REPORT OF THE WORLD SYMPOSIUM FOR THE STUDY INTO THE STOCK FLUCTUATION OF NORTHERN BLUEFIN TUNAS (*THUNNUS THYNNUS* AND *THUNNUS ORIENTALIS*), INCLUDING THE HISTORIC PERIODS

(*Santander, Spain – April 22 to 24, 2008)*

1. Background

The aim of the Symposium was to provide a deeper investigation of events that took place decades ago and to improve the understanding of these intriguing past events. This information should further help in improving current management and conservation measures for bluefin tuna fisheries.

The Symposium was a response to a recommendation of the Standing Committee on Research and Statistics (SCRS) in 2006.

Previous studies carried out within the framework of ICCAT have stressed the disappearance of some past fisheries or the drastic fall in the yields of others that generate changes in the spatial distribution of the catches.

Although these events occurred in past decades, they have marked the future of the fisheries. In the Atlantic, these events occurred in the 1960s, whereas in the Pacific, during the late 1800s and early 1900s, several fisheries that occurred in northern Japan suddenly disappeared, while more recently, several new fisheries have started in the Sea of Japan and coastal areas of northern Japan.

The Symposium was jointly organized by ICCAT and the *Instituto Español de Oceanografía*-IEO (Spanish Institute of Oceanography).

2. Opening

The Symposium was open on April 22, 2008 with an official opening ceremony presided by Dr. Fabio Hazin, ICCAT Chair. Dr. Hazin thanked the Government of Cantabria and the city of Santander for hosting the meeting. The ICCAT Chair emphasized the opportunity of the Symposium in a time when the stock of North Atlantic bluefin tuna, particularly in the eastern Atlantic and Mediterranean Sea, is facing one of the worst crises in the history of the fishery. Dr. Hazin expressed the wish that the Symposium will help the SCRS better assess the bluefin tuna stock and therefore contribute towards improving the management of the stocks.

Mr. Eduardo Balguerías, Under-Director General on Research of the Spanish Institute of Oceanography, recalled the objectives of the Symposium which are to analyze and identify the causes for the decline and/or collapse of the historic fisheries so as to avoid that these historic events occur again.

Mr. Rafael Centenera, Under-Director General of the General Secretariat for the Sea considred the interest that the Secretariat for the Sea has in reconciling the productive and environmental aspect of the bluefin tuna fishery and recalled Spain´s active role before the European Commission in support of the implementation of the management measures in force and the adoption of new, more drastic, measures that could help the recovery of the resource.

Mr. Samuel Ruiz, Deputy Mayor of the Santander City Council, thanked ICCAT and the IEO for chosing to organize this Symposium in Santander and conveyed the City Council´s support for actions aimed at halting the decline of the bluefin tuna fishery.

Mr. Fernando Torrontegui, the Director General of Fishing and Food of the Government of Cantabria, on behalf of the Head Counsellor and the Government of Cantabria expressed confidence that the work of the Symposium would obtain the expected results.

Mr. Agustín Ibañez, Delegate of the Government in Cantabria, expressed the hope that the work of the Symposium and its conclusions would help ICCAT confront the current situation of the bluefin tuna fishery. Mr. Ibañez also recalled the active participation of the central Government in all the initiatives directed at the current state of the resource.

Dr. Gerald Scott, SCRS Chairman, acted as General Moderator.

The Symposium was organized into seven thematic sessions coordinated by a Moderator. The list of papers presented and session moderators are listed in **Appendix 1**.

A total of 82 scientists attended the Symposium. The list of participants is attached as **Appendix 2**.

3. Summaries of the Sessions

Summaries of presentations made and the discussions during the Symposium sessions are provided here below:

− ***Session 1: Historic Trend of Bluefin Tuna Catches: General Overview***

Fonteneau (BFT_SYMP/015) made a critical analysis of the major changes observed in the various bluefin fisheries that have been identified in various areas of the Atlantic and Mediterranean Sea during the last 10,000 years. This study first reviewed the multiple fisheries already active in pre-historic and historical times, and mainly during the period between the Middle Ages and the beginning of the 20th Century, during which major industrial fishing activities were permanently developed, especially in the Mediterranean Sea. The development of recent bluefin fisheries was also analyzed, this analysis centering mainly on the catch and effort data of Japanese longliners (the longest series available). This historical analysis of bluefin fisheries confirms the large-scale migrations of bluefin tunas, and it shows that bluefin tunas have been historically fished in a very wide range of ecosystems, in a range of SST between 2° and 29°C, and that multiple changes have been permanently observed in time and area strata when/where bluefin tuna have been caught. This major variability of the bluefin fishing strata remains widely unexplained. It could be due to a combination of environmental factors (for instance, local availability of adequate preys or availability of suitable spawning conditions), and to fishery factors (for instance, shrinking fishing zones, in relation to the decline of overfished stocks). Further data mining and research should better explain this major variability that has been playing an indirect but significant role in past and present stock assessments.

One example of fishery data mining that could add value to the information set used to evaluate bluefin stock status is the case of the Trebeurden Bay sport fishery, described by Fonteneau and Le Person (BFT_SYMP/017). That sport fishery targeted, which large bluefin in northern Brittany (British Channel) during the 1946-1953 period, was analysed and it provided various points of scientific interest. These bluefin were taken during a short fishing season, the end of august and September, and these tuna had sizes very similar to fish caught by Norwegian fisheries. This sport fishery was linked to a sardine driftnet fishery then active in the area, and to the small sardines fished during this period. It can be hypothesized that these tunas were on their migration route between the North Sea and the central Atlantic, and that the same group of tunas had temporarily acquired a fidelity to this small feeding spot. This analysis well shows the potential scientific interest to recover and to analyse data from the bluefin sport fisheries.

The Symposium noted it is apparent that there are a number of important fishery dynamics that have occurred which are not taken directly into account in our recent evaluations of bluefin stock status in the ICCAT Convention area and concluded from Session 1 that:

- Our assessments of Atlantic bluefin stock status mainly focus on the recent history for which we have available more detailed information about the catch, effort and size composition of the catch.

- These assessments are uncertain, and especially so regarding biomass levels that are necessary to meet the requirements of the ICCAT Convention.

- Incorporation of more historical information could better inform us of stock productivity and abundance levels consistent with the ICCAT Convention objectives.

- Our challenge will be to apply methods for stock status evaluations that are more appropriate to the added complexities of the history we can piece together.

− ***Session 2: Collapse of the Fisheries in the North Sea and off the Norwegian Coasts***

The session had four presentations which described the development and subsequent collapse of the bluefin tuna fisheries in northern European waters.

Tangen and co-authors (BFT_SYMP/016) discussed the development of the Norwegian fisheries for bluefin in 1920-1986, years largely pre-dating the data records held in the ICCAT database. The methods of fishing and relative success rates were described. It was pointed out that the current generation of Norwegian fishermen have virtually no recollection of these fisheries, since bluefin have rarely revisited Norwegian waters since the late 1960s.

Nøttestad and co-authors (BFT_SYMP/017) provided an evaluation of the Norwegian fishing of Atlantic bluefin tuna up until around 1970, after which bluefin virtually disappeared from the Norwegian zone. They observed that during the last decades very few adult Atlantic bluefin tuna have been migrating and feeding in the highly productive northern ecosystems such as the Norwegian Sea and along the Norwegian coast. The authors concluded this situation is indicative of the present unhealthy state of the bluefin tuna population and represents a long-term sign of considerable growth over-fishing, signalling that the bluefin tuna population is not managed in a sustainable way.

MacKenzie and Meyers (BFT_SYMP/019, BFT_SYMP/020) re-emphasized that bluefin no longer commonly migrate to northern European waters where the species once supported important commercial and sport fisheries. The authors also provided documentation of the development of the fishery in terms of landings, effort, and gears with focus on the time period from 1900-1950 when landings were increasing. The species was frequently sighted while fishermen were targeting other species (herring, mackerel) and occasionally was caught as by-catch with these and other species. The most important countries which participated in bluefin tuna fisheries in this period were Norway, Denmark and Sweden, but bluefin tuna were also exploited by France, Germany, the Netherlands and the United Kingdom. While the reasons for the disappearance of bluefin from the region are unclear and have not been investigated in detail, the authors suggest that ecosystem conditions (e.g., temperatures, North Atlantic inflow intensities, food abundance) in the last 5-10 years in the area appear suitable for the species, but abundance remains low. They further suggest absence from the area may be due to overall decreased abundance associated with long-term changes in fishing pressure and selection pattern or low recruitment, or to density-independent changes in migration patterns.

It was noted that in combination, the presentations in Session 2 gave a comprehensive view of fisheries by all northern European countries in the Norwegian and North Seas as well as the Skagerrak, Kattegat and Øresund. These fisheries developed following the sightings of bluefin tuna and some by-catches in other fisheries, especially herring fisheries. Equipment used in the earliest fisheries was handlines with hooks, harpoons, and harpoon-rifle but eventually purse seine methods were developed by Norwegian fishermen in the 1920s and fully operational by the late 1940s. The purse seines were later (*ca.* 1950s) operated with hydraulic winches which enabled larger catches to be made. Sportfisheries also developed in the 1920s and continued until the collapse in the 1960s.

Written and archaeological evidence from the region shows that the species had been present and captured decades, centuries and even millennia (*ca.* 4000-5800 BC) before the onset of heavy fishing in the 1950s. The species was only rarely exploited before the 1900s because of difficulties to catch it and low demand for its meat, particularly in comparison with other species present in these waters (*e. g.*, cod, salmon, herring).

The Norwegian fisheries from the 1950s onwards are particularly well documented in terms of catch statistics, including size (length, weights), landings and effort data. Approximately 260,000 individual weight records are available and it is anticipated that this information can be used to derive snapshot biomass estimates for at least the early 1950s and will be deposited at ICCAT.

The ecosystem situation before, during and after the disappearance was described with respect to hypotheses concerning temperature, food abundance, and fishing effects on population abundance, migratory behaviour and (meta)population structure. Regarding temperature, bluefin tuna were present in both relatively cold and warm periods until the 1960s. In addition, bluefin tuna are caught near Iceland and the Faroe Islands in temperatures as low as 3ºC (BFT_SYMP/016). These observations suggest that the disappearance is not likely due to direct effects of large-scale changes in temperature on bluefin tuna.

Bluefin tuna were also present when food abundances were moderate and high (expressed as spawner biomass of herring, the only forage species for which abundance estimates are available for the time period before tuna disappearance and during its northern collapse). Herring biomasses were declining when the tuna fishery decreased and eventually collapsed to only very low levels. The collapse of herring populations in the Norwegian and North Seas was driven by a combination of overfishing and climate effects on their productivity and distribution. It is possible that the large decrease of forage fish led to a change in bluefin tuna migration behaviour, particularly among the medium-sized tuna (see for example BFT_SYMP/025). Interestingly large tuna (e. g., >200 cm) continued to migrate to the Norwegian and North Sea. It was hypothesized that the absence of smaller tuna and eventually also the largest tuna could be due to changes in:

(1) their migration behaviour,
(2) their production rate (due to few adults remaining in the population) and/or
(3) their survival (due to increasing exploitation of juveniles (BFT_SYMP/022, 023)).

During the recent 10-15 years, bluefin tuna have still been very rare in the region. This situation is unexpected, if the presence in northern European waters depends on warm water and high food abundance: temperatures and prey abundance (herring, mackerel, sprat, blue whiting and sandeel) biomasses in the North and Norwegian Seas) have been high during most of the 1990s and early 2000s. Moreover many southern species, including some which bluefin tuna eat in southern regions (*e.g.* anchovy) have increased in abundance in the North and Norwegian Seas. The observation that ecosystem conditions appear suitable yet bluefin tuna are still rare suggests that overall population abundance is now becoming very low.

Several demographic and fishery considerations presented in the Session indicate that the population in the northeast Atlantic and Mediterranean is having difficulties to reappear in the northern area and is generally in serious decline. These include:

- a continued decrease in spawner biomass during the last 10-12 years;
- spawner biomass at its lowest level since the start of ICCAT records in 1970;
- change in age/size structure of the population (*i.e.,* the share of older individuals in the population has decreased) since the 1970s;
- an increase in exploitation of juvenile bluefin tuna since 1950s;
- an exploitation pattern in which 80-90% of reported catches are composed of ages 1-3, and additional unreported catches of 0-groups, meaning that large numbers of bluefin tuna recruits never have the opportunity to spawn in their lifetimes; and
- the absence of bluefin tuna from formerly occupied habitat (North Sea, Norwegian Sea, Black Sea (BFT_SYMP/028).

Important reasons for the decline in northern areas in the 1960s are therefore the exploitation of bluefin tuna in various regions (*e.g.*, Norwegian Sea, North Sea, Bay of Biscay) and an important forage species (herring in northern waters). This exploitation pattern and the population consequences listed above are major factors inhibiting recovery in this area.

The Symposium raised a number of research questions in the discussion of presentations in Session 2:

- the role of learning of migration patterns by young tuna from older tuna, and the necessity for overlap of spatial distributions of young and old tuna; the mechanisms by which learning is accomplished are unclear;
- the possibility to acquire observational and occasional landings data via commercial and sport fishermen targetting other species and via whaling observers in northern European waters;
- possible links via migration to the population in the west Atlantic;
- attempts to estimate biomass in the early 1950s from age composition of catches and cohort identification;
- uncertainty of stock-recruit relationship;
- the potential for individual tuna to skip spawning and subsequently to reduce fidelity to former spawning sites; and
- the role of squid abundance and prey (especially herring) condition on bluefin tuna diets and condition.

− ***Session 3: Decline of the Spawning Fisheries in the Cantabrian Sea***

Cort (BFT_SYMP/021) presented information on the history of bluefin fishing in the Bay of Biscay wherein references to this activity date from the 16th century. *Curricán* (troll line) and *chapa* (silver plated spoon) were the gears used in the fishery ~~up~~ until the middle of the 20th century, when the baitboat fishing system was introduced. Fishing with single rods was used for tuna <10 kg, and with rods supported at the top by a cable leading to a pulley on the boat for larger tuna. Also, lines with reels were used to catch large bluefin in large numbers. The migration route from wintering areas towards the Bay of Biscay feeding ground was described. These movements are related to surface isothermal displacement in latitude. From the mid-1950s' length distributions from Atlantic traps, baitboats in the Bay of Biscay and purse seiners in Norwegian area, a relationship between these three fisheries for the 1950 and 1951 year classes was seen. In the Bay of Biscay, there was a constant presence of adults (group of age 5+) in their trophic migration towards northern European waters, prior to the 1970s.

Cort and Rodríguez-Marín (BFT_SYMP/022) described the development of the abundance of bluefin tuna spawners, age 5+ group, in the Bay of Biscay since the beginning of the 1970s. Using information since then, a sharp decline was observed in the abundance of group 5+ fishes (60 to 150 kg) that, prior to that time, were present in the Bay of Biscay from mid-June to mid-August, heading towards feeding areas in the North Sea and the Norwegian Sea. Since the early 1970s, the age 5+ group has practically disappeared from the fishery. The current length composition reveals the absolute predominance of juveniles.

Cort and others (BFT_SYMP/023) presented results of an analysis of the juvenile bluefin tuna population based on the fisheries data from the Atlantic coast of Morocco, Portugal, and the Bay of Biscay, between 1949 and 1960. In order to do so, the catches at age of these fisheries were estimated. The results show that, under different scenarios, the high fishing mortality exerted on the juvenile fish groups (< 5 years) in the years studied, may be one of the reasons for the later decline in the northeast Atlantic spawner fisheries from 1963. The presentation concluded with a summary of the current advances in the knowledge of bluefin migrations in the Mediterranean Sea.

Rodríguez-Marín and others (BFT_SYMP/024) presented evaluations of length distributions of baitboat fisheries, both in the Bay of Biscay and areas close to the Strait of Gibraltar, as well as trap catches from the Spanish Atlantic coast were converted to age distributions using age length keys from calcified structures. Data from these fisheries covered ages ranging from juvenile to adult bluefin tuna. Relative abundance and mean size-by-age analyses were accomplished in search of an exceptionally abundant cohort. The 1994 cohort, whose strong signal was detected for east and west populations, was clearly followed in the Bay of Biscay baitboat catches and in the Strait of Gibraltar baitboat catches, but it was not so clear for the trap-fisheries data. Factors affecting the identification of a strong year class were discussed: gear selection pattern, size sampling, age conversion and population dynamics. From these results, the authors suggested that the juveniles' fisheries in the western part of the Iberian Peninsula are connected with the western Mediterranean, the Balearic Islands area, because it is the closer reproduction area described, and because it is also supported by conventional tagging studies. Thereby they infer that the relative abundance index for juveniles in the Bay of Biscay represents a fraction of the population from the east Atlantic and western Mediterranean.

The different presentations showed a general view of the Bay of Biscay fishery that can be summarized as follows:

- The Bay of Biscay fishery is mainly made up of juveniles (1-4 years old, between 4-35 kg). In the past, adult fish (5+ group) were traditionally present in the Bay of Biscay between the middle of July and the middle of August, when they made their annual trophic migration to feeding areas in the North Sea and off the coasts of Norway from the spawning areas in the Mediterranean Sea. At present, the groups of adults have disappeared from the fishery.

- A sharp decline from the 1970s is observed in the abundance of group 5+ fish (mainly age 5+, 62 kg mean weight), in a fishery in which there has been a clear predominance of juveniles (96.6 % of the total catch in number of fish) over the last three decades.

- The results of an analysis of the juvenile (< 5 years) bluefin tuna population shows very high fishing mortality exerted on the juvenile fish groups between the years 1949-1960. The hypothesis considered in the analysis supports the existence of a certain independence ('resident populations') of the juvenile

bluefin tuna of the western from those of the eastern Mediterranean, based on recent pop-up electronic tagging.

The Symposium raised a number of research questions in the discussion of the presentations in Session 3:

- To what degree did development of fishing on the juvenile component of the stock from the 1950s to the 1970s influence the success of fishing adults in traps, in northern European waters, and the loss of age 5+ fish in the Bay of Biscay fishery ?

- What is the utility of strong annual year classes to establish relations between fishing grounds?

- It is important to know the contribution of recruits from the Mediterranean to the Atlantic fisheries:

  > Is there wide variation in the proportion of fish leaving the Mediterranean?
  > Does this proportion have any relation to density-dependent effects (competence for space and for food)?
  > As recovery rates in the Mediterranean are lower than in the east Atlantic, cpuld this result in over-estimating the number of Atlantic bluefin tuna leaving the Mediterranean?
  > What are the general trends in distribution and movements of the juvenile component that leaves the Mediterranean?
  > How important are learned behaviours and does the extirpation of abundances from other fishing grounds have strong implications in maintaining the presence of fish for the Bay of Biscay fisheries?

− Session 4: Overview of the Eastern Atlantic and Mediterranean Fisheries, in Particular, the Traps

Fromentin (BFT_SYMP/025) provided an historical overview of Mediterranean and eastern Atlantic fisheries for bluefin, focusing on traps. He pointed out that in 1963, the leading bluefin tuna fisheries which took place in the Norwegian Sea and North Sea suddenly collapsed without any warning. Little is known about this collapse while several hypotheses can be put forward, *i.e.*, changes in bluefin tuna migratory routes, recruitment failure or eradication of a sub-population (all three hypotheses could be due to natural causes and/or overfishing). To try to clarify this mysterious event, an original dataset of the main bluefin tuna fisheries of the 20th century, including total catch and size composition of the catch, has been constructed and analysed. The results display a strong and clear link between the Nordic and Spanish trap fisheries during the 1950s and 1960s which, however, vanished during the 1970s. In addition, the northwest Atlantic and Mediterranean trap fisheries also appeared partially connected with the Nordic fisheries. All together, the results give strong support to the hypothesis of changes in bluefin tuna migration patterns that could have resulted from both the collapse of the northeast Atlantic herring stocks on which bluefin tuna fed and the cooling of the northeast Atlantic of the early 1960s. From this perspective, current overexploitation in the Mediterranean Sea could explain why bluefin tuna did not return massively in the northeast Atlantic since the 1990s. This retrospective analysis further leads to an original, albeit more speculative, hypothesis on Atlantic bluefin tuna population structure, herein conjectured as an assemblage of three interacting subpopulations.

Abid and Idrissi (BFT_SYMP/026) presented an analysis of the Moroccan tuna trap fishery targeting bluefin tuna which shows that in general the CPUE decreased from 1986 to 1995, increased during the period 1996 to 2001, and since then the CPUE has shown a downward trend. There is no strong correlation between the bluefin tuna catches and the fishing effort targeting this species. Instead, the catch level is determined by the abundance of the spawners migrating every year along the Moroccan Atlantic coast. The mean weight of the individuals caught also shows a decreasing trend during the period 1997-2005.

Bridges and others (BFT_SYMP/027) presented results of an investigation supported through the auspices of the EU-Project IN-EXFISH, an analysis of historical data sets on catch and also model-generated data on spawning stock biomass (SSB) and recruitment have been used to look for possible influences of the North Atlantic oscillation (NAO) on the eastern bluefin tuna stock. Initial evidence has shown that total catch can be correlated to the winter NAO but only after a lag of two years. A further analysis of remote sensing sea surface temperature (SST) data for the main spawning areas in the Mediterranean (Balearic, Tyrrhenian, Ionian and Levantine Seas) revealed an SST anomaly which is increasing and already indicates values in summer during the spawning season of up to +3° C. These changes in SST anomaly do not appear to be correlated with changes in the NAO.

Karakulak and Oray (BFT_SYMP/028) presented information on Turkish trap fisheries for bluefin, which date back to the 15th century. Fish traps used to be set in the Sea of Marmara, Bosphorus and in the Black Sea from April/May to late August. The number of bluefin tunas captured in a single fish trap in one fishing season varied between 100 to 150–, each weighing 100 to 450 kg. With the decrease of fish stocks, marine pollution, urbanization, fish traps lost their importance in the Turkish bluefin tuna fishery. Recent studies show that bluefin tunas have not been migrating to and from the Black Sea since 1986. Most probably, due to this reason the fish traps have lost their effectiveness in the bluefin tuna fishery. Today, the former bluefin tuna traps are utilized to capture small pelagic fishes, such as horse mackerel and silversides. Purse seining for bluefin tuna began in the 1950s, primarily in the Sea of Marmara. The purse seine fisheries in the mid-1980s were limited to the Sea of Marmara catching large fish (even over 300 to 400 kg per fish); the fishing season was during the winter months. Many owners of tuna purse seiners replaced their old boats, utilizing the special government credits and improved their fishing power considerably. Since 1989, the fishery has developed in the North Aegean Sea, expanding gradually to the South Aegean Sea, catching small to medium sized fish (25 to 45 kg) from winter to early spring, and later from early spring to the end of May. Between 1988 and 1990, the expansion of the bluefin tuna fishery was accelerated with the low production of anchovies. When the catch of anchovies declined, the effort of the purse seiners went to targeting more bluefin tuna. In 1994, the purse seiners started operating in the Mediterranean Sea. Since 2000, the Turkish bluefin tuna fishery is conducted in May and June, in the eastern Mediterranean Sea in the international waters off northern Cyprus and in the waters between Cyprus and Turkey.

Vella (BFT_SYMP/029) described the fisheries of the Maltese Islands which have caught bluefin (traps) since 1748, reaching stable usage around 1948. However, this fishing method was finally replaced by longline, initially as a by-catch in the swordfish fisheries, prior to focusing on bluefin tuna longlining in 1995 when the Japanese opened the doors to bluefin tuna trade caught by Malta. Thus, looking back at historic data, changing efforts and gear may not be the only single method to understand the causes for the decline of bluefin tuna in certain regions, where a variety of environmental and fishing gear changes leading to fishing intensification has been taking place. With an increase in purse seining and the advent of tuna penning (cage storage of live tuna for a number of months after the fishing season has ended) and the greater interest in this same species with poor off shore monitoring tools, the results of this study assists in better understanding the impacts and extinction risks of this species in one of its important spawning areas. The ecological research considerations side by side with the bluefin tuna population's DNA study undertaken by the Conservation Biology Research Group of the University of Malta, targets a detailed picture of the bluefin tuna species spawning in the central Mediterranean. Over 300 bluefin tuna specimens caught offshore were sampled since 1998 in order to study variations in sizes, sex ratios, biogeographical setting and molecular genetic identity and various interesting results have been obtained.

Addis and others (BFT_SYMP/030) presented an evaluation of the anthropogenic impacts on the bluefin tuna trap fishery of Sardinia. The traditional traps (tonnara) harvest the ancestral migratory flow of the Atlantic bluefin tuna at a fixed site. Therefore, it is reasonable to consider local perturbations generated by social and economic events and environmental changes, as disruptive to the pathways of bluefin tuna schools and thus account for variability in the Mediterranean trap captures. This region, for at least two thousand years (since Cartage and Roman domination), was also historically important for lead, silver and copper mining. The cumulative impacts of environmental hazards resulting from historical mining and recent industrial activities is well documented: on land, in the coastal zone and in human health risk factors. Results showed that the effect of run-off from watershed mine tailing dams creates a pulsing boundary 'reflective' effect for tuna migration schools in one *in-shore* trap, resulting in a periodic oscillation of captures.

The Symposium concluded from Session 4:

- There was a strong connection between the Nordic fisheries and the northeast Atlantic traps (from Spain, Portugal and Morocco) and secondarily with Mediterranean traps as well as the northwest Atlantic trap. The collapse of the Nordic fisheries is not an isolated event.
- Atlantic bluefin tuna might be seen as a metapopulation constituted by at least by 3 three sub-populations that have varied in size in response to environmental changes and overfishing. Individual markers may be of great help to investigate/test the metapopulation hypothesis and thus stock structure of bluefin tuna, as first results tend to show.
- The fishing grounds have also changed significantly in the eastern Mediterranean Sea during the 20th century, moving from the Marmara Sea to the Black Sea and finally to the Aegean Sea. In general, there were several extinctions/discoveries of important fishing grounds in the Mediterranean as well as in the East Atlantic during the 20th century.

- The importance of investigating fisheries at different spatial scales: *i.e.* large scales to detect connectivities between fisheries/stocks and impact of large-scale events (*e.g.* fishing, climate) and small -scale events to detect the impact of local events (*e.g.* coastal pollution due to industrial activities).
- Traps provide highly valuable scientific information from an ecological and a fisheries perspective as they are passive fishing gear being set at the same location and submitted to low technical modifications.
- Causes for drastic changes in fisheries of the 20th century are likely to result from interactions between biological, environmental trophic and fishing processes.

− **Session 5:** ***Overview of the Western Atlantic Fisheries***

Lutcavage provided an overview of the western Atlantic fishery. In her presentation, she noted that the western fisheries also had a long historical record, and provided some landings information from the late 1800s for the New England fishery. Lutcavage noted key points in the development of the fishery, including the provision of air freight services, changes in the gear used in the fishery, and implementation of size limits. In the more recent fishery, she contrasted the patterns of landings in the Canadian fishery which is currently experiencing good catch rates (particularly in the southern Gulf of St. Lawrence) to the U.S. fishery, which has had large quota shortfalls in recent years for the commercial component of the fishery. Additional material was presented that highlighted the development of the angling component of the U.S. fishery, and the reduction in the presence of larger size-classes in the fishery.

Lutcavage then discussed the recent changes in the U.S. fishery, and noted that there is some evidence for a change in distribution to the northeast. Possible reasons for the change could be related to prey distributions, and there have been observations of decreased condition of western bluefin tuna in the Gulf of Maine and southern Gulf of St. Lawrence. Lutcavage then focussed on the reproductive status of bluefin tuna, and she noted some of the uncertainties in the reproductive schedule. She concluded by presenting some results from pop-up satellite archival tagging studies. She noted that the results to date indicate that bluefin tuna movements are complex and highly variable, with differences noted among years of release, size-classes and location.

Suzuki then presented an account of the Japanese longline fishery which appeared suddenly and virtually disappeared in about 10 years with a substantial catch around the early 1960s (BFT/SYMP/031). Changes in time/area of the Japanese longline operations by 1 degree square and month indicated migrations probably for spawning to the Gulf of Mexico and adjacent waters and further north to New England waters of the United States followed by return migration to Brazil-central tropical Atlantic in autumn, and then, further southward movement to Argentine waters. Among several hypotheses that were proposed to explain this event, the authors favoured the temporal distribution hypothesis (similar to the concept of metapopulation). The authors noted that a comparative study with Pacific bluefin fisheries shows that similar events seem to have also occurred in the Pacific. For further investigations with this hypothesis data mining of the old Japanese longline fishery around this time period should be made, especially for size data. If the metapopulation hypothesis is supported, there could be significant implications both to science and to management of bluefin tuna.

The Session concluded by emphasizing that:

- The western stock is in a low state of abundance, and the spatial distribution may be changing.
- In common with the eastern stock, there are examples of tuna assemblages that have been extirpated. These have included large-scale aggregations, such as the one off Brazil in the 1960s, and smaller ones, such as the one that supported the trophy sport fishery off Nova Scotia (Sharpe Cup, 1930s-1960s).
- PSAT tagging results show diversity of movement patterns; areas where bluefin have been extirpated would be expected to be periodically revisited, raising the potential for recolonization.
- Changes in size structure can provide a warning of imminent fishery collapse.

− ***Session 6: Overview of the Pacific Ocean Fisheries***

Miyabe's contribution (BFT_SYMP/033) described the geographical distribution of Pacific bluefin tuna as Pacific-wide, but most of the population exists in the northwest Pacific near Japan. Another significant distribution is known in the area off Baja California and west coast of the United States. Other minor distributions occur around New Zealand as well as eastern coast of Australia. Pacific bluefin tuna have been

exploited by the various Japanese fisheries in the near-shore waters around Japan. Traditional gears were trap, pole-and-line and various types of angling. Longline catches are mostly comprised of large adult fish while other fisheries catch mostly small fish less than 100 cm in fork length, except for purse seine fishery, which takes both small and large fishes. In the western Pacific, Korea catches smaller fish by purse seine gear, and Chinese Taipei has a longline fishery targeting large fish in the spawning area. It is well known that the young fish (age 1 and 2) make trans-Pacific movements from western to eastern Pacific, and then go back to the western Pacific after staying there for two to three years. Since the 1950s, the total catch in the Pacific Ocean fluctuated between 8,700 mt in 1990 and 40,000 mt in 1956. The average catch during the past 10 years was 22,500 mt.

Muto and others (BFT_SYMP/032) presented the results of an on-going data mining study undertaken to roughly estimate the long-term level and trend of catch of Pacific bluefin tuna. During the 1800s, longline and gillnet fisheries commenced their activities. Japan has been collecting annual tuna catch statistics since 1894, and the complete species of specific catch statistics has been available since 1951. This study was undertaken to estimate the catch of Pacific bluefin tuna around Japan before 1951. Archival materials on Japanese tuna fisheries from public archives in Japan and Chinese Taipei were searched as were other sources. For the years 1894-1950, the annual Pacific bluefin tuna catches in Japan and adjacent areas are tentatively estimated as 1,600-25,000 t. The annual amounts of catch in this period are comparable to the present level. The estimated catches also show large fluctuation over time.

Aires da Silva and others (BFT_SYMP/035) described the fisheries for Pacific bluefin in the eastern Pacific Ocean (EPO), which generally exploit a juvenile (mainly age-1 and age-2 fish) segment of what seems to be a highly migratory northern Pacific-wide bluefin stock. Purse seining for bluefin tuna in the eastern Pacific Ocean was initiated in about 1914. Prior to 1930, fishing took place only off California, from about 1930 to 1948 there was considerable fishing effort off both California and Baja California, Mexico, and since about 1948 fishing has taken place mostly off Baja California. The catches were taken predominantly by U.S. and Mexican purse seiners. Annual catches have fluctuated considerably since the early days of exploitation, with an historical peak at about 16,000 t in 1966. Two major historical events occurred in the fishery. First, starting in the early 1980s, increasingly effective measures by the Mexican government to enforce its Exclusive Economic Zone resulted in a gradual exodus of U.S. boats from the fishery. Second, beginning in 1996, bluefin farming initiated in northern Baja California, and some Mexican vessels began to direct their effort toward bluefin off Baja California during the summer and early fall. The fish are transported to holding pens, where they are fattened for several months before being slaughtered for the production of sashimi, considered to be a delicacy in Asia and other parts of the world. During recent years (1999-2006), the catches of bluefin by Mexican vessels have averaged about 4,500 t, and peaked at about 9,800 t in 2006.

Masuma (BFT_SYMP/034) presented the results of three decades of research on industrial farming of the Pacific northern bluefin tuna in captivity has developed mainly around southern Japan. Farming of PBT in a pen made it easy to observe the behavior, growth, and biological development of them until harvesting. The Fisheries Laboratory of Kinki University began research into the technical improvement for broodstock rearing of PBT in pens starting in the 1970s and succeeded in the spawning of Pacific northern bluefin tuna in captivity for the first time in the world in 1979. The Japanese Fisheries Research Agency (FRA) started research on developing techniques for seedling production with the objective of enhancing the Pacific northern bluefin tuna resources in the Pacific Ocean by releasing the artificial seedlings at the island on the Nansei Archipelago: Amami Ooshima and Ishigaki. These techniques have included the research on broodstock and embryonic and larval stages of Pacific northern bluefin tuna. To date this research has provided many biological findings for PBT in captivity, such as behavior, growth at age and with water temperature (WT), maturation and spawning at age and size etc., though there may be differences in the findings between fish in the wild and fish in captivity. Growth of bluefin tuna in captivity can exceed that in the wild. The differences in WT (annual average) at bluefin growout sites in Japan can make a difference in weight gain, though there does not seem to be any difference over about 23°C. It appears that the growth of Pacific bluefin tuna is dependent on annual WT: WT strongly affects feeding activity.

Matsuma also pointed out that gonads of Pacific bluefin tuna among the broodstock in captivity start to develop from 2 years old for males and 3 years old for females. The actual evidence of first age of spawning of Pacific bluefin tuna in captivity at specific areas in Japan occurs from 3 years old. Spawning sites appear to spread widely with age around Japan with different environment, although appropriate condition for spawning area needed at least. Spawning occurs intermittently from mid-May to early November in the latest case, with a peak during June-July, similar to the spawning period reported previously for wild bluefin around Japan. It was suggested that the start of spawning might be influenced by rising ambient temperatures. The number of eggs varies greatly by year and broodstock. Some findings, such as individual spawning frequency and fecundity, for spawning ecology of Pacific northern bluefin tuna in captivity became clear by the mitochondrial DNA analyses.

In addition to spawning ecology, many data sets related with egg size of Pacific bluefin tuna have also been stored under the captive condition so far. These findings extracted from tuna farming in a pen, including findings impossible to obtain from the wild specimens, must help to increase scientific understanding and management of wild resources of PBT as well as the other bluefin resources.

From these presentations, the Symposium noted that Pacific bluefin tuna underwent large fluctuations several times, without trend, in the past 50 years, both in recruitment and spawning stock size, possibly a unique characteristic compared with Atlantic bluefin and southern bluefin tunas. On the other hand, there is a clear similarity between Pacific and East Atlantic bluefin (including the Mediterranean Sea) fisheries that both fisheries are highly dependent on small juveniles with younger reproductive capability starting with age 3 and fully matured at age 5.

The bluefin fishery in the eastern Pacific has a long history starting in the early 1900s, mostly by purse seine boats catching juveniles. The catch fluctuated widely due to socio-economic factors as well as likely changes related to fluctuation in stock dynamics. Mexican tuna farming in the eastern Pacific has rapidly increased recently with high economic competitiveness of this country.

Data mining for the PBT for some 50 years before World War II shows that the level of bluefin catch in the period was at a comparable level with that after the War. Efforts to recover bluefin fishery records from older times than the past 100 years are now in progress and appear promising.

Information provided from various experiences on captive Pacific bluefin tuna tuna indicates that spawning does not always take place annually, egg quality is likely the same between young and medium-old adult Pacific bluefin tuna, and that a rapid increase of sea surface temperature to 24 C triggers spawning etc.

The Session concluded with the following recommendations.

- Further studies are highly encouraged in data mining of the historic period and size information should be searched in addition to the catch records.
- Monitoring of tuna farming in the eastern Pacific should be continued with further refinement of measuring catch in number/weight/length by new technology, such as stereo-video camera, which is expected to be implemented in the farming cages of southern bluefin tuna.
- More information on captive bluefin tuna should be provided and comparison between-wild and captive fish will provide useful indication for future studies.

− Session 7: Similar Situation in Other Fisheries

This session focused on southern bluefin tuna (SBT) as it was considered the most relevant and closest fishery to that for northern bluefin with respect to the underlying biology and fishery management issues. The moderator in introducing this session suggested that an understanding of the history of the science and the assessment/management process was also an important component for understanding the history of fishery and interpretation of the available data and information from the fishery.

A single presentation was made by Polacheck in this session who provided an overview of the history of the fishery, estimates of temporal trends in abundance of the stock and information on distributional changes for southern bluefin tuna. The following are a summary of the main points of his talk with respect to the history of the fishery and temporal trends in the stock:

- Substantial commercial fisheries for southern bluefin tuna developed rapidly in the 1950s, with the largest catches ever taken in the early 1960s.
- Large IUU longline catches occurred in the 1990-2005 period and have seriously compromised the catch, size data and main tuning index (i.e., Japanese longline CPUE) used in the southern bluefin tuna stock assessment.
- Despite the problem of the large IUU catches in the 1990-2005 period, all analyses suggest that the spawning stock has continually declined since 1960 (current levels are perhaps 5-15% that of 1960).
- The same analyses suggest substantial recruitment declines since the late 1960s-early 1970s.
- Estimates of growth rates indicate that juvenile growth has increased during each subsequent decade of the fishery, somewhat in parallel with declines in the overall stock.

The presentation also provided information on the distribution and movement patterns of juvenile southern bluefin tuna. It reported that there have been large changes in the distribution and movement patterns of juveniles and that these appear to be related, at least in part, to locally high exploitation rates. The main points in this regard were:

- In the late 1970's a major component of the juvenile stock and fishery (i.e., the summer feeding area off New South Wales) collapsed. The collapse was associated with high exploitation rates. There has been no sign of recovery in this area despite subsequent increases in juvenile escapement and abundance in winter in the Tasman Sea;
- Current fishing mortality rates for age 3 and 4 fish found in the Great Australian Barrier (GAB) appear extremely high and are substantially greater then in the1990s;
- Archival and conventional tag return data suggest that juveniles found in the GAB in the summer are now rarely going into the Tasman Sea during the winter in contrast to the 1990s;
- Tag return data suggested that only a small fraction of the 1-year-old fish found off western Australia are subsequently utilizing the GAB as a summer feeding area in the 2000s in sharp contrast to 1990s. What has happen to these one year old fish is unknown and as are the implications of the changes in migration for those fish found in the GAB.

Finally, the presentation briefly considered the question of changes in distribution for the adult component of the stock. It concluded that:

- The data available for analysing changes in adult distribution are limited and problematic;
- Interpretation of the available data is confounded by changes in fishing effort distributions and operational/management changes plus issues of data reliability;
- Given the available data, there is no strong evidence for large, major shift/contraction in the spatial distribution of the adult stock. However, the data do suggest the possibility that some relatively substantive changes may have occurred as well as the existence of finer scale changes in use of space.

In closing this session, Polacheck presented a summary of what he considered to be relevant general lessons learned from the history of the fishery, science and management of southern bluefin tuna as a basis for providing a focus for subsequent discussion. The lessons identified included:

- In the absence of meaningful verification and compliance systems, under-reporting and IUU catches can be expected, particularly in quota managed fisheries. The problem is not limited to non-members of RFMOs and flag of convenience vessels;
- Rebuilding trajectories for a depleted stock are likely to be different from those predicted based on estimates of the dynamics of the decline;
- Simple assumptions (parsimony) in the absence of data are likely to be wrong;
- Consideration of spatial dynamics is important for understanding the history of a resource and stock assessments;
- Integrated, statistical catch-at-age approaches provide a more scientific rigorous assessment method which allows for incorporation of a wider range and expanded time series of historical data and improved characterization of uncertainty then VPA;
- Management procedures provide a substantially improved approach for providing scientific management advice but are not a "silver bullet";
- Modeling input data scenarios are a poor substitute for acquiring reliable, high quality data in the first place;
- Managers need to understand and become realistic about the actual level of risk associated with their decisions and that they are willing to accept;
- The role of science in the management process needs to be better clarified/understood (*e.g.*, science can advise on the consequence of alternative actions, while recommendations on management actions can only be meaningfully provided in the context of well articulated management objectives);
- Political interference in the scientific assessment/advice process is not uncommon but is rarely discussed or documented.

4. General Discussion, Recommendations

There are important dynamics in the Atlantic bluefin fisheries that took place prior to 1970 which should be incorporated into our overall analysis and be utilized to shape our scientific advice to the Commission.

In the short-term (before the June 2008 stock assessment), it is unlikely that appropriate methodologies for incorporating historical information with different statistical characteristics into our stock assessment can be achieved to the full satisfaction of SCRS. This could only be achieved over a much longer period. While the current workplan for the 2008 bluefin stock assessment partly addresses the need to incorporate more biological realism into our evaluation of stock status, it is not clear that the current level of uncertainty in the assessment will be reduced in the short-run. Even in view of the high uncertainty, available information indicates that under recent conditions, Atlantic bluefin tuna appear rapidly headed toward biological bankruptcy: spawning biomass is quickly shrinking and exploitation rates are much higher than the rate of interest nature provides. Our evaluations tell us that catches of bluefin tuna now are the highest in ICCAT's history; biomass of age 8 and older bluefin tuna ~~are~~ is at the lowest level estimated, and possibly the lowest since 1950 or before; and that these catches are much too high to permit achieving the Convention objectives. Capturing more history is likely to inform us better about biomass levels to which rebuilding must occur to be consistent with the Convention objective and the rate at which rebuilding can occur to meet the Convention objective, but it is less likely to greatly alter our assessment of current exploitation rates. Critical to the issue is seeking an answer to the question: can bluefin tuna abundance levels previously observed off the coast of Brazil, the North Sea and traps be re-established?

In view of the above, it is incumbent upon SCRS to fully describe the information needed to progress in improving the advice we can offer the Commission and how to obtain such information. This is likely to involve coordinated data collection mechanisms which, in general, have not yet been realized through the various national programs under way.

An important aspect of recovering historical information which can better inform our assessment of bluefin is a data mining activity designed to capture and incorporate historic information into the ICCAT database. It is of key importance for SCRS to have full access to all historical fishery data collected on bluefin tuna, especially those from the early years of the 20th century. This data mining should, for instance, target the recovery of all the historical data collected (published and unpublished) on the North Sea fisheries (for instance, within the ICES Tuna Working Group on Norwegian, Swedish, German fisheries and from all other potential sources), from the various traps active in the Atlantic and the Mediterranean Sea and the various bluefin fisheries that have been active during the period, but not recorded in the ICCAT database. Data mining efforts should also target the recovery of the various sport fisheries that have been targeting bluefin tunas in the Atlantic and the Mediterranean during the 20th century (allowing identifying the place and dates of positive activities and the CPUE and sizes of fishes caught by each of these sport fisheries).

5. Adjournment

El General Director of the IEO, Dr. Enrique Tortosa, thanks the participants for their attendance and for the excellent work carried out. Dr. Tortosa pointed out the current false paradox between the exploitationof the fishing resources and the conservation of the species. He recognized the importance of the conclusions of the Symposium and the SCRS' work to provide scientific advice. He further noted the relevance of the continued work of ICCAT in the adoption of measures for the management and conservation of the resources. The Director General of the IEO expressed the Spanish Government's wish that public policies in general be based on science and that economy and resources be considered jointly.

Dr. José Luís Cort, the General Coordinator of the Symposium, thanked the participants for the exceptional work carried out. He recognized that the Sympsium had represented an excellent forum for discussion on subjects that are rarely discussed in other fora and he judged very positively the discussions held and the conclusions reached.

The report of the Symposium was adopted by correspondence.

The Symposium was adjourned on April 24, 2008.

Appendix 1

Session Themes and Papers Presented

***Session 1 – Historic Trend of Bluefin Tuna Catches: General Overview* (G. Scott, Moderator)**

BFT_SYMP/015 Fonteneau, A.
Atlantic bluefin tuna: An overview of 100 centuries of moving fisheries.

BFT_SYMP/016 Fonteneau, A. and A. Le Person.
Bluefin fishing in Lannion Bay, northern Brittany, during the 1946-1953 period.

***Session 2 – Collapse of the Fisheries in the North Sea and off the Norwegian Coasts* (B. MacKenzie, Moderator)**

BFT_SYMP/017 Tangen, M., Ø. Tangen and L. Nøttestad.
The Norwegian bluefin tuna fishery for the period 1920-1986.

BFT_SYMP/018 Nøttestad, L., Ø. Tangen and S. Sundby.
Possible mechanisms and explanations for the drastic decline and disappearance of Atlantic bluefin tuna in the Norwegian fisheries since the early 1960s: What went wrong and what can we do?

BFT_SYMP/019 MacKenzie, B. R. and R. A. Myers.
The development of the northern European fishery for North Atlantic bluefin tuna *Thunnus thynnus* during 1900-1950.

BFT_SYMP/020 MacKenzie, B. R. and R. A. Myers.
Ecological and fishing influences on presence of bluefin tuna in northern European waters.

***Session 3 – Decline of the Spawning Fisheries in the Cantabrian Sea* (E. Rodriguez-Marín, Moderator)**

BFT_SYMP/021 Cort, J.L.
The bluefin tuna (*Thunnus thynnus*) fishery in the Bay of Biscay.

BFT_SYMP/022 Cort, J.L. and E. Rodríguez-Marín.
The bluefin tuna (*Thunnus thynnus*) fishery in the Bay of Biscay. evolution of 5+ group since 1970.

BFT_SYMP/023 Cort, J.L., P. Abaunza and G. De Metrio.
Analysis of the northeast Atlantic juvenile bluefin tuna (*Thunnus thynnus*) population between 1949 and 1960.

BFT_SYMP/024 Rodríguez-Marín, E., J. M. Ortíz de Urbina, E. Alot, J. L. Cort, J. M. de la Serna, D. Macias, C. Rodríguez-Cabello, M. Ruiz and X. Valeiras.
Following bluefin tuna cohorts from east Atlantic Spanish fisheries since the1980s.

***Session 4 – Overview of the Eastern Atlantic and Mediterranean Fisheries, in Particular, the Traps* (J. M. Fromentin, Moderator)**

BFT_SYMP/025 Fromentin, J.M.
Back to the future: investigating historical data of bluefin tuna fisheries.

BFT_SYMP/026 Abid, N. and M. Idrissi.
Analysis of the Moroccan trap fishery targeting bluefin tuna (*Thunnus thynnus*) during the period 1986-2006.

BFT_SYMP/027 Bridges, C.R., O. Krohn, M. Deflorio and G. De Metrio.
Possible SST and NAO influences on the eastern bluefin tuna stock-the inexfish approach.

BFT_SYMP/028 Karakulak, F. S. and I. K. Oray.
Remarks on the fluctuations of bluefin tuna catches in Turkish waters

BFT_SYMP/029 Vella, A.
Bluefin tuna (*Thunnus thynnus*) fisheries of the Maltese Islands in the central and southern Mediterranean Sea.

BFT_SYMP/030 Addis, P., I. Locci and A. Cau.
Anthropogenic impacts on the bluefin tuna (*Thunnus thynnus*) trap fishery of sardinia (western Mediterranean).

***Session 5 – Overview of the Western Atlantic Fisheries* (J. Neilson, Moderator)**

BFT_SYMP/031 Takeuchi, Y., K. Oshima and Z. Suzuki.
Inference on the nature of Atlantic bluefin tuna off Brazil caught by the Japanese longline fishery around the early 1960s.

***Session 6 – Overview of the Pacific Ocean Fisheries* (Z. Suzuki, Moderator)**

BFT_SYMP/032 Muto, F., Y. Takeuchi, K. Yokawa, S. Ochi and M. Tabuchi.
Pacific bluefin tuna fisheries in Japan and adjacent areas before the mid-20th century.

BFT_SYMP/033 Miyabe, N.
Overview of the Pacific bluefin tuna fisheries.

BFT_SYMP/034 Masuma, S.
Biological information from Pacific northern bluefin tuna in captivity.

BFT_SYMP/035 Aires-da-Silva, A., G. Compean and M. Dreyfus.
An historical overview of the bluefin fishery in the eastern Pacific Ocean.

***Session 7 – Similar Situation in Other Fisheries* (T. Polacheck, Moderator)**

BFT_SYMP/036 Polacheck, T.
Changes in abundance and spatial distribution of southern bluefin tuna.

BFT_SYMP/037 Polacheck, T.

Appendix 2

LIST OF PARTICIPANTS

World Symposium for the study into the stock fluctuation of Northern Bluefin tuna (*Thunnus Thynnus* and *Thunnus Orientalis*), including the Historic Periods.
Santander- Spain, April 22 to 24, 2008

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