MEDITERRANEAN TUNAS AND ASSOCIATED SPECIES: FISHING, RESEARCH AND RESOURCE MANAGEMENT.

Present situation and perspectives [1/]

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1 THE MEDITERRANEAN SEA: A REVIEW OF THE OCEANOGRAPHIC FRAMEWORK AND THE ENVIRONMENT

A short review:

Hydrology

The Mediterranean sea covers a surface of 2.5 million km^2 (excluding the Black sea) , whereas the Atlantic ocean covers a surface of 94.3 million km^2. The Mediterranean sea communicates with the Atlantic ocean by the Gibraltar strait, a narrow (14 km width), shallow passage (a maximum depth of 290 meters). The circulation of the water masses in the Gibraltar strait is characterized by:

I. A permanent surface current towards the East (entry of superficial Atlantic waters in the Mediterranean sea),

II. A deep current of the Mediterranean waters flowing westwards.

The Gibraltar strait is the unavoidable way for all the tuna migrations between the Mediterranean sea and the Atlantic ocean. The surface current facilitates the access to the Mediterranean sea for the tunas.

The Suez canal, opened a century ago, has enabled a certain colonization of the Mediterranean sea by an Indian ocean fauna, but probably without any significant effects on the tunas.

The Mediterranean sea is characterized by a negative hydrological balance: the evaporation, more important than the precipitation, is permanently compensated by an excess of Atlantic water entry. The turnover of the Atlantic waters in the Mediterranean sea is about 80 years, that is to say that any mass of water present at a given time in the Mediterranean sea is "statistically" replaced

[1/]/This report does not necessarily reflect the views of the European Community and in no way anticipates the Community's future policy in this area.

after an average time of 80 years by an equivalent surface Atlantic mass of water.

The Mediterranean sea is characterized by a marked seasonality of the surface temperatures:

III. during the summer, warm waters (more than 20° C) at the surface and important stratification of the waters.

IV. during the winter, cold waters (12 to 15° C), which are homogeneous between the surface and the depths, with important vertical convections (upwelling), recycling the nutrients abundant in the depths (these convections are induced in particular by the wind and thus largely depend on the wind speed).

This marked seasonality of the Mediterranean environment has very important biological effects on the biology of all the tuna species thus conditioning the spawning, the migrations, the growth, etc.

Productivity

It is classically considered that the Mediterranean sea has a low productivity, its nutrients coming from two sources:

(1) The superficial waters from the Atlantic (thus not very rich).

(2) The fluvial supplies (bringing certain nutrients).

The fraction of these nutrients that come from the deep layers is recycled in the winter and in the springtime (in the Alboran sea for example). Because of the lack of nutrients, the Mediterranean remains an "oligotrophic" sea, which on an average shows relatively poor phytoplankton and zooplankton biomasses compared to those of the classical productive systems such as the upwellings of the Eastern Atlantic facade. This low primary (phytoplankton) and secondary (zooplankton) productivities thus imply that the fishery potentials must logically also be poor.

Ecology

A major biological characteristic of the Mediterranean is its large species diversity (large number of species present) and the high rate of endemism (numerous species found only in the Mediterranean) observed in this sea, particularly for the benthic fauna. Another ecological particularity of the Mediterranean sea is the heterogeneity of its two large eastern and western basins which are separated by the strait of Sicily. Each of these two basins is further divided into ecologically and oceanographically heterogeneous units (Figure 1), with a gradient of specific diversity decreasing from the west to the east:

I. at the east: the Adriatic sea, the Ionian sea, the Aegean sea, the Levant sea.

II at the west: the Alboran sea, the Ligurian sea, the Tyrrhenian sea, the Algero-Provence basin.

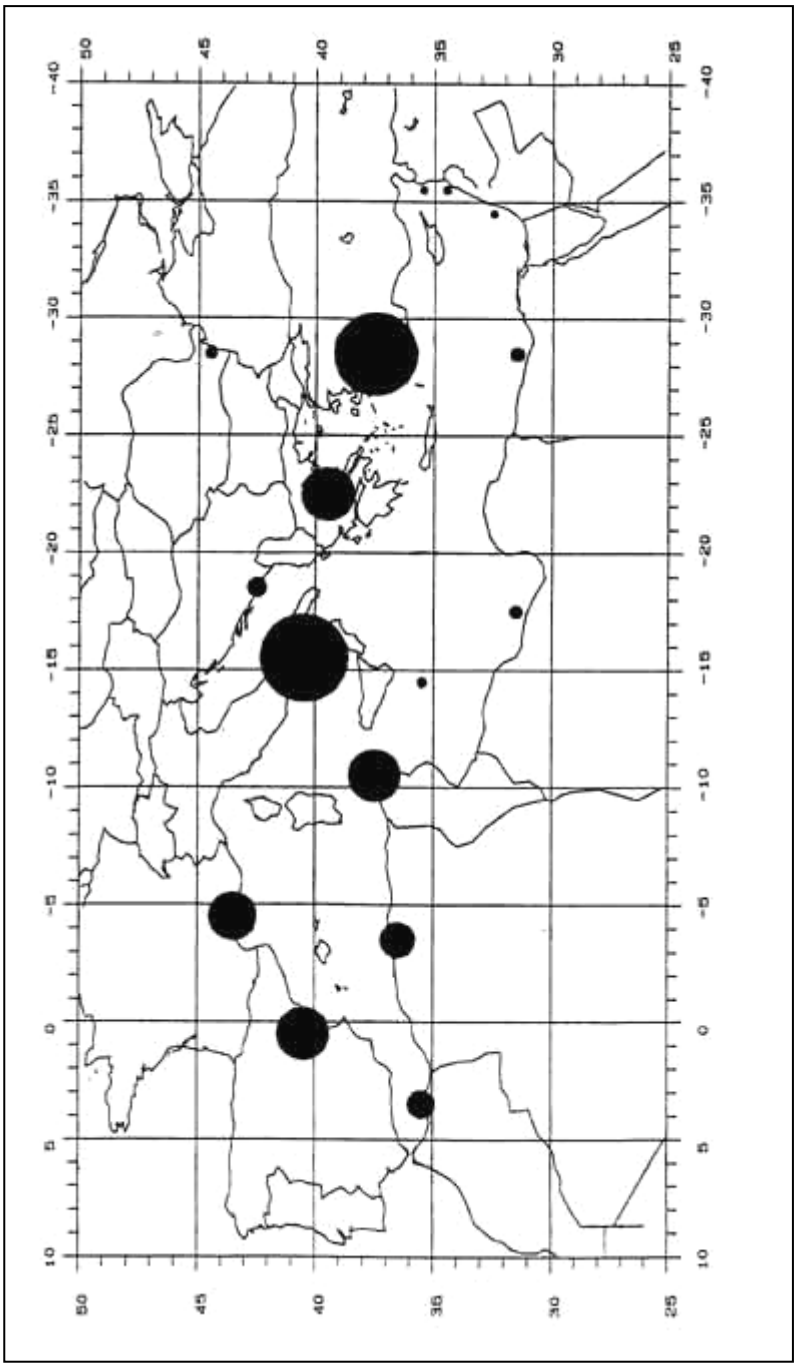

Figure 1 The various geographical components of the Mediterranean sea and average tuna catches by country

Geology

The Mediterranean sea has had a complex geological past, which is important to recall, since, to a certain extent, it conditions the vital cycles of the species present in the Mediterranean sea, including those of the tunas. The colonization of the Mediterranean sea by the tunas coming from the Atlantic ocean has only taken place at the beginning of the Pliocene, that is at the end of the tertiary era (Hsu 1974) or approximately ten million years ago. The Mediterranean sea remained an isolated basin during the Miocene and was thus unfit to the survival of tunas and associated species. At the beginning of the Pliocene, one can notice a colonization of the Mediterranean by a **tropical Atlantic fauna**, numerous species of which can still be found in the Mediterranean. It should also be kept in mind that during the quaternary, the Mediterranean sea has had alternances of cold phases (icy periods unfavorable to the presence of species with tropical affinities) and warm phases, comparable to the one observed at the present time. These geological fluctuations of the environment, implying several degrees of temperature decreases and modifications of the salinity and of the currents in the Gibraltar strait, have probably caused important "natural" fluctuations of the tuna resources spawning and living in the Mediterranean. We must thus consider that the subpopulations[1] of tunas now spawning in the Mediterranean sea are well adapted to this considerable ecological variability natural to this closed sea, especially during their larval and spawning periods.

2- PANORAMA OF THE FISHERIES OF TUNAS AND ASSOCIATED SPECIES IN THE MEDITERRANEAN SEA:

2.1- Historical review

The tuna fishing in the Mediterranean, and in particular that of the bluefin tuna, has been practised in the Mediterranean since millenaries. These fisheries were already described by Homer in the Odyssey (800 a.c.) and by Herodotus (500 a.c.). The migrations and the spawning of the bluefin tuna were also described long before the modern scientists by Aristotle in 350 a.c. The tuna trap fisheries have been particularly active all around the Mediterranean since this remote time. Yet, the catches of these "old" fisheries were most likely of little importance in comparison to the fisheries of the present time capable of deploying considerable modern means of detection (radar, sonar, satellites, etc...) and of tuna catches (seiners and longliners for example). This recent spectacular increase of the bluefin tuna catches is well shown in Figure 4.

2.2- The legal framework of the rational exploitation of these species

No exclusive economical zones exist in the Mediterranean sea, any country having a free access to the practice of tuna fishing outside the territorial waters. The rational management of these species should yet, as a rule and according to the new law of the sea and its article 64 on the highly migratory species, follow the conservation recommendations given by the ad hoc international commissions. The General Fishery Council for the Mediterranean (GFCM), which is an FAO *ad hoc* organism, is in charge of the resource management in the Mediterranean sea, but considering the highly migratory character of the tunas and the necessity to take into account the interactions

1. Subpopulation: A subpopulation of Mediterranean tunas is defined as a fraction of the tuna population constituting a genetic autonomous entity (as opposed to the other tuna subpopulations which spawn in others areas of the Atlantic ocean).

between the Atlantic ocean and the Mediterranean, the management recommendations for the tunas are confided to the ICCAT, which is an international commission active since 1969 (headquarters in Madrid). A cooperation between the ICCAT and the GFCM is established in an agreement of November 1973. All the countries of the Mediterranean basin are members of the GFCM, but only three countries of the region - France, Morocco and Spain - are, at the present time, members of the ICCAT. The tuna fishing is also practised in the Mediterranean by several non border ICCAT member countries (Korea, Japan) and other non ICCAT member countries.

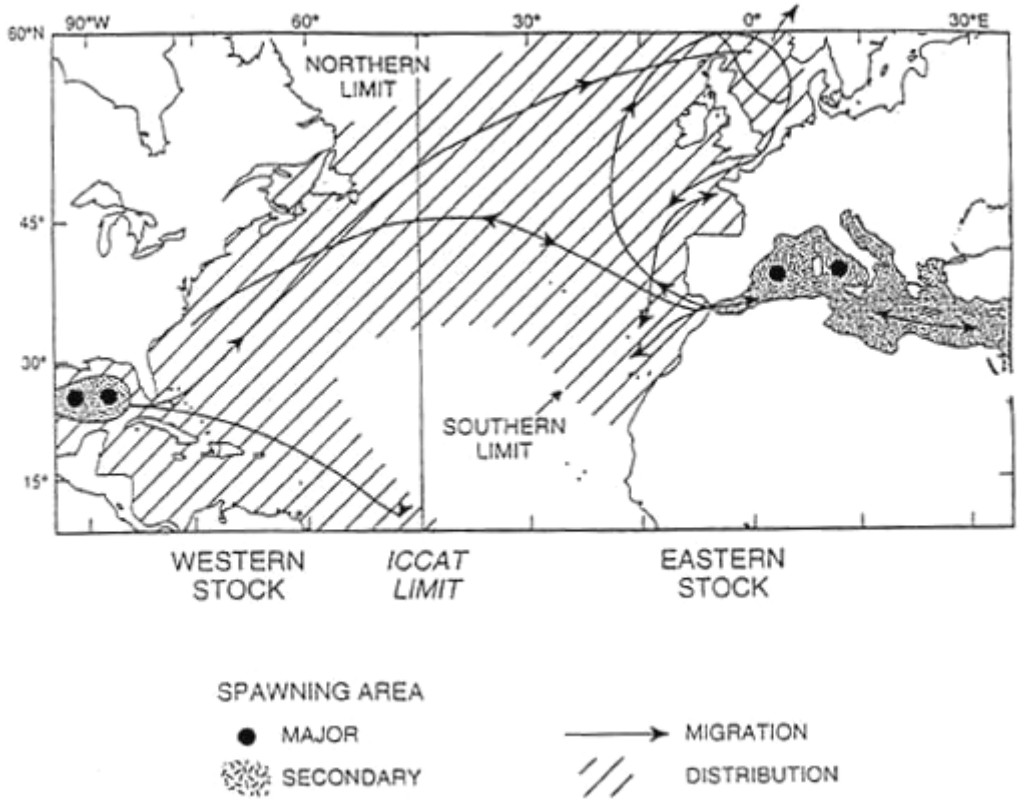

Figure 2 Some possible migratory patterns of bluefin tuna between the Atlantic (western and eastern) and the Mediterranean Sea

2.3- A panorama of the present fisheries: countries, gears, species

The Mediterranean fisheries annually catch about 800,000 tons of fish , of which 65,000 tons are tuna and billfish (8% of the catch). The average tuna catches by country are shown in Fig. 1. The trends of the tuna and associated species catches in the Mediterranean are shown in Fig. 2.

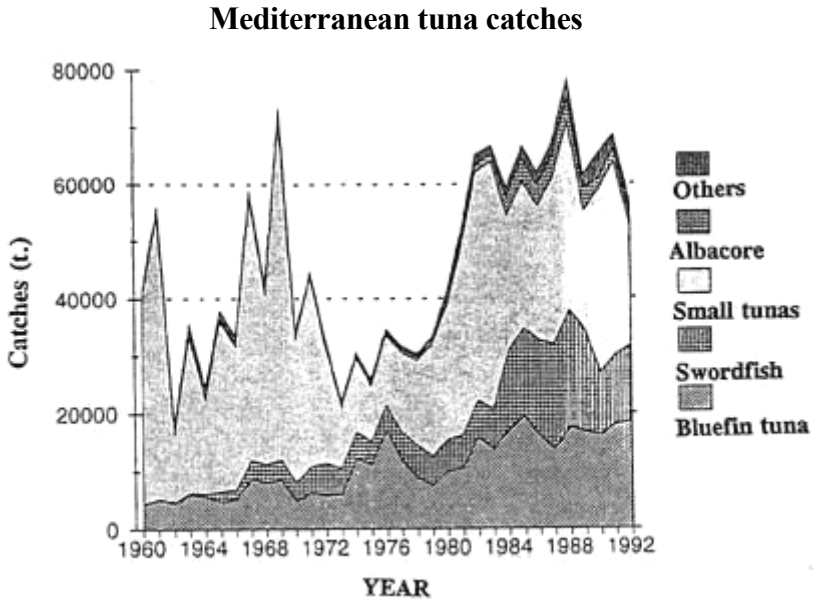

Figure 3 Tuna catches in the Mediterranean Sea, evolution from 1955 to 1992 for the main species

2.4- A comparison of the Mediterranean and the Atlantic tuna fisheries

The Mediterranean provides on an average, from 1983 to 1992, 65,000 tons of tunas, that is 11% of the 605,000 tons of annual tuna catches in the Atlantic and the Mediterranean.

The study of the ICCAT fishery statistics shows that only temperate tuna species (and associated ones) are abundant in the Mediterranean: Bluefin tuna, Albacore, Swordfish, Sarda, etc. Species with tropical affinity are sporadically present in the Mediterranean. This can of course be explained by the present oceanographic conditions observed in the Mediterranean with, in particular, the general presence of cold waters (less than 15 degrees) during the winter in the whole basin (a possible exception is that of the Auxis, a small tuna with tropical affinities which is very little fished at the present time, but the larvae of which are abundant in the Mediterranean during the summer).

The Mediterranean catches are particularly important for the bluefin tuna (Figure 3a), swordfish (Figure 3b) and Sarda (Figure 2). For these three species, the Mediterranean provides respectively 66%, 35% and 31% of the average total (Atlantic + Mediterranean) catches in the period from 1983 to 1992, although the surface of the Mediterranean is largely inferior to that of the Atlantic ocean (2.5 versus 95 millions of km2) and the biological productivity of the Mediterranean is, at least in theory, low. This remarkable productivity of the tunas in the Mediterranean is all the more surprising, as the tunas and swordfish are tertiary producers situated at the top of the production pyramid and thus a priori have a reduced biomass and catch potential.

2.5- Pollution and tuna fishing

The Mediterranean sea is an almost "closed" sea where large quantities of polluted substances of human origin, urban (partly coming from the intense touristical pressure on the whole Mediterranean basin), as well as industrial (via the big rivers in particular) are discharged. The most obvious effects of this pollution can be observed mainly on the littoral fringe and on the benthic communities (for instance mussels) and demersal resources (Sepia, red mullets for instance). The available data, however, indicate that this pollution would surprisingly have only little or no significant influence on the tuna resources, probably because the Mediterranean pelagic zone inhabitated by the tunas would globally be only little or not at all polluted. This remains a potential problem to monitor more particularly in the future if the pollution keeps increasing.

2.6- Responsible tuna fishing ?

The concept that fishing must be "responsible" and preserve the environment is becoming a well accepted concept since the Cancun meeting, the agenda item 21 of the Rio conference, the results of the UN conference on the “straddling stocks”, and following several FAO recommendations trying to elaborate a rules for a responsible fishing practice. This responsible fishing must secure, at the same time the conservation of the "targeted" species (here tunas and billfishes), but also of the species which are ecologically associated with the tunas and more generally the ecosystems exploited by the tuna fisheries. These concerns for a "responsible" tuna fishing in the Mediterranean sea have only been little studied, in particular by the ICCAT. A significant number of fishing gears presenting a certain ecological risk, especially the large drift nets and the longlines, are presently active in the Mediterranean. They should probably be closely monitored on scientific bases and their proper use should be controlled in the management of the fisheries.

3- REVIEW OF THE PRESENT KNOWLEDGE ON THE MEDITERRANEAN TUNAS AND ASSOCIATED SPECIES

3.1- Summary of the researches

Research structures:

The researches on the Mediterranean tunas and associated species are carried out by the coastal countries having laboratories and conducting research programs on these species. The principal countries active in these researches are logically the countries where the tuna fishing is most active: Italy, France and Spain. Several countries of the Mediterranean basin also carry out more punctual

Total bluefin tuna catches
Mediterranean and Atlantic

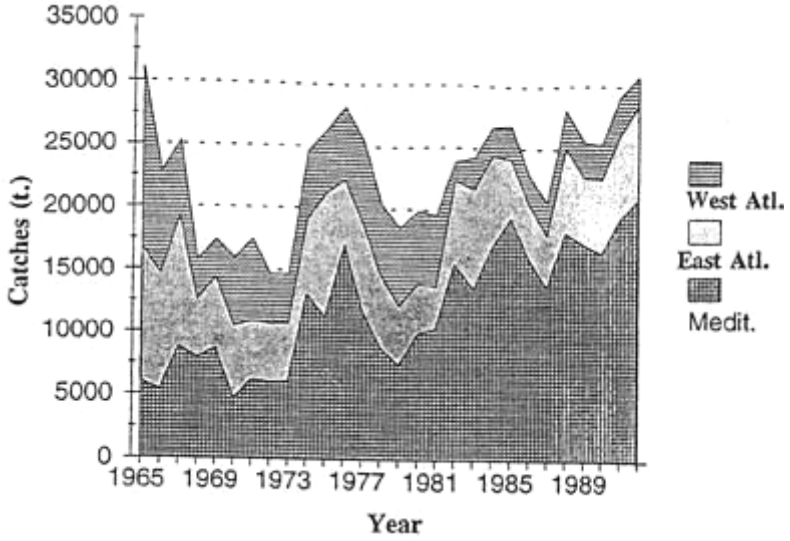

Figure (4a) Catches of bluefin tunas in the Atlantic and in the Mediterranean sea between 1960 and 1992

Swordfish catches
Mediterranean and Atlantic

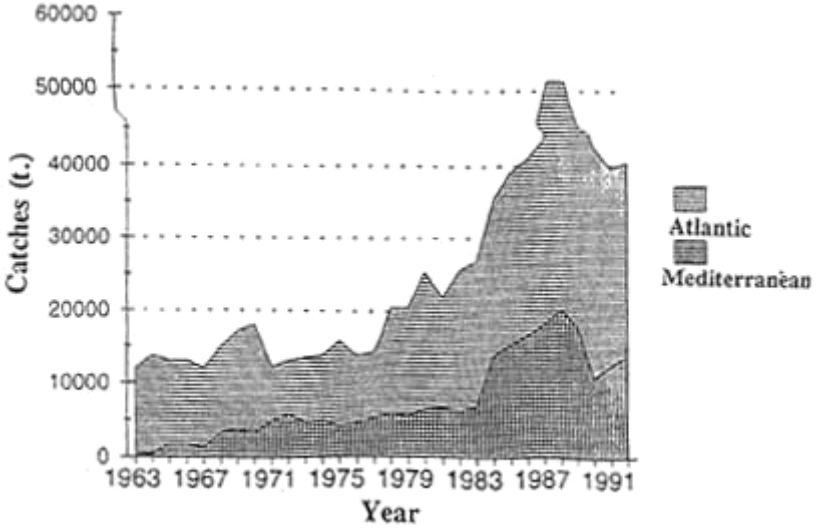

Figure (4b) Catches of swordfish in the Atlantic and in the Mediterranean sea between 1960 and 1992

but active researches in the field, for example Morocco, Algeria, Tunisia, Greece, etc. These researches on the tunas are independent for each country, but they are conducted within the framework of a certain research co-ordination by the ICCAT (the International Commission for the Conservation of Atlantic Tunas) and its scientific committee, the SCRS (Standing Committee for Research and Statistics). Yet, only three countries of the Mediterranean basin, Spain, Morocco and France, are members of the ICCAT ; Italy, Algeria and Tunisia participate at the ICCAT meetings as observers. The General Fishery Council for the Mediterranean (GFCM, of which all the Mediterranean coastal countries are members), a specialized FAO agency, also participates to a lesser degree - but with more participating countries - in the co-ordination of these tuna researches. Three joint ICCAT/GFCM scientific meetings realized since 1990 enables a co-ordination of the works of these two structures. The realization of research programs financed and coordinated by the European Community within the ICCAT identified and recommended researches (the bluefin tuna program, for example), can also be noted. These programs have largely developed the scientific co-operations in the tuna researches in the northern facade of the Mediterranean.

These programs have globally produced quite interesting results, but their geographical and thematical scales remain insufficient to be able to answer the present multiple and important questions about these stocks (result of the cumulated deficiencies in both statistics and researches).

3.2- Review of the fishery statistics: attainments and desiderata

The fishery statistics on the Mediterranean tunas generally show a very poor coverage and quality (in comparison with the Atlantic tuna statistics), and most of them do not comply with the SCRS (Standing Committee for Research and Statistics of the ICCAT) rules, which require for all the fisheries:

I. reliable estimates of the specific catches,

II. "effective" fishing efforts, that is to say efforts which are calculated in order to be proportional to the fishing mortalities undergone by the stocks,

III. the captured sizes (on a monthly and 1 or 5 degree square time-area basis).

These problems are constant during the last 20 years from the readings of the SCRS annual reports (very little statistical progress can be noted during these 20 years...). It follows that for most of the stocks, the total catches as well as the fishing efforts or the sizes of the fishes caught in the Mediterranean are not well known (and variable from one official ICCAT report to another...). These problems are noted for the coastal countries (more particularly the countries where the artisanal fishing is important, especially for the catches of small tunas), as much as the non coastal countries of the Mediterranean. The most "sensitive" statistical problem at the present time is the one raised by some industrial ships that operate in increasing number since a few years in the Mediterranean without real flags or under flags of convenience; they do not declare any catch to the ICCAT. The magnitude of these catches (probably still not very important) is recently becoming estimated, since these tunas are mostly sold on the Japanese market, and these importations are reported to the ICCAT by Japan.

These global statistical problems are variable according to the countries and the fisheries, but they severely hampered the analyses of the state of the stocks for most of the Mediterranean tuna

species. Indeed, no stock assessment model can give trustworthy results in the absence of these basic data (total catches, effective efforts, sizes caught).

3.3- Review of the biological knowledge

Biological parameters

The basic biological parameters, such as the growth, the length - weight relationships, the sex ratio by size, the spawning, etc. have been the subject of a certain number of studies in several countries of the Mediterranean basin since many years. Only the natural mortality, which is a biological parameter of the highest importance for the stock assessments, is almost unknown for most of the species, but this problem is unfortunately not limited to the Mediterranean sea.

Although the results of these studies are sometimes not consistent, the major biological parameters of the tunas and neighboring species are at the present time relatively well-known in the region. This knowledge is however variable according to the species: it is good for bluefin tuna, fairly good for swordfish and poor for the other tunas (Albacore and small tunas). One of the most interesting biological results is the evidence that the Mediterranean is **an important spawning area** for several tuna species. This is for instance the case for bluefin tuna: although this species usually spawns in warm tropical waters (+26 degrees), the spawning of this species actively takes place in several areas of the Mediterranean, in the east as well as in the west (Picinetti 1993), during the summer at a temperature of only 22 to 25 degrees. This good adaptation to the "temperate" conditions of the Mediterranean of the bluefin tuna's spawning, made clear by the works of the Italian scientists, constitutes a major biological particularity of the Mediterranean bluefin subpopulation and probably explains the high abundance of this resource and its good resistance - at least until now - to an intense and sustained exploitation. The same characteristic can also be observed for the swordfish, whose abundance in the Mediterranean is also exceptional (although this has been less studied).

Stock structure: mixing between the Atlantic and the Mediterranean sea

One of the most important parameters in the stock assessment and the rational management of the tuna stocks is related to the migrations and the stock structure. These migrations indeed determine the potential interactions between the fisheries located in more or less remote areas, either inside the Mediterranean sea or between the Mediterranean fisheries and those operating in the Atlantic. This is clearly the case for bluefin tuna which seasonally accomplishes important trophic and spawning migrations between the Atlantic and the Mediterranean (and *vice versa*) (Figure 5).

This **stock** structure (**concept of management unit**) is different from the **genetic concept of "subpopulations"**, which are genetically homogeneous units made of individuals accomplishing spawning migrations (generally towards their birth place: "homing") in order to reproduce in a particular area (for the Atlantic bluefin tuna, either in the Mediterranean or in the Gulf of Mexico).

The main problem about the stock structure is to estimate the migration rates between the Mediterranean and the Atlantic. The fishery data allow a qualitative evaluation of these migrations, in particular due to the Gibraltar strait fisheries, which largely exploit the entry or exit tuna migrations. These data from fisheries, when they exist, are however nearly always insufficient to

quantitatively estimate the migratory rates, which **can be obtained only from tagging results**. Indeed, only the recoveries at given places of fish tagged elsewhere, can provide the proof of migrations. These results must, in order to be significant, be based on numerous taggings and be associated to good fishery statistics. This has scarcely been the case in the Mediterranean sea, despite the multiple tagging programs (in general conducted on a small scale) realized in the region, in particular the interesting tagging programs recently developed in the Mediterranean thanks to the financial support of the European Community .

The problem of the tuna migrations inside the Mediterranean and thus of the interactions between regions, is also unsolved. This problem is however of secondary importance for the rational management of the resources which must be realized on the basis of large stocks.

Structure of the major stocks:

I. Bluefin tuna:

The working hypothesis adopted until 1993 by the SCRS was that of the existence of two bluefin tuna stocks situated in the eastern and western Atlantic. Under this "classic" hypothesis, the eastern Atlantic and the Mediterranean bluefin tuna constitute a single stock, which implies important migrations between the Mediterranean and the eastern Atlantic (well shown by the fishery statistics and the recoveries of bluefin tuna tagged in these two areas). On the contrary, in this "classic" SCRS hypothesis, there would be no significant migrations from the Mediterranean to the western Atlantic (despite the existence of some transatlantic recoveries...), thus no potential interactions between the fisheries and the eastern and western stocks. It is moreover well known that there are at least two independent spawing areas for the bluefin tuna, situated in the Mediterranean and in the Mexican gulf, and which very probably correspond to two genetically relatively isolated "subpopulations". The existence of these two independent spawning subpopulations does not imply the existence of two stocks: indeed, the bluefin tunas born in the Mexican gulf can migrate towards the Mediterranean, and reciprocally, "Mediterranean" bluefin tunas can migrate towards the western Atlantic before returning to spawn in the Mediterranean (Figure 5). The transatlantic bluefin tuna recoveries have been observed in both directions. These exchanges can cause interactions between the western Atlantic and the Mediterranean fisheries.

The resources of **the Mediterranean and the western Atlantic bluefin tuna can thus constitute two fractions of a same stock having important potential interactions**. It seems to be the new hypothesis of the SCRS since this year, following the reexamination of the several observations originating from the genetics, the biochemistry of the bones and a few transatlantic recoveries. There then seems to be a tendency towards the hypothesis that some migration exists - significant but minor, probably variable from one year to the other - between the western Atlantic and the eastern Atlantic-Mediterranean zone. This hypothesis is scientifically more logical than that of two independent stocks. It also has important potential implications concerning the management of the resources: the Mediterranean stock is at the present time and according to all the SCRS analyses, very important in biomass compared to the western stock. Consequently, all migratory rates coming from the Mediterranean, even minor, are susceptible to rapidly modify the biomasses present in the western Atlantic. On this assumption, the low present level of the bluefin tuna stock

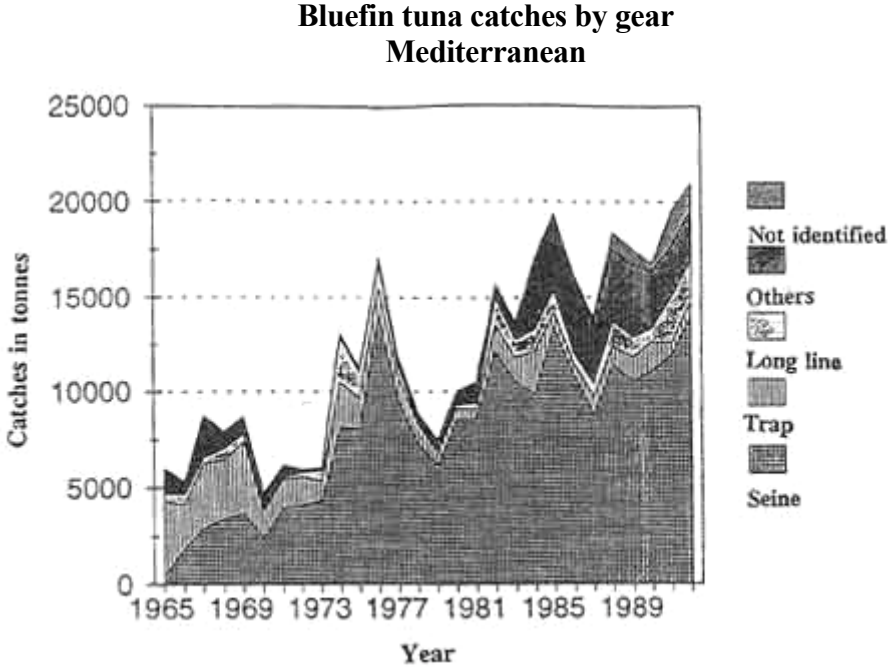

Figure 5 Bluefin tuna catches in the Mediterranean Sea between 1965 and 1992

in the western Atlantic might require strict management measures in the Mediterranean: application of limited sizes or reduction of the Mediterranean catches in order to preserve the recruitment levels in the western Atlantic.

The problem of a "genetic" extinction danger for the population of the western Atlantic bluefin tuna and of a serious loss of the genetic diversity of the population remains unsolved, even in the hypothesis of two stock fractions with significant mixing. It should be noted that it is this risk of genetic extinction which had been the basic argument given by Sweden in 1992 to the CITES (International Convention for the Commerce of Endangered Species) in order to consider that this stock was “genetically” in danger and that the international trade of the bluefin tuna should be limited. This danger does not seem to occur in the Mediterranean (recruitment kept at a sustained level).

II. Swordfish:

The available data (tagging and fishery statistics) seem to indicate that the Mediterranean swordfish constitute a relatively isolated stock. Even though the Gibraltar strait in no way is a barrier to the migrations of the Mediterranean stock, only a marginal fraction of the stock seems to

accomplish minor migrations to the Atlantic area near Gibraltar. The swordfish caught in the northern Atlantic would thus constitute a second stock, independent of the Mediterranean stock. A sufficient genetic heterogeneity between the Mediterranean and the Atlantic swordfish supports the hypothesis of two genetically independent subpopulations in these two areas (according to DNA mitochondrial analyses recently submitted to the SCRS).

It is on the basis of this hypothesis that the management measures recently recommended by the ICCAT have only concerned the northern Atlantic and not the Mediterranean.

III. Albacore:

The available data (tagging, biometry, fishery statistics) clearly show that the Mediterranean albacore, like the swordfish, would constitute a stock isolated from that of the northern Atlantic (but probably of small size).

IV. Small tunas:

There are several small tuna species (Sarda sarda, Euthynnus alleteratus, Auxis thazard) which in general are more coastal and much less migratory than the large tunas (the potential to accomplish important migrations is largely linked to the size of the individuals). There are very few studies on the structure of these stocks (whether in the Mediterranean or in the Atlantic) , but the relatively low migratory potential of these species would suggest that these resources should be considered as Mediterranean stocks, although passages of tagged small tunas have been observed in the Gibraltar strait and in the Dardanelles towards the Black sea. The potential existence of relatively isolated fractions of stocks within the Mediterranean sea (and relatively independent from the Atlantic ones) cannot be excluded. For instance, it is possible that the Sarda exploited in Egypt and in Spain correspond to independent stocks without potential interactions.

4- STATE OF THE STOCKS

4.1- A general review of the rational exploitation of the long living species

The bluefin tuna and the swordfish are the two most important Mediterranean tuna resources, economically, historically and at the present time. These two species have in common a low natural mortality, long exploited lifespan (approximately twenty years) and a large potential weight (maximum weight of several hundreds of kilograms). These two species have in common a certain number of exploitation particularities which are essential to keep in mind for the stock assessment as well as for their management:

I. Important biomass and low productivity of these resources:

These species have an "instantaneous" **biomass** which can be **important** (numerous age classes can be exploited), whereas the biological **productivity** of the resource is **low**. In the "classic" comparison of a stock and a capital having a banking interest, these species would correspond to a banking account having a very low interest rate (for instance 5%). On the contrary, the tropical tunas - as yellowfin or skipjack - have a lower relative biomass (few age classes, high natural mortality), but an important productivity (as a capital bringing 20 to 30% of annual interests, or more...). Consequently, if the rational exploitation aims at using the interest of the

resource without consuming the capital, the danger of overexploitation is always structurally more important for resources with a low productivity (temptation and danger to voluntarily or "accidentally" use a part of the huge capital, for instance due to lack of *ad hoc* scientific analyses).

II. Danger of a fishery disequilibrium and of long response delay of the stock to any management measure:

Thus, these resources are easily overexploited (by confusion of the poor productivity and the important biomass of the resource), and there are always two "structural" dangers to their exploitation:

-1- Their overexploitation is difficult to show:

Long series of good statistical data are required: when the fishing effort rapidly increases (this is for instance the case of the bluefin tuna and the swordfish in the Mediterranean), the increasing or sustained catches can for a while make believe (wrongly !) that the stock is in good condition, even though there often is only a squander of a capital which had been accumulated for years.

-2- The recovery of these stocks is inevitably, and in the best case, always very slow:

III. In the most favorable case where the reproductive potential of the stock is not damaged ("size overfishing"), all effective reduction of the fishing effort realized by the stock managers would have positive effects on the resources, but only after ten years or more.

In the unfavorable case where the reproductive potential of the stock has been damaged by the fishing ("recruitment overfishing"), the recovery of resources can only be expected after decades (or after centuries....). It is at present more or less the hypothesis adopted by the tripartite commission between Australia, New Zealand and Japan, which manages the southern bluefin tuna on a basis of reduced quota catches. In the most unfavorable case, this recovery might be impossible at an historical time scale if the "genetic" potential of the stock has been too much damaged by the overexploitation (such a pessimistic hypothesis is the one which is, at the present time, under discussion for the western Atlantic bluefin tuna in the framework of the CITES although the present low level of this stock is still not well evaluated by the scientists).

-3- Interest of not catching the small individuals

As soon as these species are **"significantly" exploited** (which is mostly the case at the present time for species with high trade value as the bluefin tuna or the swordfish), **a rational management must always aim at reducing the catches of small individuals**. Indeed, these catches always have a very negative long term potential effect on the productivity of these resources which show a large potential of ponderal growth, at least as soon as the resource is significantly exploited (while it is hardly the case for most of the tropical tuna species).

To conclude, it should be considered that the management of these long living resources is particularly difficult, with a permanent danger to overexploit the stocks, situations structurally difficult and long to reverse.

4.2- Small tunas

Although there are no particular scientific problems concerning the exploitation of small tunas (these species have in general a relatively short life span), it presents a socio-economical interest which is especially important in several countries of the Mediterranean basin: the commercial values of these species are generally minor, but being taken by artisanal fisheries and commercialized to the coastal populations (locals or tourists), these catches are often important from a socio-economical point of view. This fact should lead to a careful management of these resources.

4.3- Present time scientific conclusions

The evaluations of the state of the stocks of the tunas and associated species in the Mediterranean have all been carried out in the framework of the SCRS (ICCAT). The assessment has principally been carried out on the bluefin tuna, since no other species can be analyzed at the present time due to the lack of ad hoc biological and statistical data.

Bluefin tuna:

Concerning the Mediterranean bluefin tuna, the SCRS concluded that the increasing trend of the catches, observed during the last thirty years, mainly is the result of a constantly increased fishing effort (especially by the purse seiners, see Figure 4) and increased fishing mortality. A better submission of catch statistics to the ICCAT is also partly a cause for this trend. This has caused a regular and spectacular decrease of the stock biomass. The statistics also show the existence of massive and systematic catches of juvenile bluefin tunas, 25 to 50% -in number- of under sized fish (*i.e.* less than 6.4 kg), declared to the ICCAT during the recent years; these figures are very probably underestimated. These catches are, according to all the analyses, extremely negative for the stock productivity (a loss of about half of the stock productivity). This is all the more serious as these individuals are immature, and thus have not yet accomplished their first spawning (and this consequently constitutes a danger for the future of the resources...). The conclusions reached in September 1994 by the ICCAT/GFCM experts on the Mediterranean bluefin tuna are very alarming.

Despite this "alarming" situation with an important increase of the catches and of the fishing effort and massive captures of juveniles (3 to 5 million individuals per year!), it should be noted that the Mediterranean bluefin tuna stock has remained until now in a much better condition than the western Atlantic bluefin stock:

I. Increasing sustained catches since nearly twenty years (but not necessarily sustainable):

II. Recruitments (number of fish entering the fishery each year) which are relatively stable and at a high level (several hundreds of thousands of fish recruited each year at the age of one ear, against only a few ten thousands in the western Atlantic).

III. Biomass of the spawning stock which remains at a high level in comparison to that of the western Atlantic: the ICCAT estimates that the number of bluefin spawners aged more than 8 years is several hundreds of thousands of individuals present in the Mediterranean, against only some thirty thousand in the western Atlantic (1988-1992 period).

This relatively good situation of the Mediterranean bluefin tuna, despite the total absence of rational management measures (in comparison to that of the western Atlantic where severe quotas and limit sizes are strictly applied since the early eigthies), constitutes a surprising paradox and is not well explained by the scientists.

Swordfish :

No analysis of the state of the stock of the Mediterranean swordfish has yet been carried out, due to the lack of basic data necessary for these analyses (total catches per size and fishing efforts in particular). This is all the more regrettable as this species is of a great importance in the Mediterranean (this sea provides on an average 35% of the Atlantic swordfish catches). It is considered that these high catches are relatively stable since about ten years, but this is insufficient to determine the state of the stock. The sizes of the swordfish catches estimated by the ICCAT scientists indicate important catches of small swordfish by fisheries targeting on very small swordfish: 50 to 70% (in weight) of the swordfish landings since 1985 were smaller than 125 cm. As for the bluefin tuna, these massive catches of juveniles are negative for the stock productivity and potentially dangerous for the potential of the spawning stock (at least when the stock is highly exploited, which is probably the case in the Mediterranean).

Albacore and small tunas:

No analysis has unfortunately been carried out on the state of these stocks (lack of data).

4.4- Scientific uncertainties on the state of the Mediterranean tuna resources

Each year it can be noticed in the ICCAT scientific report that the scientific uncertainties on the Mediterranean tunas (and associated species) are very important. These uncertainties, which are at the same time in the fields of statistics, biology and stock assessment, are due to multiple factors among which:

I. the important heterogeneity of the Mediterranean tuna fisheries, which makes reliable estimations difficult (especially since a low priority has probably been given to these statistical tasks....)

II. the great diversity of the countries exploiting these species (about fifteen fishing countries, each of which having very different political status and research structures), and the majority of them being non ICCAT members.

III. the low scale researches realized on the Mediterranean tunas, and the lack of coordination of these researches. This limited research and its relative inertia is due to a certain lack of priority for the researches in the region; a need for increased training of the technicians (fishery statistics) and of the scientists (assessment) should also be stressed. It is clear that a rational choice of research axes coordinated between the different countries of the Mediterranean basin, the ICCAT and the GFCM and with an ad hoc financing, should be carried out.

IV. Finally, the modern stock assessment methods, for example the analytical stock assessment models for bluefin tuna and swordfish (the most relevant methods), now demands important

knowledge in statistics and data processing, which is very uncommon in most countries around the Mediterranean basin. This implies a need for more training for the scientists in the region.

5- THE RATIONAL MANAGEMENT OF THE MEDITERRANEAN TUNAS AND ASSOCIATED SPECIES:

5.1 Past and present: review of the problems

The chronic weakness of the tuna fishery statistics in numerous countries of the Mediterranean basin and the weakness of researches carried out on these species strongly limit the stock assessment of the resources, which is the basis of their rational management. This is all the more serious as a certain number of these stocks, bluefin tuna and swordfish in particular, have a very important commercial value and are the subject to a very sustained and increasing fishing pressure caused by their very high prices (attracting more and more "pirate" tuna boats without flags...).

The two most important Mediterranean stocks, in weight and in value, the bluefin tuna and the swordfish, have *de facto* not been subject to any real management measure. The various measures taken by the ICCAT (freezing of the effort for the bluefin tuna and a size limit of 6.4kg adopted since 1975; fishery closure for longliners during the spawning from June 1st to July 31st, adopted in 1993) have not had any real effects in the Mediterranean. The swordfish size limit of 25kg adopted by the ICCAT for the Northern Atlantic swordfish since 1991 is not applied to the Mediterranean, although it would (very probably) have been useful also in this area. The fishing effort carried out on the bluefin tuna has since 1975 regularly increased in several countries (ICCAT member countries or not). The undersized catches of bluefin tuna and swordfish remain at very high levels in most of the Mediterranean fisheries, without any measure being taken to limit them.

Thus, one can notice at the present time that, if apparently these two stocks are not presently in a too bad condition, it is essentially because of their strong productivity potential (not well explained?), and absolutely not thanks to the rational management measures adopted within the ICCAT framework. The conservation of these stocks at a medium and long term is thus more and more uncertain....

The small tunas, although their commercial value is lower than that of the preceding ones, have not been the subject of any ICCAT management measure. Even if there is no indication of overexploitation, this is essentially due to lack of knowledge on these resources (statistics, biology, state of the stocks).

5.2 Perspectives of rational management in the Mediterranean

The problem of the application of the management measures recommended by the international organizations (like the ICCAT) for the management of the tunas on scientific bases will soon become very important. Several partners are involved in the non application of the ICCAT regulations:

(1) ICCAT member countries having accepted the principle of these regulations,

(2) Mediterranean coastal countries non members of the ICCAT and not having accepted the regulations legally.

These coastal countries, ICCAT members or non members, also show a lack of political interest to apply the management measures internationally recommended.

Non identified commercial interests (longliners fishing the bluefin tuna without flag, real "tuna pirate boats").

Only a legally founded formula based on international cooperation, enabling the efficient application of the regulations by all the boats fishing tunas in the Mediterranean would enable to carry out the measures for a rational management of the resources decided by the coastal countries (for example within the framework of the GFCM), in unison with the ICCAT and its scientific committee, and with the participation of the non-coastal ICCAT member countries fishing tunas in the Mediterranean.

6- RECOMMENDATIONS: A BETTER RESEARCH FOR THE RATIONAL MANAGEMENT OF THE MEDITERRANEAN TUNAS AND ASSOCIATED SPECIES

At the present time it is unfortunately clear that the scientific knowledge now available in the region does not enable a rational management of these resources. It is thus important, in order to preserve the future of these resources, to develop the fishery statistics systems (at least for the important fisheries), and to establish coordinated research programs on a Mediterranean and Atlantic level and to efficiently apply a certain number of scientifically demonstrated management measures.

Fishery statistics:

The improvement of the collection, the data processing and the integration at the level of the Mediterranean + Atlantic of the tuna fishery statistics by all the countries would be the priority task. A correct data collection in the future will unfortunately not solve the problem of the absence of "historical" data: these data would have been extremely useful for long living species such as bluefin tuna and swordfish, species whose biomass have long reaction times to the changes in the fisheries, and thus need long statistical series before obtaining trustworthy estimations. This data collection should logically follow the statistical rules established by the ICCAT, and should cover the catches, the fishing efforts and the captured sizes, by gear and by month (by 1 or 5 degrees square). Such statistics are not difficult to obtain on a scientific basis; they require however a good statistical organization on a national level and good sampling schemes, for the artisanal fisheries in particular. The species identification for the small size species is often a difficult task (important quantities of small bluefin tunas might thus have been wrongly classified as Auxis or Sarda in the statistics...). The human and material costs of such routine statistical systems are not negligible, but the collection of these data constitute a "**national**" responsibility for all tuna fishing countries in the region.

The centralization of these Mediterranean data and their analysis in an integrated data base (in connection with the northern Atlantic tuna data, for instance ICCAT/GFCM) is then another unavoidable requirement. The problems related to the creation of such a standardized data base should be carefully studied.

Research:

The major pending problem in the region is probably that of the stock structures and of the quantitative estimation of the migrations, within the Mediterranean (migrations between the different seas), as well as - and above all - between the Mediterranean and the northern Atlantic. To answer these questions, only large scale research programs, carefully planned and simultaneously carried out at the level of the Atlantic ocean and the Mediterranean sea, can potentially answer the multiple questions presently pending.

Consequently the following recommendations should rapidly be applied:

I. As a first priority, **intensive tagging by classic "spaghetti" tags** (preferably with double tags) and by **"archival" tags**. The classic tagging could be very useful in order to be able to better estimate the movements between the different fisheries of the Mediterranean basin and with the Atlantic. These taggings should, if possible, be carried out in coordinated Atlantic (east and west) and Mediterranean programs. The new technology of the **archival tag** enable, at the recovery of the tagged tuna, to estimate the migrations realized between the tagging and the recovery positions; it now seems technically efficient and available at an affordable price. It is particularly suitable for the bluefin. These taggings should be coordinated via the ICCAT and with the projects now being studied in the USA.

II. As a second priority, **biochemistry studies** of the vertebrae and analyses of the **genetic heterogeneity** of the individuals captured in the principal fishing sectors, in particular in the spawing areas and during the spawning season, in order to determine the fidelity of these species to their birth zone (homing rate). These two technics - the biochemistry of the microconstituents and the genetics - have made important progress in the recent years and they can now furnish trustworthy results at an acceptable cost.

The joint realization of these two types of researches would enable to determine at the same time the structure of the subpopulations present in the Mediterranean and in the Atlantic (genetic concept) and that of the exchange rates between fisheries (concept of exchanges and interactions between *stocks*). These two types of researches should be carried out in priority on the bluefin and the swordfish, whose stocks seem to be the most endangered by the increase of efforts and catches, and which are able to accomplish very large migrations.

The traditional tags on the small tunas would also be essential to know the potential interactions between the different Mediterranean fisheries. The quantitative tuna stock assessment methods (necessarily carried out within the ICCAT framework for most of the species) should be the subject of an increased training of the Mediterranean scientists in this field.

Management:

Although this is not specifically a scientific problem, it must be stressed that it is dangerous and inefficient for the conservation of the resources to adopt management measures which *de facto* have no practical application in the Mediterranean, due to lack of political will and of *ad hoc* legal framework.

Although the scientific knowledge is fragmentary, it seems clear that the considerable increase of the fishing effort on the tunas, - particularly the effort on fragile species such as the swordfish and the bluefin -, is dangerous for the future of these resources, all the more since important quantities of juveniles of these species are captured each year. A strict application of **size limit** regulations for species with large potential growth (bluefin tunas and swordfish) would undoubtedly be a wise conservation measure. Moreover, the problems of a "**responsible tuna fishing**" remain poorly evaluated and not really taken into account in the Mediterranean, neither by the scientists nor by the managers of the tuna resources. These potential problems should also be better managed.

Conclusion

As a conclusion, one could compare the present fisheries of the Mediterranean bluefin and swordfish to a car without brakes (no political will nor any legal framework allowing an efficient control of the fisheries), driving very fast on a wet road (long living species, stock difficult to manage, massive catches of juveniles), and in almost complete darkness (no fishery statistics and no reliable stock assessment).

It is not, at this stage, the absence of accidents in the past that can allow to consider that this is a safe way of driving... An important increase of well coordinated researches and the implementation of a firm and cautious management of these resources should then be recommended.