landing Time (UTC)	10:05:02
Total Time	1:54:51
On effort time	1:09:31
Circle time	0:00:00
Off effort time	0:45:20

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	0	SWO	0
FIN	0	MOB	0
UDO	0	SDO	0
RIS	1	MIN	0
PIL	0	CUV	0
UNF	0	BOT	0
SHA	0	CAR	3
TOTAL			4

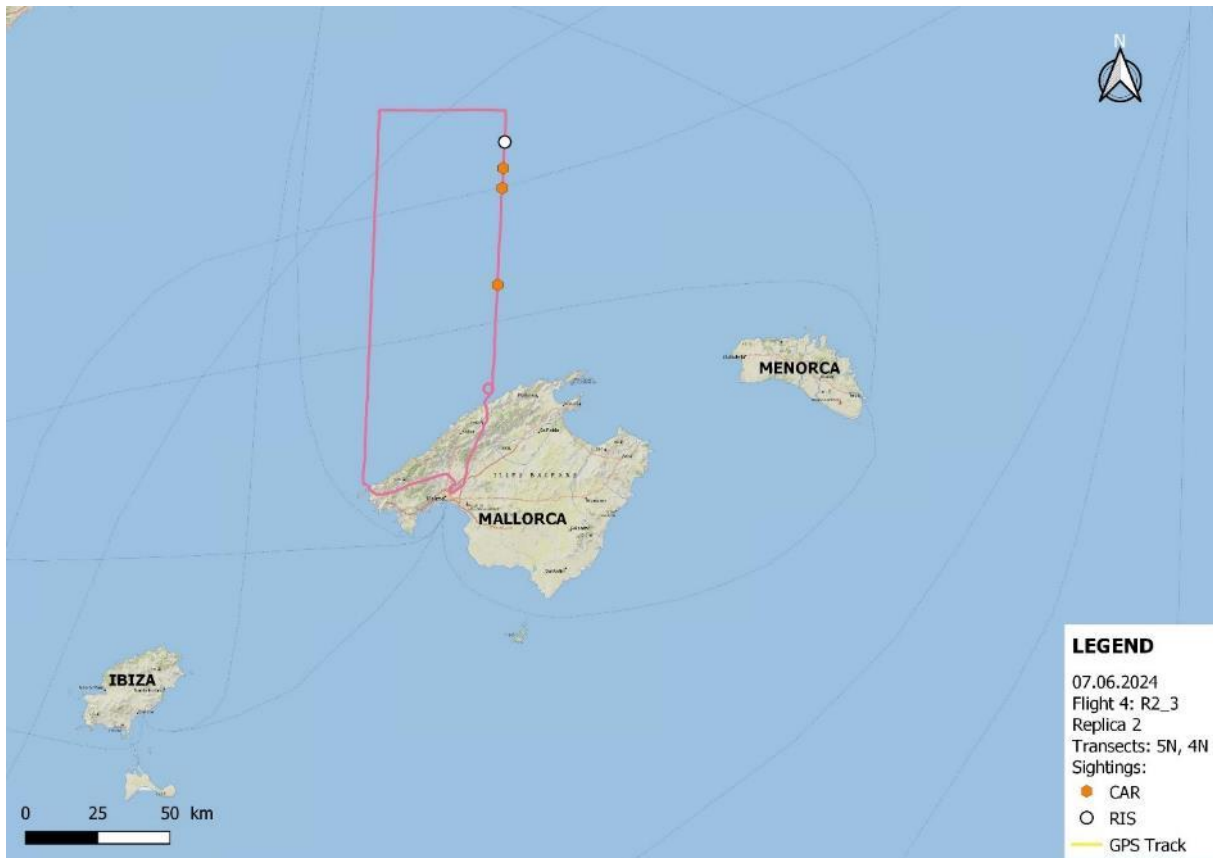


Figure 15: GPS track and recorded sightings in flight 4

Flight 5: 10 June 2024, Replica 2: Transects 5S, 6, 7

SURVEY DATA SUMMARY	
Date	10.6.2024
Survey	5
Departure Time (UTC)	9:00:06
Landing Time (UTC)	12:40:37
Total Time	3:40:31
On effort time	1:59:48
Circle time	0:00:00
Off effort time	1:40:43

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	0	SWO	0
FIN	0	MOB	2
UDO	3	SDO	0
RIS	2	MIN	0
PIL	0	CUV	0
UNF	0	BOT	0
SHA	0	CAR	19
TOTAL			26

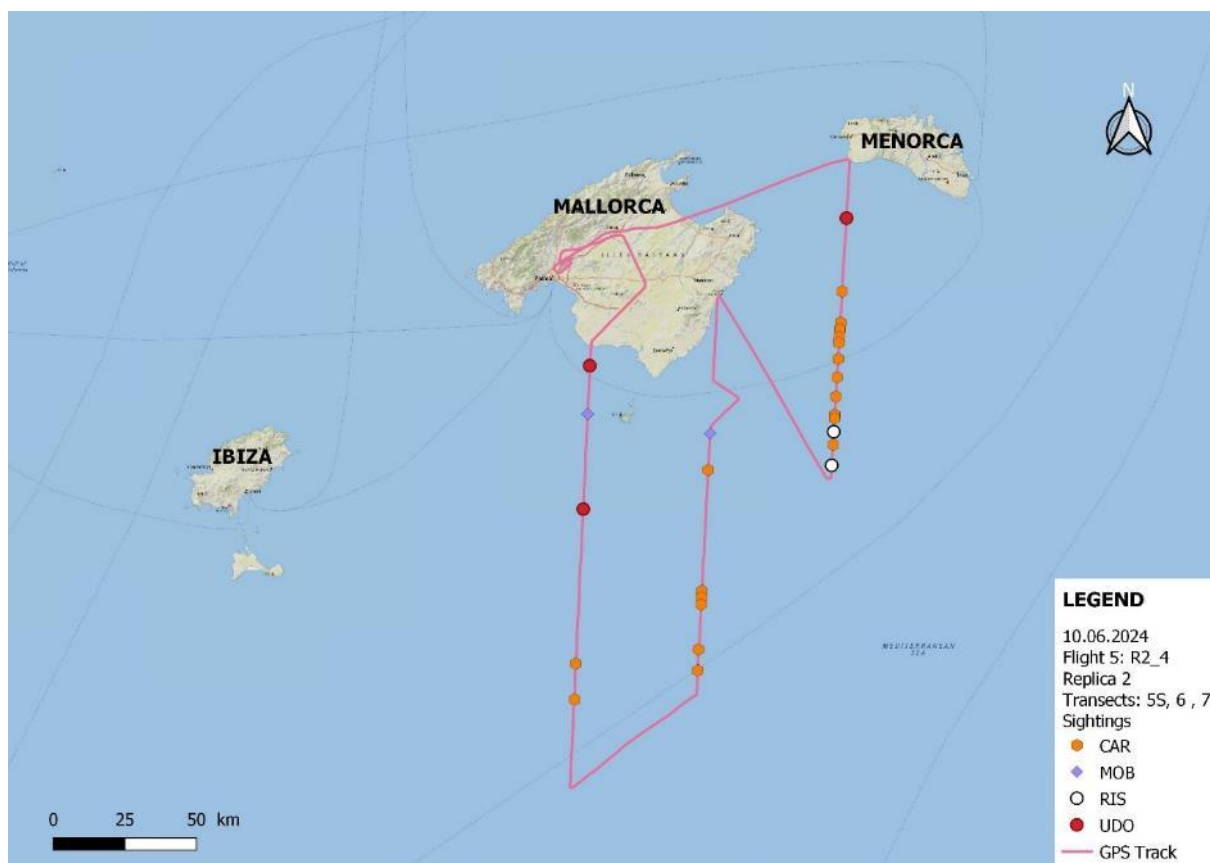


Figure 16: GPS track and recorded sightings in flight 5

Flight 6: 12 June 2024, Replica 2: Transects 3, 4S

SURVEY DATA SUMMARY	
Date	12.6.2024
Survey	6
Departure Time (UTC)	11:50:23
Landing Time (UTC)	15:25:25
Total Time	3:35:02
On effort time	2:30:08
Circle time	0:02:37
Off effort time	1:04:54

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	1
BFT	0	SWO	0
FIN	0	MOB	0
UDO	3	SDO	0
RIS	1	MIN	0
PIL	0	CUV	1
UNF	0	BOT	0
SHA	1	CAR	9
TOTAL			16

*1 CAR - OFF EFFORT

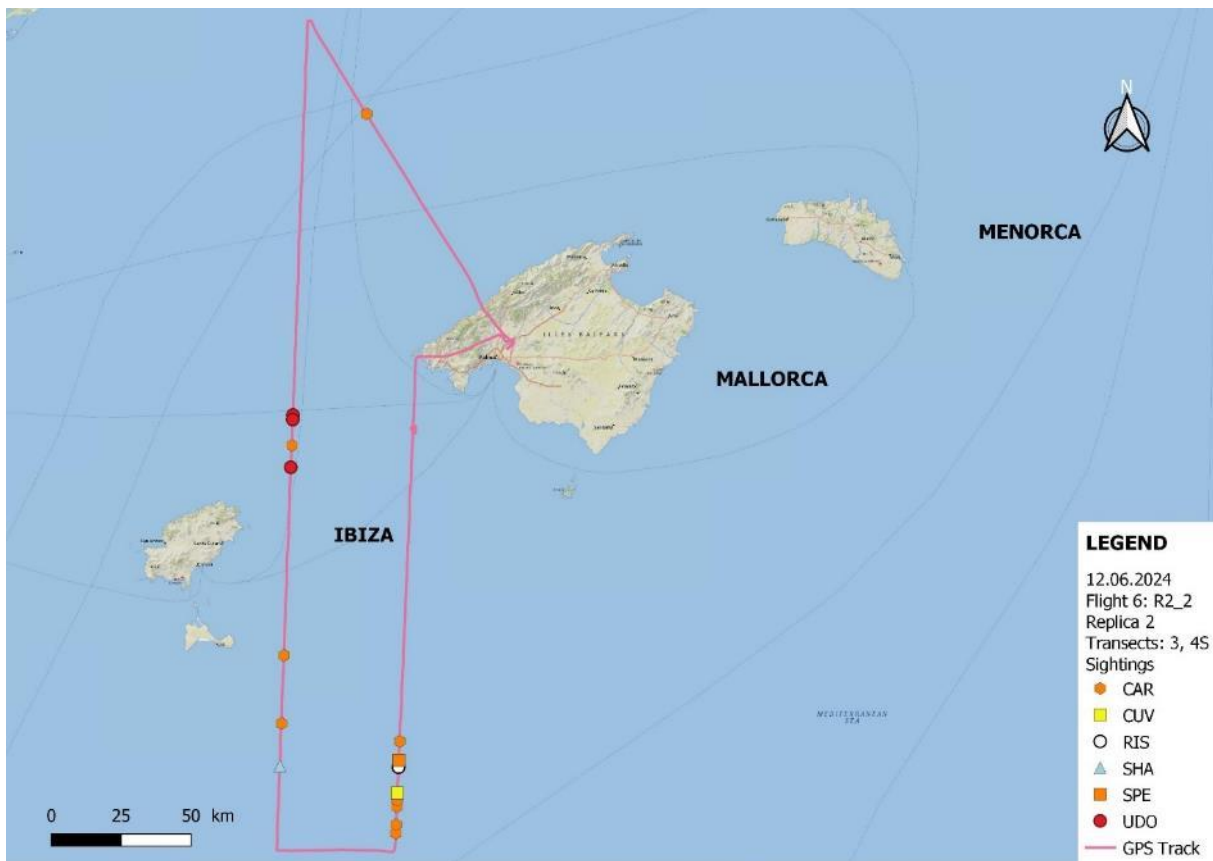


Figure 17: GPS track and recorded sightings in flight 6

Flight 7: 13 June 2024, Replica 1: Transects 1, 2

SURVEY DATA SUMMARY	
Date	13.6.2024
Survey	7
Departure Time (UTC)	7:55:06
Landing Time (UTC)	11:45:37
Total Time	3:50:31
On effort time	2:02:15
Circle time	0:10:48
Off effort time	1:48:16

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	1
BFT	1	SWO	0
FIN	0	MOB	3
UDO	11	WHA	1
RIS	0	MIN	0
PIL	0	CUV	0
UNF	0	BOT	0
SHA	13	CAR	18
TOTAL			48

*3 UDO and 1 SPE - OFF EFFORT



Figure 18: GPS track and recorded sightings in flight 7

Flight 8: 13 June 2024, Replica 3: Transects 4N, 5N

SURVEY DATA SUMMARY	
Date	13.6.2024
Survey	8
Departure Time (UTC)	13:45:27
Landing Time (UTC)	15:35:47
Total Time	1:50:20
On effort time	1:08:15
Circle time	0:00:00
Off effort time	0:42:05

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	0	SWO	0
FIN	0	MOB	6
UDO	5	WHA	0
RIS	0	MIN	0
PIL	0	CUV	1
UNF	0	BOT	0
SHA	1	CAR	3
TOTAL			16

*1 UDO and 1 MOB - OFF EFFORT

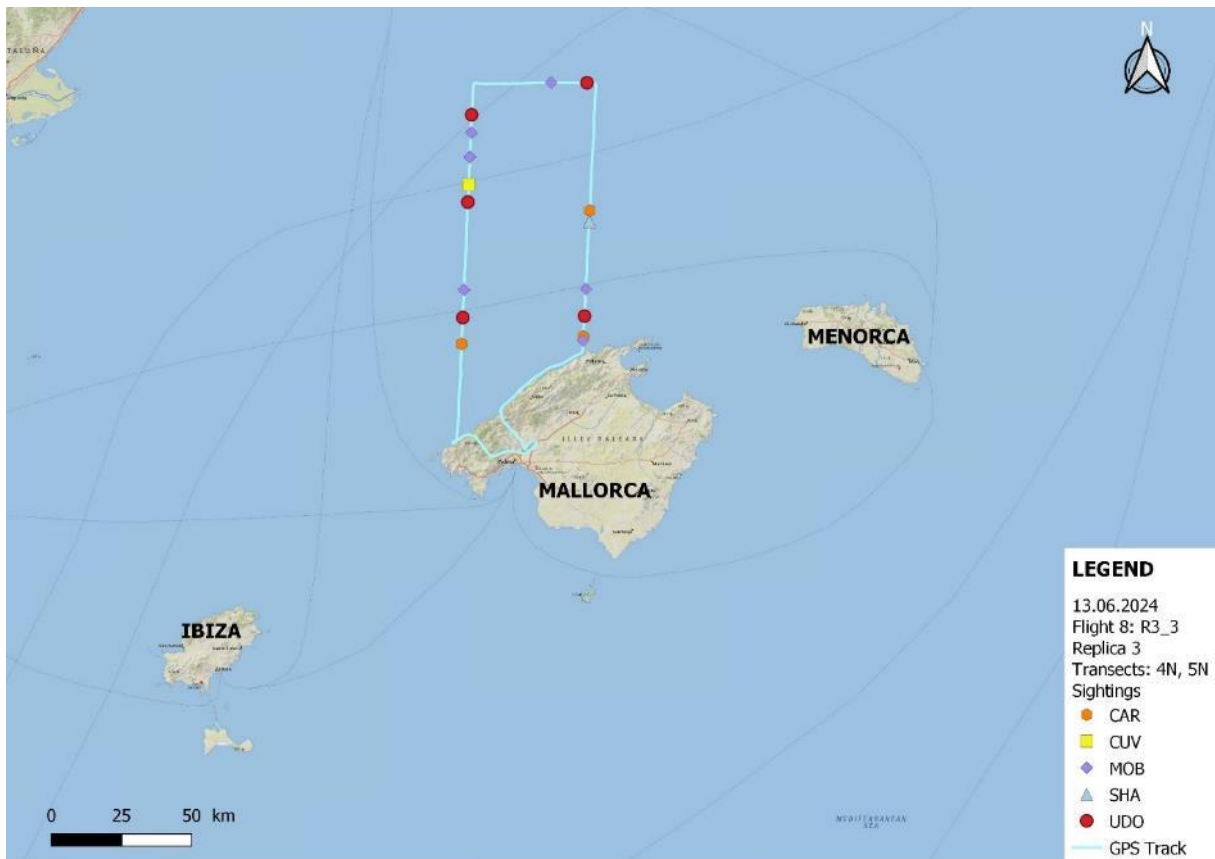


Figure 19: GPS track and recorded sightings in flight 8

Flight 9: 15 June 2024, Replica 3: Transects 5S, 6, 7

SURVEY DATA SUMMARY	
Date	15.6.2024
Survey	9
Departure Time (UTC)	6:45:06
Landing Time (UTC)	10:40:37
Total Time	3:55:31
On effort time	2:12:30
Circle time	0:00:00
Off effort time	1:43:01

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	0	SWO	1
FIN	1	MOB	2
UDO	3	WHA	0
RIS	0	MIN	0
PIL	0	CUV	0
UNF	1	BOT	0
SHA	3	CAR	46
TOTAL			57

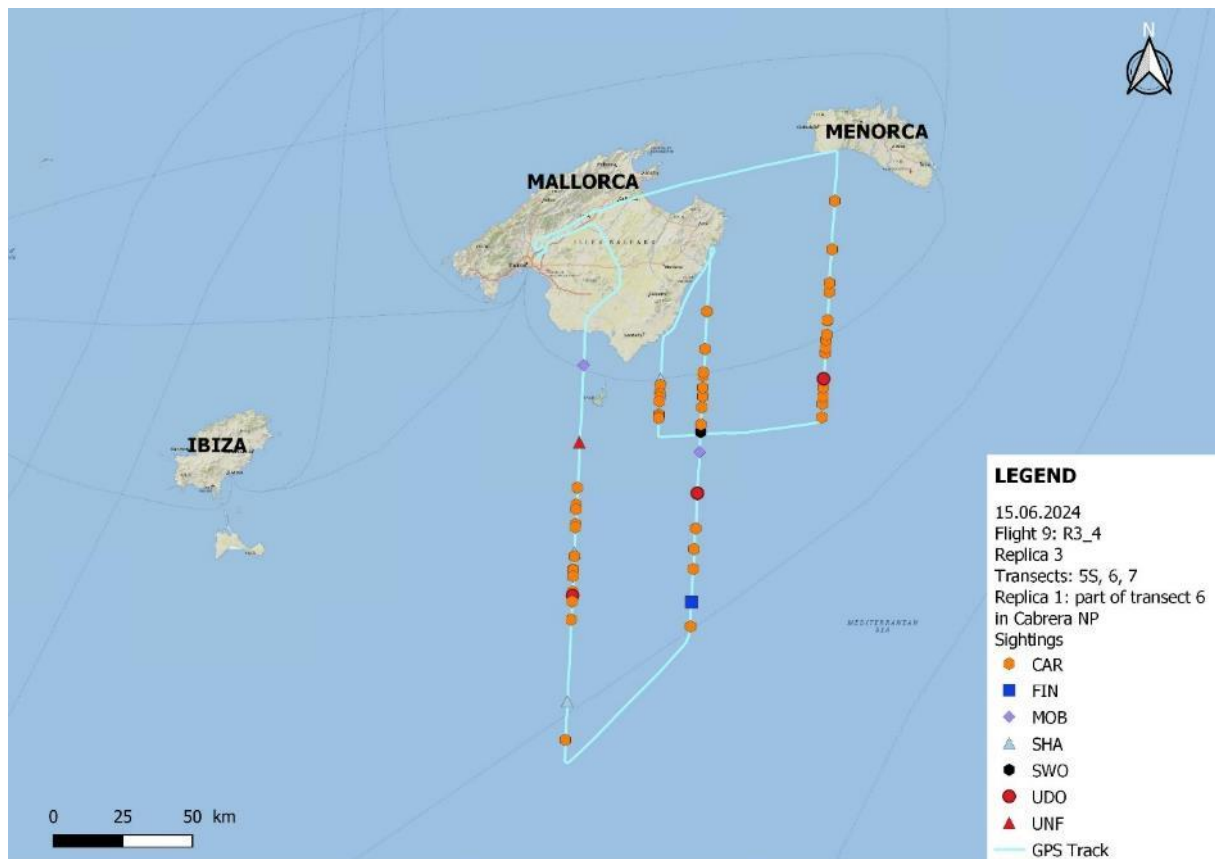


Figure 20: GPS track and recorded sightings in flight 9

Flight 10: 16 June 2024, Replica 2: Transects 1, 2

SURVEY DATA SUMMARY	
Date	16.6.2024
Survey	10
Departure Time (UTC)	9:55:16
Landing Time (UTC)	13:45:17
Total Time	3:50:01
On effort time	2:01:08
Circle time	0:07:26
Off effort time	1:48:53

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	1	SWO	0
FIN	0	MOB	3
UDO	7	WHA	0
RIS	0	MIN	0
UMM	0	CUV	0
UNF	0	BOT	0
SHA	3	CAR	20
TOTAL			34

2 UDO AND 1 CAR – OFF EFFORT

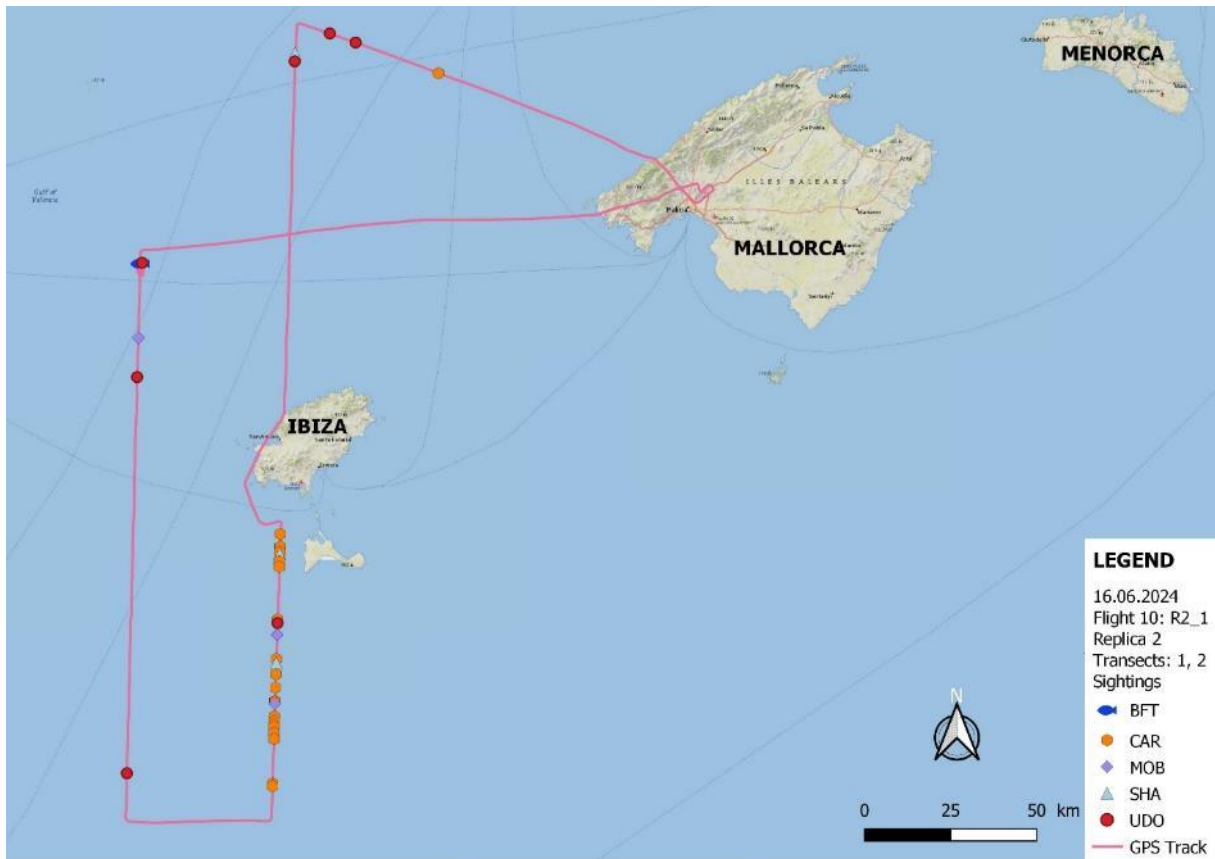


Figure 21: GPS track and recorded sightings in flight 10

Flight 11: 17 June 2024, Replica 3: Transects 3, 4S

SURVEY DATA SUMMARY	
Date	17.6.2024
Survey	11
Departure Time (UTC)	7:30:11
Landing Time (UTC)	11:05:53
Total Time	3:35:42
On effort time	2:29:53
Circle time	0:00:00
Off effort time	1:05:49

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	0	SWO	0
FIN	0	MOB	1
UDO	6	WHA	0
RIS	0	MIN	0
UMM	1	CUV	0
UNF	3	BOT	0
SHA	0	CAR	16
TOTAL			27

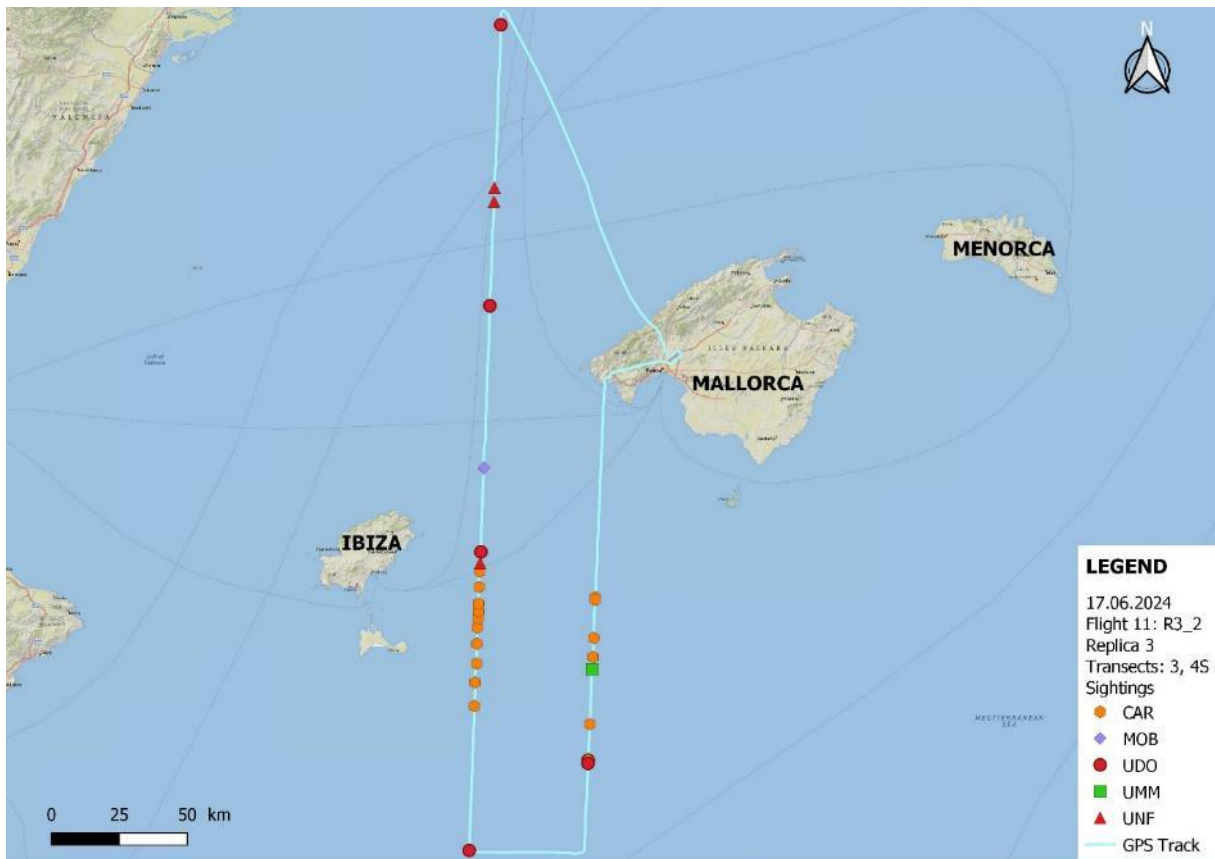


Figure 22: GPS track and recorded sightings in flight 11

Flight 12: 18 June 2024, Replica 3: Transects 1, 2

SURVEY DATA SUMMARY	
Date	18.6.2024
Survey	12
Departure Time (UTC)	10:10:15
Landing Time (UTC)	14:20:17
Total Time	4:10:02
On effort time	2:19:24
Circle time	0:23:17
Off effort time	1:50:38

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	3	SWO	1
FIN	0	MOB	0
UDO	7	WHA	0
RIS	0	MIN	0
PIL	0	CUV	0
UNF	0	BOT	0
SHA	0	CAR	22
TOTAL			33

*1 UDO – OFF EFFORT

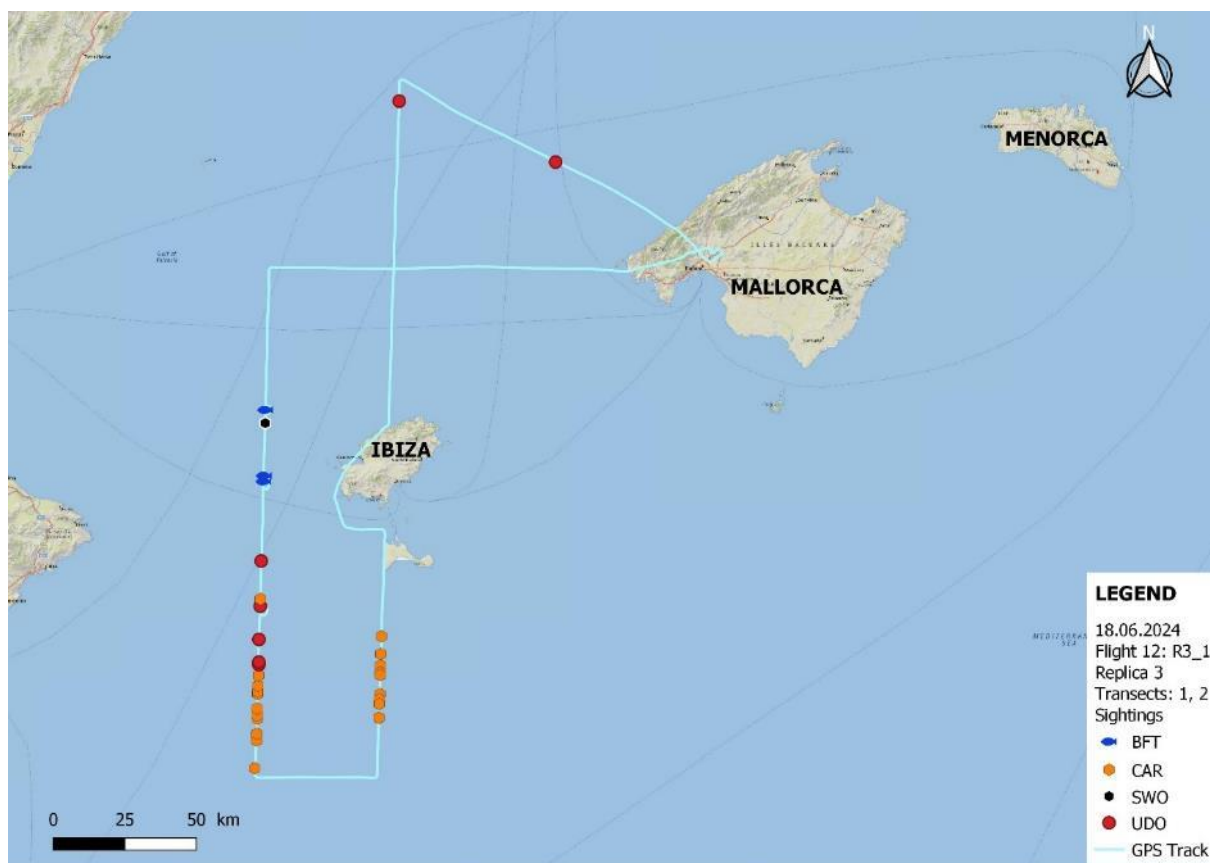


Figure 23: GPS track and recorded sightings in flight 12

Flight 13: 21 June 2024, Replica 4: Transects 5S, 6, 7, 8

SURVEY DATA SUMMARY	
Date	21.6.2024
Survey	13
Departure Time (UTC)	7:05:24
Landing Time (UTC)	11:25:07
Total Time	4:19:43
On effort time	2:39:18
Circle time	0:00:00
Off effort time	1:40:25

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	0	SWO	0
FIN	0	MOB	2
UDO	4	WHA	0
RIS	0	MIN	0
PIL	0	CUV	0
UNF	0	BOT	0
SHA	0	CAR	6
TOTAL			12

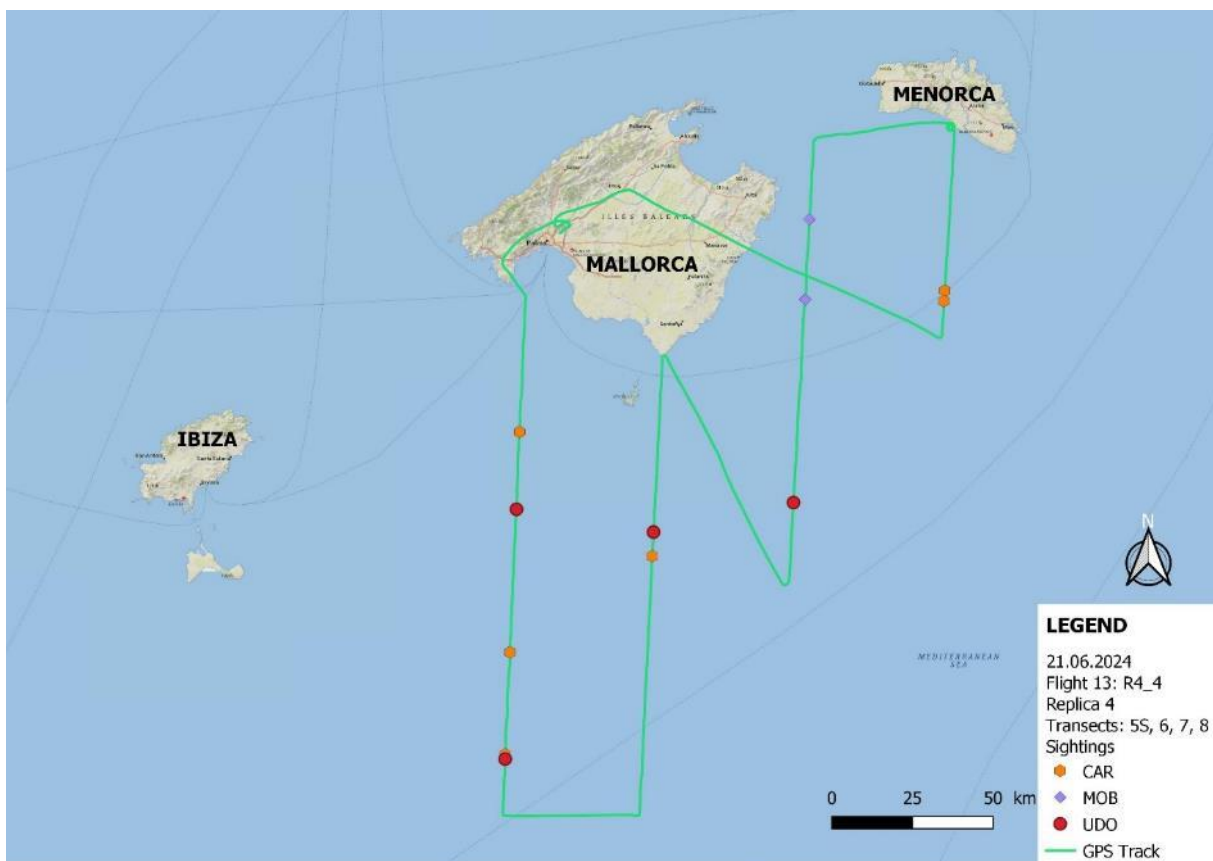


Figure 24: GPS track and recorded sightings in flight 13

Flight 14: 21 June 2024, Replica 4: Transects 4N, 5N

SURVEY DATA SUMMARY	
Date	21.6.2024
Survey	14
Departure Time (UTC)	13:40:53
Landing Time (UTC)	15:40:04
Total Time	1:59:11
On effort time	1:16:41
Circle time	0:00:00
Off effort time	0:42:30

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	0	SWO	0
FIN	0	MOB	4
UDO	5	WHA	0
RIS	0	MIN	0
PIL	0	CUV	0
UNF	0	BOT	0
SHA	1	CAR	1
TOTAL			11

2 UDO – OFF EFFORT

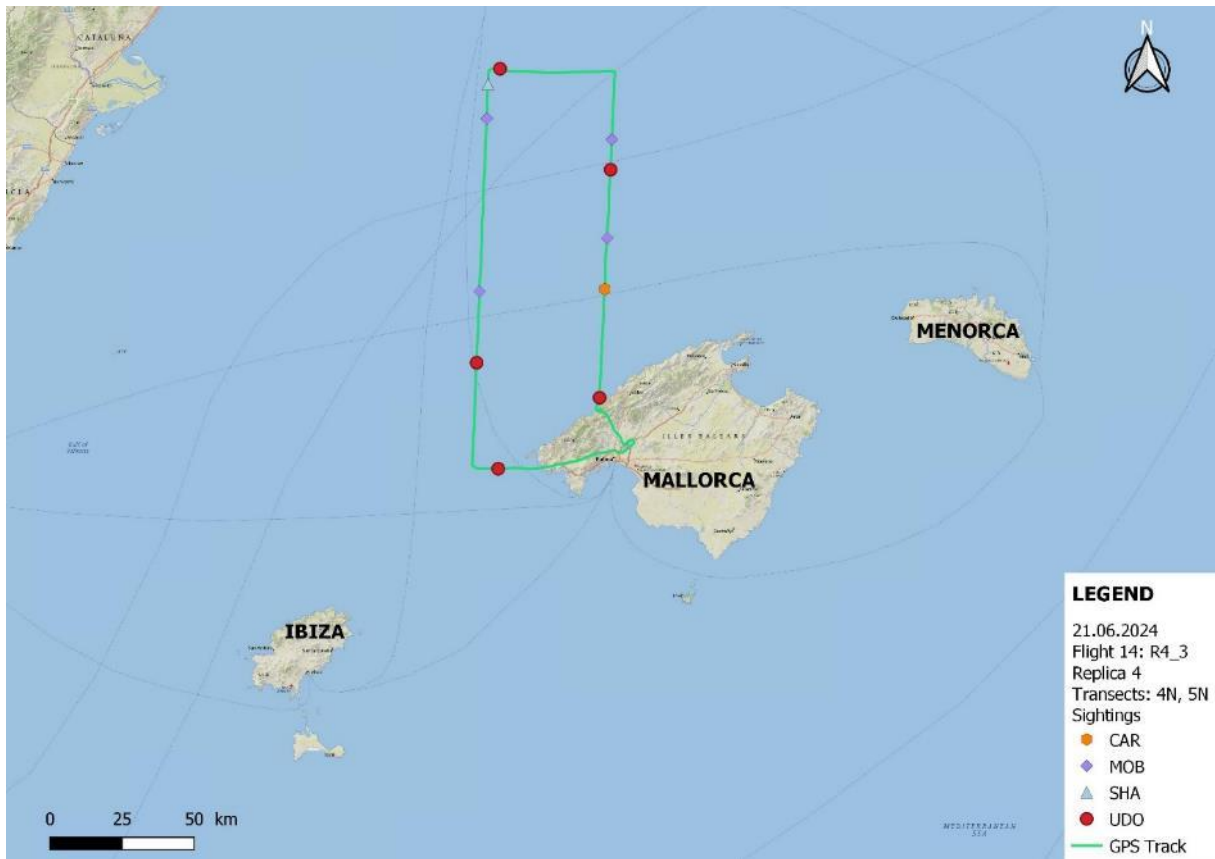


Figure 25: GPS track and recorded sightings in flight 14

Flight 15: 22 June 2024, Replica 4: Transects 1, 2

SURVEY DATA SUMMARY	
Date	22.6.2024
Survey	15
Departure Time (UTC)	7:30:18
Landing Time (UTC)	11:30:44
Total Time	4:00:26
On effort time	2:14:39
Circle time*	0:30:35
Off effort time	1:45:47

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	2	SWO	1
FIN	0	MOB	5
UDO	35	WHA	0
RIS	1	SPE	1
PIL	0	CUV	1
UNF	3	BOT	0
SHA	4	CAR	35
TOTAL			88

*Only circling on effort

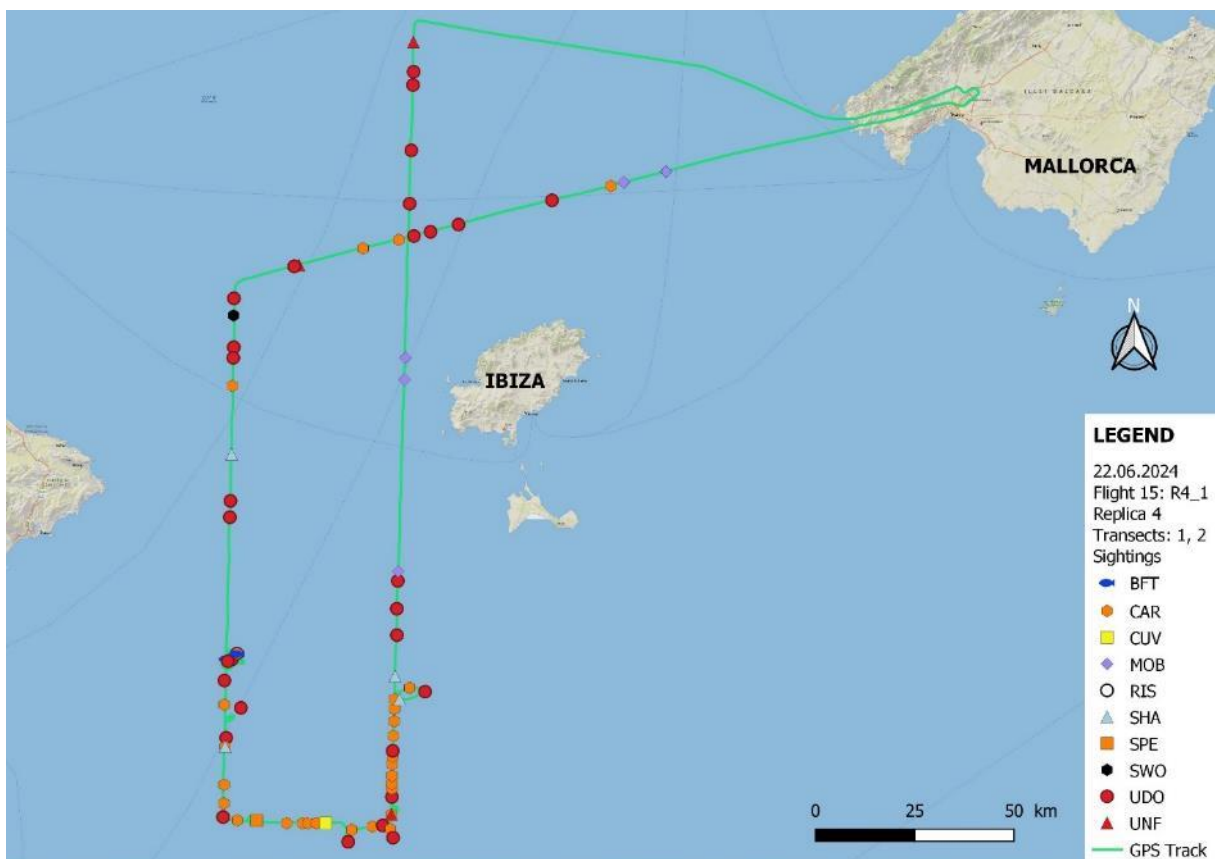


Figure 26: GPS track and recorded sightings in flight 15

Flight 16: 24 June 2024, Replica 4: Transects 3, 4S

SURVEY DATA SUMMARY	
Date	24.6.2024
Survey	16
Departure Time (UTC)	7:10:19
Landing Time (UTC)	10:45:47
Total Time	3:35:28
On effort time	2:25:19
Circle time	0:12:24
Off effort time	1:10:09

SIGHTINGS DATA SUMMARY			
ALB	0	SPE	0
BFT	2	SWO	4
FIN	0	MOB	3
UDO	6	SDO	1
RIS	0	MIN	0
CDO	1	CUV	0
UNF	2	BOT	0
SHA	1	CAR	18
TOTAL			38

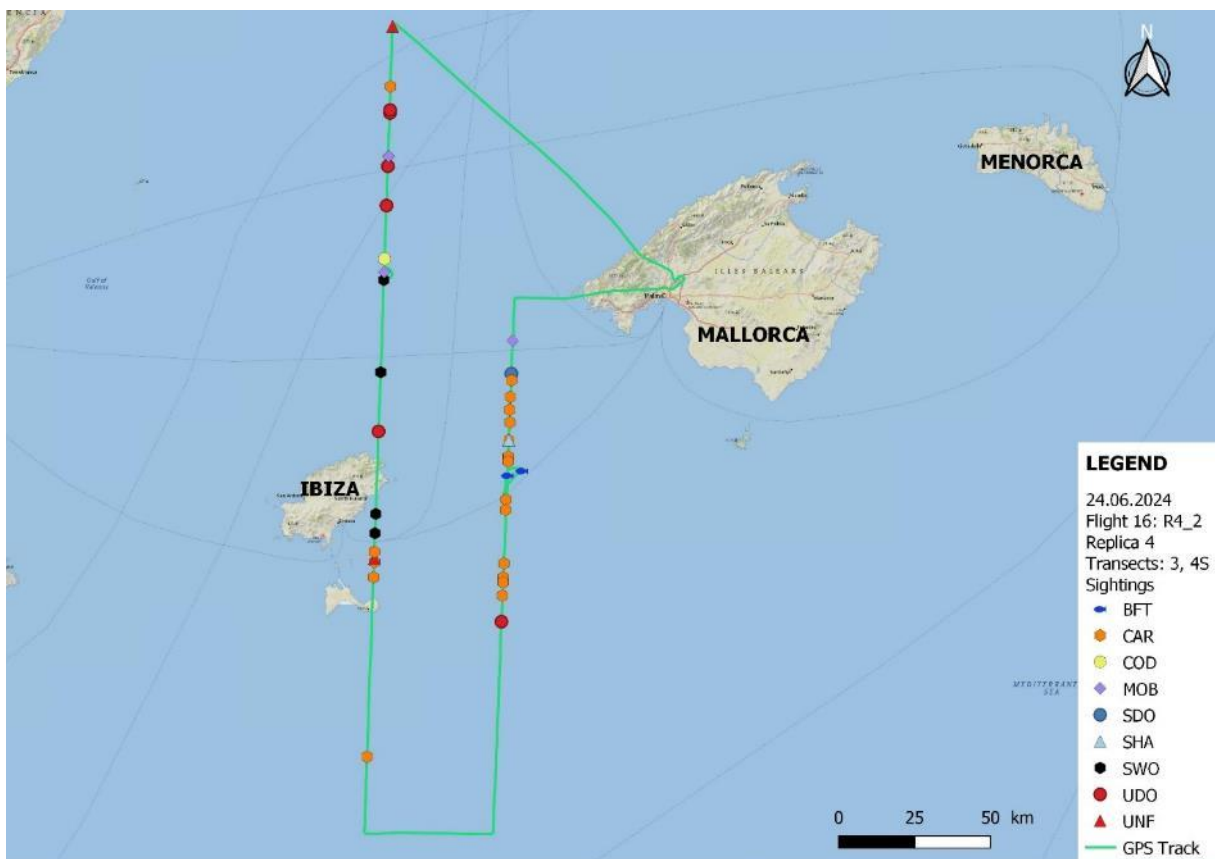


Figure 27: GPS track and recorded sightings in flight 16

BLUEFIN TUNA SIGHTINGS

During the survey in area A, 12 BFT observations were made along the 30 transects and all of these were on effort (Table 3). This represents 1,935 individuals with a total weight of 403.3 tons. Of these, there were 7 observations, of small groups ranging from 10 to 30 individuals which ranged from small to medium category of fish. The other 5 observations were schools of tuna ranging from 100 to 1000 individuals, made up mainly of fish in the medium to giant category. The majority of BFT observations were located in the western part of the block and mostly in the southwestern part around Ibiza and between Mallorca and Ibiza (Figure 28). No observations were recorded around Menorca. The highest number of sightings were registered during flights in Replicas 3 and 4 – 4 in each (Figure 29). The highest number and weight of tuna was recorded in Replica 1.

Date	Time (UTC)	Latitude	Longitude	School size	Weight	% small	% medium	% large	% giant
4.6.2024	14:12:30	40.55767	2.79251	100	NA				
6.6.2024	12:17:04	38.07934	2.15834	200	40000			100	
6.6.2024	13:11:28	39.30871	2.22349	1000	300000				100
13.6.2024	8:53:55	39.44276	1.24717	20	400	100			
16.6.2024	12:46:49	39.43272	0.84052	100	20000			100	
18.6.2023	12:57:31	38.91569	0.91080	10	300		100		
18.6.2023	13:02:00	38.93315	0.91169	30	750	100			
18.6.2023	13:13:55	39.13584	0.91699	400	36500		70	30	
22.6.2024	8:56:18	38.35831	0.57656	15	300	100			
22.6.2024	8:56:48	38.37001	0.60609	20	400	100			
24.6.2024	7:47:27	39.04825	2.06551	30	4500		100		
24.6.2024	7:54:57	39.06202	2.11922	10	150	100			

Table 3: Sightings of Bluefin tuna in Area A

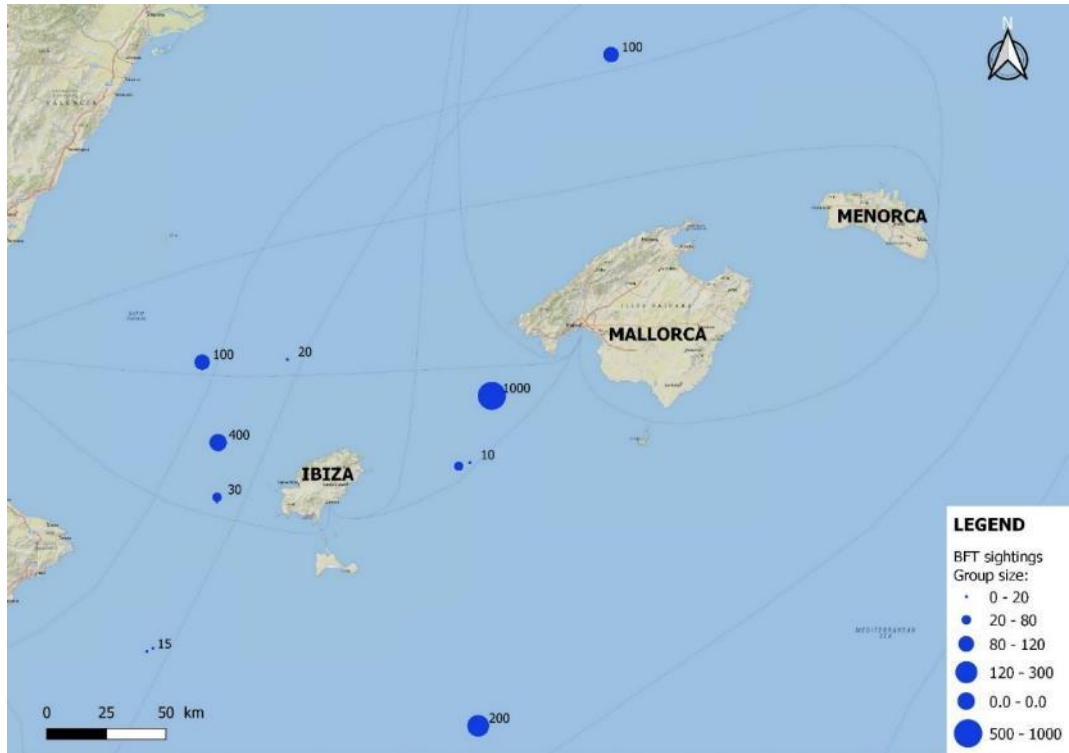


Figure 28: Observed Bluefin tuna schools by size (no of ind.)

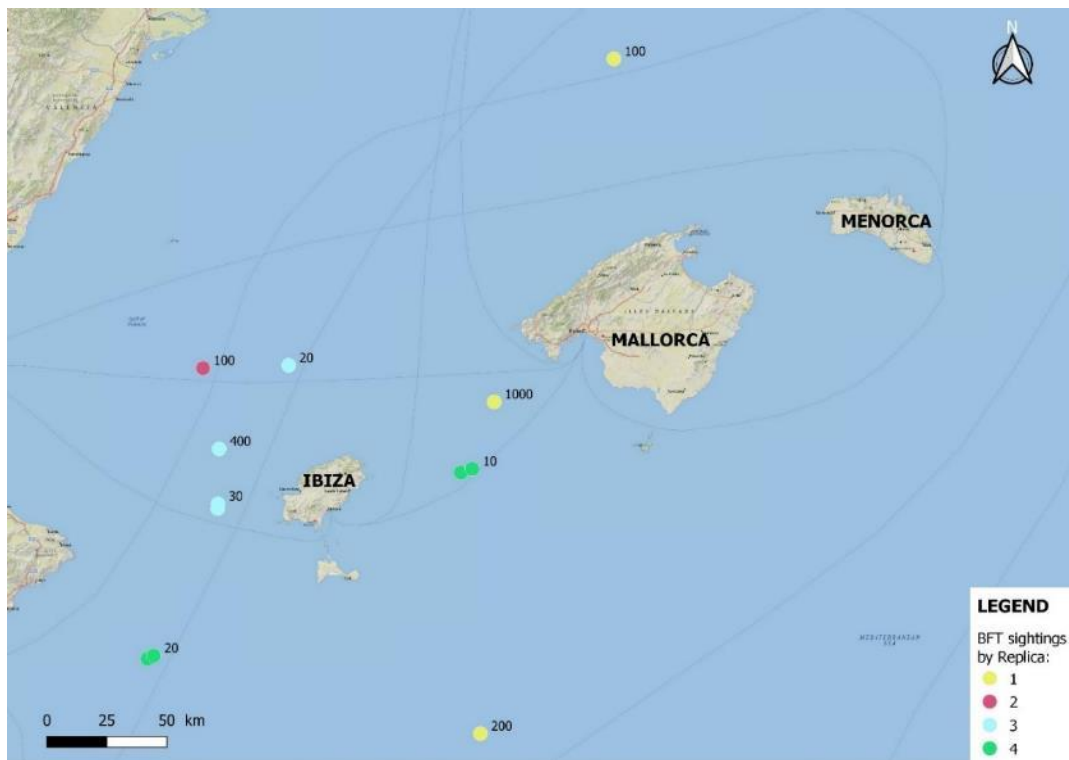


Figure 29: Observed Bluefin tuna schools by Replica.

OTHER SPECIES

The survey's main objective was the census of spawning Bluefin tuna, but in line with field protocol observations of other species were also collected without undermining this objective. During the survey of Area A, 473 sightings of other species were collected (Table 4). 26 of these were off effort. Loggerhead turtles were the most numerous with 261 sightings, followed by unidentified dolphins with 106. Dolphin species were identified just on a few occasions (common, striped, and bottlenose). Some large groups of more than 100 dolphins suggested these could have been striped, but the high altitude (1000 feet) didn't allow the species to be identified with certainty. Among other observed cetaceans were Risso's dolphin, Cuvier's beaked whale, Sperm whale, and Fin whale. Devil's rays, sharks, and swordfish were also observed including several Sunfish (*Mola mola*) that due to lack of a specific code were recorded as unidentified fish with species added in comments.

Code	Species	Scientific name	No of sightings
CAR	Loggerhead turtle	<i>Caretta caretta</i>	261
COD	Common dolphin	<i>Delphinus delphis</i>	1
CUV	Cuvier's beaked whale	<i>Ziphius cavirostris</i>	4
FIN	Fin whale	<i>Balaenoptera physalus</i>	2
MOB	Manta (mobula)	<i>Mobula mobular</i>	38
RIS	Risso's dolphin	<i>Grampus griseus</i>	5
SDO	Striped dolphin	<i>Stenella coeruleoalba</i>	1
SHA	Shark		29
SPE	Sperm whale	<i>Physeter catodon</i>	4
SWO	Swordfish	<i>Xiphias gladius</i>	9
UDO	Unidentified dolphin	<i>Delphinidae und.</i>	106
UMM	Unidentified cetacean	<i>Cetacea und.</i>	1
UNF	Unidentified Fish		10
WHA	Other whale	<i>Mysticetus und.</i>	1
Total			473

Table 4: Sightings of other species

DISCUSSION

The 13th aerial survey of the ICCAT GBYP program in the Balearic Sea took place from 3 to 25 June 2024. Survey flights were conducted from 4 to 24 June 2024. On 30 May 2024, the team participated in online training on the survey protocol of this mission.

To cover the entire 4 replicas (30 transects in total), 16 flights made in 14 days during period of a total of 19 days were necessary. In five days, weather conditions were worse than allowed by the field protocol – wind stronger than 10 knots or high chance of low clouds. The 16 flights had a total duration of 54h 15min of flight with 30h 32min of these on effort.

Some transects could not be flown in their entirety. That was mainly because they cross the airspaces of commercial airports with high traffic. That was highly relevant for the Ibiza airport that affected transect 2 in three of the replicas. However, the number of nautical miles that were not flown was low, and this did not have significant impact on the completed effort. Thanks to the intervention of ICCAT, the regulated zone of the Park Cabrera National Park could be flown over. Fortunately, military dangerous area D 26 was always free at the time of the eight flights that required penetration of this area.

In total, 485 sightings were recorded during the 2024 campaign, including 12 observations of Bluefin tuna (*Thunnus thynnus*) schools ranging from 150 kg to 300,000 kg. Seven (58%) of these 12 observations were of small “isolated” bluefin tuna schools ranging from 10 to 30 individuals, with weights ranging from 15 to 150 kg per individual. The other five sightings were of larger bluefin tuna schools, ranging from 20,000 kg to 300,000 kg total weight. Those were composed mainly of individuals ranging from 55 to 300 kg. Most of the BFT observations were located in the southwestern part of the area – west of the island of Ibiza and between Ibiza and Mallorca. Most of the observed schools were close to the transect or just under the

plane. That suggested that the tuna schools were not close to the surface making detection harder. The other 473 sightings were of other marine megafauna species. The most numerous were the loggerhead turtles and dolphins, including Risso's dolphins. It was interesting that deep-diving species of the large whales – Cuvier's beaked whale and Sperm whale were encountered more often than surface-feeding species like the Fin whale. Giant devil rays, swordfish, sharks, and Sunfish complemented the sightings.

During our flights covering replicas 1 and 2, we encountered numerous tuna fishing vessels – either with filled cages heading towards their home port, or engaged in circling tuna. During the latter part of the survey encounters of tuna fishing vessels were scarce. This can perhaps explain the low number of sightings and prevalence of small schools. The Professional spotter's opinion was that tuna had already gone into the deep or left the Mediterranean Sea. His recommendation was for earlier start of the survey.

REFERENCES:

Fromentin J.-M., Powers J. E. (2005) Atlantic bluefin tuna: population dynamics, ecology, fisheries and management. *Fish and Fisheries* 6: 281-306.

Mather F.J., Mason J.M., and Jones A.C. (1995) Historical document: life history and fisheries of Atlantic Bluefin tuna. NOAA Technical Memorandum NMFS-SEFSC – 370:165 pp.

Ravier C., Fromentin J.-M. Long-term fluctuations in the eastern Atlantic and Mediterranean bluefin tuna population, *ICES Journal of Marine Science*, Volume 58, Issue 6, 2001: 1299–1317.

Annex 1



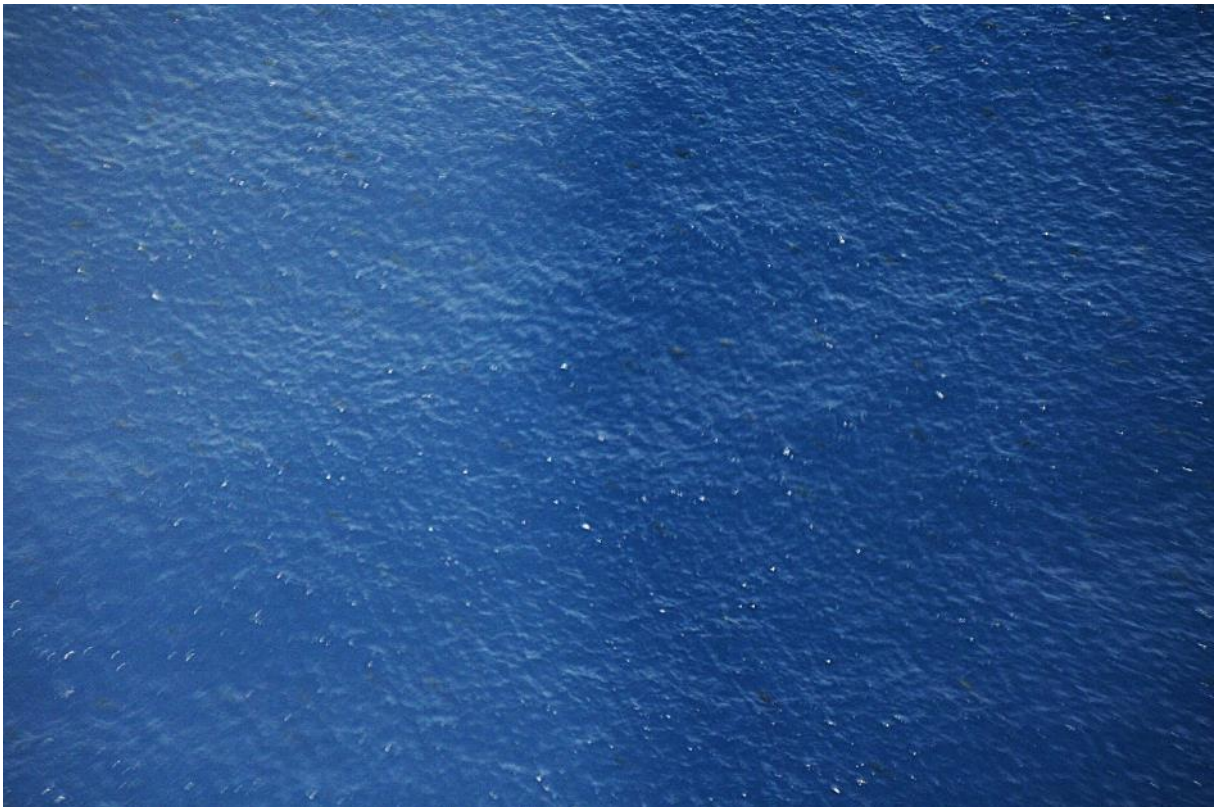
EFFORT FORMS

SURVEY DETAILS								TEAM				SURVEY CONDITIONS						GLARE				COMMENTS	
Date	Time	Event	LAT	LON	Subarea	Survey	Transect	Pilot	Front Spotter	Left rear Spotter	Right rear Spotter	Altitude	Sea State	Haze	Turbidity	Clouds	Glint	Side	Sector	Intensity	Subjective P		Subjective S
18.6.2024	10:26:45	OFF	39.83616	2.219907	A-I	12		16	93	99	101	293	1	1	0.0	1	0	P	100-120	1	G	G	
18.6.2024	10:45:05	ON	40.13689	1.444204	A-I	12	2	16	93	99	101	303	2.5	1	0.0	4	1	P	220-290	2	M	G	
18.6.2024	10:56:13		39.82109	1.436274	A-I	12	2	16	93	99	101	304	2	1	0.0	4	1	P	220-290	2	M	G	WEATHER CHANGE, PATCHES OF LOW CLOUDS
18.6.2024	11:22:31	LA	39.09200	1.405854	A-I	12	2	16	93	99	101	314	2	1	0.0	4	1	P	220-290	2	M	G	OVER LAND - IBIZA
18.6.2024	11:37:00	ON	38.75864	1.390931	A-I	12	2	16	93	99	101	333	2	1	0.0	4	1	P	220-290	2	M	G	REJOIN THE LINE
18.6.2024	11:38:02	LA	38.72637	1.38995	A-I	12	2	16	93	99	101	342	2	1	0.0	4	1	P	220-290	2	M	G	OVER LAND - IFORMENTERA

Annex 3 Photos



Flight 3, 6 June 2024: 200 BFT * 200 kg



Flight 3, 6 June 2024: 1000 BFT * 300 kg



Flight 7, 13 June 2024: Tuna fishing vessels



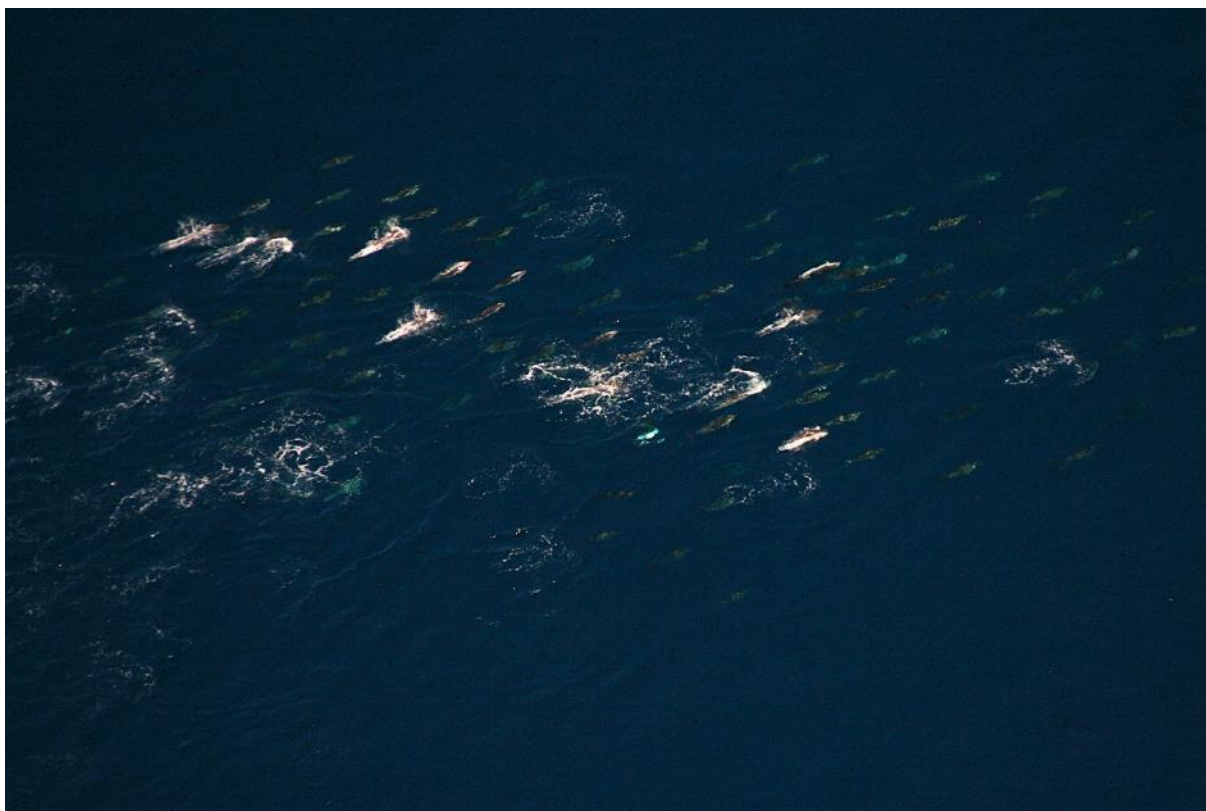
Flight 7, 13 June 2024: 20 BFT * 20 kg



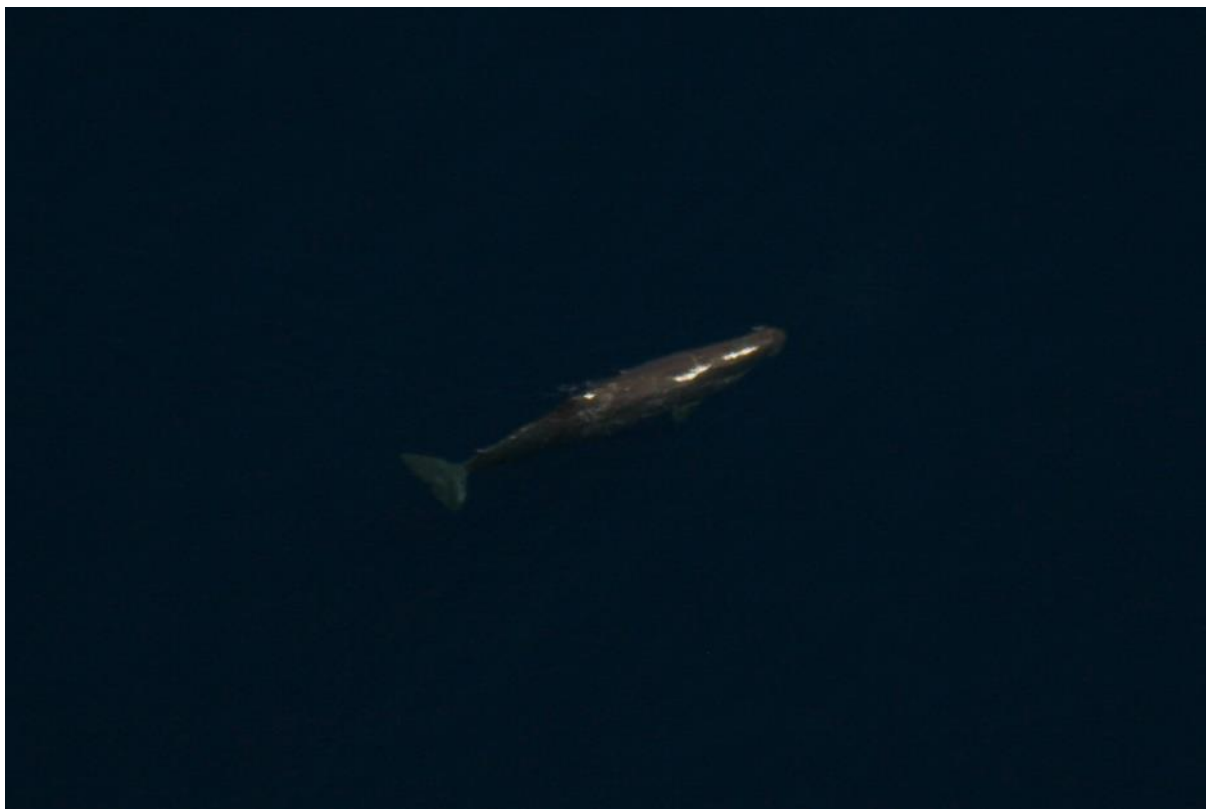
Flight 7, 13 June 2024: Two Sperm whales, off effort



Flight 15, 22 June 2024: Dolphins



Flight 15, 22 June 2024: Dolphins



Flight 15, 22 June 2024: Sperm whale