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COMMENTS AND RECOMMENDATIONS ON THE FIRST RESULTS OF THE SEAPODYM MODEL APPLIED TO THE NORTH ATLANTIC ALBACORE STOCK

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SUMMARY

This working paper discusses the 2013 assessment of the albacore stock, the fisheries and their environment in the North Atlantic. Various potential questions and problems related to this analysis are discussed, for instance, concerning stock structure, uncertainty in the asymptotic size by sex, natural mortality as a function of age, changes in fishing power of the longline fleet targeting albacore, thermal preference of the various ages, etc. The main results of this model are discussed in comparison with previous results of stock assessment models, reaching a conclusion that they appear to be more realistic. These first results appear to be widely positive but they are still preliminary, and further work is needed to improve them.

RÉSUMÉ

Le présent document de travail discute de l'évaluation du stock de germon de 2013, des pêcheries et de leur environnement dans l'Atlantique Nord. Diverses questions et problèmes potentiels se rapportant à cette analyse sont discutés, par exemple la structure du stock, l'incertitude entourant la taille asymptotique par sexe, la mortalité naturelle servant de fonction de l'âge, les changements de la puissance de pêche de la flottille palangrière ciblant le germon, la préférence thermique des différents âges, etc. Les principaux résultats de ce modèle sont comparés aux résultats antérieurs des modèles d'évaluation des stocks, la conclusion étant qu'ils semblaient être plus réalistes. Ces premiers résultats semblent être largement positifs même s'ils sont encore préliminaires et davantage de travail est requis pour les améliorer.

RESUMEN

En este documento se debate la evaluación de stock de atún blanco de 2013, las pesquerías y su entorno en el Atlántico norte. Se de debaten varias cuestiones y problemas potenciales relacionadas con este análisis, como la estructura del stock, la incertidumbre en la talla asintótica por sexos, la mortalidad natural como una función de la edad, cambios en la potencia pesquera de la flota palangrera que se dirige al atún blanco, preferencias térmicas de las diferentes edades, etc. Los principales resultados de este modelo se debaten comparándolos con los resultados previos de modelos de evaluación de stock y se llega a la conclusión de parecen ser más realistas. Estos primeros resultados parecen muy positivos, pero todavía son preliminares y tienen que realizarse más trabajos para mejorarlos.

KEYWORDS

North Atlantic, albacore, environment, modelling

1 Introduction

These comments on the Northern albacore stock are a follow up of the SEAPODYM analysis presented at the ICCAT 2013 albacore WG by Lehodey *et al*. As a whole, this new approach and its results are clearly very new & very interesting: its good use of a wide range of detailed fishery & environmental data clearly allows a much better understanding of the dynamics and status of the North Atlantic albacore stock. Most of its results are probably more comprehensive & more realistic than many of the previous results obtained by SCRS, even if these SEAPODYM results are still provisional ones. This note will simply develop some considerations or recommendations in order to improve the future SEAPODYM work.

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2 Heterogeneity of the albacore Northern stock?

SEAPODYM work presented by Lehodey *et al.* 2013 was based on the fact that:

"There is no evidence of subpopulation structure within the north Atlantic basin, where a single population seems to inhabit (Arrizabalaga et al 2004)".

This statement remains questionable: on one side this simplified hypothesis has been always kept and used by ICCAT, but it should also be kept in mind that various French ISTPM works in the seventies firmly concluded, after several years of research cruises at sea between Bay of Biscay & Azores Islands, that there was 3 sub populations of juvenile albacore in the NE Atlantic, see **Figure 1**.

This heterogeneity in the population would need to be better studied, using genetics & biochemistry based on albacore samples collected in these 3 areas. It should not be abandoned, as it may play a significant role in conditioning MSY changes, for instance if these sub population are real ones, the present shrinking of the albacore fishing zones would reduce the MSY of the today stock. This scientific question remains today a valid one, even if recent work using genetics concluded that "no significant heterogeneity was detected within ocean" for the Atlantic Ocean albacore population (this conclusion being of very little interest for albacore stock assessment, for instance because exchange rates between N & S albacore are very limited, even if genetics does not allow to identify these 2 stocks). This potential heterogeneity of the North Atlantic stock and its sub populations may be very difficult to introduce in any of the stock assessment models, but this question should deserve further study…

3 L_∞ and Catch at size of North Atlantic albacore?

SEAPODYM work noted on L_∞ that:

"*However preliminary test simulations showed L_∞ = 122 cm FL and the relatively high proportion of fish > 130 cm in the length frequency samples…. An intermediate solution was selected with growth with L_∞ set to 137 cm"*
But this statement can be questioned. By definition there is a biological variance of sizes under & above L Infinity... easily 5 % of SD as in human population. When on the other side, there is only 0.6O % of excessively large albacore caught at size over 122 cm in the average CAS of adult albacore (over 90cm) in the average CAS 1975-2011 (**Figura 2)**. This rate is in fact very low and probably too low! The biological asymptotic size of albacore may well be lower than 122 cm! Alternate way to estimate & to choose L infinity, for instance the Wetherall *et al.* 1998 method, should usefully be used to analyze the albacore CAS and to estimate more realistic L∞ that should be used in stock assessment, because this parameter is very important in most stock assessment analysis!

Furthermore, it should also be noted that there is a marked decline of females at adult sizes, see **Figure 3** .This figure shows a significant dominance of young mature females in a range of size between 90 & 100 cm, followed by a fast and major decline of these females in the albacore catches over 1 meter. This result is well shown by **Figure 4** showing the average CAS by sex of albacore during the period 1975-2011 in the hypothesis of the average sex ratio of **Figure 3**. This result is very similar to the sex ratio at size observed for YFT in the Atlantic (Fonteneau & Chassot 2012). Such result could be explained by a **lower L infinity of females, for instance at least 10 cm lower**, that are accumulated at their adult sizes <1 meter. Such lower asymptotic sizes of female have been well demonstrated on yellowfin & on bigeye by the recoveries of tagged sexed tunas. This point should be better studied & preferably well introduced in the SEAPODYM & in the assessment models as such lower $\mathbf{L_\infty}$ would widely change the catch at age of adult ALB.

4 Post 1986 changes in catchability of albacore caught by LL?

This is an interesting & important question in the stock assessment. I see that SEAPODYM is trying to estimate the changes in the albacore LL catchabilities… It should be kept in mind that this analysis should be mainly targeting the gyre areas where most of the albacore catches are taken by LL. It is possible to estimate the CPUEs in value in the 2 albacore & TropicalTuna areas (see **Figure 6**), based on the yearly landing values of the main tunas landed by LL. This result shows that since 1989 the CPUE in value in the albacore areas are most often very low **Figure 5**): CPUE in value have been 60% higher in the equatorial area compared to the albacore northern areas during the 1989-2010 period, when they were similar before. In such context it is hard to understand why part of the LL fleets are still fishing in the albacore areas.

This type of question has been answered in the Indian Ocean, where similar question was raised, by Taiwanese scientists: their logical explanation was that all the modern & more efficient longliners equipped with deep freezing did moved during the late eighties to the equatorial areas and the targeting of BET & YFT, when the old longliners, less profitable ones, have been staying in the albacore areas. If this logical conclusion is valid, it should produce a decline of albacore catchability in the albacore area. This decline of catchability should possibly be estimated by an ad hoc statistical analysis, based on the detailed log book data and on the characteristics and CPUEs of the individual vessels that have been staying or moving from/in the albacore area.
This question may be of major importance, as the decline of LL CPUEs in the albacore core area would be explained by a decline in efficiency, & not by a decline in local biomass, when most assessment models are assuming constant efficiency of the LL fleets.

5 What Natural Mortality at age?

SEAPODYM 2013 paper has been noting that:

"ICCAT stock assessment studies assume a constant natural mortality rate of 0.3 yr-1 (0.025 mo-1) for all cohorts (ICCAT 2010), somewhat lower than the coefficient used (0.4 yr-1 or 0.033 mo-1) for the most recent stock assessment in the south Pacific (Hoyle et al 2012)….. From this SEAPODYM optimization experiment, the mortality is estimated to decrease rapidly in the early life stage from above 0.1mo-1 in average in the first year of life to a minimum of 0.04-0.05 mo-1 (0.48-0.6 yr-1) between 3 and 10 years, then slowly increasing for older cohorts (Fig. 3.7)".

These values of Mi are shown by **Figure 7**. Natural mortality at age is probably the most important but the most cryptic parameter in all the analytical stock assessments models & results of most tuna stocks! It could be noted that these Mi SEAPODYM values are very high for an albacore stock, probably unrealistic, and showing a strange pattern: M too low for juvenile albacore???? And the adult Mi too high for such a long living species? for instance compared to Lorenzen Mi? (this method being in my mind fairly realistic to estimate Mi for most tuna species!) or to the Gislason Mi. At least this major structural uncertainty in Mi should be better explored, as the today high M should have a major impact in the present SEAPODYM analysis: potentially transforming albacore from a BFT like species to a SKJ like species.

6 Canary Island baitboat albacore fishery

The SEAPODYM analysis reached the conclusion that: "*Fishery records for the Spanish-Canary has only few (110) records with both catch and effort and thus was not included in the optimization experiment"*.

This conclusion may be questionable: this pole and line albacore fishery has been active seasonally targeting albacore around Canary Islands since the early seventies, and it has been quite well followed by IEO scientists, even if their catch and effort statistics are available only by 5° month strata. This fishery is catching significant quantities (**Figure 9**) of quite large albacore (**Figure 8**) in a geographical area positioned in the Canary current, outside the N Atlantic gyres, and at the SW periphery of the geographical distribution of the albacore stock. Then this fishery may be of great interest in the SEAPODYM analysis and this prospect should be further explored. Data mining should then be conducted with the IEO tuna scientists from Canary in order to recover all these data and to incorporate them as well as possible in the SEAPODYM analysis, even if the 5° areas are wider than the SEAPODYM strata.

7 Albacore & water temperature?

SEAPODYM model is producing interesting range of optimal temperatures of albacore during its life cycle, see the appended **Figure 10**. However this SEAPODYM result may be quite surprising, for instance when compared to the average temperatures (SST & at 100°) in the 5°-quarters of the albacore catches by longliners: albacore caught in warm waters (spawning strata) are not visible: why? There is also a marked divergence between optimal temperature of albacore less or older than 9 years old in the SEAPODYM results that is not at all visible in the temperature of fishing strata, see **Figure 11**. All adult albacore are swimming and they are caught in similar temperature, most often >15°C, and very seldom/never in very cold waters <9°: a figure 8 strange result? Why?

8 Stock biomass: now & before?

The levels and recent trend of spawning stock biomass estimated by SEAPODYM & by the recent SCRS stock assessment are delivering quite opposite results (see **Figures 12 & 13**):

- much higher biomass estimated by SEAPODYM
- increasing adult biomass estimated by SEAPODYM during the last 20 years, when SCRS model has been estimating during this period a marked decline in the spawning biomass.

This major divergence in the results of the 2 types of models is partly due to the higher level of Natural mortality used by SEAPODYM, but it should be understood, and a choice should be made by SCRS upon the more realistic results based on the new stock assessment analysis conducted in 2013. At this stage, we would favour the SEAPODYM approach and its diagnosis:

- because it makes a quite comprehensive use of fishery & environmental data and of the life cycle & ecology of albacore,

- when on the opposite, the VPA & statistical models (such as MFCL and SS3) are often "blind" and prisoners of their best fit results: for instance most often producing artificial increase or decrease of estimated recruitments in order to compensate for increasing or decreasing catches by fisheries (even when these trends in total catches were clearly due to economical or management factors, not to biological reasons). The albacore north Atlantic fisheries were typically a case where the dome shape trend of the 1930-2010 recruitments was not a real one, but simply created by the dome shape total catches of changing fisheries (**Figures 14 & 15**).

This is typically a potential problem that has often been observed world wide in the results of many tunas stock assessment results (analyzed by Fonteneau *et al.* 1998)

9 Conclusion

This first SEAPODYM work on the North Atlantic albacore stock was clearly a positive step in the assessment of its past changes & today condition and they are good reasons to consider that this approach is more realistic than other analytical (VPA) or statistical methods (MFCL or SS3) that can be used by SCRS on this stock. However there is still a wide range of parameters and of uncertainties in the present analysis and results that should be explored before being fully confident in the results of this model. It should also be kept in mind that most of these uncertainties in the input & in the hypothesis of the SEAPODYM model are also faced by most of the stock assessment models. All progresses in their knowledge would benefit to all types of models.

Cited literature

Albaina A., M. Iriondo, I. Velado, U. Laconcha, I. Zarraonaindia, H. Arrizabalaga, M. A. Pardo, M. Lutcavage, W. S. Grant and A. Estonba. 2013, Single nucleotide polymorphism discovery in albacore and Atlantic bluefin tuna provides insights into worldwide population structure. Animal genetics. 15p.

Aloncle et Delaporte 1973, Données nouvelles sur le germon dans le Nord Est Atlantique, *Rev. Trav. Inst. Pêches marit.*, 37 (4), 197., 104p.

Arrizabalaga, H., E. Costas, J. Juste, A. González-Garcés, B. Nieto and V. López-Rodas. 2004, Population structure of albacore *Thunnus alalunga* inferred from blood groups and tag-recapture analyses. Mar. Ecol. Prog. Ser. 282: 245-252.

Fonteneau A and M Chassot. 2012, An overview of yellowfin tuna growth in the Atlantic Ocean: Von Bertalanffy or multistanza growth? Collect. Vol. Sci. Pap. ICCAT, 69(5): 2059-2075 (2013).

Fonteneau A., D. Gascuel et P. Pallares Soubrier 1998. Vingt-cinq ans d'évaluation des ressources thonières de l'Atlantique: quelques réflexions méthodologiques. Col. Vol. Sci. Pap. ICCAT, 50 (2): 523-561.

Gislason H., N. Daan, J.C. Rice & J. G Pope. Size, growth, temperature and the natural mortality of marine fish, 2010, FISH and FISHERIES, 11, 149–158.

ICCAT 2013, Report of the 2013 ICCAT north and south Atlantic albacore data preparatory meeting, ICCAT Document, 72p.

Lehodey P, I. Senina, A.C. Dragon, H Arrizabalaga. 2013, Modeling spatial population dynamics of North Atlantic Albacore tuna under the influence of both fishing and climate variability with SEAPODYM. SCRS/2013/125, 26p.

Lorenzen, K. 1996, The relationship between body weight and natural mortality in fish: a comparison of natural ecosystems and aquaculture. J. Fish Biol. 49: 627–647.

Wetherhall J.A., J.J. Polovina and S. Ratlston, 1986, Estimating Growth and Mortality in steady State Fish Stocks from Length-Frequency Data. Fishbyte, 1986, vol. 4, issue 1, pages 12-14.

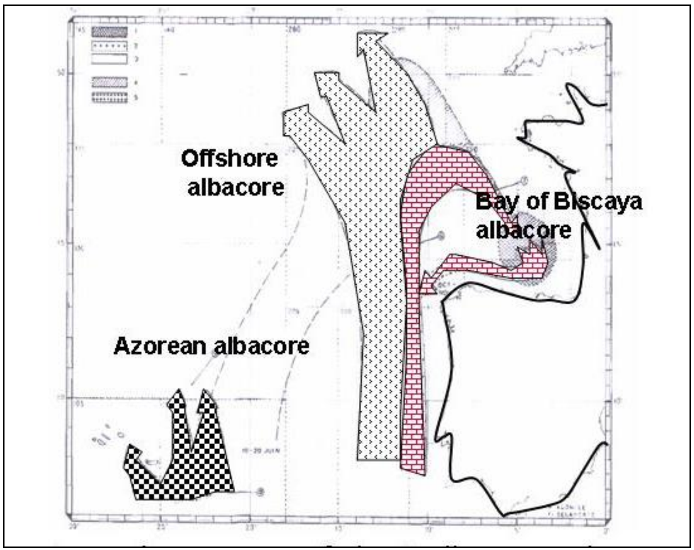


Figure 1. Hypothesis of 3 sub populations of albacore in the NE Atlantic surface fisheries (Aloncle & Delaporte 1973)

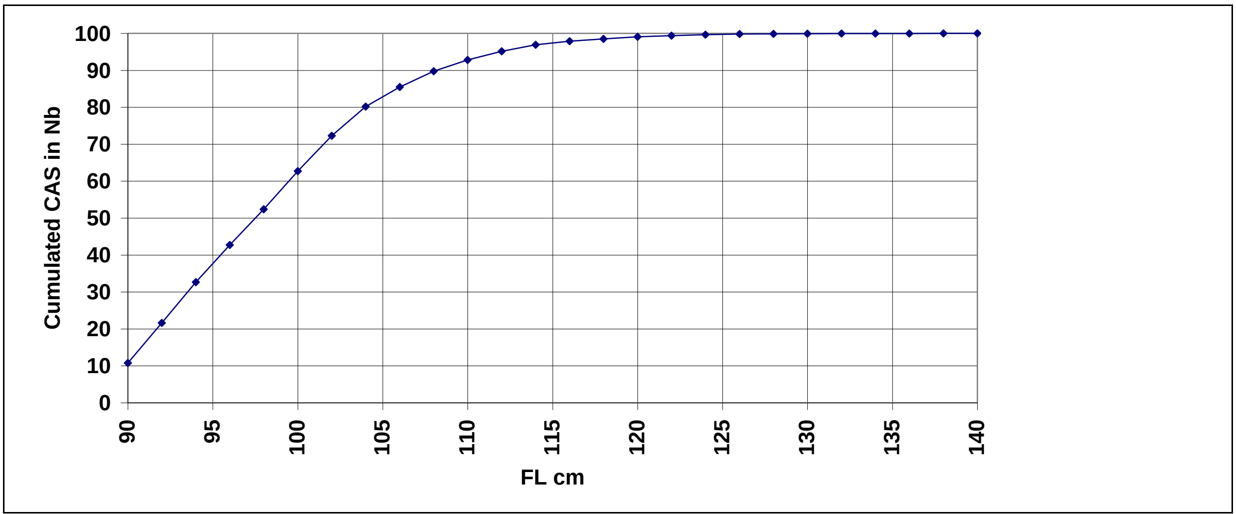


Figure 2. North Atlantic albacore cumulated CAS of adult albacore during the average period 1975-2011.

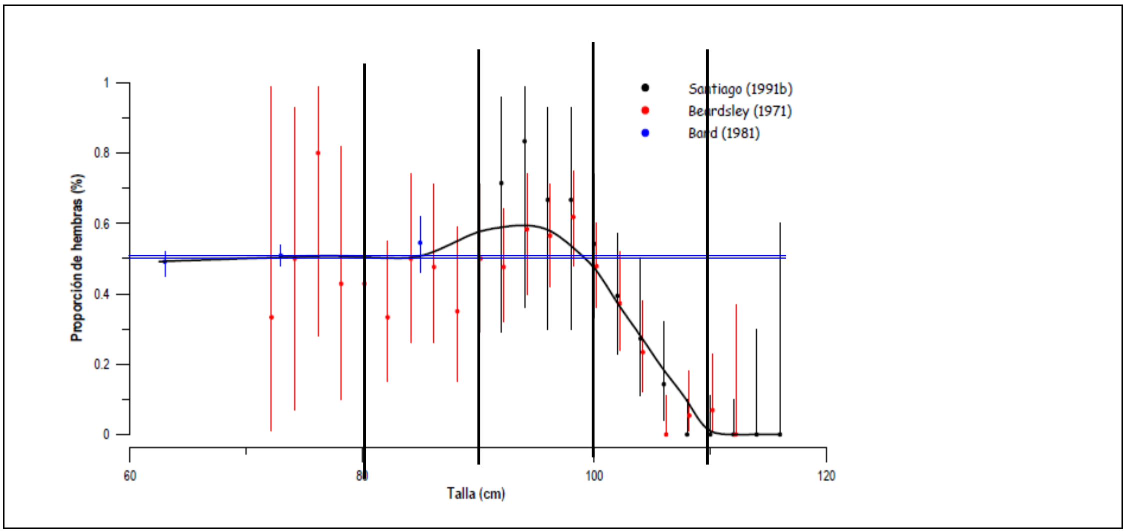


Figure 3. Sex ratio at size of Northern albacore estimated by various authors (ICCAT albacore data WG 2103).

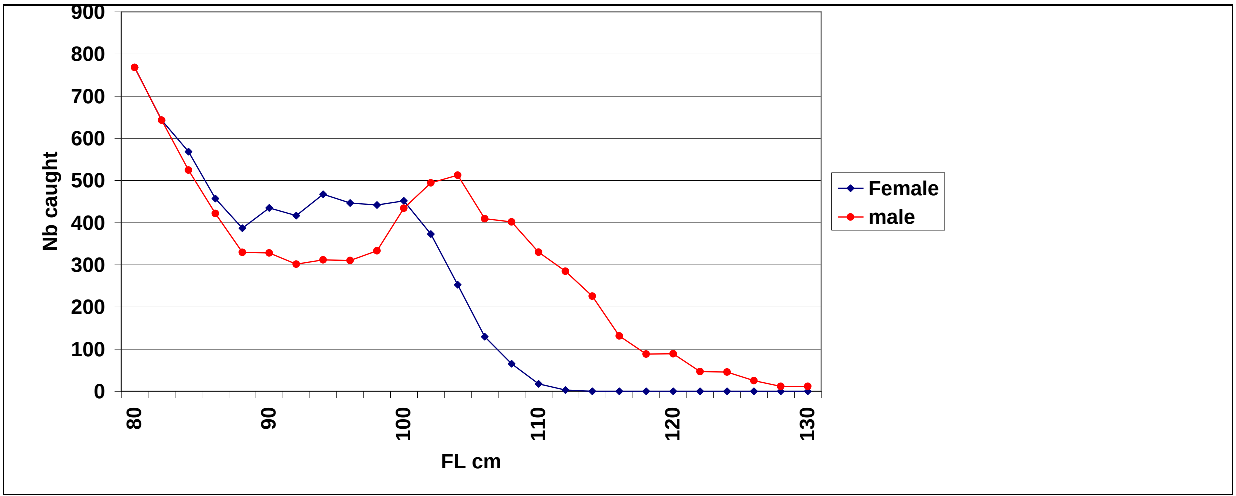


Figure 4. Average CAS by sex of albacore during the period 1975-2011.

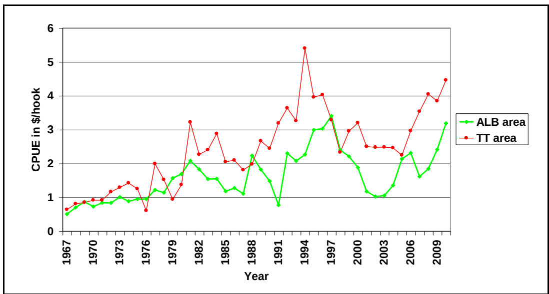


Figure 5. Taiwanese LL multispecies CPUEs in dollars in the albacore core area and in the equatorial area dominated by catches of YFT & BET (**Figure 6**).

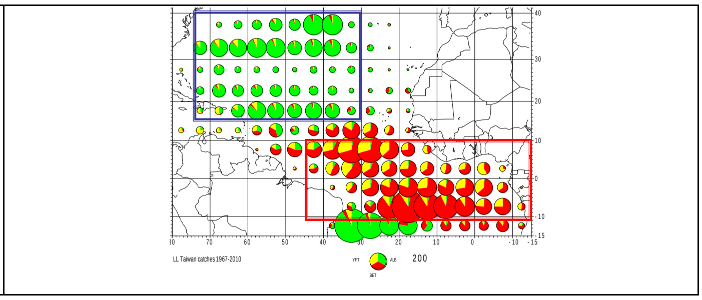


Figure 6. Average catches of ALB and of tropical tunas and core areas used to estimate CPUEs in $ of tropical and temperate tunas.

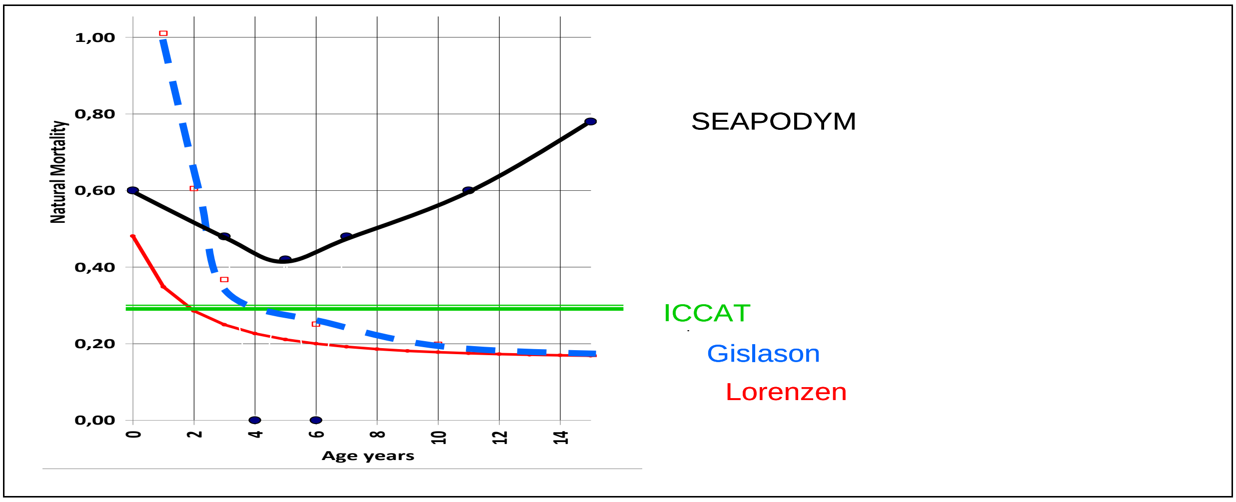


Figure 7. Potential values of albacore Mi.

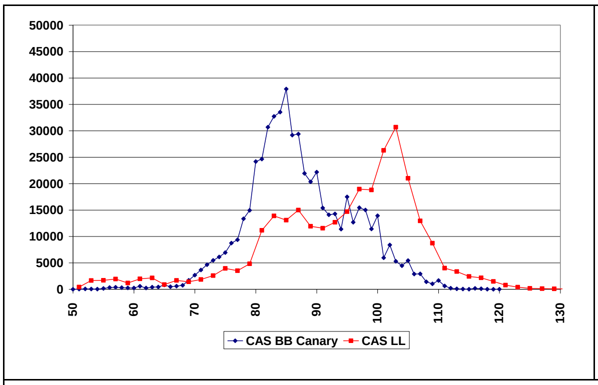


Figure 8. Average catch at size of the Canary Island BB and of the LL fisheries (average 1999-2010).

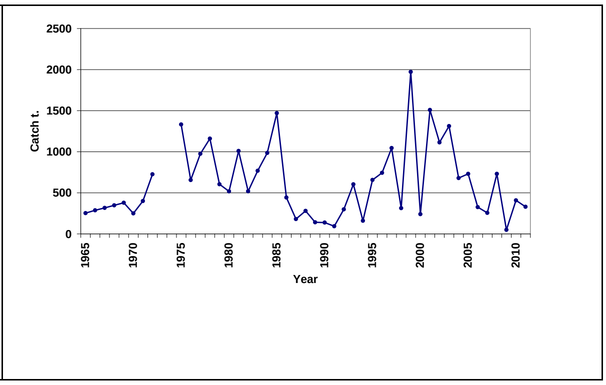


Figure 9. Yearly catches of albacore by the Canary Islands BB fishery.

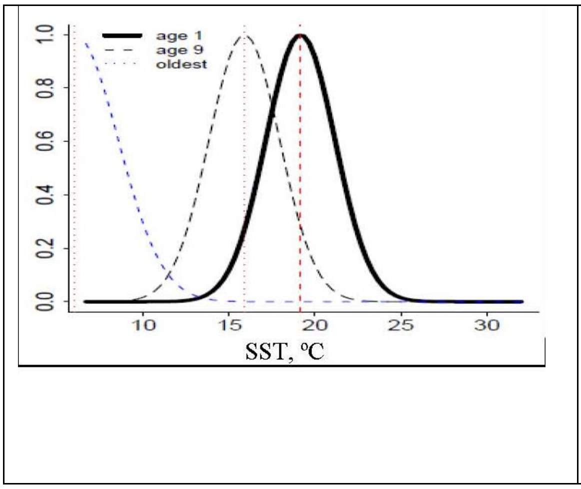


Figure 10. SEAPODYM Optimized functions for temperature.

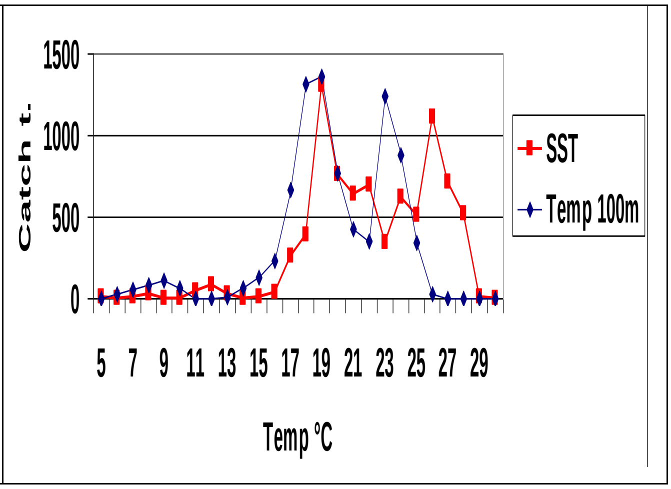
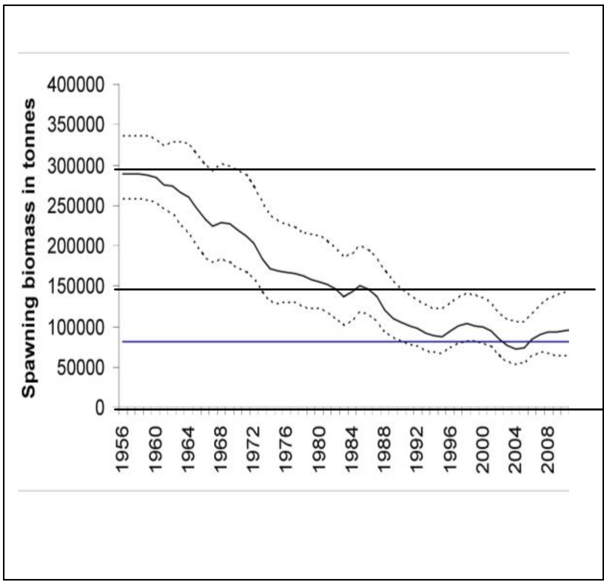


Figure 11. Average catches of albacore caught by LL during the 1960-2011 period as a function of average SST & Temperature at 100 m.



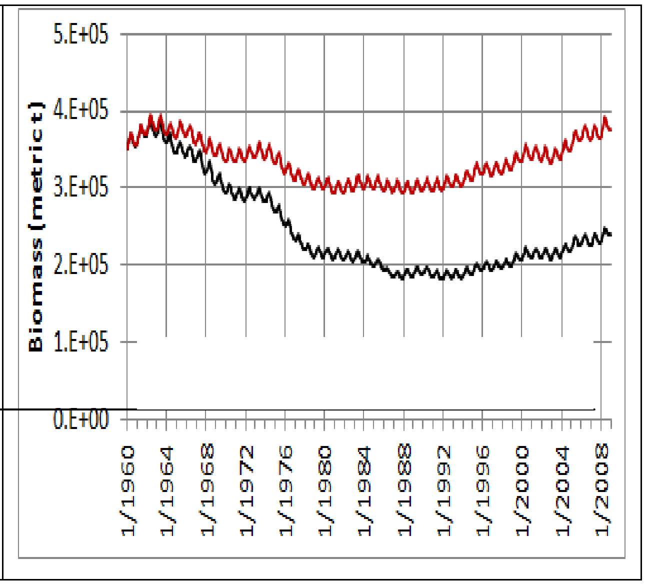
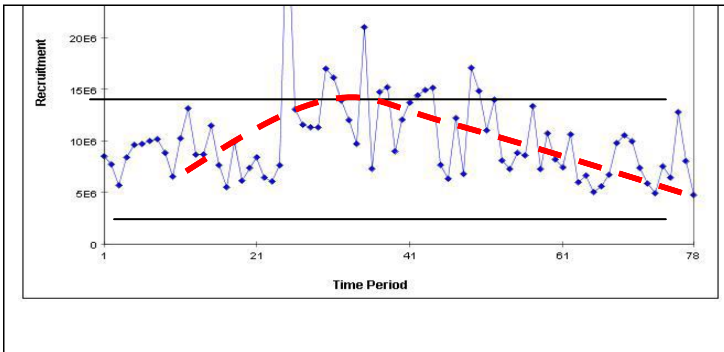


Figure 12. Trend of the albacore adult biomass estimated by SCRS in 2010.

Figure 13. Same result estimated by SEAPODYM (black curve).



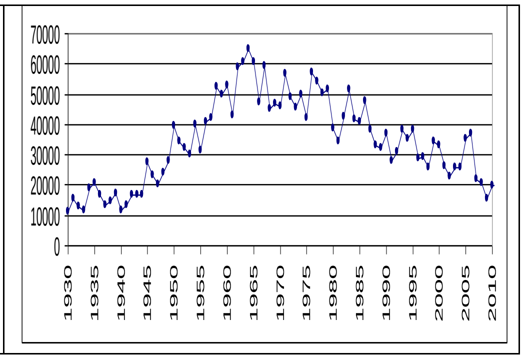


Figure 14. N-Atlantic albacore yearly recruitment estimated by MFCL in 2010 during the 1930-2008 period.

Figure 15. N-Atlantic albacore yearly catches.