AN ATLANTIC "BIGEYE TUNA YEAR PROGRAM"\textsuperscript{1}: WHY AND HOW?

Fonteneau, A.\textsuperscript{2}, P. Pallarés\textsuperscript{3}, D. Gascuel\textsuperscript{4}

SUMMARY

It is quite surprising to note that although the Atlantic bigeye fishery statistics have been excellent in the past, since the beginning of the fisheries (a unique situation worldwide), very little scientific research has been focused by ICCAT towards this species. This is very surprising, considering the very high value of the bigeye landings. The spectacular increase in bigeye catches during recent years, by both the purse seine and the longline fisheries, is putting a new and serious threat on the conservation of this highly valuable resource. Only an intensive and well coordinated ICCAT research program will allow the scientific community to determine if the present high catches of bigeye are sustainable, or if they drive this stock towards dangerous over-fishing. This large program should be aimed at much better knowledge of bigeye biology, stock structure, ecology and dynamics under increased exploitation rates. Considering the present very high value of the bigeye landings, this program would be a necessary investment in the context of the "responsible fisheries" even if the recommended research action may be quite expensive, primarily because of the lack of accumulated research on bigeye since the beginning of ICCAT.

RÉSUMÉ

Il est tout à fait surprenant de remarquer que, malgré les statistiques excellentes de la pêche du thon obèse dans le passé (ce qui constitue une situation unique dans le monde), cette espèce a fait l'objet de très peu de recherches scientifiques dans le cadre de l'ICCAT depuis le début de la pêche. Cela est d'autant plus surprenant au regard des valeurs très élevées des débarquements de thon obèse. L'augmentation spectaculaire des prises de thon obèse ces dernières années, aussi bien par les senneurs que par les palangriers, constitue une nouvelle et sérieuse menace pour la conservation de cette ressource extrêmement importante. Seul un programme de recherches intensif et bien coordonné dans le cadre de l'ICCAT permettra à la communauté scientifique de savoir si les captures actuellement élevées de thon obèse sont soutenables ou si elles conduiront ce stock vers une surpêche dangereuse. L'objectif de ce grand programme est de disposer de connaissances bien meilleure sur la biologie, la structure du stock, l'écoologie et la dynamique du thon obèse dans le cadre de taux d'exploitation croissants. En tant que donnée actuellement très élevée des débarquements de thon obèse, ce programme représente un investissement nécessaire dans le contexte de la "pêche responsable", même si les actions de recherche recommandées s'avèrent onéreuses, principalement du fait de l'absence de recherches menées sur le thon obèse depuis la création de l'ICCAT.

RESUMEN

Es bastante sorprendente observar que si bien las estadísticas de la pesquería de patudo atlántico han sido excelentes en el pasado, desde el inicio de las pesquerías (situación única en el mundo) ICCAT ha dedicado escasa investigación científica a esta especie. Considerando el gran valor de los desembarques de patudo esto resulta muy sorprendente. El espectacular aumento de las capturas de patudo en los últimos años, tanto en las pesquerías de cerco como en las de palangre, es una nueva y seria amenaza para la conservación de recurso de gran valor. Tan sólo un programa ICCAT de investigación, intensiva y bien coordinado, permitirá a la comunidad científica determinar si las importantes capturas de patudo actuales son sostenibles, o bien si están conduciendo a este stock a una sobrepesca peligrosa. Este amplio programa debería tener como objetivo llegar a conocer mucho mejor la biología del patudo, la estructura del stock, ecología y dinámica bajo una explotación en aumento. Considerando el alto precio que alcanza hoy día el patudo, este programa sería una inversión necesaria en el contexto de "pesquerías responsables", incluso si la investigación que se recomienda resulta bastante cara, sobre todo debido a las lagunas en la investigación sobre el patudo que se han ido acumulando desde los principios de ICCAT.

\textsuperscript{1} or BETYP.
\textsuperscript{2} ORSTOM. BP 5045, 34032 Montpellier, France.
\textsuperscript{3} IFO. Corazón de María 8, 28002 Madrid, España.
\textsuperscript{4} ENSAR Halieutique, 65 route de St Brieuc, 35042 Rennes, France.
1- INTRODUCTION

The ICCAT fishery data (Statistical Bulletin) well shows the recent spectacular increase of the bigeye yearly catches (figure 1). This species is presently fished in the entire Atlantic, predominantly in the intertropical areas, but also significantly in the temperate Northern and Southern Atlantic reaching 50°N et 40°S (figure 2). The total bigeye catches are in excess of 100,000 tons since 1994.

Since the late seventies, bigeye tuna is becoming a species of very high value on the sashimi market. This is perfectly well shown by the figure 3 which shows the price of various tuna species (yellowfin, bigeye and albacore), converted into dollars, for the sashimi Tokyo market: when bigeye was sold at the same price as yellowfin or albacore during the sixties (those three species being primarily used by canneries?), the average bigeye price is presently (1994) four times higher than the price of the two other species. This fundamental change in the fisheries was developed because of the deep freezing introduced on the longline fleet during the seventies. Then, a permanent increase of the longline fishing efforts targeting bigeye was observed worldwide and in the Atlantic. A subsequent slow but systematic increase of the longline catches was then observed in the Atlantic. The longliners were catching during recent years about 60% of the Atlantic bigeye catches. It appears now that the bigeye tuna catches are probably the most valuable among the other tuna stocks exploited in the Atlantic, primarily because of the sashimi price. Bigeye is only a secondary species for all the purse seine fisheries (catching 19% of the total bigeye catches, average 1984-1993), but it is quite an important species for various baitboat fisheries (in Dakar, Canary, Madeira or Azores Islands), this gear catching 21% of the total bigeye catches, average 1984-1993. A very spectacular increase of the bigeye catches by purse seiners was observed during recent years: this increase of the catches, most often small and medium bigeye, was observed in the traditional purse seine fishing zones. Part of those increased catches seems to be in relation with increased catches on artificial lures, but also due to other factors. The potential causes for those increased catches of bigeye by the purse seine and longline fisheries will then be reviewed.

The simultaneous spectacular increase of both the longline and surface catches may introduce a significant risk in the management and even the conservation of bigeye tuna: it is a general rule in fishery management that a very fast and uncontrolled increase of the catches is always (and by nature) dangerous, especially for a long living species like bigeye. The obvious risk is to have, during several years, catches which are excessive for the biological productivity of the stock, and then to produce an overfishing, potentially a dangerous recruitment overfishing. (This potential danger is similar to the dangerous condition of various bluefin stocks). The potential risk of overexploitation of the Atlantic bigeye stock will then be reviewed and discussed, based on the available knowledge and information upon the stock and the fisheries.

Unfortunately, it is quite obvious that the bigeye stock assessment is facing a critical lack of basic researches on the species: if the bigeye catch, effort and size statistics for the Atlantic bigeye are quite good for the last 15 years (this is not the case in various other oceans...), very little basic researches have been conducted under the ICCAT framework until now on the Atlantic bigeye (the exception being the recent thesis by Pereira 1995 on the Atlantic bigeye): surprisingly very little is known in the Atlantic on the bigeye natural mortality, its stock structure and migrations, its growth, its spawning, its ecology and ethology as a function of its age. It is thus a priority to immediately develop an intensive BETP in order to obtain all those basic informations. The possible framework for this BETP will then be examined and possible research priorities be discussed.

II-The increased bigeye catches by both surface and longline gears:

A significant increase of the bigeye catches was observed during recent years in both the longline (figure 4) and purse seine fisheries (figure 5). This increase of the bigeye catches is especially important for both fisheries in the medium size bigeye as it is well shown by the figure 6.

The reasons for the increased bigeye catches are quite different for the longline and surface fisheries as discussed thereafter.

Surface fisheries

The cases of the baitboat and purse seine fisheries must be distinguished:

Purse seine fisheries:

Bigeye is not really a primary target species for any purse seine fishery, but it is still a valuable species for
this gear: bigeye taken by purse seine was sold during recent years at about the same price as small yellowfin or large skipjack. However bigeye is most often (or always?) taken by purse seine in mixed schools in which bigeye is associated with skipjack and yellowfin. Those bigeye are most often of small sizes with an average weight of approximately 5 kg. The increase of bigeye catches by purse seine is not entirely well explained: one part of this increase is obviously due to increased catches on artificial logs by all purse seine fleets since 1990. As it is well known, the small and medium bigeye are always associated to floating logs (at least in the Atlantic...); consequently, any significant increase of this fishing technique (as observed recently in the eastern Atlantic) will increase the bigeye catches. However, it is also quite clear that significant catches of bigeye have been taken during recent years in the traditional fishing zone of the purse seiners, but in areas where bigeye tunas was not taken before. And as far as we know (from the log book data), those catches were obtained independently of floating logs. Those increased catches of bigeye are apparently linked to a better use of the sonar by the skippers, but this new fishing mode needs to be understood, in conjunction with other potential reasons. It should also be noticed that the average weight of bigeye taken by the purse seine during recent years was equal to approximately 5 kg, and corresponds to a large proportion of very small bigeye, but also to a significant proportion of medium size bigeye (Fialares and Fonteneau 1996).

Baitboat fisheries

Bigeye is significantly fished by various baitboat fisheries: the species is never a target species for the Tema fisheries catching a small proportion of small bigeye (average weight 2kg) associated with skipjack (and small yellowfin). However, medium size or large bigeye are a primary target species for various baitboat fleets operating in the northern temperate eastern Atlantic: in Mauritania (Dakar fleet, average weight of bigeye=10kg), in Madeira and Açores (Portugal) and in Canary Islands (Spain) (average weight of approximately 20 to 30 kg). The yearly catches of those baitboat fleets show moderate fluctuation at a high level, but no major increasing trend during recent years (figure 7) in comparison with purse seine; their recent catches is quite high, especially in Canary Islands and in the French baitboat fishery based in Dakar, probably in relation with the new fishing technique developed (Fonteneau and Diouf 1994) during recent years by the baitboat fisheries in those two areas.

Longline fisheries

As it was previously explained, bigeye is now economically, in terms of the value of the catch, the first tuna species for the longline fisheries, because of the large quantities of fish caught, and because of the high nominal value of this species (see figure 3 showing the relative price per kg of yellowfin, albacore and bigeye). Most major longline fleets in the Atlantic are now primarily targeting bigeye: bigeye was already a major target species for the Japanese longline fleet since the mid seventies, as is well shown by the figure 8 (value of the longline catches by species). This targeting of the longline fishing effort towards bigeye has also been linked to the development (mid seventies) of the deep longline, a gear specifically adapted to fish bigeye more efficiently. It is now economically becoming a major target species for the Taiwanese longline fleet as shown by figure 9. The Korean longline fleet, recently at a low level, was also primarily targeting bigeye instead of yellowfin, during its last years of intensive fishing operation e.g. since 1978(bigeye being the major species in terms of its value since 1980, see figure 10). The recent increase of the longline catches, primarily due to the Taiwanese fleet (the Japanese longline keeping a quite stable level), is well explained by the high value of the bigeye catches on the sashimi market. The average size of bigeye taken by longline is always high, close to an average 45kg.

III-Why a bigeye program? What is the present risk of overfishing the bigeye stock?

The analysis of the relationship between the yearly bigeye catches and the corresponding estimated effective effort seems of key importance (1) to provide a comprehensive view of the past history of the bigeye exploitation and (2) to discuss its future condition.

The estimation of bigeye effective effort:

The effective effort in the bigeye fishery is traditionally estimated in an indirect way, dividing the total catches by an index of abundance of the adult stock, calculated by the Japanese longline cpue (a GLM index corrected for deep longline during recent year, SCRS report 1995). Even if this index of effort appears to be quite consistent, the very indirect nature of this index of effort should always be kept in mind.

An overview of bigeye past exploitation:

The past exploitation of the Atlantic bigeye stock (figure 11) can be summarized as follows:
Period before 1960: a virgin stock (more or less)

Period 1961-1968: a 1st equilibrium: low effort & low catch (30,000t), primarily by longliners

Early seventies 1969-1974: a 2nd equilibrium: moderate increase of the fishing effort by surface and longline fisheries & catches already reaching about 50,000t.

Period 1975-1992: systematic and rapid introduction of the deep longline (targeting on large bigeye) and development of purse seine and Tema baitboat fisheries catching small bigeye. A 3rd equilibrium of catches, with large increase of the effective fishing efforts followed by a moderate increase of the bigeye catches. The expected negative effect of the massive catches of small bigeye by the purse seine on the longline yield is not apparent... This lack of effects in the 1/K was primarily due to the relatively small fishing mortalities exerted on juvenile bigeye during this period (the estimated F was quite low because a high natural M of .8 was used in the VPA).

Period 1993-1994: A spectacular increase of the bigeye equilibrium effects and of the bigeye catches on both juveniles (purse seine) and adults (longline). This present situation of the stock and fisheries is not an equilibrium (as bigeye is exploited during approximately 8 years), and it is unknown if this level of high catches can be sustained. A general comment at this stage is that it is always dangerous to increase so rapidly the catches of juveniles, especially for a long living species such as bigeye, as these increased catches may not be sustainable and may, a few years later, produce a long and irreversible recruitment overfishing (as is well shown by the southern bluefin tuna).

What equilibrium?
The production model adjusted to this catch and effort relationship allows to estimate the possible equilibrium curves corresponding to those observed yearly catches and efforts; various equilibrium models can be fitted to those data, among others:

* the Exponential production curve, assuming a m=1.0 in the generalized production model. This equilibrium curve is most often found for tropical tunas, probably because the recruitment shows some stability for those stocks, even at relatively high exploitation rates.

* the Hyperbolic curve, at m approaching 0.0, assuming that the equilibrium yield will be permanently increased by increased fishing mortalities. This fit is often the best fit for tuna stocks, but is quite unrealistic biologically.

* the Schaefer model, with m=2.0, assuming a decreased equilibrium catch, when F is greater than the Fopt (MSY). This model is probably too pessimistic for tropical tunas and in fact has never been observed for any tropical tuna, probably because of the biological peculiarities of those oceanic species.

Possible changes in the yield per recruit:
This general overview of the catch and effort relationship does not take into account the possible changes in the yield per recruit of the fisheries. It is quite clear that significant changes of the global fishing pattern of the bigeye fishery occurred during recent years. However the multi gear yield per recruit analysis presently conducted (Pereira) on the fishery does not allow to conclude firmly on the levels or trends of those potential changes, primarily because of the multiple uncertainties in this analysis. One of the worse uncertainty in this yield per recruit is related to the natural mortality of the juveniles: if the M of juveniles is very high, the yield per recruit may have increased during recent years; the opposite is true (decrease of the yield per recruit) if the M for juvenile is moderate or low. Those potential changes of the yield per recruit are not handled by the production model, but they should be kept in mind in the interpretation of the figure 11.

What future for the bigeye stock and fisheries?
Based on the observed catch and effort relationship and those potential equilibrium productivities of the bigeye stock, various hypothesis can be developed concerning the future status of the Atlantic bigeye stock:

(a) In the exponential model (m=1.0), if the Effort is kept at the 1994-1995 levels, status quo of the fisheries, the catches should decrease quickly and should reach the equilibrium curve corresponding to this high effective effort (probably a yield close to 60,000t?); a duration of 4 to 5 years would be necessary to reach this equilibrium. This situation would correspond to a sustained overfishing, with fishing mortalities well in excess of the MSY. The biological sustainability of this overfishing is unknown.

(b) The stock collapse hypothesis: The hypothesis of a recruitment overfishing due to a too low spawning biomass may still be a valid one, even when the recruitment appears to be quite stable until now. This hypothesis cannot be eliminated, even if it seems to have a low probability for bigeye (because of its tropical biology), because the reduction of the bigeye spawning stock due to the 91-95 high
catches of immature bigeye will be seen in the spawning stock only within a few years. The spawning stock and the recruitment of bigeye should then be monitored carefully.

(c) A reasonable management would probably be to reduce the effort to its previous 1984-1992 levels (MSY), as those levels are proven to be safe in the past. If the effort was limited to its level observed during the period 84-92, a low catch at about 40 to 50.000t could be expected in the short term. A duration of about 5 years would be necessary to go back to the MSY at approximately 70.000 tons. A general comment is that this low catch is the price to pay for the 91-94 overexploitation, even without recruitment overfishing! However this recommendation relative to the "fishing effort" may be quite unrealistic in term of practical management, because of the poorly known relationship between the nominal and effective efforts upon bigeye (for both the surface and the longline fisheries).

(d) the bigeye catches may also stay at the high 1994 level (or higher?); this optimistic hypothesis could be valid if a new fraction of bigeye was recently becoming available to the fisheries or if the present yield per recruit was improved by the recent changes of the fishing patterns. Such phenomenon has been often seen in the tuna fisheries; the subsequent error to conclude that an increased catch of the tuna fisheries was not sustainable has often been done world wide by various scientists and tuna bodies (including the ICCAT). An alternative hypothesis explaining this sustained increase of the catches could also be linked to a change of the environmental regime, temporarily producing an increase of the bigeye recruitment. However, as the bigeye fishing zones, sizes taken and fishing depth of each gear were stable during recent years, the probability that this high bigeye can be sustained catch seems low.

It is unfortunately very difficult or impossible to exactly answer any of those questions now. The major and fundamental reason is that very few researches have been conducted until now on the Atlantic bigeye: major uncertainties remain on the species at various levels such as its biology, its stock structure and migrations, its dynamics and the potential interactions between fisheries, its relationship with the environment, the association between bigeye and logs, etc... It is very surprising that a species with a very high economical value such as bigeye tuna, has received until now so little attention by the scientific community, and so little funding for its research. As the Atlantic bigeye stock may now face a serious conservation problem, it is obviously time now for the ICCAT and its member countries to immediately develop a well structured and complete international bigeye research program. This program should be coordinated with other similar bigeye research programs world wide, as the problems faced by the Atlantic bigeye are also encountered world wide.

IV- HOW A BETYP?
The bigeye program should primarily be based on two types of intensive at sea activities, the first one with a large tagging program, the second one with a large program of observers on board of both the surface and longline fleets (doing detailed observations on the bigeye fisheries and collecting biological samples of bigeye tuna). The major uncertainties concerning the Atlantic bigeye which are of key importance in its assessment, and the corresponding necessary research actions, can be summarized as follows:

1) Statistics: improved catch statistics of small bigeye would improve the quality of most potential analysis, even if this problem has been relatively well handled since the late seventies in the Atlantic ocean; an active statistical research should be developed to improve the bigeye data processing (species composition and sizes) on all fleets catching bigeye (this problem is partly covered by the ongoing "BT" program on the European Union purse seinest seinse fleet (Pallares and Norstrom 1996).)

2) Index of age specific abundance for a large range of sizes and ages: those indices are necessary in order to efficiently tune the VPA. They are not presently available, primarily due to lack of intensive studies on this problem. This work should target in two directions: first the collection of data obtained by observers and second the use of ad hoc statistical analysis, such as GLM indices taking into account the factors which will be proven to be important for the fishing efficiency on bigeye. Monitoring of the recruitment levels would be a first priority: until now, the recruitment levels in the bigeye stock seems to be quite stable (at least from the VPA analysis...). However it would be critical to be able to estimate a relative index of bigeye recruitment (This index could probably be calculated from the purse seine data using detailed observation and an ad hoc GLM method).

3) Stock structure: the bigeye stock structure remains seriously unknown; a single stock hypothesis is used by the SCRS, but there may well be a significant segregation between two Northern and Southern components of the adult stock (similar to the albacore, see figure 12). This N-S heterogeneity of the adult populations and the
relationship between the various geographical components of the bigeye stock (see fig. ) should then be evaluated by direct methods (such as tagging) and by indirect methods (such as genetics). A large tagging program of both juvenile (Tema baitboat), preadult (Bakar baitboat) and adult bigeye (spawners, by longline and BPS spawners by northern baitboat) will be a necessary and key component of the BETYP. This large tagging program needs to be carefully planned and well designed. The genetic study should be based on a significant sampling covering all the major fishing zones (see figure 2) and should cover small individuals from the equatorial nursery and adults from the various component of the Northern and Southern fishing zones.

4) Growth: the growth of bigeye is fairly well known only for the juvenile bigeye, primarily from a few tagging and recovery data; other methods should be used in a wide variety of ages in order to estimate the growth of bigeye at all ages (average growth and its variability) from the age at recruitment in the purse seine and baitboat fisheries to the longline fisheries on adults (as the adult catches are a key component in the bigeye fishery).

5) Age specific natural mortality: the age specific mortality of juvenile bigeye is a key uncertainty in all the age specific analysis: if the mortality for juvenile is low (for instance M=0.4) or high (for instance M=0.8 or higher), the number of small bigeye in the ocean may be very different (large numbers for high M, low numbers for low M). Subsequently the fishing mortality rates calculated by VPA and all their future uses (Yield per recruit, projections, interaction between surface and longline fisheries, etc.) are also closely linked to this Natural Mortality of juvenile. An ad hoc biological research program should then be elaborated in order to better estimate this juvenile M and/or the real absolute numbers of bigeye in the nursery area. At least the equatorial of the analysis to this major biological uncertainty should be estimated.

6) Reproductive biology: very little is known on the reproductive biology of bigeye. When this basic parameter remain of key importance to estimate the relative spawning biomass of the stock (potentially a key parameter in its conservation). A significant sampling of the spawning bigeye should then be conducted on longline in the strata of potential bigeye spawning (North and south of the equator) for the analysis of the reproductive biology of bigeye.

7) Association with floating logs: the small and medium size bigeye are often associated with floating logs. It appears that the increasing use of the artificial logs by the purse seine fleet is a key factor explaining the recent increase of bigeye catches by the purse seine. This fishery could potentially provide a reasonable index of bigeye recruitment based on the catch per set under log. A comprehensive study of this association should then be conducted.

8) Increase of fishing power on bigeye by the purse seine fleets: it appears that the purse seine fleets are now using new methods to catch more bigeye independently of floating logs. This new behavior of the purse seine fleet should then be evaluated in detail (for instance by observer program) and taken into account in the analysis.

9) Modeling the bigeye exploitation: further improvement of the standard stock assessment models are necessary in order to adjust their behavior to the biological peculiarities of the bigeye. These guidelines are only a shopping list of the most important research topics that should be part of the BETYP. The more detailed program should be discussed by the SCR, its potential cost evaluated and submitted to the Commission.

BETYP: a necessary investment

Taken into consideration (1) the very high value of the bigeye catches, approximately 500 millions of US dollars yearly (see figure 11), (2) the absence of any significant research program on the Atlantic bigeye, and (3) the serious conservation problem presently faced by the bigeye stock, the funding of the BETYP program by the ICCAT at a reasonably high level (for instance at 5% of a yearly catch, i.e. 2.5 millions of $) is now a necessity for an International Commission like the ICCAT, which adopted recently the principles of responsible fisheries. A collapse of the stock in the coming years (for instance due to a severe recruitment overfishing, as seen for southern bluefin tuna), is probably now a real risk. This potential collapse would have a long term economical cost which could potentially be in the long run ten to one hundred times higher!!.

V-Conclusion

The BETYP is clearly becoming an obligation for the ICCAT and its member countries involved in the bigeye fisheries: there is presently a serious potential risk of overexploitation, the bigeye stock, possibly a risk of conservation, due to the fast and uncontrolled increase of bigeye catches. It is thus now a responsibility for each ICCAT fishing nation to conduct, immediately and under an ad hoc ICCAT research program, all the basic researches which are fundamental to manage this stock. The major
Responsibilities are equally shared between the two gears, purse seine and longline, which are primarily responsible of the present increase of catches. Those researches should cover all the bigeye fisheries, from the tropical juveniles taken by surface gears, to the adults taken by the longline in various locations between 50°N and S. If this research program cannot be conducted, for instance because of a lack of funding, the precautionary principle should then immediately lead to take important management measures in order to drastically reduce the present bigeye catches, by both the surface and longline fisheries, because of the high risk probably linked with those sustained high catches.

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Figure 1: Yearly landings of bigeye by gear in the Atlantic, fig. 1a surface area and 1b line for each gear (LL=longline, BB=baithook, PS=purse seine).

NB: These figures are redundant, but each one shows a different and complementary view upon the bigeye fisheries: fig. 1a on the global trend of the bigeye fisheries and 1b on the trends by gear.
Figure 2: Average fishing map of the bigeye catches by gear in the Atlantic (period 1989-1993). (Lt=longline, Bb-baitboat, Ps=purse seine).

Figure 3: Average yearly value of longline tuna by species for the Tokyo market (in yen, without correction for the inflation). (YFT-yellowfin, BET=bigeye, ALB=swordfish, GER=albacore or sarmon in French).

Figure 4: Bigeye yearly catches of the longline fisheries in the Atlantic ocean.

Figure 5: Bigeye yearly catches of the purse seine fisheries in the Atlantic ocean.
Figure 6: Bigeye catches by weight categories for the purse seine, baitboat and longline fisheries.
Cat 1 = <7kg
Cat 2 = 7 to 20 kg
Cat 3 = >20kg
(LL=longline, BB=baitboat, PS= purse seine).

Figure 7: Bigeye yearly catches of the various baitboat fisheries in the Atlantic ocean.

Figure 8: Yearly catches by species (yellowfin, bigeye and albacore) in tons (ICCAT Statistical Bulletin) and in value (US dollars) estimated by the product of the yearly catches and the landing values of figure 2, for the Japanese longliners.
(YFT=yellowfin, BET= bigeye, AK= albacore or mercon in french)
Figure 9: Yearly catches by species (yellowfin, bigeye and albacore) in tons (ICCAT Statistical Bulletin) and in value (US dollars) estimated by the product of the yearly catches and the landing values of figure 2, for the Taiwanese longliners.
(YFT=yellowfin, BET= bigeye, GE= albacore or germon in french)

Figure 10: Yearly catches by species (yellowfin, bigeye and albacore) in tons (ICCAT Statistical Bulletin) and in value (US dollars) estimated by the product of the yearly catches and the landing values of figure 2, for the Korean longliners.
(YFT=yellowfin, BET= bigeye, GE= albacore or germon in french)
Figure 11: An annotated production model for bigeye: observed relationship between catch and effort, and possible equilibrium productivities of the stock.

1. Observed relationship between bigeye catches and effective fishing effort.
2. Potential equilibrium curves estimated by the PRODFF model.
3. Comments on the potential future catches of the bigeye fisheries.

Figure 12: A summarized overview of the hypothetical nursery, feeding zones and spawning zones for the bigeye (Taken from Pelizares & Fontanes).

Figure 13: Estimated value of the bigeye catch taken by gear during 1994.
(LL=longline, BB=baithook, PS=purse seine).

BETlanding value 1994 = 600 millions $