2011 GBYP WORKSHOPS ON AERIAL SURVEYS, AND OPERATIONAL MEETINGS ON BIOLOGICAL SAMPLING AND ON TAGGING ON BLUEFIN TUNA
(Madrid, Spain – February 14-18, 2011)

1. Opening, adoption of Agenda and meeting arrangements

As part of the activities of the ICCAT Atlantic Wide Research Programme for Bluefin Tuna (GBYP), a Workshop on Aerial Surveys and two Operational Meetings on Biological Sampling and Tagging were held at the ICCAT Secretariat in Madrid from February 14 to 18, 2011. Dr. Pilar Pallarés, on behalf of the ICCAT Executive Secretary, opened the meetings and welcomed participants ("the Working Group"). Dr. Pallarés emphasized the importance of those meetings in the future development of the GBYP.

Dr. Antonio Di Natale, Coordinator of the GBYP, chaired the meetings. Dr. Di Natale welcomed meeting participants and proceeded to review the Agendas which were adopted with minor changes. The reports of the three meetings are included in **Appendices 1** to **3**; Agendas are attached as **Appendix 4**.

The List of Participants is included in **Appendix 5**. The List of Presentations and Documents presented at the meetings is attached as **Appendix 6**. The summaries of the presentation are attached in **Appendix 7.** Presentations are available in the ICCAT web site (http://www.iccat.int). Dr. Shannon Cass-Calay (United States) served as rapporteur of the Aerial Surveys Workshop, Dr. John Neilson (Canada) reported the Biological Sampling meeting and Dr. Benjamin Galuardi (United States) the tagging operational meeting.

2. Adoption of the report and closure

The reports were adopted by correspondence.

The Chairman thanked the Secretariat and participants for their hard work.

The meetings were adjourned.

Literature cited

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L. 2001, *Introduction to Distance Sampling: Estimating Abundance of Biological Populations*. Oxford University Press, Oxford, UK. vi+xv+432pp.

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Appendix 1

REPORT OF THE ICCAT-GBYP WORKSHOP ON AERIAL SURVEYS ON BLUEFIN TUNA
(Madrid, Spain, February 14 to 16, 2011)

1. Invited speaker presentations

Six invited presentations were made at the Workshop. The presentations were as follows: (summaries are provided in **Appendix 7**, while full presentations are available on the ICCAT web page, http://www.iccat.int).

- Lutcavage, M. *et al.*, Combining aerial and acoustic methods to develop fishery independent approaches for assessment of Atlantic bluefin tuna in the NW Atlantic.
- Fromentin, J.-M.,Bonhommeau, S., Farrugio, H., Aerial survey on bluefin tuna in the Mediterranean Sea.
- Sorell Barón J.M., Aerial surveys targeting bluefin tuna (*Thunnus thynnus*) juvenile and adult aggregations in the NW Mediterranean during 2009.
- Eveson, P.J., Bravington, M.V., Farley, J. H., A mixed effects model for estimating juvenile southern bluefin tuna abundance from aerial survey data. (Presented by Dr. Laurie Kell, ICCAT Secretariat)
- Donovan, G.P., Aerial surveys: the cetacean experience.
- Palka, D., US aerial observer experiences in the Northwest Atlantic for Cetaceans and sea Turtles. (Presented by Dr. Clay Porch, United States)

The presentations described the survey objectives, statistical designs, methodologies, sampling and training protocols, and equipment currently used during aerial surveys of bluefin tuna adults and juveniles, as well as cetaceans and sea turtles in many oceanic regions including: the northwest Atlantic, Mediterranean, and the Southern Ocean.

After the presentations, a thorough discussion of the many aspects of the use of aerial survey programs to provide information relevant to management advice took place. This formed the basis for the discussions held under Items 4 onwards and led to the development of a number of detailed recommendations that are provided as Section 6 of this report. A 'bullet point' summary of the main topics considered under this Item is provided below.

- **Survey objectives**: The Group recognized that the objective of any aerial survey should be to improve stock assessment methods and management advice for the target species, while reducing uncertainties.

- **Multi-target aerial surveys (e.g. BFT and cetaceans and other large fauna such as turtles):** The Group recognized that multi-target aerial surveys may have a higher appeal to fisheries management agencies which determine funding, and can be cost-effective. However, this requires careful consideration to ensure that multi-target surveys do not result in compromised objectives which lower the value of the survey results to be used to improve management advice. This can be addressed in a number of ways including survey protocols and priorities.

- The Group further recognized that the final objectives of the aerial surveys strongly drive the protocol and the sampling design. Estimating the absolute abundance or an index of relative abundance would have for instance serious implications on the sampling design.

- **Data quality:** The Group noted that the quality of the data is paramount, and that modeling techniques cannot compensate for or correct poor data. To improve this requires:

    - thorough review of the data collection protocols including the collection of environmental covariates
    - choice of appropriate platforms and equipment
    - definition of the roles and responsibilities of survey personnel and choice of suitable personnel
    - adequate training both in classroom and the field
    - consideration of issues related to estimation of school size and length classes of sighted animals including use of life size models and overflying cages
    - calibration of individual sighting estimates should be carried out, by using at the same time spotting aircrafts and vessels equipped by acoustic instruments able to quantify tuna schools

- Use of electronic tagging information to evaluate the vertical distribution of bluefin tuna during the spawning season for providing correction factors to the aerial survey analysis.

- **Survey area and timing:** The Group agreed that the appropriate size and timing of the survey area depended upon a number of factors:
  - Survey program objectives
  - Full consideration of the synoptic versus non-synoptic surveys given objectives and current state of knowledge on distribution, movements and behaviour of the target species
  - Appropriateness of using catch data to infer stock distribution, including the need to consider the effect of management regulations including size limits and time-area closures.
  - Spatial and temporal scales of environmental variability.
    - Environmental conditions are variable and affect the distribution of juvenile and adult bluefin. Therefore the size of the survey area(s) must be sufficient to accommodate fluctuations in distribution due to the environment.
  - Spatial and temporal scales of population increase/decrease.
    - Bluefin tuna are under a rebuilding plan which, if successful, will result in increased abundance and perhaps expansion of distribution into habitats that have not recently been occupied and/or fished. Therefore the surveyed area and the number of years surveys occur must be sufficient to detect changes in abundance and distribution.

- **Survey methods and design:** The Group agreed that the appropriate survey methods and design depended upon a number of factors:
  - Survey program objectives, survey area and timing
  - Choice of the most appropriate analytical technique (and hence appropriate data collection protocols), including estimation of variance
  - Consideration of possible adaptive sampling strategies and their proper usage
  - Determination of survey lines (e.g. using program DISTANCE) and the need for replication

- **Survey equipment and protocols:** The Group highlighted the following issues:
  - Safety is paramount
  - Choice of aircraft and equipment (including engine specifications and bubble/belly windows) and relationship with objectives and analytical methods.
  - Cameras (geo-stabilized, high resolution, with GPS tagging) – value for recording sightings and provide estimates of number and size of individuals.
  - Additional survey methods to complement aerial surveys, e.g. by assisting in calibration work and developing correction factors for availability bias[1] (tagging, time-depth recorders, multi-beam sonar)

- **Simulation studies:** The Group reiterated the value of simulation studies to inform best scientific practices, especially when examining potential biases in surveys and the effect of this on assessment methods and the provision of management advice.

2. Historical aerial surveys of bluefin tuna

An additional presentation was made to the Working Group.

- Di Natale A., Arena P., Aerial surveys on bluefin tuna spawning aggregations in the Southern Tyrrhenian Sea in the '80s.

This presentation detailed a historical aerial survey conducted in the 1980s in the Southern Tyrrhenian Sea. This was an opportunistic survey that was conducted without a statistical design, with the main objective to study the ethology of bluefin during the spawning season. The details of this survey and its results can be found in **Appendix 1**.

[1] Availability bias refers to the inability of observers to see animals on the trackline because the animals are submerged; this differs from perception bias which refers to observers missing animals that that in principle they should have been able to see.

The Group discussed the potential use of this information in a stock assessment context. In was generally agreed that in order to compare the historical series to recently acquired survey information, identical techniques must be used across the two time periods. If it was possible to carry out new surveys using the old techniques (e.g., pilots, search techniques) then in principle, this may allow broad qualitative comparison of population abundance over time as has been occasionally done for cetaceans. However, the Group also cautioned that similar efforts to use historical aerial survey information on tuna had proved to unsuccessful, despite the best efforts of statisticians. The Group did not believe such work should receive high priority.

3. Information about the results of the first-year activities and the objectives aerial surveys under GBYP

Two presentations were made to the Group that described the objectives of the ICCAT-GBYP aerial survey program.

- Hammond, P., Cañadas, A., Vázquez, J.A., ICCAT GBYP Aerial Survey Design and Analysis 2010. (***Presented by Dr. Laurie Kell, Secretariat***)

- Di Natale A., GBYP Aerial survey on spawning aggregations: objectives and approaches.

These two presentations described the objectives, methods and results of the 2010 ICCAT-GBYP aerial survey program (the executive summaries are provided in the detailed report, while full presentations are included in the appendices). The Group had many comments and suggestions, including the following.

The Group recognized the future value of spatial modeling techniques both to estimate abundance and to prediction of bluefin distribution from environmental data, and recommended that these efforts continue to be refined. They also agreed with Hammond *et al.* that the data from the 2010 survey were not sufficient to predict the distribution of bluefin tuna spawners throughout the Mediterranean Sea.

The Group recognized the value of the power analyses presented, and their potential use for informing survey methodologies and expectations. However, the Group noted that the true CV for the 2010 estimates was probably greater than the estimated CV owing to the need for the authors to make several assumptions due to the quality of the data.

Hammond *et al.* had identified a number of problems with the data and made suggestions for improvements in data collection. For example, the distribution of perpendicular distances from the 2010 GBYP survey in areas 1 to 3 **(Figure 1)** highlighted the need for improved training of observers and the importance of using a searching strategy consistent with the Distance sampling approach. The lack of sightings close to the trackline is not surprising given the lack of bubble windows but the unexpected peak in sightings at 3 km suggests that the observers were focusing their search effort well away from the trackline. Such a distribution results in such a poor fit for a detection function, limiting the use of these specific data to produce a reliable estimate.

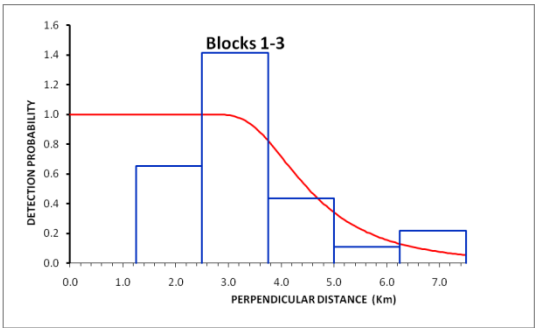

Figure 1. The detection function from the 2010 ICCAT aerial survey in areas 1-3.

In considering survey areas, the Group noted that the use of recent VMS data alone to select the survey areas (as had been done for the 2010 surveys) could be problematic for a number of reasons primarily (1) the distribution of fishing effort has varied greatly in recent years due to management regulations and (2) the fact that the distribution of bluefin changes in response to environmental conditions and population expansion. This led the Group to discuss the value of synoptic surveys over a broader area, which has been agreed to be a crucial point

for a good understanding of the distribution and concentration of bluefin tuna spawners in the full Mediterranean area.

In particular, attention focused on the possibility of conducting a large-scale, synoptic survey every 2-3 years rather than an annual survey over a smaller area. The advantages/disadvantages of this approach can be summarized as follows:

- Advantages:
    - If bluefin tuna stock distribution is influenced by environmental variables (as it was demonstrated by several scientific papers), a larger sampling area will improve estimates of abundance.
    - Such surveys can avoid confusing apparent changes in abundance over time with changes in distribution over time.
    - As the stock recovers under the rebuilding plan, it is expected to expand into areas that are not currently densely occupied or fished. A larger scale survey is required to detect and quantify this expansion.
    - A larger-scale synoptic survey will improve the sample sizes over a larger set of environmental variables, and will improve the ability to undertake reliable spatial modeling. The results of this could allow for improved survey design in the future as well as improved estimates of abundance.
- Disadvantages:
    - A survey that occurs every 2-3 years may degrade the ability to conduct consistent survey techniques due to transitions in survey staff, difficulty obtaining funding to continue an intermittently occurring survey, infrequent training, etc. This could be ameliorated by conducting small scale annual surveys to better inform spatial modeling and training exercises when the synoptic survey does not take place.

The Group also recognized that the current six-year ICCAT-GBYP aerial survey program has already been endorsed by the Commission and its objectives and budget have already been agreed upon in principle. Thus, extensive changes to the aerial survey methodologies will have to be carefully justified. However, the Group stressed that the results of the power analysis show that the detection of trends from indices of abundance to inform science-based management requires long-term monitoring.

In order to obtain a reliable index of abundance of bluefin spawners (the objective set by the ICCAT-GBYP, and endorsed by the Commission), the Group developed recommendations (Section 6) for 2011 and 2012. Without this level of effort it stressed that the desired objective established by the Commission cannot be met.

4. Use of aerial surveys in stock assessment

One of the critical limitations of the current stock assessment model for eastern Atlantic BFT is that the sources of data used are all fisheries dependent. It is well known that considerable misreporting of catches has occurred following the introduction of TAC (Total Allowable Catch) based management and that both catch and effort have been influenced by management measures. As a source of fisheries independent data, the GBYP aerial survey is therefore crucial for calibrating the stock assessment models (i.e., VPA) actually used and for testing and eventually adopt new assessment or management procedures (such as an empirical harvest control rule).

The current stock assessment and advice for bluefin tuna is based upon Adapt-VPA. A main assumption of Adapt VPA is that the catch data are known without error and that unbiased time series of catch per unit of effort (CPUE) are available to calibrate the VPA i.e., to help estimate numbers-at-age in the oldest age used in the VPA and the plusgroup (i.e., all ages greater than the oldest true age) and in the most recent year. These terminal numbers-at-age are the most uncertain values in the VPA, but also the most important since for bluefin, 60% of the spawning stock biomass is in the plusgroup and current estimates are needed to agree on management measures. If the data are biased due to misreporting or changes in catches and fishing effort due to management, then the estimates will highly uncertain. An unbiased fishery-independent estimate of the SSB (such as that from an aerial survey program) is therefore essential to be able to provide robust advice consistent with a precautionary approach.

An aerial survey will also be an important component of alternative methods and management advice frameworks being developed under the GBYP. For example, a fisheries independent index of abundance (either

relative or absolute) will also be extremely valuable when new advice frameworks (e.g., Management Strategy Evaluations) are developed and evaluated with respect to achieving management objectives and the trade-offs between them using simulation approaches.

5. How the current surveys can be eventually modified to achieve the objectives

5.1 Objective

To develop a relative index of abundance for the spawning stock of Mediterranean bluefin tuna that will improve stock assessment and management. (As knowledge improves it may ultimately be possible to turn this into an absolute abundance series.)

5.2 Long term plan

5.2.1 Survey area: all the potential/known spawning grounds i.e.:

The entire Mediterranean Sea, except:

- the Alboran Sea
- the northern part of the western basin (north of the line between Barcelona and Southern boundary of the Ligurian Sea).
- the northern part of the Adriatic Sea
- the northern part of the Aegean Sea

Rationale: Given the present lack of understanding of both the spatial dynamics of the environmental conditions that are necessary for spawning, and of population structure within the Mediterranean Sea, to be a suitable index, the sampling area should cover all potential spawning grounds i.e. it should be larger than the areas surveyed in 2010. With improved knowledge, it may be possible to define a smaller area(s) that provide an appropriate index or indices.

5.2.2 Survey period: The survey should be conducted in June.

Rationale: The spawning period of BFT in the Mediterranean Sea typically begins in mid-May in the eastern basin and ends in July in the western basin, and can be affected by environmental conditions. The peak spawning season is June. This conclusion is supported by historical information from traps and the distribution of eggs and small larvae.

5.2.3 Synoptic survey: Ideally, this should be a synoptic survey.

Rationale: the advantages given under Section 3 far outweigh the disadvantages. After a number of surveys, it may be possible to determine a multi-year ('mosaic' program but this will require consideration of a number of factors such as additional variance and the implications of this for management must be evaluated.

5.2.4 Sampling design

Designed using "Distance" software over the whole spawning area using equidistant parallel lines.

Rationale: whilst such lines throughout the whole areas should be designed for possible highest coverage, such a design should allow for flexible strata (with highest coverage in expected primary areas) amongst years without compromising the index.

In addition, whilst replication within all strata is not strictly essential for a synoptic survey covering the entire spawning area, the uncertainty over the behavior of tuna discussed under Item 5.3.2 relating to availability bias, the Group agreed that it would be advantageous if national parties considered additional sampling effort, provided that in terms of choice of survey lines, training and data collection protocols, the synoptic survey methods are used and the effort is coordinated with the GBYP aerial survey steering committee.

5.3 Short-term plan (for survey in 2011)

5.3.1 Survey areas: Similar to those used in 2010 but a subset to minimize the logistical issues. The Group recommends the following areas be sampled.

- Northern Sicily
- Balearic Islands
- South of Malta and the western Gulf of Syrta (the Group considered this area of secondary importance)
- Between Cyprus and the Turkish coast.

5.3.2 Objectives: The primary focus of the work should be to: (1) address the issues raised during the 2010 surveys; (2) determine and test final field protocols and build up the expertise necessary for a 2012 synoptic survey, (3) undertake suitably thorough training (to ensure consistency e.g. in recording sightings data and appropriate covariates, there should be training for all teams together for part of the time and also exchange of observers amongst areas); (4) calculate indices of abundance for the areas chosen; and (5) address the issue of the need for replicates given the behaviour of tuna.

The Group also noted the following:

- The need to improve training of pilots, professional spotters and scientific observes in field and in classroom implies the need for experienced trainers!

- That consideration must be given to the qualities needed for survey personnel, and their roles and responsibilities, which must be clearly defined. All personnel must receive adequate training, including an understanding of the purpose of the aerial survey. For a Distance sampling method to work, all personnel, including commercial spotters, must follow survey protocols. The scientific observers must ensure the full respect of protocols and survey methodologies.

- That the difficulties in handling large schools should be informed by simulation studies if possible, before finalizing the protocols.

5.3.3 Availability bias: Since the survey area will be smaller area, replicates can be used in 2011 to begin to examine availability bias.

- Note that if it can be assumed that biases do not vary by year, this will not affect the use of the estimates as an index (although it will affect absolute abundance estimates) but this assumption must be evaluated. For example, it was suggested that areas with higher fishing pressure could have a higher availability bias (spatial variance). There could also be environmental factors that influence the behavior of BFT, and cause interannual variations in availability bias. Care should be taken to collect suitable covariates and a full evaluation of this should be undertaken prior to the 2011 survey.

- Consideration should be given as to whether it may be advisable to use separate surveys (not part of the overall synoptic survey) to allow a detailed analysis of important parameters, such as availability bias.

5.4 Indices of abundance for juvenile bluefin tuna

Getting an accurate index of abundance of bluefin spawners is the defined objective of the ICCAT-GBYP steering committee, and is crucial to monitor the population of bluefin tuna in the long term. However, development of an index of abundance for juvenile bluefin is also useful to follow short-term dynamics, such as the response of the population to specific management measures (which can hardly be detected in less than a decade for spawners) or to detect the effects on recruitment of variations in environmental conditions, fishing or pollution (e.g. oil spill).

Although juveniles are detected in some spawning grounds during the spawning season, getting an accurate index of abundance of juveniles requires aerial surveys on the specific key feeding grounds of juvenile bluefin tuna, such as the Catalan Sea, the Gulf of Lions, the Ligurian Sea and the Adriatic Sea for the Mediterranean. Such surveys are furthermore facilitated by the higher detectability of juvenile bluefin from aircraft as those fish often swim and hunt at the surface. These considerations also apply in the Western Atlantic, where aerial surveys could be conducted for juveniles because of their high surface availability in summer months on the mid-Atlantic shelf (VA- New England).

Initial trials using sonar and aerial mapping approaches demonstrated the feasibility of determining size, area, and total biomass of schools, as well as sizes of individuals in schools with relatively simple, affordable data collection systems. For aerial survey alone, the elaboration of simple estimates of the school size (e.g. small, medium, large) might provide another quantitative estimate, in addition to the professional spotter estimate. An additional advantage is that the distribution of juveniles and their annual dispersal patterns, vertical behavior and oceanographic associations have been documented via electronic tagging.

6. Recommendations

The Group made the following recommendations, for the consideration of the GBYP Steering Committee:

a) The aerial survey on spawning aggregations in 2011 should be conducted in a maximum of four areas (eastern Mediterranean, central southern Mediterranean, southern Tyrrhenian Sea and Balearic Sea), modifying the design of the Southern Mediterranean Sea area according to the considerations provided above. The survey should be restricted to June. Distance sampling methods will be followed. The five primary objectives are given under Item 5.3.2 and should be addressed.

b) The aerial survey in 2012 should be synoptic, enlarged to most of the Mediterranean Sea (as specified under Item 5.3.1), with the purpose of surveying all the potential spawning grounds (for the reasons given under Item 3). The results from 2011 will greatly improve survey design and protocols for 2012 and thus measures to ensure prompt analysis of the 2011 data should be put in place.

c) Training is an essential part of the survey; training in classroom and in field must be carried out before and during the 2011 and future surveys (see Item 5.3.2).

d) The aerial survey protocols should be further improved, in accordance with the conclusions of this Workshop (and any recommendations for analyses undertaken).

e) Serious consideration should be given to using aircraft equipped with bubble windows, for improving the detection rate beneath the aircraft, as recommended by Hammond *et al*.

f) The number of observers onboard should be increased to three (one in the front seat who will primarily be a data collector) and two in the rear seats – all should be trained to understand the importance of searching in accordance with a Distance sampling approach (e.g. recognizing that sightings made far from the trackline will probably be truncated from the analysis).

g) Any cameras used for the survey should be of sufficient standard to meet the objectives (e.g. improved school size, assigning animals to length class) and be stabilized and equipped with geo-reference tools.

h) Aerial surveys on bluefin tuna juveniles should be encouraged for consideration of all the concerned CPCs.

7. Other matters

The Group also discussed additional work which would help us interpret aerial surveys, such as the analysis carried out to correlate sightings data and environmental parameters, underlining the importance to use only SST data calibrated in situ and to possibly get data on the vertical distribution of the thermocline in the various spawning areas. The high relevance of using electronic tags on spawners, which could provide data in the same period of the aerial survey was also stressed, inviting GBYP to possibly use some tags in Phase 2, with the purpose to better calibrate the survey data.

Appendix 2

ICCAT-GBYP OPERATIONAL MEETING
ON BIOLOGICAL SAMPLING FOR BLUEFIN TUNA
(Madrid, Spain, February 17, 2011)

1. Introduction by the GBYP Coordinator

The Coordinator noted that he considered the role of GBYP was to contribute to the best possible sampling, Atlantic-wide coordination, and training. With regard to training, participants were given an opportunity to receive hands-on training on otolith removal techniques used by scientists working within the Southern Bluefin Tuna (SBT) Commission (see Section 5). Finally, the Coordinator noted that an important function for the GBYP would be to facilitate inter-lab comparisons of the results from biological sampling, such as age determinations and determination of natal origin.

The Coordinator also noted that there would be an open call for tenders to conduct the biological sampling program identified by this Group. He encouraged cooperation and collaboration leading to a multi-national team tendering an offer to conduct the biological sampling. Sampling activities are expected to begin this year, with the 2011 fishing season.

A meeting participant asked for clarification on the scope and coverage of the biological sampling program. The Coordinator noted that while the GBYP is clearly an Atlantic-wide activity, some countries (USA and Canada would be examples) are establishing domestic sampling programs that are intended to emulate the GBYP activities. The United States and Canada will keep the GBYP apprised of the development of their respective sampling programs and welcome collaboration with scientists from other CPCs.

2. Short practical training course for sampling otoliths in medium-large bluefin tuna (by Sakai Osamu, National Research Institute of Far Seas Fisheries, Shimizu, Japan)

A short presentation and a video showing details of the sampling used by SBT scientists were provided to the Group. It was explained that due to market considerations, it was preferable not remove the heads for otolith extraction in the SBT fisheries. A procedure was therefore developed to extract the otoliths (see Thorogood (1986), modified by CSIRO Australia (Clear *et al.*, 2000). It was noted that this technique results in little external damage to the fish, which could be advantageous when seeking cooperation from fishermen or buyers. A practical hands-on session revealed that the procedure worked well on Atlantic bluefin tuna heads, even when the heads were partially frozen. The GBYP acknowledged the very kind support provided by Grup Balfégo, who made several tuna heads prepared and available for the training trial. In discussions concerning this method, it was indicated that the equipment costs were modest, perhaps 150 Euros for the cordless drill. A participant asked if there was morphometric landmarks used to guide the angle of the drill. The demonstrator responded that it was largely a matter of experience and practice.

3. Discussion on the research needs for biological sampling

In the context of describing existing data collection systems, Mr. Franco Biagi provided an overview presentation on the EU data collection framework started in 2000 (originally DCR). This program, co-funded by EU and member States, is not limited to bluefin tuna, but includes many other species of commercial importance. It was established recognizing that many national sampling programs were not continuous in nature, and there was a need for dedicated long-term monitoring of the fisheries. The fisheries that are targeted by this activity include purse seine, longline, handline, traps, and recreational fisheries. The information collected by samplers includes age, length, weight, sex, maturity, and fecundity. Coordination occurs at the regional level. Length sampling must be done annually; intensity varies from year to year depending on the reference level of catch, while biological sampling is done tri-annually. The last biological sampling was done in 2010 and it was noted that ageing is not mandatory based on otoliths, because the national programmes could include ageing using various hard parts (i.e.: commonly the first dorsal spine and vertebrae). There is a mis-match between EU and GBYP objectives noted by the presenter in this regard. Regardless, possible synergies between this program and the GBYP were noted. The presenter advocated avoiding redundant sampling, taking advantage of the EU initiative where possible. For example, he suggested that annual length sampling done within the EU program

could be used to opportunistically collect genetic samples, given that such materials are straightforward to collect. It was further noted that redundancy was not a consideration for biological sampling in 2011, since the EU does not plan to conduct such sampling in that year.

A participant noted the critical problem of size sampling during cage operations. He noted that the issue of conversion factors is controversial within the SCRS, and the only reliable solution at the moment is the dual camera system to record fish length upon stocking of the cages (a solution that has been also adopted by the SCRS and reported in the last BFT executive summary, see Costa *et al.* 2009). The presenter recognized that it is a significant issue. The EU is considering further development of camera systems in 2011, but it the implementation of such a system will probably take a few years. He advocated using alternative data sources in the interim, such as information from observers.

The GBYP Coordinator and other participants asked about the sampling allocation table used by the EU, and noted that the total catch levels used in the tables did not appear to match their expectations from knowledge of the fisheries. The Group noted it would be helpful to better understand the methodology used for construction of the table. The Presenter provided revised information for the Group later in the meeting.

A participant noted the need for greater involvement of scientists associated with Atlantic fisheries in regional coordination meeting. The presenter responded that participation is a responsibility of Member States.

The Group noted that some of the sample targets seemed inadequate for such a diverse fishery as Eastern Atlantic bluefin tuna, and asked how we can be sure that the sample is representative of the catch. The presenter responded that mechanisms are in place for independent peer review (by EU-STECF) of the plans of sampling submitted by member states, as well as the results and that sampling must provide a certain level of CV.

A meeting participant asked how biological sampling went in 2010, and if the sampling objectives were met. The presenter responded that it was not possible to comment at this time, as a review of the sampling activities is scheduled for later in 2011.

The Group observed that it might be possible to link sampling levels to management outcomes. For example, if the quality of data declined, and more uncertainty in meeting rebuilding targets followed, the quota would have to be lower.

John Neilson presented information on the plans for biological sampling for Canada (SCRS/2011/022). The spatial and temporal distribution of the Canadian fisheries was described using logbook information from 2002 to 2009. The presenter indicated that pending funding; the plan was to place a full-time port sampler into the field to collect hard parts, length, weight, maturity and other special collections as requested. He indicated that with the available resources, the target was for between 300-500 otoliths to be collected.

The Group questioned if this sample size would be sufficient for the generation of an age length key. Proportional sampling of the catch would be an alternative approach, particularly given that the length composition of the Canadian catch is known, and may be a more effective use of the available sampling resources. In general, however, the Group indicated that the planned sampling activities should provide a representative view of the age and natal origin of the Canadian catch.

A meeting participant enquired if there were plans to intercalibrate ages determined from otoliths with spines, noting that some institutions possessed considerable archived collections of such material. It was observed that a small workshop was planned for April of this year, and one of the goals of that workshop was to compare ages derived from both otoliths and spines collected from the same individuals. A participant also asked about the precision of age estimates from otoliths compared with hard parts. The Presenter noted that such studies have been completed (see, for example, Rodriguez-Marin et al. 2006) and concluded that ages determined from otoliths have acceptable precision. The trade-offs involved with this hard part involve cost and difficulty of extraction, but without the problems encountered in other parts, such as the reabsorption of the central part of fin spines as the animals grow.

After discussion of three contributed presentations described above, the Group returned to its discussion of the characteristics of the biological sampling activity of the GBYP.

The Coordinator informed the Group that based on the terms of the GBYP grant agreement with the EC, there is a requirement to collect no less than 2000 samples from the 2011 fishery in the eastern Atlantic and

Mediterranean. The Coordinator indicated an available budget of 505,000 Euro in 2011. For 2012, it is expected that similar funding levels will be available, but details will become clearer after the next Commission meeting. Funds allocated for 2011 must be spent by end of the year.

The Group observed that sampling should be done by gear and by country, and should be representative of the fishery. This consideration is critical from the stock assessment function. Further, it was also noted that by focusing on main fishing areas, important parts of the population may be excluded from sampling. There is a need to avoid this possibility by ensuring that population components of special interest are also sampled.

The Group reiterated the importance of having annual information on the age structure of the catch. The alternative of using growth curves to convert lengths to ages was considered a poor one, given the lack of good information to characterize the size structure of the catch, as well as the imprecise relationship between length and age for this relatively long-lived species.

The question of avoiding duplication between GBYP sampling efforts and those conducted by other parties was discussed. In general, it was concluded that the GBYP should look for synergies and efficiencies whenever possible, but recognize that there is an urgent need to initiate the GBYP sampling program at the earliest possibility. It was also noted that existing national sampling programs might not be adequate for GBYP objectives. It was also noted that no biological sampling activities will be carried out on bluefin tuna in 2011 and 2012 within the EU-DCF.

The Group was reminded that the GBYP represents an important opportunity to resolve current uncertainties in our understanding of the reproductive biology, both for eastern and western Atlantic bluefin tuna. Biological sampling should therefore include information on reproductive status, while all the most recent available data on fecundity should be possibly recovered.

4. Discussion on the research needs for genetic sampling

The Group agreed that genetic sampling was relatively inexpensive and easily accomplished in the field. Acknowledging the key importance of the uncertainties in the population structure on stock assessment outputs, it was concluded that genetic sampling should be conducted whenever otolith collections were made. This could create some cost savings for the biological sampling program. The Group also noted that the genetics sampling should have the widest spatial coverage that is possible, eventually taking advantage also of the observers on cages and traps and the eventual mortality during tagging.

The Group considered the possibility of supporting a larval survey within the GBYP. It was noted that as a specific budget item, the larval survey was not currently included. Such material may be required as part of the genetic or micro-constituent analyses, to characterize fish of known origin. If larval collections were not available, it was suggested that young of the year may be a suitable alternative. The Coordinator commented that such material should be readily available. Finally, it was noted that the Balearic Islands larval survey may be restarted.

5. Practical aspects related to the GBYP biological sampling and agreed sampling design

The Group discussed some of practical considerations in obtaining representative fishery samples. It was concluded that given the two year long commitment for biological sampling, it should be possible to report to the Commission what progress was made in 2011, and where particular problems were encountered. The Commission's authority could then be used to help overcome those problems in time for the 2012 field season.

The Group reviewed recent Task I landings information, and together with expert knowledge on Atlantic bluefin tuna fisheries, identified the following key regions and areas that should be included in biological sampling activities:

Eastern Mediterranean

- Northern Levantine Sea (medium-large): Turkish PS
- North Egypt coast (medium-large): PS if in activity in that area
- Crete (medium-large fish): Greek LL

Central Mediterranean

- Gulf of Syrta (medium-large): French, Italian and Libyan PS
- Malta (medium-large): Maltese LL
- South of Sicily and Ionian Sea (medium-large): Italian PS and LL
- Adriatic Sea (small): Croatian and Italian PS
- Gulf of Gabes (small): Tunisian PS

Western Mediterranean

- Balearic (medium-large): French and Spanish PS
- South Tyrrhenian (medium-large): Italian PS
- Sardinia (medium-large): Italian Trap
- Catalan-Gulf of Lion-Ligurian (small): Spanish, French and Italian artisanal fleets, French sport
- Tyrrhenian (small): Italian handline
- Southern Spain (juveniles & medium size): Spanish LL
- North African coasts (medium size): Algerian PS

Northeast Atlantic

- Gibraltar (small, medium-large): Moroccan and Spanish HL, Portuguese & Spanish traps, Spanish BB
- Bay of Biscay (small): Spanish BB & French TW
- Western coast of Africa (medium-large): Moroccan trap
- Madeira - Canary Islands (medium-large): Portuguese & Spanish BB

Central North Atlantic

- Central and North (medium-large): Japanese & Chinese Taipei LL
- Azores (small-medium): Portuguese artisanal

Northwest Atlantic

- U.S. coasts (medium - large): US LL, recreational, RR, HL and PS
- Gulf of Saint Lawrence (large): Canadian HL
- Nova Scotia (large): Canadian HL and LL
- Newfoundland & St. Pierre & Miquelon (large): Canadian HL & LL

Gulf of Mexico & Caraibes

- Gulf of Mexico (large): US and Mexican LL
- Bahamas and Caraibes (medium - large): Japanese LL

6. Recommendations

The Group noted that large scale projects of this nature generate a lot of information and consideration should be given towards data management, including possibly establishing a database that collaborating scientists could have access to. The Coordinator commented that this activity could be subsumed within the budget for data recovery, another project within the GBYP.

It was stressed that establishing the sampling strata was important, and the Group made progress during its discussions. However, it is also important to consider how sampling effort is deployed within strata to ensure that all fish within that strata have an equal likelihood of being sampled. Moreover, the most cost effective method for estimating the age composition (whether directly by representative sampling or indirectly via age–length keys) will depend on the accessibility of hard parts in each fishery. The Group felt that it was necessary to perform simulations to assess the number of fish that would need to be sampled in order to get acceptable estimates of accuracy and precision in the catch at age. The Group noted that catch at age could be estimated by: (i) sampling age from the catch at random or (ii) sampling size from the catch at random and applying and age-length key afterwards. The outcome of such simulation exercise would be quite useful to guide priorities and effort allocation of the biological sampling program.

The Group considered that a short-term contract to an SCRS specialist that would offer guidance for optimization of sampling effort would be useful. The contractor should work with the guidance of the

Secretariat, to gain their critical knowledge on the nature and distribution of the various fisheries, which might require different approaches to ensure they are sampled representatively. However, the time frame for implementing this work is very short. In addition, the Group agreed that more work is required to develop the TORs for the contract. The Coordinator will set up a discussion of this by email.

7. Other matters

None.

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Appendix 3

ICCAT-GBYP OPERATIONAL MEETING ON TAGGING
(Madrid, Spain, February 18, 2011)

1. **Presentation of the GBYP tagging manual (presented by Dr. José Luis Cort, IEO and Dr. Eduardo Belda, University of Gandía).**

   - In summary, an overview of Atlantic bluefin tuna movements, of different age classes, and electronic tagging in the Mediterranean Sea, from 1998-2006, was presented. Various options for conventional and electronic tagging (i.e. implanted archival, pop-up and PIT tags) were reviewed.
   - Simulations were provided according to the revised terms of reference, performing estimated F. Relative standard error and bias from the simulation indicate the level of tagging required to obtain the best possible estimates.
   - The presentation is available on the ICCAT web page, while the executive summary is in **Appendix 7**.

2. **Presentation of the GBYP tagging design (presented by Dr. Eduardo Belda, University of Gandia, and Dr. José Luis Cort, IEO).**

   - The speakers presented a simulated tagging study (using the program MARK) was presented. A Brownie model estimating F while holding M constant was carried out. Simulated tag recoveries, in the context of a VPA, gave simulated catch at age information. Three different tagging strategies tested the number of tagged age classes needed each year to achieve an acceptable level of bias and precision in catch at age determination.
   - It was concluded that although mixing was assumed to be nearly complete, this is not realistic and tagging should take place throughout the range.
   - Small batches per area tagged should add up to 6000 over three years across age classes 1-3. A minimum of 2-3000 tags are needed to obtain an acceptable level of bias in the estimation of F.
   - Electronic tagging and high reward tags can reduce the number of conventional tags needed due to an increased reporting rate.

3. **Presentation of the WWF electronic tagging program: presented by Dr. Antonio Di Natale, GBYP Coordinator**

   - Brief overview of electronic tagging activities in the western Mediterranean. From 2008 through the present. Future plans were also presented.

4. **Discussion of WWF presentation (This presentation and discussion occurred in between the discussion described in section 7)**

   - Participants noted that deployments made in April and May could aid aerial survey results by assessing migrations.
   - The Group noted that the Ocean Tracking Network (OTN) has plans to install an acoustic receiver near the Gibraltar. This could represent a unique opportunity in the future if challenges associated with acoustic receivers are addressed (i.e., battery life, damage).
   - The Coordinator and SCRS chair called for advice on electronic tagging design for the coming year.

5. **Discussion and Recommendations on the operative aspects of tagging (conventional and PITs, double tagging)**

   - The Group recommended double tagging to assess tag shedding. Type of anchor may be assessed in this manner as well. A double tagging rate of about 40% was suggested.
   - The Group recommended that the Japanese be contacted concerning sale of PIT tagged fish before further consideration of PIT tag usage.

° A discussion took place concerning whether age 4+ fish (adults) should be included in conventional tagging efforts. The Group concluded that given current operative constraints, maximum benefit would be achieved by focusing on ages 1-3 (juveniles). The aerial surveys will provide information on adults and the biological sampling will cover all age classes caught by the fisheries.

° Non-mixing rates were mentioned as an impediment to estimation of fishing mortality rates. Therefore, particular attention needs to be put into sampling in rough proportion to the local abundance of juveniles across as much of the range of juvenile habitat as possible. The most critical areas were identified as:

- Bay of Biscay, Catalonian Sea, Gulf of Lion, Adriatic Sea, Gulf of Gabes, Ligurian Sea and Tyrrhenian Sea.
- The Gibraltar area was also suggested as a possible area to intercept migrating juveniles.
- The Group concluded that the most important areas are in the Central/Western Mediterranean

° The western Atlantic was not considered in the GBYP tagging plan but it was noted that exclusion of this area may influence parameter estimation later in an assessment. The Group encouraged commensurate levels of tagging of age 1-3 bluefin tuna in the western Atlantic using the GBYP protocols wherever possible.

- It was suggested that canvassing in the Western Atlantic nations is needed to standardize reporting probability.
- Molly Lutcavage (US) noted that expertise for tagging juveniles using purse seines exists in the western Atlantic but may be lost as captains and crews age. Lutcavage also noted the ongoing Tag-a-Tiny ™ conventional tagging program as groundwork for possible tagging actions in the western Atlantic.
- The Group suggested the possibility of including a western Atlantic area within the call for tender for tagging designers. The Coordinator noted the goals of the GBYP may not be changed at this time, because the design has been already provided, but this possibility could be considered in the next future.

° Optimal gear type was discussed in depth. The Group noted the success of bait boats in the Bay of Biscay both at catching large numbers of fish/day, and the low mortality from these operations. The Group also discussed the success of the large tagging program that has recently been carried out in the Indian Ocean. For Mediterranean operations, two options emerged:

- Commission a baitboat from Bay of Biscay for use in the western Mediterranean, and transit from area to area using same crew and captain
- Use local purse seiners with local captains and crew for spatially explicit sampling areas.

° Each of these had operational advantages and drawbacks (i.e., consistent sailing and tagging crew for rented baitboat vs. local knowledge and reduced transport costs for purse seining), but past large-scale tagging programs in the Atlantic, Indian and Pacific Oceans showed that success rates are much improved when a single tagging team is involved. It has been therefore asked to deeper investigate both options and to evaluate corresponding costs. The final decision will be made on the basis of these results by the GBYP Steering Committee.

° Estimated cost options were: 5-7,000 €/day for baitboats, 5,000 €/day for local purse seine vessels from most sources, and 15,000€/day for big Italian purse seine vessels. It was noted that negotiations would most likely reduce the last cost of the last option. Multi-day commissions may also reduce the overall cost.

° August through October was determined as the optimal time period for juvenile bluefin tagging activities to occur.

° The GBYP Coordinator stressed the importance to involve in the tender proposal teams from several countries, also with the purpose to increase the capacity building and the transfer of knowledge to various research teams in several CPCs, increasing the potentiality for future activities.

° The Group noted that potential tagging mortality could better be addressed once gear specifications are finalized. Current information points to low (almost zero) mortality from baitboats. The mortality when tagging is performed from purse seiners is less well known. This will be an important consideration if permitting or some kind of scientific quota/exemption is required. The GBYP Coordinator shall inform the ICCAT Executive Secretary about the need to get a minimum quota for the GBYP field activities,

exploring the possibility to initiate a special procedure with the Commission to obtain this small quota before beginning the tagging activity.

- A SWOT (strengths, weaknesses, opportunities, threats) analysis was suggested to assess pros and cons of each gear type.
- Although no funds were appropriated in year one for electronic tagging, this could change.

6. Discussion on eventual additional tagging activities already in place.

- The GBYP Coordinator reported that some tagging activities are already carried out by various groups, including the PATs activity by WWF and some CPCs (e.g., France and Spain), the opportunistic tagging with conventional tags by sport fishers in several areas and some limited conventional tagging activity by some scientific institutes. The ICCAT Secretariat has the necessary information to follow these activities.

7. Advantages derived from the ICCAT Regional Observers Programme (particularly on cages) and national observers on traps.

- This was not covered in detail but was noted that if PIT tagging carries forward further discussion will be essential.
- The use of ROP observers on cages, purse-seiners and national observers on cages should necessarily result in improving the reporting rates, taking into account that more than 80% of the BFTE catches are concerned by these activities.

8. Discussion on awareness and rewarding strategies tagging

- It was suggested that a professional company be used to conduct canvassing due to the difficulty arising from the number of countries and languages involved.
- The use of high value tags was determined to be an effective means to increase reporting rates; the ICCAT annual lottery should be eventually improved for GBYP purposes. All electronic tags should be high reward. All reported tags must be rewarded, even if at different levels.
- Rewards were determined to be monetary in nature rather than material due to a variety of issues.

9. Practical aspects related to the GBYP tagging activities

- The Group concurred that some synergy should exist between tagging program and biological sampling.
- There was Group consensus that non invasive genetic samples should be taken for all tagged fish

10. Recommendations

Due to extensive discussion and to the lack of time, the Group did not have the time to properly list the recommendations. Therefore, it was decided to make reference to the previous points, discussed during the meeting.

11. Other matters

The GBYP Coordinator informed the Group that MoUs for tagging activities are in preparation with some other organizations, following the cooperative philosophy suggested by SCRS. In particular, MoUs are foreseen with WWF and the Confederación Española de Pesca Marítima de Recreo Responsable.

Appendix 4

ICCAT-GBYP WORKSHOP ON AERIAL SURVEYS ON BLUEFIN TUNA
(Madrid, Spain, February 14 to 16, 2011)

Agenda

1. Opening, adoption of agenda and meeting arrangements.
2. Nomination of the Rapporteur
3. Invited speakers presentations (up to 20' each)
4. Others speakers presentations
5. Information about the objectives of Aerial Surveys under GBYP
6. Additional Aerial surveys carried out on bluefin tuna under other research programmes
7. How the current surveys can be modified to achieve the objectives
   - 7.1 Spatial coverage
   - 7.2 Temporal coverage
   - 7.3 Coverage within defined strata (line spacing versus increased replications)
   - 7.4 Airplane types
   - 7.5 Calibration experiments
   - 7.6 Sighting protocols
   - 7.7 Minimum acceptable conditions for conducting survey operation
8. Use of aerial survey data in stock assessment
9. Recommendations
10. Other matters
11. Adoption of the report and closure

ICCAT-GBYP OPERATIONAL MEETING ON BIOLOGICAL SAMPLING FOR BLUEFIN TUNA
(Madrid, Spain, February 17, 2011)

Agenda

1. Opening, adoption of agenda and meeting arrangements.
2. Nomination of the Rapporteur
3. Introductory speech by the GBYP coordinator
4. Short practical training course for sampling otoliths in medium-large bluefin tuna
5. Discussion on the research needs for biological sampling
6. Discussion on the research needs for genetic sampling
7. Practical aspects related to the GBYP biological sampling and agreed sampling design
8. Recommendations
9. Other matters
10. Adoption of the report and closure

ICCAT-GBYP OPERATIONAL MEETING ON TAGGING
(Madrid, Spain, February 18, 2011)

Agenda

1. Opening, adoption of agenda and meeting arrangements.
2. Nomination of the Rapporteur
3. Presentation of the GBYP tagging design
4. Presentation of the GBYP tagging manual
5. Discussion on the operative aspects of tagging (conventional and PITs, double tagging)
6. Discussion on eventual additional tagging activities already in place
7. Advantages derived from the ICCAT Regional Observers Programme (particularly on cages) and national observers on traps.
8. Discussion on awareness and rewarding strategies tagging
9. Practical aspects related to the GBYP tagging activities
10 Recommendations
11. Other matters
12. Adoption of the report and closure

Appendix 5

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Kell, Laurence
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Appendix 6

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SCRS/2010/046 Distribution of ecological related species in the Atlantic Ocean: Sighting by Taiwanese tuna longline fishing vessels from 2004 to 2008. Huang, Hsiang-Wen, Huang, Yu-Wen.

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Sorell Barón, J.M., Aerial surveys targeting bluefin tuna (*Thunnus thynnus*) juvenile and adult aggregations in the NW Mediterranean during 2009.

Eveson, P.J., Bravington, MV., Farley, J.H., A mixed effects model for estimating juvenile southern bluefin tuna abundance from aerial survey data. (Presented by Dr. Laurie Kell, ICCAT Secretariat).

Donovan, G., Aerial surveys: the cetacean experience.

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Di Natale, A., Arena, P., Aerial surveys on bluefin tuna spawning aggregations in the southern Tyrrhenian Sea in the '80s.

Hammond, P., Cañadas, A., Vázquez, J.A., ICCAT GBYP Aerial Survey Design and Analysis 2010. (Presented by Dr. Laurie Kell, Secretariat) Di Natale, A., GBYP Aerial survey on spawning aggregations: Objectives and approaches.

GBYP tagging manual (presented by Dr. José Luis Cort Basilio, IEO and Dr. Eduardo Belda, University of Gandía).

GBYP tagging design (presented by Dr. Eduardo Belda, University of Gandia, and José Luis Cort Basilio, IEO).

WWF electronic tagging program by WWF Mediterranean Programme (presented by Dr. Antonio Di Natale, GBYP Coordinator.

[2] Presentations are available on the ICCAT web site.

Appendix 7

SUMMARIES OF THE PRESENTATIONS

Lutcavage, M. *et al.*, Combining aerial and acoustic methods to develop fishery independent approaches for assessment of Atlantic bluefin tuna in the NW Atlantic.

Lutcavage presented results from fishery dependent and independent studies on adult and juvenile bluefin tuna in the NW Atlantic from 1993- present. Her presentation included findings from aerial spotter surveys conducted on adult bluefin tuna (BFT) in the Gulf of Maine, 1994-1996, and hydroacoustic tracks documenting dispersal rates of adults and juveniles. She highlighted LPRC's research on juvenile BFT that attempts to integrate results from electronic tagging, tracking, and environmental analysis to help develop an optimal survey design and framework for direct assessment. Lutcavage presented results from a feasibility study combining multi-beam sonar and aerial mapping techniques to determine school biomass and size composition of juvenile BFT. A rationale for conducting long-term, synoptic surveys to obtain indices of abundance and to improve stock assessments was presented within the context of annual dispersal patterns, vertical behavior, oceanographic associations, and centers of distribution. She noted that it will be important to resolve stock related questions such as the proportion of eastern Atlantic juveniles on the western foraging grounds where surveys might occur.

Fromenti, J.-M.,Bonhommeau, S., Farrugio, H., Aerial survey on bluefin tuna in the Mediterranean Sea.

A retrospective overview of aerial surveys on bluefin carried out by IFREMER since 2000 in the northwestern Mediterranean Sea was reported. The aim of that survey was to compute an index of relative abundance from fishery-independent observations that are scarce for Atlantic Bluefin tuna (as for most large pelagics species). The presentation includes the protocol that is based on line transect theory and a retrospective of temporal and spatial distribution of detected schools during the 2000-2003 period and the most recent years (2009-2010). The number of BFT schools being detected was, on average, rather high and the variance between transects appeared satisfactory. The main characteristics, e.g., location and size of schools, fish behaviour, perpendicular distance of the detection, were consistent among the surveys. The last two years tend to show a significant and strong increase in abundance of juvenile BFT in the northwestern Mediterranean Sea that may result from recent management measures (especially increased size limit since 2007). Several proposals which could improve the data collection method itself and the statistical method have been presented.

Sorell Barón, J.M., Aerial surveys targeting bluefin tuna (*Thunnus thynnus*) juvenile and adult aggregations in the NW Mediterranean during 2009.

The aerial survey is a technique allowing improving the available information on the abundance and the spatio-temporal distribution of bluefin tuna (*Thunnus thynnus*) aggregations. In 2009 two aerial survey campaigns have been carried out, targeting spawners in the Balearic area in June-July and juveniles in the Gulf of Lion in August-October. The survey was carried out in areas with the higher probability to have presence of tunas, by using a non-systematic methodology combining historical fishery data and surface temperature. The results showed a concentration of spawners in the area NW of Ibiza and in the Channel of Majorca. During the survey it was noticed a decreasing in the density of juveniles. The weak point was the operational methodology and the lack of a sampling design. This experience suggests adopting a standardized spatial methodology, to evaluate the sampling bias and the need to combine sightings with other methods, like the acoustic one.

Eveso, P.J., Bravington, M.V., Farley, J.H., A mixed effects model for estimating juvenile southern bluefin tuna abundance from aerial survey data. (Presented by Dr. Laurie Kell, ICCAT Secretariat).

Juvenile southern bluefin tuna (SBT) are found in large numbers in the Great Australian Bight (GAB) each summer. While in the GAB, they form schools visible at the surface. An aerial survey of the area has been conducted each year from 1993 to 2000 and from 2005 to present (2011), with the aim of providing an annual index of juvenile SBT abundance. The survey occurs over 3 months (Jan, Feb, Mar) and consists of one or two planes (depending on budget and availability) flying along 15 north-south transect lines. Two spotters per plane search the sea surface on their respective sides of the plane for schools of SBT. When a sighting of SBT is made (which can consist of one or more schools), the plane leaves the transect line and flies directly to the sighting so

that the two spotters can independently estimate the biomass of each school. The plane then returns to where it left the transect line to resume searching. As many replicates of the 15 transect lines as possible are completed each year, generally 4-6 depending on budget and weather (since planes only fly when minimal weather conditions are met).

The data are analysed using a strip-transect approach, for which the expected sightings rate is assumed to be constant within 6 nautical miles either side of the transect line. For analysis purposes, the survey region is divided into 15 areas, and within each year, month and area stratum, SBT abundance is modelled as 2 components: sightings per mile (SpM) and biomass per sighting (BpS). Environmental conditions, such as wind and sea surface temperature, affect what proportion of tuna are present at the surface, how easy they are to be seen, and also the size of the schools formed. Moreover, different spotters vary in their ability to see SBT schools and in their estimation of school size. Thus, we need to standardize observed SpM and BpS to a common set of environmental and observer conditions. This is done by fitting a generalized linear model to each component of abundance with the appropriate environmental and observer effects as covariates. The models are used to predict SpM and BpS in each stratum under standardized conditions. The standardized estimates can then be multiplied together within each stratum and summed across years to get an annual index of juvenile abundance in the GAB. Note that the index can be used to monitor relative changes in abundance of juvenile SBT in the GAB over time, but that it is not suitable as an index of absolute abundance.

Donovan, G., Aerial surveys: The cetacean experience.

Donovan presented an overview of the use of aerial surveys to obtain information on absolute abundance and trends to provide information relevant to the conservation and management of cetaceans. The focus was on distance based methods (e.g. see (Buckland *et al.*, 2001; 2004) and he stressed the importance of the Distance software as a tool for both the design and analyses of surveys[3].The presentation stressed a number of key points that are summarised briefly below.

(1) It is essential to determine the objectives for the surveys e.g. absolute abundance, relative abundance indices, both, population level, within a geographic area etc. Ideally the use of the results should be pre-specified in a management context and the implications of various levels of uncertainty understood (e.g., the IWC's Revised Management Procedure and Aboriginal Subsistence Management Procedure[4]). It is important to remember that a survey produces an estimate of abundance (or relative abundance) for a given geographical area at the time of the survey. Additional information (e.g. on population structure, range, natural annual variation etc) is required to interpret the results in a management context. Use of power analyses to evaluate the ability of surveys to detect assumed trends with various levels of CVs is essential (and relevant to issues of coverage and design).

(2) Given the objectives, survey design (area, stratification, tracklines) is dependent on a number of factors including: knowledge of the species (e.g., distribution, stock structure, migration, behaviour, past encounter rates); oceanographic features; expected weather conditions for allowance for 'down time', endurance of the plane and availability of airports; efficiency; resources. Use of the program Distance facility to explore alternative survey designs (e.g., equal coverage probability, known but not equal coverage probability, parallel lines, zig-zags etc.) is recommended.

(3) There are perhaps four key assumptions relevant to Distance-based methods and cetacean surveys: all animals/groups are seen on the trackline; animals/groups do not move (responsive movement is not usually a problem with aerial surveys); distances are recorded accurately (should not be a problem with good field technique); group sizes are recorded accurately (can be difficult for certain species). Not all of these can be met fully and approaches to address these were discussed. Missing animals on the tracklines is associated with two types of bias: availability bias (due to the fact that animals are not always at the surface) and perception bias (for many possible reasons, observers miss animals that are at the surface). It was stressed that to the extent possible, addressing issues related to assumption violation should be incorporated into the data collection protocols (including double-platform methods where feasible) such that established analytical tools can be used. Complex analyses are not a substitute for good data collection. The importance of collecting good data on potential covariates was emphasised, as was the value of collecting data that may allow alternate analyses both now and in the future (e.g. strip transect and line transect, index and absolute). Simulation studies are valuable in determining how best to address such issues both in the field and in subsequent analyses.

[3] The software is available from http://www.ruwpa.st-and.ac.uk/distance
[4] www.iwcoffice.org

(4) With respect to practical issues, safety is paramount. Given that, platforms should have bubble windows to allow full coverage of the trackline, full training (both theoretical and practical) is essential to ensure consistency in data collection and recording of variables. For long-term monitoring, stability of methods and personnel is important (where changes are made, calibration exercises should be undertaken to ensure continuity of series).

(5) Beware of false economies. Coverage, equipment and data collection must be sufficient to allow the surveys to meet stated objectives; anything less results in a complete waste of money.

Palka, D., U.S. aerial observer experiences in the northwest Atlantic for cetaceans and sea turtles. (Presented by Dr. Clay Porch, United States).

The goal of the study was to get precise and accurate absolute abundance estimates of all cetaceans and sea turtles in the US waters of the NW Atlantic, using line transect theory with the aim to estimate a detection function for each species. To obtain absolute estimates there was a need to account for: (i) availability bias, which occurs when animals are diving and so are not available, (ii9 perception bias, which occurs when animals are missed even though they are available to be seen.

In terms of design there were large regions to be covered thru a uniform coverage in each of those areas with high and low density, as it was necessary to document areas with zeros as well as those with high density. In some surveys the coverage was increased by adding more track lines in regions of high density to provide more precise estimates or to areas of high interest.

In terms of logistics, Twin Otter and Cessna 337 planes were used, for the following reasons: (i) bubble windows have excellent visibility, particularly straight down, because line transect theory assumes all animals on the track line are seen with certainty, and allow to stick heads "outside of the fuselage" offering a much better view to detect more groups, and (ii) belly window allowing for excellent coverage of the track line (to see about 30˚ on either side of the track line). For safety reasons there are always two pilots and for long surveys a rest position is provided which allows rotating observers to insure high quality data.

To estimate perception bias some experiments were conducted: (i) the use of two independent teams on board, and (ii) the use the Hiby circle-back method and for short duration divers which can estimate availability bias also. The author believes the quality of the results depends on the quality of the data going into the analysis. To achieve that there is need for: (i) training the observers and pilots thru "practice flights" both on the ground and in the air, (ii) good equipment on board (computers with programmable keys, electronic inclinometer, time-synced cameras, etc.), and (iii) collection of covariates that influence the probability of detecting a group.

Di Natale, A., Arena, P., Aerial surveys on bluefin tuna spawning aggregations in the southern Tyrrhenian Sea in the '80s.

A comprehensive report of the aerial surveys carried out in the Southern Tyrrhenian Sea in the '80s was presented, showing the methodology adopted at that time and the major objective, which was the study of the reproductive behavior of bluefin tuna and its ethology. The surveys were conducted within the framework of a larger project, including observers on board fishing vessels and at landings and factories, able to provide a comprehensive overview of the Italian purse seine fishing at that time, including behavioural data, catch data, biological data, size frequencies by year and fishery data. The surveys resulted in a huge amount of information and, at the same time, provided data on the distribution of spawners in that area over several years. The aerial surveys were conducted by using the spotting aircraft working for the fishing fleet and then without a precise sampling design, which was not necessary for the main objective of the study. At the same time, the lack of a sampling design does not allow to use these data for a comparative analysis with the most recent data.

Hammond, P., Cañadas, A., Vázquez, J.A., ICCAT GBYP Aerial Survey Design and Analysis 2010. (Presented by Dr. Laurie Kell, ICCAT Secretariat).

Aerial surveys were initially designed based on expected available aircraft time for six sub-areas (1) around the Balearics; (2) in the Tyrrhenian Sea; and off the coasts of (3) Tunisia, (4) Libya, (5) Egypt and (6) Turkey. Two additional sub-areas were subsequently added (7) northwest of Malta and (8) southeast of Malta.

The design was for equally spaced north-south parallel lines to achieve equal coverage probability and maximise efficiency. Survey effort was allocated more or less proportional to sub-area size. Surveys for each block were

designed so that the whole block could be surveyed in two days and then repeated multiple times. The number of surveys in each block was determined by the size of the block.

Sub-areas 1, 2, 7 and 8 were well covered, sub-area 3 was covered well in the north but not in the south, sub-area 6 was mostly well covered. Sub-areas 4 and 5 were not surveyed. A total of 30,880 km were surveyed yielding 72 sightings of bluefin tuna schools. Encounter rates per 1000km varied from 0.7 (CV=0.43) in sub-area 2 to 8.9 (CV=0.35) in sub-area 6.

There were a number of issues with the data collected: declination angle data for sightings were not collected (perpendicular distance data were eventually provided by survey teams based on GPS of track and schools); aircraft had no downward visibility (perpendicular distance data were left truncated in analysis); school size data not collected consistently (estimated weight of school was used in analysis); observer (spotter/scientist) search patterns were not clear (observer teams were created from the data for analysis); glare data were inconsistently recorded (data not used).

Detection functions were fitted to perpendicular distance data stratified into sub-areas 1 and 3 and sub-areas 2, 6, 7 and 8 because of large differences in data (left and right truncation distances required, and shape of function) between these strata.

Estimated density of schools varied between 0.16 and 0.51 tuna schools per $1000km^2$ in most sub-areas but was 3.05 (CV=0.40) tuna schools per $1000km^2$ in sub-area 6. Estimated mean school weight varied from 19 tonnes (CV=0.68) in sub-area 7 to 293 tonnes (CV=0.51) in sub-area 8. Total estimated weight of tuna in all sub-areas combined was 18,158 tonnes (CV=0.33).

Illustrations were given of the use of a simple power relationship allowing number of survey years and CV of estimated weight to be related to the statistical power to detect a population trend of given magnitude.

Generalised Additive Modelling (GAMs) was used to relate counts of tuna schools to spatial and environmental variables including latitude, longitude, depth and sea surface temperature (lagged by varying number of days). The best model included depth and sst on the day of the survey as covariates. The predicted number of schools multiplied by average weight of schools was predicted across each surveyed sub-area for different time periods. Predicted abundance of tuna was higher in the east in June and higher in the west in July, as expected. An exploratory extrapolation of the model to the entire Mediterranean showed a similar pattern.

In conclusion: abundance can be estimated from aerial surveys but there is a need to ensure that data are collected appropriately; power analysis indicates how useful these data could be as a fishery independent measure of abundance; spatial modelling of the data is informative for exploring the relationship between abundance and sst, etc and for indicating likely areas of high abundance.

Di Natale. A. GBYP Aerial survey on spawning aggregations: objectives and approaches.

The ICCAT GBYP has, among its priorities, the collection of fishery independent data and aerial surveys have been selected to provide indices over the years. The GBYP Steering Committee decided to focus the attention on bluefin tuna spawning aggregation and the first campaign was carried out in 2010, facing many operational difficulties. The survey was carried out on several Mediterranean areas, based on a survey design adopting the "DISTANCE" software and common agreed protocols. Three companies provided five aircrafts and all the professional spotters and scientific observers, which operated from the last part of May to the early beginning of August. This first campaign was able to show potentialities and limits of covering the most relevant spawning areas of the Eastern bluefin tuna stock and was considered very positive for further improving the methodology in the following years. The main objective is to develop an index of abundance of bluefin tuna spawners, improving the assessment and reducing uncertainties. The minimum time frame to develop the index is now estimated in not less than 6 years.

Biagi, F., The EU Data Collection Framework: sampling of large pelagic species in the Mediterranean.

The EU Data Collection Framework, the system for providing fishery and biological data for a considerable number of species for scientific purposes, was presented with a particular focus on large pelagic species and specifically for bluefin tuna. The DCF (before there was the DCR, the EU Data Collection Regulation) involves all EU member States, is implementing a routine and standard collection, based on commonly agreed and very precise rules and procedures, ensuring a transparency of the system. The DCF system was explained in details, including the scientific scrutiny procedures of both national plans and reports. Several large pelagic species are actually included for the ICCAT convention area: *Coryphaena hippurus, Coryphaena equiselis, Sarda sarda,*

Thunnus thynnus, Thunnus alalunga, Istiophoridae and *Xiphias gladius*, and in addition there are also several pelagic sharks.

The most recent development of the DCF is the métier approach, which includes for large pelagic the purse-seine, the long-line, the traps, the handlines and the recreational fishery for bluefin tuna, to be sampled quarterly for catch and size (length and weight) variables. Biological variables (age, sex, maturity and fecundity) and discards are to be collected every three years, always quarterly. The protocols are prepared by a Regional Coordination Meeting and its Planning Group (PGMed), which also establish the levels for sampling the various variables. The sampling intensity is reviewed yearly. The sampling levels for bluefin tuna in 2011 for the various States concerned were reported in details, along with the sampling levels for biological variables in 2013.

GBYP tagging manual (presented by Dr. José Luis Cort Basilio, IEO and Dr. Eduardo Belda, University of Gandía).

The contents of the GBYP tagging manual have been presented, including all the various parts:

- a technical and scientific description of most relevan aspects of the bluefin tuna fishery and biology;
- a detailed description of the bluefin tuna fisheries in the Eastern Atlantic and the Meiterranean Sea which are more suitable for tagging;
- a full description of the various tagging methods and application methodologies, including: (a) conventional tagging; (b) electronic tagging (archival tags and pop-up tags), and (c) PIT tagging (Passive Integrated Transponder);
- a summary concerning the ICCAT GBYP plan for bluefin tuna tagging and the results derived from the conventional tagging design study for 2011-2013.

GBYP tagging design (presented by Dr. Eduardo Belda, University of Gandia, and Dr. José Luis Cort Basilio, IEO).

Multiple-year tagging experiments are a fundamental tool to estimating fishing and natural mortality rates and abundance in fisheries. The best approach to estimate natural and fishing mortalities is the use of multiyear tagging of a single cohort. The tagging experiment should be conducted on the same cohort in different years thus tagging of juveniles where age can be inferred from size more accurately is desired. We conducted simulations to explore the number of releases of different age or age groups needed to achieve precise and unbiased estimates of mortality in order to reduce uncertainty in future stock assessments.

Simulations consider tagging to be carried out in 2011, 2012 and 2013, and data gathered until 2023. Number of releases considered was at least 10,000 fish per year. We considered three different tagging strategies: *i)* tagging of a cohort, starting at age 1, during three years; *ii*) tagging of two cohorts thus in the first year to tag individuals of ages 1 and 2 years; *iii*) tagging every year three cohorts –individuals of 1, 2 and three years. Simulations (n = 500) were conducted using software MARK 6.0 (White *et al*. 1999). In order to measure precision we used the relative standard error (RSE). The different simulated scenarios were based in the expected change in fishing mortality rates due to the recovery plan for a constant quota of 11,900t. Models considered three cohorts and age and time dependent effects. These impose limitations to the numbers of parameters that can be estimated using the Brownie approach. In addition we also simulated a VPA analysis in which we incorporated tagging data and recovery data. We used a hypothetical scenario using projected Fs and Ns for a fixed quota of 11,900tn. We used catch at age data since 1975 until 2009 and scenario 13 (run13) conducted in the 2010 ABFT eastern stock assessment (ICCAT2010). For the period until 2023 we used the projected Fs and Ns to estimate catch at age data. We used VPA-2BOX 3.05. We compared how the estimates of this analyses changed by the use of *different* tagging strategies.

The simulations showed clearly that the use of tags recoveries may improve the precision of fishing mortalities even under the scenario of the low present quota. In general, estimates of mortality were quite precise and unbiased. However the improvement in precision seems to be asymptotic, i.e. increasing the number of releases did not yield a linear increase in precision but it increases linearly the costs. There was an inverse relationship between precision and reporting rates. A minimum of 2000 releases per age and year was needed to obtain a precision with RSE < 0.15. Integrating recovery data within a VPA also improved the estimates and precision of fishing mortalities even for $F_{10+.}$ Thus a better possibility to discriminate the trends in Fc expected in the rebuilding plan for the ABFT. In addition, models with tagging data had a more or less constant RSE through the period 2011-2023. In all the scenarios considered SSB increased as expected from the rebuilding target.

One of the assumptions that will be most likely violated by the experiment is the fact that the models assumed complete mixing. In order to reduce bias, tagged animals should be released in small batches in as many locations as possible rather than in large batches at a few locations. Tagging should take place in different areas and at least covering eastern Mediterranean and the western Mediterranean and Eastern Atlantic areas.

In order to estimate fishing and natural mortality we need to estimate tagging mortality, tag retention rates and tag reporting rates. This is usually undertaken through: *i*) the use of double tagging experiments. We recommend double tagging at least 500 tuna or 30% of tuna tagged per area and team; ii) The use of the an observers programme (at least 30% of the catch should be checked for tags by observers). In addition, an appropriate programme to encourage the report of tags recovered should be implemented. Additionally it is important the use of high reward tags in at least all the years of the experiment. The use of high reward tags together with the reporting rate of the observer programme may be used to estimate reporting rates. This estimation is required in order to estimate natural and fishing mortality rates.

WWF electronic tagging program by WWF Mediterranean Programme (presented by Dr. Antonio Di Natale, GBYP Coordinator)

WWF tagging operations took place from May to September of the years 2008, 2009 and 2010, in three main areas of the Mediterranean (Northern Cataluña, North of Mallorca and Central Adriatic), on different size of bluefin tuna (large adults, small adults and juveniles). A total of 22 pop-up tags, 23 internal archive tags and 2 mini pop-ups were used. The WWF France's sailing boat "Columbus" was also used, with the collaboration of Pesca Recreativa Responsable, Circolo Nautico Sambenedettese, and Big Game Italia.

Based on the recovery rates obtained so far, these operations are qualified as encouraging, the reason for which further bluefin tagging expeditions will be undertaken in the near future, at least until 2012. For the year 2011, the plan will be based on the available tags (6 pop-ups, 11 mini pop-ups, 5 internal archive tags and an interesting stock of acoustic tags), which are expected to be deployed in the western Mediterranean, the Adriatic and the Strait of Gibraltar. For the latter the plan will be: (i) tagging with pop-ups and archrivals and (ii) tagging with acoustics, although this will depend on the deployment date of the curtain.