




MID-TERM REVIEW OF THE ICCAT ATLANTIC-WIDE RESEARCH PROGRAMME ON BLUEFIN TUNA (ICCAT/GBYP PHASE 4–2013)

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Executive Summary

The review team (the authorship named above) was tasked with evaluating a large programme with many terms of reference and objectives. Therefore, within the constraints of time available to it, team focus had to be on the issues it considered most important but allowing too for considering advice garnered from many of the people involved in the programme. In general, the Atlantic-wide research programme on bluefin tuna (hereafter GBYP) has produced an impressive increase in scientific investigations into Atlantic bluefin tuna (hereafter BFT), delivering much of the background scientific evidence crucial to conducting and improving stock assessments and ultimately management advice. The large-scale tagging, the microconstituent and genetic analyses, and the aerial surveys conducted under the auspices of the GBYP have been largely successful. However, with the cumulative challenges of such a programme mounting, it was unsurprising that some of the original objectives of the programme needed to be modified over time, and the review team's opinion is that such divergence from the original plans was warranted. Issues about priorities and geographic coverage remain, though, and these are addressed within the proposals made for work going forward. Two specific issues of major concern identified by the team are (i) the fact that managers rather than scientists seem from the start to have played the major role in determining the priorities of the programme, and (ii) that Atlantic BFT fisheries are still managed and GBYP investigations conducted on the archaic assumption that the population is divided into two components, separated at the 45° meridian. The first issue is inappropriate, the second assumption flawed.




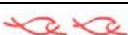

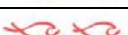


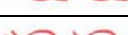
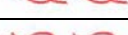
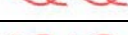
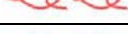
Understanding the need for the programme to move forward positively rather than to criticize past “mistakes”, the team evaluated the merits of or developed 35 major issues that it considers embrace most of the challenges now facing the programme and ICCAT management of BFT generally in terms of improving both assessment and management during the next phase and father into the future. These issues are covered under the second section of this review report, and there the main findings/recommendations on each issue are depicted in emboldened font. The team does not believe that there is merit here in repeating every salient consideration made during the course of the review, so the reader of this report is directed to each numbered section listed in the overview, and specifically to the emboldened main conclusions in each, if more detail is wanted, although the main recommendations for high priority issues are also summarized below. In terms of priority, every programme is forced to “cut its cloth” to meet its available budget, so to allow readers of this report as well as decision-makers to be able to evaluate them easily, the team also made a relative assessment of the urgency and need for each proposal and assigned a priority against each. Notwithstanding, all 35 suggestions are, in the team's opinion, worthy of consideration and possibly implementation if the aim remains to improve BFT assessment and management, but as both funding and scientific expertise will likely be limiting, then the simplified priority assignment table below should facilitate decision-making. Note, though, that no internal priority is assigned within any of these three main categories; the position of each entry in the list assigned to that category is merely the same as the item is listed numerically within each section in the main report. Hence, all high priority items are of equal importance, at least in the opinion of the review team, and the main recommendations stemming from those four high priority items are also listed in the table below.

	Priority low
	Priority medium
	Priority high


















High priority

	Catch/effort statistics by 1° and month for Mediterranean purse-seiners (Point 1)
<i>Main recommendation:</i> Using data from the compulsory observers on Mediterranean purse-seiners and from observer reports at fish farms, create new catch, effort and fish size files to supplement missing TASK 2 information.	
	Catch at size of Mediterranean BFT (Point 3)
<i>Main recommendation:</i> Use observer data from farms (all sources) to ensure that a true purse-seine catch-at-size matrix is developed urgently, at least before the next BFT stock assessment.	
	Synthesize knowledge on mixing rates between East and West Atlantic BFT (Point 7)
<i>Main recommendation:</i> Develop a comprehensive synthesis of all information on BFT movements/migrations in the Atlantic Ocean and the Mediterranean Sea, using all data available to stimulate the further development or refinement of mixing models.	
	Modelling migratory subpopulations and stocks (Point 25)
<i>Main recommendation:</i> As the current assessment models that assume two self-sustaining subpopulations of BFT separated at 45°W are unrealistic, revisit all appropriate data to review this assumption, at the same time trying to identify and estimate the size of each of the true subpopulations spawning in the Gulf of Mexico and the Mediterranean.	

Medium priority

	Growth and routine age determination of BFT (Point 10)
	Age at first spawning of West Atlantic BFT (Point 12)
	Natural mortality at age (Point 14)
	Aerial surveying (Point 16)
	Are tag recovery rates unrealistically low? (Point 21)
	Reporting rates of tagged BFT (Point 22)
	Creating a single database for electronic tag return information (Point 23)
	Short-term prospects for improved modelling of BFT stocks (Point 26)
	Improved bibliography and communication (Point 29)
	GBYP data, confidentiality and the ICCAT database (Point 30)
	GBYP planning and funding split at 45°W (Point 31)
	The future of the GBYP beyond 2015 (Point 35)

Low priority

	Data mining of historical results (Point 2)
	Monitor Mediterranean and East Atlantic recreational fisheries (Point 4)
	Evaluate catches of BFT in the southern hemisphere (Point 5)
	Estimate BFT transatlantic movement (Point 6)
	Heterogeneity and migrations of Mediterranean BFT (Point 8)
	Geographic origin of BFT caught off Ibero-Morocco (Point 9)
	BFT homing (Point 11)
	West Atlantic BFT spawning areas outside the Gulf of Mexico (Point 13)
	BFT and the BOFFFF hypothesis (Point 15)
	Scientific longline fishing for adult BFT in the Gulf of Mexico (Point 17)
	Routine scientific trolling for recruiting BFT (Point 18)
	Scientific use of sonar, surveying close to historical trapping sites (Point 19)
	Larval surveys to estimate SSB (Point 20)
	Establishing a large-scale electronic tagging programme for BFT (Point 24)
	BFT and the environment (Point 27)
	CLOSE KIN study on BFT (Point 28)
	Administrative functioning issues (Points 32–34)

Background and general issues

In conducting this review, the team had to consult a massive literature and consider an impressive and indeed daunting set of terms of reference (ToRs) under which the Atlantic-wide research programme on bluefin tuna (hereafter GBYP) has been operating. The team knew that its task was actually to evaluate the success or otherwise of the programme in meeting or handling all its ToRs and objectives. In reality, however, the limited and challenging time and resource constraints available to carry out the review, along with the need to absorb the contents of that impressive literature, on the formal website and elsewhere, mitigated against being able to conduct an in-depth analysis of every single ToR and objective. What is produced here, therefore, is an evaluation of the salient aspects of the programme to date that the team felt were most important, though the team kept permanently in mind its own ToRs for the review, i.e. to evaluate the programme's successes and failures according to the original ToRs set. In the next section of this review report too, proposals and recommendations are made in an attempt to suggest how to improve the supporting evidence behind Atlantic bluefin tuna (hereafter BFT) management. Many recommendations clearly lie outside the scope of the current GBYP, but because of their importance in supporting future BFT stock assessment, they are included in an attempt to support future general planning for enhanced research input to BFT management. It needs to be borne in mind, though, that some of these proposals by their very nature, cost or time requirements will be impossible to carry through in the final phase of the GBYP or programmes running alongside it, or perhaps in some cases even in whatever programme eventuates as a future "GBYP". The proposals are therefore listed merely to make the future plans all-inclusive, and hopefully they will be taken up within ICCAT or in other plans for BFT research among interested countries and scientists.

The team also wishes to draw the attention of the readers of this review to the report produced by Sissenwine (2011) as part of a large volume of ICES Advice that year. It appears that few knew that such a report on the GBYP had been commissioned/requested (even the ICCAT Secretariat was not aware of it) and little notice has been taken subsequently of its recommendations. The review team believe, however, that some of that report's proposals and comments bear careful consideration, and therefore, where appropriate, has referenced them in the body of the review that follows.

The review team notes that the GBYP is the first large-scale programme to have been undertaken by ICCAT since its creation in 1969. The team notes too that for the Secretariat of ICCAT, a non-research organization, to be running such a large scale, complex international research programme, may not be ideal. For instance, the annual tendering process implemented by ICCAT to run the GBYP as a mosaic of annual tenders may not be the most efficient way to run such a large-scale research project.

The team noted too that there was not a comprehensive detailed GBYP research proposal when the programme was approved and launched by the ICCAT Commission. As a consequence, the GBYP's Steering Committee (SC) had to estimate at each of its meetings, on an *ad hoc* basis, the content, budget and priorities of the annual GBYP research actions (e.g. estimating the numbers of tags, and the time and areas of aerial surveys). However, on the whole, the GBYP did yield an impressive increase in scientific investigations into Atlantic BFT, delivering much of the background scientific evidence crucial to conducting and improving stock assessments and ultimately management advice. Although work had been done historically on BFT, until 2009 the investment in scientific research had seemingly not been commensurate with the value of the fishery. This situation was seemingly rectified somewhat with the establishment of the GBYP. Phases 1 through 3 covered a broad range of activities crucial to providing inputs to the assessment and management process, and the investment in coordination of the programme through ICCAT is another shining example of good practice. On a research subject scale, the large-scale tagging, the microconstituent and

genetic analyses, and the aerial surveys conducted under the auspices of the GBYP have been largely successful (although the reporting rate for tags is still questionable), despite there having been manifold difficulties in planning and execution. Results are already forthcoming from the research work and feeding into stock evaluations, and valuable additional output is expected once the analysis of the manifold data has been advanced further and cooperatively. It is notable too that a good team of scientists drawn from many of the interested countries worldwide has been involved in the planning and delivery work to date.

There have, however, been some seemingly insurmountable, often cumulative, challenges that have had to be faced: wars, an uncooperative climate, uncooperative fisheries, some uncooperative countries, an occasional lack of fish, insufficient, sometimes reducing annual funding, administrative problems, etc. Such difficulties have occasionally forced the GBYP's SC to modify some of the activities planned, and without the effective and efficient support of the small ICCAT team charged with managing the logistics of the investigations, it is the review team's opinion that the programme might well have foundered.

Some serious questions about GBYP priorities and geographic coverage remain; this review covers some of them. In the team's opinion, several crucial research questions should have been raised before, not in the middle of the programme as is being done now, prior to the final phase of the programme. On the subject of research questions and priorities too, it is the team's belief that priorities should have been established by scientists and by the SCRS of the Commission, not by managers at the Commission (as was done at the Marrakech Commission meeting in 2008). It is the scientists who know best what information is needed to assess and to manage the stocks more effectively, not the managers, who tend to put their own national interests (often social and economic ones) at the heart of their deliberations. Therefore, the team believes that the current GBYP priorities need to be amended notably, adding several research aims to the present programme and reducing some of those currently planned, possibly even halting some of the research immediately or perhaps conducting some of the expensive surveying (e.g. aerial surveys) less frequently than annually. Finally, the review team is forced reluctantly to criticize the current double management of GBYP activities, one that is based on the stock separation mid-Atlantic (at 45°W) that has been the management approach since 1981; it appears currently that there are two programmes operating – ICCAT GBYP and US GBYP. The success of the overall programme would be vastly enhanced were the research activities covered under the GBYP to represent more homogeneously the geographic extent of the Convention Area. It is the team's opinion therefore that GBYP research activity would be far more efficient if its planning was conducted for both East and West stocks under the auspices of the SCRS and funded and managed in the same way.

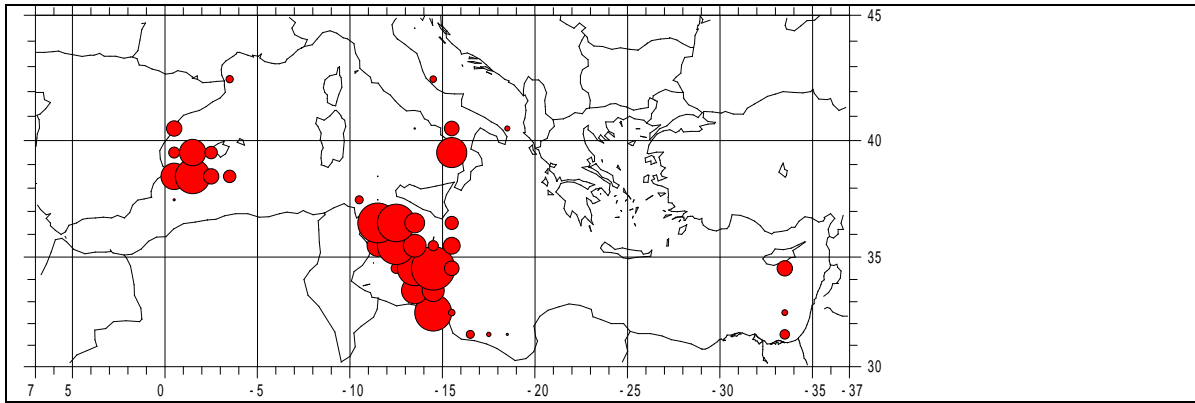
Potential future actions and improvements to the GBYP

A Fishery statistics

1. Catch and effort statistics by 1° and month for Mediterranean BFT purse-seiners



These (TASK 2) are still broadly missing in recent formal statistics, or available only at the inadequate scale of 5° (Spain), even for most of the EU-flagged purse-seiners. The map below shows the distribution of purse-seine BFT catches reported by 1° rectangle for the period 2000–2011 (note that this is a partial figure: only 10% of the declared TASK 1 are covered by these 1° TASK 2).



Surprisingly, the team can find no evidence of any ICCAT or GBYP pressure being applied on CPCs (CPC is an acronym meaning “**C**ontracting **P**arty, **C**ooperating non-Contracting Party, Entity or Fishing Entity fishing”) to submit these basic data, which they are legally obliged to submit. The information is needed, for instance, in determining BFT catches being taken in each spawning stratum. These data are more informative than VMS data because they contain catch information, so the aim must be full recovery of purse-seine logbooks, for EU and as many as possible other fleets at the very least: knowledge of the annual catches taken of each of the known Mediterranean spawning aggregations (which a 1° scale would allow) is vital for future analysis. **With observers now compulsory on board Mediterranean purse-seiners (since 2010), the review team considers that it is possible to create catch, effort and fish size files from their records as well as from observer records at farms to supplement the missing TASK 2 information (catch and effort, as well as size),** ultimately to be made available to SCRS scientists. The purpose of observers was originally to ensure conformity with catch regulations, but this valuable dataset should now also be used by the SCRS to estimate a fully realistic TASK 2 of the purse-seine and longline fleets.

2. GBYP data-mining historical results

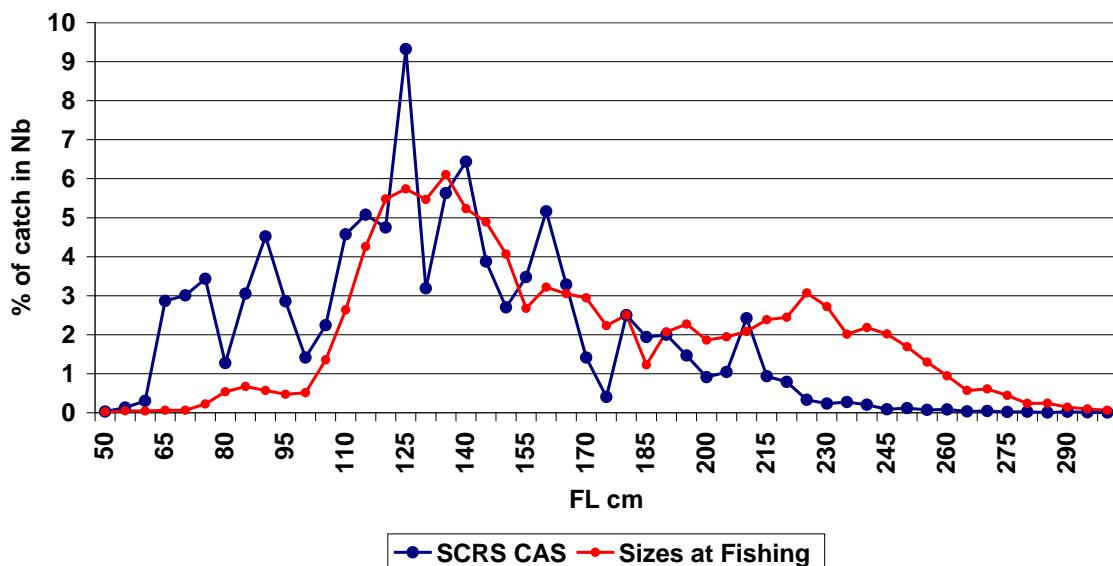
Data-mining for the results of historical trap fisheries in the Mediterranean has been successful. However, it is now necessary to demonstrate the quality and quantity of the new data recovered under the auspices of the GBYP as well as the impact these new data may have on the material held in the ICCAT database. Such work would build upon and compare the material used by, e.g., Ravier and Fromentin (2001) as well as compare new information with ICCAT’s historical database, as available in 2013. Such an analysis would need to incorporate all data previously collected on historical catches of traps made on an annual basis. The review team recommends that ICCAT request these data to be submitted by the various scientists who have worked on them and that they be made available to all in the GBYP database.

Sissenwine in his 2011 report on the GBYP posed the question “it is unclear how valuable this [sic.] data will be for contemporary stock assessments and fishery management advice”, so **an analysis is needed of the value of the new GBYP-derived data in terms of supporting BFT stock assessments and especially inputs to management now and in future.** The analysis would also need to cover the large quantity of recently collected data on the daily catch by traps: 2.6 million of the fish caught being identified and recorded on a daily scale over two centuries. Quality checks have been carried out already by the GBYP on these data and they now need to be incorporated swiftly in the ICCAT BFT database and hence made available for further scientific study. That analysis will at least provide better estimates of the daily scale of BFT migration pathways and dates prior to and after spawning (cf. the

work of Fonteneau and Pereira, 2012, on historical traps off Portugal's coast just west of the Straits of Gibraltar).

3. Catch at size of Mediterranean BFT

The catch at size of Mediterranean BFT made by purse-seiners and used in SCRS stock assessments is almost certainly misleading because of the scarcity of size samples in the databases (Fonteneau, 2013). Furthermore, the conclusion by the 2012 SCRS that “current information that consists in individual weight after fattening remain [sic.] too uncertain to be used within stock assessment models” is flawed. The individual weights of fish derived from farms cannot be used because of variability in the condition factor, but many individual lengths of BFT have been collected by observers at farms when those fish have been harvested, so that dataset should be used to construct improved purse-seine catch-at-size tables. Almost certainly, the new tables will differ widely from those used in previous stock assessments. The Figure below is taken from the Tenerife BFT 2013 WG (ICCAT, 2013), and it shows the average sizes sampled at harvesting and estimated when they were caught in the wild (Sizes at Fishing) relative to the average catch at size used by the SCRS (SCRS CAS) in the period 2008–2009.



The Tenerife BFT WG supported the new procedure for determining catch at size, so new tables of catch at size and at age of Mediterranean purse-seine BFT since 2003 need now be constructed using the size data sampled by observers at the farms, after correcting for estimated growth in length while the fish were held at the farms, as well as the traditionally used data (all this information is critical in VPAs and other stock assessment models in use). The output should also be tuned to data on Japanese imports of BFT (e.g. the Bregazzi file available at ICCAT). Because the average weight of BFT caught by purse-seine is estimated to be twice as much as the average weight estimated previously from logbooks, and noting that purse-seine catches already make up 50% of the total catch of BFT in the Mediterranean, the actual total purse-seine catch will almost certainly be shown to have increased by a concomitant amount. **The GBYP needs access to the observer data from farms (from all sources) and it needs to ensure that a true purse-seine catch at size matrix is developed** by either the ICCAT Secretariat or externally. This needs to be done urgently, at least **before the next BFT stock assessment**.

It is acknowledged that any increase in the apparent catch of older BFT (>10 years) resulting from this proposed re-analysis will add to the challenge in determining a realistic

catch at age for the species (given the wide age range determined for BFT at size). The apparent age determination problem needs to be addressed too (see point 10 later) to allow the stock assessment output to be viewed with more confidence than it can be currently.

The SCRS recommendation that underwater cameras be installed soon and used at all farms as a means of recording the catch at size of BFT is still valid. However, for the purpose of validation, any **output from underwater cameras in the Mediterranean needs to be validated against parallel output from observer measurements.**

4. Monitoring of Mediterranean and East Atlantic recreational fisheries

BFT are often caught recreationally in the Mediterranean and eastern Atlantic by fishers operating out of France, Spain, Italy and Ireland, and maybe also out of Portugal and Greece. Providing these data is mandatory for all EU countries, but very limited information has been made available to date on these recreational fisheries despite ICCAT calling for such data to be supplied by CPCs. The **catches and the catch rates derived from, for example, fishing tournaments could be used to support or tune stock assessments.** Sissenwine, in his 2011 evaluation of the GBYP, also felt that there would be utility in designing and implementing a programme for monitoring the recreational catch of BFT, at least for European countries. The review team adds its support to that suggestion and believes that any such programme should be similar to the programme of recreational monitoring developed and implemented in the US for at least 20 years. The design of the programme would ideally be much the same too as the programme that samples scattered artisanal fisheries. The team encourages ICCAT/GBYP to check immediately whether these data have been collected by CPCs and, depending on the outcome of that check, to present proposals on how the situation can be improved in future.

5. Catches of BFT in the southern hemisphere (e.g. Angola, South Africa)

There have been many **rumours over recent years that BFT are being taken also by various fisheries operating in the South Atlantic** or slightly north, and there is merit in determining how accurate these rumours might be. Succinctly, such BFT catches, if true, remain undeclared because southern hemisphere and other countries do not have a quota to catch the species (one example of a non-quota catch was the take at 17°N off Senegal in 2010: 19 large individuals, average weight 230 kg). A time-series of BFT catch data in countries other than those that traditionally supply commercial extraction data for BFT in the North Atlantic would therefore be a valuable adjunct to the stock assessments. Also, given the scientific interest in determining whether these rumoured catches of BFT are real and made in different areas from those exploited traditionally, ICCAT/GBYP needs to find a means of confirming or denying these rumours of cryptic catches, quantifying them in a time-series and, if they exist and are still being made, obtaining biological samples (bearing in mind that the related southern bluefin tuna, SBT, is definitely present and fished south of 30°S, between southern Africa and South America).

B The biology of tuna: movements and migration

6. BFT transatlantic movements: what are the best methods of estimating them?

When one talks about Atlantic BFT, one invariably ends up discussing populations, subpopulations and stocks, about which different readers will understand different things. The review team therefore appends to this report (Annex 1) its own descriptions of those three items, drawn from common usage elsewhere.

There is much in the literature already on the topic of transatlantic movements/migrations, with data obtained by a range of methods: dart tags, electronic tags, microconstituent and

stable isotope ratio in otoliths, bones and flesh, various types of genetic analysis, parasites, hooks and shark bites, fishery data from traps and longliners, etc. All these methods have been applied and described on a case-by-case basis by their authors, but there has not yet been any formal Commission scientific evaluation of their scientific worth or cost-effectiveness. Therefore, it is difficult for ICCAT or the GBYP to prioritize the outputs from any of these methods in terms of which to follow in identifying routinely the area of origin of BFT. It is hence the review team's opinion that the GBYP should now carry out this comparative analysis so that management in future can be based on the best set of information on BFT migratory paths. There seems to be an implied belief in GBYP documents that mixing rates are best determined on the basis of genetic analysis, although new GBYP results have confirmed the feasibility of using various microchemical analyses to identify the spawning ground origin of the fish sampled (Tenerife 2013 WG report). As Sissenwine said correctly in his 2011 report, "this method may be an effective and economical alternative to tagging studies or genetic studies. It has the potential of being applied operationally to determine the proportion of fish of Gulf of Mexico and Mediterranean origin in catches on either side of the boundary between eastern and western Atlantic management units." **The goal of this suggested methodology and analyses of the output by the GBYP would be to select an efficient sampling method (broadly accepted as accurate and replicable, but at modest cost) that would allow the geographic origin of BFT catches in different areas to be determined reasonably fast.**

7. Synthesize knowledge on the mixing rates between East and West BFT

Although this was one of the primary questions posed at the initiation of the GBYP in 2003¹, the output/result is certainly not obvious to the review team. The issue remains central to ICCAT stock assessments, which are still based on there being two independent stocks, even though tag returns and various observations discussed under point 6 above have shown at least some mixing. SCRS reports on the topic have been sparse since the decision in 1982 to base stock assessments on the concept of two separate (East and West) stocks in the North Atlantic, separated at longitude 45°W. The 2012 SCRS report specifically says "Although the Atlantic bluefin tuna population is managed as two stocks, conventionally separated by the 45°W meridian, its population structure remains poorly understood and needs to be further investigated. Recent genetic and microchemistry studies as well as work based on historical fisheries tend to indicate that the bluefin tuna population structure is complex". All information on this fundamental question crucially needs to be summarized now, specifically relating to the validity of the assumption (sensitivity analyses of different assumptions for separation, if appropriate, can be carried out) about population substructure.

A comprehensive synthesis of all information on BFT movements/migrations in the Atlantic Ocean and the Mediterranean Sea, using all data available, would, in the opinion of the review team, be very useful in terms of GBYP communications on the topic and help to stimulate the further development of this or the establishment of other mixing models (this subject was discussed at the Tenerife 2013 WG meeting).

¹ 2003 report: "There are several other methods to analyse stock structure in addition to the tagging experiments. These include micro-constituent analysis of otoliths, parasites, morphometry and genetic studies. Such studies require the types of biological specimens that have been the target of much of the recent BYP. Among them, micro-constituent analysis has provided promising preliminary results to identify the origin of fish. Therefore, while not to deter the progress of other methods, renewed emphasis should be placed on the micro-constituent analysis"

8. Heterogeneity of Mediterranean BFT and of their migratory behaviour?

This issue remains quite cryptic in many ICCAT and GBYP reports whereas the genetic diversity of BFT in the Mediterranean is well established. It appears, for instance, that a (large) part of the stock in the Mediterranean resides there for a long period (perhaps more than a year), and that other BFT stay there for less than two months (following the traditional BFT spawning migration into and out of the Mediterranean in June). It is not clear in the literature whether these two portions of the Mediterranean “stock”, sedentary and migrant, are different subpopulations spawned in different parts of that largely enclosed water body. The two may also show different biological characteristics, for instance in growth, but this vital question has seldom been raised by the SCRS, or at least the formal reports do not show it. The relationships between different movement patterns and the heterogeneity of BFT in the Mediterranean are still largely unknown, other than some belief that certain subpopulations are more migratory than others (for instance BFT spawned off the Balearic Islands). **More investigation now is clearly needed, for instance with genetic and microconstituent analysis of BFT born in the Mediterranean and subsequently caught in both the Atlantic and the Mediterranean, in an attempt to identify with some degree of certainty their subpopulations of origin.** The review team believes that the GBYP should reinforce its support for this task, because it is an important means of improving the overall assessment and management of BFT and also covers the pressing issue of conserving genetic diversity.

9. The geographic origin of BFT being caught in the Ibero-Moroccan area

GBYP output on microconstituent analysis and archival tag trajectories has demonstrated, somewhat surprisingly, that a notable portion of the BFT caught by Atlantic Moroccan fisheries could be from the West Atlantic (and noting that recent annual BFT catches off Morocco have been bigger recently than in the whole West Atlantic). The Moroccan continental shelf is rich in small pelagic fish (Moroccan fisheries alone catching >500 000 t of small pelagic fish annually), likely a primary source of food for BFT. At least two US dart tags have been recovered off Morocco, so if this migration pattern is quantitatively significant, it needs to be taken into consideration in future stock assessments. Moreover, the review team notes that many BFT experts in the past analysed the apparently strange trajectories of BFT in the Ibero-Moroccan area (west of Gibraltar).

The GBYP needs to assign priority to **studying the BFT caught off Atlantic Morocco (deploying more tags, and using genetic and microconstituent analysis) to remove any doubt about the origin and migration patterns of those fish.**

C BFT growth and reproductive biology

10. Growth and routine age determination of BFT

Although the GBYP has provided additional stimulus to the need for more research on growth and age of BFT (see the Tenerife WG report), it is still not obvious to the review team whether the contentious issue of the age of especially larger BFT has been addressed adequately. There is a wide range of potential ages in the data for medium and large BFT: such a great range is rather difficult to defend, although it may be real and based on, for instance, differences in BFT growth as a function of subpopulation and/or feeding areas. It could also be an artefact derived from basic errors in age reading, for instance where the number of rings is in reality not proportional to time. Errors in age determination can be introduced too by the techniques of preparation and interpretation of the rings on the otoliths varying over time, or by different people nationally and internationally being given the responsibility for age determination. Such uncertainties in age reading need to be evaluated

and quantified so that they can be taken up in the stock assessments. This latter issue can be addressed for BFT, as it has been for many other species, by **known experts collaborating in developing a formal manual and photographic guide to BFT age determination**. There is also the pressing question as to whether otoliths or spines are best used for age determination. Moreover, unlike southern bluefin, BFT have not to date been injected with tetracycline, which many believe is a better way to validate the age increments than marginal increment analysis by eye.

All these issues need to be addressed before the age reading of BFT can be regarded as a routine function and employed confidently in support of the annual stock assessments, although the unavailability of suitable archive material for checking may well mitigate against developing a historical time-series of revised ages of BFT. If injection with tetracycline or strontium chloride (a chemical used successfully already for SBT) is deemed feasible by the SCRS, then it should be introduced in the GBYP tagging programme in future. In the short term, though, a comparison between the growth curves derived from tag returns and from formal reading of increments on otoliths is needed (first results presented at the 2013 Tenerife WG were encouraging).

In summary, the review team recommends that the GBYP support the holding of a workshop in which a formal manual and photographic guide to BFT age determination can be developed (the recommendation emboldened above) **and at the same time also compare the ages determined by reading otoliths or other body structures with the results derived from tag returns**.

11. BFT homing behaviour

If BFT really do follow a strict homing signal, then every adult would be imprinted with its season and area of birth precisely, with little error (as do salmon and most marine turtles). Under that hypothesis, the Atlantic BFT population should be stratified into various genetically independent self-sustainable subpopulations, each with an independent stock–recruitment relationship (cf. metapopulations). Knowledge of this issue is critical in terms of modelling stocks and subpopulations, the management of catch quotas by area, and conservation generally, including of genetic diversity. However, although the scientific literature contains an abundance of observations favouring this hypothesis of BFT displaying strict homing behaviour, the issue remains unproven biologically. Precisely defined navigational pathways with little variance seem to be demonstrated by daily trap catch rates in the eastern Atlantic and Mediterranean, supporting the concept of homing behaviour. However, the subject urgently needs **more rigorous study including targeted investigation, primarily using selected microconstituent analyses but also evaluating the results of theoretical studies** (such as that of Fagan *et al.* 2013) **on the biological capacity of BFT to memorize spawning and optimal feeding areas**, and to navigate efficiently between them in the huge oceanic environment it inhabits (a sea surface area of some 50 million miles²), making use of their own internal compass, memory, seabed relief and water mass heterogeneity.

12. Age at first spawning of West Atlantic BFT

This basic biological question is still pending in SCRS stock assessment work: **do West Atlantic BFT spawn at 4 years or at 10 years?** The question needs to be answered urgently. Currently for stock assessment purposes, the age at first spawning of West Atlantic BFT is taken to be 9 or 10 years, a value notably higher than the 5 years at maturity observed by studies such as those of Mather *et al.* (1995) and, more recently, Knapp *et al.* (2012) for the western Atlantic. The difference in age is difficult to understand; it could be artificial and attributable to inadequate sampling of longline catches. However, it is a crucial biological

question and apparently is not being addressed by the US GBYP. As stated above, the paradox is that biological sampling of BFT spawning has supported fresh investigation through the GBYP of the already well-known spawning ages and areas of Mediterranean BFT, but there has been no concomitant activity in the West Atlantic. It is the opinion of the review team that gonad samples of young BFT (5–10 years old) caught in warm waters of the West Atlantic (during the apparent spawning season there) by surface fisheries or by scientific sampling need to be obtained and analysed too in an attempt to provide an answer to this basic biological question. However, it is also important to evaluate the proportion of each age class that actually migrates to the spawning grounds and hence contributed to the subsequent recruitment.

13. BFT spawning areas outside the Gulf of Mexico in the West Atlantic

SCRS studies of West Atlantic BFT have been dominated by the paradigm that the Gulf of Mexico is the only spawning area. However, other work, older (cf. Mather *et al.*, 1995), recent (Lutcavage *et al.*, 2012) and information based on BFT catch and effort data from Japanese longliners in the 1960s, strongly advance the case that there may be other spawning areas in the west, for instance in May and June offshore of the east coast of Florida. Potential alternative spawning areas may be scattered too across wide oceanic areas in the North Atlantic where the sea surface temperature is warm ($>24^{\circ}\text{C}$), as was envisaged by Mather *et al.* (1995). This issue could be addressed by the GBYP supporting a 2-month (May and June) scientific cruise on a longliner targeting spawning BFT and BFT larvae in shallow water in the area off Florida where archival tags of adults were observed by Lutcavage and her co-workers and where Japanese longliners caught large quantities of BFT in warm water in May and June during the 1960s. If BFT spawning concentrations are identified there, then **biological samples of gonads and tissues need to be collected in order to identify possible spawning activity as a function of fish size, and to determine whether those spawners comprise a genetically different subpopulation or belong to the known Gulf of Mexico subpopulation.**

14. Natural mortality at age

Natural mortality at age (M_i) is one of the most important parameters in stock assessment models, but as a biological parameter it has not been investigated by the GBYP. It was noted that SCRS assessment work has been using two widely different trajectories of M_i in the East and the West Atlantic: a high value assumed for juvenile BFT in the East (M at age 1 = 0.5) and a low value assumed in the West (M at age 1 = 0.14). The value of M_i for older BFT (which includes many of the spawners) has generally been assumed to be flat and low: a constant 10% of the population of larger BFT suffering natural mortality each year in the East (after declining gradually from the higher level as the fish grow), but a constant 14% in the West throughout the entire life of the fish. This difference in M_i may be artificial and it could be equally valid to assume that the values of M_i for BFT are similar in the East and the West Atlantic. It may also be envisaged that the natural mortality of large BFT would increase because of the great physiological investment of older fish in spawning (extensive and fast migration before and after spawning and gonad maturation, parasite accumulation and wounds) and the universal biological process of senescence, especially at greater age.

Biological studies on the condition of large BFT could be conducted easily on a sample of fish at the farms and yield valuable results: for instance, are the large, older BFT in good condition or are they already showing signs of biological damage to their bodies as they age, and how much energy proportionally do they expend in spawning? Archival tag results may also help in estimating the level of natural mortality by groups of ages, as was

attempted by Whitlock *et al.* (2012) for Pacific BFT. BFT are virtually unique among fish species in that M_i might be estimated by a large programme of tagging on the three general size categories: small, medium and large. It is unlikely that M can be estimated from the dart-tagging programme because of the small numbers of tags being applied generally, but pop-up tagging does have promise in terms of estimating BFT natural mortality. To date, at least 1700 pop-up tags have been deployed, many of them successfully, on all sizes of Atlantic BFT throughout their distributional range in the West and East Atlantic and the Mediterranean, apparently not causing undue mortality. Given too that there are good fishery data on BFT catch at size by area, the review team believe that future investment in a large-scale pop-up tagging programme building on the manifold results already achieved and then conducting a rigorous statistical analysis of the output might well provide better and earlier estimates of M for the various size groups of BFT than is currently possible from other efforts. Such a programme would be far more expensive than the GBYP or ICCAT could consider, of course (5000 tags at €4000 each = €20 million, plus an equivalent or larger investment in tagging and analysis, perhaps a total of €50 million), but there might well be conservationist lobbies or rich sports fishers interested in conserving this totemic species and who might be willing to invest in such a programme.

Notwithstanding, because of the great importance of the M_i parameter in stock assessment models, the review team **strongly recommends that the GBYP find ways to have work funded on juvenile and adult BFT natural mortality, including any possible subsequent increase in natural mortality for older BFT.** The work should make full use of the results obtained for other bluefin stocks (SBT and Pacific bluefin) but also incorporate the results of the various models estimating M as a function of size or age.

15. BFT and the BOFFFF (Big Old Fat Fecund Female Fish) hypothesis

This hypothesis, recently developed by South African scientists for several fish species, could be of potential interest to BFT assessment and management: according to analysis and results, large females would have a much greater “effective” fecundity because of their capacity to spawn (sometimes larger, stronger, i.e. more yolk) eggs during a longer spawning season, with an improved likelihood of there being a favourable environmental window for development of the spawning products with a longer season (Field *et al.* 2008). It should also be noted that the enhanced fecundity of larger SBT is one of the results obtained on SBT by the CLOSE-KIN model (Bravington *et al.* 2012). As a biological concept, this hypothesis would appear logical to many researchers, but it does warrant careful analysis before being accepted.

If the BOFFFF hypothesis is valid for BFT, the review team considers that it might play a significant role in future stock assessment models and management, with the biomass of older females in the population playing an enhanced role in the productivity of the population as a whole. Hence, it is **recommended that effort be devoted to investigating the BOFFFF hypothesis’ applicability to Atlantic BFT** through a small targeted project.

D Scientific surveys

16. Aerial surveys

The aerial surveys are clearly one of the success stories of the GBYP, but the number of years in the series is still too short and their geographic coverage too variable to be able scientifically to detect a clear trend in biomass. The question also needs to be asked whether the survey should be looking at juvenile BFT instead of or in addition to the adult BFT it currently surveys. Apart from considering the issue of seasonal presence in or absence

from the survey area by different components of the Mediterranean “stock” (see point 8 above), and given that the natural mortality of such big fish is anyway low and the population probably more stable (apart from the effects of fishing), **there may be justification in surveying the adult component less frequently, perhaps every two years (but bearing in mind the fact that any reduced frequency of surveying might introduce complexity in terms of efficient functioning of the programme and may not be ideal in terms of producing a data series that is statistically robust)**. However, the GBYP does need to find a way to evaluate the cost-effectiveness of these aerial surveys and whether and how soon the output results might feed with some value into the stock assessment process. Also, **is there a possibility that absolute spawning biomass in the Mediterranean and the Gulf of Mexico might be compared if both stocks are surveyed from the air in a similar manner?** Annual aerial surveys of juvenile SBT aged 2–4 years have been conducted in the Great Australian Bight since 1991 (two aircraft used over a period of 3 months, so surveying a large area: (2° of latitude, 7° of longitude; Eveson *et al.* 2012); this might be an interesting example to follow, because those surveys are providing an index of abundance that is taken up in the annual SBT stock assessment.

Notwithstanding what is stated above, **the review team considers that aircraft do not provide the only or necessarily the best means of evaluating the biomass of BFT, and aerial surveys are in any case difficult to organize (especially in the Mediterranean Sea) and quite expensive. Further, the uncertainty in any estimate of biomass will remain difficult to determine, so the review team considers that other methods of surveying could be developed too; see the suggestions below (points 17–20).**

17. Experimental scientific fishing of adult BFT by longliners in the Gulf of Mexico

The review team considers that **routine scientific fishing cruises taking place each year in the Gulf of Mexico, in April and May, preferably by Japanese longliners with experience of deploying such gear experimentally and commercially, could be a cheaper and more effective alternative to aerial surveying**. Any results obtained from such a project could also be compared with those of Japanese longline catches of BFT made in the Gulf during the period 1975–1981 (when that fishery was at its peak: ~3000 t of BFT being caught per year).

18. Routine experimental scientific fishing using troll surveys in selected coastal strata, targeting recruiting BFT (classes 0 and 1)

Such annual troll surveys could be planned for the West Atlantic and Mediterranean, although there would need to be an initial evaluation of target strata, fishing methods and general feasibility. There is already an example of such a survey in Australia targeting SBT being successful; it is carried out over less than one 1 month every year with a trolling vessel 18 m long equipped with seven lines, primarily looking to determine the number of SBT schools (Itoh *et al.* 2012). The potential for such a survey of BFT would be to derive a scientific estimate of the relative abundance and hence year-class strength of such pre-recruits well before they become available to the fishery. The main advantage of such a survey, if taken up, would be its relatively low cost.

19. Sonar and traps

Sonar is employed actively in the Mediterranean and the Bay of Biscay to locate and estimate the sizes of schools of BFT. It seems to work up to a distance of ~2 km, is carried out by night and day, and since the 2006 ICCAT ban on the use of air-borne surveillance, is the main method of location used by Mediterranean purse-seiners to detect BFT schools. The historical work by Lozano Cabo (1959) using echosounders near Gibraltar provided useful information too. The GBYP should investigate the feasibility of such means being used to estimate the

migrating biomass of adult BFT in selected strata, especially to complement the data already available or becoming available from traps that have been catching migrating BFT effectively in the same place for centuries. A small boat operating in the Bay of Biscay with long-range sonar could for instance be chartered for scientific use and positioned for some 1–3 months on the continental shelf close to the location of some selected efficient traps, posted along the migration path of BFT into and out of the Mediterranean. **The review team proposes that the possibility of using sonar in this way to evaluate BFT biomass be investigated by a task force or small workshop including scientists knowledgeable about BFT, acoustic experts (for instance from AZTI, an organization that has conducted many investigations on tuna acoustics), selected trap operators and purse-seine skippers experienced in the use of sonar to locate BFT schools and to estimate their size.**

20. Surveys of BFT larvae as a means of estimating the biomass of adult spawners

A larval index is one fishery-independent index that is available for the West Atlantic stock of BFT. However, its results have been confronted with a basic but major question: are the larvae collected by methods now in use representative of spawning-stock biomass? For instance, in the Gulf of Mexico annual survey of BFT larvae, the very small numbers of BFT larvae caught are a concern. One reason why the number of BFT larvae caught is so small is because the sampling is not designed specifically to collect bluefin larvae but has other, ancillary objectives. In addition, the daily mortality of the larvae is assumed to be constant across years, but this is a very bold assumption considering that the critical period of survival of larvae is subject to great interannual variation. Consequently, the review team is of the opinion that the BFT larval index is likely not representative of spawning stock size in the West Atlantic. Therefore, **it is recommended that the larval survey be revised somewhat, extending it to a broader area of the Gulf of Mexico and using additional, more-effective sampling gears in an attempt at obtaining estimates of daily mortality per year.**

E Tagging activities

21. Are the rates of tag recovery unrealistically low?

The number of recoveries of tags is increasing following the GBYP-supported enhanced tagging programme and the better publicity; this is good for scientific knowledge, but recovery rates appear still to be very low at just 0.36%: at the time of writing, there have been just 49 recoveries of dart tags since 2011 (and only three recoveries from farms), whereas some 13 000 BFT were tagged during phases 2 and 3 of the GBYP. The traditional problem of very low reporting rates of tagged tunas in the East Atlantic and the Mediterranean (and by many longliners working the open sea) has seemingly undermined previous BFT tagging programmes in the area, although the fundamental problem is seldom discussed within the GBYP. However, the attempts by the GBYP at wide-scale publicity to encourage the reporting of tag recoveries do need to be acknowledged, although penetration to all parties and the acceptance by those parties of their responsibility to report their tag recoveries are not yet fully evident. In theory, for instance, reporting rates by farms should be 100%, and the GBYP SC acknowledged this in their recent statement that “The SC noted that the situation with respect to tag recoveries for adult BFT has changed substantially in recent years. In the past, ensuring high return rates and having a method for estimating reporting rates from the fisheries harvesting adults were problematic. However, currently, a very high percentage of the adult catch is either caught in traps or placed in farm cages. In addition, there is now 100% observer coverage of these fish when they are harvested from the traps and cages. This

means that both high return rates for recapture tagged fish and a 100% reporting rate for these fisheries should be achievable”.

Given the above perfectly fair statement by the SC and the low rates of tag return, however, the GBYP tagging programme is still confronted with the question as to whether its current rates of recovery are real or being biased downwards by non-returns and apparent refusals by some fishers and farm managers to support the overall programme. For instance, there are rumours that, at some farms, tags are sometimes being removed by divers before the fish are harvested. Conversely, though, are the low rates of recovery attributable to the low exploitation rates at the size of BFT being tagged/caught (most of the fish tagged during phases 2 and 3 of the GBYP were juveniles, a size seldom caught by fisheries), or to poor tagging practice and high tagging mortality? Perhaps, however, the programme is simply not recording or being sent the tag returns from farms; if so, why not? It is the review team's belief that the answers to these questions might have been forthcoming already if a tagging coordinator had been appointed to oversee the work. The GBYP's SC motivated and recommended to ICCAT several times in reports and meetings that such a post be established by the Secretariat, but to date such an appointment remains elusive.

As well as reconsidering the appointment mentioned above, **the review team urges the GBYP to commission an immediate quantitative analysis of current recovery rates of dart tags (by gear and area): such an analysis should allow the overall tagging programme to be improved, based on recoveries by gear, by fishery, by fish size and by geographic area.**

22. Reporting rates of tagged BFT

Reporting rates within the GBYP tagging programme are still broadly unknown. As assumed by the SCRS (see the point above), 100% reporting rates from the farms should be a given, but that assumption remains unproven. **Better knowledge of reporting rates by gear (and of the uncertainties) is essential in supporting all quantitative analysis of recoveries: for determining migration rates, natural mortality, exploitation rate and ultimately stock size.** The review team questions whether it is possible to estimate the reporting rates of dart tags for some segments of the various fisheries and/or at some farms (e.g. by conducting tag seeding experiments at some farms) and/or on longliners targeting BFT (those with 100% observer coverage, for instance on the Japanese fleet targeting BFT in the North Atlantic and on longliners fishing in the Mediterranean). Such information is essential in estimating the real reporting rates of all the fleets catching Atlantic BFT, with a view to finding ways to allow the future quantitative use of all recovery data.

23. Creation of a single database for electronic tag return information

Electronic tags have been widely used on BFT for nearly 20 years by independent scientists and teams, for instance the 1700 pop-up tags released on Atlantic BFT since 1995 producing scientifically fascinating results quite independently of fisheries (see the work of, *inter alia*, Block, Lutcavage, WWF, Ifremer and DeMetrio). Various papers have been published in the scientific literature based on the results obtained, but overall they constitute a plethora of information that is difficult to apply to ICCAT assessments and management advice.

The review team strongly recommends that the SCRS and the GBYP construct a common file and database with all these archival tag results included by working with the current owners of the data. Hopefully, this file will be under the overall management of ICCAT and the GBYP so that the results can be used in future ICCAT stock assessments, giving a broader dimension to the multiple but scattered results that have been obtained generally by archival tags on Atlantic BFT.

24. Establishment of a large-scale electronic tagging programme for Atlantic BFT

The EU has since 2000 supported and funded such programmes for at least cod (code-named CODYSSEY) and European eel (code-named EELIAD). Such a programme would be of clear interest for Atlantic BFT, because the research output is virtually totally independent of fisheries. **A large-scale multi-year electronic tagging programme conducted at the scale of the whole BFT population can be planned** best by the GBYP and the SCRS. Such a programme should, however, be conducted under the auspices of the GBYP and led by both ICCAT-associated and experienced independent scientists, but likely seeking alternative sources of funds (e.g. from the US, the EU, Japan and elsewhere).

F Modelling BFT stocks

25. Modelling migratory subpopulations and stocks of Atlantic BFT

This is a complex issue, and it is the opinion of the review team **that the current SCRS-approved assessment models that assume two self-sustaining subpopulations of BFT separated at 45°W are unrealistic**. The much smaller West Atlantic “stock” is probably least favourably assessed and managed according to the present VPA-based evaluation: (i) many of its Gulf of Mexico spawners are taken when they are migrating around the East Atlantic, and (ii) a notable portion of that western stock in all probability reality belongs to the Mediterranean subpopulation. It is an euphemism to caution, as does the 2012 SCRS report, that “the conclusions of this assessment – of the western stock – do not capture the full degree of uncertainty in the assessments and projections”. The between-year variability in BFT migration/movement adds even greater complexity to the model parameters (West Atlantic BFT used to be caught regularly off Brazil and Norway). However, various past works (e.g. NRC 1994, and various other BFT reports) have recommended that Atlantic BFT stocks be modelled taking into account movement rates between areas, and preferably with more than two areas, for instance the 6-box model proposed by the SCRS in 2001. However, whenever one increases the number of subpopulations through geographic stratification, one automatically increases the complexity of model parameterization and reduces the number of data available to tune the model for each substock.

Future models should attempt too to identify and to estimate the size of each of the true subpopulations spawning in the Gulf of Mexico and the Mediterranean, independently of their geographic movements and in the various areas where they are fished. Such improved modelling of BFT has been envisaged and recommended by SCRS and others² for at least 20 years, but there has been little or no progress to date: all ICCAT stock assessments for BFT are still made by VPA on a 2-stock basis. It is now crucial that these geographic BFT models be constructed to operate at the scale of the whole Atlantic BFT population, at least as a first step of exploring the main uncertainties faced by the two current VPA models (especially that for the West), and also immediately to start collecting routinely the additional data needed to run the future smaller area models efficiently.

Notwithstanding the above, the review team believes that **realistically modelling BFT stocks and subpopulations might well lead to the routine identification of the natal origin of Atlantic BFT caught in the various areas (in addition to routinely determining their ages)**. Routine sampling of microconstituent analysis (of flesh and/or otoliths) or based on genetics, should be conducted on the BFT catches of major fleets (including at least the EU, USA and Japan), allowing determination of the origin of the BFT caught with some confidence.

² cf. the NRC (1994) report

26. *Short-term prospects for improved modelling of BFT stocks*

The prospects for improved modelling of BFT stocks and subpopulations were discussed at the Tenerife BFT working group meeting and subsequently at the meeting in Gloucester, MA, USA, in summer 2013. It needs also to be acknowledged that such improved modelling could allow, at least in theory, evaluation of the importance and value of different data and be able to handle better some of the uncertainties in the existing data. However, to base any enhanced modelling on the totally flawed catch-at-size distribution in the database used now will not enhance management advice for BFT; all future stock assessments need to be based on a revised catch at size formulated from sampling information derived by observers at farms, and not on the present distribution incorporated in the stock assessments (cf. point 3 above). That aim is a definite research priority for GBYP. Moreover, any **positive prospects associated with improved modelling can only be realized and incorporated into future GBYP activities if the basic data needs and methodologies have been agreed** initially by the modellers and approved by the SCRS.

27. *Analysis of BFT and their environment*

The scientific contention that BFT recruitment (year-class strength), abundance and movement are broadly conditioned over a wide range of scales of time and area by the environment is well accepted by all BFT scientists. However, **environmental parameters and their potential effects on the BFT population are noticeably absent from current GBYP studies, and this absence may hamper the formal understanding of stock status and the ability to predict future trends.**

The review team considers it both urgent and important to conduct an in-depth, comprehensive analysis of BFT populations and stocks and their environment. The analysis needs to cover a long period of time, for instance at least the most recent 50 years, and it should be based too on both fishery and pop-up tag data being considered relative to the many environmental data that are now available from at-sea and satellite observations and from models.

Another approach could be to develop the use of the SEAPODYM model on Atlantic BFT. That fishery model, built by Lehodey *et al.* (2008), is based on detailed fishery and environmental data, but also on food chains, and it has provided encouraging results and improved understanding for many tuna stocks worldwide, especially in the Pacific (the results are published in various scientific papers). There is potential value in attempting to develop a full-scale SEAPODYM model for Atlantic BFT under the GBYP because that may, for instance, allow management strata to be delimited better on the basis of BFT spawning-area suitability and the survival of larvae, support evaluation of the effect of environmental variability and changes on BFT distributions, or help determine the relative biomass and movement patterns of BFT subpopulations spawned in the West Atlantic and the Mediterranean Sea. The estimated cost of such an extended SEAPODYM study on BFT would be around €200 000 for two years of a post-doc (such funding might be obtained from external sources, such as the Marie Curie fellowship, and not necessarily need GBYP budget).

28. *Feasibility study of using the CLOSE KIN method for Atlantic BFT*

This new method, described by Bravington *et al.* (2012), has been used with some success for SBT. The method was summarized by the authors as being “A genetic analysis analogous to a paternity test between spawners and juvenile fish is performed. Spawners and juveniles are sampled. All combinations of spawners and juveniles are tested for a paternal match. If the test is positive (i.e. the juvenile is an offspring of the spawner), it is a quasi recovery of a

tagged spawner. The number of quasi tag recoveries is a function of the number of adult/juvenile pairs tested and the number of spawners in the population”. Preliminary testing of this approach on SBT indicates that it is both feasible and cost-effective to evaluate sufficient spawners and juveniles to obtain reasonably precise estimates (e.g. CVs of 12–20% have been obtained) of absolute spawning stock size. However, application of the method to Atlantic BFT may be more difficult, for instance because of the multiple spawning grounds the population uses.

Based on the recent results obtained by this method, **the review team considers the CLOSE KIN method deserving of evaluation and study by ICCAT BFT scientists and by the GBYP, for example by obtaining an analysis and advice on the methodology from a neutral expert in genetics who has some knowledge of Atlantic BFT.** Such a diagnosis should help to determine the merits or otherwise of including the CLOSE KIN method in the GBYP in future (see point 35).

G GBYP administrative framework and functioning

29. Improved GBYP bibliography and communication

There have been many ICCAT documents dealing with the GBYP during recent years: on its planned research, on its functioning problems and detailing some of its results. The ICCAT website contains many of those documents, but **there is no overview or updated basic ICCAT text available on the GBYP:** having easy access to such a document is crucial to those wishing to develop an updated comprehensive overview of the programme (on the scientific questions at the origin of the programme, its changes in priority, in the research actions conducted, the main results obtained and expected, etc). This lack of a GBYP synthesis document, which would need to be updated and available permanently on the ICCAT website, may be at the heart of the misunderstanding of people apparently interested in the GBYP programmes and research goals. The same problem has been faced too by this review team for the GBYP: there are complexities and difficulties in getting to the heart of the contents of the multiple ICCAT documents and reports related to BFT available to them.

Furthermore, the review team noted that (i) with the BFT literature extremely rich and covering centuries of scientific documents published in various countries, in both grey and ranked literature, (ii) ICCAT scientists do not have ready access to a comprehensive bibliographic database and system allowing them easily to access this vast literature on BFT. Therefore, **the review team recommends that ICCAT or the GBYP promote the creation of such a computerized BFT bibliographic database,** the task to be handled by someone versed in bibliographic systems working under a short-term contract in close collaboration with the ICCAT Secretariat, ICCAT BFT scientists and librarians working in the field of fisheries. The work should also try to obtain PDF copies of all the BFT documents thought to be important and to make them fully available to interested scientists. This bibliographic database on BFT should be made available later on the formal ICCAT website.

30. GBYP data, their confidentiality and the ICCAT database

Given that the future of the GBYP after 2015 is currently uncertain (though see point 35 later), the review team recommends that the final two years of the current project include **dedicated effort to capture all relevant BFT data (especially including GBYP data) in well-designed and visible format on the ICCAT database, for use by BFT WGs and scientists.** Further, although the review team understands that rigorous confidentiality issues have to be maintained on many ICCAT data, it is the hope that the GBYP and other associated data on Atlantic BFT captured on the ICCAT database do not disappear into a

“black hole” from which they cannot be extracted for genuine analytical reasons under the protective guise of their “confidentiality”.

The review team considers that all ICCAT BFT data (including those derived from the GBYP) that are of scientific interest need to be available for appropriate scientific analysis now and in future, their confidentiality being managed by the ICCAT Secretariat.

31. The limit of GBYP planning and funding at 45°W

The geographic area of GBYP was in theory intended to be the ICCAT Convention Area, but in reality, GBYP funding and activities have targeted mainly the East Atlantic, east of 45°W. In the West Atlantic, the US has been supporting a similar US-GBYP with NOAA funds, and developing and selecting projects mainly in the US (GBYP coordinator Antonio Di Natale is a member of the NOAA Steering Committee for that project). However, the GBYP Steering Committee recently agreed to fund a US tagging programme of young BFT aged 1–3 years (to be handled by Molly Lutcavage and her team) and Phase 4 of the GBYP has developed contracts with a Mexican research organization (for biochemistry) and is discussing a possible contract with a Canadian State institution (for data recovery). This geographic heterogeneity in the GBYP programme is artificial and far from ideal from a scientific perspective: it is attributable, however, to understandable “political and financial” reasons³. It does, though, reduce the efficiency of Atlantic-scale investigations on BFT, for example on the fundamental question of BFT movements between East and West. The fact that NOAA handles the US BFT budget and controls both the activities and the identity of the scientists mandated to carry out the investigations in the West is also of concern. For instance, funding provided to universities or for research topics that are of great scientific value but not viewed favourably by some decision-makers (e.g. investigations that seek to estimate the annual percentages of BFT that are temporary migrants from the Mediterranean to the West Atlantic, and on the age at first spawning of the West Atlantic stock) can be reduced. **The ideal solution would be for the two components of the funding sources of GBYP activities (the US and the EU) to find a means of collaborating in research topic selection and analytical delivery.**

32. Improving the means of functioning of the GBYP Steering Committee (SC) and its relationship with the SCRS

The GBYP SC needs to be acknowledged with thanks for the tedious work it carried out in terms of the complex routine planning and advice it gave the GBYP, but it is difficult for the review team, on the basis of the various reports of the SC that are available, to determine whether or not that effort was optimal. At least in terms of the delivery of crucial output, there is no evidence visible in the reports made available to the team. However, some of the deficiencies identified above and the apparent absence of certain crucial research actions itemized in GBYP plans and reports may be indirectly attributable to the framework within which the SC has had to operate. It was also noted that membership of the SC will soon be changing as the duties of rapporteur for the West and the East Atlantic are passed on; this expected change will probably have an impact on the efficiency of the GBYP SC. Some of the potential weaknesses in the GBYP identified above may of course be due in part to deficiencies in the functioning of the GBYP’s SC, perhaps attributable to the close relationship all members of the SC have with ICCAT and indeed BFT processes, but there may be other reasons too, so it would be inappropriate for the review team to criticize the SC directly. However, having an additional scientific member of the SC that is truly external to

³ For instance, because it may be difficult to allocate significant funds from EU DG MARE to BFT research conducted on the US east coast.

current ICCAT processes would likely enhance the credibility with which the SC and the GBYP is viewed from outside.

A recommendation that the review panel certainly feels empowered to make now, however, is that an external peer review of the GBYP's work and results needs to be carried out every two years. Such a peer review could help identify and solve some of the problems that might have arisen inter-review and to suggest how such issues should be addressed in future, i.e. it would be both backward-evaluating and forward-looking, as this review has been. **Such a review should also contain an element of totally independent evaluation,** i.e. by including on the review panel of several respected scientists at least one member who is and has been totally independent of Atlantic BFT and perhaps even tuna research. Having to be subject to such a review regularly might also facilitate better interaction between the GBYP and the SCRS. This recommendation would be validated mainly by the logical belief that large-scale, long-term active investigations will be conducted on Atlantic BFT going forward, in order to ensure its sustainable and optimal use (cf. point 35 below).

There is also a clear lack of real communication/interaction between the GBYP and the SCRS. Detailed reports are produced by the GBYP and submitted to the BFT species group and the SCRS, but it appears *de facto* that the SCRS has approved virtually “blindly” all the conclusions of the GBYP's SC, when the contents of this review would tend to indicate that some of them at least were of questionable value (for instance, Mediterranean catch at size, the natural mortality at age assumed in the West Atlantic, and the lack of at-sea surveys). Perhaps one of the reasons for this is that individual SC members are or at least were influential members of the SCRS themselves, but another more obvious reason is that the broad-scale work of the global SCRS framework is different in many ways from the specialized, often complex work of the GBYP. All the changes in Phases 1–4 of the GBYP programme attributable to funding issues, lack of cooperation from various CPCs, and even logistical constraints, are also complex for the SCRS in the broader sense to follow. This situation is likely why the SCRS 2012 report concluded that “Although there is general satisfaction /for the GBYP work/, it is recommended to have a mid-term evaluation of the work already done in these first three Phases ...”. That recommendation was further approved by the ICCAT Commission. **It is important in future, in the opinion of the review team, to find ways to promote better and closer interaction between the GBYP SC, the BFT WG and the SCRS,** for instance in building a framework for the SCRS that would allow it to adjust research priorities and individual work plans of the GBYP efficiently, and in addition to adjust its planning accordingly, which is done now solely by the Steering Committee.

33. GBYP and the ICCAT Commission

It is striking and surprising that the scientific priorities set for the GBYP, a scientific programme, were established not by the SC of the GBYP or SCRS scientists, but mainly by the ICCAT Commission at its 2008 meeting in Marrakech. At that meeting, it was decided that the initial GBYP priorities were to be coordination, data mining and aerial surveying (and these were generally rather different from the priorities suggested for the project by the SCRS in its advice to the Commission). There is nothing wrong with (politically motivated) commissioners who remain in charge overall of the budget of a project expressing their views, in this case specifically on the research to be planned or to be incorporated in the programme because it is already ongoing and a crucial part of the general need for information, but it is questionable whether suggested priorities for a project proposed by respected SCRS scientists and other BFT scientific experts should then be changed for political rather than scientific reasons. Very few commissioners, in any organization, will be in a position to evaluate technically the scientific merit of a complex research or monitoring

task. For instance they are not in the best position to evaluate the cost and the priority given to aerial or at-sea surveying, or to sampling programmes aimed at delivering an unbiased catch at size. In this case, therefore, it is hardly surprising that scientists and the SCRS felt moved on initiation to propose alternative, perhaps more pressing research priorities in terms of management advice. What this has meant is that **the GBYP has diverged somewhat over the four phases from the main priorities established initially as suggestions for the main aims of the programme**. Those changes have been motivated in terms of cost, efficiency and the need to allow better stock assessment of the Atlantic BFT.

The review team concluded that the revised priorities set during the operating phase of the GBYP were fully justified.

34. Administrative functioning of the programme

Although originally envisaged to require up to six full or part-time staff to be recruited to fulfil its mandate, the first year of the project took place with just a single full-time coordinator carrying the administrative load; a second full-time scientist was recruited during phase 2. By Phase 4, the situation had improved slightly, with another short-term contracted person (working on a monthly contract) being placed in charge of data handling. There is no doubt that the GBYP has had a notable impact on ICCAT Secretariat activities, the cooperation of the latter group being necessary to fulfil many of the GBYP tasks set (multiple calls for tenders and contracts, translations, administrative and financial support, continuous assistance by the Executive Secretary, etc). The group has a very broad mandate to coordinate and report the efforts of many worldwide attempting to meet the requirements for research and data to support management of Atlantic BFT, to tender and oversee the contractual delivery of manifold and crucial research and monitoring activities for BFT, to mine disparate sources, sometimes historical, for information currently not in the direct public eye, to ensure the validity and cleanliness of the manifold data being acquired and incorporated into appropriate ICCAT databases (but see point 30 above), and generally to ensure the efficient and cost-effective management and delivery of the whole project. However, GBYP staff levels now would seem to be appropriate and adequate for the task in hand as the programme moves into its final phase, other than, perhaps, establishing a post for a tagging coordinator. So too is the annual funding available for the project adequate, although scientists will always say that they require far more resource. The review team also understands that careful prioritization will be necessary as the GBYP moves into its final few years, because the budget will not allow all the additional research actions recommended here to be taken up.

In terms of finance, the review team notes that every year has been beset with uncertainty about the total available budget right up to the end of each phase (some CPCs do not provide the contribution requested of them by the Secretariat) and also that the available GBYP budget so far is only 43% of that initially adopted by the Commission. Such unpredictability in budget does not lend itself to the successful realization of the essential programme that the GBYP has become.

As stated earlier in this report, there is evidence that some GBYP suggestions and/or recommendations were not implemented by the ICCAT Secretariat, or perhaps were implemented too late to be effective, for reasons not clear to the team from the documentation at its disposal. Close communication between the Secretariat and the programme is essential, so all means should be employed to foster it, to everyone's benefit. For a start, all relevant decision-making has to be documented. The review team believes too that having a long-term chair of the SC would help to foster positive ICCAT Secretariat/GBYP relationships and allow both to work harmoniously in a spirit of full and transparent cooperation, with few if any misunderstandings between the parties.

Also, although funding for the GBYP has to be secured annually, the normal process for EU funding of this nature and form, **the review team recommends that the current experienced GBYP administrative staff corps be provided contractual certainty of their positions at least until the end of the current GBYP programme in 2015.**

35. The future of the GBYP

In the present context of ICCAT BFT investigations, there is little doubt that **the GBYP**, having already provided a broad spectrum of vital research results and monitoring output to underpin management advice for BFT, **will be required to maintain and probably even to reinforce future investigations on BFT after the scheduled end of the current GBYP.** It has to be stressed that Atlantic BFT population and stock structures are very complex and variable over time, as difficult or in many cases more difficult to understand and manage than the resource structure of many commercial fish resources currently enjoying large-scale research support and analysis. BFT stocks, or at least a large part of them, remain in danger of being overfished, mainly because of the very high value of sashimi on the open market (a value increased by farming activities) and because the spawning behaviour of Atlantic BFT is concentrated in the same small time and area windows known to fishers for millennia. Therefore, there will be an ongoing need to maintain active, in-depth investigations and routine intensive sampling effort on the species, similar to what has been realized for SBT. It needs to be stressed too that Atlantic BFT behaviour and dynamics are hugely different from those of most other tuna stocks for which a lesser level of permanent research may be sufficient to maintain understanding at a level commensurate with efficient assessment and management. ICCAT commissioners and contracting parties and countries therefore need to be prepared to confront the call for long-term scientific and monitoring activity on BFT to be ensured and to find the best and most efficient means of building routine funding for such activities into their thinking. The review team considers, for instance, that the suggestions of the SCRS in 2012 to create an ICCAT scientific quota of BFT or a special tax on BFT catches are valid ways to create such routine funding for future BFT investigations. The review team does, however, believe strongly that sustaining the level of additional research effort initiated during the GBYP will be vital if the current marked and apparently fast recovery of Atlantic BFT stock biomass in the East Atlantic is to be maintained, allowing realistic BFT TACs to be proposed to the Commission.

The review team considers too that (i) a future GBYP-type project should be developed by ICCAT with a view to it commencing as the current GBYP ends in 2015, and (ii) the SCRS and the ICCAT Commission be tasked now with investigating and promoting such an ambitious project as part of its long-term investigations into improved management of Atlantic BFT. The review team also recommends that any next generation of a GBYP be fully justified and described by means of a full-scale research plan showing in detail the proposed content of the programme: research actions planned and their priorities, cost and time-scales, etc. Ideally, a small task force should be created to take cognizance of all GBYP results to date in making their recommendations.

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Annex 1

Definition of tuna stocks, populations and subpopulations used in this report

Clear and stable definitions⁴ of these terms should always be used in scientific discussion of BFT fisheries, movements and stock status⁵, but the two terms **Population** and **Stock** need to be clear to all.

- ❏ **Population:** all individuals of a species that inhabit a specified region, e.g. Atlantic bluefin
- ❏ **Subpopulation:** a biological unit, a subset of a population that is a self-sustaining genetic unit. For instance, in the West Atlantic in the Gulf of Mexico (surely), off the Bahamas (possibly) and in the Mediterranean Sea around the Balearic Islands and Sicily (surely), and off Libya and Turkey (Eastern Mediterranean subpopulation).
- ❏ **Stock:** a geographic management unit, or the exploitable group of tunas existing in a particular area. Such a stock may contain several subpopulations, for instance BFT born in the Mediterranean or the Gulf of Mexico exploited in the West and East Atlantic. Each subpopulation may be stratified/exploited as various stocks: for instance, Mediterranean-born BFT being fished on both sides of the Atlantic. The ideal definition and understanding of a stock in term of its assessment and of its management should correspond to a given subpopulation or population, for instance as the SBT stock or the north Pacific stock.

The identification of subpopulations is essential to the assessment process, in order to evaluate interactions between fisheries and to allow the possible effects of exploitation of a fishery in one area on other fisheries active in the same area or other areas to be predicted. For instance, the fishing mortality on the Gulf of Mexico subpopulation may be greater in the East Atlantic than in the West, having a significant and negative impact on the Western subpopulation (this is now a cryptic question in the two-stock management hypothesis). Good follow-up of the various original subpopulations is also important in order to evaluate the potential risk of genetic erosion of the overall population being fished, because some subpopulations can be extirpated by overfishing or by changes in the environment in their spawning strata.

Although the ecological theory of a metapopulation appears to be valid for Atlantic BFT, there is no true relationship between these proposed definitions of populations, subpopulations and stocks and the behavioural and ecological concept/theory of a BFT metapopulation.

⁴ Definitions are basically taken from an SPC Skipjack WG meeting in 1976, at that time proposed by Gulland.

⁵ This is far from reality: in many documents and in SCRS reports, there is often dangerous confusion between the two concepts.