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AN OVERVIEW ON THE USE OF PRECAUTIONARY APPROACH AND TUNA MANAGEMENT

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SUMMARY

This paper develops a critical overview of the various problems and uncertainties faced in tuna stock assessment, management and conservation. This presentation is based on Atlantic tunas, but also on various tuna stocks worldwide. Tuna fisheries management is characterized by major uncertainties in the stock assessment; since these stock assessments are always done only on fishery data which are often biased. Fortunately most tuna stocks are showing a strong resistance to overfishing. These major characteristics of tuna stocks and fisheries, and the bias in the scientific analysis, are presented and discussed. As a result, many of the reference point recommended for the precautionary approach applied to fisheries are often quite inappropriate for tuna stocks and fisheries. It is quite clear however that the precautionary approach could help to manage and to conserve tuna stocks, primarily because of these large uncertainties in most stock assessments. This precautionary management policy should carefully evaluate the risk of taking measures which are unnecessary in terms of stock conservation, and which could have deleterious effects on the fishery economy. Precautionary management should be based primarily on reference indices which are neutral and unbiased, giving little weight for instance to sequential population analysis results (too often biased), and more importance to strong selected indices such as sizes taken, size of the areas fished versus size of their habitat, trend of catches, etc?.

RÉSUMÉ

Cet article fait un bilan critique des divers problèmes et incertitudes dans l'évaluation des stocks de thons et dans leur gestion. Cette réflexion se fonde sur les thons de l'Atlantique, mais elle prend aussi en considération divers autres stocks de thons mondiaux. La gestion des stocks de thons se caractérise par des incertitudes majeures dans les évaluations, principalement du fait que les évaluations reposent presque exclusivement sur des indices issus des pêcheries qui sont souvent biaisés. Fort heureusement, la plupart des stocks de thons montrent une forte résistance à la surexploitation. Les principales caractéristiques

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biologiques des thons et des pêcheries qui les exploitent sont présentées et discutées. En conséquence de ces problèmes, beaucoup des points de référence qui sont classiquement recommandés dans l?approche de précaution appliquée aux pêches sont de fait assez inappropriées pour gérer les stocks de thons et les pêcheries thonières. Il reste clair toutefois que l?approche de précaution reste souhaitable pour aménager et conserver les stocks de thons, principalement du fait qu'il existe de grandes incertitudes dans la plupart des évaluations. Cette politique de gestion selon selon l'approche de précaution devra aussi bien tenir compte du risque de prendre des mesures inutiles en terme de conservation mais qui peuvent avoir des effets très négatifs sur l?économie du secteur thonier. Cette approche de précaution devrait être basée en priorité sur des indices robustes et non biaisés, et donner par exemple peu de poids relatif aux résultts des analyses séquentielles des populations (trop souvent biaisés), et une forte pondérations aux tendances des tailles, celles des surfaces exploitées et de l'habitat du stock, la tendance des prises, etc?

RESUMEN

Este documento realiza una revisión crítica de los diversos problemas e incertidumbres que se encuentran en la evaluación de los stocks de túnidos y su gestión. Esta presentación se basa sobre los túnidos atlánticos, pero también tiene en cuenta otros stocks diversos de túnidos a nivel mundial. La gestión de los stocks de túnidos se caracteriza por las importantes incertidumbres existentes en las evaluaciones de stock, debido principalmente al hecho de que éstas descansan casi únicamente sobre datos de pesquerías que frecuentemente están sesgados. Afortunadamente, la mayor parte de los stocks de túnidos muestran una fuerte resistencia a la sobrepesca. Se presentan y debaten las principales características biológicas de los túnidos y de las pesquerías que los explotan. Como consecuencia de estos problemas, muchos de los puntos de referencia que de forma clásica se recomiendan en el enfoque precautorio, aplicados a la pesca, resultan bastante inadecuados para gestionar los stocks de túnidos y sus pesquerías. Sin embargo, queda claro que el enfoque precautorio sigue siendo válido a la hora de gestionar y conservar los stocks de túnidos, debido principalmente a la existencia de grandes incertidumbres en la mayor parte de las evaluaciones de stock. Esta política de gestión debería valorar cuidadosamente el riesgo de tomar medidas inútiles en términos de conservación, pero que pueden tener efectos muy negativos sobre la economía del sector atunero. Este enfoque de precaución debería basarse principalmente en índices sólidos y no sesgados, y dar, por ejemplo, un escaso peso a los resultados de los análisis de población secuencial (sesgados, con demasiada frecuencia) y una mayor importancia a las tendencias de las tallas, el tamaño de las superficies explotadas y el área del hábitat del stock, la tendencia de las capturas, etc.

Key words
Tunas, precautionay approach, Atlantic, management, assessment

1-Introduction : Precautionary approach & highly migratory species and fisheries

Following the principle of precautionary approach, pre-emptive actions should be taken when there is a **risk of severe or irreversible damage to the resources**. In this new context, the lack of full scientific certainties (often the case for tunas..) should not be used as a reason for postponing effective measures [FAO, 1995 #857]. This concept is now increasingly accepted by most of the fisheries management committees, including those targeting migratory species. The exploited fish resources should be managed with precaution and **kept for future generations** (principle of inter generation equity, [FAO, 1995 #857]).

However, too much precaution could easily lead, without biological reasons, to an economic chaos and collapse of sustainable fisheries, industries and markets. A good a posteriori case study of this risk was given by some tuna fisheries, for which a sharp drop was observed world wide in most of the longline cpues. This drop was then interpreted as a decline of the stock. It appears now that this decline was not at all proportional to the decline of the tuna or billfishes biomasses. A precautionary management based on these historical longline cpues would have frozen the world tuna fisheries at its 1965-70 levels at about 1 million tons, although tuna catches reached over 4 million tons in the 90?s, and appeared quite stable and most of them sustainable (Fonteneau 1997).

It is now also quite clear for most tuna experts that the precautionary measures and reference points recommended for coastal fisheries (both demersal and pelagic) may be quite often inappropriate for highly migratory stocks.

The goal of this paper is to discuss the various peculiarities of tuna stocks and fisheries, and to discuss some recommendations on the implementation of this precautionary approach for highly migratory species such as tunas and billfishes.

2- Uncertainties related to tuna stocks

2-1- Measurement uncertainties

All stock assessments done on tuna are mainly based on fisheries data[1]: tuna schools are too rare, too deep and too difficult to be observed by scientific gears (as it is commonly done for most coastal resources).

Total catches are a major component in stock assessment analysis. Unfortunately they are often biased in many fisheries (especially for stocks under quotas, such as SWO and BFT) because of under-reporting catches taken under flags of convenience.

Ageing problems: the ageing used for sequential population analysis is primarily based on sizes caught and slicing of size distribution. However, there are **important uncertainties with the ageing of large tunas**. These ageing problems are faced for most large species: yellowfin, albacore, bluefin, bigeye, billfishes. These ageing problem are even worse for species showing many year classes in the fisheries (such as BFT, for individuals older than 6 years, see e.g. Farrugio, 1981, or SBT). Alternative statistical methods, such as MULTIFAN have also been used for tunas (Majkowski 199) but the real age composition of large tunas catches remain fairly difficult to estimate, even using this type of models (cf SBT uncertainties). These uncertainties are known to introduce **severe potential biases in the results of the VPA analyses** (Lowestoft report, 1998).

Increased catchabilities (at unknown rate). A tremendous increase of the fishing efficiency which was observed world wide for most tuna fisheries was due to multiple factors, such as improvement of fishing and searching technology, improved cooperation between fishers, better choice of their fishing strata, etc.: This increase of efficiency remains poorly estimated by scientists and is probably most often underestimated. This bias can have deleterious effects on any subsequent ASP, primarily because most tuned sequential population analysis will misinterpret this increased efficiency, as an increase of stock size and as an increased recruitment.

Unknown discards of tunas, especially at small sizes.

Bias in the local cpue when local F is high or low: a cpue can be correctly interpreted **only when the <u>total effort</u>** in the area is known and used in the model used to estimate the abundance.

Bias in the longline initial cpues: the fast and sharp decrease of most longline cpue (yellowfin, billfishes, bluefin, bigeye, etc..) remains poorly understood but was clearly quite independent of any decrease in the whole population. The further development of the fisheries have shown that most of these stocks were in fact under-exploited .

As a final result most of the stock parameters obtained by tuna fisheries tend to provide biased indices, and ?**out of focus**? reference points on the stocks status.

2-2- Uncertainties in stock assessment models

Unknown **stock recruitment relationships** for most tuna stocks (but most tunas stocks world wide are resilient until now...)

Low **variability of recruitment** for most tropical tunas within a large range of spawning sizes, but recruitment and MSY appear to be quite variable for various temperate species (albacore, bluefin)

Stock structure is most often poorly known, primarily because of lack of data. The effects of this type of errors are very difficult to estimate (e.g. the North Atlantic BFT: if transatlantic migration is significant, the 2 stock hypothesis may lead to poor management of the BFT stocks). More generally, migrations are poorly taken into account by most models (analytical or global).

There is still in most tuna stock assessment models, serious and poorly studied **uncertainties on the forms of the functional relationships** and of the basic assumptions. For instance the choice between a Schaeffer[2] vs a Fox production model, equilibrium approximation and non equilibrium models, are still facing very large uncertainties in their results, especially at high exploitation rates (F>Fmax) and over MSY. Tuning methods in the production model are often producing misleading results (cf some biased results obtained from ASPIC model, Prager 1994, cf Fonteneau et al 1998).

Error in the M estimates: **M of young and old tunas** remains very uncertain. For the moment, tuna stock assessment mostly uses constant M for all ages, whereas it is likely that young tunas have higher M than older ones; see the estimates of M of the Southern bluefin tuna from an extensive tagging experiment which revealed a M for young stages around 0.49 and for the older fish around 0.1. Very high natural mortalities of juvenile tunas were also recently estimated for tropical tunas by SPC scientists (from tagging data)..

Complex stock structure which is not handled in the present sequential population analysis.

Severe biases in tuning indices, because of (i) changes in gear-technology and tactics, (ii) changes in vessels cooperation and competition, (iii) changes in ages targeted, (iv) the expansion of the fishing area (v) the fact that unsuccessful efforts are rarely taken into account (see SCRS 1999).

2-3-Other sources of uncertainty

Effects of the environment poorly known: the possible effects of regime changes on the tuna productivity has been analyzed for the first time very recently (see, e.g. [Maury, 1998; Lehodey, 1997, Santiago 1998].

Unknown risk of **genetic erosion**. Genetic erosion has not yet been demonstrated for any tuna stock.

However, such a process could be a reasonable hypothesis for various tuna stocks showing a homing behavior and precise spawning strata which are heavily fished (such as BFT). This risk of genetic erosion could have irreversible consequences in case of severe local overfishing. This potential risk of irreversible damage could be a case study for precautionary management.

As a final result, the fishing mortality and biomass levels, and all reference points obtained on tunas from sequential population analysis such as spawning stock size, numbers of recruits, exploitation rates, etc..) , can be very often doubtful or misleading, even in relative terms.

The peculiar position of the ?frontier fisheries? located at the periphery of the habitat are difficult to handle: they are more sensitive to the environment variability and to the abundance level of stocks. However these peculiar characteristics are most often not taken into account in the analysis, nor well studied and understood. .

2-4-Cascading & additive uncertainties of types 1 to 3

All these errors in the data and models have cumulative and **cascading negative effects**. The real uncertainties in the results and subsequently in the projections, are much larger than the statistical uncertainties estimated by any bootstrapping (only a minor part of the uncertainties are indeed incorporated in the models). One may thus get the impression that stock sizes (at age) and fishing mortality rates are known with a reasonable uncertainty, when this is unfortunately not at all the case! Even the population size estimated from the convergent part of the sequential population analysis do not necessarily represent the true biomass of those past years (see e.g. Sinclair & al 1990, Fonteneau and al. 1998). These multiple independent or additive causes can explain the major potential errors in past tuna sequential population analysis.

Only retrospective analysis done several years later can detect some of the past errors, but not all. For instance, it is difficult or impossible to demonstrate that an historical underestimation of recruitment has occurred.

2-5- Shrinking basins?

There are various examples in fishery science that the increasing exploitation rate and overfishing may lead to a **shrinking of the area of distribution** (basin). This was, for instance well shown, for various small pelagic stocks (North Sea herring). If this kind of process also applies for tuna, even a moderate decline in the tuna biomass could produce a shrinking of the distribution area, and a collapse of the fisheries located in the range of the periphery of the distribution. Such a phenomenon could for instance explain the severe decrease of yellowfin cpues of surface fleets in Senegal and Angola+Cap Lopez areas, which was observed during recent years.

This potential problem should be better studied and taken into account in a context of precautionary management (even keeping in mind that this type of changes is probably reversible).

2-6- Local overfishing versus global underexploitation

Tuna basins are most often very large and tuna stocks are quite ?viscous? (MacCall 1990). Then **local overfishing** can be observed, with spectacular decrease of the local biomass and local cpue, when the **stocks are still underexploited**.

This characteristic is typical of tropical tuna stocks because of their large distribution area and low catchability. This may lead to two types of problems:

A false impression that a stock is overfished because CPUE are mostly local.

A real danger of overfishing in the spawning area, when the species displays a seasonal homing behavior during which adults are easily caught (see the North Atlantic BFT case). This situation may produce a potential high total fishing mortality within a small area, and possibly a local exploitation rate of 100%.

Multiple biological parameters will determine how much a tuna stock will be ?viscous" (Mac Call concept) and **how much the local and global exploitation rates** will be related. Such factors are for instance:

The size and shape of the oceanic basin in which the stock is distributed,

Its vertical heterogeneity and movement patterns. It is quite striking to see that most tuna species, for instance large yellowfin or bigeye, clearly do show a vertical viscosity.

Movement patterns: rate of advection and diffusion.

These biological characteristics are a key component to explain how local cpue and local catches can be representative of the entire stock.

3-Tuna precautionary approach and environment impact

More precaution should be given to the potential impact of tuna fisheries on the ecosystem, for instance on **the by-catches** and the potential environmental threats due to this accidental mortality.

Each fishery could be characterized permanently (by gear & by area) by **various reference points** concerning their potential environmental impact, for instance:

% of undersized catches caught and dumped

% of dumping of selected non target and sensitive species (for instance protected species, such as sharks, turtles, birds, mammals, etc..). Significant rates of observers are clearly necessary to get data on these dumpings.

Size of the area fished. The areas fished by tuna fisheries are often large or very large (90 millions of km2 are fished in the Atlantic!), and this large size of the ecosystem can be a positive factor reducing the negative impact of by-catches and dumping.

_. Others?

Observer programs are the only way to obtain this type of information on by-catches. In the new context of responsible fishery and of precautionary approach, such **scientific observers programs should be conducted permanently on all major tuna fleets**, with special emphasis given on gears which are known to show large potential by-catches. A quite small rate of **10% of observers** could probably be a reasonable minimum sampling rate (which should allow a good follow up of most by-catches, if these data are processed using log book data).

Those reference points should be **permanently maintained** and they could be used as auxiliary management tools. These reference points should be specific of each gear and of each ecosystem, because by-catches are dependent of the gear used and of the ecosystem fished.

4- Poor data and unreliable analysis: the n precautionary TAC

The ICES ACFM has concluded that, when sequential population analysis cannot be conducted, then precautionary TAC or reference points based on past fishery yields or empirical approaches (Caddy, 1998) should be established in the meantime to limit F and any risk of overfishing. This type of precautionary TAC could allow an efficient precautionary management of all tuna stocks for which the available data and analysis are poor. Tuna fisheries should be managed more carefully when poor data do not allow to estimate reasonably well the stock size trends and levels. Each stock assessment could be rated in a binary way, as ?**poor**? or ?**reliable**?. A strong penalty should be given to the TAC when a quotation ?poor? is given to the stock assessment.

A precautionary limitation of fishing effort could also be an efficient management alternative. Some limitations of fishing efforts targeting BFT were for instance recommended by ICCAT in 1974 or on BET in 1996, but these limitations were never efficiently applied. An early precautionary TAC or effective control of efforts could produce either positive or negative effects on the quality of statistics: positive because research activity could be then stimulated, but more likely negative because of **an international commission, such as ICCAT, has to accept official statistics as being reliable, even if they are known to be not**. Reference points based on past fishery yields or empirical approaches could well be used for the Mediterranean bluefin (see Fromentin et al., same volume) and Atlantic swordfish.

Even recognizing the uncertainties faced by most reference points for tunas, the precautionary approach is necessary for the conservation of tunas and pelagic ecosystems, which are now under **increasing fishing pressure worldwide**. However, it is of importance to take into account the peculiar features of the fisheries, the quality of the statistics and the biases in estimations, as well as the peculiar aspects of the population dynamics, biology and main life history traits (Longhurst 1998).

5- Closed areas: size of area fished and precautionary approach

A comparative analysis of worldwide tuna data shows that the presence of an unexploited area (or suffering a low exploitation rate) within the geographical distribution of a population leads to a **cryptic biomass**, that prevents from overfishing.

When stock assessments are done on a fishery which exploits a coastal fraction of the stock, **the MSY and recruitment levels are then constantly and significantly underestimated,** see e.g. the case of the Atlantic and the Eastern Pacific yellowfin tuna (Fonteneau et al. 1998).

The characteristics of tuna stocks, to inhabit a large basin and to show some ?viscosity?, were probably key components to explain their resilience (this cryptic biomass has probably been a **safety belt** in the management of many tuna stocks!).

Well **selected closed areas** (spawning zones?) of convenient sizes (a minimum fraction of the habitat would be required? Probably including part of the spawning zone?) could then be a convenient precautionary management approach in order to prevent their overfishing. The ratio of the size of the habitat inhabited by the stock and of the fished area should be at least well estimated, since it would be used routinely as an index in the management process.

Those closed areas could easily be controlled for large vessels of participating fleets, if boats were equipped with real time satellite positioning. The negative socio economic effects of such measures should be evaluated and balanced against their potential effectiveness.

6- Comparative studies between various tuna stocks and oceans

The comparative analysis between various tuna stocks and fisheries do show **striking similarities between the various oceans**: large differences are observed everywhere between temperate and tropical tunas, but each species shows very similar biological patterns (growth, movement patterns, spawning and swimming behavior, maximum sizes, schooling and feeding behavior, longevity, natural mortality, etc..) and environmental affinities in each ocean. These strong biological similarities and the homogeneity of the world tuna fleets (same gears showing in each ocean very similar fishing patterns: purse seiners, longliners, and baitboat..) will offer a very interesting potential to compare the validity of potential indices obtained in the various oceans. The comparative analyses could provide two positive outputs, first an **improvement of stock assessment models used** and results obtained, and second, **more significant and useful reference point**s for tuna stocks and fisheries, based on the real characteristics of stocks and fishers (this very useful work will be carried out very soon within the FAO framework).

These comparative analyses should probably lead to precautionary policies, which are variable for each category of tunas, for instance:

Temperate tunas such as bluefin tunas (or albacore and swordfish), e.g. species showing large virgin biomass, large variance of their recruitment, but low biological productivity (because of their long life cycle) should be managed very carefully following the rules of precautionary approach.

Tropical tunas such as skipjack and yellowfin, species showing large P/B ratios, and little variance in their recruitment, could be managed quite safely with less precaution because of their biology.

The comparative analysis should help to establish and validate these fundamental biological characteristics which condition the management risks.

7- Conclusion

Precautionary actions can be very expensive in terms of short-term costs (social and economic) when these actions are taken effectively. It must then be used carefully and based on a reasonably well established and scientific probability of a **conservation risk**, e.g. a risk of severe or **irreversible damage** to the resources (as **unjustified precautions can ?kill? the fishery, industry and fishers, without significant benefit for the resources**).

It must also be kept in mind that most of the tuna stocks have shown to be resilient and rather resistant to overfishing (the depletion of the SBT stock, however, showed that over-exploitation can be reached rather quickly in some cases), so that most of them can sustain durably high exploitation rates (especially tropical tunas).

However, there is clearly a global need for a precautionary management for tunas and billfish resources and the pelagic ecosystems because of the very large amount of uncertainties. In order to conciliate these two faces of the problem, the risk of errors in the indices used should be reduced as much as possible. Therefore it appears important to define **appropriate biological reference points** for each population, to use **several of them for each stock** (e.g. Rosenberg and Restrepo 1995) and to perform **comparative analysis** between tuna stocks exploited in the various oceans during the last fifty years (and more.).

As a general principle, ?poor data = poor quality of the scientific analysis = more precautionary approach? should be applied in the management.

But tuna experts should modestly face this responsibility, remembering well and honestly the multiple uncertainties in their present data and analysis concerning tuna stocks, and fully recognizing these stock assessment uncertainties.

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[1] the only exception is for bluefin tunas stocks, which are often followed using a wider range of scientific indices, such as larvae surveys, acoustic and airplane surveys.

[2] The Schaeffer model was often used by SCRS scientists, as this model is the basic framework of the ASPIC model.