# Note on the prospects of electronic tagging during the IOTTP The ELECTAG project

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## Summary

The planned IOTC tagging programme has been targeting a low number of electronic tags, only 200. The analysis of recent results provided by this type of electronic tags shows that they do provide a wide range of new results that cannot be obtained by dart tags of by any other scientific methods. These original results being of key importance for the assessment of tuna stocks, this paper makes a recommendation that at least a total of 1000 electronic tags should be released during the incoming IOTTP. It is recommended that this tagging should use predominantly internal tags, but also some pop up tags (100). This electronic tagging would be done at a moderate cost as it would use the facilities already available within the planned programme: tagging vessel, manpower and system for tag recoveries. It is concluded that this unique present opportunity to release a significant number of these valuable electronic tags should not be missed by the IOTC.

## 1- Introduction

The present RTTP programme prepared by the European Union under its proper funding has already included in its tagging plan and budget to release about 200 internal archival tags (corresponding to a budget of € 260 000) during the period 2005 and 2006. This prospect was discussed by the tagging WP during its 2004 meeting; the conclusion of these discussions was that this number was too low taking into account the wide scope of scientific results than can be obtained by such modern tagging as well as the unique tagging opportunity that will be offered by the two RTTP tagging vessels that will be doing tagging operations during 2 years. There is no doubt nowadays that this new type of data obtained by electronic tagging are very important for the stock assessment models already used, and they will be vital for the next generation of models that will be based on a comprehensive environmental framework.

The subsequent conclusion by the WP was the following:

*"The WPT proposed that a task force should prepare, before the next Scientific Committee meeting, a detailed and well justified plan for an electronic tagging program - including a budget and a description of the expected outputs".*

This conclusion should be considered as being realistic. As dart tags and archival tags do provide a wide range of peculiar results that are both very useful for a better tuna stock assessment, it would be rather inconsistent and unsatisfactory to conduct in 2005 and 2006 a large scale tagging operation with a very limited number of archival tags.

The goal of this note is to prepare for the 2004 IOTC Scientific Committee such larger scale and more ambitious plan for an electronic tagging that could be incorporated into the future IOTTP tagging operations. This note describes a recommended level of electronic tagging plan, evaluates its goal and budget, and discusses the feasibility of its potential funding (as this funding should be obtained from external sources, and not from the present

EU funding as this funding has been already established with a limited budget for the archival tags).

## 2- A reminder upon the goals of electronic tagging

### 2-1- General comment

Electronic tagging, using both internal and pop up external electronic tags, have been increasingly used world wide during the last 10 years on various tuna species and stocks in many tagging operations. Ten years ago, these experimental tagging operations developed by Australian scientists (Gunn 2001) were considered to be quite risky, because scientists were wondering upon the survival of tunas tagged by these new electronic tags, the difficulties in transmitting the data by satellite from a floating tag, and because the real prospects of data collection by these new tags was still unclear. Nowadays, there is an unanimous and enthusiastic opinion shared between all tuna scientists that these tags can provide invaluable scientific results than could never be obtained using dart tag or any other scientific method. These tags offer a unique opportunity to follow and to understand much better the behaviour and horizontal movements at various scales of individual tunas as a function of their environment.

These invaluable recent results were often obtained on a small number of fishes (such as the lonely swordfish described by Takahashi and al 2003), and in most tagging experiments they have been proven to be highly informative. Dart tags only provide to scientist on the information upon the released and the recaptured points, but nothing is known between these two positions, when the archival tags enable to estimate the all trip followed by the fish together with other information upon its fine scale behaviour (vertical behaviour, sea and fish temperature, light, etc…). With pop-up tags, one does not even need the recapture of the fish to obtain the data, while dart tags remain always fishery-dependant (tagged tunas being potentially lost in unfished areas, figure 6, or recovered tags being unreported to scientists, a problem often faced for longliners).

### 2-2- Typical results obtained by electronic tags

These results have been well examined in various recent meetings and papers, such as in the book recently published on this matter (Sibert and Nielsen editors and the Cairns billfish symposium 2002) following the first symposium held in 2000 on electronic tagging or in "Tagging methods for stock assessment and research in fisheries" coordinated by Thorsteinssen (2002) and published with the help of EU funds. It should also be noticed that since this 2000 symposium on electronic tags, the use of these tags in tuna tagging have been widely increased and that the results of such tagging have been proven to be very positive.

The results with internal archival tags on bigeye by the IATTC (K. Schaefer 2002 and 2005) can be cited among the best examples of these extremely positive results obtained by this type of tagging: very little was known on the vertical and geographical movements of bigeye tuna in the eastern Pacific until the late nineties, when there is nowadays a good knowledge of these parameters obtained by the successful archival tagging recently conducted by the IATTC.

### 2-3-Geolocation obtained by electronic tags

Geolocation of electronic tags has been one of these key most interesting features. There are still serious uncertainties in this positioning (simply based on light and time recording, see Musyl et al 2001). These uncertainties tend to be greater in latitude than in longitude, and greater in the equatorial than in the temperate areas, but these uncertainties are now widely reduced in most areas using modern tags, detailed environmental data and improved mathematical software. The uncertainty in this geolocation has been studied using tags placed on anchored devices at known positions; these studies have shown that the uncertainty tend to be at the scale of about 1°, e.g. a very good precision for most studies on tuna movements. It

can then be concluded that the prospects to obtain quite realistic positions during the entire time at liberty are now already quite high (with the exception of swordfish, because this fish spend most of its day time at great depth and in a complete obscurity, then reducing to nearly zero the potential of geolation offered by the knowledge of light and time, see figure 1b). This type of electronic tags are the only way to answer to the basic question faced by most dart tag long term recoveries: often, tagged tuna have been recovered close to their tagging positions, 6 months or 1 year after, but did these fishes stayed in the tagging area, or did they made a long migration, far away from the tagging and recovery spot? (figure 1). Furthermore, this geolocation facilty can also offer valuable information outside the regulat fishing zones, for instance in the Lutcavage 2000 results showing that most giant bluefin tagged moved in an unfished area (figure 6).

**2-4- FADs and electronic tags**

The association of tunas to FADs (observed for skipjack, but also for bigeye and yellowfin) also offers a wide potential to archival tags: it has been well shown by the recent work on bigeye by Schaefer (Schaefer 2005) in the Eastern Pacific that the fidelity rate of these tuna to the FADs can be well estimated with archival tags, as shown by figure 2 taken from K. Schaefer (Although these results need to be confirmed by sonic tags followed by research vessels such as in the FADIO programme presently conducted in the Western Indian Ocean). There is then a great scientific interest offered by electronic tagging around FADs to provide valuable information on the behaviour of FAD associated tunas and on their fidelity to these FADs. The EU DG FISH project TAGFAD was targeting this goal, but most of its tags are still waiting to be released on FAD associated tunas, this tag release being planned in association with the RTTP regular tagging cruises.

**2-5- Vertical movements as a function of environmental conditions**

One of the basic results offered by the electronic tags has been the information of the short term vertical movements of tunas, as a function of their sizes and species, and in each ecosystem (as a function of the oceanic framework encountered). These basic information, see for instance figures 3, 4 and 5) cannot be obtained by dart tags, when they are of key importance in the modelling of the tuna resources (allowing for instance to interprete the changes in CPUE as a function of the environment, or as a result of changes in the gear configuration).

**2-6- Conclusion on present results**

As a conclusion, there are no doubts nowadays that archival tags do provide a wide range of comprehensive answers on how the various tuna species, both juveniles and adults, are using their habitat. These results are clearly of great interest for scientists, both in the short term providing a better and more realistic parameterization of present modelling of tuna stock status, and in the medium term for the parameterization of the promising next generation of models based upon the fine scale interactions between tuna resources and their habitat, for which they area absolutely necessary (Kirby 2001, Maury 2005).

## 3- Targeted types and levels of tagging operations

The number of archival tags potentially available at this time for the RTTP are of about 400 tags (e.g. 200 tags remaining from the EU TAGFAD project, and 200 tags already planned in the present EU programme), and this number is considered to be by far insufficient for such a large scale tagging programme conducted upon two large stocks in a wide and heterogeneous area, where the tuna tagging operations has been very rare in the past. As a comparison, the recent IATTC tagging programme successfully ran by K. Schaefer has been using mainly on bigeye 265 archival tags (104 being already recovered), when the tagging programme ran in Hawaii placed a total of 215 archival tags, both programmes being conducted in quite small geographical areas. The goal of this additional “electronic tagging

project" would be to significantly increase this tagging by archival tags, using a combination of internal and pop up tags.

The two species targeted by the archival tagging operations should be **yellowfin and bigeye**. Skipjack tuna should not be targeted by the archival tagging, as this species is considered as having a lower priority in the IOTTP and as its prospect of post tagging survival are probably quite low (fragile and small individuals showing high natural mortality). The two species should be targeted in a wide range of sizes covering pre-spawning sizes (for instance in a range between 5 and 30 kg) and size at maturity (>30 kg). These tagging operations should be planned and conducted during special tagging cruises in well selected strata where the targeted sizes and species are expected to be caught and tagged in significant numbers (such as bigeye tunas in the Coral sea, or on the FAD associated bigeye around Galapagos Islands). But prior to these specific archival tagging operations, it will be necessary to identify the time-area strata where the targeted sizes and species are abundant and easy to tag. Before, archival tagging will be tried anytime the proper sizes and species will be available and keeping in mind the dart tag target of the RTTP.

This electronic tagging should use a significant number of pop up archival tags because the recovery of these tags is independent of fisheries (when the recovery of large internally tagged fishes caught by longliners is quite questionable). Furthermore, a high proportion of recovery can be expected for these tags (nearly 100%?), at least with the new tags and the new satellite technology and if the tagging procdures have been perfectly well followed by the tagging scientists.

However, it should be recognized that the full use of these pop up tags is still hampered by several additive problems such as:

- Their **higher cost**, as a pop up tag costs about 3500$ a piece, e.g. about 3 times the price of a basic internal tag; furthermore the time of data transmission through the ARGOS system add an other cost to the budget of these tags.
- Their early potential **detachment** from the tuna: these tags are quite large, and they offer a serious drag for a fast swimming tuna. As a consequence, it appears that the early detachment of the tags has been quite frequently observed. The perfect attachment of these tags with a very low probability of losing the tag is still questionable.
- **Their larger size** prevent their use for tunas less than 40 kg (the size limit advised by their manufacturers).
- The **transmission by satellite** of the data may be problematic, due to problems of the ARGOS satellite in some areas and/or battery failures, and these data may be lost (De Metrio bluefin tagging, EU FAIR report); in the best case, the quantity of data that can be transmitted by satellite tend to be lower than the data recorded in the archival tags (knowing that a fished pop up tag can have the same storage capacity than an internal tag). These problems have been well discussed by the ICCAT bluefin WG in 2001, see annex.

In this context, the final recommendation could be that taken from the Block and al. 2001 paper: *"the recommended electronic tagging should then use a combination of internal and external pop up tags, as "both types have advantages and disadvantages, but when used together they are capable of providing enormous insight into the movements and natural history of the fish"*, but giving a clear priority in term of number of fishes tagged, to the less expensive and more reliable internal tags.

A ratio of 500 new internal tags and of 100 pop up tags could then be a reasonable target for the IOTTP (these tags being in addition of the already planned tags, from the TAGFAD project and form the RTTP programme).

This number of new tags should be equally divided between sizes and species for instance following the following rules:

| | Small YFT | Large YFT | Small BET | Large BET |
|---|---|---|---|---|
| Internal tags | 100 | 150 | 100 | 150 |
| Pop up tags | | 50 | | 50 |

Similar guidelines should also be used in order to deploy the 400 archival tags already budgeted (RTTP) and in store (TAGFAD). These guidelines are only a starting base for further discussions and they should remain flexible and potentially adjustable, for instance following the practical difficulties faced during the tagging operations (for instance the 150 tags recommended on large BET could be transferred to small bigeye or to small yellowfin if these large fishes were too difficult to catch and to tag).

It would be interesting to scatter the geographical distribution of these tags in a wide geographical area, but selecting a given number of tagging spots as a function of tagging feasibility and of the running tagging operations.

The local-scale tagging projects planned in the IOTTP (Mayotte, Maldives, Lakshadweep -India-, Iran….) should also be considered as potential interesting platform and area where these archival tags can be deployed, giving at the same time the corresponding expertise to the local scientists in this new field of electronic tagging. Part of these tags could also well be released by scientists in cooperation with selected sport fishermen, for instance in South Africa or in Kenya, if some of these possibilities can be identified during the tagging programme.

All these tagging operations using archival tags, internal or pop up, should of course be **conducted only by tagging scientists who are already fully expert and experienced in this type of tagging** (and in its chirurgical phases). This obvious requirement is due to the necessity to be fully efficient in all these expensive tagging operations.

## 4- Total cost of this electronic tagging

New additional tags, 500 internal and 100 pop up tags are needed in order to increase at reasonable levels the use of electronic tags, and to recover the wide range of data that can be expected from such tags. This new electronic tagging would be conducted at the marginal cost of the tags, the cost of some minor tagging accessories and the cost of tags rewards (assuming that all the other costs, tagging technicians and tagging vessels) are already included in the IOTTP programme (All these tagging operations becoming a full part of the IOTTP).

The reward cost of pop-up tags is at the same level as an internal archival tag (200 $) in the case of tunas caught with their pop-up tags before the pop-off of the tag (only 5 tags out of the 100 being recovered before the release of the tag). This cost can be estimated as following:

| | Internal | Pop up | Total |
|---|---|---|---|
| Cost of new tags $ | 1300$*500=650.000$ | 3500$*100=350.000$ | 1.000.000 $ |
| Transmission ARGOS | | 10.000$ | 10.000 $ |
| Rewards | 200$*50= 10.000 $ | 5*200$=1.000 $ | 11.000 $ |
| Total | 660.000 $ | 361.000 $ | 1.021.000 $ |

These costs are only indicative prices, but they can provide an estimate of the cost of this additional tagging operation.

## 5- Conclusion

The conclusion is that the additional use of electronic tags in the IOTTP would probably be a highly positive investment allowing to provide a wide range of detailed behavioural data that are more comprehensive and that cannot be obtained from the use of dart tags. It must be recognized that the present budget of the IOTTP cannot in any case provide the 1 million US $ that are needed to conduct this additional electronic tagging. However, this project should first be discussed by the IOTC Scientific Committee in its 2004 meeting and the SC could make a recommendation upon the interest of its realisation. It should be recognized that this additional funding would be *de facto* very modest in view of its potential results, because this electronic tagging would be making a full use of the existing IOTTP programme: tagging vessels, tagging scientists, publicity for recoveries, rewards systems, logistics. This would be really a unique opportunity, probably the first and the last one, to do such archival tagging in the Indian Ocean at such low additional cost!

The present opportunity offered by the IOTTP should not be missed by the IOTC, given the fundamental importance of the results provided by the new electronic tags for the parametrization of both present assessment models and the new environmentaly based population models.

Such recommendation by the IOTC Scientific Committee to support this electronic tagging could possibly facilitate (1) the recuperation of potential additional funds **in the existing IOTTP and RTTP programmes** and/or (2) to obtain additional funds from **external donors** that should be identified as soon as possible in the countries, agencies and private sectors interested by the conservation of Indian Ocean tunas and by the potential results of electronic tagging.

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**Annex: extract from the ICCAT"Workshop on bluefin mixing", 2001.**
**Technological discussion of pop up tags:**

*The relative merits and shortcomings of the tag types, pop up and internal, were discussed. It was agreed that the archival feature of the electronic tags is essential to study the movements of bluefin tuna. In order to answer questions about spawning site fidelity, the duration of the tag deployment is important. The rate of data return, as well as the fishery-independent data associated with the archival recaptures were emphasized. Both an archival capability as well as inclusion of pressure sensors on tags can help to determine that tags remain on the fish. There was discussion about the determination of the latitude estimates and their reliability. Methods included the use light levels alone, as well as augmentation with sea surface temperature and depth to generate latitude. Reliability of reception of single-point pop-up satellite tag transmissions in the eastern Atlantic and Mediterranean was a source of concern, and postulated as a reason for differing tag reporting success between western and eastern Atlantic tagging programs. Recent tests conducted by Service Argos, Inc. in three locations around the world confirmed that a shift in frequency improved reception of tag transmissions from the eastern Atlantic and the Mediterranean. In addition, two new satellites with improved receivers have gone online, and the latest popup archival tags have "satellite in view" features that extend battery life for expanded data transmission. The importance of tag placement was emphasized by all programs. Careful handling of fish and placement of tags are also essential for successful long-term attachments. Tag shedding (premature detachment of the pop-up tag from the fish) of pop-up tags was a source of concern. New features of tags (pressure [depth] sensors, and a fail-safe detachment when the fish goes to a pre-determined depth or at a pre-determined constant depth) will clarify interpretation of the data in this regard in the future. While there was some opinion that the results from the first-generation point location pop-up tags should be viewed cautiously if on the fish for long durations, others felt that the results are consistent with some of the implantable archival tag data, and are important to our understanding of bluefin movements. Premature tag shedding rates can now be determined using the data from the archival pop-up tags (with pressure sensors). While the pop-up tags are now much improved and include improved features, it was noted that fishing mortality and non-reporting of tags cannot be ruled-out as a cause of apparent pop-up tag failure.*

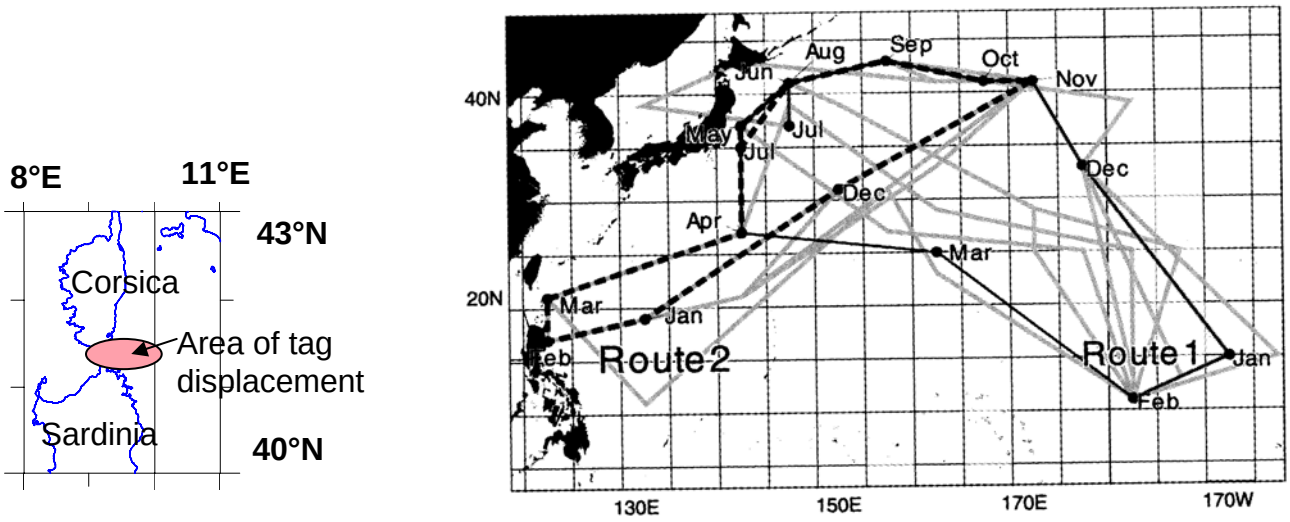



Figure 1: Results of tagged fishes recovered close to their tagging position and showing during several months:

(1) a pattern without movement for Mediterranean bluefin, left: 9 fishes tagged, 8 of them recovered very close to the tagging location), figure redrawn and simplified from DeMetrio and Al. FAIR report , or

(2) long range circular movement estimated on a swordfish from data recorded with an electronic tag (right) (taken From Takahashi and al. 2003)

NB: positioning of swordfish is very difficult due to the deep behaviour of the fish.

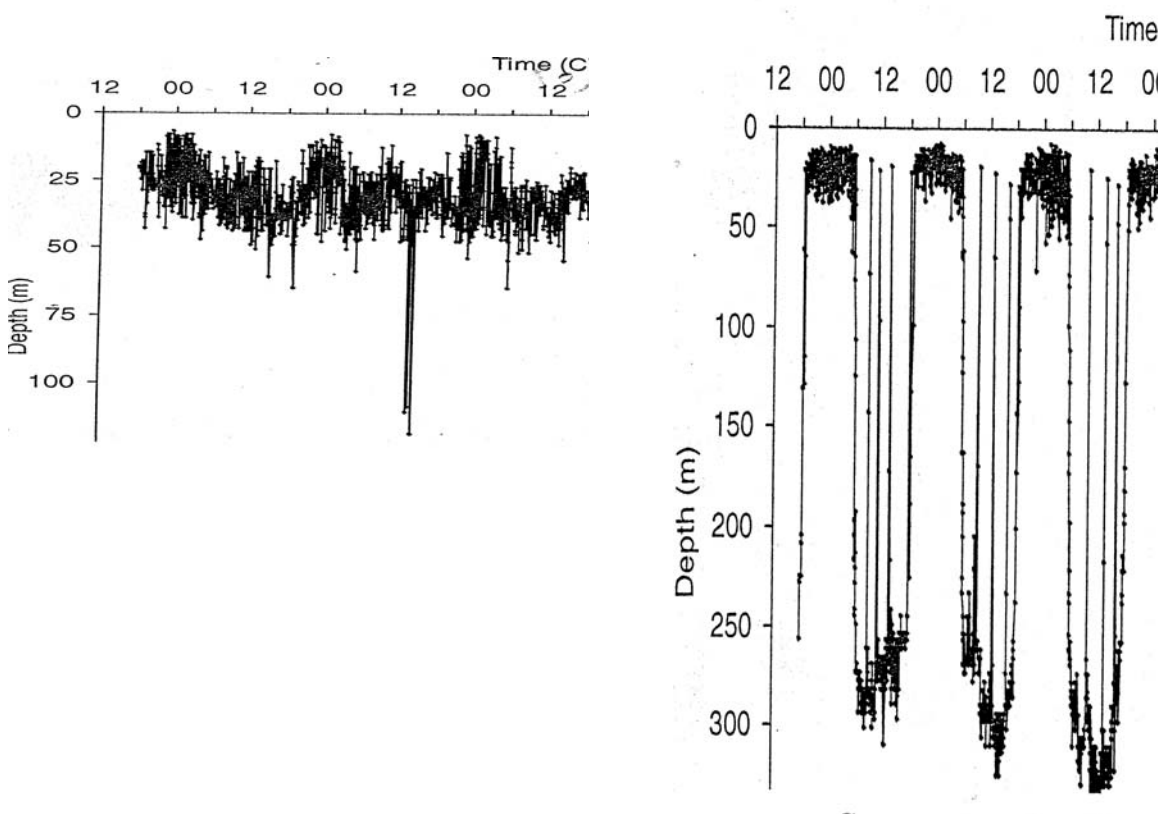



Figure 2: Vertical behaviour of bigeye tunas close to a FAD (no vertical movement, left) or in a free swimming schools right (typical vertical movement pattern) ( from K. Schaeffer)

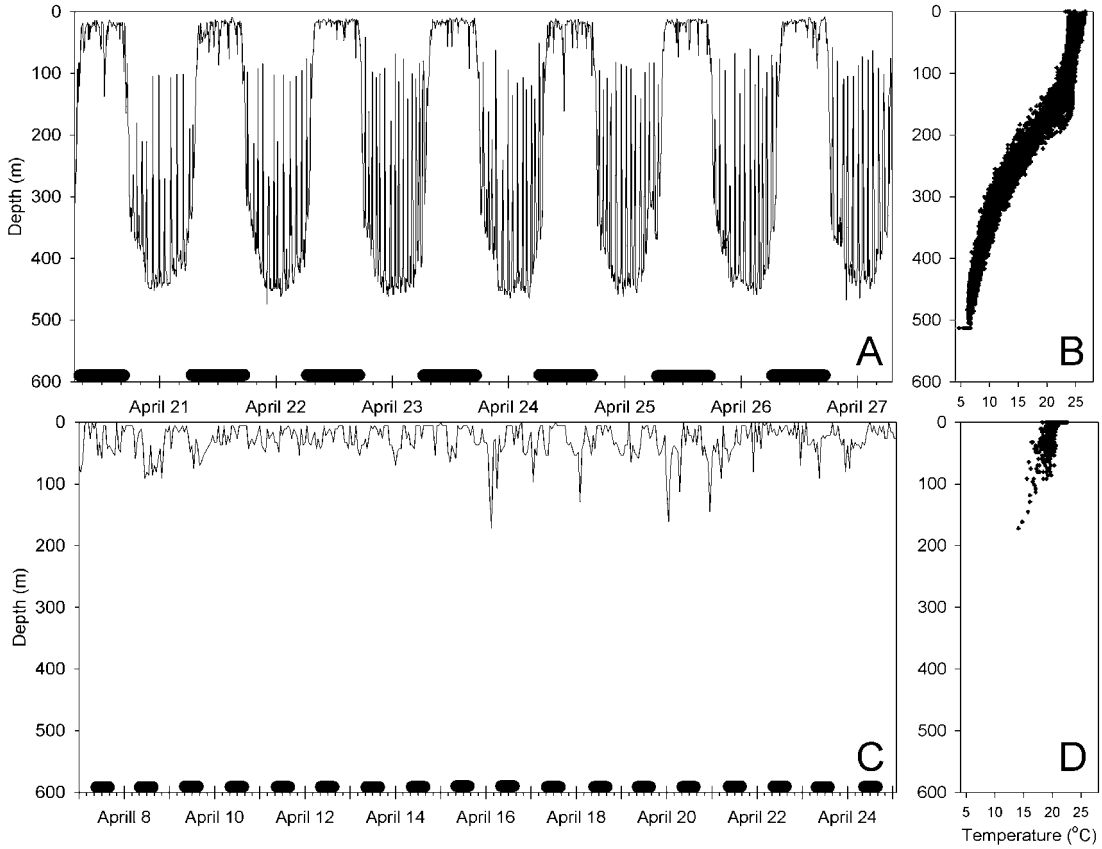



Figure 3: Comparison of the vertical behavior of a yellowfin (lower) and of a bigeye (upper figure) in the same habitat around Hawaii (Musyl 2005)

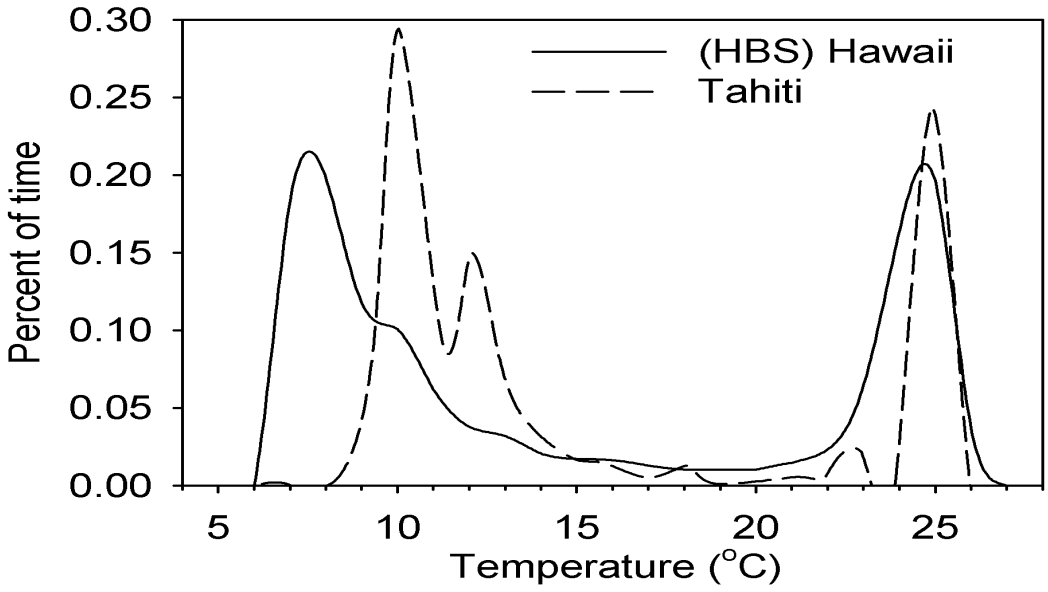



**Figure 4.** Observed bigeye tuna time-at-temperature data from Hawaii (Musyl et al. 2003) and Tahiti (Dagorn et al. 2000a). Each distribution is bimodal which reflects time spent in cooler, deeper waters during the day and warmer, shallower water at night. These data have been used to correct bigeye tuna CPUE in the deterministic"habitat based standardization" (HBS) method where effort is modeled as the joint probability of the effectiveness of the gear (the depths of longline hooks) and the distribution of the species in the water column.

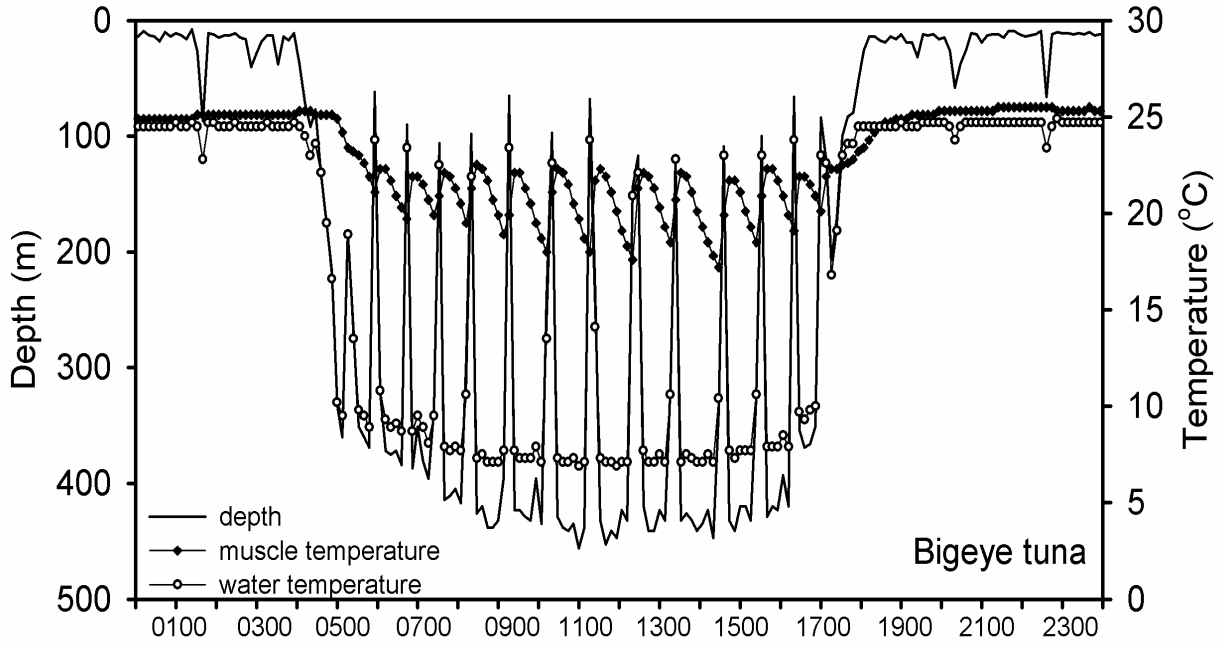
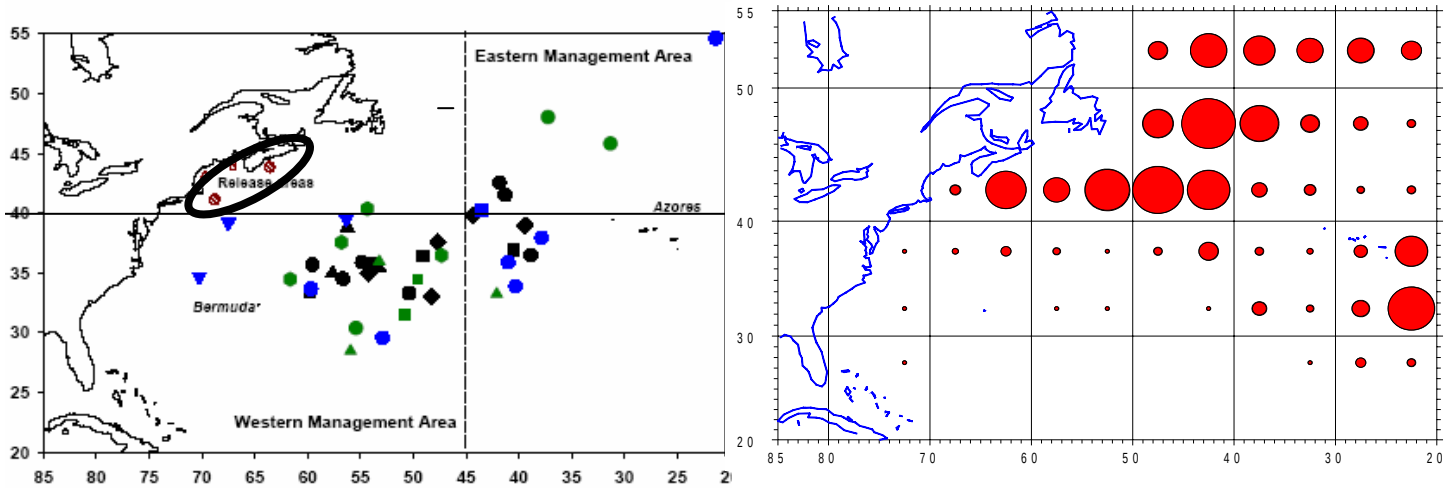



**Figure 5.** Twenty hour record of depth, body temperature, and water temperature for 45 kg bigeye tuna carrying an archival tag. Note that after the fish descends at sunrise, it makes regular upward excursions into the warm (.25E C) surface layer. In essence, the fish is returning to near the surface to get a "gulp" of heat in a way analogous to the way marine mammals return to the surface to get a "gulp" of air. By this behavior, the fish was able to maintain muscle temperature between .17-22EC, in spite of remaining for up to .45 minutes in water of . 5-7EC. (Figure is from Brill and Bushnell 2001). (figure and legend taken from Brill




Pop off locations

Average catches by fisheries 1990-2000

Figure 6: Pop up locations of electronic tags placed on giant bluefin tunas in the east coast of the USA: most of these releases were observed outside the common bluefin fishing zone shown on the right, average catches by longliners, and was not thought to be the bluefin habitat (Taken from Lutcavage 2000). These « strange » locations where still unknown in 1999 after 40 years of tagging programmes using dart tags.