SCRS/2015/143 Collect. Vol. Sci. Pap. ICCAT, 72(6): 1463-1476 (2016)

TENTATIVE SWOT ANALYSIS FOR THE CALIBRATION OF ICCAT GBYP AERIAL SURVEY FOR BLUEFIN TUNA SPAWNING AGGREGATIONS

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SUMMARY

The ICCAT GBYP aerial surveys for spawning aggregation were carried out in 2010, 2011, 2013 and 2015 in the Mediterranean Sea. They are considered a method for obtaining fishery independent indices for the bluefin tuna spawning stock biomass over several years. These surveys revealed many operational and scientific challenges and limits, mostly because of the large area to be covered, which includes 24 different air spaces, the complex bluefin tuna behaviour and the high variability of both oceanographic and meteorological conditions in the Mediterranean Sea. Furthermore, changes in the strategy and even in methodology have been introduced at each survey by the Steering Committee. At the same time, ICCAT GBYP was requested to evaluate the possibility to carry out a calibration exercise, which was never done in a survey covering a large area, with so many aircrafts and observers. This paper presents a tentative SWOT analysis, which shows how this calibration will be too challenging for covering all variance components or useless if carried out only on some of them. Furthermore, the legal and logistic constrains are also examined.

RÉSUMÉ

Les prospections aériennes de l'ICCAT-GBYP des concentrations de reproducteurs ont été réalisées en 2010, 2011, 2013 et 2015 dans la mer Méditerranée. Elles sont considérées comme une méthode destinée à obtenir des indices indépendants des pêcheries pour connaître la biomasse du stock reproducteur de thon rouge sur plusieurs années. Ces prospections ont révélé de nombreux défis et limites opérationnels et scientifiques, principalement en raison de la grande surface à couvrir, qui comprend 24 espaces aériens différents, le comportement complexe du thon rouge et la forte variabilité des conditions océanographiques et météorologiques en mer Méditerranée. En outre, le Comité directeur a introduit des changements dans la stratégie et même dans la méthodologie lors de chaque prospection. Dans le même temps, on a demandé à l'ICCAT-GBYP d'évaluer la possibilité d'effectuer un exercice de calibration, qui n'avait jamais été fait dans une prospection portant sur une vaste zone, avec tant d'aéronefs et d'observateurs. Ce document présente une analyse SWOT provisoire, qui montre comment ce calibrage sera trop difficile pour couvrir toutes les composantes de la variance ou inutile s'il n'est effectué que sur certains d'entre elles. En outre, les contraintes juridiques et logistiques sont également examinées.

RESUMEN

En 2010, 2011, 2013 y 2015 se llevaron a cabo en el Mediterráneo prospecciones aéreas de concentraciones de reproductores del GBYP de ICCAT. Se consideran un método para obtener índices independientes de la pesquería para la biomasa del stock reproductor de atún rojo a lo largo de varios años. Estas prospecciones revelaron varios problemas y límites operativos y científicos, principalmente por la gran zona a cubrir, que incluye 24 zonas aéreas diferentes, por el complejo comportamiento del atún rojo y por la elevada variabilidad tanto de las condiciones oceanográficas como meteorológicas del Mediterráneo. Además, en cada prospección, el Comité directivo ha introducido cambios en la estrategia e incluso en la metodología. Al mismo tiempo, se pidió al ICCAT-GBYP que evaluara la posibilidad de llevar a cabo un ejercicio de calibración, que nunca se había hecho en una prospección de una gran zona, con tantas aeronaves y observadores. Este documento presenta un análisis SWOT provisional, que muestra cómo esta calibración sería muy difícil para cubrir todos los componentes de la varianza o sin sentido si se lleva a cabo solo en algunos de ellos. Además, se examinan también las limitaciones legales y logísticas.

KEYWORDS
Bluefin tuna, ICCAT, Aerial survey, SWOT analysis, Calibration, Spawning areas

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1. Introduction

Aerial survey are used for obtaining fishery independent data for some marine species (Rivas, 1978; Stéquert and Marsac, 1989; Polacheck *et al*., 1996; Lutcavage *et al*., 1997; Lutcavage and Newlands, 1999; Buckland *et al*., 2001; Thomas *et al*., 2002; Nicholson and Jennings, 2004; Newlands et al., 2006, 2007; Newlands and Porcelli, 2008; Basson and Farley, 2014), and a large experience is particularly available for southern bluefin tuna (Cowling *et al*., 1996; Cowling and O'Reilly, 1999; Farley and Bennet, 2008; Eveson et al., 2011). The ICCAT GBYP aerial surveys for bluefin tuna spawning aggregations are a method for having fishery independent indices of the bluefin tuna spawning stock biomass over the years, for possibly obtaining trends. They were carried out in 2010, 2011, 2013 and 2015, depending on the availability of funds and the choices of the GBYP Steering Committee, the SCRS and the Commission.

The four ICCAT GBYP surveys were carried out with yearly changes, set by the GBYP Steering Committee. The plan set at the beginning of GBYP was to survey three areas for three years.

The first year (2010) it was planned to carry out the survey in 8 subareas all to be densely monitored, but finally, due to many security problems, the survey included 3 full areas and 3 partial areas. The survey was carried out by aircrafts not equipped with bubble windows and declinometers.

The second year (2011) it was planned to carry out the survey over 6 areas, all to be densely monitored. Finally, due to security and permits problems, the survey included only three areas. In this year, following the updated recommendation of the Steering Committee, the survey was carried out by aircrafts equipped with bubble windows and declinometers and these tools were used in all following surveys.

The third year (2013) the GBYP Steering Committee requested an extended survey, covering all possible areas in the Mediterranean Sea. It resulted in 11 different areas, 4 to be densely monitored (these 4 almost overlapping most of the areas surveyed in previous years) and 7 with less dense transects. At the end, almost all areas were surveyed, except some parts in three areas, due to security reasons or permit issues. The logistic was extremely complex.

The fourth year (2015) the GBYP Steering Committee requested again an extended survey, covering all possible areas in the Mediterranean Sea (about 60% of the surface). It resulted in 11 different areas, 4 to be densely monitored (almost overlapping most of the areas surveyed in previous years) and 7 with less dense transects (**Figure 1**). The shape of both types of areas was different from the ones in 2013, with limited changes for the areas to be densely monitored. Finally, all areas were surveyed, with the exception of most of the Tunisian FIR, while security and permits issues affected even this last survey. The logistic was again extremely difficult.

The companies, pilots and observers were only partly the same during the four survey. This was due to the administrative structure of ICCAT GBYP (each Phase is administratively independent from the following one), which implies to operate with different Call for tenders and contracts in each Phase.

Therefore, the GBYP Steering Committee requested since 2013 a calibration exercise for the spotters, with the objective to calibrate their sightings and attribute individual CVs for smoothing the additional variance when elaborating the aerial survey data, but so far it was not possible to carry out any due to serious budget or operational constraints.

The calibration is an important part of many field activities where various components may bias the results in various ways. The GBYP Steering Committee included the calibration of the aerial survey in Phase 5, within the request of a total GBYP budget of 2,825,000 euro, which was approved by the SCRS and endorsed by the Commission. At a later stage, the budget was reduced to 2,125,000 according to the maximum availability of funds from the main donor and it was possible to initially keep aside the funds for the calibration at a level of about 90,000 euro max within the aerial survey budget item.

Besides the budget issues, the calibration of the aerial survey was always considered by the GBYP Coordination as an extremely difficult tentative, possible in theory but almost impossible from a practical point of view, taking into account all various components.

According to previous experiences for both tuna species or marine mammals, most of the calibration exercises carried out so far for aerial survey concerned only one aircraft and a very limited number of spotters (from 2 to 5) (Cram and Hampton, 1976). Only a couple of calibration trials were carried out with two aircrafts at the same time, several years ago (Hiby & Lovell, 1998; Hammond *et al*., 2002), with 6 maximum spotters. Most of the calibrations for marine mammals were presented to IWC Scientific Committee, ASCOBAM or ACCOBAMS, even in 2014, while those on tunas were conducted mostly on the Eastern North American coast and Australia. Most of the aerial surveys conducted so far on marine mammals or tunas (in the Indian Ocean or the Mediterranean Sea) were not calibrated. Calibration of a large number of spotters at the same time was carried out by the NATO-SOLMAR Project, where 16 "visual" spotters were tentatively assessed at the same time, but it was necessary to repeat the calibration trials even if the platform was a vessel and not an aircraft and, therefore, sightings were relatively more easy to assess and it was possible to use parallel information (hydrophones) for further assess the sightings.

According to the available information, the large majority of aerial surveys carried out so far were conducted in only one country from aircrafts registered in the same country. One of the very few exceptions was the aerial survey for marine mammals in the North Sea (SCAN-II, http://biology.st-andrews.ac.uk/scans2/inner-furtherInfo.html), which included several FIRs, but all belonging to EU countries; no information is available about the nationality of the aircraft(s).

As a matter of fact, the best way for calibrating an aerial survey is comparing the estimates from two independent platforms at the same time and on the same animals. This is usually done using aircrafts and vessels in the same area, with the objective to detect the differences between the two estimates according to the many environmental variables at each time (visibility, time of the day, light incidence, glaze, clouds presence-sky coverage, water transparency, water colour, sea state, swells, wind strength) and the animal behaviour (surfacing, underwater swimming, vertical distribution of the school, etc.). Visibility is obviously a key factor (Marsh and Sinclair, 1989). At the same time, another important objective of the calibration is assessing the different capabilities in detection of all spotters /pilots, professional spotters and scientific spotters), providing a personal CV to all spotters, because each person has a different capacity for detecting animals at sea, depending on the experience, training and visual capabilities. Usually, professional spotters for tunas have a considerable experience in easily detecting the tuna schools (distinguishing them from other species of the same size, i.e. adult tunas from dolphins), while the capacity for assessing the number of individuals, the length range and the estimated total weight of the schools are strictly linked to the years of experience in aerial survey and their previous opportunities for calibrating these estimates with the catches. A further calibration can be related to the different types of aircrafts used for the survey, the type of the window (bubble[2] or flat) and the side of the aircraft, getting additional CVs.

A partial alternative methodology, limited only to the estimation of the "perception bias" of each spotter, is possible using two spotters on the same side of each aircraft, assessing the same sighting in an independent way (Palka, 2011).

These efforts will be able to provide a series of "correction factors" for improving the assessments made by the spotters and, in total, by the aerial survey.

In some cases, the calibration has additional problems, particularly in the case of small or juvenile tunas, because in many areas they have the same size of other tuna or tuna-like species, and the species identification from the aircraft platform is very uncertain, when any, while a sonar identification is equally difficult.

The ICCAT GBYP aerial survey for spawning aggregations covers most of the Mediterranean Sea, including many air spaces (24, see **Figure 2**) and with a very difficult logistic, within a very limited time frame, imposed by the peak of the bluefin tuna spawning season (June). So far, for carrying out the survey, it was necessary to use up to 7 aircrafts at the same time and a total of 28 spotters (pilots, professional spotters and scientific spotters), while a total of 32 spotters were on the list (including some reserves).

The aircrafts used for the last survey carried out in 2013 were 1 CESSNA 206 (upper wings, one front engine), 3 CESSNA 337 (upper wings, two engines push-pull), 1 PARTENAVIA P68 (upper wings, two engines, one per side), 1 PARTENAVIA P68CTC (upper wings, two engines, one per side) and 1 PARTENAVIA P68V (upper wings, two engines, one per side). All aircrafts except the CESSNA 206 (which came on line in emergency, for replacing another aircraft which was not authorised by the Italian authorities because was registered in USA) were equipped with bubble windows for the spotters in the rear sits. In 2015 the aircraft were a PARTENAVIA P68-Observer (equipped with a transparent bottom on the front part), one PARTENAVIA P68, one PARTENAVIA P68B and three 3 CESSNA 337G Skymaster.

All spotters had a specific training course in 2015 and most of them had already attended to the three previous GBYP training courses in 2010, 2011 and 2013. All pilots and professional observers had a very long experience in tuna spotting (some having more than 30-year experience), while most of the scientific spotters had previous experiences with GBYP surveys conducted in 2010, 2011 and 2013 or in aerial surveys for marine mammals.

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[2] Bubble windows are mandatory for the ICCAT GBYP aerial survey since 2011.

It is standard practice for professional tuna spotters to identify species and to estimate average size, weight, and total tonnage before a set is made. The situation is different for the scientific spotters or for professional spotters when they have experience only for marine mammals, because in this case they are not used to estimate the weight of each school and they might have additional difficulties due to the different behaviour between cetaceans and tunas.

Due to the peculiarities of ICCAT GBYP aerial survey, the Coordination is proposing a SWOT analysis, in order to help the decision-making process of the Steering Committee and for providing a tool for assessing the calibration needs in any similar type of survey.

2. Technical items

In order to carry out the calibration of the aerial survey as it was requested by the GBYP Steering Committee, it will be necessary concentrating all spotters (about 30) in the same site and at the same time, along with at least two aircrafts and one or two large tuna purse seiners, having on board also a scientist trained in sonar tuna assessment.

Based on previous experiences, considering that not-favourable weather conditions in late spring-early summer are usually over 50% of the available working days, the minimum time required for the calibration can be set in one full week at least, possibly extending the period to 10 days.

Here following we examine all possible different technical components of the calibration trial.

I. Location
   a) The eastern Mediterranean area should be excluded, because of the limited air spaces available, the high level of security problems, the difficulties for authorizing foreign aircrafts and the earlier bluefin tuna spawning period in this large area.
   b) The central Mediterranean sea has a larger BFT spawning season, variable from year to year within some limits, but always with a peak in June; the southern Tyrrhenian Sea is all under the Italian FIR and the best area for spotting spawning BFT is around the Aeolian Islands (available airports: Naples, Lamezia Terme, Reggio Calabria or Palermo), here weather conditions might be usually more stable; the Strait of Sicily includes several air spaces and some of them cannot be used at the moment but if we take into account the central part, the Malta FIR provides quite a large area along one of the main migratory courses of bluefin tuna and where spawning usually occurs (available airport: Malta; other airports but in the Italian FIR: Pantelleria, Lampedusa, Comiso), here the weather conditions might have sudden changes.
   c) The western Mediterranean sea has another large BFT spawning area around the Balearic islands, but spawning in the last years was very variable in time, in some years starting quite early in May, then resuming in late June or July, while in other years the spawning occurred only in the last part of the season; all the main spawning area is within the Spanish FIR (available airports: Palma de Mallorca, Menorca, Ibiza, Barcelona El Prat, Malaga, Valencia, Reus, Alicante, Cartagena); here the weather conditions are more stable, but when strong winds reach the area from the Gulf of Lion the sea can stay rough for days.

II. Timing
   a) The calibration exercise must be done anyway after having all contracts in place for the aerial survey in this given year, because it is needed to previously select the companies and have the list of pilots, professional spotters and observers from each company. This is due to the administrative constrain of having separate contracts for each Phase of GBYP.
   b) If the calibration will be set before the survey, therefore it should be around May 15, when weather is usually more unstable; the presence of BFT spawners in the eastern or central Mediterranean or in the Balearic areas depends on the general oceanographic conditions at that time.
   c) If the calibration exercise will be set at the end of the survey, therefore it should be around July 1; usually in that period the weather conditions are more stable. The presence of BFT spawners in the central Mediterranean or in the Balearic areas depends on the general oceanographic conditions at that time and on the situation in the previous month.

III. Logistic issues
   a) The BFT spawning season usually coincide with the main tourist season in the Mediterranean area; this fact implies the need to book the hotels well in advance and costs are higher than normal.
   b) The area must have at least one airport available at any time, possibly with at least a secondary airport for any emergency.

c) Each airport must have the right type of fuel for the aircrafts, without any quantity restriction.

d) Parking and handling for the aircrafts must be programmed and booked well in advance.

e) The purse-seiners must have a dedicated space in one harbour and this shall be booked and agreed in advance.

IV. Travels

a) All pilots, professional spotters and scientific spotters must be available and contracted for the whole period of the calibration, reaching the location the day before.

b) At least two aircrafts must be available for the whole period, reaching the location the day before.

c) The purse-seiner(s) must be available for the whole period, reaching the location the day before.

V. Technical needs

a) It is extremely difficult to make a choice of the best aircraft type required for the calibration. Assessing the main three types (CESSNA 206 one engine, CESSNA 337 push-pull and PARTENAVIA, all with 2 engines) should imply repeating the calibration three times, which is impossible under the current situation. As a matter of fact, forgetting the calibration among aircrafts, it should be better to use one single type of aircraft, CESSNA 337 push-pull or PARTENAVIA P68). The PARTENAVIA type seems the best choice, but even here there are contrasting opinions.

b) The two aircrafts (or any additional aircraft) must be equipped with bubble windows for the rear seats; this fact implies that pilots and professional spotters will be assessed with flat windows only, while scientific spotters, even rotating internally, will be assessed for bubble windows only. Rotating the professional spotter internally will add further complications and variables, particularly taking into account that assessments should be evaluated likely when spotting the same school.

c) The choice to operate with one or two purse-seiners is both economic and technical. The possibilities to reach the site where an aircraft discovered a BFT school in a large area and within a short time obviously increases having two vessels available at sea. The purse seiners must be equipped with top quality sonar and the captains and fishing masters must be able to read the data and provide a preliminary assessment of the school.

d) A well-trained scientist, having a good experience in assessing BFT or pelagic species using sonar images, must be specifically contracted and shall stay on board for the whole period. If the purse seiners will be two, then two specialists are needed.

e) Using two aircrafts at each time, the maximum number of spotters on board must be limited to four per aircraft, including the pilot. Considering that the scientific spotters must rotate on board and that different light conditions should be considered, the two aircrafts should operate in parallel, repeating the sighting from two different interchanging positions if possible. Taking into account that pilots must belong to the same company owning the aircrafts and considering the aerial survey in 2013 and 2015, we had a total of 7 pilots and 21/25 spotters (including professionals and scientists); this implies that two (max 3 pilots) will be always driving the aircrafts, while 26 to 30 spotters (without considering any reserve spotter) must rotate, 6 each time. Therefore, the total number of trials shall be 5, without any repetition.

f) If the calibration is carried out in a non-EU country, then the presence of a national spotter/observer for each aircraft shall be considered; this fact will increase the total number of spotters and calibration flights.

g) The maximum allowed flight time for pilots by contract is 6 hours per day and, therefore, the maximum number of calibration trials per day, if sightings will not be too far from the coast, should be about 2, but at two different hours of the day, and this will add further variance.

VI. Assistance

a) ICCAT shall provide all initial assistance with the CPC concerned, asking for enforcing the Rec. 11-06 and a strong support of the local authorities for releasing all necessary permits, within the legal limits.

b) The GBYP Coordinator will assist all process in detail.

c) The GBYP Coordinator will stay on the calibration site for the full duration of the calibration exercise, for providing real time assistance.

d) The national authorities concerned shall provide all permits on time and the best possible assistance during the calibration trial.

VII. Legal issues

a) Some EU domestic rules are preventing civil aircrafts registered outside the EU to operate for working reasons in the national FIR; this excludes any civil aircraft not register in the EU and owned by any non-EU company from the calibration trial. In any case, all aircrafts shall be duly authorised by the competent national authorities.

b) In some non-EU CPCs, the flight authorisation for foreign aircrafts for working reasons within the national FIR is very difficult to get and it is usually conditioned by the participation of a national observer on board.

c) Some domestic rules are preventing foreign fishing vessels to operate for working reasons in national waters of a given country, even without any specific fishing activity. In any case, all vessels shall be duly authorised by the competent national authorities and usually they also ask to place a national observer on board.

d) The participation of non-EU spotters could be a problem if the calibration will be carried out in any EU country, because non-EU persons need special permits if they work even for a very limited time in any EU country. This might be the case of the Turkish national observer.

e) Pilots must belong to the same company owning the aircrafts. This is a very strict rule existing in all countries. This obligation implies that pilots from other companies must be evaluated and calibrated like any other spotter.

f) If the calibration will be conducted with the marine area covered by the national FIR, then the aircrafts can use any airport of the same country. If the survey will be carried out even outside the area covered by a domestic FIR, then the aircraft are allowed to take-off only from an international airport. Not all the international airport have the right type of fuel for the two types of aircrafts.

g) The company owing the aircrafts must provide the insurance for all the spotters, independently from their origin.

h) The purse-seiners shall be fully insured and the insurance must cover also the specialist.

VIII. Calibration design and data analysis

a) The calibration shall be conducted by using a specific design, based on the DISTANCE technique used for the aerial survey.

b) The calibration design shall be provided by an independent external expert to be contracted by ICCAT GBYP.

c) The data collected during the calibration trial shall be analysed by an independent external expert, following the best possible methodology. It is reasonable that this expert would be the same who designed the survey and therefore the contract should be all inclusive.

IX. Contracting issues

a) From a practical point of view there are two main possible choices:

a1) a special contract is released to one of the entities engaged in the aerial survey in the same year of the calibration, for being in charge of all aspects of the calibration exercise; the selection should be done comparing the offers from all companies. This choice implies that ICCAT GBYP will assist for all needs, providing protocols for the calibration, while the entity will assume all duties and field risks, contracting the purse seiners, the specialists and all other necessary components.

a2) ICCAT GBYP will manage directly the calibration exercise, contracting the aircrafts, the vessels, the specialists and providing the cost and insurance coverage for all spotters, organizing directly all logistics and permits. This choice implies a huge desk and field workload, for the many contracts to be released.

X. Economic issues

a) The costs for a calibration exercise like the one discussed by GBYP Steering Committee in 2013-2014 are difficult to assess, because they are conditioned by many preliminary choices (see **Table 1**); anyway, they are quite high and can easily be over 100,000 euro.

b) Even a high cost can be justified by the scientific relevance of a good calibration.

c) A bad or partial calibration, caused by various factors, implies that costs are not justified.

3. Tentative SWOT analysis

Selecting the various components for this tentative SWOT analysis is not very easy, due to the many factors identified above and to the implicit subjectivity of the SWOT technique. In this case, some points are quite objective and not subjective. Anyway, **Table 2** shows the elements which are selected for the analysis.

4. Results

Looking at the various components considered in the SWOT analysis (which are not exhaustive), the negative components are clearly more numerous than the positive ones, at least in terms of listing. Weighting all of them is very difficult, particularly because there is a mix of technical and scientific components, but the negative aspects seems always more than the positive ones.

Of course, the analysis can be even more sophisticated, attributing a numerical "weight" to the various components, but in this case the subjective bias will certainly increase.

The 13 **Weakness** components are all very important and most of them are really challenging, while others depending on preliminary choices might be risky.

The 5 **Threats** components are all extremely relevant. The high risk of failure, included in both Weakness and Threats, is very realistic, either in technical/logistic terms or in scientific terms.

The 5 **Strength** components are very important too, because they are at the base of the scientific need for calibrating an aerial survey.

The 2 **Opportunities** components are representing both a scientific challenge and the final objective of the calibration.

The permits issue is very serious, because the domestic procedures in each country may be able to seriously affect even the most perfect plan, even in the presence of the best good will of each CPC concerned. According to recent experience, this may happen even for other GBYP activities, if conducted in national waters of many CPCs. Anyway, the permit procedure can last for even more than two months in some areas.

5 Discussion, conclusions and recommendation

An aerial survey on bluefin tuna is very different from one on marine mammals. An aerial survey on bluefin tuna spawners, as discussed in a previous SWOT analysis within the GBYP activity (Di Natale and Idrissi, 2013), is quite different from one on bluefin tuna juveniles. The main advantage point is that bluefin tuna spawners cannot be confused with any other species, because no other fish species in the Mediterranean Sea have the same size, while distinguishing bluefin tuna from dolphins living offshore (usually, the striped dolphin, *Stenella coeruleoalba*, and more rarely, the common dolphin, *Delphinus delphis*) is very easy, particularly for trained pilots and professional observers.

Bluefin tuna aggregations of adult fish might range from just a few individuals to many thousands of fish, usually having different size; recent sightings reports even an enormous bluefin tuna school distributed over an extension of more than 5 nautical miles area.

The vertical distribution of bluefin tuna spawning aggregations might range from the most upper part of the sea (surface to 10/15 m) to more than 50 m depth.

The possibility to detect and assess the number of individuals in a school and their total weight from an aircraft at 300 m altitude and having a speed of 100 miles/hour depends from the light conditions, the sky coverage, the presence/absence of glare, the aerial visibility, the water transparency, the presence/absence of wind, the wind strength (no sightings are accepted with a wind speed over 3 Beaufort) and the consequent presence of waves, the presence/absence of swells and their high, the distribution/concentration of the school in the horizontal water space, its vertical distribution, its behaviour component, the declination angle, besides the individual experience, skills and capacity of the spotter. Fatigue or moment inattention by spotters are additional factors to be considered, as well as the requirement to use declinometers for getting the sighting angle. All these factors combined are potential biasing components of the aerial sightings.

Counting the number of schools is not a problem in all conditions, while assessing the number of individuals, their size range and their total weight is the main challenge, particularly for large schools or schools distributed over a range of depths. There, the tuna sighting experience plays a basic role, but numbers are always an individual estimate, even using the most sophisticated technologies or the best spotters.

The major problem for comparing the sighting obtained from an aerial survey on bluefin tuna spawning aggregations with a sonar assessment of the same bluefin tuna school is linked to the technological limits of sonar when dealing with a huge amount of fish distributed over a large surface or in a huge water mass. Even in this case, counting the number of schools is not a problem, while assessing the number of individuals, their size range and their total weight is the main challenge. In this case, the bias in estimating a school by sonar can be even higher than the aerial survey one for very large schools.

Whenever we consider that estimates for size and weight during a tuna transfer in cages, using a reduced distance and at least two stereo-video-cameras (sometimes four) are still providing uncertain estimates and that when many tunas are passing grouped together along the transfer tunnel even the number of fish is uncertain, than we can easily realise how uncertain could be a sonar estimate for a large school of bluefin tuna.

This technological limit, which is usually not well defined (or even not mentioned) in most of the very few calibration exercises carried out so far, makes the calibration of the aerial survey an uncertain tool for large tunas. Strongly simplifying this type of calibration exercise, two different estimates are compared, possibly wrongly assuming that one (the sonar) is more reliable than the other (the aerial sighting), therefore attributing individual CVs to all spotters based on this basic assumption.

Furthermore, as mentioned in the first part of this document, calibrating about 30 spotters cannot be done in one shot on a small aircraft having usually a total of 4 seats (including the pilot) and it will be necessary to calibrate them in various trials on different days, necessarily under different environmental conditions, adding uncertainties to uncertainties, but always getting a theoretical CV not reflecting any real one.

Efforts for better assessing by sonar schools of bluefin tunas, using sonar from aircrafts, are still under study by a project granted by NOAA in 2014 to a team headed by Ph.D. Molly Lutcavage. This project is anyway related to non-spawning and small aggregations of bluefin tuna, comparing high-resolution images with sonar images.

As a matter of fact, technological limits already exist for a proper calibration of the aerial surveys and most of the limiting factors are not easy to overcome, at least in a short time and under the current available technologies. All these serious and strong doubts together seem suggesting that calibrating so many spotters has very low sense if any, because the results would not be fully reliable in any case. The final results will be adding a further undefined bias to other undefined biases, possibly increasing uncertainties.

The calibration issue was discussed during the ICCAT GBYP Workshop on Aerial Survey in 2011, at the presence of various experts, and was not among the actions recommended by the group, taking into account the many practical difficulties and the great uncertainties (http://iccat.int/Documents/Meetings/Docs/2011_GBYP_WORKSHOPS_ENG.pdf).

As a matter of fact, an aerial survey on adult bluefin tuna will miss some fish, even directly along the line-transects, because some fish will be underwater and not visible when the aircraft pass over them. Since there is no way to know what proportion of fish is missed, there is little point in trying to come up with a direct estimate of the true biomass (Farley and Bennet, 2008). It means that the aerial survey estimates for tunas, by definition, are the minimum possible estimates of a relative biomass, because fish cannot be less that those spotted by the observers on the aircraft; on the opposite, they can be much more and therefore the aerial survey data can be considered as the most prudential estimate. At the same time and according to a power analysis (Cañadas and Vázquez, 2012), an aerial survey, particularly if targeting bluefin tuna spawners, carried out over a series of year (at least 6 or 7), in the same areas and with the same basic methodology, is able to provide relative abundance indices and a trend. If the survey is carried out from one or two platforms maximum, with a very limited number of spotters (not more than 6 in total), then a calibration can provide individual CVs to be used for partly correcting the sighting, always taking into account that both sightings and CVs are estimates. If the survey is carried out from many platforms and spotters, therefore calibration seems a theoretical and very expensive exercise, able to produce numbers and theoretical CVs but not any useful tool for improving the original data reducing uncertainties.

In this loop, it is anyway important reducing all possible biases caused by different individual capacities and experiences and, using the same methodology which is used for carrying out landing controls and size frequencies, one of the best methods to get data having an almost stable bias is to use always the same spotters in the same area over the various surveys. This approach will reduce variability in estimates, because the individual CV will be always in place in the same area, even without defining it from a statistical point of view. This is the practical approach followed by several aerial survey carried out so far on marine mammals or fish species (Kessel *et al.*, 2013). Of course, repeated and good training is always a must.

This is not obvious under the current contractual system enforced by ICCAT GBYP, which is the consequence of several administrative constraints and annual budget uncertainties. So far, each survey was carried out by companies selected after a specific call for tenders, limited to the single survey to be carried out in a given year and according to the best offer. Taking into account that administrative constraints will remain even in the future, a possible solution is to provide contracts able to be renewed if funds will be available for future surveys, requesting the companies to keep always the same spotters in the same area.

There is an additional worry to be taken into account: professional tuna spotters derive their skills and experience from their variable period of practical training when aerial spotting for fishing reasons was allowed. Some of them were spotters since the early '70s and have an important experience. Since 2006 the use of aircrafts for bluefin tuna fishery was prohibited in the ICCAT area and therefore most of the professional tuna spotters retired, or continued a fishing activity or moved to other activities. At the moment, GBYP is still finding some of these professionals which are available for the aerial survey, but their availability and number is decreasing year after year and in a short time, they will have less spotting capabilities or their number will not be sufficient for the survey.

As reported before, one of the parameters used for the aerial survey is counting the tuna schools: this was used mostly for juvenile bluefin tunas, like in the surveys in the Gulf of Lion carried out by IFREMER (Fromentin, 2001; Fromentin *et al*., 2003, 2013; Bonhommeau *et al*., 2010, Bower, 2014), surveys that produced an index which was used by ICCAT SCRS also in some sensitivity analyses in recent EBFT assessments. Counting the schools usually produces unbiased results, independently from the individual capacity of the spotters. Then, schools are not stable entities and they are highly variable in the number of components, therefore the results of these estimates are highly disputed and they are not always accepted, but anyway the trends have been considered indicative of a relative abundance in a given area. The number of schools are available also from all GBYP aerial surveys carried out so far and they are very reliable, because they have also all other details, but this limited approach is not able to produce any type of quantitative estimate of the minimum spawning biomass or any trend related to SSB.

This very difficult discussion can continue for each single variable of the aerial survey, but the main point is that ICCAT GBYP must optimise the cost efficiency and a calibration for so many spotters and with so many uncertainties seems far from any acceptable cost/benefits rough analysis and even far from producing any reliable result able to improve the current and future data. There is always a balance between theoretical approaches, research optimal requirements, budget constraints and realistic possibilities.

Therefore, logic recommendations are the followings:

A. Cancel the calibration planned so far, because the results will not fundamentally improve the data coming from the aerial survey in any case.

B. Provide a contract to each selected company which can be extended for the necessary number of years, depending on the availability of funds, for having a possible stable team in each area.

C. Use the available funds for improving the observations and the density of line transects.

D. Further assess the possibility of calibrating the observer's "perception bias" in a next survey, using two separate and independent estimates in parallel, by two spotters on the same side of each aircraft. This possibility will not be very easy in practice, because the pilot and the professional spotter are usually sitting in the front seats, while scientific spotters are on the rear seats. Furthermore, the aircraft can be equipped by bubble windows only for the rear sits, while the front seats must have a classic flat window and this technical limit cannot be overcome.

E. Use part of GBYP funds for carrying out retrospective analyses of previous sighting by individual spotters, in order to detect possible individual "perception bias".

F. Continue working with the best specialist in this field for finding solutions for further improving the data quality.

G. Try to work for improving the quality of the assessment by studying the additional variance caused by factors for which we can have scientific data, i.e.: assessing the percentage of the time at the surface of bluefin tuna spawners in the Mediterranean spawning area, using the data from the electronic tags.

As a very famous Italian poet (Dante Alighieri, 1317) wrote in the XIV century: "*vuolsi così colà ove si vuole ciò che si puote e più non dimandare*"[3] (Divine Comedy, Gate of Hell, III, 95-96), and this sentence clearly shows the obvious limits we have for everything we search for.

Acknowledgments

A particular note of thanks is for Prof. Phil Hammond and Ph.D. Greg Donovan, for their availability and kindness for discussing and sharing the contents of this paper, taking advantage of their large experience in aerial surveys. Their kind support was essential.

Another note of thanks is for Ph.D. Tom Polacheck, because the extensive discussions we had, either at the GBYP Steering Committee or in many e-mails helped for better defining many aspects of the calibration.

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[3] The best translations for this sentence in ancient Italian are the followings: "This deed has so been willed where one can do whatever he wills" or "It is so willed there where is power to do that which is willed; and further question not."

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Table 1. Possible cost components estimates for a calibration of the ICCAT GBYP aerial survey (calculated on the GBYP average costs in 2013).

Item	*Cost/unit €*	*Min units*	*Max units*	*Min. No. components*
1 Aircraft (in activity)	630/hour	30	42	2
1 Aircraft (stand-by)	320/day	3	5	2
1 Aircraft (transfer)	tbd	2	2	2
1 purse seiner (in activity)	8000/day	4	6	1-2
1 purse seiner (stand-by)	6000/day	3	4	1-2
1 purse seiner (transfer)	tbd	2	2	1-2
1 Spotter (salary)	210/day	7	10	30-32
1 Spotter (per diem)	100/day	7	10	30-32
1 spotter (transfer)	tbd	2	2	30-32
1 external expert for survey design and data analysis	tbd	1	1	1
1 external expert for sonar monitoring and assessment	tbd	1	1	1-2
1 GBYP Coordinator (per diem)	tbd/day	8	11	1
1 GBYP Coordinator (transfer)	tbd	2	2	1
Aircraft parking and handling	tbd/day	8	11	2
Vessel mooring	tbd/day	8	11	1-2
Local transfers	tbd/day	8	11	tbd
Permits	tbd	1	1	3-4
Insurance	tbd	1	1	tbd
Other costs	tbd	1	1	1

Table 2. SWOT Analysis of the calibration for the GBYP aerial survey on bluefin tuna spawning aggregations

<table>
<tr><td>Strengths

1. Sightings will become more statistically sound.
2. Each spotter will have a personal CV factor.
3. Previous experiences provides good basis, even if they were done for a much more limited number of spotters.
4. It is supposed that all pilots and professional spotters have already a good experience and the calibration will provide them more incentives and define possible differences among them.
5. Scientific spotters have usually much less experience and the calibration will be very useful for identifying the best ones and their personal capabilities and skills.</td>
<td>Weaknesses

1. Extreme difficulty for assessing about 30 spotters at the same time; sequential flights will be necessary.
2. Impossibility to evaluate all spotters at the same time will increase biases and personal CVs in an undefined manner.
3. Instability of environmental external factors during calibration will increase biases.
4. The assessment of a target BFT school using sonar has already a bias, which is difficult to assess.
5. BFT schools are sometimes huge and difficult to assess in terms of individuals and weight.
6. Pilots cannot operate in aircrafts not belonging to their company.
7. Difficulties in organising it at the beginning of the survey.
8. Impossibility to assess the differences from different aircrafts types.
9. The assessment about the number of schools will not further improve.
10. Very high cost of the calibration.
11. Legal problems
12. High risks of failure.</td></tr>
<tr><td>Opportunities

1. A similar calibration, with so many spotters, was never carried out so far.
2. The calibration will allow for re-assessing the observations from previous Phases.</td>
<td>Threats

1. A similar calibration, with so many spotters, was never carried out so far.
2. The calibration shall be done in a fixed number of days; weather conditions might impede the exercise, while the costs will be there.
3. Concentrating all spotters from various CPCs in the same place and bringing them on board implies difficult legal problems.
4. Permits problems may arise for the use of aircrafts and vessels from foreign countries.
5. High risks of failure.</td></tr>
</table>

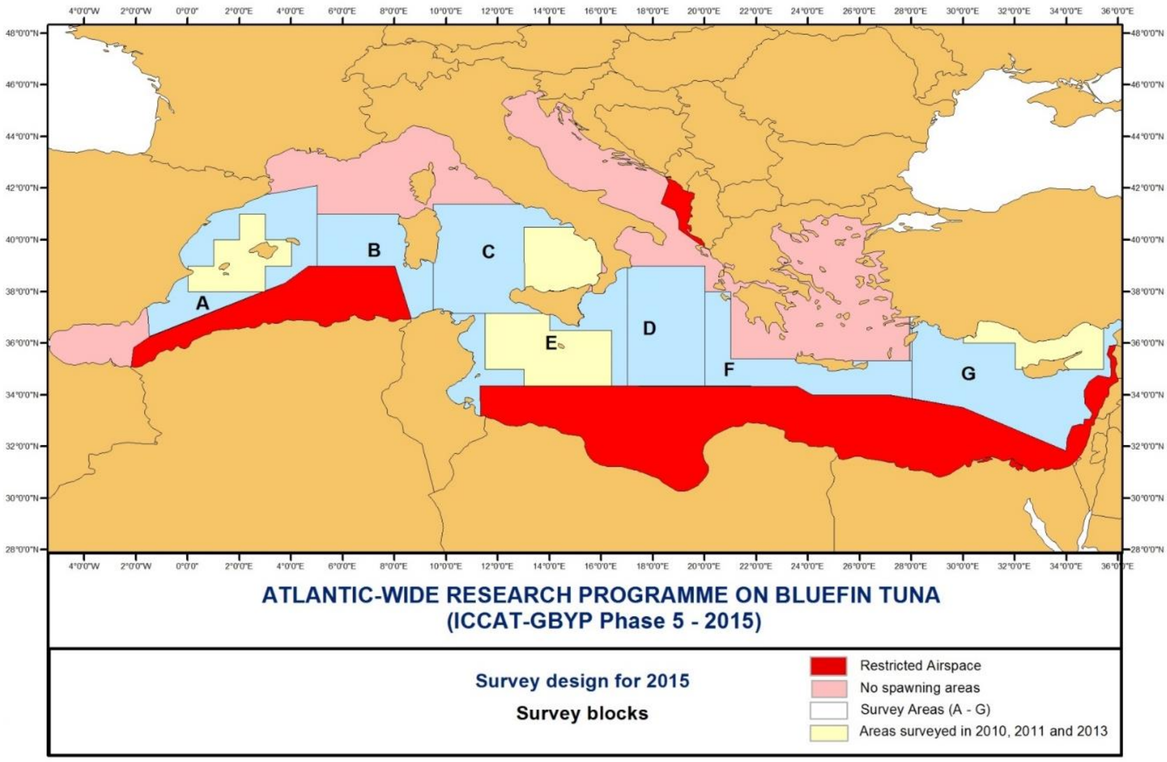

Figure 1. ICCAT GBYP map for the aerial survey in 2015, as it was planned.

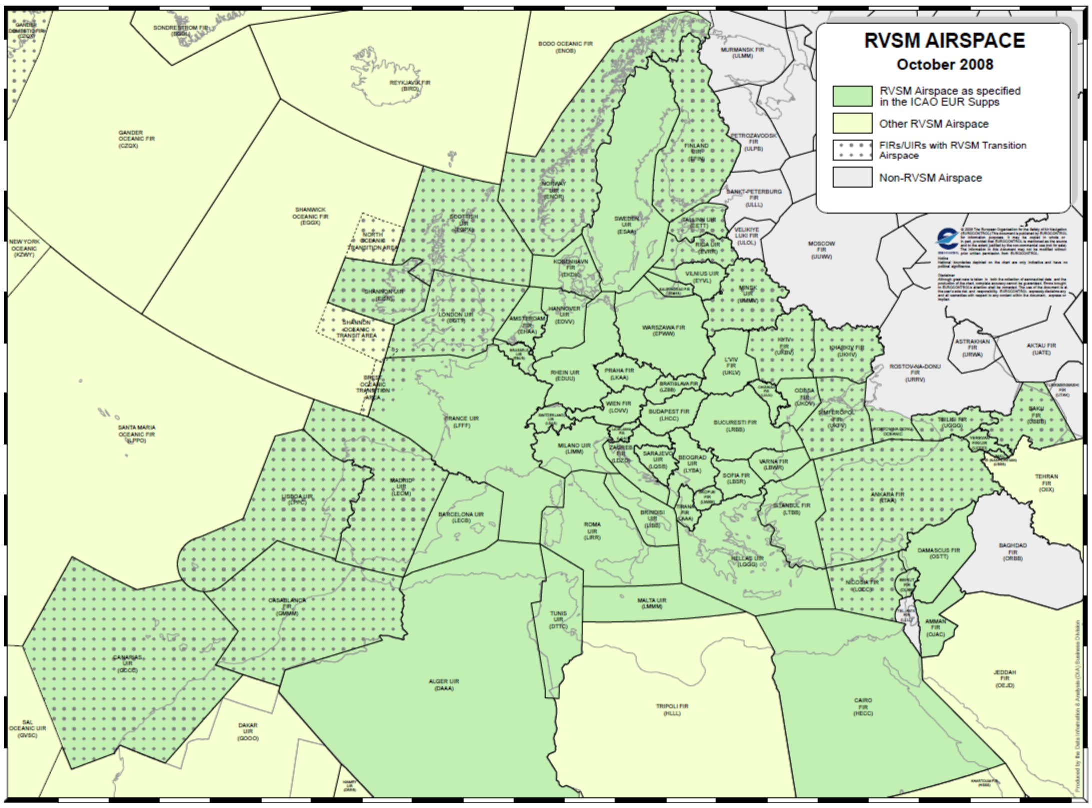

Figure 2. Official map of the 24 air spaces (FIRs) in the Mediterranean Sea.