WORKSHOP ON FARMING, MANAGEMENT AND CONSERVATION OF BLUEFIN TUNA

5 – 7 APRIL 2003
ATAKÖY MARİNA
ISTANBUL – TURKEY

Edited by

Işık K.ORAY and F.Saadet KARAKULAK

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AN OVERVIEW OF WORLD BLUEFIN TUNA FISHING AND FARMING

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INTRODUCTION

Both Southern and Northern bluefin tunas (*Thunnus maccoyii* and *Thunnus thynnus*) are captured worldwide. Because of their flesh quality, bluefin tuna are among the most desired and expensive species; the Japanese market (sushi and sashimi tradition) is the main driving force for the captures.

In recent years, the wholesale price paid at landing for top sashimi-quality tuna has reached more than US $500 per kilogram. However, only very small quantities sell at these high prices.

The bluefin tuna fishery system changed deeply in the Mediterranean basin and in other parts of the world. This is due to the expansion of the tuna farming that is growing exponentially (particularly in the Mediterranean area) fuelled by the high profits related to the Japanese market. An overview of world bluefin tuna fishing and farming will follow.

BLUEFIN TUNA FISHERY

The Northern bluefin tuna fisheries are regulated by the International Convention for the Conservation of Atlantic Tunas (ICCAT), the Southern bluefin tuna by the Commission for the Conservation of Southern Bluefin Tuna (CCSBT). As a consequence of over-fishing, regulations and quotas are annually established or revised by the regional management bodies.

Bluefin tuna fishing is mostly carried out using purse seines, longlines, traps, hand line and harpoons, driftnets (now banned almost globally), etc. In 2000, Asia was the leading bluefin tuna fishery continent with 25,762 tonnes, followed by Europe with 20,288 tonnes, Africa with 8,989 tonnes, Oceania with 5,664 tonnes, North America with 4,030 tonnes and others with 683 tonnes.

The Mediterranean and the Black Sea account for 29 % of total captures, followed by South-western Pacific - 23 % and North-eastern Atlantic - 13 %.

Northern Bluefin Tuna Fishery

The Mediterranean and the Black Sea are the major fishing areas for northern bluefin tuna, with 38 % of global captures. The Mediterranean fishery was the first industrial one in the world, using the traditional tuna trap. Japanese economic support to north

African countries during the 80s and 90s, and joint ventures with European companies have increased the Mediterranean countries fishing and commercial capacities.

Europe was the leading continent in 2000 with 20,288 tonnes, followed by Asia with 16,471 tonnes, Africa with 8,987 tonnes and North America with 4,030 tonnes.

Southern Bluefin Tuna Fishery

In 2000, Southern bluefin tuna (*T. maccoyii*) was captured mainly in Asia (9,291 tonnes) and Oceania (5,643 tonnes). Total captures for 2000 amounted to 15,629 tonnes.

North-western Pacific area accounts for 34% of the total with 9,171 tonnes of southern bluefin tuna captures. The main Australian fishery area is around Port Lincoln (South Australia), with purse seine fleets as the main catching method.

PURSE SEINE FISHERIES (THE CONNECTION BETWEEN FISHERY AND FARMING)

The adoption by ICCAT of the quota system for the bluefin tuna in the Mediterranean brought a change in all the fishery. Purse seine fisheries became the most important providers for farming. Purse seining is more efficient than longlining as it targets identified shoals due to the technological developments of fishing operations. The impact of intensive fishing is compounded by new fishing technology which makes it possible to detect bluefin tuna shoals, e.g. aircraft and true-motion sonar systems; and a large proportion of the world's bluefin tuna are now caught by industrial fisheries.

The purse-seine fishery has become the most important provider of live tunas (minor quantities are provided by some tuna traps) for farming. The fish are first caught using a purse seine in the traditional manner, before being transferred to transport cages by "swimming through".

Purse-seining is a modern fishing technique developed in the 1960's. The method involves paying out a large net off the stern of a fishing vessel, with a bottom weighted (lead) line and a top float line extending the net vertically in the water. A second smaller vessel (skiff) pulls one end of the net from the purse seiner as both vessels encircle a school of fish from opposite directions until finally reconnecting the skiff end of the net with the purse seine vessel.

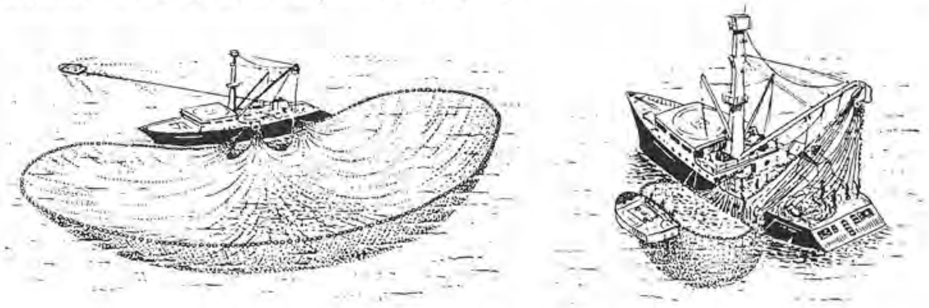

Figure 1. Purse seine system (Source: FAO)

The purse seiner then draws the bottom lead line closed, creating a "purse" to entrap the school of tuna.

Tab. 1 shows purse seine captures vs. total catch in the Mediterranean area (TUDELA, 2002).

Tab. 1. Purse seine captures versus total catch in the Mediterranean

Mediterranean area, Bluefin tuna captures	**1998**	**1999**
Purse seine catches	20,391	14,061
Total catch	26,813	24,036

While purse seine catches show a decrease - mostly due to the ICCAT catch limits - the total amount of farmed bluefin has continuously increased and the proportion of farmed tuna in the total purse seine catches has also increased annually. In 1999 and 2000, 30% and then 37% of purse seine catches were introduced to farming.

TUNA FARMING TOTAL PRODUCTION

The global supply of cultured tuna reached 20,000 tonnes in 2001 (IKEDA, 2002). Bluefin tuna are cultured world-wide; northern bluefin tuna in the Mediterranean area (Croatia, Spain, Italy, Turkey, Morocco, Tunisia, Malta), in Canada, Mexico, Japan and USA; southern bluefin tuna in Australia. Some of these activities are irregular or are at experimental levels. In general, tuna farming is expanding and license requests are increasing (France, Italy, Malta, Lybia, etc).

The supply of farmed tuna is mainly for Japanese sashimi, but it constitutes only 4% of the total amount of tuna required by the Japanese market. The supply of tuna (all the species) to the Japanese market ranged from 451,000 to 507,000 tonnes during the 1998-2001 period, but the ratio of fish with a high product value, called *toro* , is decreasing. *Toro* forms only approximately 30% of the captures, but the farmed tuna is considered as *toro* almost in its entirety. The advantages of cultured tuna are its low price (a third or half the price of the wild-caught variety) and its easy availability at supermarkets, fresh fish shops or kaiten-zushi restaurants throughout the year.

The trend in bluefin tuna farming production from 1999 to 2001 is showed in Figure 2.

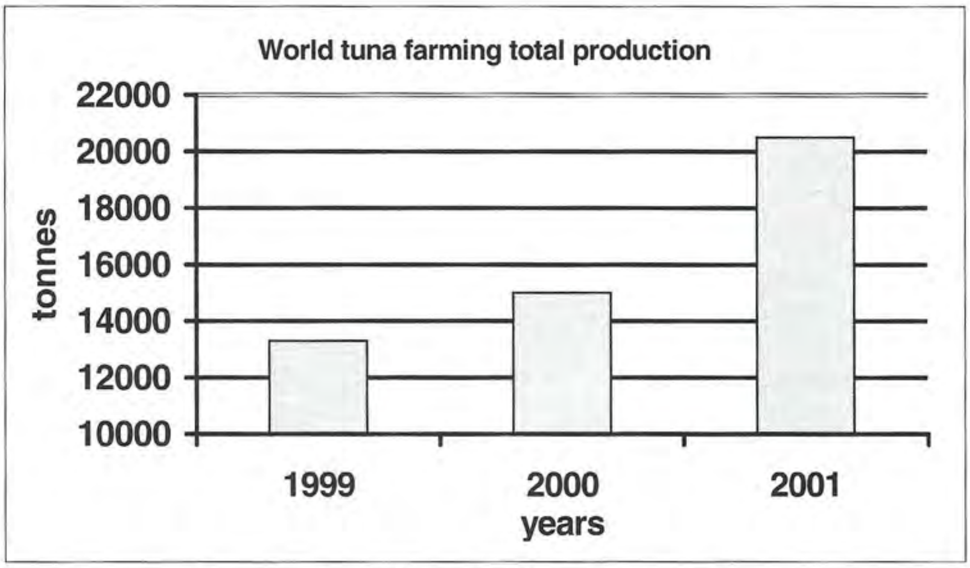

Figure 2. The world total production of farmed tuna.

The main tuna farming producers in 2001 were Australia, Spain, Croatia, Malta and Mexico (Figure 3). In these countries farms are often in joint venture with Japanese companies.

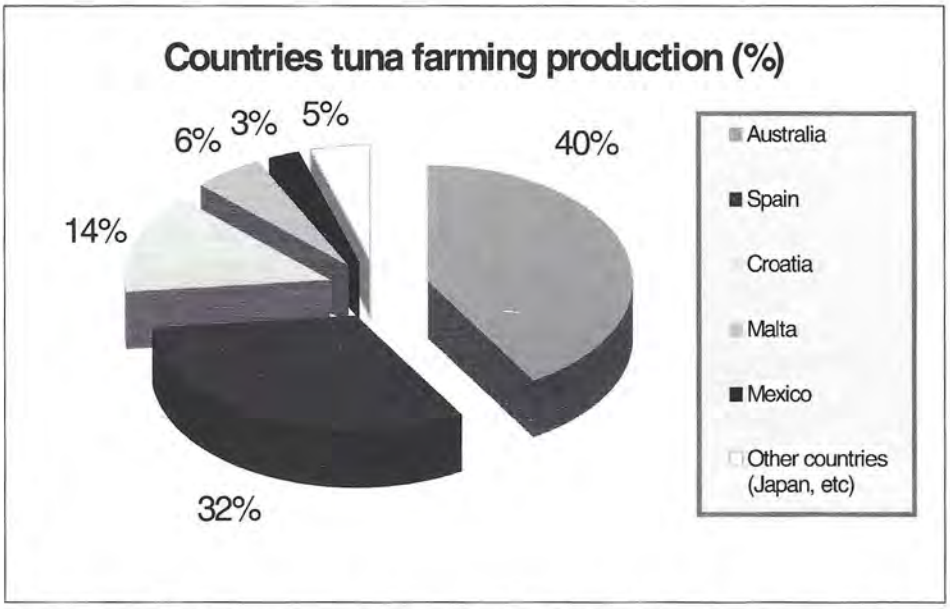

Figure 3. Total countries production (%) of bluefin tuna farming in 2001

Tuna Farming in Japan

Motoo Inoué, a Tokai University Professor (INOUÉ, 1973a,b), financed by the Fisheries Agency of Agriculture Ministry, started experimentation on bluefin tuna culture in 1970. The aim of the experience was to grow out juveniles to commercial size and, in the future, to actually breed the bluefin tuna.

The etology and physiology of the species created several problems to adapt the species to captivity, with low survival rates due to the capture stress.

At present, 18 companies and organizations farm bluefin tuna in Japan: 3 in Okinawa, 4 in Nagasaki, 2 in Wakayama, 6 in Amami and 3 in Ehime and Kochi.

In contrast with overseas tuna culture methods, juveniles of 150-500 g body weight are caught off the coastal areas of Japan and are reared for 3 to 4 years in net cages until their body weight increases to between 30 and 70 kg, when they are harvested.

The most severe problem for the Japanese bluefin tuna farming is supplying fingerlings to culture farms. Even after capture, the newly-caught young fish react strongly to the stress of the capture and confinement. Their skin is also delicate, and it is damaged easily by mishandling. As a result, mortality rates are high at first. Fish which survive and acclimatise to farm conditions remain susceptible to mortality from sudden changes of climatic conditions.

It is necessary also to improve the rearing techniques used during growing out. The loss of juvenile and young adult bluefin tuna is often caused by collisions with the walls of tanks or nets that fatally damage the bones of the vertebral column and the parasphenoid (MIYASHITA *et al.*, 2000). The high number of deaths caused by bumping into the tank and net-pen walls at dawn can possibly be attributed to visually disoriented fish.

As wild-caught fingerlings are difficult to obtain and supply is uneven, the industry must rely on hatchery-produced fingerlings. A new and important goal was finally reached in June 2002: Japan researchers breed bluefin tuna full cycle for the first time. Researchers at the Kinki University in Wakayama Prefecture have successfully completed a full-cycle bluefin tuna (www.intrafish.com).

The fish spawned one million eggs and the achievement may pave the way for full-scale farming of the species in the future.

Tuna Farming in Mediterranean Area

In recent years, bluefin tuna culture has spread throughout the Mediterranean. This expansion is directly related to the interest and development in Japanese market. The culture is specifically aimed at producing tuna that have the optimal fat content demanded by the sushi and sashimi market, and both fresh and frozen tuna farmed products are exported to Japan.

Tuna farming in the Mediterranean is expanding and the production accounts for more than half of the world total.

The main production countries are Spain (Murcia region), Malta and Croatia which accounted for more than 11,000 tonnes in 2001. The Murcia region (Spain) alone exported more than 7,000 tonnes to Japan, worth more than €150 million. The trend in the main Mediterranean tuna farming producing countries for 2000 and 2001 is shown in Figure 4.

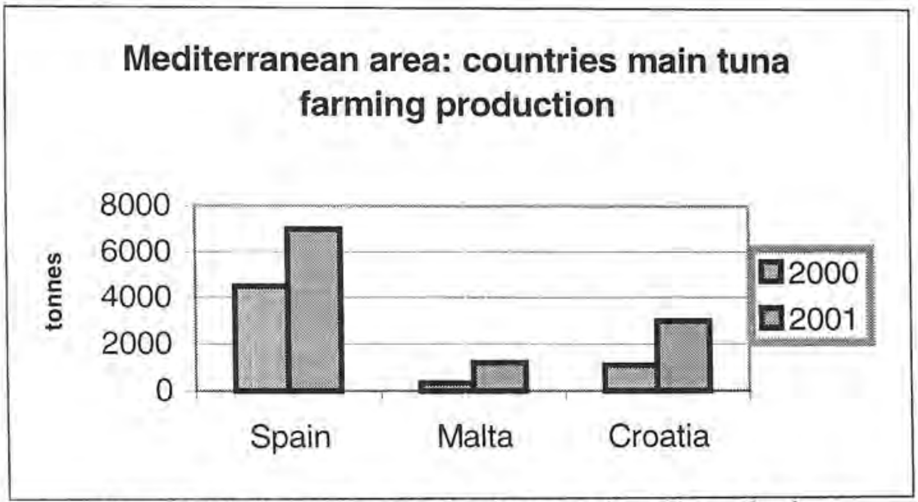

Figure 4. Mediterranean area: farming countries main production

In Mediterranean tuna farming is based on catches taken from wild populations (of different sizes), which are moved alive to floating cages in off-shore areas. The fish are then kept in large cages for variable periods, ranging from a few months to years, depending on the farming location and fish size.

In Malta, fish are put in the cages from May-July and kept there until October-January. The fish size ranged from 80 to 250 kg in 2000 and from 50 to 620 kg in 2001. About 1,200 tonnes were exported during 2001.

In Spain tuna farming started in 1996. The fish supply comes from purse seiners in the western Mediterranean (Spanish, French and Italian seiners), particularly around the Balearic Islands. Fish range from small (20 kg to 90 kg) to medium size (80 kg to 120 kg), and are mostly pre-maturity. Generally no fish are kept more than 10 months in this location (MIYAKE *et al.*, 2002). Project proposals for new tuna farms have been submitted to virtually all autonomous government regions along the Spanish Mediterranean coast, from Andalucia to the Balearic Islands, including Catalunya (TUDELA, 2002).

In Croatia, during the last five years, bluefin tuna farming averaged about 2,500 tonnes of harvested fish per year. The industry consists of 6 commercial companies using 9 lease sites (KATAVIC *et al.*, 2002). In Croatia the capture of juveniles for tuna farming occurs at the end of spring to early summer. The individuals captured range from some extremely small fish (less than 10 kg, including undersized or just legal minimum size set by ICCAT at 6.4kg) to small fish (20-80 kg); these are caught by the Italian and Croatian purse seiners in the Adriatic Sea.

The farming period differs widely between farms, but usually lasts 2-6 months, while the smallest specimens are usually kept in cages to grow for two or three years.

Small tunas usually dominate the catch composition in the Adriatic Sea (KATAVIC *et al.*, 2002).

Two farms were built in Italy for experimental use, and in 2001 a commercial farm was built near Trapani on the Tyrrhenian coast, where 400 tonnes of medium to large tunas were farmed (MIYAKE *et al.*, 2002).

In Morocco experimental culture of bluefin tuna started in the mid 1990's. The Moroccan Kingdom and the Japanese government undertook a joint venture; a large scale experimental project for the bluefin tuna farming in the North-West of the country, on the Mediterranean Coast. Its main purpose was to develop the technology for artificial breeding of the bluefin tuna.

The rapidly growing practice of bluefin farming in the Mediterranean has created a series of difficulties for the estimation and reporting of related fishery statistics. At present fishery statistics are based on catches, while production form farming is prepared from export data. The primary reason is the lack of accurate estimates for the total weight and the size composition of the catch: the problem is due to the transfer of live fish caught from the wild, and solutions e.g. the use of underwater cameras to count the transferred fish are not very precise. Therefore, the average weight of the bluefin tunas caught is only a rough estimate in order to calculate the total weight of the fish transferred to the cages

The pressure on bluefin tuna fisheries in the Mediterranean area has increased considerably over recent years. It is vital for future fisheries management to follow a precautionary approach to ensure that the existing equilibrium is not disrupted further.

Tuna farming in Mexico

In Mexico, Northern bluefin tuna (*Thunnus thynnus orientalis*) fishing for the farming is more difficult than in any other part of the world, due to problems with water depth and fish deep behaviour. The main fishing period goes from July to late August, but depending on fishing locations, the season can extend into November.

Tuna farming began in 1996, and Mexican tuna farming operations currently represent 3% of world production. The majority of operations are located on the pacific side of the Baja peninsula (SYLVIA *et al.*, 2002).

The original farms were Mexican owned and operated, but the current production companies are a combination of Mexican, Australian and Japanese partnerships. There are fourteen new tuna lease applications currently under review. Investigations are currently in progress for the development of tuna farming operations off the west coast of the United States - particularly in southern California - and also off the Hawaiian coasts (SYLVIA *et al.*, 2002).

Tuna farming in Australia

Southern bluefin tuna farming began as a result of a declining fishery.

The industry started in 1990 near Port Lincoln (South Australia), and has now developed into the largest farmed seafood sector in Australia (CLARKE, 2002). The development of the southern bluefin tuna farming industry was possible thanks to the collaboration between the Tuna Boat Owners Association of Australia (TBOAA), the Japanese Overseas Fishery Cooperation Foundation and the South Australian Government.

Today, Australian bluefin tuna is mainly sold to Japan, and in 2001, 99% of the Australian bluefin tuna farmed in Port Lincoln (South Australia) was exported to the Tsukiji market, Tokyo.

In 2002, the industry consisted of about 16 commercial companies.

Tuna farming in Canada

Since 1975, American enterprises and Japanese specialists have started capturing (with the trap system) and farming the bluefin tuna entering the St Margaret Bay (Nova Scotia).

The importance of an accurate knowledge of species etology is fully demonstrated by the Canadian fishing practice for farming: following some years of commercial success, a sudden change in the migratory pattern of northern bluefin tuna, due to hydrological changes in the warm current flowing into the Bay, has led to the closing down of the business for many years.

CONCLUSION

Japan is the main market for bluefin tuna produced from world fisheries: the Japanese custom to eat fresh tuna as sushi and sashimi is a driving force behind the development of tuna fishing, and is also supporting the development of the farming sector worldwide.

Tuna farming is expected to grow during the next few years due to further technological developments and the market demand.

Following the recent and sudden development of this practice, there is an undergoing discussion on the precise definition of the activity and its implications concerning economic, environmental, social, management and health issues, which will have to be evaluated with great care.

Environmental and ethical concerns (e.g. Mediterranean area) will continue to affect the functioning and image of the industry. Regulations are needed to create and control product traceability, quality and environmental issues.

The prospect of achieving the breeding of captive bluefin tuna and being able to manage the complete life cycle could represent a base from which the industry could grow. This issue alone would remove ecological concerns and guarantee a sustainable future for the sector.

It is therefore of crucial importance to establish interaction and cooperation procedures between the scientific world and the industry, both at national and international levels. This is the basis for a practice development in accordance with the most recent guidelines provided by FAO's Code of Conduct for responsible fisheries and aquaculture (FAO, 1995).

REFERENCES

CLARKE, S. 2002. Grow-out of southern bluefin tuna – the Australian experience. First International Symposium (Domestication of *Thunnus thynnus*; Cartagena- Spain 3-8 February 2002).

FAO 1995. Codes of Conduct for Responsible Fisheries, FAO, Rome.

IKEDA, S. 2002. Market and domestic production of cultured tuna in Japan. Cultured tuna in the Japanese market. First International Symposium (Domestication of *Thunnus thynnus*; Cartagena- Spain 3-8 February 2002).

INOUE, M. 1973a. Recent trends in artificial propagation of tunas. Propagation of marine resources of the Pacific Ocean. Pap. 1st Japan-USSR Joint Symp. Aquacul. Pac. Ocean. Recueil des travaux du départment d'océanographie de l'université de Tokai, 6: 37-46.

INOUE, M. 1973b. Possibility of artificial culture of the pacific tunas, review of the studies. J. Fac. Mar. Sci. Technol., Tokai Univ., 7: 297-312.

KATAVIC, I., VICINA, V., FRANICEVIC, V. 2002. Rearing of small bluefin tuna (*Thunnus thynnus* L.) in the Adriatic sea-preliminary studies. First International Symposium. (Domestication of *Thunnus thynnus*; Cartagena- Spain 3-8 February 2002).

MIYAKE, P.M., DE LA SERNA, J.M., DI NATALE, A., FARRUGIA, A., KATAVIC, I., MIYABE, N., VICINA, V. 2002. General review of bluefin tuna farming in the Mediterranean area. Col. Vol. Sci. Pap. (ICCAT SCRS/02/36 1-12).

MIYASHITA, S., SAWADA, Y., HATTORI, N., NAKATSUKASA, H., OKADA, T., MURATA, O., KUMAI, H. 2000. Mortality of northern bluefin tuna *Thunnus thynnus* due to trauma caused by collision during growout culture. Journal of the world aquaculture society, 31(4): 632-639.

TUDELA, S. 2002. Tuna farming in the Mediterranean: the "coup de grãce" to a dwindling population? WWF Document prepared with the collaboration o Niki Sporrong, WWF European Fisheries Campaign Policy Officer and the WWF European Fisheries Working Group: 1-14.

SYLVIA, P.C., BELLE, S., SMART, A. 2002. Current status and future prospective of bluefin tuna (*Thunnus thynnus orientalis*) farming in Mexico and the West Coast of the United States. First International Symposium. (Domestication of *Thunnus thynnus*; Cartagena- Spain 3-8 February 2002).

WEB SITES. www.intrafish.com

TUNA FARMING AS A NEW ACHIEVEMENT IN MARICULTURE OF CROATIA

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ABSTRACT

The farming of the bluefin tuna in Croatia has developed rapidly since 1996 followed by the dramatic increase of fattening units in the several Mediterranean countries. Initially, purse-seine caught bluefin tuna were fattened over a period of four to six months, harvested and exported to Japanese market. Recently, an entirely new concept was developed in Croatia. The small to medium sized fish (<10 to 20 kg and more) are being fattened for over two or even three years before being shipped, aiming to better use a limited fishing quota by increasing biomass several times, to improve the value of the fish produced, and thus, to obtain better market price. Tuna farming has important commercial, social and environmental impact. It brought dramatic change into the commercial fishery and created many new jobs on the heavily depopulated Croatian islands. However, if not properly planned and managed, tuna farming may produce an undesirable impact on the marine environment causing conflict with other coastal users. Sea water can be polluted either from leftovers, metabolic waste produced by farmed tuna, or from slaughtering and processing the fish. The focused effort and collaborative research is needed if sustainable bluefin farming industry is to be established.

INTRODUCTION

The northern bluefin tuna (*Thunnus thynnus* L.) belong to a family *Scombridae*. It is a large pelagic fish species inhabiting both the Atlantic and the Pacific. Bluefin tuna fisheries in the Atlantic are found along the North American coast, in the West Atlantic, along northern Africa and the European coasts, in the East Atlantic, as well as in the Mediterranean Sea, including Adriatic. It is a big, marvelous fish, which grow to over 3 meters and a weight of 650 kg. It is perfectly adapted to swimming, and migrates several thousand kilometers every year. When being fished or in pursue for food its speed reaches up to 35 miles per hour. It is able to swim across the Atlantic in less than 50 days. It is a top predator that feeds on fish and squids, sharing these resources with marine mammals and men. Another peculiarity is bluefin tuna life span: it can live more than 20 years. Sexual maturity is reached at the age of 5 to 8 years depending on the stocks.

The fact that the meat of wild caught fish is normally of variable quality over the year, because of many uncontrolled factors, has led to increased subjection to improving its quality before being marketed. The tuna farming is being specifically challenged by a highly specialized and categorized Japanese *Sushi* and *Sashimi* market, where bluefin tuna (BFT) have, towards the end of the year, very high commercial value if the meat contains proper fat contents. The price may oscillate in the same market from a few dollars for a lean bluefin tuna up to $ 200 to 300 per kg for fat tuna (MIYAKE *et al.*, 2002). Usually, the ideal size for the Japanese market is a tuna larger than 40 kg. if its meat has the necessary content of fat demanded by the market. In the past Japanese bluefin tuna market used to recognize expensive fat pre-spawners and cheap lean post-spawners and juveniles.

The first tuna farming started in Canada in the late 1960's by a Japanese farm with an idea to keep and feed tuna in a cage for a few months. During this period fed tuna has increased fat content. However, soon after first Canadian experience, the Mediterranean purse seiners discovered that even medium size tuna could be sold to Japanese market for a rather good price if its meat has a high fat contents and pink flesh color, and consequently similar type to Canadian BFT farming was started in late 1970's (MIYAKE *et al.*, 2002). During 1980's, on another side of the globe, Australian fishermen established a completely new market for southern bluefin tuna *(Thunnus maccoyii)*. In the 1990's, stirred by the success of farming southern bluefin tuna, the farming of the northern bluefin tuna spread very quickly throughout the Mediterranean Sea. The Croatian fishermen living in Australia, who were engaged in the southern bluefin tuna farming, returned to their home country and started the operation in 1996. The 1st pilot program resulted with 39 metric tons of gutted and gilled tunas exported to Japan. The further investment by Croats living in Australia enabled a rapid increase of tuna farming activities.

The fattening process of bluefin tuna is a relatively simple practice with fish being typically kept in the cages and fed with a variety of small pelagic fish species as well cephalopods such as squid, during several months before landing and shipping. The economic gains in bluefin tuna fattening in the Mediterranean have lead the private sector in Spain, Italy, Malta, Morocco to invest into this relatively new mariculture system. In these countries bluefin tunas usually have been fished by purse seine and entered into cages in May to July, and they are kept in the cages until November to January, as they are ready to be exported to Japan. According to a GFCM/ICCAT report (MIYAKE *et al.*, 2002) from 1996 to 2001, there was at least a 20-fold increase in the number of cages in the Mediterranean. Recently, about 2/3 of the Mediterranean bluefin tuna exported to Japan originate from cages.

However, the tuna farming led by high profits, brought a dramatic change in the Mediterranean fishing industry and has also a significant socio-economic impact. It has changed fishing strategies as majority of fish caught by purse-seiners are now transferred to cages for fattening rather than landed and sold directly. With the new practice the reliability of catch statistics has further deteriorated that may cause further difficulties in proper management of the eastern bluefin tuna population. In this paper growing interest for farming of this marvelous fish is discussed from different points of view. In addition, some specific information on the farming practice in Croatia is reviewed and its socio-economic and environmental impacts are discussed.

CROATIA BLUEFIN TUNA FARMING AS A SPECIFIC CASE

The farming in Croatia is based on the concept of the collection of wild specimens of bluefin tuna, ranging from <10 kg to fish >200 kg, being confined within large floating net cages, and get it fattened until shipped. Generally, the fish supplied to the Croatian farms are small fish (mostly from 10 kg to 80 kg), caught by the Croatian purse seine fishing fleet in the Adriatic Sea. Since all the Croatian purse seine bluefin tuna catch are being used for farming, it can be assumed that size of the fish entered into cages correspond to catch size composition (Figure 1). Recently, some of Croatian vessels go out from the Adriatic Sea for fishing bluefin tuna in the Mediterranean.

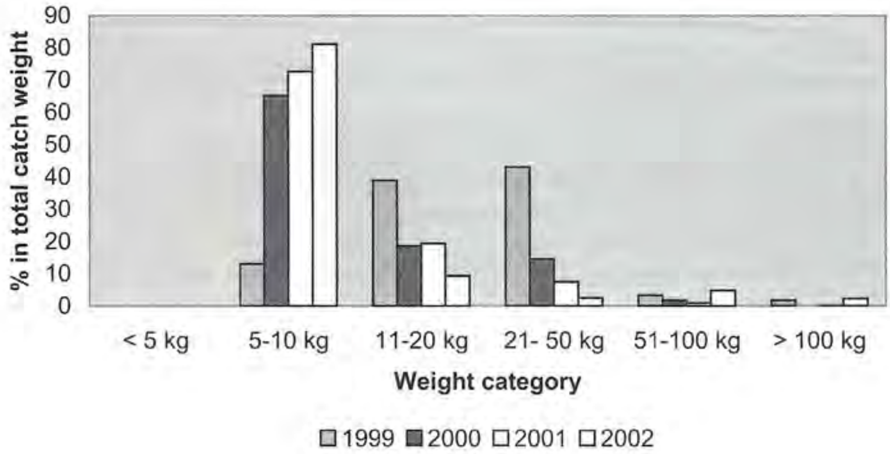

Figure 1. The catch size composition of the bluefin tuna in the Adriatic by year (1999-2002).

It is known that the spawning area for the eastern stock of blufin tuna in the Mediterranean Sea is mainly around the Balearic Islands, the Tyrrhenian Sea and the Central Mediterranean, while Adriatic Sea seems to be important nursery ground for the small size fish (TIČINA, 1994; TIČINA *et al.*, 2002). This is also clearly indicated by the size composition of bluefin tuna in Adriatic Sea. Consequently, if very small fish were fished (from 7 to 10 kg), they are kept in the cage to grow over two or even three years. These fish were fattened until shipped to Japan, and the weight increments are gained through standard on-growing fish farming practices. It should be pointed out that this practice make some problems in terms of catch statistics, because there is a large gap between the catch, amount of fish introduced into the cage and amount of fish harvested in the same year (Figure 2). However, because of low fat content, these small farmed fish belongs to less quality category in the Japanese market than those large farmed tuna.

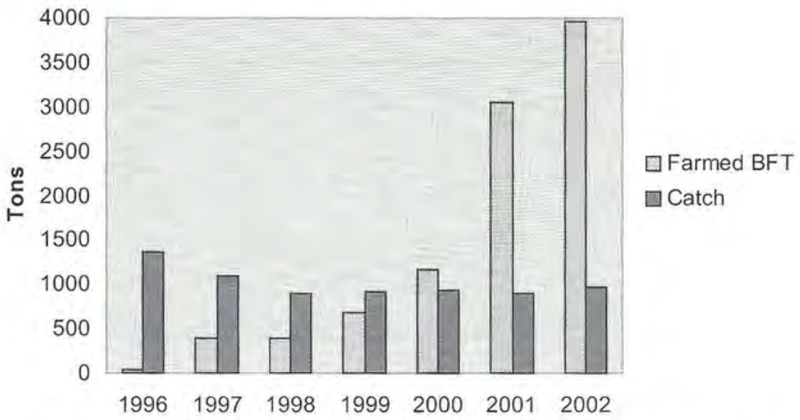

Figure 2. Comparison between Croatian catch and export of farmed bluefin tuna.

The type of the growth-out cage used for tuna farming is developed in Australia and adjusted to the local circumstances. That is a floating circled cage of a diameter of 50 m, suspended net of about 20 to 25 meters depth (KATAVIĆ *et al.* 2003a). They are only anchored partially and hence can be moved from one location to another. The farming is already performed by six medium to large farms at nine leased sites (Figure 3).

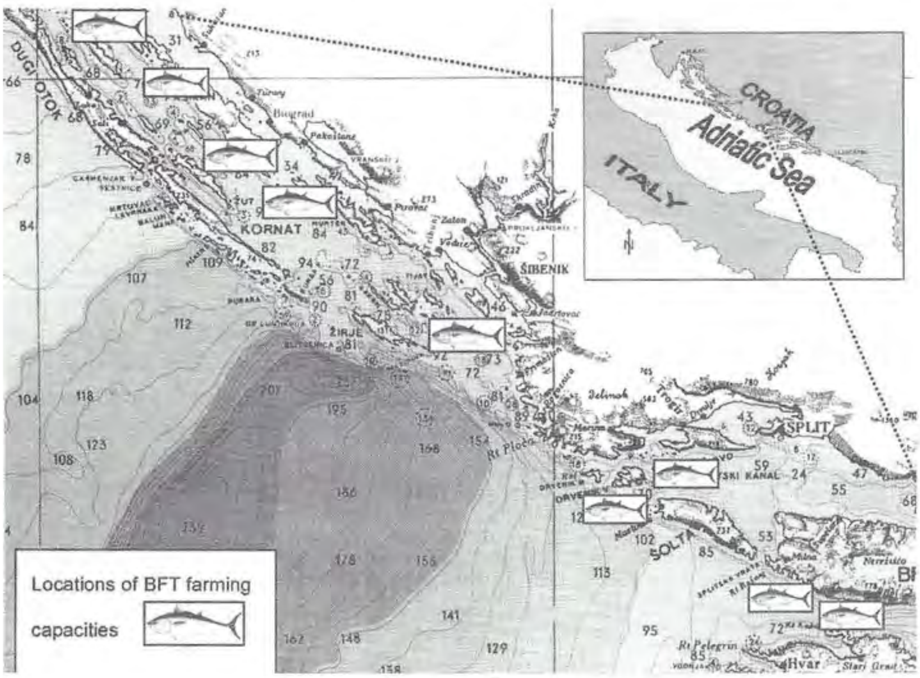

Figure 3. Locations of bluefin tuna grow-out cages on the central part of eastern Adriatic Sea (KATAVIĆ *et al.* 2003a).

As the demand for live bluefin tuna for farming purpose well exceed the catch quota assigned to Croatia, more than half of total amount of live fish entered in the cages were imported from EU and other countries fishing vessels during 2000-2002 years (Figure 4).

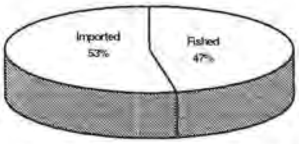

Figure 4. Origins of live bluefin tuna entered in the growth-out cages for farming during 2000-2002 years (Croatia).

The bluefin tuna are usually caught from April to October (except during closed season) by purse-seines (TIČINA, 1997), and than follows the transfer of the live fish from the seine net to the towing cage. This is done by joining both nets under water by divers. After that, fish are transshipped from purse seine fishing grounds to the farms, tugging a towing cage by a boat. The distance between fishing ground and farming location can be up to hundred miles if fish are captured within Adriatic Sea, but also a several hundred miles or even more if fish are captured in other areas of the Mediterranean Sea. Due to the fact that cage can not be tugged at a velocity higher than 1.5 knots, this operation can last from several days to several weeks. Underwater cameras are used to count the fish when they are transferred from the seine to the towing cage so that the total amount of the fish is estimated, and the mean weight is calculated as average weight of specimens which died during the transport and adaptation period in captivity. Hereafter, some additional important topics concerning bluefin tuna farming practice in Croatia are reviewed:

Stocking density - Adequate stocking density should take into account characteristics of the species behavior and environmental preferential factors such as dynamics of water masses, water temperature and pH, oxygen content, size and weight of fish, feed quality and quantity, and expected fouling of the nets. In most cases in Croatia, the stocking density is not exceeding $3kg/m^3$ with everything else being in accordance with the other parameters of production circumstances. Higher stocking density may be allowed only for a short period of time, i.e. before the catch, or other specific operation as relocations or prophylactic treatments.

Mortality and growth in the cages – The research reveals that the largest mortality rate can be noted in the period immediately after stocking of tuna in the towing and grow-out cages (Figure 5). This is assumed to be strongly stress-induced, as the fish suffer from some stress after having been towed from the area of the catching. Tuna farmers expect at least a 25% increase in body weight during six months fattening period, and mortality which does not exceed 3% in the course of the adaptation period.

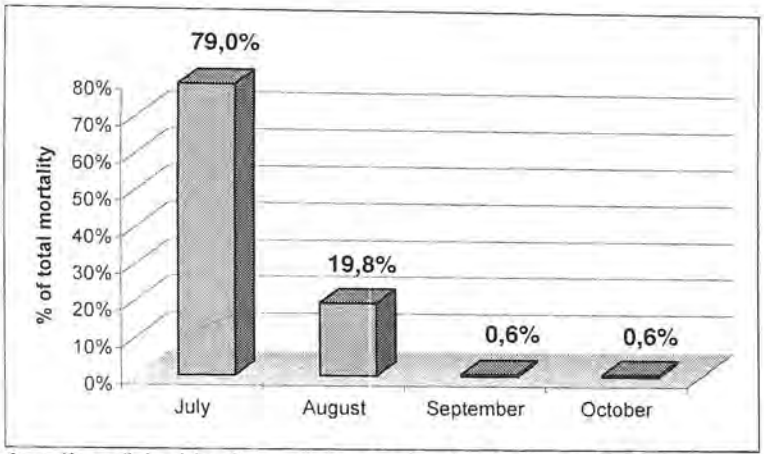

Figure 5. Mortality of the bluefin tunas entered at beginning of July in the growth-out cage (modificated after KATAVIĆ *et al.*, 2003b).

By analysing first tag-recapture data obtained in tagging experiment (KATAVIĆ *et al.* 2002), it was found that juvenile bluefin tuna of estimated age 1+ year weighing averagely 12 kg reached body weight of approximately 45 kg after 540 days rearing period. During the same period, smaller juvenile tunas with estimated age of 0+ year and 5 kg average body weight increased their weight up to 25-30 kg (Figure 6). This means that 1+ year old tunas weighing approximately 12 kg in average have increased their weight three to four times after 540 days rearing period. However, in the same time, smaller juvenile tunas with estimated age of 0+ year and approximately 5 kg body weight showed an increase of nearly 600% regarding to their initial weight.

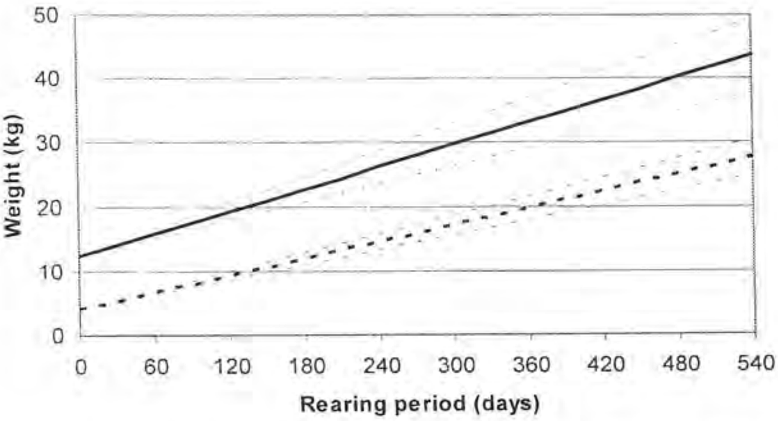

Figure 6. Weight increment of two different sizes of bluefin tuna during 540 days rearing period in growth-out floating cage in the Adriatic Sea (preliminary data).

It should be pointed out that this new farming practice aims at better use of a limited fishing quota, and to improve the value of the product. Given the fact that the small tunas dominate in the catch composition of the Adriatic Sea over the most part of fishing season (TIČINA *et al.*, 2002), the reduction in quotas has further stimulated real farming instead short term fattening. On the whole, practice of small to medium sized tuna farming over an extended period of time allows an increase of biomass, fat contents and quality in whole and hence fish value, as well as allows better utilization of existing natural resources without increasing the fishing mortality. Divers check up the cage nets on daily basis, with aim to detect and remove possible dead fish.

Feeding practices and food deprivation - The experience from the practice indicates that healthy tuna, after being fished, is capable to tolerate starvation period of 50 days while being tugged in the towing cage. Distribution of food in the floating cages is manual, i.e. thrown on the surface in a wide area. Tunas have been fed with a variety of small pelagic fish species (herring, sardines, mackerels, anchovies) as well cephalopods such as squid. Sometimes, underwater camera is used for monitoring feeding and fish behavior. In cages, its feeding needs are 3 to 8% of its live body weight, while the conversion index is about 16 to 20 kg of feed for 1 kg of growth in live fish weight, depending on various factors such as the initial size of the fish in the cage.

Harvesting, killing and slaughtering - All the tuna production in Croatia is devoted to exportation to the Japanese market. Harvesting usually follows the situation on this market (price, supply and demand), and commonly only periodical partial harvesting of tuna in the cages is required. Different harvesting strategies have been put in practice: from use of the hook and line system to harvest very few specimens or lifting up the whole net of the cage to take out all the fish. However, the most frequent method is as follows: part of the fish is first closed by use of smaller encircling nets into a narrower space where the divers, who are going down into the cage, stun the individual specimen by probing its frontal bone, which proved to be the most effective when applied correctly. Immediately after the stunning, the fish is tied up by the tail fin and lifted on board of the vessel. Once on board, the lateral veins are cut immediately behind the pectoral fins for bleeding purposes. After that, the spinal chord is destroyed, and fish are gilled and gutted. The whole operation does not last longer than two minutes. It seems clear that a fish which struggle during the slaughter have a less pink or reddish meat and therefore the quality and market price is inferior.

Water quality conditions - Among the different physical factors, dissolved oxygen concentration seems to be the most limiting one. Tuna are obligate ram ventilators and rely on forward movement to develop the pressure necessary to move water past the gills (ROBERTS, 1978). Because of continuous swimming, a large energetic investment is needed to sustain body maintenance and locomotory cost. Its oxygen consumption rate is similar to those of mammals of a similar size and is 3 to 4 times higher than those of the most active fish (GOODING *et al.*, 1981). A suitable rearing site must have much flow from open sea, high transparency, and high dissolved oxygen content. The oxygen concentration measured in the experimental growth-out cage varied within a range from 6.8 to 7.6 mg/l, which means that the water was well oxygenated and often even saturated with oxygen. Even at the lowest measured value (6.8 mg/l O_2 at 20°C and salinity 37.0‰) the oxygen saturation level was 93.3% (KATAVIĆ *et al.*, 2003b). In any case it must not be affected by muddy waters from rivers. Mass mortality of tuna caused by storm events which increased water turbidity in the rearing areas and clogged the gills of the fish (LEE, 1998), have been reported in Morocco and in Australia. Some farmers in Croatia also reported mass mortality after lightening that is probably caused by stress and mechanical damages while in contact with suspended nets.

Impact on the rearing environment - Bluefin tuna farm, if not properly located and managed, might cause water pollution. Water may be polluted either from uneaten feed and metabolic waste of cultured fish or from slaughtering and processing the fish. The most common problems are caused by overfeeding and smell pollution during the summer season. Uncollected fat on the sea surface may be widespread much outside of the farm and have disastrous effect on the tourist destinations. Prior to the start up of farming activities, the study on impact on environment is recommended as well as regular monitoring of water and sediment together with benthic community surveys.

Socio-economic impact - The farming practice completely changed the operational procedure, including both fishing area and season. A couple of years ago, the tuna caught by purse seines used to be sold for canning and a little for fresh consumption that is now hardly available. By increased demand for purse seine caught fish prices were dramatically increased. The demand for small pelagic fish such as sardine, mackerel, herrings, squids, etc. also increased, as the quantity approximately equal to 3 to 8% of the mass of the tuna farmed are required daily as a feed. In Croatia the prices for frozen sardines has almost doubled since 1997. Also tuna fish price increased three to five times, and changed the operational fishing procedure required to catch and sell live fish. However, with much higher price obtained for live fish there remain really small quantities of tunas to be sold at the fish cannery and local markets for fresh consumption. Bluefin tuna farming created a lot of new jobs and currently employs about 500 people, giving a significant income that helps revitalization of heavily depopulated Croatian islands where new job opportunities are badly needed. Further positive impact is in reducing fishing pressure on already overexploited Croatian demersal fisheries as 33 bottom trawlers are fully integrated into tuna farming operations in transporting and delivering feed to the tuna in the cages.

The effect of bluefin tuna farming on statistics and stock assessment - The ICCAT has started the Bluefin Tuna Statistical Document (BFSD) Program, and all the ICCAT members have to request any bluefin products, when imported to their lands, to be accompanied with a BFSD in which the weight of products by flag of the fishing vessels, general area and type of the products have to be recorded. However, in the tuna farming, farmers expect at least 25% increase in body weight during five to six months of farming. Therefore, in order to estimate the original catch quantities (live weight of fish at the beginning of farming), the weight of tunas at the end of farming should be back calculated by applying a factor of weight increase.

But, farming the small size fish over prolonged period, in the case of Croatia, create a large gap between the fish biomass introduced into the cage (catch) and that harvested and landed in the same year. This means only a part of the catches of one year is landed in that year and the rest will be landed during the following two or three years. At the same time, some catches taken 2-3 years ago can be included in the harvest from the farming and have no relation with the catches of the year in concern. Therefore, the landing (or harvest from the farming) has no relation with the catches. These elements all add up to the increasing uncertainties of the bluefin catch statistics and significantly affect bluefin tuna data collection, and hence the stock assessment procedure. Also, the difficulties in estimating size composition of catch are recognized by most of countries that have purse-seine fleets involved in fishing for farming.

BLUEFIN TUNA FARMING RESEARCH

As the interest in BFT farming is constantly growing, at the same time there is also a need to conduct various scientific research concerning this activity.

Due to fact that farming activity caused an huge problems in reliability in catch landing statistics, currently under way, within framework of ICCAT Bluefin Year Program (BYP), are tagging experiments aimed to assess tuna growth during its farming in the growth-out cages, in order to estimate the original live weight of fish at the beginning of farming of different size groups. Growth rate of various size groups is to be elaborated under variable environmental and zootechnical conditions.

As the tuna farming operations expand, the environmental aspect will be very important issue. Therefore, prior to starting up with BFT farming activities, environmental studies are carried out at possible cage locations. Also, further studies in improving husbandry and reducing pollution are needed if a negative image of such a mariculture industry is to be avoided.

In addition, studies on quality control of tuna products using Hazard Analysis and Critical Control Point methods, as well as studies on concentrations of heavy metals in different tissues of farmed bluefin tunas with aim to compare these findings with concentrations in the wild fish, are under way.

More biological information on the maturity in the Mediterranean is needed with the aim to test if the currently adopted conservation measures should be revised. Also, with aim to conserve natural stock of bluefin tuna, research targeted to better understanding of reproductive biology and further possible control of reproduction and breeding of tuna in captivity, thus obtaining the full domestification of this species. The progress is expected in the comparison of gonadosomatic indices corresponding to indices from different areas of eastern and western Mediterranean.

CONCLUSIONS

Tuna farming is a new, rapidly growing industry in the Mediterranean region. This industry brought revolutionary changes in the Croatian fishing industry. All bluefin tuna purse seine catches in Croatia are now transferred to cages for farming and fattening. The growing interest over past few years has increased remarkably as reflected by increased number of fattening units established and new applications for license submitted to relevant authorities. Tuna products from the cages have a greater commercialisation and a higher price in the market, increasing considerably the turnover in respect to a commercialisation of wild tuna.

Tuna farming definitely has important economic, social and environmental consequences and receives considerable public attention. In addition to positive economical effects, tuna farming has generated several problems. Competition for space on the sea coast with other coastal users (i.e. tourism) and potential environmental impact, as well as problems in collecting catch statistics after landing because the fattened product weighs more than twice with respect to its original weight A scientific approach to assessment and monitoring of possible environmental problems should be considered and problems resolved.

A harvesting of wild bluefin tuna stock may not be sustainable on the long-term bases. On the other side, expanding of the market for bluefin tuna results in increasing market demands and further increase in fishing pressure. However, this farming techniques also should not be considered as a true form of sustainable aquaculture practice as the initial stages of the life cycle are not controlled and artificially propagated. So, in our opinion, it represents a needed step from "wild" bluefin tuna fisheries towards domestication in captivity with full control of the entire production cycle that will eventually decrease future pressure on the overexploited natural stocks.

This new farming practice is aiming to better use of a limited BFT fishing quota, and to improve the value of the fish. As a whole, practice of farming small to medium sized tuna over an extended period of time allows a significant increase of BFT biomass, thus the number of fish that is needed to satisfy growing market demand is considerably reduced. In other words, this practice allows better utilization of existing natural resources without increasing the BFT fishing mortality.

The development of bluefin tuna aquaculture needs applied and coordinated collaborative research program such as DOTT (Domestication of *Thunnus thynnus*) funded by the EU as well as studies supported through ICCAT Bluefin Year Program (BYP), if a long-term and sustainable farming industry will be established. Bluefin tuna domestication should aim at controlling all the phases starting from reproduction in captivity via rearing of the early developmental stages and the breeding of juveniles up to commercial size fish. This would likely decrease fishing pressure on tuna natural stock, and would contribute to the conservation of these resources. Also, studies aimed to improve husbandry and reduce pollution, as well as environmental monitoring, are needed if a negative image of such mariculture industry is to be avoided.

REFERENCES

GOODING, R.M., W.H. NEILL, A.E. DIZON. 1981. Respiration rates and low oxygen tolerance limits in skipjack tuna, *Katsuwonus pelamis*. Fishery Bulletin 79(1). 31-48. W.H.

KATAVIĆ, I., V. TIČINA, V. FRANIČEVIĆ. 2002. A preliminary study of the growth rate of bluefin tuna from Adriatic when reared in the floating cages. ICCAT Coll. Vol. Sci. Pap., 54(2):472-476.

KATAVIĆ, I., V. TIČINA, V. FRANIČEVIĆ. 2003a. Bluefin tuna (*Thunnus thynnus* L.) farming on the Croatian coast of the Adriatic Sea – present stage and future plan. Proceedings of First International Symposium Domestication of the Bluefin Tuna, *Thunnus thynnus thynnus* (DOTT), 3 – 8 February 2002, Cartagena, Spain, (in press).

KATAVIĆ, I., V. TIČINA, V. FRANIČEVIĆ. 2003b. Rearing of small bluefin tunas (*Thunnus thynnus* L.) in the Adriatic Sea - preliminary study. Proceedings of First International Symposium Domestication of the Bluefin Tuna, *Thunnus thynnus thynnus* (DOTT), 3 - 8 February 2002, Cartagena, Spain, (in press).

LEE, C.J.A. 1998. A study on the feasibility of the aquaculture of the southern bluefin tuna, *Thunnus maccoyii*, in Australia. Department of Aquaculture, Fisheries and Forestry, Australia /AFFA, Canberra: 1-99.

MIYAKE, P.M., J. M. DE LA SERNA, A. DI NATALE, A. FARRUGIA, I. KATAVIĆ, N. MIYABE, V. TIČINA. 2003. General review of bluefin tuna farming in the Mediterranean Area. Report of the 6th GFCM-ICCAT Meeting on stocks of large pelagic fishes in the Mediterranean, Sliema, Malta, 15-19 April, 2002, ICCAT Coll. Vol. Sci. Pap., 55: SCRS/2002/036 (in press).

ROBERTS, J.R. 1978. Ram gill ventilation in fish. In: The physiological ecology of tunas. SHARP, G.D. and DIZON, A.E., (eds). Academic Press, New York, 83-8.

TIČINA, V. 1994. Morphological characteristics, feeding and fishing on the bluefin tuna (*Thunnus thynnus* L.) in the Adriatic Sea. (In Croatian) M.Sc. Thesis, University of Natural Sciences, Zagreb: 84 pp.

TIČINA, V. 1997. Bluefin tuna (*Thunnus thynnus* L.) purse-seine fishing in the eastern Adriatic sea. ICCAT Coll. Vol. Sci. Pap., 46(2): 126-128.

TIČINA, V., I.. KATAVIĆ, V. FRANIČEVIĆ. 2002. Croatian bluefin tuna catches in the Adriatic during 1999 through 2001 by year/month/size structure. ICCAT Coll. Vol. Sci. Pap., 54(2): 465-471.

RESULTS FROM PROJECT COPEMED '*LARGE PELAGIC* APPLICABLE TO BLUEFIN TUNA AQUACULTURE

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Taking into account the development of bluefin tuna in the Mediterranean Sea. Considering that further research in bluefin tuna aquaculture was recommended by the Scientific Committee of ICCAT. Having in mind that bluefin tuna could be a possible way to control fishing effort and to optimize allowed catches (TAC), currently a management tool for bluefin tuna fisheries, Project COPEMED '*Large Pelagic* preliminary results could significantly contribute to establishing and developing bluefin tuna aquaculture:

A. From the fishing point of view, preliminary results of Project COPEMED '*Large Pelagic* can contribute some information about where, when, which fishing gears and the amount (yield) of bluefin tuna that can be caught alive for subsequently processing in the aquaculture installations (Figure 1).

B. From the biological point of view, preliminary results from Project COPEMED '*Large Pelagic* would contribute some information about the biological characteristics of bluefin tuna caught for farming (Figure 2, 3, 4, 5, 6, 7, 8, 9 and 10).

C. Data on export: Finally, Project COPEMED may propitiate the development of a biological sampling plan addressed to obtaining several biometric relationships as well as conversion factors in order to improve ICCAT's Bluefin Tuna Statistical Document.

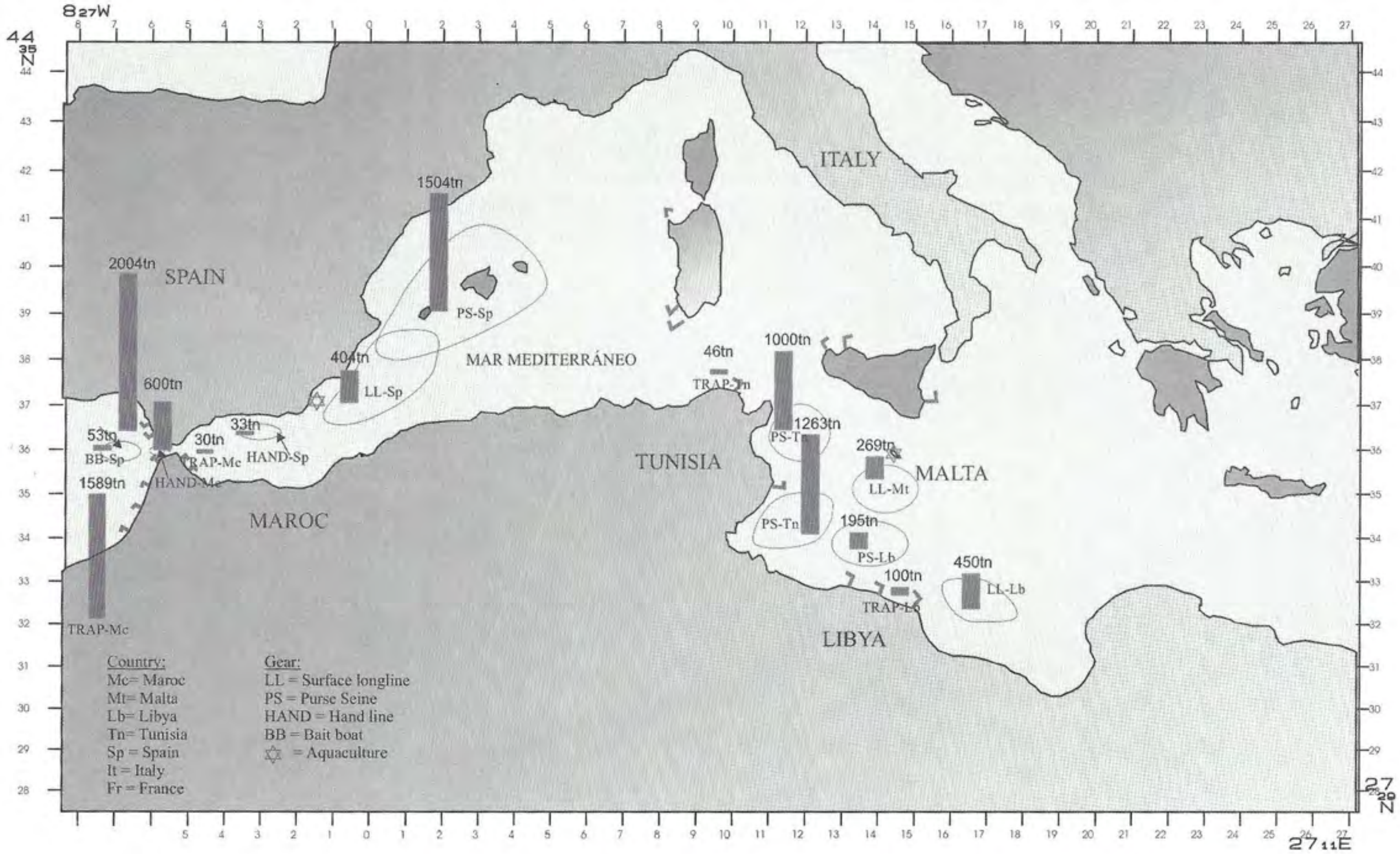


Figure 1. Bluefin tuna fisheries for participant countries in Project FAO-COPEMED

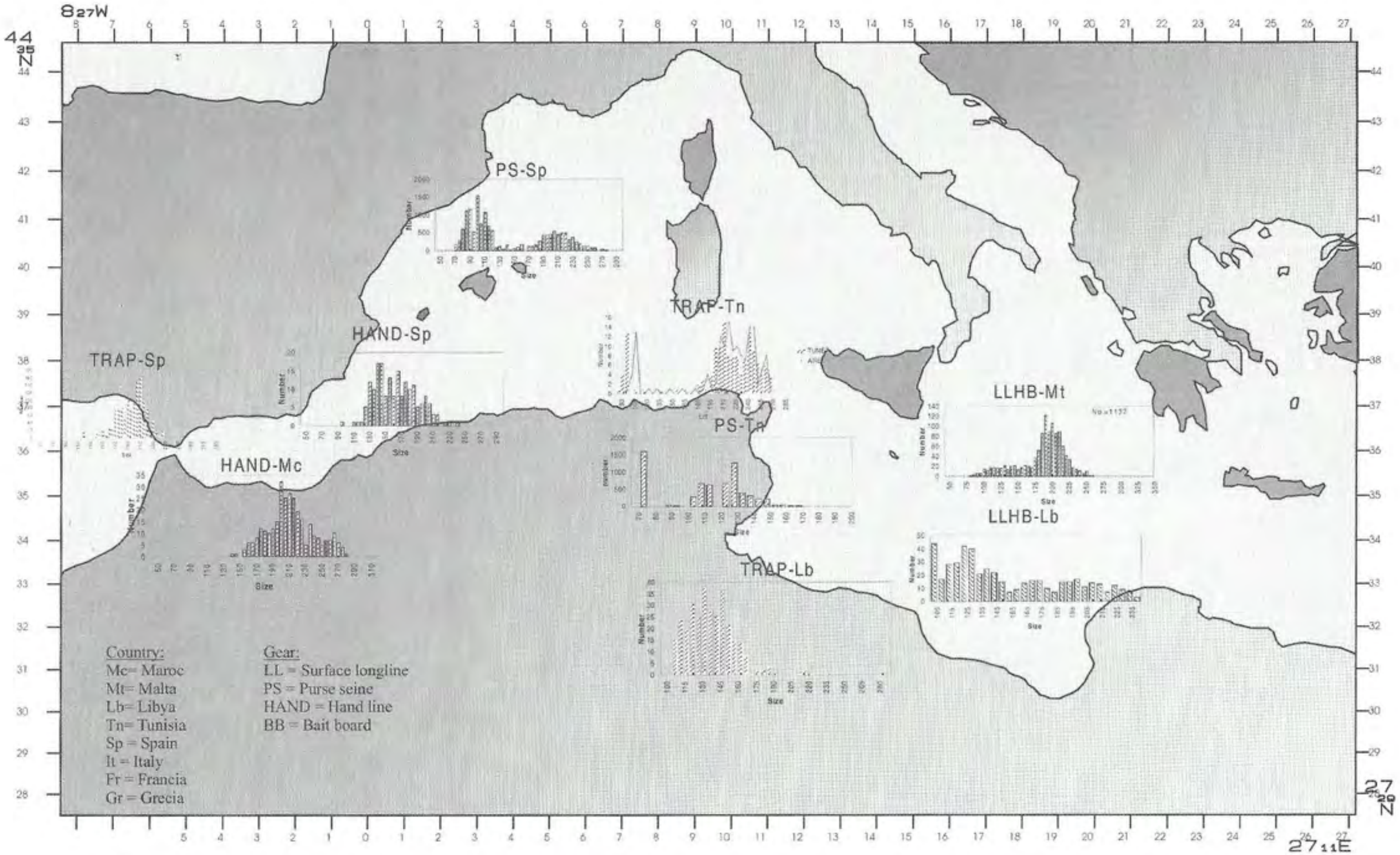


Figure 2. Length distributions by gear (trap and/or purse seine) by spatial-temporal strata (**bluefin tuna size**). Project FAO-COPEMED

Species	Relation	Type	Year	Number of samples	Country
BFT	$RW=0.0101LF^{1.7854}$	HAND	1998	65	Maroc
BFT	$RW=9E\text{-}05\ LF^{2.677}$	TRAP	1997	54	Maroc
BFT	$RW=15.3*10^{-5}\ LF^{2.6381}$	TRAP	1998	118	Tunisia
BFT	$RW=3.74869E\text{-}05*LF^{2.8589}$	BB	2000	503	Spain
BFT	$RW=0.0004\ LF^{2.4295}$	PS	2000	200	Tunisia
BFT	$DW=0.0026\ LF^{2.0775}$	LL	2000	141	Malta
BFT	$RW=2E\text{-}05\ LF^{2.9957}$	TRAP	2000	197	Libia

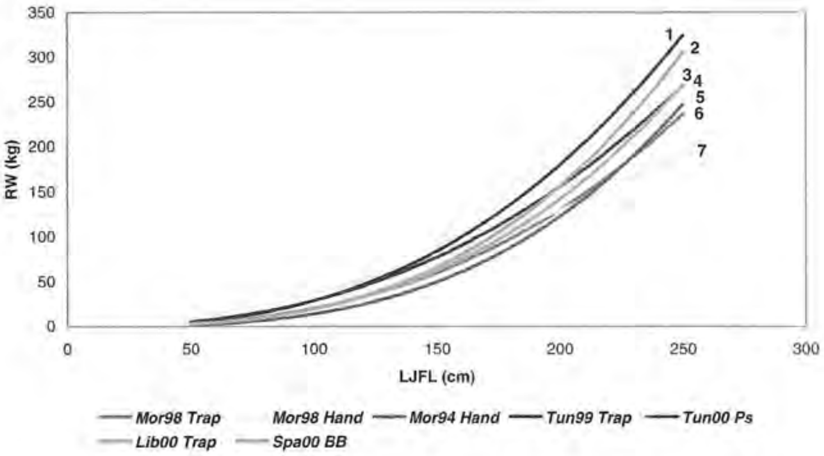


Figure 3. Condition factor or fattening degree based on length- weight relationships by fishing gear and spatial- temporal strata (bluefin tuna vitality condition). Project FAO-COPEMED

1- $1.53E\text{-}04 * RW^{2.6381}$

2- $2E\text{-}05 * RW^{2.9957}$

3- $4E\text{-}04 * RW^{2.4295}$

4.- $3{,}74869E\text{-}05 * RW^{2.8589}$

5.- $7.6416E\text{-}06 * RW^{3.1316}$

6.- $9E\text{-}05 * RW^{2.677}$

7.- $0.0101 * RW^{1.7854}$

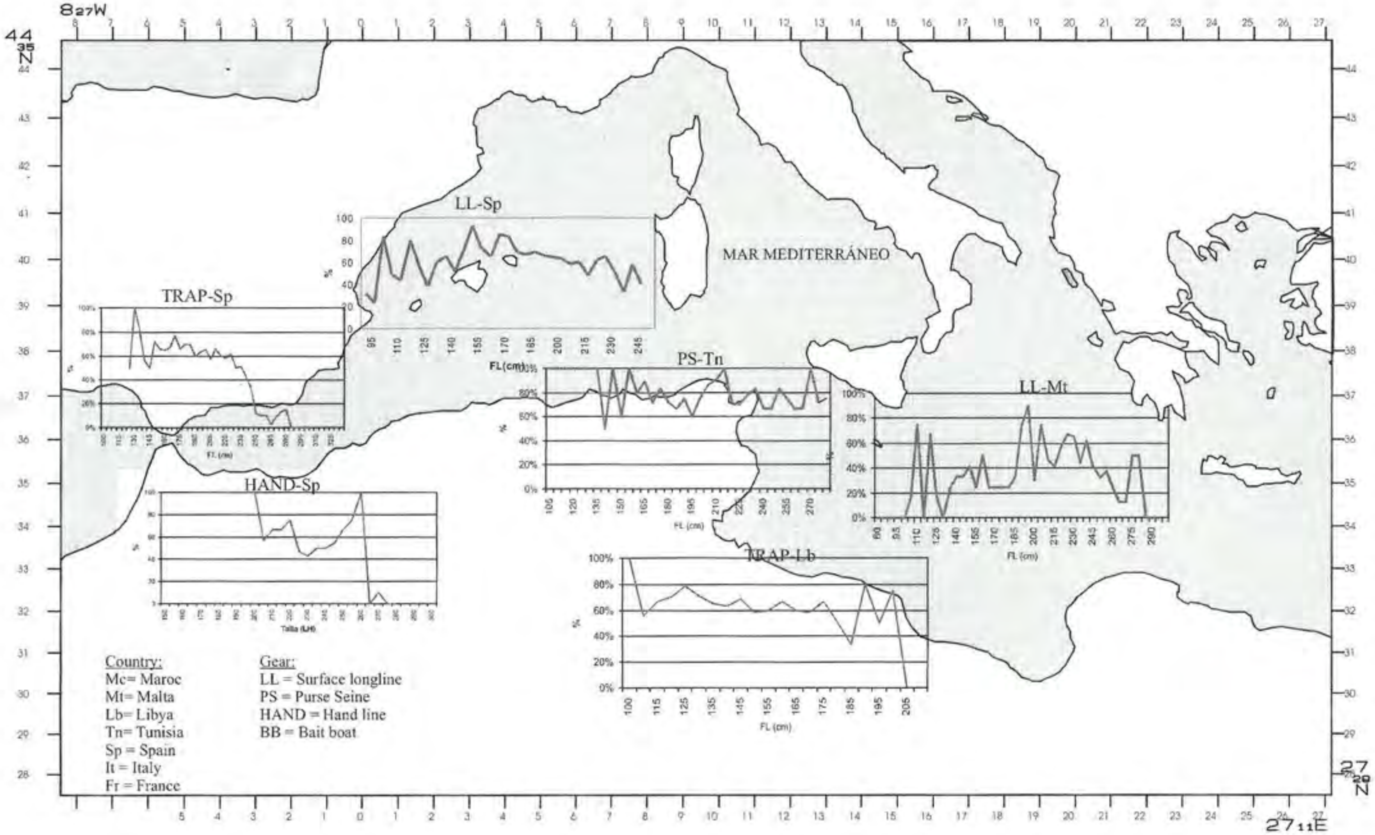
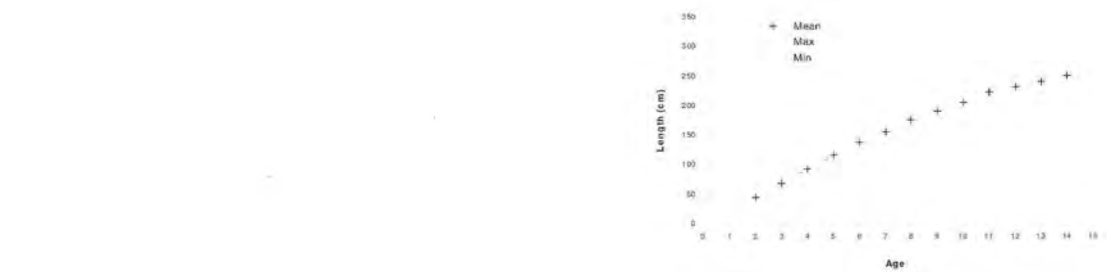


Figure 4. Female and male proportion by lenght class, fishing gear and spatial-temporal strata (**differences in yield**). Project FAO-COPEMED

	Age											
Length	4	5	6	7	8	9	10	11	12	14	16	Total
110-												
115-	2											2
120-		2										2
125-	1	3										4
130-		1										1
135-		2	3	1								6
140-				1								1
145-			4	2								6
150-			4	3								7
155-			7	2								9
160-			2	7	1	1						11
165-				4	2		1					7
170-				2	4							6
175-					2							2
180-				3	1	1	1					6
185-					1							1
190-					1				1			2
195-					1					1		2
200-					1	2						3
205-						1						1
210-												
215-								1				1
220-						1	1					2
225-												
230-							1					1
235-												
240-										1		1
245-												
250-												
255-												
260-												
265-								1				
270-												
275-												
280-												
285-									1		1	2
Tota	3	8	20	25	14	6	4	2	2	2	1	87



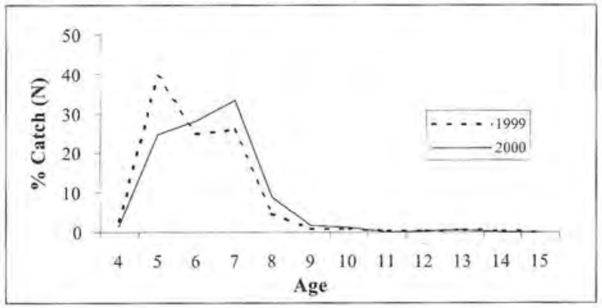


Figure 5. Growth studies: age- length keys (**demographic composition**). Project FAO-COPEMED

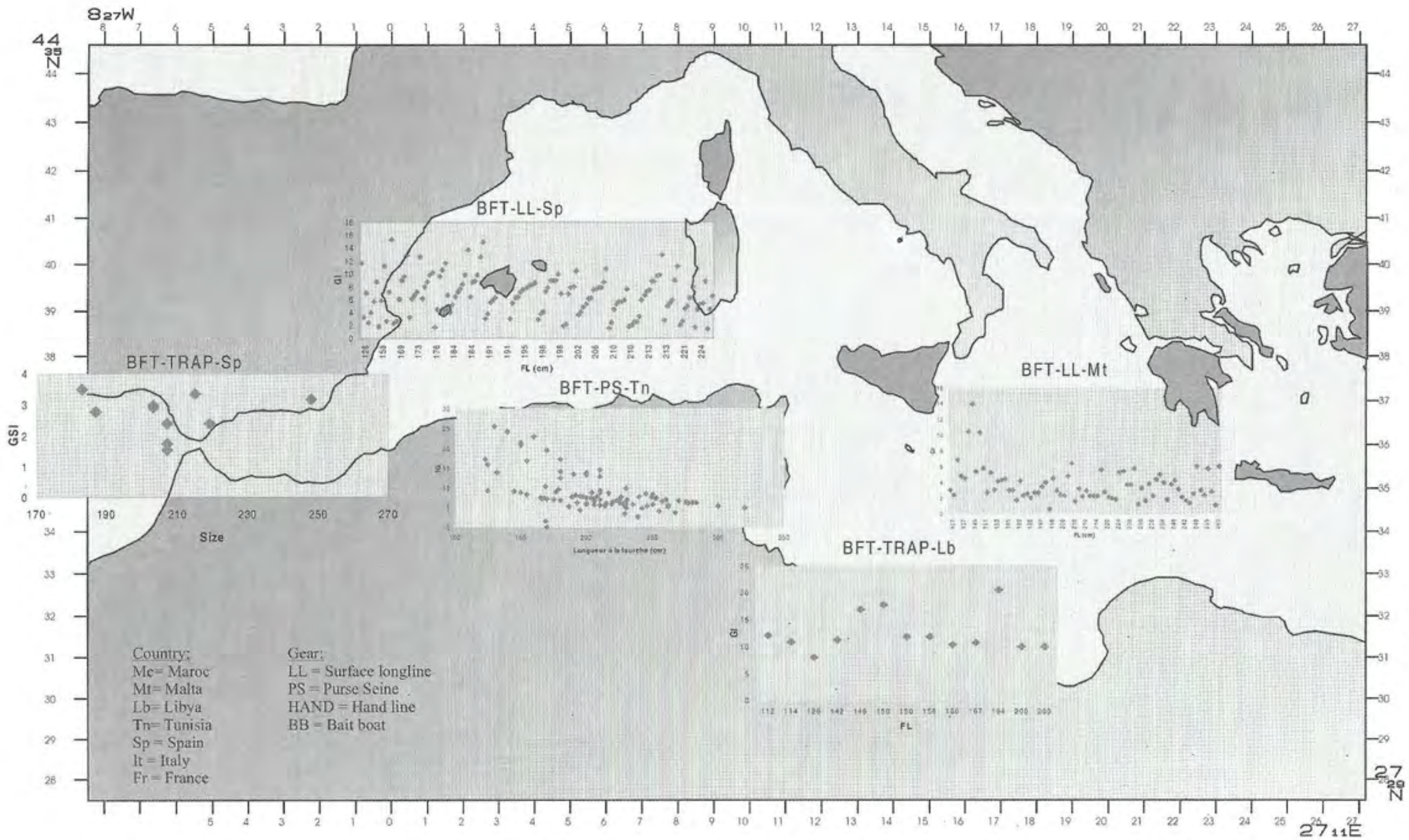
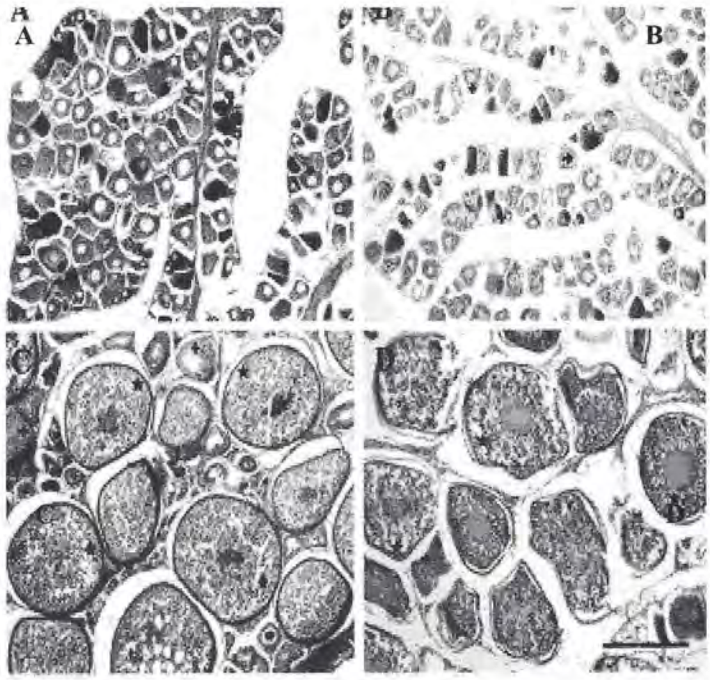


Figure 6. Trends in bluefin tuna sexualmaturity by fishing gear and area by means of Gonosomatic Index analysis (**recomended fishing periods**). Project FAO-COPEME



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Tunissian bluefin tunas GSI

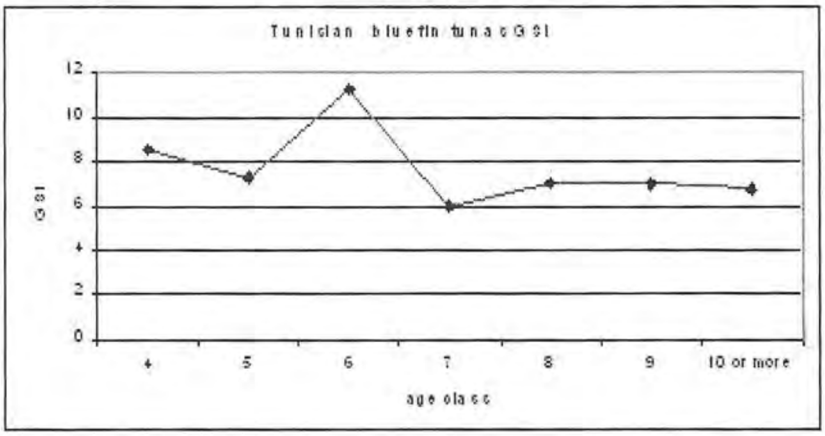


Figure 7. Maturrity stages in the Tunisian Bluefin tunas (bar = 400mm.).

A and B images show two inmature three year old ovaries that show a lot of unyolked oocytes (cross).

C. A five year old mature ovary that shows maturity signs: yolked oocytes (stars).

D. This image show a four year old mature ovary <ith many yolked oocytes (stars) and some unyolked ones (cross).

E. The graphic shows the gonadosom atic index by age calss of the tunas used in this study.

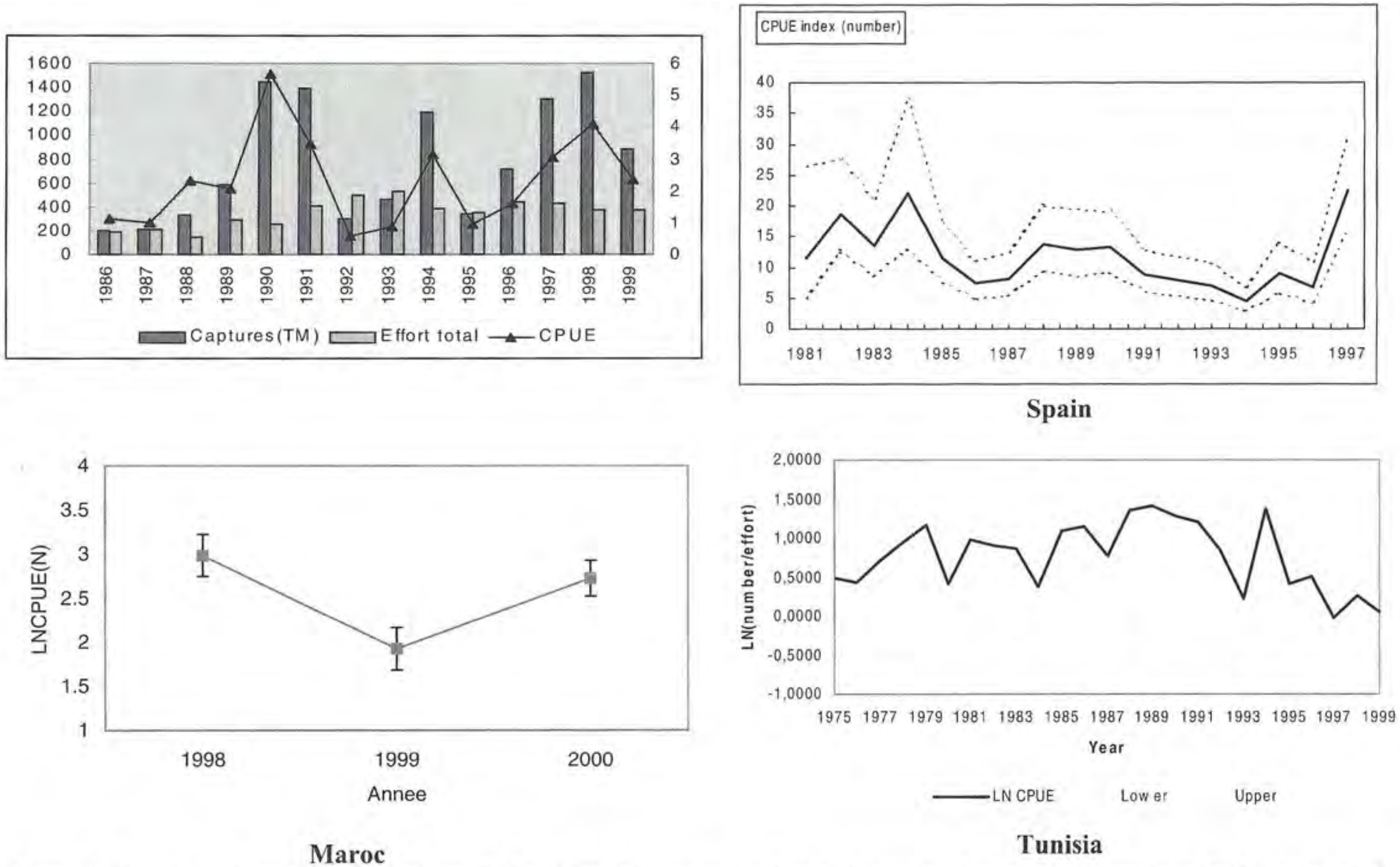
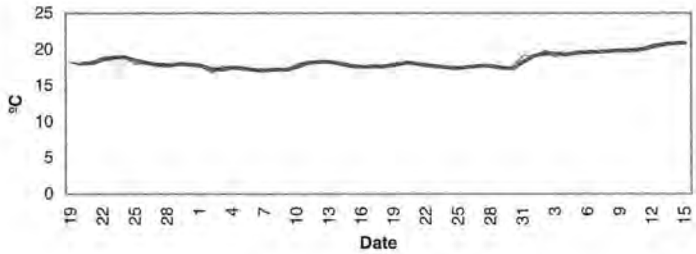
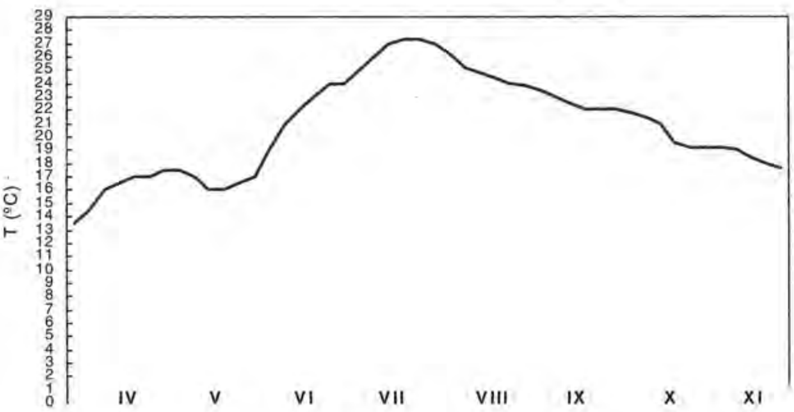


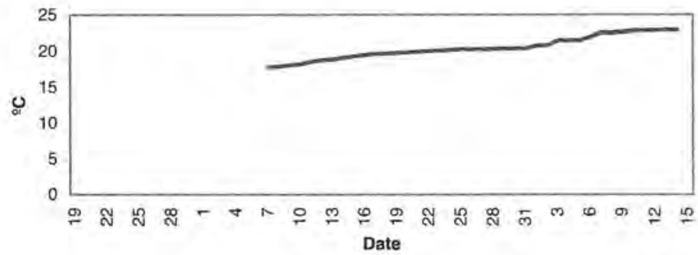
Figure 8. Trends in abundance (Abundance Indices) by fishing gear and spatial- temporal strata (**guarantee capital investment**).



TRAP (Atl) – Spain (V-VI)

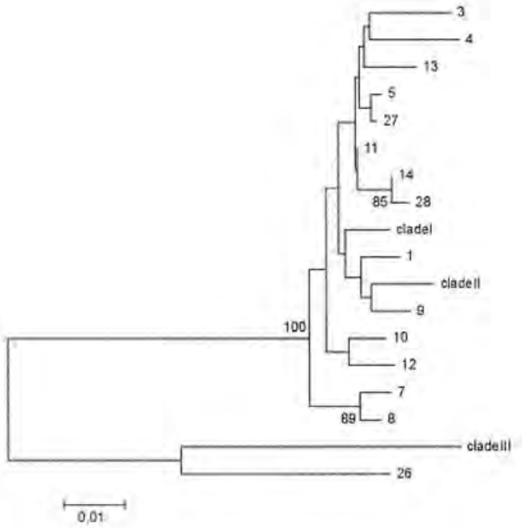


LL – Baleares



LL - Malta (V-VI)

Figure 9. Bluefin tuna and environment interactions for consecutive phisiological stages (genetic and trophic migrations, reproduction, etc.) (**farming installations location and adaptability**)



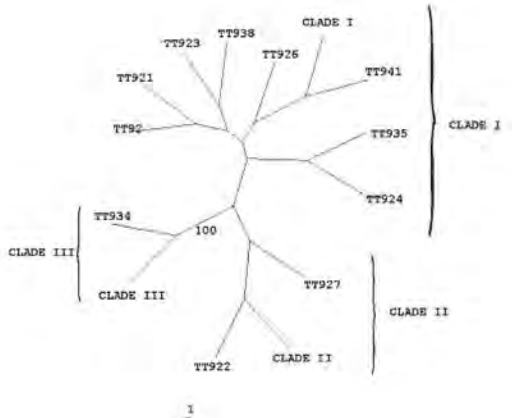


Figure 10. Árbol filogenético basado en distancias de Neigbor-joining de las diferentes secuencias. Los números en las ramas muestran valores de bootstrap superiores al 50%.

GENERAL REVIEW OF BLUEFIN TUNA FARMING IN TURKEY

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INTRODUCTION

Bluefin tuna farming began in 2002 in Turkish waters. In all five bluefin tuna farms, two in the Eastern Mediterranean Sea (Antalya) and three in the Aegean Sea (two in Çanakkale and one in Izmir area) were established (Figure 1). Presently, only three of these farms are working. The bluefin tunas were caught by purse seiners and transfered to the feeding cages. After about 6-7 months these fish were exported to Japan.

Figure 1. The bluefin tuna farms in Turkey.

DATA ON THE BLUEFIN TUNA FARMS IN TURKEY

The fattening of bluefin tunas started in Turkey in 2002 and presently is carried in three farms. The number of the bluefin tunas, number of cages and their capacities are shown in Table 1. This information was supplied by the Turkish Ministery of Agriculture and Rural Affairs.

Table 1. Information on the bluefin tuna farms in Turkey

Number of farms	3
Total area (m^2)	231200
Total volume (m^3)	798054
Capacity (ton/year)	2435
Feed quota quantity (ton/year)	1702
Number of cages	17
Number of BFT taken for on growing	32367
Live weight (kg) before fattening	1.580.350
Live weight (kg) after fattening	2.004.768
Duration of the fattening (days)	180-188
Feed conservation rate	5.44-17-21.7
Total feed imported	8.830.884

The Turkish bluefin tuna farms, have 17 round and 1 rectangular cages. Each of the round cages are 50 m in diameter with net depth of 15-20 m, the rectangular cage being 65x35 m long with a net depth of 25 m. The cages are installed in 40-70 m, about 1-2 miles away from the shore.

The catch of the bluefin tunas was carried out by 28 Turkish purse seiners between April and June 2002 in distant waters in the Bay of Antalya. The weights of the caught bluefin tunas varied between 15-400 kg. The total catch of the bluefin tunas amounted to 2300 tons. Of these 1580 tons were sold to bluefin tuna farms. Around 720 tons were exported fresh.

The bluefin tunas were brought to the feeding cages of the farms in 2-3 days to Antalya. It took 20-25 days to bring the bluefin tunas in towing cages to the feeding cages of the farm in the Aegean Sea.

After the transfer of the bluefin tunas to the feeding cages, they were under stress and long did not take any feed one month long. The feeding of the bluefin tunas was done twice a day in 6 days of the week. In some farms, the bluefin tunas were fed once aday. As feed; imported hering (*Clupea harengus*), capelin (*Mallotus villosus*), shad (*Alosa alosa*), sardine (*Sardina pilchardus*), Atlantic mackerel (*Scomber scomber*) from Spain, Mauritania, Norway and Holland were used. Apart from these fish, imported calamares and horse mackerels, anchovy caught in Turkish waters were given as feed to the bluefin tunas. The feed was given by means of shovels and automatic feeding systems to the bluefin tunas.

During the transfer of the bluefin tunas, the mortality was 10 %. The mortality during the feeding amounted to 15-20%. During sacrificing the bluefin tunas were either killed by electricity or by harpooning and taken out of the cages. They were either exported as fresh fish or taken over by the Japanese processing ships, which came to the fish farms and processed the fish on board. In a fish farm in the Mediterranean Sea, during the sacrifice of the bluefin tunas, 2 % were under 45 kg, 73 % between 46-100 kg and 25 % over 100 kg (DARDANEL, 2003).

CONCLUSIONS

Due to the economic competition between the countries, bluefin tuna farms are becoming widespread in the Mediterranean Sea. Although the eastern Mediterranean Sea inhibits bluefin tunas since about 2400 years, fish farming started quite late in this region. There is concern that the sustainability of the natural stocks could be negatively effected. The work of GFCM-ICCAT Working group on the sustainable farming of bluefin tunas in the Mediterranean will surely be of great help. Since six years, the Spanish bluefin tuna farms were monitored and a lot of positive information was gathered (MARIN *et al.*, 2002). The advantages and the disadvantages of bluefin tuna farming which could be grouped as follows.

Advantages

Owing to the lean meat of the bluefin tunas in May and June, the export value of the bluefin tunas is quite low. In May and June 2001 and 2002 an intensive bluefin tuna fishery was conducted for the first time by Turkish purse seiners in the eastern Mediterranean Sea. The bluefin tunas which are taken for fattening are brought to top quality are exported to Japan when the demand is good. This economical gain guarantees high profits to the producers, farms and to the economy of the country, creating jobs in the region where the farms are situated.

Disadvantages

The catch of bluefin tunas is conducted in the months of May and June. We do not know exactly the effects of this fishery on natural bluefin tuna stocks. The bluefin tunas showing gonad development could be understress when they are transfered to the feeding cages. The fertilazation of the eggs could be effected. The unused feed and the excrements of the bluefin tunas could eventually have negative impact on the environment. With the accumulation of these in benthos, the seagrass meadows could suffer. Since the establishment of bluefin tuna farms in 1986, the environmental impact of tuna farming was monitored in southeastern Spain. It was found that, the tuna farms did not generate any increase in phytoplankton biomass of harmful algalblooms. No signs of hyper -nutrification of the watercolumn adjacent to the tuna farms was recorded . The areas close to the cages had the same phytoplakton biomass and nutrient levels as the control stations (D0TT, 2002). Such investigations are useful for developing guidelines for the location of new farms and for environmental monitering (MARIN *et al.*, 2002; DOTT 2002) and should be encouraged.

The basic criterias for choosing suitable sites for establishing bluefin tunas farms should not be overlooked. Otherwise wrong images in the public opinion could occur.

In choosing the farm sites, the public opinion and remarks of the fishermen should be respected.

Bearing in mind that the number of entrepreneurs desiring to make such investmeats will be numerous, allocations of quotas for bluefin tuna farms should be planned carefully. Scientific research on bluefin tunas in Turkish waters are limited. Almost all of these investigations are conducted with the funds of Istanbul University and Turkish Scientific Council. Research on bluefin tuna catch technology (IYIGÜNGÖR, 1957; ORAY and KARAKULAK, 2001), larval-surveys (ORAY *et al.*, 2000), catch and effort (KARAKULAK, 2002), age composition (KARAKULAK and ORAY, 2001), length and weight relationships (AKYÜZ and ARTÜZ, 1957; KARAKULAK, 1994) have been carried out successfully.

By becoming a contracting party to ICCAT, Turkey will surely bring more motivation to bluefin tuna research, and farming in the eastern Mediterranean Sea.

ACKNOWLEDGEMENTS

Thanks are extended the Turkish Ministry of Agriculture and Rural Affairs and Dardanel Bluefin Tuna Farming Company for suppling us with information. Cordial thanks are also extended to the Turkish fishermen, Bluefin Tuna Farming Companies, and Turkish Bluefin Tuna Exporters. We thank TUDAV (Turkish Marine Research Foundation) and ATAKÖY MARINA for enabling us to make this workshop.

REFERENCES

AKYÜZ, E. F., ARTÜZ, İ. 1957. Some Observations on the Biology of Tuna (*Thunnus thynnus*) Caught in Turkish Waters. Conseil général des pêches pour la Méditerranée, Document Techniques, No. 14, pp. 93-99, Rome.

DARDANEL, 2003. Dardanel Bluefin Tuna Farming Company

DOTT, 2002. I. International Symposium on Domestication of the bluefin tuna *Thunnus thynnus thynnus*. 3-8 February 2002, Abstracts, Cartagena-Spain.

IYIGÜNGÖR, D. (1957): Méthods et Moyens de Pêche au Thon Actuellement en Usage en Turquie. Gen. Fish. Coun. Medit., No. 33, pp. 251-255.

MARIN, A., VITA, R., JIMENEZ, B., MARIN-GUIRAO, L., CESAR, A. 2002. Environmental impact of tuna (*Thunnus thynnus*) aquaculture in Murcia (SE Spain). I. International Symposium on Domestication of the bluefin tuna *Thunnus thynnus thynnus*, 3-8 February 2002, Abstracts, Cartagena-Spain.

KARAKULAK, F.S. 1994. Length-weight relationship of bluefin tuna (*Thunnus thynnus* L. 1758) caught in Turkey (master thesis). 46 pp. İstanbul University, İstanbul. (In Turkish)

KARAKULAK, F. S., ORAY, I.K. 2001. Age et croissance du thon rouge (*Thunnus thynnus* L.1758) pêche de la mer Egée et de la mer Méditerranée en Turquie. Rapp. Comm. Int. Mer Médit., 36, p.284, Monaco.

KARAKULAK, F.S. 2002. Catch and effort of the bluefin tuna purse seine fishing in Turkish waters. I. International Symposium on Domestication of the bluefin tuna *Thunnus thynnus thynnus*, 3-8 February 2002, Abstracts, Cartagena-Spain.

ORAY, I.K., KARAKULAK, F.S. 1997. Some remarks on the bluefin tuna (*Thunnus thynnus* L.1758) fishery in Turkish waters in 1993, 1994, 1995. ICCAT, Coll. Vol. Sci. Pap., Vol. XLVI (2): pp. 357-362, Madrid.

ORAY, I.K., DEVAL, C., BÖK, T., KARAKULAK, F.S. 2000. Investigations on the distribution of the bluefin tuna larvae (*Thunnus thynnus* L.1758) in the sea of Marmara. Oceanography of the Eastern Mediterranean and Black Sea, Zappeion International Conference Centre, 23-26 February 1999, Athens, Greece, p. 285.

BLUEFIN FARMING IN THE MEDITERRANEAN SEA

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Bluefin tuna farming is a new concept for Turkey, utilizing sources in the eastern Mediterranean and Aegean Sea, and Dardanel has taken the initiative to launch business engagement and projects in this area.

Dardanel is one of the leading food processing companies in Turkey. It was established in 1983 in the area of canning tuna and Turkish people tasted tuna fish by the products of Dardanel. Ever since 1983 the strong brand image has led Dardanel to diversify in canned and frozen fruits and vegetables, pastry and tomato products.

As of today, Dardanel runs four factories in Çanakkale region which have production capacity of;

- 60,000 tonnes/year of fish
- 30,000 tonnes/year of shell fish
- 50,000 tonnes/year of canned and frozen fruits &vegetables
- 3,000 tonnes/year of frozen pastry and precooked food
- 15,000 tonnes/year of tomato paste

In 2001, Dardanel was engaged in another business area; tuna farming.

Dardanel, has formed a joint venture with a Japanese sea food trading company, Tohto Suisan, and established the very first tuna farm in Gazipasa/Antalya. Today, a large investment is underway to extend this partnership in bluefin tuna farming in various locations of the Mediterranean Sea. The simple reasons shown below draw our attention to this business naturally.

- There is a sustainable bluefin tuna stock in the eastern Mediterranean.
- Some fish simply bears little value before and without fattening.
- Fosters export oriented strategies.
- Utilizes local fishery fleets and fish stocks.

As a leading company of seafood market in Turkey, Dardanel has been involved in an effort to generate feasible projects for bluefin tuna farming industry in Turkey. On this roadmap, Dardanel imported an extensive know-how, expertise and technical assistance through consultancy and partnership agreements by both local and international means.

Currently, Dardanel has a farming plant or a plant project in:

Alanya-Gazipaşa = 840 tonnes capacity (operating since 2001).

There is another farming project near Bozcaada, an island close to Çanakkale Province. The project was subjected to public intervention in 2002. Despite a delay of the project due to bureaucratic reasons, after the recent concerning public resolutions, the project will soon be underway.

At this point, I have to stress that, we all have a bottleneck, regardless of the project plans and investments employed, that is, the total production capacity is eventually subject to the ICCAT quotas and Ministry of Agriculture regulations.

The project areas in Gazipasa and Bozcaada for bluefin tuna farming have been chosen because of;

- Not impeding marine and naval traffic.
- No adverse effect on tourism.
- Most available sea/land in terms of hydrographic, geographic and meteorological conditions.
- Close links to transportation channels.

The initial investment of a farming plant simply consisted of two Japanese-designed rectangular and four-round cages providing the capacity of 840 tons. During the first year of production, we used; 4 towing boats, 1 large and 1 small feeding boats, 1 diving boat and 1 processing boat. Additionally, we contracted 3 different cold storage facilities to meet our needs. Some ground transportation vehicles were also utilized.

In order to keep initial investments we rented some of our needs for the first year.

For the coming season, the items as follows will be used for 840 tonnes production capacity plant in Gazipaşa – Alanya;

- 10 feeding cages (50 m diameter, 16 m depth) some of which are used for towing process also.
- Mooring equipment
- 4 feeding boats (under construction to be completed in Apr.03)
- 1 processing boat
- 2 diving boats (1 is under construction to be completed in Apr.03)
- Underwater camera and diving equipments
- 3 fridged on-road truck (20 tonnes of capacity)
- 3 cold storage for feeding food stocks (rented)
- Utility vehicles (car, small trucks, forklifts etc.)

The area of the farming sea/land is about 2 km^2 and there will be 30 persons employed for the process.

One of the boats mentioned above may be a focus point in terms of how processing requirements are met; Dardanel 1, a converted processing boat. It is originally a fishing boat and it has been taken under renovation to fulfill the processing needs and is equipped with:

- Chilled water tanks (60 tonnes of capacity)
- Ice maker machine (1 tonnes - hour of capacity)
- Other processing items

Today, Dardanel 1 has all specification that is in accordance with the HACCP regulations.

Catch Season

The catch and transfer of the fish at sea is done by the contract with the local fishermen of a total number of boats involved up to 16.

Some of the farming cages are equipped to be a towing cage and towing boats are contracted for the process.

Capacity of each towing cages may be up to 200 tonnes for a single transfer. The distance between the farm and the fishing ground varies within range of 20 to 150 miles.

Transfer and Transportation

This stage is a process that should be handled with care. We are using our very well trained and experienced professional teams for that purposes and we do not want intention to get consultancy for the coming season.

As you know well, one of the other important aspects of transferring fish to the cages is to accurately determine the amount of fish transferred. To ensure the closest measures in transfer, all necessary equipments should be prepared, as the underwater camera system, professional diving equipments, and specialized staff.

Farming

We start feeding as the fish are transferred into the farm cages and the things get settled down for the fish. The fish is fed 2 to 3 times a day and it is regulated by the farm manager in accordance with the divers' reports. We measure and record sea water temperature, oxygen levels, other current information and weather condition twice a day. During the feeding period every fish consumes food equal to 5 % of its body weight daily. In feeding process, mainly sardines, mackerel, anchovy and others are used as bait. Feeding food is subject to the inspections of fat content, supply region and health quality.

The process lasts for 6 months, which means that the harvesting is about 5-6 months ahead of the fishing season.

Harvesting

Last season, the ratio of the gained weight of the fish was 23-25 % on average, and the size composition of harvested fish was;

0-45 kg	2 %
46-100 kg	73 %
Over 100 kg	25 %

Troubles Faced in Farming

We faced various type of troubles during the first season. Most of those were solved by quick but temporary problem-solving methods. Despite of our endless efforts, in some cases the loss of fish could not be impeded. The output of all sorts of problems we experienced in the farm was, losing almost 60 tonnes of fish during the season of 2002.

The main reasons of fish loss were:

- Initial stress of fish during the early days after transfer.
- Strong currents (above average ratings up to 3 knots)
- The shape and volume of the nets disturbed,
- Stressed fish started to move faster and faster.
- Fish entangled to the net due to panic.
- As a result of experience gained in recent years, we are aiming to minimize fish loss and reach higher targets in the coming season.

PRIMARY APPLICATIONS ON BLUEFIN TUNA (*Thunnus thynnus*) FATTENING IN TURKEY

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INTRODUCTION

The bluefin tuna (*Thunnus thynnus*), is commonly seen in the temperate waters of the world. It is also distributed at cold latitudes (SLASTENENKO, 1955; AKSIRAY, 1987). Distribution of the bluefin tuna (BFT) includes the European and the American coasts of Atlantic Ocean, the Mediterranean Sea, the Marmara Sea, the North Sea and the Baltic Sea. It is reported that BFT migrates form the Black Sea during winter in Turkey. Its breeding season is July-August in the Black Sea. Eggs of BFT are pelagic; they have a diameter of 0.1-1.1 mm and include single oil globule. Larvae length is 3 mm. Tuna fish are reported to have average length of 3-4 meters and average weight of 300-400 kg (SLASTENENKO, 1955).

It has been observed that BFT starts breeding at the age of 4; their breeding period is between June and August and they spawn when water temperature is between 21.6-29.2°C in the researches done in Japan (MIYASHITA *et al.*, 2000a,b).

General Features and Distribution in the World

BFT makes trans-ocean migration and swims fast. Juveniles are generally in schools. They can be mixed with similar species. Immature individuals live in temperate waters while mature fish live in colder areas. Their feeding habits are quite predator except the spawning period. They eat every kind of fish, crustacea and molluscs (ANON., 1987).

They distribute alongside the North African Coast, from Gibraltar to the coasts of Libya, at the coasts of Spain and France, around Sicily and Sardine Islands and to Mediterranean and Black Sea. They exist from Atlantic Ocean to polar latitudes; at Russian and Norwegian coasts; at Lafonten Islands and at the coasts of Iceland (ANON, 1987).

Atlantic BFT can grow to the length of 300 cm and to the weight of 650 kg. They can live as long as 20 years as reported by the tagging studies (ICCAT, 2002). BFT from the western Atlantic region are longer than those of the eastern Atlantic. They breed from mid-April to mid-June at the coasts of Florida and in Mexican Bay. They spawn between the end of May and July at the east coast of the Atlantic Ocean according to their spawning grounds. They spawn mainly around the Baler Islands, Tiran Sea and mid-Mediterranean regions when the water temperature reaches 24°C in the Mediterranean Sea (ICCAT, 2002; www.europasifictuna.com).

Tuna Market in Japan

The only BFT market in the world is in Japan and it has a capacity of 600 000 tons/year (Table 1). The demand in this market has a growing tendency (IKEDA, 2002; www.aquanet.org).

Table 1. Bluefin tuna market in Japan (fishing + rearing) (fresh and frozen) (IKEDA, 2002; www.aquanet.org)

YEAR	CAPACITY (1000 tons)
1998	507
1999	451
2000	466
2001	477

BFT fed in the cages and supplied to the market in Japan are frozen (85 %) and fresh (15 %) (CUNNINGHAM and BEJARANO, 2002).

Bluefin Tuna Rearing in the World

BFT rearing is done mainly in Japan, Australia, Spain, Italy, USA, Croatia, Tunusia and Malta. These are also known to be best BFT catcher countries. The Mediterranean catcher countries are Italy. Spain, Croatia, France, Malta, Morocco, Tunisia and Libya. Tuna catching countries of the Atlantic Ocean are USA and Mexico and Australia in the Pacific Ocean. BFT fish caught in nature are fattened by feeding with ringa, sardine, mackerel. etc.. then sold in the market.

Some researches are done with the purpose of the enrichment of natural BFT stocks and to make advanced aquaculture of tuna fish, primarily in Japan, Spain, Australia. Morocco and Croatia (HATTORI *et al*., 2001; MIYASHITA *et al*., 2000a,b; NHHALA, 2002; NORITA, 2002; RESTREPO, 2002; SAWADA *et al*., 2000).

Eighteen tuna farms in Japan realised 500 tons production in 1998-2000 and 300 tons in 2001. Juvenile BFT fish of 150-500 g in July-August period are fed for 3-4 years and then sold in the market when they reach 30-70 kg. But, there is a risk of losing some of the fish because of the typhoons during the long term feeding. Therefore the costs rise and the marketing price is quite high. High quality fish are produced with this method, but their prices are not competitive (IKEDA, 2002).

The public interest in BFT in Spain has begun after the export of caught tuna fish to Japan in 1987. BFT farming practices in the cages began in 1995 (CUNNINGHAM and BEJARANO, 2002). Only one company in Spain produced 7000 tons tuna fish in 2000 and earned 150 millions Euro. More than 500 people works in such companies.

In Australia, BFT rearing practices began in cooperation with Japan in 1991. Fishermen brought tuna fish 300 km away from Australia coasts to the floating net cages. Purse seine was used in catching BFT. They fed BFT with sardines, etc. for 3-6 months and then they were ready for the market. Market price reached 20 US $.

Their production began with annual capacity of 140 tons in 1992 and reached to 4700 tons in 1998 (ANON., 1999).

Bluefin Tuna Fisheries in Turkey

It is known that *T. thynnus* has the highest economical value in all of the seas around Turkey, including the Black Sea. Fishing amounts of previous years in Turkey are given below (Figure 1) (ICCAT, 2002).

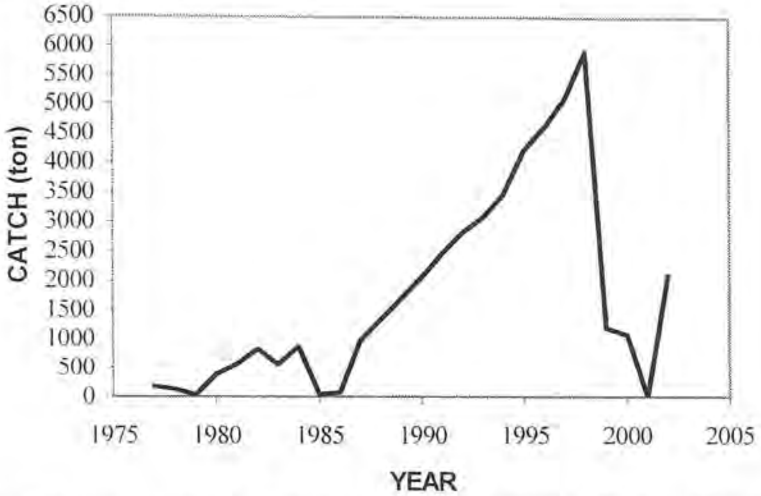

Figure 1. The yearly catch of BFT between 1977 and 2002 in Turkey (ICCAT, 2002).

This figure shows that, BFT catching capacity has reached to even 6000 tons in Turkey. This amount is almost equal to the capacity of the most important BFT catcher countries.

First BFT rearing projects were started by private sectors with extensive efforts in 2000-2001 season and the first production was made in 2002. This production was about 2000 tons.

New scientific researches are essential to determine the distinct BFT population which enter the seas around Turkey and to estimate the maximum consumable amount in this population. BFT stocks should be preserved and their continuation should be guaranteed. Scientific researches which enable the determination of BFT stocks and their characteristics will make it possible to manage the existing stocks economically.

Any comments which are not based on good researches would be out of the scientific understanding and this valuable export material of Turkish economy would be caught by other countries. Common projects with other Mediterranean countries and evaluation of the data together with the countries of Atlantic coast are very important.

Support of the education programs of the Faculties of Fisheries with courses about underwater systems, their control and supply, cages, nets, and the connection systems would be very useful.

Bluefin Tuna Farming in Turkey

First BFT farming projects started in 2001 in Turkey and 3 private companies had permissions for production, and installed their farms in 2002(GÜVEN *et. al.*, 2002). The companies begun installation just after they received the permissions. Essential BFT individuals were bought from the fishermen in May – June 2002. BFT were fed afterwards (Table 2).

Table 2. The capacities of the Turkish BFT rearing companies in 2002 (tons) (Ministry of Agriculture and Rural Affairs, Department of the Development of Agricultural Production)

FARM	CAPACITY
Sagun Fisheries Corp. Antalya	760 ton
Dardanel Fisheries Corp. Antalya	638 ton
Aquadem Sea Products Corp. İzmir, Çanakkale	304 ton, 304 ton
Marmaroz Sea Products Co. Ltd. Çanakkale	91 ton
TOTAL	2097 ton

These companies which use similar systems make harvest in September – November season. Feeding season is about 3-6 months in Turkey, similar to the periods in other countries. Turkish companies sell all of the BFT they produced. Only one company tried to keep some part of its production for selling fresh. The results were quite successful for the first year. However, because of the specific quality concept of this market, BFT product of Turkey was sold with a lower mean price than the products of Japan, Spain or Italy (Figure 2).

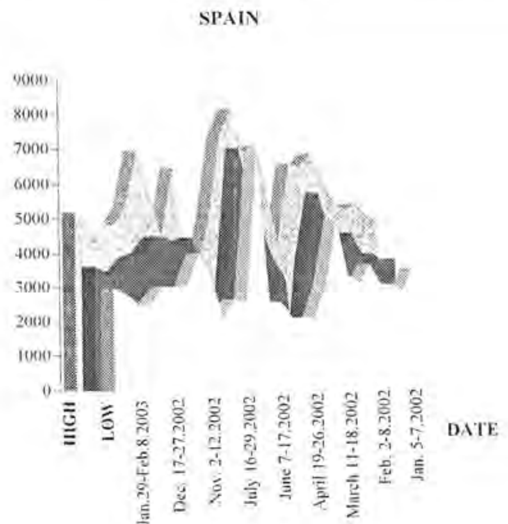

Figure 2a

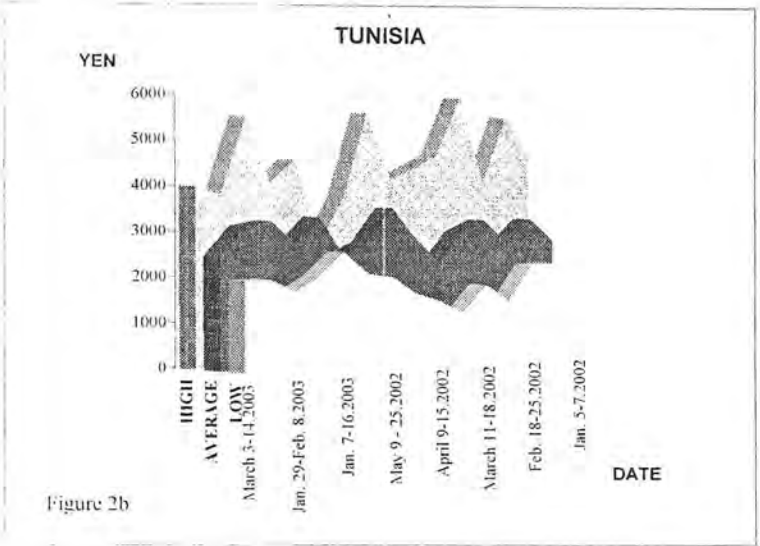

Figure 2b

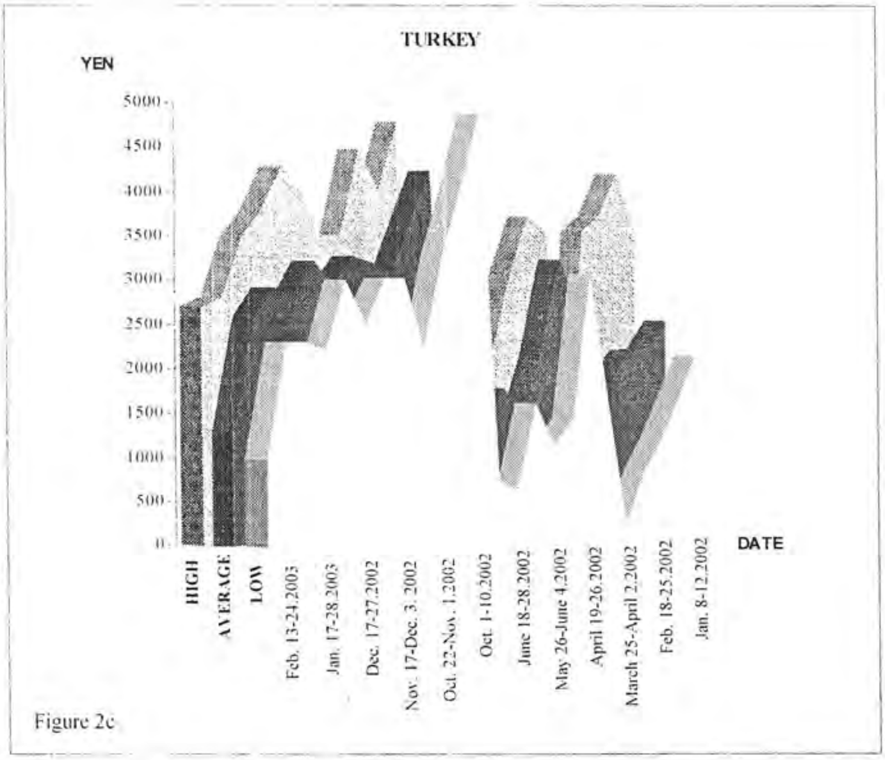

Figure 2c

Figure 2 a,b,c. Bluefin tuna fish prices in various countries (in Japanese Yen) (http://swr.ucsd.edu/fmd/sunee/twprice/twpnew02.htm).

Stages of General Practice in Bluefin Tuna Rearing

BFT rearing is quite different from the rearing of other fish species. BFT is not grown from the aquacultured juveniles, but bought from the fishermen as mature individuals and then fattened. This is quite a risky method, because the fish are supplied from the natural resources. This is why it is difficult to make detailed production planning (CUNNINGHAM and BEJARANO, 2002).

The seasonal preparation stages are:

Following period, planning, preparation and construction for campaign.
Capture and transport of the BFT
Development, handling, maintenance, feeding and fattening season.
Harvesting, processing, quality control, marketing and analysis phase

Following period, planning: Studies about the effects of the environment at the farm, choosing the place of the farm and its limits, structure of the basis of the farm, its depth, characteristics of the streams and the winds, determination of the habitat and the biological communities, estimations about the annual production amount, transport of the captured BFT to the cages, transport of the live BFT to the farm, methods of feeding and supply, types of the food used in the farm, frequency of feeding and the amount of food given, harvest intervals and methods, packaging and exports, materials used in packaging and stocks of food, the amount and the types of the waste material in the farm, the docks and the ships used in the production, transfer periods, effects of other activities in the sea, activities on land and related studies, management of the wastes and energy, minimisation of environmental effects and their measurement (CUNNINGHAM and BEJARANO, 2002).

Preparations must be applied according to these factors:

Capture and transport of BFT
Development, handling, maintenance, feeding and fattening season.
Sacrifice, processing, quality control, marketing and analysis phase

Bluefin Tuna Rearing in Turkey

Catching: Catching period is between May and June for BFT rearing. BFT are captured by purse seine. Fish in the purse seine are transferred to the floating net cages by the help of diver teams. There are special exits in purse seine which enable the transfer to the cages.

Transport: BFT transferred to the cages are towed to the farm site by the boats with a speed of 1 mile/hour. In two farms at Antalya coast of Mediterranean region of Turkey, BFT are towed to the farm site in 7 – 10 days depending on the distance of the capture area from the farms and the conditions at the sea. At a farm at İzmir, this period is 30 – 35 days and the divers control the nets regularly during this period.

Transfer of BFT to the Cages in the Farm: The cages are regularly controlled by the divers after they are bound at the farm site. BFT do not feed during transportation.

They start eating after an adaptation period of 20-40 days to the conditions of the new environment. Dead fish are removed from the cages immediately by daily dives.

Feeding starts 2-3 weeks later in order to have the fish get used to the food. The divers control the BFT during feeding. Diver's control is essential for feeding even if the BFT get used to the food. The amount of the food is determined according to the interest of BFT to the food. Daily food amount is 5-8 % of the live weight of the fish (KATAVIC, 2002a,b). It is important to promote the interest of the BFT to the food and to give adequate food to them.

Frozen sardines (*Sardina pilchardus*, *Sardinella aurita*), ringa (*Clupea harengus*), mackerel (*Scomber japonicus*) and some squid species are used in feeding BFT. Characteristics of these fish are given in Table 3 (GIMENEZ and GARCIA, 2002).

Table 3. Average values (%) of macro and micronutrient composition from fish food for tuna fattening (D.S.: dirty substance) (GIMENEZ and GARCIA, 2002).

%	Moisture	Lipid	Lipid D.S.	Protein D.S.	Protein D.S.	Total Nitrogen	Total N. D.S.	Total Phosfor D.S.
July 2001								
Sardinella aurita	72.57	4.37	15.77	18.53	67.88	2.94	10.86	0.21
Clupea harengus	66.86	15.33	46.19	15.70	47.49	2.51	7.59	0.12
Scomber japonicus	72.85	6.63	24.23	17.72	65.56	2.83	10.48	0.17
Ilex coindetii	75.51	0.72	2.96	17.35	70.88	2.77	11.34	0.25
Boops boops	68.60	7.73	24.61	20.37	65.02	3.25	10.40	0.14
August 2001								
Sardinella aurita	70.89	8.08	27.35	16.95	58.89	2.71	9.42	0.15
Clupea harengus	73.45	2.90	10.80	18.07	68.12	2.89	10.90	0.15
Scomber japonicus	71.73	8.51	29.21	17.69	63.61	2.83	10.17	0.11
September 2001								
Sardinella aurita	75.60	0.99	4.11	17.57	72.05	2.81	11.52	0.17
Clupea harengus	66.88	12.55	37.35	18.07	55.06	2.89	8.80	0.17
Scomber japonicus	73.08	5.44	18.82	18.64	70.88	2.98	11.34	0.17

Stock density in the rearing cages are 2-4 kg/m^3

The cages are made of HDP (high density polyethilene) (500 mm ø) pipes with a diameter of 50 m. Nets with a depth of 30 m are bound to this circular structure. Mesh size of the nets is 80-110 mm. The cages are fixed to the base with an anchoring system convenient to the regional conditions.

Fattening season lasts 3-6 months. Fattening of the fish is followed by daily controls. Meat quality of the dead fish also continuously controlled. Harvest time is chosen according to the quality of the meat determined by sampling.

Harvest and Transport to the Market: Harvesting is the most important factor in the most quality of BFT. Inappropriate harvesting can eliminate all of the previous successes in BFT rearing. Harvesting should be done according to a detailed planning for this reason. Presentation of BFT to the market (frozen or fresh) must be decided previously and harvesting must be planned according to this decision.

Almost all of the BFT harvest of Turkish companies in 2002 was frozen at – 60°C, and given to the freezer ships. Appropriately harvested BFT fish in the cages are given immediately to the ships. These BFT are differentiated according to their characteristics on the deck of the ship and frozen in parts or as a whole. Ice water tanks are used in the transport of BFT. The body temperature of dead fish is around 28-30° C. This is quite high. Body temperature of dead BFT must be reduced to 10° C immediately during the transport.

Fresh BFT are similarly captured, their body temperature is reduced to 10 °C, and then frozen in specially produced isolated packages and carried by air. Appropriate harvesting and immediate decrease in body temperature is very important. If these requirements are not met, heart rate and the level of cortison and adrenalin increases in the blood. As a result of this increase, vigorous muscular contractions begin. This increase in the muscular activity depletes the oxygen reserves of the muscles and the normal process of aerobic glycolysis cannot proceed. The muscle tissues then resort to anaerobic glycolysis for the production of energy. As a result of this process, accumulation of lactic acid in the muscles starts, pH value and energy capacity goes down. The cumulative result of this process, is autolytic degradation and bacterial breakdown. This primarily affects the quality of tuna meat. Muscles lose normal appearance, colour and tissue characteristics at the end of this process (CUNNINGHAM and BEJARANO, 2002).

The Factors Affecting the Quality of BFT Meat

The method of harvesting is the most important factor which determines the quality of BFT meat. Appropriately harvested BFT's visceral organs and gills are cleaned, the blood is removed and the fish is placed in water with ice so that their body temperature becomes lower than 10°C.

Another important factor which affects the quality of the meat is the experience of the fishermen who catch and clean the BFT. Even if the colour, tissue, the fat percentage, the appearance and freshness of the fish are very good, their quality would be very low if the processing team is unexperienced.

Problems and Recommendations

Problems of BFT farming are not very different from those in the rearing of other fish farming sectors. The most important problem is the lack of supportive policies for this industry. Because of the similar lack of promotive policies in the field of agriculture and livestock, very basic advantages of Turkish economy in these fields will disappear in the near future and Turkey will be obliged to import basic food materials from the countries which advise her not to promote agriculture and livestock industry today. However, Turkey has serious potential to develop its agriculture and livestock industry together with tourism industry.

The design of BFT rearing systems and the management of the process from catching stage to marketing phase needs the knowledge and the experience of engineers. Planning and the existence of an experienced team together with essential machines and equipment for the successful production is very important. Serious and experienced engineering services are necessary for the installation of BFT farms in coastal regions, transport of the captured BFT to the cages, towing of the cages to the farm, adaptation of the fish to the food and their feeding, harvesting and presentation to the market. Serious economical losses are inevitably faced if knowledge and experience do not exist at several phases of the production like: the design of the rearing system; the purse seine, ropes, anchor, chain and the buoy which are used in the farm; correct choosing of the materials for the pool; transfer of the captured BFT from the purse seine to the cages; towing of the cages full of the fish to the farm by boats; harvesting and the processing. It is reported that all of the captured fish were lost at an accident in Australia in 2003 season. The cause of the accident was the choosing of wrong kind of connection equipment for towing the cage. (www.atuna.com)

Technical Problems: The first problem in BFT rearing is the supply of the fish. The investor is dependent on nature and must make planning according to this reality. Serious projects must start in Turkey, like other developed BFT producing countries. Successful techniques used in the fish farming of other species should be applied for this fish too. Natural stocks of BFT should be determined accurately, existing stocks must be protected from excessive catching and their continuation must be preserved.

Although the capturing techniques are very developed, counting of the fish and accurate determination of the stocks are still difficult. Because, counting and measuring of each fish is practically not very easy. Today's technologies need to be improved so that, these problems could be solved.

It would be success to improve the techniques of BFT feeding and underwater controls.

New methods should be found for higher quality in rearing, for better harvesting and sacrificing ways.

Feeding Problems: New researches are essential in food and food technologies in order to obtain fat and colour quality which are important factors in the quality of meat. New feeding methods are necessary to increase meat quality.

Environmental Problems: Aquaculture industry should be very sensitive to environmental problems. Environmental changes directly effect BFT. They are very sensitive to the environment. For instance, most of the specialists believe that BFT originates from the Atlantic Ocean. However, Russian scientists inform us that they breed in the Black Sea also. Apparently because of the environmental reasons, BFT do not enter the Black Sea nor the Marmara Sea anymore.

Relations with Other Sectors: The most related sector with BFT rearing is tourism. Adequate technical knowledge is formed together with the formation of the sector and many people informed with wrong information have negative ideas about BFT rearing. However, BFT farming is an efficient business as well as the agriculture or tourism. The fish not captured in Turkey will be caught in other countries and Turkey will lose its resources. This fish is also a valuable export material.

Marketing Problems: Marketing is as sensitive as production. The product determines its own price because of the specific quality concept in this business. As seen in Figure 2, BFT of Turkey is sold in the market for approximately half of the price of the BFT from other countries. This is a very important subject. Inappropriate handling in harvesting, cutting, packaging, transporting and other phases cause lower market prices. The level of the quality of the companies and then the country will directly effect the market price and its continuity. Stability in quality will guarantee the stability in the market prices.

Finally, it is obvious that new researches are necessary about rearing of BFT which is a new species in the field of aquaculture sector of Turkey. We think studies n stocks, enrichment of natural stocks by production activities under controlled conditions and to increase the quotas determined for Turkish producers to the level they should reach must be the basic aims of these researches.

REFERENCES

AKSIRAY, F. 1987. Thunnidae. Türkiye Deniz Balıkları ve Tayin Anahtarı. İ.Ü. Rektörlüğü Yayınları No. 3490. s. 471-477.

ANONYMOUS 1987. Mediterranee et Mer Noire Zone de Peche 37 Révision 1, Vol. 2 Vertebres. Fisches FAO D'Identification Des Especes Pour Les Besoins de la Peche. p. 1278.

ANONYMOUS 1999. Southern Bluefin Tuna.CSIRO Marine Research, Australia. 4 pp.

CUNNINGHAM, E.M., BEJARANO J.M.S, 2002. Aspects of BTF Grow-Out Experience. I. International Symposium on Domestication of the bluefin tuna *Thunnus thynnus thynnus*, 3-8 February 2002, Cartagena-Spain.

GIMENÉZ, F.A., GARCIA, B.G. 2002. Macronutrient Composition of Food for Tuna Fattening. I. International Symposium on Domestication of the bluefin tuna *Thunnus thynnus thynnus*, 3-8 February 2002, Cartagena-Spain.

GUVEN, E.; COLAK, S., COLAK, A. 2002 Ege Deniz'nde Deniz Balıkları Yetiştiriciliği ve Yeni Türler, Ulusal Ege Adaları Toplantısı, 10-11 Ağustos 2001, Gökçeada, Türkiye. TUDAV Yay. No. 7, Bildiriler Kitabı. 204 -223

HATTORI, N., SHIGERU, M., SAWADA, Y., KATO, K., NASU, T.; OKADA, T., MURATA, O. KUMAI, H. 2002. Lateral Muscle Development of the Pacific Bluefin Tuna, *Thunnus thynnus orientalis*, from Juvenile to Young Adult Stage Under Culture Condition. Suisanzoshoku, 49 (1) 23-28.

ICCAT. 2002. Collective Volume of Scientific Papers, Vol. LIV, Madrid.

IKEDA, S. 2002. Market and Domestic Production of Cultured Tuna in Japan. Cultured Tuna in the Japanese Market. I. International Symposium on Domestication of the bluefin tuna *Thunnus thynnus*, 3-8 February 2002, Cartagena-Spain. Abstracts Book.

KATAVIC. 2002. Bluefin Tuna (*Thunnus thynnus* L.) Farming on the Croatian Coast of the Adriatic Sea – Present Stage and Future Plans. I. International Symposium on Domestication of the bluefin tuna *Thunnus thynnus*, 3-8 February 2002, Cartagena-Spain. Abstracts Book.

KATAVIC, I., TICINA, V., FRANICEVIC, V. 2002. Rearing of Small Bluefin Tuna (*Thunnus thynnus* L.) in the Adriatic Sea – Preliminary Study. I. International Symposium on Domestication of the bluefin tuna *Thunnus thynnus*, 3-8 February 2002, Cartagena-Spain. Abstracts Book.

MIYASHITA, S., MURATA, O., SAWADA, Y., OKADA, T., KUBO, Y., ISHITANI, Y., SEOKA, M., HIDEMI K. 2000 a. Maturation and Spawning of Cultured Bluefin Tuna, *Thunnus thynnus*. Suisanzoshoku, 48 (3) 475-488.

MIYASHITA, S., TANAKA, Y., SAWADA, Y., MURATA, O., HATTORI, N., TAKII, K., MUKAI, Y., KUMAI, H. 2000 b. Embryonic Development and Effects of Water Temperature on Hatching of the Bluefin Tuna, *Thunnus thynnus*. 48 (2) 199-207.

NHHALA, H. 2002. Research and Development Experience in Bluefin Tuna Experimental Breeding in Morocco. I. International Symposium on Domestication of the bluefin tuna *Thunnus thynnus*. 3-8 February 2002, Cartagena-Spain. Abstracts Book.

NORITA, T. 2002. Pacific Bluefin Tuna (PBFT) Breeding at Central South Japan Coast. I. International Symposium on Domestication of the bluefin tuna *Thunnus thynnus*, 3-8 February 2002, Cartagena-Spain. Abstracts Book.

RESTREPO, V.R. 2002. ICCAT Functions and Stand Towards BFT Aquaculture. I. International Symposium on Domestication of the bluefin tuna *Thunnus thynnus*, 3-8 February 2002, Cartagena-Spain. Abstracts Book.

SAWADA, Y., MIYASHITA, S., AOYAMA, M., KURATA, M., MUKAI, Y., OKADA, T., MURATA, O., KUMAI, H. 2000. Rotifer-Size Selectivity and Optimal Feeding Density of Bluefin Tuna, *Thunnus thynnus*, Larvae. Suisanzoshoku, 48 (2) 169-177.

SLASTENENKO. 1955. Grup: Thunniformes. Karadeniz Havzası Balıkları. Et ve Balık Kurumu Yay. s. 518-521.

www.atuna.com

www.europasifictuna.com

http://swr.ucsd.edu/fmd/sunee/twprice/twpnew02.htm

THE 'SUSTAINABILITY' OF CURRENT BLUEFIN TUNA FARMING PRACTICES IN THE MEDITERRANEAN

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Tuna farming is a new inflationary practice in the Mediterranean that is completely reshaping the fishery of bluefin tuna and is susceptible of producing a number of very important -and diverse- problems that need to be addressed without delay. Indeed, the 2002 meeting of the Joint GFCM/ICCAT Working Group on Large Pelagics, held in Malta, provided a detailed account of the main related problems undermining the sustainability of this large-scale industrial activity.

The main emerging issues of concern detected by WWF in the region could be outlined as follows:

1) The so-called 'tuna farming/penning' is just the new final step of a standard capture fishery that relies on a severely overexploited stock. As the experts point out, this new practice is expanding the market for this resource, thus resulting in an increase in the fishing effort deployed on it. It is evident that increasing dramatically the capital invested in a fishery harvesting on an overexploited stock is clearly undermining the viability of any possible rebuilding plan for the overfished species. This aspect was made clear by the political decision taken by ICCAT in 2002 to set up an unsustainable quota for the next 4 years, at a level 28% higher than the maximum harvest scientifically recommended (ICCAT/SCRS, 2002) to merely stop the decline of the population.
2) All authorized sources suggest that tuna farming is exacerbating the chronic problem of achieving a good statistical reporting process for the species, leading to reliable catch information. This is a matter of serious concern since ICCAT/SCRS is being acknowledging that the shortening of this information prevents any reliable scientific assessment of the stock, which would be necessary to design a rational management for the species.
3) Given the high biomass of baitfish needed to feed tuna during their captivity period, it is also a matter of concern the effect of these associated fisheries on local small pelagic populations as well as on their statistical reporting.
4) The fact that farms are installed very near the coast results in a big pressure on the littoral fringe, competing for space with other human activities and, in some cases, with the conservation needs of valuable natural areas. At this regard, it is noteworthy the referendum that took place the last 2 Feb in the island of Vis, Croatia, by means of which the local population stopped a new tuna-farming project.

5) Given that the aim of tuna farming is more related to the improvement of the quality of meat through the increase in oil content rather than the quantitative increase in biomass of fish, conversion efficiencies seem to be very low. This results in a rather "morally poor" aquaculture, where much fish biomass is wasted and, in addition, contributes to the organic pollution of the surrounding habitats. In all cases, what the ecological science tells is that the farming of a top predator such as tuna will never be an energetically profitable activity, since the ecological footprint on the marine ecosystems will be of an enormous magnitude.
6) Pollution seems to be a problem as far as it concerns both the effects of farms on the nearby coastal area as well as the bioaccumulation of pollutants in the tissues of farmed tuna, as has been denounced in international fora. As recently as March 2003, the Croatian Ministry of the Environment launched an official report where tuna farm facilities in this country were considered hazardous to human health due to the deleterious effects on coastal marine ecosystems they entail.
7) The high-tech, large scale activities associated to tuna farming practices -from purse seine fishing to the installation of cages, to the tug boats towing cages for very long distances- are susceptible to cause disturbances to other local fleets, as has been claimed by fishermen in Malta and Spain.
8) In some places, from Spain and Malta to Croatia, tuna farms have repeatedly behaved illegally, as has even been acknowledged by the local authorities. Also, to fulfill the increasing demand by farms, purse seine fleets behave illegally using airplanes to locate the shoals of tuna during all the fishing season, a practice banned by ICCAT.

The relative importance of the different points highlighted above is not balanced, so failing solving the problems associated to the more acute of them- even a single one- could be enough to undermine the ecological sustainability of this practice. In summary, the dramatic development of the activity in a very short time, fuelled by the huge economic benefits obtained, makes the addressing of the points raised above an urgent priority before this activity could be considered acceptable in terms of the sustainable management of the Mediterranean marine ecosystems. This is exactly the aim of the 'Cartagena Call For Action for Sustainable Tuna Farming and Fisheries in the Mediterranean', a petition to ICCAT, the GFCM, the EU and all Mediterranean states launched in October 2002 and signed by more than 100 scientists an organizations from all around the Mediterranean.

To this end WWF fully supports the important work to be done along 2003 and 2004 by the recently created joint GFCM/ICCAT Working Group on Sustainable Tuna Farming in the Mediterranean. This international expert group has the mandate to develop practical guidelines to address the main threats posed by tuna farming on the management of the bluefin tuna fishery, the conservation of Mediterranean ecosystems and the socioeconomy of coastal populations, especially traditional fishermen. In the meantime, in the line of the 'Cartagena Call for Action', WWF believes that a precautionary moratoria on new tuna farms is urgently needed in the Region.

TUNA FARMING IN THE MEDITERRANEAN: THE 'COUP DE GRÂCE' TO A DWINDLING POPULATION?

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ABSTRACT

A new practice in the Mediterranean – tuna penning – is threatening one of our most valuable fish resources. The bluefin tuna is already under considerable pressure and has been declining for years. Now tuna farming has opened up a new section on the Japanese market, which will further increase the demand for bluefin tuna and make the situation of wild stocks even more perilous.

The rapid increase in tuna penning has changed fishing strategies in the Mediterranean. Nearly all fish caught by purse seiners are now transferred to cages for fattening, rather than sold directly. With the new practice the reliability of catch statistics has further deteriorated –an already serious problem hampering efforts to properly manage the eastern Atlantic bluefin tuna population.

In addition, demands from the tuna farming industry have created increasing fishing pressure on small pelagic fish stocks. Some of these fisheries are poorly regulated and affect stocks already in decline, such as the anchovy. The low conversion factor from feed to tuna meat also makes tuna farming a wasteful practice.

Now WWF warns that the eastern Atlantic bluefin tuna stock could collapse within the next years, unless fishing pressure is significantly lowered and tuna farming is regulated by the responsible management bodies.

THE BLUEFIN TUNA: AN OVERVIEW OF BIOLOGY AND FISHERIES

The bluefin tuna (*Thunnus thynnus*) is a large pelagic species found both in the Atlantic (including the Mediterranean) and in the Pacific. It is a massive fish, which can grow to over 3 metres and a weight of more than 650 kg. Bluefin tuna is marvellously adapted to swimming and migrates several thousands kilometres every year. From an ecological point of view, bluefin tuna is a key species in the pelagic food web. It is a top predator that feeds on fish, squids and crustaceans – a very important ecosystem function that, to some extent, it shares with marine mammals and man.

Another relevant biological feature is the long life span of bluefin tuna; it can live more than 20 years. Sexual maturity is reached at the age of 5 to 8 years, depending on the stock. These characteristics – long life span and late sexual maturity – make bluefin tuna especially vulnerable to fishing, since it is prone to growth overfishing[1].

[1] By catching fish before they have had an adequate chance to grow, a decrease in the average size of fish in the population will occur. In general, the smaller the fish, the less reproductive capacity it has. Therefore, a high fishing pressure may easily result in a much lower than optimal yield.

Bluefin tuna fisheries in the Atlantic are found in the areas where the species is abundant: along the North American coast, in the West Atlantic, along northern Africa and the European coasts, in the East Atlantic, as well as in most of the Mediterranean Sea. The biological knowledge of bluefin tuna in the Atlantic is still limited, but there are believed to be two, largely separate stocks. Therefore, the International Commission for the Conservation of Atlantic Tunas (ICCAT) has defined two management units, one referring to the West Atlantic tuna and the other referring to the East Atlantic population, which includes the entire Mediterranean population. Both stocks are assessed and managed separately.

Recently, tagging studies have provided evidence of mixing of the two stocks, including transatlantic migrations as well as the existence of a previously unknown area of concentration of fish in the north central Atlantic, where fisheries have quickly developed. The presence of adult fish in the central Atlantic during the spawning season adds further uncertainty to the demography of the species. All this evidence does raise questions regarding the validity of the current management scheme based on two entirely separate stocks.

Current catches from the western stock are modest (2,397 tonnes in 1999) and the stock is clearly overexploited. A 20 year Rebuilding Program was adopted in 1998, which is now on-going. The state of the East Atlantic population, quantitatively more important, is described below. The primary spawning area for the eastern stock is the Mediterranean Sea, mainly around the Balearic Islands, the Tyrrhenian Sea and the Central Mediterranean, which implies a marked migratory behaviour by both adults and juveniles along the Mediterranean coasts as well as throughout the Gibraltar Straits.

In the Mediterranean Sea, bluefin tuna is caught mainly by purse seine and longline fleets. Purse seining is a rather recent catch method. It developed in the 1960's and the purse seine fleet now accounts for 60 to 80 per cent of the total catch. It relies on high-tech equipment and is very species-selective as well as efficient; also, contrary to what happens in other regions of the world, purse seine fishing in the Mediterranean does not entail high by-catches of cetaceans. The efficiency of purse seining has lead ICCAT to establish some technical limitations in order to restrict fishing capacity, such as the decision in 2001 to ban the use of spotter helicopters or planes during the month of June.

Generally, fisheries management in the Mediterranean region involves control of fishing effort and technical measures. But in line with the stock differentiation mentioned above, ICCAT has developed a management regime for the eastern stock based on quotas (TAC) allocated on a state by state basis. This makes bluefin tuna the only fish resource in the Mediterranean managed through quota regimes. However, the efficiency of the bluefin tuna management regime is limited, mainly due to the lack of Exclusive Economic Zones (EEZ's) in the Mediterranean and the related problems of enforcing legislation in international waters. Other factors of importance are the presence of a substantial fleet, either flying flags of convenience or none at all, and the high profits in the tuna fishery, which have resulted in a lack of political will to limit fishing effort.

State of the Mediterranean stock

The last report on the state of the East Atlantic bluefin tuna stock (which includes the Mediterranean population) by the Standing Committee on Research and Statistics (SCRS) of ICCAT was published in 1998. Assessments indicated a strong decline in the spawning stock biomass since 1993, as well as an increase in fishing mortality rates. The spawning biomass was estimated to be less than 20 per cent of the 1970 level. The analysis also indicated that future catch levels in excess of 33,000 tonnes would not be sustainable and only catches of 25,000 tonnes or less would halt the decline in biomass. *In the absence of a drastic reduction of fishing effort (and catches), projections predicted a high probability of collapse within the next few years.*

In 2001, the Committee expressed concern about the intense fishing pressure on small tunas, since it contributes to growth over-fishing and reduces the potential long-term yield from the resource. It also expressed concern about the recent abrupt increase in catches of large fish. The Total Allowable Catch (TAC) for the East Atlantic stock for 2001 was set to a 29,500 tonnes, of which 18,590 tonnes were allocated to the European Community and 876 tonnes to Croatia. This TAC is significantly higher than the level recommended by ICCAT scientists to prevent a continuous decline of the stock reported above.

No assessments of the stock have been carried out since 1998 due to a lack of sufficient data. Already then, the Standing Committee of ICCAT expressed its concern about the quality of the catch effort and size data. Today, the large uncertainties in the data are still a serious concern. The Committee stated that largely due to unreported catches there is a lack of detailed data on catches (Task I data) and production in the fish farms. ICCAT's Standing Committee acknowledges that these uncertainties will influence the advice provided to the Commission in the future. In an effort to include unreported catches, ICCAT has in the past compared the catch data (Task 1) reported by the different countries with the import figures to Japan (biannual BTSD). A comparison of 1999 figures amounted to an estimated 3,242 tonnes of unreported catch in the Mediterranean by Spain, Croatia, France, Italy, Portugal and Morocco. This was about 10 per cent of the TAC set for that year and almost certainly still below the actual catch. ICCAT also recognises that the increased practice of tuna fattening results in further uncertainties in catch and trade data.

Involvement of the different Mediterranean countries in the fishery

A summary of the total catch of bluefin tuna (in tonnes) in the Mediterranean Sea reported over the last 3 years shows that the purse seine fleet, the supplier of living fish to the farming industry, is responsible for the bulk of captures.

	1998	1999	2000*
Purse seine catches	20,391	14,061	13,302
Total catch	26,813	24,036	19,405

* incomplete, preliminary data; ICCAT

The relative share in the fishery of the different coastal states and Japan is summarised below.

Croatia
The total catch of bluefin tuna in the Adriatic Sea in 2000 was 930 tonnes, mostly caught by purse seine fleets and primarily intended (almost the entire catch) for farming purposes. This has resulted in further contradictions between catch and trade data. To meet the needs of the farming industry, the number of active purse seiners fishing for bluefin tuna increased from 19 in 1999 to 30 in 2000. A significant share of the tuna captured and transferred to cages is undersized or just within the legal minimum landing size set by ICCAT to 6.4 kg. In 2000, the average weight of the tuna caught for farming purposes was just 10 kg, so the bulk of the catch clearly consists of immature individuals (KATAVIC et al., 2002).

France
In 2000, the total French catch in the Mediterranean was 6,780 tonnes, all caught by the purse seine fleet. French fleets supply 70 per cent of the live tuna farmed in Spain.

Greece
Tuna catches during the 1990s fluctuated from 200 to 1,200 tonnes, mainly through hand-lining. A few purse seiners operate on an opportunistic basis.

Italy
According to ICCAT, it is increasingly difficult to collect reliable catch data and, particularly, data on fish sizes that is vital in population analysis from Italian tuna purse seine activity. This is due to increasing direct transfers of fish to cages for fattening, without landing or reporting the catch in any Italian harbour.

Japan
Less than 35 Japanese longline vessels are active in the Mediterranean. This fishery only targets pre-spawning, large bluefin tuna that congregate in the western Mediterranean for spawning. In 1999, the catch was estimated to 381 tonnes.

Libya
In 2000, 1,549 tonnes of tuna were caught using different types of fishing gear such as trap nets, purse seiners and longliners.

Malta
The fishing fleet is composed of 52 multipurpose vessels (< 20 m length), which capture large tuna (mean length about 226 cm) using surface longlines. Tuna catches in 2000 were 376 tonnes.

Morocco
In 2000, Morocco caught about 695 tonnes of tuna in the Mediterranean.

Spain
Bluefin tuna catches in the Mediterranean were 2,772 tonnes in 2000 (2,004 tonnes in 1999).

Tunisia

The purse seine fleet composed of 70 fishing boats catches the majority of the tuna. In 2000 estimated catches were 2,184 tonnes. In 2001, a large part of the purse seine catches has been exported to Spain for fattening prior to export to Japan.

Turkey

50 Turkish purse seiners caught 1,407 tonnes of tuna in the Turkish seas during 1999 – this should be compared to just 25 boats landing about 2,000 tonnes in 2001. Since the fishery in Turkish waters expanded, a dramatic decline in the abundance of tuna from 1994 to 1999 has been described (KARAKULAK, 2002).

In 2001, ICCAT and its Standing Committee on Research and Statistics stated that Mediterranean catches attributed in the statistics to the category "nowhere else included" declined from 1996 to 1998. They also pointed out that figures for 1999 and 2000 are difficult to evaluate because of increasing uncertainty about 1) information from fish fattening operations and its relation to reported national statistics and 2) bluefin tuna import statistics. The Committee suspects that there has been an increase in unreported catches in the last few years, especially in 1999. Therefore, SCRS strongly recommends the collection of information on the number, size and origin of fish entering cages. It also stresses its need to have access to both this information and the basic Bluefin Tuna Statistical Document (import data) to build a reliable catch database.

THE PRODUCTION OF 'FARMED' TUNA

An expanding practice in the Mediterranean has further complicated management of the bluefin tuna stock – tuna farming. This cannot be considered true aquaculture since the fish are not bred and reared in captivity. Instead, the rapidly growing industry is based on wild tuna caught alive from already declining stocks. Purse seines are the only mobile gear able to capture tuna alive; a feature that makes the purse seine fleets a necessary element of the tuna farming industry.

The wild fish are put in cages and fattened for a relatively short time to improve the oil content of the flesh in order to meet the Japanese market standards. According to some information this focus on meat quality entails a very low food conversion efficiency. In Murcia, Spain, the conversion is on average 4.26 per cent – a factor less than 20:1 (CUNNINGHAM and BEJARANO, 2002). So, the large amounts of fish fed to the caged tuna (mainly small and medium pelagics, such as anchovy or round sardinelle) only result in a relatively modest increase in tuna biomass.

The tuna farming industry is currently expanding rapidly not only in the Mediterranean, but also in Australia, Mexico (Baja, California) and Japan. The production of farmed tuna in 1999 was 13,300 tonnes. In 2000, total world production reached 15,000 tonnes (all species), with bluefin tuna (*Thunnus thynnus*) making up the bulk. Major producer countries were Spain, Croatia, Mexico, Malta and Japan, the latter with tuna farms in 18 different locations. Predicted yields of farmed tuna for 2001 are estimated to around 20,000 tonnes, significantly higher than the previous year. In the Mediterranean, tuna farming started just a few years ago, but estimated production in 2001 (see below) gives an indication of the huge development of this activity in the region. In fact, production in the Mediterranean is likely to make up more than half of the world total and is almost exclusively intended for the Japanese market.

Farmed Production (2001)

Country	Production (tonnes)	N° of farms
Spain	7,000	6
Malta	1,200	2
Croatia	3,000*	6
Total	11,200	14

* estimation

Source: Fish Information and Services (FIS Int'l. Co. Ltd.) & DOTT Symposium

In September 2001, the General Fisheries Commission for the Mediterranean (GFCM) recognised the problems posed by tuna farming on the management of the resource through a recommendation: "the issue of increasing tuna penning/farming in the Mediterranean. needs to be addressed in order to ensure the sustainability of the bluefin tuna fisheries". The Commission requested that the Joint GFCM/ICCAT Working Group address these concerns in collaboration with the Committee on Aquaculture (CAQ).

THE ROLE OF THE JAPANESE MARKET FOR TUNA

It is well known that Japan is the main market for tuna produced from world fisheries; it is also the underlying force driving the current development of the tuna-fishing sector in the Mediterranean.

Japanese customs clearance statistics for *Thunnus thynnus* imports from Mediterranean countries for 1999 (supplied by FIS Int'l. Co. Ltd.) can be compared to estimated national landings of East Atlantic bluefin tuna (ICCAT, including some non-Mediterranean catches) in the following table:

Country	Exports (Japan)			Landings
	Fresh (t)	Frozen (t)	Total BFT (t)	Total BFT (t)
Croatia	78	-	78	970
Cyprus	1	-	1	31
France	32	460	492	6,741
Italy	259	816	1,074	3,278
Libya	2	14	16	1,195
Malta	29	-	29	269
Morocco	22	312	334	2,227
Spain	2,325	2,351	4,676	5,358
Tunisia	446	61	507	2,352
Turkey	266	-	266	1,407
Total	**3,460**	**4,014**	**7,474**	**23,828**

Source: Fish Information and Services (FIS Int'l. Co. Ltd.) & ICCAT

Given the overall statistical problem, a thorough analysis of these data would require much more attention; however, it is worth noting that a large amount of bluefin tuna production is devoted to meet Japanese demand. This is irrespective of if the fish has spent a limited period in captivity in farming cages or not (in fact, in 1999 tuna farming was just starting in the Mediterranean). It should also be noted that whereas landing figures refer to round weight, export figures refer to product weight (such as filleted or gilled-and-gutted tuna). So the actual share of the catch exported to Japan is much higher than suggested above.

According to the Japanese National Report presented to the 4th session of the GFCM Scientific and Advisory Committee, no farmed bluefin tuna was imported to Japan from the Mediterranean Sea before 1997. The import of farmed tuna increased from 200 tonnes in 1997 to about 4,300 tonnes in 2000, according to the Bluefin Tuna Statistical Document provided by the Japanese Fisheries Agency to ICCAT.

In Japan, most sashimi grade tuna is used for either sashimi or sushi. The higher oil content in farmed tuna seems to make it particularly suitable for sushi, since the oil is balanced and absorbed by the rice. For the same reason, farmed fish is often too oily to be used as sashimi, because the taste is too heavy. Farmed tuna from the Mediterranean has a higher oil content than its Australian equivalent, and is more appreciated in Japan because the oil gives the flesh a more reddish colour which makes it more attractive.

Spain also exports some frozen farmed tuna to Japan to be sold during February and March when the supply of fresh bluefin tuna is likely to be at its lowest. Some of this is exported through Torei -Toyo Reizo, the tuna arm of Mitsubishi. The main market for this product is the *medium* range restaurants and sushi shops. Sales of Spanish frozen and fresh farmed bluefin tuna to the actual consumers in Japan are very limited, primarily because of its price (on average 4,500 yen/kg in early 2000).

THE CONSEQUENCES OF TUNA FARMING ON STATISTICS

After the last stock assessment in 1998, the SCRS recognises that uncertainty associated with catches has increased due to the increase of unreported catches following the imposition of quotas and the development of tuna farming.

In the report from the 5th meeting of the GFCM/ICCAT Working Group held in 2000, explicit reference is made to the fact that "some bluefin tuna transhipped after catch from purse seine to farming cages might not be included in the catch statistics of the flag country of fishing vessels, particularly when the nationality of fishing country and the fish farms are different". Indeed, MIYAKE (2001) states that "the worst problem" with tuna farming is that this practice has further confused catch statistics because of transhipments at sea and the lack of data on fish weight at capture. It is worth mentioning here that tuna is assumed to increase their weight by 25% at the end of the farming period.

In view of the rapid development of tuna farming, ICCAT made a request to SCRS through a formal ICCAT resolution in 2000. SCRS was asked to present a report on the effects of bluefin tuna farming on the collection of catch statistics, and to recommend possible solutions, if needed, to improve the Bluefin Tuna Statistical Document (BTSD). In 2001, the Committee responded that for stock assessment purposes its primary interest was detailed information about the fish when they are first caught (such as size, location, gear and fishing effort). It also stated that tuna farming makes it more difficult to obtain these data because fish cannot be sampled at the time of capture. In short, the SCRS recommended the following:

1. to study the feasibility of indirect sampling methods to estimate catch numbers and catch size before fattening takes place
2. to study the growth rates of farmed tuna
3. to look at the feasibility to modify the BTSD so that individual fish can be tracked and the time of fattening is indicated
4. to modify the BTSD so that it contains export data on the transfer of live fish captured by one country into cages of another country.

The SCRS states that it is "especially concerned with the lack of ability to accurately track catches, catch at size, origin of catches and fishing effort expended on fish that are farmed in cages". It also recognises that as a result the detail of the stock assessment in 2002 and the subsequent level of management advice will be limited.

SOME FACTS ABOUT TUNA FARMING PRODUCTION IN THE MEDITERRANEAN

In a recent report, MIYAKE (2001) explains that before the development of tuna farming, the Japanese bluefin tuna market was consistent with very high quality tuna (pre-spawners) and cheap tuna (post-spawners and juveniles). Tuna farming has creating a new medium-quality product filling the gap between these two categories on the market. He warns that the consequent increase in demand for tuna from fish farms will further increase the fishing effort, and have a very negative effect on an already severely overexploited stock.

The same author also states that the increasing market demand for tuna is making it harder and harder to reach an agreement on how to share the TAC between the fishing nations under ICCAT, and that various nations are suspected to have "well exceeded" their quota.

Some relevant aspects related to tuna farming in the different Mediterranean coastal states (and Japan) are summarised below.

- **SPAIN**

In June 2001, the Scientific Forum on Spanish Fishing in the Mediterranean, composed of some of the most respected fishery scientists in the region, expressed concern regarding the increasing tuna farming activities: "tuna penning is undoubtedly worsening the situation by distorting even more the management system applied to this fishery, besides its possible negative impact on the ecosystems".

Tuna farming in the Spanish part of the Mediterranean is limited to the region of Murcia, where the first farm started to export tuna to Japan as recently as in 1997. In 1999, the major producers of farmed tuna were R. Fuentes, Albaladejo, G. Mendes and Caladeros del Mediterráneo. In addition, a company called Mariviz based near Barbate worked with set nets, instead of floating cages. Much of the fish was frozen for export to Japan, though some was exported fresh. Some fresh tuna was also shipped to the US, where Spanish farmed fish has been changing the market. At that time, farmed tuna fetched much higher prices than wild caught tuna on the Japanese market.

In the last few years, as the volume of farmed fish has increased and the price of fresh bluefin tuna has gone down, the volume of frozen fish has become increasingly important. Frozen products affect the market less than fresh since they can be stored and then sold when the supply of fresh fish is low. Since all the farmed tuna has the high oil content that is so appreciated on the Japanese market, the portion frozen fish sold later in the season is increasing.

After the 1999 annual Memory of the Economic and Social Council of the Region of Murcia (Consejo Económico y Social, CES), the production of farmed tuna that year was reported to be 3,196 tonnes in total, with a value of 62,8 million euros. This figure, however, is not consistent with the official value of tuna exports from this region, reported by the same source to be 124.8 million euros. If these estimates are compared to the official estimates of landings of bluefin tuna in the region of Murcia, reported to be only 76.4 tonnes, the mismatch becomes dramatic. Tuna farming is also driving the dynamics of the pelagic fishery in the region; a previously valueless species – the round sardinella *Sardinella aurita* – has become an important target species very appreciated for feeding tuna.

The same CES report also acknowledges the tensions between the local purse seine fleet targeting small pelagics and the tuna farmers, grouped under the association ASETUN. Local fishermen claim that their diminishing catches are a result of the combined effects of pollution from tuna farms and the presence of cages in shallow coastal areas, which they say would result in tuna, being large predators, scaring small pelagic shoals.

The most recent data for 2001 points to a huge increase in tuna production: a total export of 7,000 tonnes, worth 150 million euros.

Most tuna farms in Murcia are located in a heavily polluted coastal area. Local NGO's have raised this issue to the Japanese diplomatic delegation in Spain, together with concerns about whether the health standards are met by the exported product. Also, the Murcia-based NGO ANSE has sued tuna farming companies operating in the area, claiming that they have been operating illegally; some resolutions from the Ministry of the Autonomous Government are supporting the environmentalists' claims.

Project proposals for new tuna farms have now been submitted to virtually all of the different Autonomous Governments of the Spanish Mediterranean coastal regions, from Andalucia to the Balearic Islands, including Catalonia.

- **CROATIA**

In Croatia, fattening of bluefin tuna started in 1996. In January 2001, 6 farms with a predicted farming capacity of 3,000 tonnes were in place.

Kali Tuna, jointly owned by Croatian, Australian and Japanese interests, is the largest Croatian tuna farming company. Is was founded by Croatian expatriates in Australia, who learned the process of farming Southern bluefin tuna in the area of Port Lincoln and imported this technology into the Adriatic. The company has 104 employees and 7 fishing boats at its disposal to supply the baitfish to feed the tuna. One of the owners declared that the amount of anchovy needed for one year amounted to 4,500 tonnes.

It has been reported that wild tuna approaches the cages of the Kali tuna farm in quest of sardines and other baitfish fed to the farmed tuna. These wild tuna are fished by hook and line. Many of them are unusually fat and fetch high prices on the Japanese market.

According to KATAVIC *et al.* (2002) most of the farms in Croatia are located in very shallow areas with poor water exchange. There is also a lack of environmental monitoring of the effects of tuna farms on the quality of water and sediments, and some operations have clearly had negative impacts on both ecosystems and communities. A great public opposition to these practices is also described.

- **FRANCE**

The French purse seine fleet targeting tuna in the Mediterranean is the main supplier of live tuna to the farms in the region. Their strong influence over French fisheries authorities has so far governed the French position at the GFCM Plenary Sessions.

An experimental project for a 4-cages farm with 200 tuna in each cage have been envisaged for the Fréjus gulf in French Mediterranean waters, only 650 to 700 metres offshore and next to a *Posidonia* seagrass bed, a habitat protected under the EU Habitats Directive. An impact study based on a hydrodynamic model of the area addressing the potential effects of the farm on water quality on nearby beaches concluded that under conditions prevalent in spring and summer (easterly winds and breezes) the risk of direct pollution by farm waste on the beaches was important (MARCHESE *et al.*, 2001).

Representatives from IFREMER (the French governmental fisheries institution) have recently stated that 'following the Spanish example, several farming projects may be launched in France in the near future'.

- **MALTA**

In 1999, Birdlife Malta warned that an application for a tuna farm project had been submitted to the authorities. The project entailed the location of cages only 300 metres offshore and threatened important nesting colonies of seabirds such as Cory's shearwater (*Calonectris diomedea*), Yelkouan shearwater (*Puffinus yelkouan*) and storm-petrel (*Hydrobates pelagicus*) found at the cliffs at Ta'Cenc in Gozo.

According to the Nature Trust, the north of Malta is becoming an important area for tuna farming. Recently, the Planning Authority Board approved the extension of a tuna farm from 4 to 8 cages against the recommendations made by the technical advisors of the same Planning Directorate; in fact the tuna farm was already operating with 8 cages without permission. Another tuna farm was also approved despite having been operating illegally. At present, most of the sea bream farms at Malta have applied for changing their farms into tuna pens.

Having started as recently as in 2000, the two Maltese farms produced 1,200 tonnes during 2001. Over the next 2 years another 3 companies will start farming tuna, with a forecasted production of 2,500 tonnes per year.

There are serious frictions between local tuna fishermen (small- to medium-scale longliners) and the tuna penning industry and its associated purse seine fleets. Disputes involving Italian (from the Adriatic) and Spanish fishermen, on one hand, and Maltese longliners, on the other, have required the presence of the Armed Forces this year.

In September 2001, the Maltese national delegation to the GFCM 26th Session proposed the establishment of a box in international waters south of Malta, that would be closed to purse seine fishing. It was claimed that increasing purse seining by a diverse fleet aimed at supplying the farms with tuna and the activity of tug boats towing the tuna cages were dramatically disturbing traditional longline fisheries by Maltese, Italian, Tunisian and Japanese fleets, as well as reducing tuna catches. The Maltese proposal was rejected following radical opposition from the EC delegation.

Fenech Farrugia from the Malta Center for Fishery Sciences recently declared that 'regulatory measures that directly control the registration of tuna caught by purse seiners in the Mediterranean must come into action so that all catches are recorded by ICCAT'.

- **TUNISIA**

A Tunisian delegation is known to have visited the tuna farms in Murcia in Span, the most important area for tuna farming in the whole Mediterranean region. The delegation wanted to learn more about the industry with view to possibly develop tuna farms in their own country.

- **JAPAN**

Since Japan has a national longline fleet operating in the Mediterranean, the Japanese Fisheries Authority is greatly concerned about the diminishing returns of Japanese longliners caused by the increasing competition from production of farmed tuna. The Japanese authorities also claim that national consumer associations are increasingly worried about the supposedly much higher pollutant content in the meat of farmed tuna compared to wild-caught fish.

Other Japanese stakeholders, however, have strong vested interests in the tuna farming industry. Virtually all farmed tuna is exported to Japan through Japanese middlemen and big companies like Kali in Croatia are co-owned by Japanese citizens.

- **ALGERIA**

In July 2001, the Algerian Fisheries Firm Union-Pêche (the first industrial subsidiary of the privately owned Union Bank) with an aim to invest in 'first class industrial opportunities in Algeria', announced that they had signed an agreement with the Spanish-Portuguese ship building company Navalfoz. Under the agreement, a fleet of 20 tuna vessels with a deck length of 30 metres and 1 measuring 47 metres will be built. This new fleet will be able to keep tuna alive in mobile cages, and negotiations with Japanese clients are already on-going.

This case illustrates the powerful economic interests behind tuna farming activities that are fuelling the development of the sector in the region. The economic investments associated with this operation amount to 20 million dollars. It was agreed despite the fact that Algeria did not become a contracting party to ICCAT until February 2001 and lacks any allocated fishing quota for bluefin tuna that would legitimate new industrial exploitation of the stock. Simultaneously, Algeria has supplied ICCAT with revised figures on national catches of bluefin tuna for the last years. The new figures show a peak in the landings in 1993 and 1994, surprisingly the same years that ICCAT uses as the reference point for quota allocation among the different states.

CONCLUSIONS

Tuna farming is a new, rapidly developing practice in the Mediterranean region and it is completely reshaping the bluefin tuna fishery. Most of the purse seine catches in the region are now transferred to cages for fattening. Tuna farming has potential positive effects on the commercial aspects of the fishery, since it creates mechanisms for regulating market supply, but we cannot overlook that it also creates a number of serious problems that must be addressed without delay.

Issues of particular concern to WWF are outlined below. The brief history of tuna farming in the Mediterranean does not allow us to draw any very conclusive "lessons learnt" regarding the real magnitude of the problems. However, the rapid development of the activity fuelled by the huge economic benefits involved creates urgency.

Until a proper management system is in place that addresses the concerns raised below, this activity cannot be considered sustainable. WWF has not attempted to balance the relative importance of the different points highlighted, but a failure to resolve any of the more acute problems might well undermine the ecological sustainability of the entire practice. In this context, it is worth remembering that according to the Precautionary Approach, one of the cornerstones of the FAO Code of Conduct for Responsible Fisheries now fully endorsed by nearly all relevant international fora, the burden of the proof is on the industry side. This means that it is up to the industry to provide the scientific evidence that this practice is sustainable.

1) The so-called 'tuna farming' in the Mediterranean is just an added final step of a standard capture fishery that relies on a severely overexploited stock. As scientists have pointed out, this new practice is expanding the market for bluefin tuna, resulting in a further increase in fishing effort. A dramatic increase in capital invested in a fishery harvesting an already overexploited stock is clearly going to undermine any attempts to rebuild the overfished stock.

2) Tuna farming is obviously exacerbating the already substantial problems with accuracy in catch data from the region. This is of serious concern since ICCAT acknowledges that the lack of information is preventing any further reliable scientific assessment of the stock - a necessary basis for any rational management plan for the species.

3) Currently, tuna farming is considered a post-harvest practice and therefore falls outside the regulations and fishing management systems put in place by GFCM and ICCAT. It has been allowed to develop in a relatively unregulated manner because it falls in between the definitions of a fishery and true aquaculture.

4) Given the large amounts of baitfish needed to feed the tuna during captivity, the effects of these associated fisheries targeting local medium and small pelagic populations is also a matter of concern. Many of these fisheries are poorly regulated and very little data is available to monitor them. Some of the small pelagics, such as anchovy, are already well below natural/optimal levels in some areas.

5) The fact that farms are installed very close to the coast creates in a high pressure on the littoral fringe. Farms are also competing for space with other human activities and are, in some cases, in conflict with attempts to protect valuable natural areas.

6) Given that the primary aim of tuna farming is to improve the quality of the meat through an increase in oil content rather than to quantitatively increase the biomass of fish, conversion efficiencies from feed to tuna meat are very low. This results in wasteful practices that also contribute to the organic pollution of surrounding habitats.

7) In addition to concerns regarding pollution effects from farms on nearby coastal areas, there is also the problem of bioaccumulation of pollutants in the tissue of farmed tuna, which could have detrimental effects on the consumers' health.

8) The high-tech, large-scale activities associated with tuna farming practices – from purse seine fishing and the installation of cages to tug boats towing cages for very long distances – are likely to disturb other local fleets. Conflicts have already flared up in Malta and Spain.

9) In some cases, for example in Spain and Malta, tuna farms have repeatedly operated illegally, as has been acknowledged by some local authorities.

Based on current practices and information, tuna farming in the Mediterranean cannot be considered a viable sustainable option.

A "true" tuna aquaculture independent of capture fisheries on wild tuna – controlling all the stages of the life cycle – with cages placed in off-shore locations would greatly improve the current situation. But concerns regarding fishing pressure on small pelagics to feed the farmed tuna would remain. Large-scale captive production of a carnivorous species will probably never be a sustainable activity due to the intrinsic waste of energy it entails and the resulting enormous ecological footprint.

In any case, the domestication of a marine fish species is an extremely difficult, long and expensive process. It may never be achieved and even if it is, the economic feasibility of tuna aquaculture remains unaddressed.

WWF RECOMMENDATIONS

WWF believes that many different measures are needed to save the bluefin tuna and minimise the effects of current tuna farming.

- Governments around the Mediterranean and the European Union (EU) must put proper and harmonised regulations for tuna farming practices in place, since they are large-scale agro-industrial operations.
- A decrease in fishing pressure on the wild tuna stock is urgently required. The TAC under ICCAT must be lowered to the scientifically recommended level, and the reporting system for catch figures must be changed to accommodate the new 'fishing for farming' practices.
- A long-term management plan for Eastern Atlantic bluefin tuna must be put in place aimed at rebuilding the stock, rather than just avoid its collapse.
- Control and regulation of illegal fishing and farming operations needs to be greatly improved.
- It needs to be recognised that even though the actual penning might be a "post-harvest practice" it is only the last step of a standard capture fishery. Subsequently, tuna farming practices must be subject to tuna fishery regulations to ensure coherence with conservation measures for the stock. Therefore, it must be dealt with by GFCM and ICCAT, the bodies responsible for management of the wild stock.
- The feed fisheries of small and medium pelagics must also be regulated and monitored to prevent stock collapses and the disruption of trophic pathways in the surrounding ecosystems.

Consequently, WWF calls for a **moratorium** on the development of new tuna farms in the Mediterranean until the implications of this activity on the environment, the tuna stock and the fish stocks used for feed are properly addressed at the appropriate international and national levels. Initiatives like limiting the fraction of tuna quota susceptible of being farmed or establishing minimum farming sizes for tuna, as suggested recently by a representative of the EU DG Fisheries, would be the kind of measures pointing to the right way.

REFERENCES

CONCLUSIONES de la VI reunión del Foro Científico para la Pesca Española en el Mediterráneo. Palamós, Spain. 13-15 June 2001.

CUNNINGHAM, E.M., SANCHEZ BEJARANO, J.M. 2002. Aspects of the Mediterranean BFT grow-out experience. First International Symposium DOTT. Book of Abstracts.

ICCAT. 2001. Report of the 5th Meeting of the *ad hoc* GFCM/ICCAT Working Group on stocks of large pelagic fishes in the Mediterranean Sea. Col. Vol. Sci. Pap. ICCAT 52: 590-684

ICCAT SECRETARIAT. 2001. Unreported Catches of Atlantic Tuna. Col. Vol. Sci. Pap. ICCAT 52: 685-694.

KATAVIC, I., TICINA, V., FRANICEVIC, V. 2002. Bluefin tuna (*Thunnus thynnus* L.) farming on the Croatian coast of the Adriatic Sea – present stage and future plans. First International Symposium DOTT. Book of Abstracts.

KARAKULAK, F.S. 2002. Catch and effort of the bluefin tuna purse seine fishing in Turkish waters. First International Symposium DOTT. Book of Abstracts.

MARCHESE, A., GOUVERSVILLE, PH., THOMASSIN, B., LABROSSE, A. 2001. Impact assessment of potential tuna fish farming on coastal water quality – French Riviera. Paper presented at the 4th DHI Software Conference. Helsingor, Denmark. 6-8 June 2001.

MIYAKE, P. 2001. Atlantic bluefin tuna. Research and management. Paper presented at the 13th Annual Conference of EAFE. Salerno, Italy. 18-20 April 2001.

PROPOSAL for a Management Zone for the longline Tuna Fishery in the Central Mediterranean. Background document presented by the Maltese National Fishing Cooperative at the 26th Session of the GFCM. Ischia, Italy. September 2001.

REPORT and annexes to the Report of the 26th Session of the General Fisheries Commission for the Mediterranean. Ischia, Italy. 10-13 September 2001.

REPORT of the Standing Committee on Research and Statistics (SCRS) of ICCAT. Madrid, Spain. 8-12 October 2001. 198 pp.

SUZUKI, Z. 2001. Draft National Report of Japan. Fisheries Agency of Japan, to the 4th Session of the Scientific and Advisory Committee of the GFCM. Athens, Greece. 4-7 June 2001.

OTHER SOURCES: Nature Trust, Malta; FAO; ANSE Cartagena, Spain; Fish Information and Services (FIS Int'l. Co. Ltd.; http://www.fis.com)

BLUEFIN TUNA FARMING OPPORTUNITIES IN LEBANON

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WHY LEBANON?

At the heart of the Middle East and the crossroads of the three continents, Lebanon has long been the convergence point of trade routes and the meeting place for a wide variety of people. The land of the alphabet is now a regional and international hub for trade, finance, industry, services and tourism. Why Lebanon?

- Strategic Geographical Location
- Free Market Economy
- Investment Guarantees
- Liberal Financial Environment
- Moderate Tax Rates
- Human resources
- Expanding infrastructure

COMPANY PROFILE

Lebtuna International SARL is a multinational organization. It is a Lebanese registered International Company. Partly owned and fully managed by Lebanese. It aims to establish a new industry of aquaculture by raising Bluefin Tuna (BFT) in cages in the sea. It also aims at rebuilding the Lebanese fishing industry to compete internationally.

OBJECTIVES

1- Establish first and sole BFT fattening farm in Lebanon.
2- Bring financial and know how support from abroad.
3- Promote local economy by providing job opportunity.
4- Involve local & international fishermen in the project.
5- Involve local industries in the project (storing and trucking).
6- Develop potential new industries (food processing and packaging, ship building).
7- Buy local product to a maximum available.

PROJECT SUMMARY

Bordering a large portion of Mediterranean Sea, Lebanon occupies a strategic geographic position during the immigration of the BFT (see Appendix 1- chart of immigration of BFT). Its business environment, diversity in climate and rich human resources, makes Lebanon an attractive site for investment and business.

Lebanon has a well-educated working population, political and social stability, economic integration into the Euro-Mediterranean region, a policy of incentives for foreign investment and export, and constant improvement in administrative procedures. Most importantly, Lebanon is located in very close proximity to northern bluefin tuna migratory routes.

The close proximity of the project to Tripoli port, 20 minutes including truck & ferry, to the port allows for great flexibility in supplying fresh and frozen feed for the project. One of the best and most modern refrigerators to be used in this project is located near the sea port of Tripoli and at 20 minutes distance from Hannouch a priority site where the cages will be located. Other favorable locations are determined as well. Some other commercial and small ports for fish boats used in the feeding application are at close distance too.

Steps of the project:

1- Catch bluefin tuna in May and June. High Tech Equipped Purse seines not available in Lebanon will be used (with on board Lebanese fisherman for training) to catch the tuna and put them in cages.

2- These cages are towed by Lebanese tug boats to our feeding cages. A total of 10 cages is needed and sea area is 250,000 square meters in the first phase.

3- Feed needed by the tuna is locally available like Sardine, Anchovy and Mackerel. The locally available quantity will not be enough to reach 60 tones daily feeding needs. Locally available freezing facilities at –22 degree are needed to store the imported frozen fishes.

4- Feed tuna with fresh local and imported frozen fish. Such as Sardine, Mackerel and Anchovies. The feeding is done daily 6 days a week. 60 tons of feed is needed daily.

5- The feed is delivered by trucks to locally available fishing boats and transferred to the floating cages and fed to the tuna.

Main Fish Caught in Lebanon

Bogue, red mullet, European hake, picarel, blotched picarel, horse mackerel, golden grouper, dusky grouper, common Pandora, axillary's sea bream, common two banded sea bream, gilthead sea bream, swordfish, blue fin tuna, little tunny, Atlantic mackerel, common dentex, common sea bream, greater amberjack, john dory, spine foot, twaite shad, parrotfish, golden gray mullet, common dolphin fish, anchovy, sardines, thornback ray, common stingray, small spotted cat shark and black mouth cat shark.

Advantages of this Project

- Cheap gasoline
- Good infrastructure
- Location of the farm close to ports, freezing facilities and to capital city Beirut
- Feed fish available at low cost
- Low taxes and liberal financial policy
- Geographically close to turkey and practically in need of Turkish know how and purse seines.
- Establishment of Turkish-Lebanese business council under DEIK facilitating trade exchange and collaboration.

Disadvantages of this Project

- No local purse seines of know how.
- Absence of practical laws about aquaculture and BFT farming.
- Tough environmental regulations
- 60 tons of fish feed needed but cannot be supplied in total locally- fish feed to be imported.
- Old techniques of fishing- Lebanese fishermen still use traditional long lines and gill nets.

Environment & Species Protection

Lebtuna International Co. prepared an Environmental Impact Assessment (EIA) of this proposed project in accordance with Ministry of Environment draft EIA decree. We will conduct annual assessment of the environment of the site allocated according to general rules required by MOE.

APPENDIX 1. Equipment Used

Equipment	Quantity
Purse Seines	15
Feeding Cages	10-20
Towing Cages	10-15
Tug Boats	6
Feeding Boat	6

APPENDIX 2. The migration map of Bluefin tuna in the Mediterranean Sea

APPENDIX 3. Water Temperature During BFT Farming.

	MAY	**JUNE**	**JULY**	**AUG.**	**SEPT.**	**OCT.**	**NOV.**	**DEC.**
1999	23	27.3	28.5	30	29	26	23.5	20.5
2000	23	26.5	28.5	29	28	26	23	19.7
2001	22	27.3	28.7	30.5	28.5	26.6	24.6	20.5

POSSIBILITIES FOR BLUEFIN TUNA FARMING IN THE WATERS OF THE TURKISH REPUBLIC OF NORTHERN CYPRUS

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The Turkish Republic of Northern Cyprus (TRNC) is interested to develop the bluefin tuna fishery and the fattening of bluefin tunas in their waters and encourages investors. The coast line of TRNC is 396 km long, constituting 50,6% of the total coast line of the island of Cyprus. The fish production of North Cyprus is 450 tons per year. The fishing boats are 4-12 m long and use 16-45 mm meshed gill and trammel nets and longlines Small and big pelagic fisheries are not developed (ORAY and KARAKULAK, 2002a). A purse seine fishery does not exist There are good chances for developing the big (bluefin tuna, albacore, atlantic little tunny, bullet tuna, swordfish greater amberjack, leerfish) and small (bogue, sardinella, mediterranean horse mackerel, atlantic horse mackerel, chub mackerel, picarel) pelagis fisheries. Experimental fishing in TRNC waters for small pelagic fishes last fall gave good results On the coasts of North Cyprus exist during the whole year ideal water temperatures for fattening of bluefin tunas. Bluefin tunas are caught during the whole year all around the coasts of TRNC as by catch in the swordfish longlines fishery. The weights of these bluefins vary between 10-150 kh (ORAY and KARAKULAK, 2002b; ORAY and KARAKULAK, 2002c).

REFERENCES

ORAY, I. K., KARAKULAK, F.S. 2002a. Investigations on the artisanal fishery of Güzelyurt Bay. International Conference Environmental Problems of The Mediterranean Region, 12-15 April 2002, Near East University, North Cyprus.

ORAY, I. K., KARAKULAK, F.S. 2002b. Developing the bluefin tuna (*Thunnus thynnus* L. 1758) fishery in the waters of the Turkish Republic of Northern Cyprus. International Conference Environmental Problems of The Mediterranean Region, 12-15 April 2002, Near East University, North Cyprus.

ORAY, I. K., KARAKULAK, F.S. 2002c. Possibilities for the domestication of bluefin tunas in the eastern mediterranea sea. I. International Symposium on Domestication of the bluefin tuna *Thunnus thynnus thynnus*, 3-8 February 2002, Abstracts, Cartagena-Spain.

AGE AND GROWTH OF THE BLUEFIN TUNA (*Thunnus thynnus*) OF THE NORTHEAST ATLANTIC

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ABSTRACT

This paper studies the growth and age of East Atlantic bluefin tuna based on the observation and analysis of hard parts (fin ray sections).

The different parts and types of rings observed on the fin ray section are defined. From this study it can be deduced that:

–Hyaline rings are winter rings which are formed between fall and winter (October-March),

–Areas of active growth start forming in spring and conclude their formation in the fall (March-October),

–For younger aged bluefin (age-classes 1 to 3), summer growth is from 3 to 4 times more in size and from 4,5 to 6 times more in weight than winter growth,

–Winter hyaline rings can be single (thin or thick), or double.

From the growth equation obtained by combining data from the juvenile bluefin fishery of the Cantabrian Sea (north of Spain) with that from the adult bluefin fishery of the Strait of Gibraltar area, a value of $L\infty$=318,85 cm is obtained, which corresponds to a W_∞=615,90 kg.

INTRODUCTION

The age and growth of the bluefin tuna is studied paying special attention to the interpretation of the signs manifested in some hard parts of its body (in this case, the spinal sections).

MATERIALS AND METHODS

The sampling was done in northern and southern ports of Spain between the months of May and November.

The range of sizes covered is between 45 and 200 cm in the fishery of the Cantabrian Sea (northern of Spain), and between 170 and 304 cm in the traps of the Gulf of Cadiz (southern of Spain). In both cases fork length as reference was taken.

The method of extraction, preparation and the cutting of the spine, is the one described by COMPEAN-JIMENEZ and BARD (1980a; 1980b).

Following their same method, some cross sectional cuts ranging from 0,5 to 0,7 mm in thickness on the first dorsal fin using a slow rotating diamond saw were made.

The cuts ware prepared on slides covered with a highly transparent resin, and a slide cover. The measuring and reading of the spinal sections was carried out with a profile projector using a zoom of about 10 to 50.

The back-calculated growth size of the fish and the diameter of its spine were calculated for a sample of 300 tunas, by REY and CORT (1984). The range of sizes in this relation, is from 29 to 200 cm fork length (FL); those fish under 50 cm were from the Mediterranean Sea. Including those fish gave us a better fit to the back-calculated growth.

The growth model used was VON BERTALANFFY (1938).

The average value by age of bluefin tuna from the Cantabrian Sea, between 1 and 8 years of age, was estimated from the following equation:

$$Y = 12.780863\ X^{0.576}$$

(For 12, 24, 36. 46, 60. 72, 64 y 96; X= month)

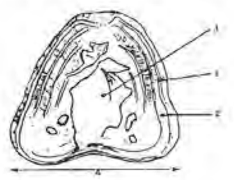
The equation in obtained by potential adjustment of the modal values of monthly size distributions (CORT, 1989).

RESULTS

GROWTH IN HARD PARTS (SPINE SECTIONS)

The cross sectional cuts of the spines show an alternation of wide areas (active growth) and translucent bands (slow growth). The correct interpretation of these marks, is fundamental in order to develop the study on growth as well as to come to conclusions on the biological and ecological aspects of this species.

Parts of a dissected spine



Different types of rings observed

Figure 1. Parts of a dissected spine

In the cross sectional cuts on the spines, the following parts can be noticed:

1. Translucent area of slow growth which can be formed by two rings or just one.
2. Opaque area of fast growth,
3. Vascularized nucleus, which in fish over two years old has a reabsorbed part in which the transparent bands disappear, and
4. Diameter of the spine.

In young individuals (up to 3 years old) it is easy to find all the hyaline rings of a spine. However, in fish over 3 years the central area of the spine is reabsorbed and consequently the bands are gone. Therefore, for those fish a back calculation of the size of the fish at the moment of the formation of the first visible rings must be made.

WINTER GROWTH

For samples of the spinal sections of bluefin caught in the Cantabrian Sea during the fishing season, different observations and measurements have been carried out on the translucent rings to study the development of the sizes by age in 1 - 7 year old fish (50 to 175 cm).

The translucent rings found respond to different interpretations due to their shape and apparent composition (Figure 1).

1. In some cases two thin translucent rings can be seen separated by an opaque band. This is called couplet and the interpretation of these is an follows:

The first ring indicates the beginning of the cold season (this translucent band shown a poor protein doses which causes a visible accumulation of minerals in the bonny parts) which can coincide with the outward migration from the Cantabrian Sea to the wintering areas.

The opaque band which appears next (between the two rings that form the couplet) is the winter growth.

Finally there is the second ring which shows the end of winter. This one, which can coincide with the migration to the areas of active feeding, has the same composition as its twin.

2. Fine single rings.

These show that the fish scarcely grow during winter. Since the begining of the cold season until the fish return to the active feeding area (in spring), the growth slowed down quite notably.

3. Thick translucent rings.

This indicate that the bluefin had a more active growth than in the previous case. Here the growth is the same as in the first case, but the diet had no proteins.

After having explained the different cases of spinal rings, the growth of bluefin tuna during the winter can be shown. To do so, measurements of the diameter of the translucent rings were taken from the beginning of these (whether simple or double) till the end of them.

Using a sample of 363 bluefin tuna aged 1 to 7, the distribution of frequencies of the diameter of the winter rings were obtained. The results and their corresponding parameters, are shown in Tables 1and 2.

Using this equation: $Y = 0.551 + 0.060 X$ (REY and CORT, 1984) which relates Y (diameter of the spine) with X (zoological length of the tuna), the results shown in Tables 3 and 4 were obtained.

In these tables the size distribution back-calculated to the beginning of the winter ring are expressed as TC (1-7) and by TP (1-7) as the end of the winter ring. (The parameters of these back-calculated size distribution are shown in Table 5.

The winter growth of bluefin from the Cantabrian Sea was obtained by calculating the difference between the average values by age at the end and at the beginning of the rings. The final results are expressed as follows:

AGE	WINTER GROWTH (cm)
1	2.90
2	3.11
3	3.83
4	6.39
5	7.00
6	6.21
7	6.03

SUMMER GROWTH

To estimate the summer growth of bluefin tuna, sampling of spines from fish of age groups 1, 2 and 3 was carried out. These fish are normally found in the Bay of Biscay from the beginning of the summer season (June), until the end of the season (October).

The idea is to follow, from the beginning, the distance from the last visible ring in the cuts of the spines to the end of the ring.

As the fishing season advances, the ring becomes farther and farther from the end of the cut. In the beginning of the season (June) this ring was at the edge of the spine.

The results are shown in Table 6 and in Figure 2, where the following growth can be observed. Therefore, the average increase in length and weight for the different age classes of bluefin tuna in the Cantabrian Sea which studied is as follows:

AGE	Autumn - Winter		Summer-Autumn	
	(cm)	(kg)	(cm)	(kg)
1	2,90	0,4	9,70	2,5
2	3,11	1,3	13,15	5,8
3	3,83	1,7	15,40	10,3
4	6,39	4,0	13,00*	10,5 (June-Sept.)
5	7,00	6,4	14,00**	14,8 (June-Sept.)
6	6,21	7,4		
7	6,03	8,4		

(*) Between October and March.
(**) Between June and October.

Average values taken from Table 8a. Summer growth in relation to winter growth, is as follows for the ages studied:

AGE	Multiple of	
	Growth in size	Growth in weight
	(cm)	(kg)
1	3,34	6,2
2	4,23	4,5
3	4,02	6,1
4	2,03	-
5	2	

That is, for age classes 2 and 3, summer growth (in cm) is four times more than winter growth. For the other age classes, summer growth is at least twice as much, and in age class 1 fish it is over three times more. As regards weight for the first three age groups, summer growth is on the average five to six times more than winter growth.

VON BERTALANFFY GROWTH MODEL

One general model has been used for the whole species, using the age-class values (1-8) of the Bay of Biscay, and the 1984 bluefin trap fishery in the Gulf of Cadiz (age classes 9 to 19), from which fin ray spines are available (Table 7).

The parameters of Von Bertalanffy equation, applying the fit of the model by Ford & Walford, are:

L_∞= 318,85 (cm)
t_0= -0,97 (year)
k= 0,093 (annual)

and the equation resulted was:

$$Lt = 318{,}85\ [1- e^{-0{,}093\ (t+0{,}97)}]$$

The estimated of W_∞ is difficult for bluefin tuna due to the numerous size/weight equations calculated in areas where there are immature and adult tunas.

Out of these, the equation by RODRIGUEZ-RODA (1964) was selected since it has a wider range of sizes (25-279 cm, FL). This equation in as follows:

$$W = 0{,}000019\ L^3$$

Replacing in this equations

$$W_\infty = 0{,}000019\ L^3_\infty$$

Where W_∞ = 615,90 kg (for L_∞ = 318.85 cm)

The Von Bertalanffy weighted equation would be:

$$Wt = 615{,}90\ [1 - e^{0{,}093(t+0{,}97)}]$$

The only information available on the integral growth of eastern bluefin tuna is from RODRIGUEZ-RODA (1964), COMPEAN-JIMENEZ (1980) and COMPEAN -JIMENEZ and BARD (1983) although the last studies are very similar with slight variations.

APPLICATIONS OF THE DESCRIBED STUDY

Studies on bluefin growth, as noted in the preceding chapter, show a considerable metabolic activity of this species during the months they spend in the Cantabrian Sea (from the end of spring to mid-fall).

Due to the almost complete stop in growth in the months corresponding to the cold season (November to March), it is important to point out that bluefin return to the Cantabrian Sea the following year and are the same size they were when they left 7 months before (Tables 8a and 8b).

Because of this, the application of the size/age keys have to be done seasonally. The use of only one key for at the catches would distort the size distribution of these catches.

REFERENCES

COMPEAN-JIMENEZ, G., BARD, F.X. 1980a. Age and Growth of East Atlantic bluefin tuna as determined by reading of fin rays cross section- ICCAT, Colec. Doc. Cient. 9 (2); 547-552.

COMPEAN-JIMENEZ, G., BARD, F.X. 1980b. Utilisation de la squeletto chronologia chez les tunides. Bull. Soc. Zool., Fr. 105: 329-336.

COMPEAN-JIMENEZ, G., BARD, F.X. 1983. Growth increments on dorsal spines of eastern Atlantic bluefin tuna (*Thunnus thynnus*) and their their possible relation to migrations patterns. NOAA, Tech. Rep. NMFS, 8: 77-86. U.S.A.

CORT, J. L. 1989. Biologia y pesca del atun rojo, *Thunnus thynnus* (L.) del Mar Cantabrico (Doctoral Thesis). Publ. Espec. Inst. Esp. Oceanog., 4, 278 pp.

CORT, J. L., 1991. Age and growth of the bluefin tuna (*Thunnus thynnus*) of the noretheast Atlantic. ICCAT, Colec. Doc. Cient. & Scientific paper SCRS/90/66), 28 pp.

REY, J. C., CORT, J. L 1984. Una clave talla/edad por lectura de espinas para el atun rojo (*Thunnus thynnus*) del Atlantico este. ICCAT, Colec. Doc. Cient. 20 (2): 337-340.

RODRIGUEZ-RODA, J. 1964. Biologia del atun (*Thunnus thynnus*) de la costa sudatlantica española. Inv. Pesq., 25: 33-146.

VON BERTALANFFY, L. 1938. A quantitative theory of organic growth (inquiries on growth larva). Hum. Biol., 10 (2): 181-213.

Table 1. Diameter frequency distribution of the winter rings. (For each age, the left column indicates the distribution of the diameters at the begining of the formation of the ring: the right column indicates the distribution of the diameters at the end of their formation).

AGE / Ø Ring (mm)	1		2		3		4		5		6		7	
1.0	--	--	--	--										
2	--	--	--	--										
4	--	--	--	--										
6	1	--	--	--										
8	10	1	--	--										
2.0	21	15	--	--										
2	24	18	--	--										
4	9	21	--	--										
6	--	9	1	--										
8	--	1	1	--										
3.0	--	--	13	3										
2			15	14	--	--	--	--						
4			16	18	--	--	--	--						
6			3	10	--	--	--	--						
8			14	13	--	--	--	--						
4.0			3	6	1	--	--	--						
2			5	4	11	--	--	--						
4			2	2	11	9	--	--						
6			--	3	15	14	--	--						
8			--	--	4	13	--	--						
5.0			--	--	7	9	6	--						
2					8	6	3	4	--	--				
4					4	4	5	4	--	--				
6					5	8	7	2	--	--				
8					2	3	8	5	--	--				
6.0					0	2	9	9	--	--				
2							7	7	--	--				
4							6	3	4	--				
6							3	10	4	1				
8							1	7	7	3				
7.0							0	1	6	3				
2							0	2	1	7	--	--	--	--
4							1	0	6	4	--	--	--	--
6							--	2	4	5	3	--	--	--
8							--	0	2	2	5	--	--	--
8.0							--	0	0	8	6	4	1	--
2							--	--	1	1	3	3	1	--
4							--	--	2	0	4	5	1	2
6							--	--	--	1	5	6	1	0
8							--	--	--	2	2	4	2	0
9.0							--	--	--	--	3	4	6	1
2											3	4	4	4
4											1	3	4	2
6											2	0	4	10
8											--	3	0	1
10.0											--	1	0	2
2											--	--	0	2
4											--	--	2	1
6											--	--	1	1
8											--	--	--	0
11.0											--	--	--	1
N	65	65	73	73	68	68	56	56	37	37	37	37	27	27

Table 2. Values and parameters obtained from measuring the winter rings. (The diameter at the beginning of the formation of the ring is shown on the left; the diameter at the end of the ring formation is given on the right).

AGE

	1	1	2	2	3	3	4	4	5	5	6	6	7	7
N	65	65	73	73	68	68	56	56	37	37	37	37	27	27
$\bar{X}$ (mm)	2,14	2,33	3,48	3,66	4,79	5,02	5,90	6,29	7,19	7,62	8,47	8.84	9,28	9,65
σ	0,18	0,20	0,41	0,39	0,43	0,44	0,52	0,58	0,54	0,55	0,57	0,55	0,60	0,57
Sy Sx (Int. Conf. 95 %)	2,10 2,18	2,28 2,38	3.39 3.57	3.57 3.75	4,69 4,89	4,92 5.12	5,76 6,04	6,14 6,44	7,02 7,36	7,44 7,80	8,29 8,65	9,02 8,66	9,05 9,51	9,43 9,87

Table 3. Numeric values of the size distributions back-calculated to the beginning of the winter ring (Ages 1-7).

FL (cm)	TP1	TP2	TP3	TP4	TP5	TP6	TP7
35-39	3	-	-	-	-	-	-
40-44	28	-	-	-	-	-	-
45-49	31	-	-	-	-	-	-
50-54	3	1	-	-	-	-	-
55-59	-	8	-	-	-	-	-
60-64	-	23	-	-	-	-	-
65-69	-	17	-	-	-	-	-
70-74	-	14	-	-	-	-	-
75-79	-	5	3	-	-	-	-
80-84	-	5	20	-	-	-	-
85-89	-	-	19	-	-	-	-
90-94	-	-	9	6	-	-	-
95-99	-	-	11	4	-	-	-
100-104	-	-	5	11	-	-	-
105-109	-	-	1	15	-	-	-
110-114	-	-	-	9	-	-	-
115-119	-	-	-	6	5	-	-
120-124	-	-	-	4	10	-	-
125-129	-	-	-	-	7	-	-
130-134	-	-	-	1	6	-	-
135-139	-	-	-	-	6	5	-
140-144	-	-	-	-	-	9	1
145-149	-	-	-	-	2	5	2
150-154	-	-	-	-	1	7	1
155-159	-	-	-	-	-	5	5
160-164	-	-	-	-	-	3	7
165-169	-	-	-	-	-	2	6
170-174	-	-	-	-	-	1	2
175-179	-	-	-	-	-	-	-
180-184	-	-	-	-	-	-	2
185-190	-	-	-	-	-	-	1
190-194	-	-	-	-	-	-	-
N	65	73	68	56	37	37	27

Table 4. Numeric values of the size distributions back-calculated to the end of the winter ring (Ages 1-7).

FL (cm)	TP1	TP2	TP3	TP4	TP5	TP6	TP7
35-39	-	-	-	-	-	-	-
40-44	14	-	-	-	-	-	-
45-49	32	-	-	-	-	-	-
50-54	18	-	-	-	-	-	-
55-59	1	-	-	-	-	-	-
60-64	-	18	-	-	-	-	-
65-69	-	25	-	-	-	-	-
70-74	-	14	-	-	-	-	-
75-79	-	8	-	-	-	-	-
80-84	-	5	8	-	-	-	-
85-89	-	3	24	-	-	-	-
90-94	-	-	14	-	-	-	-
95-99	-	-	7	5	-	-	-
100-104	-	-	10	5	-	-	-
105-109	-	-	5	7	-	-	-
110-114	-	-	-	14	-	-	-
115-119	-	-	-	9	-	-	-
120-124	-	-	-	11	4	-	-
125-129	-	-	-	1	7	-	-
130-134	-	-	-	2	7	-	-
135-139	-	-	-	2	6	-	-
140-144	-	-	-	-	9	4	-
145-149	-	-	-	-	1	5	2
150-154	-	-	-	-	1	9	-
155-159	-	-	-	-	2	7	1
160-164	-	-	-	-	-	5	4
165-169	-	-	-	-	-	3	8
170-174	-	-	-	-	-	3	5
175-179	-	-	-	-	-	1	4
180-184	-	-	-	-	-	-	1
185-190	-	-	-	-	-	-	1
190-194	-	-	-	-	-	-	1
N	65	73	68	56	37	37	27

Table 5. Sizes back-calculated to the begining and end of the formation of the winter ring.
(The difference between both indicates the growth during the winter).

	1	1	2	2	3	3	4	4	5	5	6	6	7	7
N	65	65	73	73	68	68	56	56	37	37	37	37	27	27
$\bar{X}$ (FL cm)	45	47.90	67.18	70.29	89,10	92,93	107,79	114,18	129,30	136,30	150,46	156,70	164,04	170,07
σ	3,04	3,56	6.83	6.59	7,10	7.23	8,69	9,62	8,95	9,13	9.53	9,10	10,06	9,63
Sy Sx (Int. Conf. 95 %)	41,96 48,04	44,34 51,46	65,60 68,76	68,77 71.81	87,41 90,79	91,21 94,65	105,51 110,07	111,66 116,70	126,42 132.18	133,36 139.24	147,42 153,56	153,77 159,63	160,25 167.83	166,44 173,70

Table 6. Numeric values of the last visible ring on the spines and their corresponding conservation to sizes for bluefin tuna from the Cantabrian Sea (Ages 1-3).

LAST RING					SAMPLE VALUES			
AGE1	SPINES(N)	σ (mm)	X (mm)	SY/SX	N	σ (cm)	FL (cm)	SY/SX
JUNE	23	0,069	0,22	0,19 0,25	23	1,48	57,7	57,1 58,3
JULY	21	0,096	0,28	0,18 0,26	21	2,73	57,7	56,5 58,9
AUGUST	10	0,078	0,32	0,27 0,37	9	2,00	60	58,7 61,3
SEPT.	32	0,13	0,51	0,46 0,56	32	2,38	61,1	64,3 65,9
OCT.	35	0,20	0,67	0,60 0,74	34	3,47	67,4	66,3 68,5
JUNE	40	0,062	0,16	0,14 0,18	40	2,95	75,3	74,3 76,1
JULY	35	0,12	0,27	0,23 0,31	35	5,16	80,0	78,3 81,7
AUGUST	33	0,12	0,38	0,34 0,42	33	4,88	80,3	78,7 82,0
SEPT.	39	0,17	0,66	0,61 0,71	39	4,34	88,4	87,1 89,8
OCT.	36	0,14	0,75	0,70 0,80	35	3,20	88,4	89,5 87,3
JUNE	35	0,046	0,15	0,13 0,17	35	5,49	93,9	92,1 95,7
JULY	44	0,067	0,28	0,26 0,30	44	6,14	101,8	99,9 103,6
AUGUST	42	0,13	0,46	0,42 0,50	42	8,65	102,8	100,1 105,4
SEPT.	20	0,11	0,76	0,71 0,81	20	2,48	109,5	110,5 108,4
OCT.	35	0,15	0,81	0,76 0,86	35	3,58	109,3	108,1 110,5

Table 7. Size / age key of bluefin tuna caught by traps off the south of Spain.

FL cm)	6	7	8	9	10	11	12	13	14	15	16	17	18	19
170-174	2	2	1	1										
175-179		3	2											
180-184	1	2	1	4	1									
185-189				5	1									
190-194			1	5	2	1								
195-199			1	6	4	1								
200-204				1	4	4								
205-209			1	1	4	6								
210-214					1	4	3	1						
215-219					3	6	8							
220-224					3	6		3	3					
225-229						8	4	4	1	1				
230-234					1	2	4	6	4	2				
235-239							2	2	1	3				
240-244								4		5	2			
245-249									5	1				
250-254								1	1	2	1			
255-259									2	3				
260-264									1	2		1		
265-269									1	2				
270-274													1	
275-279														
280-284												1		
285-289													1	
290-294														
295-299														
300-304														1
N	3	7	7	23	24	38	21	21	19	21	3	2	2	1
FL (cm)	-	-	-	191	206	216	222	232	242	247	-	-	-	-

Table 8a. Range of weights by age and by month for bluefin tuna from the Cantabrian Sea.

AGE	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
1	-	3,5	3,6	4,0	4,8	6,2	6,4
	2,8	4,1	4,7	4,8	5,9	6,8	7,6
2	-	7,7	8,8	9,0	10,5	13,4	15,2
	7,9	9,3	10,6	12,5	12,8	16,0	16,3
3	-	15,2	14,7	17,0	19,8	27,6	-
	15,2	17,6	19,8	22,9	26,2	32,0	-
4	-	27,9	28,8	32,4	36,3	-	-
	-	30,4	37,0	41,5	42,4	-	-
5	-	42,0	49,1	49,5	55,4	-	-
	-	48,0	55,8	61,4	64,3	-	-
6				66,9 - 79,6			
7				86,4 - 101,3			
8				109,3 - 117,7			

Table 8b. Range of sizes by age and by month for bluefin tuna from the Cantabrian Sea.

AGE	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
1	-	55,5	55,7	57,8	61,7	66,2	67
	50,9	58,3	61,2	61,7	65,1	68,4	71,1
2	-	72,1	76,5	77	81,4	88,8	92,9
	73,6	77,1	81,7	86,6	87,4	94,6	95,2
3	-	91,9	91,8	96,6	102	111,6	-
	92,9	96,7	102	107,4	112,7	117,6	-
4	-	115,2	116,5	121,5	126,5	-	-
	-	118,8	127,4	132,7	133,7	-	-
5	-	132,2	140,9	141,3	147	-	-
	-	139,7	147,4	152,5	155	-	-
6				157,2 - 161,7			
7				166,4 - 175,9			
8				180,7 - 185,4			

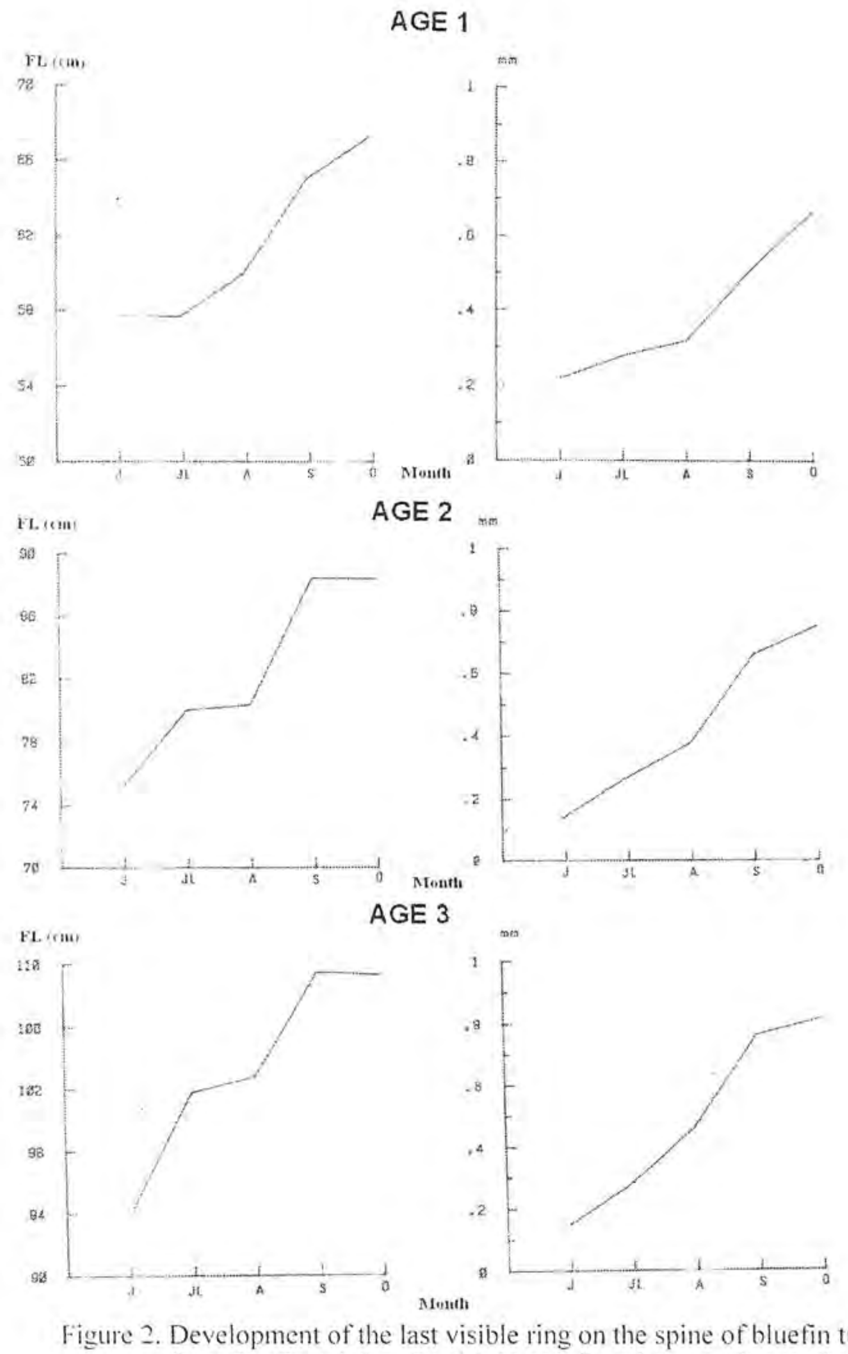


Figure 2. Development of the last visible ring on the spine of bluefin tuna from the Cantabrian Sea (right panel) and conversion to size in fork length (FL) (left panel).

WHERE DO ATLANTIC BLUEFIN TUNA (*Thunnus thynnus*) SPREAD AFTER SPAWNING IN THE MEDITERRANEAN SEA?

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ABSTRACT

A total of 84 bluefin tuna were tagged with electronic pop-up satellite tags and released in the Mediterranean and the Strait of Gibraltar between June 1998 and August 2000; 25 (32 %) were located by the Argos satellite system. Location rates were 21 % and 62 %, respectively, for single-point tags (61 PTT-100 released) and archival tags (23 PAT released). Most tags surfaced in the western Mediterranean and eastern Atlantic, but one archival tag transmitted from a position south of Iceland and one single-point tag transmitted from the Greenland Sea. No transatlantic migrations were observed. Most tags released in the western Mediterranean surfaced near the tagging location, suggesting local residency. Residency and spawning site fidelity (which was also indicated by our data), offer the potential for overexploitation, if the industry progressively catches more large tuna for fattening. Domestication needs to obviate this risk. PAT tag experiments were conducted in collaboration with the Tuna Research and Conservation Center, USA.

INTRODUCTION

Stock assessments of North Atlantic bluefin tuna are currently carried out on the assumption that there are two stocks (eastern Atlantic and Mediterranean; western Atlantic) separated by a conventional boundary at 45° W. This two-stock hypothesis is supported by the presence of small to large specimens on both sides of the Atlantic, the occurrence of spawning in the Gulf of Mexico and the Mediterranean at different times of the year, and morphometric differences between fish from different areas.

Analyses of conventional tagging data, which show a low mixing rate between west and east with most tags recaptured in the area of release, also support the existence of two separate groups of bluefin tuna in the North Atlantic.

Recently, however, several electronic tagging programmes have been initiated to improve our knowledge of the migrations of Atlantic bluefin tuna and investigate the occurrence of transatlantic movement (BLOCK *et al.*, 1998, 2001; LUTCAVAGE *et al.*, 1999).

In Europe, experiments with "pop-up" satellite-detected tags were carried out in the eastern Atlantic and Mediterranean between June 1998 and August 2000 as part of a EU FAIR Project. The aims of the project were; to identify and describe migrations and movements of bluefin tuna, both within the Mediterranean and between the Mediterranean and the Atlantic Ocean, in relation to spawning and nursery areas; to evaluate the practicalities of using pop-up satellite-detected tags; to gain experience for future projects with large pelagic fish (DE METRIO *et al.*, 1999, 2001, 2002).

MATERIALS AND METHODS

A total of 84 bluefin tuna were tagged with pop-up satellite-detected electronic tags in the Mediterranean and Eastern Atlantic, between June 1998 and September 2000. Types and number of tag used were: 61 PTT-100 single-point pop-up tags (Microwave Telemetry Inc., Columbia, Maryland, USA), which recorded a limited number of temperature measurements, and 23 PAT archival pop-up tags (Wildlife Computers, Redmond, Washington, USA), which recorded temperature, depth and daily longitude.

PAT tag experiments were conducted in collaboration with the Tuna Research and Conservation Center, Monterey, California, as part of the US co-ordinated TAG programme.

Three giants were tagged with PTT-100 tags, using an underwater gun, at the Stintino trap (Sardinia, Italy) in June 1998. Thirty-two fish were tagged with PTT-100 tags by underwater gun or hand-held harpoon in the large tuna trap at Barbate (Spain), to the west of the Strait of Gibraltar, in July 1998 and 1999. Twenty-two bluefin captured in the local sport fishery were tagged, either alongside the boat using a hand-held tagging stick (12 fish with PTT-100 tags) or on deck (10 fish with PAT tags), in the Bocche di Bonifacio (between Corsica and Sardinia) during September 1999 and 2000. Fifteen fish were tagged (13 fish with PAT tags and 2 fish with PTT-100 tags) by hand-held harpoon and underwater gun in the aquaculture pens at Puerto Mazarron (Cartagena, Spain) on 1st August 2000. Twelve tuna were tagged in the Aegean Sea (Greece) using a short hand-held stick. All tags were attached by a monofilament nylon leader to a nylon dart (PTT-100 tags) or a titanium anchor (PAT tags) embedded in the dorsal muscles of the fish. Both the nylon darts and the titanium anchors were passed through the base of the second dorsal fin rays of each tagged specimens.

A series of charts of chlorophyll-a concentration were plotted for the Tyrrhenian Sea close to Corsica and Sardinia (central Mediterranean) and the eastern Atlantic to the south of the Strait of Gibraltar, the two areas in which most of the tags surfaced. Data were extracted from the SeaWiFS database (PARRISH, 1996; IOCCG REPORTS, 1999). Data for the first area were analysed for the period September 2000 to February 2001, obtaining a fairly homogeneous temporal coverage (about three good satellite acquisitions per month) apart from January.

Some trials were made with five unused PTT-100 tags to test the ability of the Argos satellite system to detect these tags in the western Mediterranean, where there is now known to be substantial background noise and transmitter competition on the Argos radio frequency, and the eastern North Atlantic. Comparative trials were also undertaken in Madeira and Columbia, Maryland, using the same five tags.

RESULTS AND DISCUSSION

Twenty-three of the 84 pop-up tags were located by satellite, giving an overall location rate of 32 % (25/78). All of these tags transmitted valid data. Six more tags were recovered from recaptured fish.

Location rates were 21 % (12/57) for the PTT-100 tags and 62 % (13/21) for the PAT tags, which appeared to be less influenced by the high level of background noise and high density of Argos transmitters in the Mediterranean area than the PTT-100 tags. Sporadic signals, which were too weak to allow either location or data transmission, were received from a further 6 PTT-100 tags on or close to the expected pop-up day, increasing the detection rate for this type of tag to nearly 32 % (18/57) and for all the tags to 38 % (31/78).

Most tags were detected in the western Mediterranean or eastern North Atlantic, off the coast of North Africa. However, one PAT tag surfaced south of Iceland and one PTT-100 tag transmitted from the Greenland Sea.

No tags were detected in the western Atlantic showing that no transatlantic migration occurred during the investigation period (Figure 1).

Location rates of PTT-100 tags varied markedly between release sites and years. For example, in the Aegean Sea in the years 1998 and 1999 the location rate was only 8 %, compared to 23 % for Barbate in southern Spain in the same years, and 67 % for releases at Stintino, Sardinia in 1998. However, only 14 % (3) of the 23 tags released at Barbate in southern Spain in 1999 were located by satellite (a further tag was recovered from a recaptured fish) compared to 44 % (4) of the 9 tags released from the same trap in 1998.

Location rates of the PAT tags also differed markedly between release sites. Only 4 (33 %) of the 13 tags deployed on bluefin tuna in a holding pen at Puerto Mazarron in the year 2000 were detected by satellite, although a further tag was recovered from a recaptured fish before it was due to detach from the fish. In contrast, 100% of the 10 PAT tags deployed in Corsica in the year 2000 were located by satellite, although no valid data were recovered from two tags that appear to have drifted ashore shortly after surfacing, and a tenth tag was recovered from a recaptured fish, again before it was due to detach from the fish.

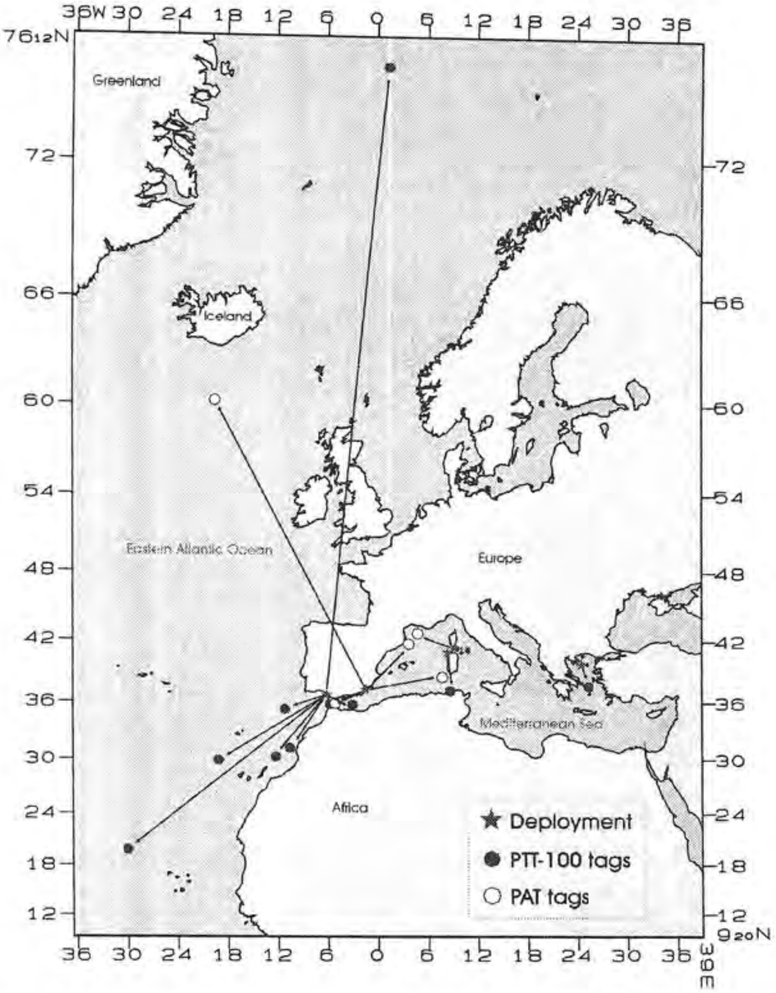

Figure 1. Pop-up locations of tags attached to tuna in the Mediterranean and eastern Atlantic from 1998 to 2000. Red circles, PTT-100 single-point pop-up tags; white circles, PAT archival pop-up tags.

Several tags showed interesting results. One PTT-100 tag deployed near the Strait of Gibraltar was detected in the Greenland Sea; another from the same release transmitted from the eastern Atlantic close to the southern limit of the eastern bluefin stock. A PAT tag deployed in the Mediterranean, close to Cartagena, was detected in the North Atlantic south of Iceland. In contrast, most of the PAT tags deployed in the area of Bocche di Bonifacio (Corsica) surfaced in the release area. Daily longitudes recorded by the tags indicated that these fish had all remained in the area between Corsica and longitude 14° E. Maximum depths indicated that, while some fish moved off into deep water in the Tyrrhenian Sea, others remained solely in the shallow water on the continental shelf around the island.

Comparison of pop-up positions with the temporal set of chlorophyll-a maps shows a correspondence with higher pigment concentration areas. In particular, the central Mediterranean and northern Tyrrhenian Sea show higher concentrations of chlorophyll-a than other parts of the western Mediterranean and eastern Atlantic (Figure 2). Given the occurrence of a persistent areas of high production in the areas where most of the tags were detected, especially to the east of Corsica, these may be feeding areas for both pre- and post-spawning fish.

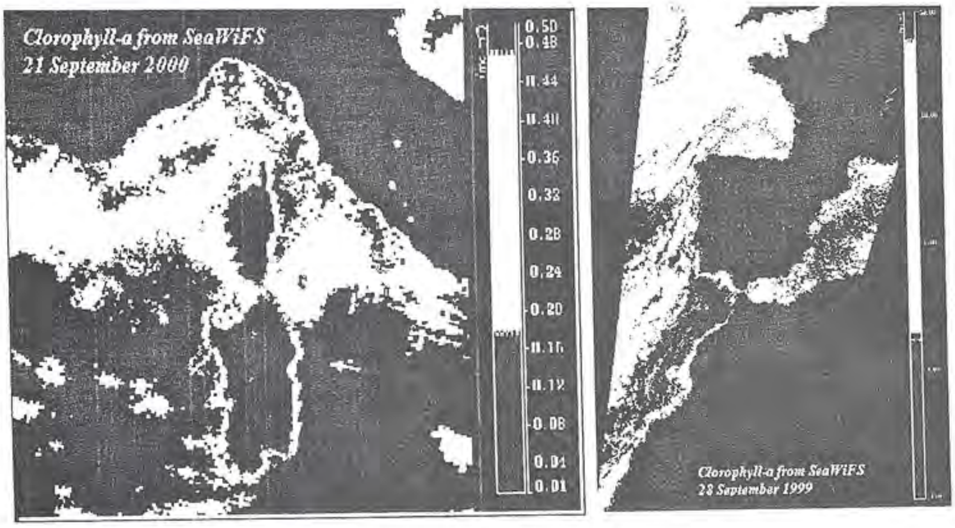

Figure 2. Chlorophyll-a concentration from SeaWiFS in the central Mediterranean (on the left) and western Mediterranean and eastern Atlantic (on the right).

The rate of tag detection and location was much lower than expected from previous studies with the same type of tag in the western and central North Atlantic, where rates of 56 to 93 % have been reported (BLOCK *et al.*, 1998; LUTCAVAGE *et al.*, 1999; LUTCAVAGE, pers. comm.). Because the difference was so large, a series of tests were conducted in order to compare the performance of five unused PTT-100 tags at a number of locations in Europe Madeira and the USA.

The results our tests clearly indicated that there is a detection problem in parts of the Mediterranean Sea, where some of our tags were expected to surface. It seems likely, therefore, that a low signal-to-noise ratio in the affected areas may have resulted in non-detection of tags that may otherwise have successfully surfaced when programmed to detach themselves from the fish. Corroborative evidence is available from six tags, from which sporadic signals were received on, or close to, the expected pop-up day. No temperature data were obtained from these six tags and the signals were too weak, or too few, for the Argos system to determine the location of the tag.

CONCLUSIONS

Reasons for the low detection rate of the PTT-100 tags may include post-tagging mortality, fish capture, premature tag release, failure of the tag as a result of exposure to high pressure and low signal-to-noise ratio. Whilst it is difficult to quantify some of these factors, our test results clearly indicate that the strength of the transmitted signal was sufficiently low to have compromised our ability to detect tags over a significant area of the western Mediterranean and north-western Europe. According to Argos, the problem, which results from a high level of background noise and competition from more powerful transmitters, is, however, confined to Europe. The ability to detect tags that surfaced in the Atlantic should therefore have been the same as that for tags attached to tuna in US waters.

In this context it is interesting to note that none of the pop-up positions of our tags were located in the central or western North Atlantic, but were confined to the eastern management area with no evidence of transatlantic migrations.

It was also noticeable that most of the tags deployed in the Mediterranean surfaced close to the original tagging location. This was especially true of fish released off Corsica, suggesting the existence of residency associated with the high productivity, or other environmental characteristics of this area.

The recapture of a big tuna (290 kg) tagged with a PTT-100 tag at Barbate trap on July 1999 is of particular interest. This fish - to which the tag was still attached - was caught near the Balearic Islands in June 2001, suggesting fidelity to the western Mediterranean spawning area.

Spawning site fidelity and Mediterranean residency clearly offer the scope for overexploitation if the industry continues to catch more and more large bluefin for fattening in cages, instead of starting to rear 'new fish' from eggs. Domestication of bluefin would need to extend to the control of all stages of the life history, including reproduction in captivity, rearing and weaning of larvae, and growth to market size, to be sure of avoiding this risk.

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REFERENCES

BLOCK, B.A., H. DEWAR, C. FARWELL, E.D. PRINCE. 1998. A new satellite technology for tracking the movements of Atlantic bluefin tuna. Proceedings of the National Academy of Sciences, USA, 95: 9384-9389.

BLOCK, B.A., H. DEWAR, S.B. BLACKWELL, T.D. WILLIAMS, E.D. PRINCE, C.J. FARWELL, A. BOUSTANY, S.L.H. TEO, A. SEITZ, A. WALLI, D. FUDGE. 2001. Migratory movements, depth preferences, and thermal biology of Atlantic bluefin tuna. Science, 293: 1310-1314.

DE METRIO, G., G. ARNOLD, J.L. CORT, J.M. DE LA SERNA, C. YANNOPOULOS, P. MEGALOFONOU, G.S. LABINI. 1999. Bluefin tuna tagging using "pop-up tags": first experiments in the Mediterranean and eastern Atlantic. ICCAT, Col. Vol. Sci. Pap., 49 (1), 113-119.

DE METRIO, G., G.P. ARNOLD, J.M. DE LA SERNA, C. YANNOPOULOS, P. MEGALOFONOU, A.A. BUCKLEY, M. PAPPALEPORE. 2001. Further results of tagging Mediterranean bluefin tuna with pop-up satellite-detected tags. ICCAT, Col. Vol. Sci. Pap., 52: 776-783.

DE METRIO, G., G.P. ARNOLD, B. BLOCK, J.M. DE LA SERNA, M. DEFLORIO, M. CATALDO, C. YANNOPOULOS, P. MEGALOFONOU, S. BEEMER, C. FARWELL, A. SEITZ. 2002. Behaviour of post-spawning Atlantic bluefin tuna tagged with pop-up satellite tags in the Mediterranean and eastern Atlantic. ICCAT Col. Vol. Sci. Pap., 54 (2): 415-424.

IOCCG REPORT NUMBER 2. 1999. Status and planes for Satellite Ocean-Colour Missions: Considerations for Complementary Missions.

LUTCAVAGE, M.E., R.W. BRILL, G.B. SKOMAL, B.C. CHASE, P.W. HOWEY. 1999. Results of pop-up satellite tagging of spawning size class fish in the Gulf of Maine: do North Atlantic bluefin tuna spawn in mid-Atlantic? Canadian Journal of Fisheries and Aquatic Sciences, 56: 173-177.

PARRISH, R.H. 1996. Time, space and fish scales: applications of retrospective environmental data to fisheries research. Changing Oceans and Changing Fisheries: Environmental Data for Fisheries Research and Management, Proceedings of a workshop help 16-18 July, 1996, Pacific Grove, California, NOAA-TM-NMFS-SWFSC-239.

GONADAL CYCLE OF ATLANTIC BLUEFIN TUNA (*Thunnus thynnus*) IN THE MEDITERRANEAN SEA

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ABSTRACT

The results obtained by the histological analysis of Atlantic bluefin tuna gonads collected in the Mediterranean Sea over a six-month period (March-August) in Italian and Spanish seas are reported. Maturity development of BFT gonads starts in early spring; exogenous vitellogenesis takes place in the ovaries from May throughout June; spawning occurs in late June-early July. The ovaries of five specimens caught during the spawning period in the North Ionian Sea and South Adriatic Sea displayed extensive vitellogenic atresia. In females which find themselves in unfavourable environmental condition during the spawning period, follicular atresia could represent a way to re-absorb highly energetic yolk reserve.

INTRODUCTION

The Atlantic bluefin tuna (*Thunnus thynnus* L.) is one the most important commercial species among the large pelagic fish living in the Atlantic Ocean and Mediterranean Sea (SUSCA *et al.*, 2001). The knowledge of the biology of reproduction is extremely important for allowing a management of the species aimed to its conservation, as well as to enhance the chance of success of the domestication attempts which have been unfruitful until now (DOUMENGE, 1996; LIOKA *et al.*, 2000). Since recent reports on the reproductive biology of the eastern Atlantic bluefin tuna (SUSCA *et al.*, 2001; MEDINA *et al.*, 2002; SARASQUETE *et al.*, 2002), did not provide exhaustive details on the reproductive cycle, the aim of this paper was to provide a histological description of the changes occurring in BFT gonads throughout the reproductive cycle.

MATERIALS AND METHODS

Ovary and testis samples (No = 101 and 81, respectively) were obtained from adult (fork length ≥ 120 cm) bluefin tuna. The samples were collected from March to September on board of professional vessels in Italian and Spanish seas. Fragments of the gonads were fixed in Bouin's solution or neutral 10% formaline, dehydrated in ethanol and embedded in paraffin wax. Sections (5 µm thick) were stained with haematoxylin-eosin. To identify vitellogenic oocytes, certain sections were immunostained with rabbit anti BFT vitellogenin serum (abBFT-VTG). The immunohistochemical reaction was visualised by means of the avidin-biotin peroxidase complex (ABC) procedure.

RESULTS AND DISCUSSION

Ovary

The ovary consists of a tick muscle wall and numerous follicles in different stages of development (asynchronous ovary) embedded in a mass of connective tissue. Each follicle consists of an oocyte rounded by a single layer of follicular cells.

The activity of the ovaries showed seasonal changes allowing the characterisation of five periods during the reproductive cycle:

Recrudescence period (March-early May) – The specimens caught during the recrudescence period showed oocytes at perinucleolus and lipid stage. Perinucleolus stage (diameter 10 -110 µm) was characterised by intense ooplasm basophily and numerous small nucleoli adjoining the nuclear envelope (Figure 1A). Oocytes at lipid stage (diameter 110-220 µm) exhibited a weak ooplasm basophily and were characterised by small lipid droplets (Figure 1A).

Ripening period (middle May) – All the specimens analysed showed the presence both of previtellogenic and vitellogenic oocytes. Vitellogenic oocytes (diameter 220-500 µm) were immunopositive with the anti Vtg serum (Figure 1B).

Pre-spawning period (late May-June) – In the ovaries of the specimens caught in this period, migratory nucleus stage oocytes (diameter ranging from 500 to 600 µm) could be observed, together with the previous stages (Figure 1C);

Spawning period (late June-early July) – All the females caught in this period showed pre-mature (diameter 600-700 µm) or mature (diameter 700-850 µm) oocytes (Figure 1D).

Spent period (late July-August) – In this period, only perinucleolus stage oocytes were found. Irregular cell masses containing pigmented inclusions and large lipid droplets, likely residue of the re-absorbing process could be observed (Figure 1E). The ovaries of five specimens caught during the spawning period in the North Ionian Sea and South Adriatic Sea displayed extensive vitellogenic atresia (Figure 1F).

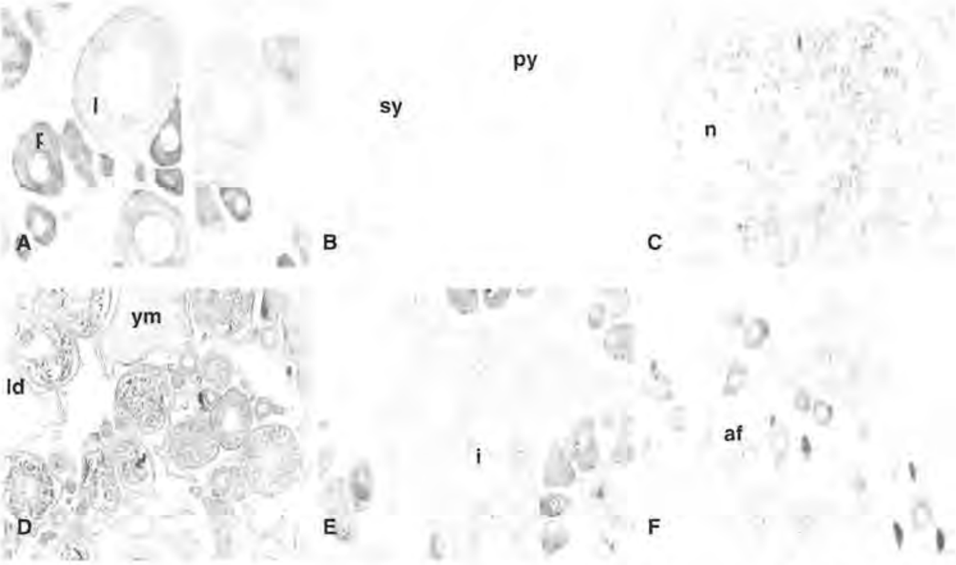

Figure 1. A – Photomicrograph of the ovary from a BFT specimen caught in April showing oocytes at perinucleolus and lipid stage. Magnification, x 100. B – Section of the ovary from a BFT specimen caught in May immunostained with abBFT-VTG. Vtg immunoreactive staining was detected in ooplasm of vitellogenic oocytes. Magnification, x 32. C – Section of the ovary from a BFT specimen caught in June showing a migratory nucleus stage oocyte. Magnification, x 88. D – Section of the ovary from a BFT specimen caught at the beginning of July showing mature oocytes. Magnification, x 36. E – Section of the ovary from a BFT specimen caught in August. Only perinucleolus stage oocyte can be observed. Irregular cell masses, likely residue of the re-absorbing process, are present in the connective tissue. Magnification, x 48. F – Photomicrograph of the ovary from a BFT specimen caught in July in the South Adriatic Sea showing extensive atresia. Magnification, x 48. Haematoxylin-Eosin staining. af, atretic follicle; i, irregular cell mass; l, lipid stage; ld, lipid droplet, n, nucleus; p, perinucleolus stage; py, primary yolk stage; sy, secondary yolk stage; ym, yolk mass.

Testis

Bluefin tuna testis (Figure 2A) is constituted by seminipherous tubules radiating from the longitudinal main sperm duct toward the testicular periphery. Testicular structure is cystic: each cyst contains germinal cells in the same development stage, branched by the cytoplasm of somatic cells (Sertoli cells).

The activity of the testes showed seasonal changes allowing the characterisation of five periods during the reproductive cycle:

Quiescence (March) - Seminipherous tubules showed germinal cysts containing spermatogonia and spermatocysts. Rare spermatidic cysts and few spermatozoa in the lumina were also observed (Figure 2B).

Early spermatogenesis (April-early May) – Testes showed germ cells at all stages of spermatogenesis and there was an increase in the number of spermatocytes and spermatids. Only few spermatozoa were observed in tubule lumina (Figure 2C).

Late spermatogenesis (middle May) – Active spermatogenesis took place in testes. The wall of seminipherous tublues was lined with meiotic and spermatidic cysts. Spermatozoa were more abundant in the lumen of seminipherous tubules, efferent ducts and main sperm duct than in previous stage (Figure 2D).

Spawning (late May-early July) – The lumen of seminipherous tubules, efferents and main sperm duct were filled with spermatozoa. Residual meiotic and spermatidic cysts were still present along the tubule wall (Figure 2E).

Regression (late July-August) – Lumina of seminipherous tubules and efferent ducts were almost devoid of spermatozoa, whereas residual spermatozoa could be observed in efferent ducts and in the main sperm duct (Figure 2F).

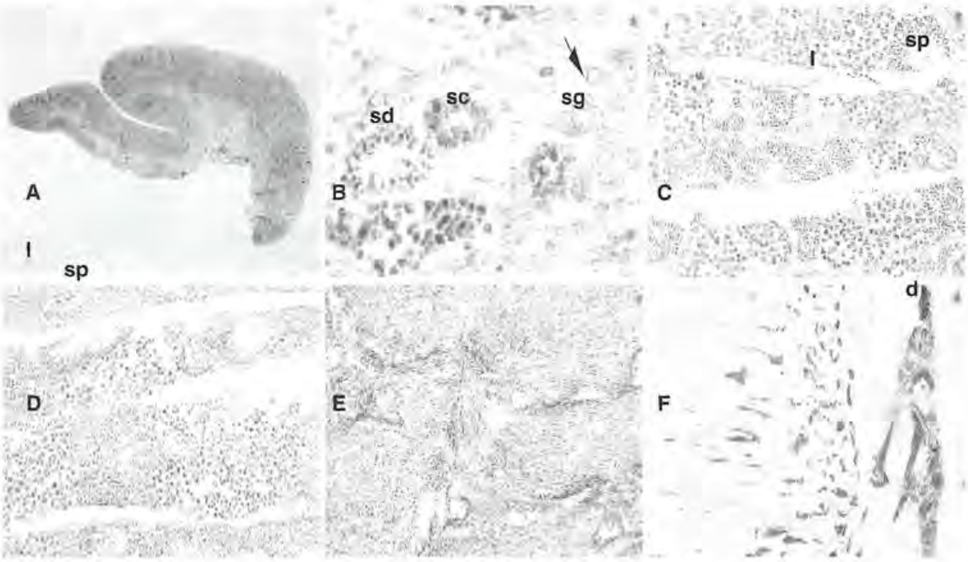

Figure 2. A – Photomicrographs of the testis from a BFT specimen caught in March. Magnification, x 9. B – Higher magnification of part of Figure 2A showing a seminipherous tubule. Magnification, x 500. C – Photomicrographs of the testis from a BFT specimen caught in April. Note the presence of rare spermatozoa in the lumen. Magnification, x 250. D – Photomicrographs of the testis from a BFT specimen caught in May. Note the abundance of sperm cysts and spermatozoa in the lumen of seminipherous tubule. Magnification, x 250. E – Photomicrographs of the testis from a BFT specimen caught in June. Seminipherous tubules are filled with spermatozoa. Magnification, x 123. F – Photomicrographs of the testis from a BFT specimen caught in August showing residual spermatozoa in the efferent ducts and in the main sperm duct. Magnification, x 30. Haematoxylin-Eosin staining. Arrow, Sertoli cell nucleus; d: main sperm duct; l, lumen of seminipherous tubule; sg, spermatogonium; sc, spermatocytic cyst; sd, spermatidic cyst; sp, spermic cysts.

CONCLUSIONS

Maturity development of BFT gonads starts in early spring when the testicular spermatogenic activity recommences and oocytes enter endogenous vitellogenesis. From May throughout June, exogenous vitellogenesis takes place in the ovaries. Vitellogenin uptake starts in oocytes having a minimum diameter of 220 μm, as revealed by immunohistochemical staining with abBFT-VTG. Testes are full mature from late May to the end of July when seminipherous tubules, efferent ducts and main sperm duct are filled with spermatozoa, while hydrated oocytes, sign of imminent spawning were found only in the Balearic Sea in late June-early July. At the end of July gametogenic activity is arrested: only residual spermatozoa can be observed in the testes and the ovaries shows only perinucleolar stage oocyte.

In the ovaries of the specimens caught during the spawning period in the North Ionian Sea and South Adriatic Sea no sign of recent spawning was observed and most of unyolked and yolked oocytes were atretic In teleosts, a high incidence of atretic oocytes has been interpreted as a sign of cessation of the spawning activity (HUNTER *et al.*, 1986; SCHAEFER, 1998) or failure in attainment of final oocyte maturation (MYLONAS *et al.*, 1997). The presence of spawning areas in South Adriatic and North Ionian Sea has never been reported in the literature. If the South Adriatic and the North Ionian seas are not spawning areas, it could be proposed that mature females, inhabiting non-spawning areas during the spawning season, reabsorb their yolk reserve and do not spawn. The finding of non-spawning specimens in non-spawning areas could account for an answer to the question: do all adult bluefin tuna migrate towards spawning areas when reproductive period approaches? LUTCAVAGE et al. (1999) and BLOCK *et al.* (2001) reported that some bluefin tuna large enough to be considered mature, tagged with electronic devices, showed no residence in any of the known spawning areas during the spawning period, thus raising questions on the existence of non-reported spawning areas (LUTCAVAGE *et al.*, 1999; BLOCK *et al.*, 2001).

REFERENCES

BLOCK, B.A., DEWAR, H., BLACKWELL, S.A., WILLIAMS, D., PRINCE, E.D., FARWELL, C.J., BOUSTANY, A., TEO, S.L.O., SEITZ, A., WALLI, A., DOUGLAS, F. 2001. Migratory movements, depth preferences, and thermal biology of Atlantic bluefin tuna. Science 293, 1310-1314.

DOUMENGE, F. 1996. Aquaculture of bluefin tuna. Biologia Marina Mediterranea 3, 258-288.

HUNTER J.R., MACEWICZ, B., SIBERT, J.R. 1986. The spawning frequency of skipjack tuna, Katsuwonus pelamis, from the South Pacific. Fishery Bulletin 84, 895- 903.

LIOKA, C., KANI, K., NHHALA, H. 2000. Present status and prospects of technical development of tuna sea-farming. Cahiers Options Mediterraneennes 47, 275 - 285.

LUTCAVAGE, M.E., BRILL, R.W., SKOMAL, G.B., CHASE, B.C., HOWEY, P.W. 1999. Results of pop-up satellite tagging of spawning size class fish in the Gulf of Maine: do North Atlantic bluefin tuna spawn in mid-Atlantic? Canadian Journal of Fisheries and Aquatic Sciences 56, 173-177.

MEDINA A., ABASCAL, F.J., MEGINA, C., GARCIA A. 2002. Stereological assessment of the reproductive status of female Atlantic northern bluefin tuna during migration to Mediterranean spawning grounds through the Strait of Gibraltar. Journal of Fish Biology 60, 203-217. doi: 10.10006/jfbi.2001.1835.

MYLONAS, C.C., WOODS, L.C. III., ZOHAR, Y. 1997. Cyto-histological examination of post-vitellogenesis and final oocyte maturation in captive-reared striped bass. Journal of Fish Biology 50, 34-49.

SARASQUETE, C., CARDENAS, S., GONZALES DE CANALES, M.L., PASCUAL, E. 2002. Oogenesis in the blefin tuna, *Thunnus thynnus* L.: A histological and histochemical study. Histology and Histopathology 17, 775-788.

SCHAEFER, K.M. 1998. Reproductive biology of yellowfin tuna (*Thunnus albacares*) in the eastern Pacific Ocean. Bulletin Inter-American Tropical Tuna Commission 21, 489-528.

SUSCA V., CORRIERO A., BRIDGES C.R., DE METRIO G. 2001. Study of the Sexual Maturity of Female Bluefin Tuna (*Thunnus thynnus*): Purification and Partial characterization of vitellogenin and its use in an Enzyme-linked Immunosorbent Assay. *J. Fish Biol.* 58: 815-831.

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SUSTAINABLE FISHING IN THE MEDITERRANEAN FOR BLUEFIN TUNA: A CASE STUDY OF ANCESTRAL FISHING TECHNOLOGIES AND CONTEMPORARY PRACTICES

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INTRODUCTION

I want to tell you a story today. This is a story of a fish that has been a significant part of the history of the Mediterranean Sea and the rich and varied cultures of its shores. Villages of the coast of Morocco, Algeria, Tunisia, Libya, Spain, Italy, Greece and Turkey have counted upon bluefin tuna as part of their annual food supply and economic well being since before written history. The bluefin is an integral part of their culture.

I want you to think about the bluefin's role in history and as far more than a fat fish that is currently of high value in the Tsukiji Market in Tokyo. There is one issue that drives all other considerations of tuna fishery management. That issue is "allocation", which is the division of the available fish among all parties that desire a share of the fishery resource. The allocation conflict is a result of two basic facts: the fisheries generally have open access and they take place in international waters (DEAN, 1997). We must consider who the players are in this dramatic high-value fishery.

I want to emphasize that it was the common people of the Mediterranean basin who primarily benefited from the use of the resource.They no longer are the beneficiaries and this works a hardship upon them. It is also very important to understand that the individuals engaged in resource utilization, the capture, marketing and consumption of the bluefin, are not the same individuals who make, monitor, and enforce the rules. This is especially true of international regimes that manage HMS.

The activities and agendas of fishermen and their support businesses must be differentiated from the diplomats, Non-Government Organization (NGO) and international civil servants that sit at the negotiating table or occupy the seats against the wall and the lounges in the lobbies. Also, the scientists from government agencies, corporations, academia, and NGOs are significant players and their roles must be recognized. Fishery management scientists are performers in the arena and cannot be removed from politics and advocacy. When fishery issues become politicized, and allocation is determined on a political basis, science becomes only a piece in the formation of public policy. However, policy must not be based upon inadequate science.

The Standing Committee on Research and Statistics of ICCAT (SCRS) has stated that the bluefin tuna that spawn in the Mediterranean Sea are being harvested beyond the capacity of the fish to recover to historic population levels. The assessment of 2002 stated that there is a strong decline in the abundance of older or larger fish since 1993 that corresponds with a large increase in fishing mortality. Model projections indicated that the levels of catch of 43,325 MT in 1997, is not sustainable and a catch level of less than 25,000 MT are necessary to stop the decline in biomass (CORT, J. Personal communication. 1999; ICCAT, 1999, 2000a, 2000b, 2001, 2002).

The accumulated scientific evidence is that modern development activities and current fishing practices threaten the well being of bluefin tuna population of the Atlantic Ocean and particularly those that use the Mediterranean as a spawning ground and nursery.

PROBLEM STATEMENT

Large numbers of the fish produced in the annual June-July spawning period migrate as juveniles through Straits of Gibraltar to the Atlantic Ocean in the fall of the year when they are about 30-45 cm fork length (2-4 kg) in size (REY and CORT, 1986, CORT, 1997). They are then subjected to capture by Moroccan commercial fisheries, and by Spanish and French purse seine fishermen in the Bay of Biscay (CORT, 1990). Juveniles that stay in the Mediterranean are harvested by Spanish, French and Italian fishermen in the Gulf of Lyon, the Ligurian and Tyrrenhenian Seas, and the upper Adriatic. Those fish are well below the ICCAT legal minimum size of 6.4 kg and 69 cm (27") fork length (ICCAT, 1975).

I want to look at the history of this fish and give it a reference in time. There is evidence that the bluefin tuna has been a sustainable fishery in the Mediterranean Sea for over 10,000 years (POWELL, 1996). Over that long period of history, the great bluefin tuna have been a source of food and oil and provided an economic base for coastal communities of the Mediterranean Sea and the Iberian Peninsula. Tuna have been a source of employment and income for fishermen, net and boat builders and processors, and sellers of tuna products.

For nine months of the year, this highly migratory fish ranges the entire north Atlantic feeding on squid and fishes. That annual extensive migration of tuna is followed by an aggregation of schools that enter the Straits of Gibraltar, and distribute themselves to their ancestral spawning grounds in the Mediterranean Sea. The distribution of bluefin larvae shows that some spawning occurs throughout the Mediterranean Sea (UEYANAGI *et al*, 1997; TSUJI *et al*, 1997; PICCINETTI *et al*, 1997; NISHIDA *et al*, 1998; ORAY and KARAKULAK, 1997, 1999). Spawning sites appear to be concentrated in the area of the Balearic Islands, the Tyrrenhenian Sea south of Sardinia, with additional spawning occurring off the coast of Turkey.

ARISTOTLE (384-322 BC) gave the first taxonomic description of the fish and discussed its biology and importance in Mediterranean culture in his 4th century BC *History of Animals*. He emphasized the importance of bluefin tuna migration into and out of the Black Sea and its use as a spawning ground at the time of the summer solstice. Although Aristotle considered the Black Sea to be the most important spawning area in the Mediterranean Sea for tuna (TYNDALE, 1849; D'ARCY WENTWORTH THOMPSON in SMITH and ROSS, 1910), they no longer pass through the Dardanelles, Sea of Marmara or the Bosphorous to spawn in the Black Sea (BOK, 1991; ORAY and KARAKULAK, 1997, 1999).

The bluefin is in trouble and many important cultural elements of the Mediterranean Sea are equally at risk and could be lost. The Mediterranean Sea is the cradle of western civilization and we should be concerned about anything so fundamental to the cultural history of the region. Ironically, even though this fish has such an important place in history, and is currently a highly valued fish on the international market, much of the fundamental biology and ecology of the bluefin still remains unknown.

We have reconstructed the history of this ancient fishery from historical and cultural records and fishery data. We have used that information to develop hypotheses that can account for the decline in the bluefin tuna abundance in modern times. We have examined aspects of the modern fishery by conducting a critical analysis of archival harvest records of three tuna traps in southwestern Sardinia for the period of 1825-1999.

Throughout the Mediterranean basin, there are numerous historical examples and records of the importance of bluefin tuna to the cultures and economies of the region. The current harvest practices are only an eyeblink in the passage of time and the historical role of this great fish in the region should be a major consideration for policy development of international regulatory bodies.

Bluefin tuna are recorded in Paleolithic paintings, whose estimated age is about 10,000 years BC, on the wall of a grotto on the island of Levanzo in the Egadi archipelago west of Sicily. In the classical period of the 6th century BC, Greek vases clearly show a bluefin tuna in a market. It is possible to take a picture today in a Moroccan, Tunisian or Turkish market with the fish being cut with the same type of knife. Coins of the 7th century BC to the 2nd century from sites in Greece and present day Turkey have beautiful and exquisitely detailed representations of bluefin. Coins with two bluefin tuna have been recovered from sites of Punic colonies Gades, present day Cadiz, Spain (TEKIN, 1996). The golden stater of Cyzicus was the staple of the gold currency of the whole ancient world until supplanted by those of Alexander the Great. From Xenophon 6.23 we learn that a Cyzicene a month was promised to soldiers as an advance upon their ordinary pay. That was the negotiated pay standard no matter where the soldiers were in the ancient Mediterranean world

In the 5th century BC, the Greek city of Melitus, which is on the Ionian peninsula, established extensive colonies on the Bosphorous and Black Sea (TEKIN, 1996). This impressive commitment of capital was for the capture of the abundant bluefin resources migrating along the coast of the Turkish peninsula each year.

The materials recovered from underwater archeological sites have provided us with another significant source of information. Amphorae are particularly useful in analyzing the role of tuna in the region because their form and use in a specific period of history is very well understood and documented. In the 5th century BC, Morocco and southern Spain were especially well known for the production of amphorae that were used to transport fish products as well as olive oil, wine and other agricultural goods (WILL, 1986; CURTIS, 1991). The bluefin were prized for their meat and the oil that was harvested from cooking and by putting the tissue through presses.

The production of salt by solar evaporation of sea water in large coastal lagoon systems was an essential component for the preservation of fish and fish products. In Aristotle's *Rhetoric* he stated: "fishes need salt, although it is neither probable nor credible that they should, being brought up in brine." The prime products preferred for commerce throughout the Mediterranean were fatty fish, and bluefin tuna and bonito were at the top of the list. Athenius and his friends described the best of these products as coming from Gades and Byzantium.

Aristotle identified the role of tuna as large predators, with a large concentration of fat in their muscle that gave them a great flavor and their very rapid growth rate. Although some of his interpretations of the biology of the tuna were not correct, they can be understood in light of the accumulated knowledge of the past 2100 years. He misinterpreted the age estimate of a life span of two years but even today we do not have a very accurate estimate of the size at age of the fish.

The role of bluefin tuna in the culture of the time is well documented by the numerous references to it in the writings of other major authors of the period (WILL, 1986; CURTIS, 1991). In his *Description of Greece*, Pausanias (115 AD -180 AD) tells of the 6th century Corcyraeans of present-day Corfu sacrificing a bull to Poseidon. The story was that a bull would leave the cows and go to the shore where he would bellow at the sea. When the Corcyraeans went to see what the bull was bellowing about, they saw great shoals of tuna, "and, straight away they caught the countless numbers of tunny fish that had previously eluded them". They dedicated a statue of a golden bull to the Oracle at Delphi and thereafter they dedicated an annual offering at Olympia and Delphi with a tithe of their annual catch.

Aeschylus (525-456 BC) used the metaphor of fishing for tuna to describe the victory of the Greeks over the Persians in the battle of Salamis in 480 BC. In *The Persians*, he writes of the Persian army of Xerxes being slaughtered by the Greek army and navy, (420, Loeb):

Messenger: "strewn as it was with wrecks and slaughtered men. The shores and reefs were crowded with our dead, and every ship that formed a part of the barbarian fleet plied its oars in disorderly flight, but, as if our men were tuna or some haul of fish, the foe kept striking them and hacking them with broken oars and fragments of wrecked ships."

Pliny also spoke of the role of the Bosphorous and the Black Sea, suggesting that the area of the Sea of Marmara and the Bosphorous, upon which European Byzantium was sited, and almost precisely where we are meeting today, was called the Golden Horn because of the abundance of the very valuable tuna.

There are some observations that lend themselves to the interpretation of the fishing techniques used in those ancient times. For example, in *The Wasps*, Aristophanes (447-386) wrote, "However, by the help of the gods, we drove off the foe towards evening. Before the battle an owl had flown over our army. Then we pursued them with our lance-point in their loins as one hunts the tunny-fish". Also, in *The Knights* he wrote (313) "and, posted upon a high rock, you have lain in wait for the tribute money as the fisherman does for the tunny-fish". Both of these references are in all probability a description of harpoon fishing, a technology that is still used in the professional fishery for bluefin tuna in the United States. Each of these references also tells us that the tunny (tuna) were readily available to fishermen in small boats or even from the shore. A spectacular Roman mosaic from the 3rd century AD in the Bardo Museum in Tunis shows two boats hauling a single net between them that contains several bluefin tuna. The Bardo mosaic is probably the first documentation of the fishing technology we now call pair trawling for a large pelagic fish.

Although it is difficult to find documentation of the development of the trap technology, it has often been attributed to the Phoenicians, who were clearly the dominant marine culture of the Mediterranean in the 8th through 7th century BC. They were replaced by the Carthaginians, who were in turn supplanted by the Romans who destroyed Carthage in 146 BC. There is also some evidence, but only from anecdotal accounts, that the trap technology was spread through the Mediterranean by the Byzantine culture during their emigration and dominance of the Mediterranean in the 7th century AD (SMITH, 1968). However, we question that as the Greeks, who already had a history of fishing for bluefin were on Sicily, then Syracuse, in the 5th Century BC. We do not have a clear record of the origin of the dalyan in the Bosphorous, but I think that is a perfectly reasonable ancestral trap and it certainly has functioned in that manner in modern history (DEVEDJIAN, 1926; TEKIN, 1996).

As has been true of most natural resources throughout history, the crown held the rights to the tuna trap concessions. Tuna traps were especially prominent on the southern coast of Spain and the holders of trap concessions became immensely wealthy. In 1584 tuna fishing brought 70,000 ducats into the treasury of the Dukes Medina Sidonia and Arcos of Andalusia.

Unfortunately, if those three great classical scholars, Aristotle, Pliny and Pausanias were to visit the Med. shores today in anticipation of seeing the great tuna and enjoying a meal of roasted tuna with olive oil and lemon, they would be seriously disappointed. Apparently, due to overfishing and pollution, there are no longer any bluefin in the Black Sea or the Bosphorous since the last harvest was recorded in 1987.

There have been significant reductions in the annual Sardinian trap landings from historical levels (CETTI, 1777). We have examined archival records of the traps in Sardinia, collected personal observations of the very experienced trap fishermen, and reviewed market records and current data. All fish captured in the trap during this period of time are sexually mature so sex determination by visual observation of the gonads is easily done. Relative fishing effort, which is the number of days that the trap net is in place and actively fishing, remained the same during this time.

The analysis of the historical data, together with some events related to the socio-economic development of the areas involved with tuna fishing with the trap net system (RUBINO, 1994), has led us to the following possible explanations for the observed decreases in the catches. The catches in Sardinian traps ranged from 22,000 to 5,000 fish per year in the period of 1860 until 1912. There were only four years during that 52 year span when the catch was less than 5,000 fish/yr. and the majority of the years (31) it was greater than 10,000 fish/yr (Figure 1).

During that time, there were significant canneries associated with the traps that employed as many as 300 people.

The last year the catch exceeded 10,000/yr. was 1912 and it has never reached that level since. This decline in modern catch coincides with the development of mining areas in southwestern Sardinia with enhanced technology. Mining is a historical part of the Sardinian culture and bronze artifacts consisting of *bronzetti*, small art objects, and weapons are found in Neolithic *Nuraghi* archeological sites (1500 BC, WILL, 1986). The Phoenicians established ports on the island in the 8^{th} century BC to trade in copper and zinc, which are the basic materials for the metallic alloy bronze. Sardinia continued to be contested for by the Carthaginians, Greeks and Romans as a source of the metals.

The mines produced lead, zinc and copper and heavy metal waste from the mining activity and processing of the ore. Sardinia was a poor island in the late 19^{th} century and was eager for any economic development (MANCONI, 1986). As the ores were mined and processed in the 19^{th} and early 20^{th} century, waste from the plants entered the rivers draining into the sea in the area of the traps. The runoff caused a measurable increase in the turbidity of the sea. A significant legal decision was that the mines had a significant negative effect on the water quality, which resulted in a serious decline in the catch of tuna in the traps of Porto Paglia and Portoscuso. Damages were awarded to the operators of the traps. The level of mining activity decreased in the mid-1900's, but the residual effects of the waste in the rivers and streams remains in the system for many years. We tested the hypothesis that the reduction in catch was correlated with the mining development and ore production by comparing the annual catch records of the Isola Piana and Portoscuso traps with the records from the La Tonnara Saline trap (Figure 2), which is located on the northern end of Sardinia. The hypothesis was that the catch in La Tonnara Saline would not demonstrate the same patterns of decline as the other traps. It is far removed from the effects of the mine effluents and prevailing north to south currents would transport any effluent effect away from it. However, there was no difference in the catch trends of the three traps as the catches also declined at La Saline during the same years (RUBINO, 1996). We concluded that the mining wastes were not responsible for the decline in trap catches in the early 20^{th} century. These results are consistent with the speculation of RAVIER and FROMENTIN (2001) and we are left with the distinct possibility that a significant decline occurred in the bluefin population throughout the Mediterranean and possibly throughout the ocean.

Catches in the traps showed another major decline in the 1970s, from about 4,000/yr to less than 1,000 fish/yr. There are two possibilities to explain those reduced catches. The first is that they were associated with the development of a major industrial area for aluminum production near the main traps of southern Sardinia. Large amounts of red waste sediment residues from the plant stored in a retention basin washed into the sea in 1974 at Portovesme when the retaining wall failed, and no catches were made in the nearby Portoscuso trap.

Ship traffic to support the industrial development also increased significantly so there have been major changes in underwater sound as well as water quality. A large thermoelectric generating facility was built near the site of the Le Saline trap of Stintino and catches were reduced so significantly that the trap was closed. It should be recognized that such changes in the Mediterranean coastline for industrial and tourism development is not limited to Italy but has occurred throughout the region. The output of rivers laden with heavy metals, pesticides, herbicides and high levels of nitrogen and phosphorous from agricultural runoff and treated and untreated sewage is now well documented for all the oceans and seas of the world. The trap at Isola Piana, near Carloforte, is located in the waters that are the least subject to ship traffic and runoff from the land or other sources of pollution. It is the trap that currently has the highest catches of bluefin. This contrasts with the historical record when the highest catches were consistently recorded in the Portoscuso trap.

The other major factor that is considered responsible for reduced catches in the traps in The Mediterranean correlated with the introduction of new types of fishing gear, specifically the introduction of longlines and purse seine boats with spotter aircraft. Both technologies were vigorously developed and exploited in the late 1960s and early 1970s. According to ICCAT statistical data, the first records of the decrease in total eastern Atlantic and Mediterranean bluefin catches were made in the late 1960s. A progressive increase in purse seine catches, in total landings, percentage of the total catch is recorded. This is mirrored to a lesser extent in longline catches; however, trap catches began a sustained decline in total landings and as a percentage of the total catch after the onset of purse seining (ICCAT, 2001a).

Beginning in 1990, ICCAT required the reporting of landings of "small fish, those less than the minimum ICCAT regulation of 6.4 kg with an allowance of 15% of that size category of bluefin as a portion of a country's annual landings. An examination of those records shows the very large number of these juvenile fish that are being harvested each year, far exceed the allowance regulation (ICCAT, 1997a). Limitations of significant landings of fish of that size would create serious economic and political problems for Spain in their Canabrian Gulf fishery (CORT, 1997).

Because of the decline in the tuna harvest in the traps, the canneries closed in the 1970's and all fishing of the traps stopped by 1980. This created a very severe economic and cultural depression in the trap villages. Because of the incredible value of the bluefin in the Japanese market, the Portoscuso the Isola Piana traps were put back in the sea in 1984 and 1989 respectively.

Another result of the intensive harvest of the 1970s to the current time is the change in the size or age structure of the catch. The reduction in the average size in the fish caught each year, the increase in the number of four and five-year-old fish and the disappearance of big fish are well documented in the trap records. Data from ICCAT also shows a significant reduction in the number of big, and presumably older, tuna. That observation is consistent with our results, which show a decline in the capture of bluefin of the larger size classes over the last nine years.

There is an ICCAT regulation that prohibits purse seining in the Adriatic Sea from May 1-31 and from July 15-August 15 in the Mediterranean Sea is ludicrous. If one seriously wanted to protect bluefin in the Mediterranean, you should use a biologically based size limit, and both seasonal and area closures. Those dates and areas should be based upon the reality of the biology of the juvenile bluefin. In the late fall and winter, the Gulf of Lyon, the Adriatic Sea and the Tyrrhenian Sea would be prime closure sites as the juveniles spawned that summer, and year class one and two fish are abundant in those areas at that time.

However, the current minimum size and small fish tolerance regulations of ICCAT are examples of regulatory manipulations that have the appearance of doing something rather that directly addressing the real problem. The evidence shows the targeting of small bluefin by purse seiners with excessive capacity is the primary source of the problem for the bluefin population. This process is well demonstrated by the adoption in 1975 of the ridiculously low minimum size limit of 6.4 kg for the bluefin and flagrant abuse of the size limit and small fish tolerance allowance (ICCAT, 1975). Shortsighted politicians also lack an appreciation of the increasing technological capability of contemporary fishing boats and seemingly ignore the behavior of fishers. In addition, the budgets necessary for the implementation of their actions, or the support of enforcement, are not forthcoming. Thus, the rhetoric at the meetings is hollow and the printed regulations and reports nothing but paper sharks.

All bluefin that we have observed during the 1992-1999 trap harvests, over a size range of 15-474 kg, are clearly sexually mature (CAU *et al.*, 2000). According to the ICCAT length to estimated age conversion table, a 20 kg fish is three years old. It is currently presumed that only females of the estimated age five-year class (136cm or 50kg) are 100% sexually mature (RODRIGUEZ-RODA, 1964). That assumption is the basis upon which the data is entered for the stock assessment calculations. ICCAT reported that 297,325 three and four year old fish were landed in 1995. Based upon the observations we have made from 1992-1999, there are a significant number of reproductively capable fish that have not been included in the data used by ICCAT for the population estimates.

The fisheries literature has a number of well-documented examples of fishes that were harvested at a young age but mature at an old age and are very vulnerable to overfishing. It is well demonstrated that harvesting a constant quota from a declining stock is apt to cause increases in selection of smaller, and presumably younger, fish. According to MYERS and MERTZ (1998),"fish should be permitted to spawn at least once before they become vulnerable to commercial gear." The best safety margin is when the difference between the age at maturity and age at which the fish are first captured in the fishery is greatest. Our data clearly indicates that a minimum size of 30 kg would insure that 100% of the Mediterranean bluefin that spawn in the sea around Sardinia would spawn at least one time before they were harvested and the same is true for those in the Turkish fishery. Such a management measure would be the best way to insure the sustained harvest of bluefin tuna and would constitute a valid part of a recovery program.

It has only been since 1998 that we have a decent direct estimate of the life span of bluefin, which we now know can exceed 33 years for a tuna of a LJFL of 267 cm (converted weight = 300 kg) (KALISH et al. 1998). It is depressing to realize that bluefin of greater than 400 kg are still captured and killed when they can contribute significant numbers of eggs for the generation of potential offspring. It is important to recognize that large old fish are the reservoirs of the specie's historical genotypes and is keeping those fish in the population pool is necessary for the maintenance of genetic diversity. The most important way to maintain genetic diversity is to have the largest possible number of individuals contributing to the population. That is a difficult argument to make in an aggressive and highly profitable fishery.

Our data shows a sex ratio of very close to 1:1 throughout the length or weight range except in very large fish, unlike the stock assessment assumption that large fish are exclusively males (DE LA SERNA *et al.*, 1997). Thus, there are significant numbers of big females that are capable of producing very large numbers of eggs that are not included in the stock assessment calculations.

CONCLUSIONS

We cannot find any evidence that the trap technology has had a negative effect on the bluefin population. The trap technology is compatible with a sustainable tuna fishery. We think that the tuna trap is an excellent example of an ecologically compatible fishery technology. The fundamental facts are that the traditional trap which has been used for hundreds of years:

- Can selectively and passively harvest only sexually mature individual tuna.
- Operates for a very limited time of the year and the result is a very low fishing effort as compared with other fishing technologies.
- Depends upon environmental cues for the concentration of the tuna.
- Is a passive technology that depends upon positive swimming behavior of the tuna.
- Does not pursue the tuna beyond their local area of concentration.
- Tuna can be released from a trap with a high probability of survival.
- Fish can be tagged and released for scientific research.

From the commercial point of view, the trap has the following advantages:

- Tuna can be captured and handled to preserve the highest quality for the market.
- Tunas can be held in the trap for several days so they can be captured and shipped when the market is the best.
- Small fish (25-35 kg) can be transferred to a pen system and fed so they will grow to a size that will give a better market price.

If we started from point zero, we could probably not do better in the design of a gear to meet several contemporary fishery management objectives. These include: 1) compatibility with the ecology of the bluefin, 2) retention of the ability to harvest the resource and 3) conservation of the fish for the future. It is very interesting that one of the first types of gear used for the capture of bluefin in the Mediterranean is also the gear that meets the needs of the fish the best. Trap nets accomplish many of the traditional objectives of fish management and can be the most easily monitored for enforcement.

And that leads us to the latest technological innovation in the bluefin fishery in the Mediterranean; which is the development of the pen grow out operation. This technique has expanded rapidly and has become a conspicuous new actor in the contemporary bluefin play. I was not fortunate enough to participate in the recent workshop on pen grow out. I will give you my perspective and how this technique fits within the historical context of the fishery. Remember, my thesis is that the methods used to bring the bluefin biomass to market should be ecologically consistent with the life history of the fish and the culture of the coastal communities. As we have said, it is feasible to operate purse seines that target adult fish and transfer those fish to pens. We know that purse seiners can target schools of sexually mature fish as this is standard practice for the US purse seine boats, and there are only three, and it has been reported to us that this is standard practice for the tuna purse seiners of Turkey. If purse seining is used to load the pens, it is essential that the number (biomass) put in the pens must count as part of the allocation based upon the size profile of the cohort placed in the pen, and that they are adult fish. They could also be regulated for the time of capture. For example, those fish to be place in the pens might be limited to capture only in the post-spawning period and no capture would be permitted in large numbers prior to spawning. Sustainable fishing technologies should be encouraged, not sacrificed for non-sustainable practices. We have a concern about the food stocks for the penned fish. Currently it is common practice to use frozen herring from Norway. This carries the risk of the introduction of exotic species to the Mediterranean, and we all know the problems and costs associated with such introductions. We think the issue of water pollution is readily solved with careful siting and rigorous review in the permitting process and monitoring of the local environment.

Another recommendation that would support the recovery of the stock would be to change the landing statistical reporting metrics. As an example, exceedingly large numbers of juveniles are still killed each year. Countries are required to report them but they do so as numbers whereas the other data is in metric tons (biomass). We suggest that the fish of less than minimum size be accounted for on a scale that would count each small fish, those less than 6,4 kg, as a 25 kg fish against their annual allocation. Thus the country could decide if they wanted to harvest four small fish or one 100 kg fish. The more juvenile fish they harvested, the sooner they would reach their allocation quota. This approach would assist in accomplishing a recovery of the stock. As always, enforcement of the regulation would be a problem.

Probably the most significant factor for the future of the bluefin tuna in the Mediterranean will be the actions of ICCAT as they deliberate on how to implement a recovery plan for bluefin. Such action is required under their charter and they are also now operating in the searchlight of conservation organizations such as Greenpeace, the World Wildlife Fund for Nature and the Audubon Society. There has also been a significant shift in the operating philosophy and policies of FAO, which are pushing nations to operate with more sustainable practices in the use of global fishery resources.

ICCAT has recommended a reduction in the level of fishing effort by all countries that harvest the bluefin in that region. Each country that uses the eastern bluefin tuna resource has been given an allocation of total allowable catch for 1999 and 2000. However, compliance is clearly very difficult to achieve and fishermen are seemingly not willing to reduce their capture of bluefin. Some countries have historically harvested tuna but have only recently begun to take advantage of the market in Japan. In the history of the bluefin fishery in the Med. the current market value is aberrant. Why should Tunisia, Greece or Turkey give up the same percentage of the current catch as Spain or France, who are relative latecomers to the use of bluefin? And, if there is no penalty extracted for violating the regulations and recommendations, why should the fishermen of Italy, Spain and France reduce their effort?

WHAT IS THE FUTURE?

Are the critical issues in the management of bluefin tuna, 1) the development of new fishery regulations for tuna management, 2) a need for more research on the biology of the fish, or 3) the development of new models of population dynamics? Presently many of the recommendations from ICCAT's own SCRS, as well as the recommendations of the international scientific and conservation community, have not adopted by the plenary session of ICCAT. Those that have been adopted are, in some cases, not scientifically supportable or implemented and enforced. It would appear that existing data on the biology of the species is not utilized in the existing population models and fundamental assumptions in the models are not supported by research.

We think the most essential aspect of future bluefin tuna management is not in the establishment and enforcement of more regulations. The passage of regulations often satisfies politicians and bureaucrats that assume they are accomplishing something; or use their actions to satisfy a short-term political agenda. In addition, implementation of new regulations and enforcement requires increased budgets.

Elected politicians, and their political appointees to boards and commissions, usually do not make decisions that will have positive results far in the future. The time frame for a politician is the period until their next election or their term of appointment by the next government or administration. A longer period of time has little meaning to them because they must take criticism of their actions in the present and will not benefit in the future from any positive results from their activity. Their actions are often not based on the realities of the current knowledge the scientific community has of the fish.

What is the future of the Mediterranean bluefin tuna? That outcome resides in a legitimate commitment to action policies by the political leadership of all countries that use the resource as producers and consumers, or both. Certainly, any hope for a recovery to population levels of the past will require the following actions:

1) A reallocation of quota based upon historical fishery practices, not just those of the last 30 years, to achieve equity.
2) A significant reduction in total landings and the elimination of fishing for juvenile bluefin.
3) A change in harvesting practices of all countries.
4) An elimination of outlaw boats and international censure of nations that tolerate them.
5) Fair, equitable and sustained enforcement of existing regulations.

And, it is most important that the development of any new regulations or amendments to existing ones must be based upon excellent objective science.

It is also imperative that all of us adopt a new attitude and respect for the fishery resources of the sea. Based upon past history and actions, one cannot be optimistic that there will be a positive outcome for this great fish, the tunny of Aeschylus, Aristophanes and Aristotle.

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REFERENCES

ADDIS, P., CAU, A., DAVINI, M.A., SECCI, E., SCIBALDI., G. 1996. Collection of tuna data catches by trap-nets in Sardinia: Historical (1825- 1980) and recent catches (1992-1999), ICCAT Collected Volume of Scientific Papers, Vol. XLVII(2) pp.132-138.

BOK, T. 1991. Beykoz dalyani'nin isleyisi ve avciligi uzerine arastirmalar. Yuksek Lisans Tezi. pp. 85 Fen Bilimleri Enstitusu, Istanbul Universitesi. Istanbul-Turkiye.

CAU, A., ADDIS P., CUCCU D., DAVINI M.A., FOLLESA M.C., MURENU M., SABATINI A., SECCI E., DEAN J.M. 2000. Methodology for increasing the knowledge of large pelagic fish assessments of Sardinian Seas. Final Report for the Italian Ministry for Agriculture, Policy, and Forestry: pp. 105. Department of Animal Biology and Ecology, University of Cagliari, Cagliari, Sardinia, Italy.

CETTI, F. 1777. Storia naturale della Sardegna. Anfibi e pesci di Sardegna. Tomo III, Sassari, Sardinia, Italy.

CORT, J.L. 1990. Biologia y pesca del atun rojo (*Thunnus thynnus*) del mar Cantabrico. Publicaciones Especiales Instituto Espana Oceanographia., 4 : pp. 272

CORT, J.L., V.O. DE ZÁRATE. 1997. The bluefin tuna (*Thunnus thynnus*) fishery in the Cantabrian Sea (Northeast Atlantic). In Developing and Sustaining World Fisheries Resources: the State of Science and Management: 2nd World fisheries Congress Proceedings. (D.A.Hancock, D.C. Smith, A. Grant and J.P. Beumer, Editors), pp. 55-66. CSIRO Australia

CURTIS, R.I. 1991. Garum and Salsamenta. 226 ppg. E.J. Brill, Leiden, Netherlands

DEAN, J.M. 1997. International bio-political fisheries management: Sashimi on the cutting edge. In Developing and Sustaining World Fisheries Resources: the State of Science and Management: 2nd World fisheries Congress Proceedings. (D.A.Hancock, D.C. Smith, A. Grant and J.P. Beumer, Editors), pp. 339-343. CSIRO Australia

DEVEDJIAN, K. 1926. Pêche et Pêcheries en Turquie. Imprimerie de l'Administration de la Dette Publique Ottomane, İstanbul , 480 pp.

DE LA SERNA, J.M., LOT, E. A., RIOJA., M.P. 1997. Proporcion de sexos y sex-ratio por clase de talla del atùn rojo (*Thunnus thynnus*) capturado por las almadrabas atlântica espanolas durante el periodo 1989-1995. ICCAT Collected Volume of Scientific Papers; Vol. XLVI (2); pp. 97-101.

FARRUGIO, H. 1980. Bluefin fishing in the French area of the Mediterranean. Development and characteristics. ICCAT Collected Volume of Scientific Papers. 11: pp. 98-117.

FOOD and AGRICULTURE ORGANIZATION, 1995. Precautionary Approach to Fisheries. FAO Fisheries Technical Report 350. United Nations, Rome.

ICCAT. 1975. Report for the biennial period. Part I (1974). Madrid, Spain.

ICCAT. 1997a. ICCAT Collected Volume of Scientific Papers. Vol. XLVI (1). Table 4, 122-123pp, Table 15, 161pp. Madrid, Spain.

ICCAT. 1997b. ICCAT Collected Volume of Scientific Papers. Vol. XLVI (2) Bluefin Tuna (*T.thynnus*) - GFCM/ICCAT Session. Madrid, Spain.

ICCAT. 1999. Annex 5-5, Recommendations & Resolutions Adopted by the Commission. Report for the biennial period. Part I (1998). - Vol 1. ICCAT, Madrid, Spain.

ICCAT. 2000a. Statistical Bulletin, Vol. 30 1999, ICCAT, Madrid, Spain.

ICCAT. 2000b. Report for biennial period, 1998-1999, Part II (1999)-Vol. 2. ICCAT. Madrid, Spain.

ICCAT. 2001. Executive Summary, 1-4, Proceedings of the 12th Special Meeting of the Commission. ICCAT, Madrid, Spain.

ICCAT. 2001. Report for biennial period, 2000-2001, Part I (2000)-Vol. 2. ICCAT, Madrid, Spain.

ICCAT. 2002. Executive Summary, Proceedings of the 13th Special Meeting of the Commission. ICCAT, Madrid, Spain.

KALISH, J., JOHNSTON, J.M., MATSUMOTO, T. 1998. Age of bluefin tuna estimated from radio carbon dating using the bomb radiocarbon chronometer to determine age of Atlantic bluefin tuna (*Thunnus thynnus*). ICCAT Collected Volume of Scientific Papers. Vol. XLVIII (1). SCRS/98/81.

MANCONI, F. 1986. Le Miniere e i Minatori della Sardegna. pp. 237 Silana Editoriale, Sassari, Sardegna, Italy.

MYERS, R.A., MERTZ, G. 1998. The limits of exploitation: a precautionary approach. Ecological Applications. 8 (1) Supplement. S165-S169.

NISHIDA,S. TSUJI, K. SEGAWA. 1998. Spatial data analyses of Atlantic bluefin tuna larval surveys in the 1994 ICCAT BYP. ICCAT Collected Volume of Scientific Papers. Vol. XLVIII (1). 107-110.

OLLA, R. 2000. Biologia Riproduttiva di *Thunnus thynnus* (L.): Fecondità e Sviluppo dell'Ovario. pp. 58. Tesi di Laurea, Università di Cagliari, Italy.

ORAY, I.K. and KARAKULAK, S. 1997. Some remarks of the bluefin tuna (*Thunnus thynnus (L.)* 1758, fishery in Turkish waters in 1993, 1994, 1995. ICCAT Collected Volume of Scientific Papers. 96/030. 357-362 XLVI (2).

ORAY, I. K. and KARAKULAK, S. 1999. Investigations on the reproductive biology of bluefin tuna (tuna (*Thunnus thynnus.L.* 1758) in the North Aegean Sea. ICCAT Collected Volume of Scientific Papers. Vol. XLIX (1). SCRS/98/56.

PICCINETTI, C. 1980. The bluefin seine fisheries in the Adriatic. ICCAT Collected Volume of Scientific Papers. 11: 346-350.

PICCINETTI, C., PICCCINETTI-MANFRIN, G., SORO, S. 1997. Résultats d'une campagne de recherche sur les larves de thonidés en Méditerranée. ICCAT Collected Volume of Scientific Papers. (Vol. XLVI (2);207-214.

POWELL, J. 1996. Fishing in the Prehistoric Aegean. pp. 266 Paul Åströms Förlag, Jonsered, Sweden,

RAVIER, C., FROMENTIN, J. 2000. Long-term fluctuations in the eastern Atlantic and Mediterranean bluefin tuna population. ICES Journal of Marine Science. 58: pp. 1299- 1317.

REY, J.C., CORT, J.L. 1986. The tagging of the bluefin tuna (*Thunnus thynnus*) in the Mediterranean: history and analysis. CIESM, 2pp.

RODRIGUEZ-RODA, J. 1964. Biologia del atùn, *Thunnus thynnus* (L.) de la Costa Sudatlàntica Espanola. Investigation della Pesq., 25: pp.33-146.

RUBINO, S. 1996. La Tonnara Saline. pp. 288 La Celere Editrice, Alghero, Sardinia, Italy.

SMITH, D.M., 1968. A history of Sicily: Medieval Sicily 800-1713. pp. 240 Chatto and Windus, London, England.

SMITH, J.A., ROSS W.D. 1910. The Works of Aristotle Translated into English: the Revised Oxford Translation. Historia Animalium , by D'Arcy Wentworth Thompson. Bekker (543 b 35). Oxford at the Clarendon Press. London, England.

TEKIN, O. 1996. The Pelamydes of Byzantium and the Golden Horn. Anadolu Araştırmaları. XIV pp. 469-478.

TYNDALE, J.W. 1849. The Island of Sardinia. Vol. III.. R. Bentley, London, England. pp. 143-179.

TSUJI, S., NISHIKAWA, Y., SEGAWA, K., HIROE, Y. 1997. Distribution and abundance of Thunnus larvae and their relation to the oceanographic condition in the Gulf of Mexico and the Mediterranean Sea during May through August of 1994. ICCAT Collected Volume of Scientific Papers. (Vol.XLVI (2);161-176.

UEYANAGI, S, NISHIKAWA, Y., TSUJI, S. 1997. Identification and occurrence of *Thunnus* larvae collected from the Gulf of Mexico and the Mediterranean Sea by the Shoyo-maru cruise in 1994 with the review of recent identification study of larval *Thunnus*. ICCAT Collected Volume of Scientific Papers. (Vol. XLVI (2):181-185.

WILL, ELIZABETH L. 1986. Amphoras and Trade in Roman Sardinia, in: Studies in Sardinian Archaeology. Vol II.Sardinia in the Mediterranean. M.S. Balmuth, ed. Ann Arbor. pp. 211-28.

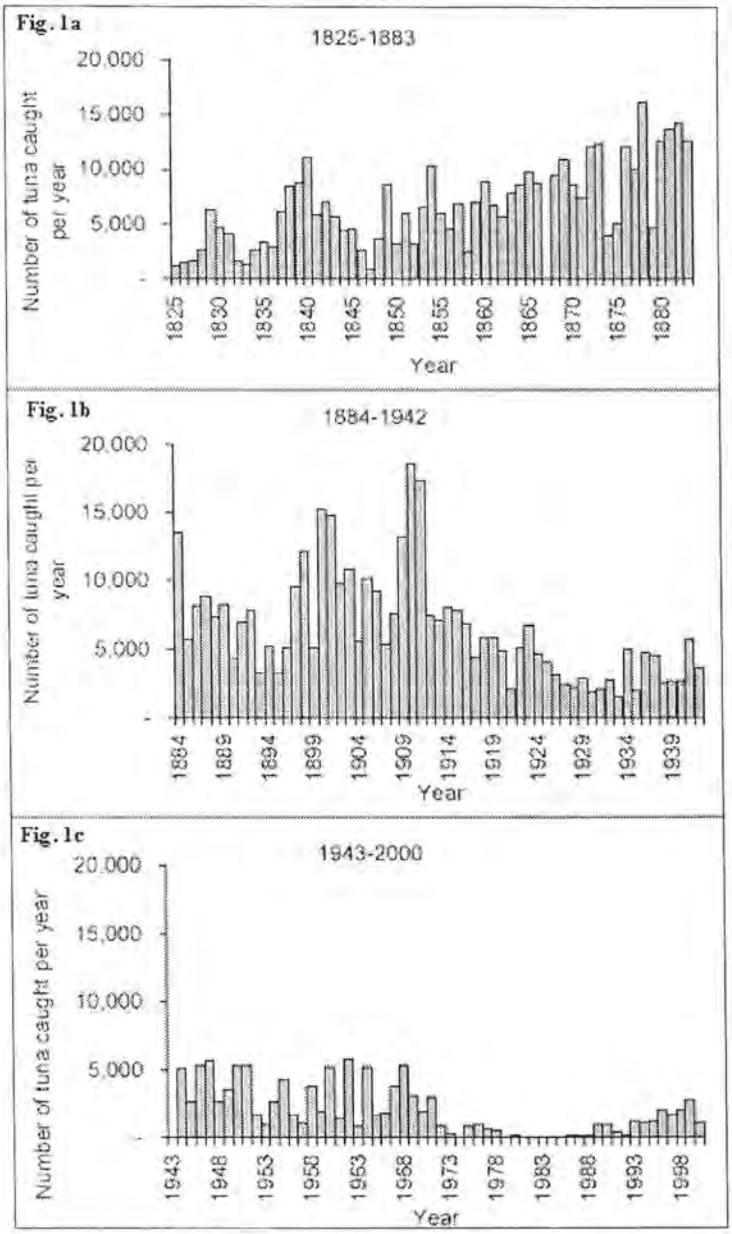

Figure 1. Combined catches in the traps of Portoscuso and Isola Pina (Sardinia) during the period of 1825-1883 (Figure 1a), 1884-1942 (Figure 1b) and 1943-2000 (Figure 1c).

BLUEFIN TUNA IN THE BLACK SEA

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In terms of zoogeography, the presence of the bluefin tuna, *Thunnus thynnus* (L.) in the Black Sea is a particular case of the Mediterranean-Black Sea faunal exchange (ZAITSEV, 2000). Its migrations through the Bosphorus in the Black Sea and back were firstly described by ancient authors Pliny and Aristotle but only in the 1930's its eggs were found in the Black Sea plankton by VODYANITSKY (1936). It was a definite proof of its breeding in this sea.

The Black Sea was always an attractive feeding and breeding area for Mediterranean fishes and regular seasonal migrations of many species occurs. Among them there are mackerel (*Scomber scombrus*), bonito (*Sarda sarda*), horse mackerel (*Trachurus mediterraneus ponticus*), bluefish (*Pomatomus saltator*) and others. All of them, except the mackerel, are breeding in the Black Sea. The most thermophylous species migrate to the Sea of Marmara for the winter.

The bluefin tuna was not a mass fish in the Black Sea, although shoals of 30-40 specimens in the north-western part and in other areas of the sea in the 1940's and 1950's were observed during aerial observations of pelagic fishes (GOLENCHENKO, 1952). This author suggests to organize the tuna fishing in the Black Sea, but only in Bulgarian coastal waters average annual catches of this fish in 1941-1960 were from 1.5 to 0,4 tons. Subsequently the catch of tuna ceased (ZAITSEV and MAMAEV, 1997).

The biology of tuna in the Black Sea is not enough investigated, but the basic stages of its life cycle are in general known. The migration of tuna from the Sea of Marmara in the Black Sea occurs in the spring, in April - May then, when by the same way are migrating two species of mackerel (*Scomber scombrus* and *Scomber japonicus*), the bonito (*Sarda sarda*), the bluefish (*Pomatomus saltator*), and sometimes the sword fish (*Xiphias gladius*).

In the Black Sea the tuna is observed from the early of April till December inclusive (SVETOVIDOV, 1964). The fish was repeatedly observed in front of the coasts of Eupatoria, Yalta, Feodosya, Anapa and Novorosiysk. From September till November during wintering migration of anchovy from the Sea of Azov in the Black Sea, shoals of tuna numbering 10-15 fish can be observed near the Kerch Strait actively feeding on anchovy. In the second half of November tunas are migrating to the south of the Caucasian coast and can be observed in front of Poti and Batumi coasts (SVETOVIDOV, 1964). Some authors (VINOGRADOV, 1951) suppose, that a part of tunas are wintering in the Black Sea.

Pelagic eggs of tuna were observed in the Black Sea in summer, mainly in early August (VODIANITSKY, 1936; VODIANITSKY, KAZANOVA, 1954; OVEN, 1959; DUKA, 1959; ZAITSEV, 1959).

As well as other representatives of the family Scombridae, the bluefin tuna grows rapidly and by the end of the first year of life achieves length 60-70 cm, however direct observation over growth of this fish in the Black Sea, as far as it is known to the author, was not carried out.

Since the 1970s, the number of the bluefin tuna in the Black Sea was sharply reduced, as well as the number of the mackerel, bonito and bluefish (ZAITSEV, 1993; ZAITSEV and MAMAEV, 1997), which allows to assume that the general reasons of such phenomenon are some factors negatively influencing migrations of fishes through the Bosphorus. It can be, for example, chemical pollution of water. One of the reasons can be the acoustic factor connected to the intensification of navigation through a narrow strait. Anyway, cases of observation and fishing of the bluefin tuna in the Black Sea after the 1970s are exceptional. In the plankton samples, it has ceased to find eggs of tuna and this has served as a reason for some authors to doubt that this species is breeding in the Black Sea (DEKHNIK, 1973).

REFERENCES

DEKHNIK, T. V. 1973. Ichthyoplankton of the Black Sea. Kiev: Naukova dumka, 236 p. (in Russian).

DUKA, K. F. 1959. About the spawning of fishes in the Sebastopol Bay. Trudy Sevastop. Biol. St., 11, p. 297-317 (in Russian).

GOLENCHENKO, A. P. 1952. To organize the tuna fishing in the Black Sea. Rybnoe khozyaistvo, 10, p. 18-19 (in Russian).

OVEN, L. S. 1959. Pelagic eggs of fishes in the Black Sea near Karadag. Trudy Karadag. Biol. Station, 15, p. 17- 21 (in Russian).

SVETOVIDOV, A. N. 1964. The Black Sea fishes. Moskow-Leningrad: Nauka Publ., 552 p. (in Russian).

VINOGRADOV, A. C. 1951. On tunas in the Black Sea. Izvestya Krim. Otdel. Geograf. Obschestva SSSR, 1, p. 77-82 (in Russian).

VODYANITSKY, V. A. 1936. Observations on pelagic eggs of epy Black Sea fishes. Travaux de la Station Biologique de Sebastopol, Tome V, p. 3-40 (in Russian).

VODIANITSKY, V. A., KAZANOVA, I. I. 1954. Key of pelagic eggs and larvae of the Black Sea fishes. Trudy VNIRO, 28, p. 240-323 (in Russian).

ZAITSEV, Yu. P. 1959. New data about the ichthyoplankton of the north-western part of the Black Sea. Naukovy zapiski Odesskoi biol. Stantsii, 1, p. 77-87 (in Ukrainian).

ZAITSEV, Yu. P. 1993. Impacts of eutrophication on the Black Sea fauna. General Fisheries Council for the Mediterranean. Studies and Reviews, Rome, FAO, 64, p. 63-86.

ZAITSEV Yu. P. and MAMAEV, V. V. 1997. Marine Biological Diversity in the Black Sea. A Study of Change and Decline. New York: United Nations Publications, 208 p.

ZAITSEV Yu. P. 2000. Mediterranean - Black Sea faunal exchange. Proceedings of the International Symposium "The Aegean Sea 2000" (7-7 May 2000, Bodrum-Turkey), p. 1-7.

BLUEFIN TUNA FISHERY IN TURKEY

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INTRODUCTION

The bluefin tuna (*Thunnus thynnus*) is a commercially important and heavily exploited teleostean fish in the world oceans and seas. It occupies a significant place in the Turkish marine fishery. Moreover, it is one of the important species of aquaculture.

Other scombrid species captured in Turkish seas are albacore (*Thunnus alalunga*), Atlantic little tuna (*Euthynnus alleteratus*), skipjack (*Katsuwonus pelamis*), atlantic bonito (*Sarda sarda*), plain bonito (*Orcynopsis unicolor*) and bullet tuna (*Auxis rochei*). Among these species, Atlantic bonito, which is called "*palamut*" in Turkish, yields the highest catch in our seas.

The history of the bluefin tuna fishery in Asia Minor dates back to ancient ages. Besides the taxes paid by the sailing ships passing through the Istanbul Strait, bonito and bluefin tuna fishery was, formerly, another important financial source during the Byzantium era. During this period, those fishes have been selected as the symbols of the city. Reliefs of bonito and bluefin tuna had been imprinted on Byzantium coins (Figure 1), emitted between the 1st and 3rd centuries A.D. Many ancient authors, such as HOMEROS (8th century B.C.), PLINIUS (1st century A.D.) and ATHENAIOS (2nd - 3rd centuries A.D.), wrote about bonito and bluefin tuna captured both in the Dardanelles and Istanbul Straits (TEKIN, 2000). According to DEVEDJIAN (1926), SARA (1964) and CUVIER (1969) those fishes were once very abundant in the waters of Byzantium, especially in the "Golden Horn".

Figure 1. Bronze coins, minted in Byzantium (TEKIN,2000).

Despite of its commercial importance, very few studies are available about the bluefin tuna in Turkey. DEVEDJIAN (1926), SLASTENENKO (1955-1956) and AKŞIRAY (1987) recorded some information about the systematics and distribution of this species. Information about the bluefin tuna fishery in Turkish seas were given by İYIGÜNGÖR (1957), ORAY and KARAKULAK (1997), ORAY *et al.* (2000) and

KARAKULAK (2002). Data on the length-weight relationship of the bluefin tuna captured in Turkish waters were reported by AKYÜZ and ARTÜZ (1957), and KARAKULAK (1994). The only information about the age determination of bluefin tuna from Turkish seas have been given in KARAKULAK and ORAY (2001).

REPRODUCTION AND MIGRATION ROUTES

DEVEDJIAN (1926), AKYÜZ (1956), and SARA (1964) reported the migration routes of the bluefin tuna in Turkish seas (Figure 2). This migration starts in April, peaks in July and terminates in late August, and covers an area from the Aegean Sea to the Black Sea. The reverse migration starts in October and lasts until December. AKYÜZ (1956) reported that, depending on the environmental conditions, the bluefin tuna may stay in the Sea of Marmara between February and March to feed on pelagic teleosteans, such as bonito, mackerel and horse mackerel.

According to SLASTENENKO (1955-1956), and AKYÜZ and ARTÜZ (1957), bluefin tuna spawns in the Black Sea between July and August. The occurrence of the eggs and larvae in the Black Sea was reported for the first time by VODYANITSKY (1936). However, no eggs or larvae of the bluefin tuna has been sampled in the most recent research carried out in the Black and Marmara Sea, in 1993 (PICCINETTI-MANFRIN *et al.*, 1995).

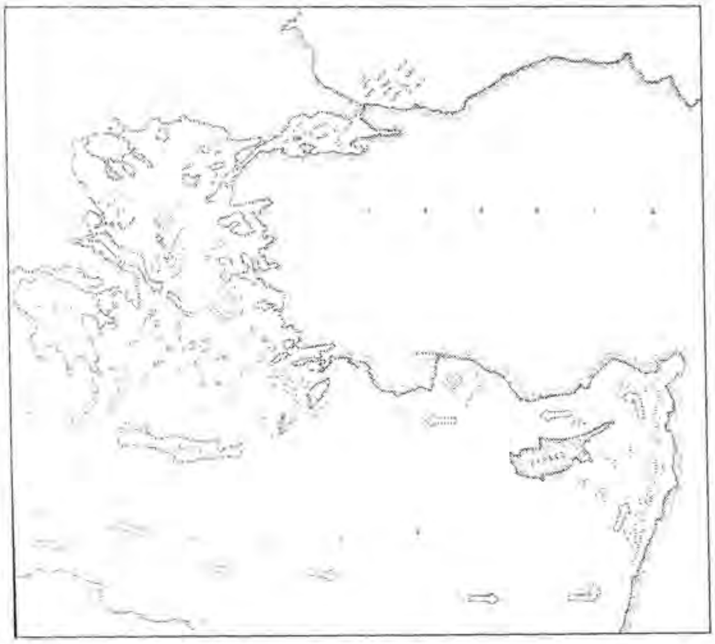

Figure 2. The migration routes of the bluefin tuna in Turkish seas (SARA, 1964).

FISHING TECHNIQUES

Techniques of the bluefin tuna fishery, fishing zones and seasons in Turkey are as follows:

A- Fish trap (dalian): The history of the bluefin tuna fishery with fish traps dates back to centuries ago. Fish traps used to be set in the Sea of Marmara, Istanbul Strait, and in the Black Sea from April or May to late August (Figure 3). Formerly, Filburnu, Çankaya, Beykoz, Bülbülsokak, Anaşya, Küçükçekmece, Salistra and Karamanoğlu fish traps were the most important ones (DEVEDJIAN, 1926; SARIKAYA, 1980).

Bluefin tuna traps may have been bigger and deeper than other dalians. The bluefin tuna dalians are traditionally called *Şıra* and *Kurtağzı* dalians (Figure 4) (DEVEDJIAN, 1926; SARIKAYA, 1980).

Dimensions of some of these fish traps are as follows: Salistra fish trap; length: 113 fathoms; width: 33 fathoms; and depth: 9 fathoms; Kartal fish trap: length: 112 fathoms; width: 33 fathoms; and depth: 22 fathoms. Twenty to 25 crew were employed in each of the fish traps. The number of the bluefin tunas captured by a single fish trap in one fishing season varied between 100 to 150 each weighted 100 to 450 kg (IYIGÜNGÖR, 1957).

With the increase of the marine transportation, urbanization, marine pollution, as well as the decrease of fish stocks, fish traps lost their importance in the bluefin tuna fishery. Recent studies suggest that the bluefin tuna has not been migrating to the Black Sea, at least since 1986, and the fish traps have, probably, lost their effectiveness in the bluefin tuna fishery due to this reason. Today, the former bluefin tuna traps, like Filburnu, Beykoz and Anaşya, are utilized to capture small pelagic fishes, such as horse mackerel and silversides (KARAKULAK, 2000).

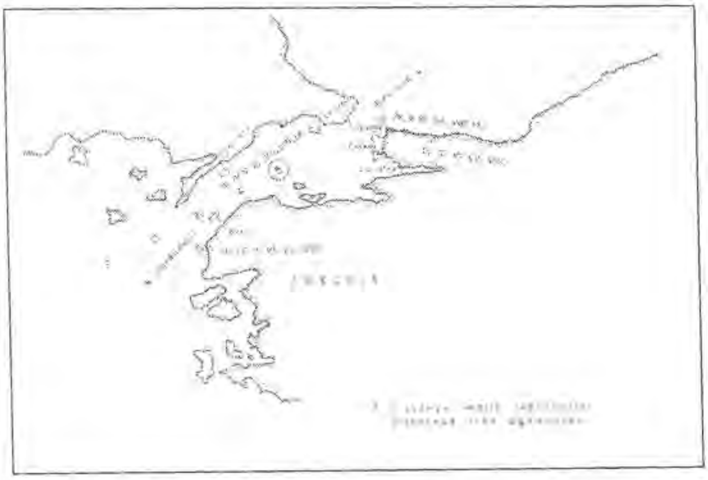

Figure 3. Locations of the fish traps in the the Sea of Marmara, Bosphorus Strait and Çanakkale Strait (SARA, 1964).

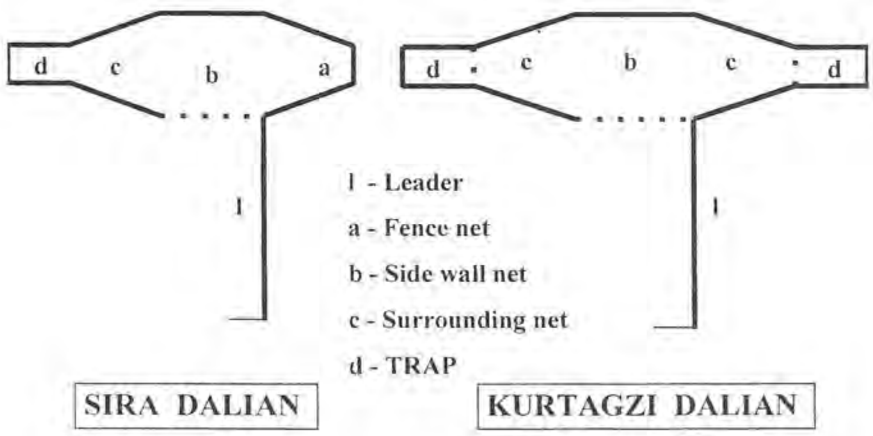

Figure 4. Kinds of Dalians.

B- Hand-lining: According to IYIGÜNGÖR (1957), the bluefin tuna has been captured by hand-lines, baited with bonito, mackerel or other teleosteans, in the Sea of Marmara and in the Istanbul Strait between November and April. This type of fishery has been carried out by small boats of 4 to 4.5 m long, by two fishermen. The author stated that the best time of hand-lining was 09:00 to 10:00 am. Weight of the captured fish varied between 100 and 450 kg.

Hand-lining of the bluefin tuna in the Sea of Marmara and in the Istanbul Strait lasted to the 1980's (KARAKULAK, unpublished data,1992). Today, hand-lining is performed only in the northern Aegean Sea between September and October, and April and May. The weight of the captured fish varies between 20 to 70 kg.

C- Purse-seining: Purse-seining of the bluefin tuna began in the 1950's, primarily in the Sea of Marmara. The fishing season is from November to February (IYIGÜNGÖR, 1957).

Application of new regulations for the development of fishery resulted in rapid increase in the number of purse-seining boats and improvement in their fishing gears. Due to the drastic decrease in the stocks of the anchovy, a commercially important species for Turkish marine fishery, between the years of 1988 and 1990, purse-seining boats have started to put most of their effort to catch bluefin tuna and other scombrids in the Aegean and the Mediterranean Seas. Although the anchovy stocks have overed within the following years, the purse-seiners continue catching bluefin tuna.

Today, the bluefin tuna fishery is concentrated in the Aegean and the Mediterranean Seas (Figures 5 and 6). Despite the annual fluctuations, the bluefin tuna fishery continued also in the Sea of Marmara, while it seems to have completely collapsed in the Black Sea since 1986 (KARAKULAK, unpublished data ,1992).

Formerly, the fishing season of the bluefin tuna was in winter. Today however the majority of the capture is concentrated in spring and summer. The reason of this shift is the declining of the bluefin tuna stocks in the Marmara and Black Seas, and the recruitment of the anchovy stocks in the Black Sea. Furthermore, the fishermen have a preference to catch small pelagic fishes, such as anchovy, horse mackerel, bonito and bluefish in the above seas, and thereafter they head towards the Aegean Sea to catch the bluefin tuna and other scombrids.

According to KARAKULAK (2002), the number of the purse-seining boats operating for the bluefin tuna fishery between the years of 1994 and 2000 varied between 22 and 62. Their engines were 300 to 2610 HP and their length varied between 22 and 62 m, with a gross tonnage of 24 to 694 tons. Depending on the size of the boat, length of the nets varied between 756 and 1980 m, and the crew between 12 and 35 persons.

In comparison with other teleostean species, the bluefin tuna fishery is a difficult fishing activity. Behaviour of the fish, and the environmental conditions cause such difficulties, as well as hazards in the fishing operations. It might be necessary to chase fish for many days. In most cases, bluefin tunas can escape from an unclosed purse-seine easily. This and other difficulties present in the bluefin tuna fishery force the fishermen to work in a coorporated manner.

Turkish fishermen carry out the bluefin tuna fishery generally in the coastal waters and 15 to 20 miles off shore. However, the fishermen began to capture bluefin tuna in the open sea areas of the eastern Mediterranean in 2001 and 2002 (Figure 6).

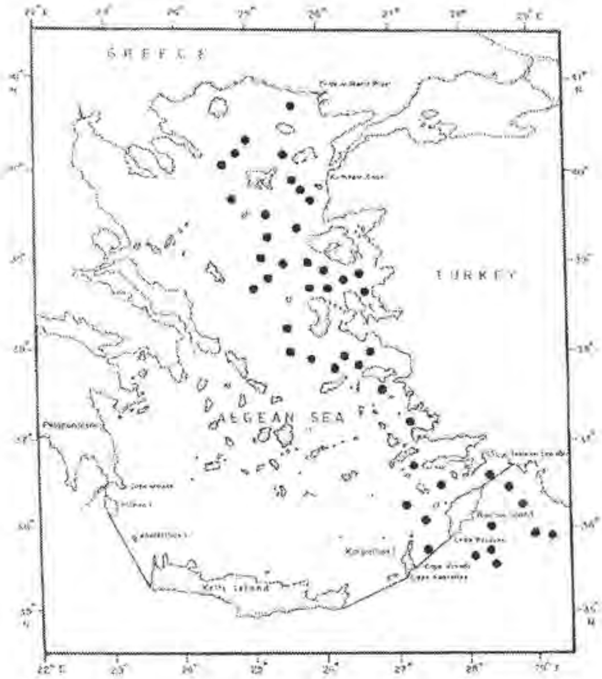

Figure 5. Fishing grounds of the Turkish fishing fleet in the international waters of the Aegean Sea (ÖZTÜRK *et al*., 2002).

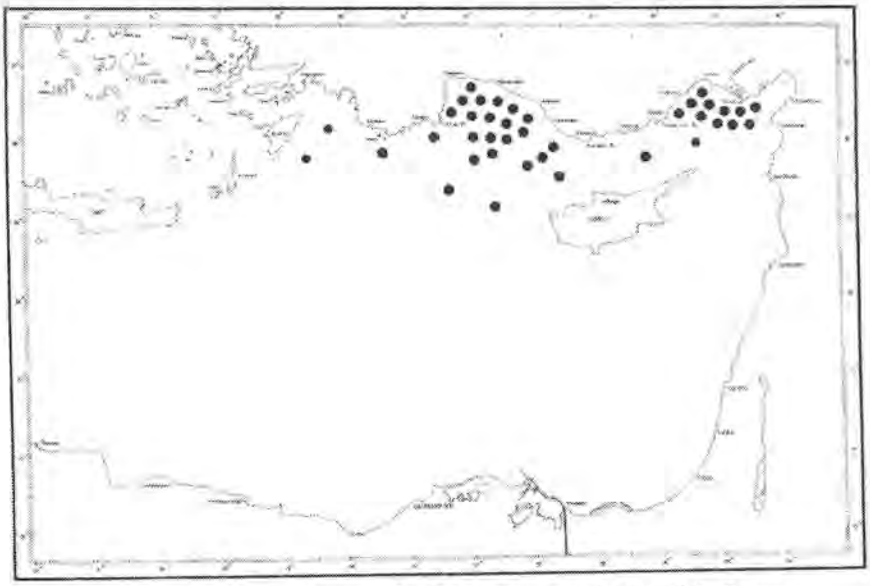

Figure 6. The catch grounds of bluefin tuna by Turkish fleets in the eastern Mediterranean.

D- Harpooning: Harpooning is the most popular way to capture the swordfish in the northern Aegean Sea, and during this fishery bluefin tunas are also captured between March and June.

E- Trials with Japanese long-line: The first trials of the Japanese tuna long-line were made in 1962 (CANYIGIT, 1962). Unfortunately, due to the bad fishing conditions occurred in the mentioned year, those trials were not successful. Furthermore, the fishermen did not accept to use this fishing gear because of its high cost. Thus, long-lining is not a popular technique in the Turkish bluefin tuna fishery.

AMOUNT OF CATCH

In 1970, 138 MT of bluefin tunas were captured in Turkish waters, however, this amount increased to 2230 MT in 1985 and 5093 MT in 1997 (DIE, 1970-2000). The increase in the amount of catch has been, probably, due to the rapid development of the fishing gears in the 1980's, as well as the increasing demand of the bluefin tuna for exporting purposes.

In order to prevent the over fishing of bluefin tunas, International Commission for the Conservation of Atlantic Tunas (ICCAT) began to set quotas to the bluefin tuna fishery. The amount of the bluefin tunas captured by Turkish fishing fleet was considered quite high by ICCAT. Following the regulations of the Ministry of Agriculture and Rural Affairs, the amount of the bluefin tunas captured in 1999 decreased to 1407 MT and 1070 MT in 2000 (Figure 7).

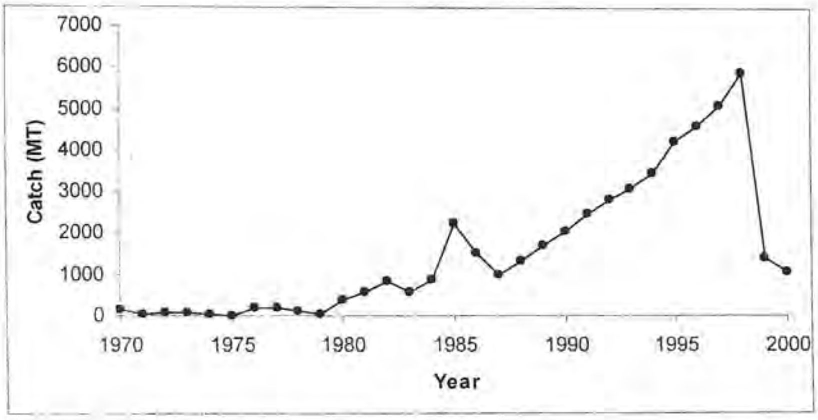

Figure 7. Amount (MT) of the bluefin tunas captured in Turkish seas (DIE, 1970 – 2000).

LENGTH DISTRIBUTION OF THE CAPTURED BLUEFIN TUNAS

According to AKYÜZ and ARTÜZ (1957), lengths of the bluefin tunas captured in the Sea of Marmara and in the Bosphorus Strait between the years of 1955 and 1956 ranged from 120 to 330 cm, with an average of 228.9 ± 2.8 cm (Figure 8).

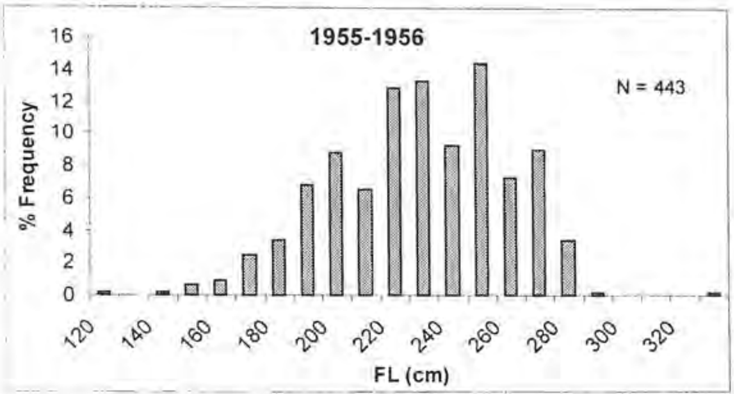

Figure 8. Length distribution of the bluefin tunas captured between the years of 1955 and 1956 (AKYÜZ and ARTÜZ, 1957).

Length and weight data of the bluefin tunas captured in the Aegean and the eastern Mediterranean Seas between the years of 1992 and 2001 are given in Table 1 and Figure 9 (KARAKULAK, 1994; KARAKULAK, 1999; KARAKULAK, 2002).

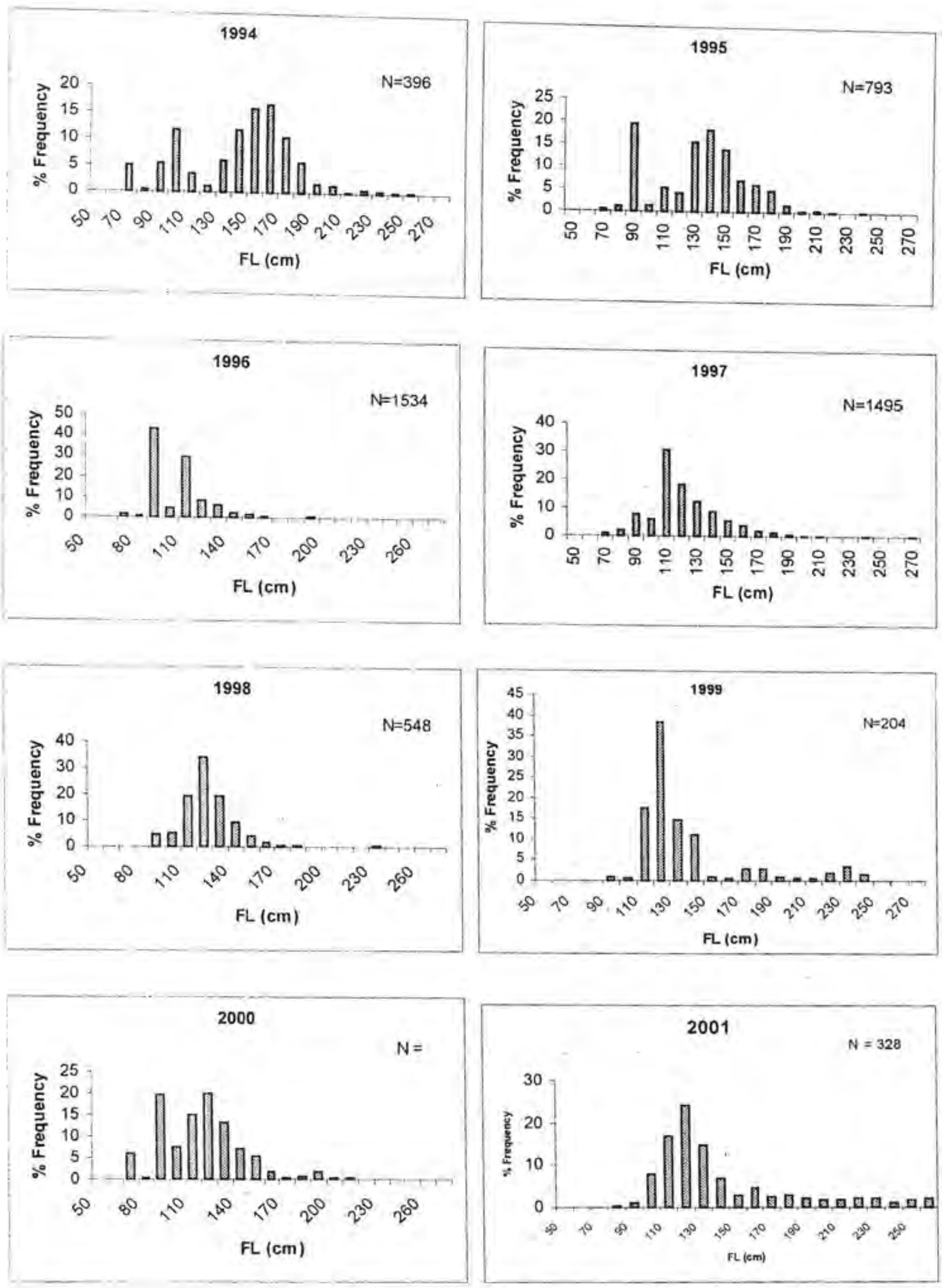

Figure 9. Length frequency distribution of bluefin tuna caught by purse seine during the period 1994-2000 in Turkish waters (KARAKULAK, 2002).

Table 1. Length and weight data of the bluefin tunas captured between the years of 1992-2001.

Years	Sample	Length (cm)			Weight (kg)		
	N	Min.	Max	Average±S.D.	Min.	Max.	Average±S.D.
1992	359	119	24	168.40 ± 1.33	18	279	87.34 ± 1.93
1993	976	59	242	171.02 ± 0.92	4	280	96.58 ± 1.46
1994	396	71	255	145.42 ± 1.74	8,5	300	60.20 ± 2.06
1995	793	77	242	137.15 ± 1.04	8,5	232	48.31 ± 0.98
1996	1534	68	225	108.42 ± 0.49	5,5	150	23.77 ± 0.39
1997	1495	76	275	125.05 ± 0.57	7,5	265	36.44 ± 0.56
1998	548	94,5	235	127.53 ± 0.72	15	217	39.52 ± 0.76
1999	204	92	248	138.84 ± 2.23	12	344	57.81 ± 4.39
2000	1201	70	258	121.02 ± 0.76	8	368	35.00 ± 0.83
2001	328	81	269	144.99 ± 2.27	8	365	68.79 ± 4.39

Compared to the average length of the bluefin tunas captured in the 1950's was greater than 200 cm, a remarkable decrease was observed in the individuals captured in 1992-2001. Average length of the latter individuals was less than 150 cm.

FISHERY REGULATIONS REGARDING THE BLUEFIN TUNA FISHERY

Some regulations regarding the smallest length of the bluefin tuna permitted to capture and the fishing season are available in the fishery circular, issued by the Department of Conservation and Control, Ministry of Agriculture and Rural Affairs . Relevant regulations of the bluefin tuna fishery, which have been appeared in the fishery circular since 1987 are presented in Table 2.

Table 2. Relevant regulations of the bluefin tuna fishery in the fishery circular between 1985 and 2002 (MINISTRY OF AGRICULTURE AND RURAL AFFAIRS, 1985-2002).

Year	Min. Length (cm) Permitted	Limitation for Season
1987	40	-
1988	70	-
1989	90	-
1990	90	-
1991	90	-
1992	90	-
1993	90	15 May - 1 September
1994	90	1 May - 1 September
1995	90	15 May - 1 September
1996	90	1 June - 1 August
1997	90	1 June - 1 August
1998	90	1 August - 1 September
1999	90	1 June - 1 September
2000	90	1 June - 1 September
2001	90	16 July – 15 August
2002	90	16 July – 15 August

The aim of these regulations is to provide a better conservation of the bluefin tuna populations. Because of the breeding season of the bluefin tuna, its fishery is strictly prohibited throughout summer lasting 3 to 4 months. The smallest length of the bluefin tuna permitted to capture is 90 cm (nearly 15 kg). According to the recommendations of ICCAT (ICCAT, 2002) in 2001, the forbidden season of the bluefin tuna fishery was reduced to 1 month.

In Turkish seas, all industrial fishing activities are forbidden between May and September. However, fishing boats operating in the bluefin tuna fishery between May 1 and July 15 in off shore waters, should be able to acquire a permission from the Ministry of Agriculture and Rural Affairs. Fortunately, most of the fishermen comply with those conservative regulations.

CONCLUSIONS

In Turkish seas, bluefin tunas are captured mostly by means of purse-seining. Hand-lining and harpooning are also utilized to catch bluefin tunas to a lesser extent. However, long-lining is not a popular technique among the Turkish fishermen to catch bluefin tunas.

Although, it is possible to catch the bluefin tunas in all seasons in Turkish seas, purse-seiners prefer to start catching the bluefin tunas, following the termination of the fishing season of bonito, anchovy and bluefish. The bluefin tuna fishery generally lasts from February to July.

Purse-seining boats, operating in the bluefin tuna fishery, are well equipped vessels with high-tech navigation electronics, such as echosounder, sonar, current meter and bird radars. However, deep-freezing storage is not available on board of all vessels. Internal organs of the captured bluefin tunas should be immediately removed and the fish should be kept in cold. Deep-freezing storage is essential to preserve the quality of the bluefin tunas. Therefore, purse-seining boats, which are intended to operate in the bluefin tuna fishery, should be designed and equiped to meet these needs.

AKYÜZ and ARTÜZ (1957) reported the presence of 3 species of tunas, *Thunnus thynnus*, *Thunnus allalunga* and *Euthynnus alletteratus*, in the Sea of Marmara, Istanbul Strait and the Black Sea. Due to marine pollution, overfishing, and decrease in the stocks of small pelagic fishes, such as mackerel, of which the tunas prey upon, today none of the above three species are captured in the Black Sea. Although the presence of the spawning areas of the bluefin tuna in the Black Sea has been previously reported by Russian researchers (VODYANITSKY, 1936), neither eggs nor larvae of this species were sampled during the recent researches in this sea (PICCINETTI-MANFRIN *et al.*, 1995).

Drastic reduction in the stocks of the bluefin tuna, in the late 1980's, was reported by ZAITSEV and MAMAEV (1997). The bluefin tuna disappeared from the Romanian waters since 1960's (DUMONT *et al.*, 1999). Furthermore, no individual of this species was captured or even sighted in the Turkish Black Sea since 1986. Unfortunately, the reduction in the Black Sea population of the bluefin tuna is, probably, reached the level of extinction. The reduction of bluefin tuna in the Black Sea belongs to marine pollution (DUMONT *et al.*, 1999).

Overfishing pressure on the Mediterranean populations of the bluefin tuna is obvious (ICCAT, 1999). Especially, the capture of the individuals under 3rd years old has a clearly negative effect on the stocks of this species. The rarity of the individuals greater than 200 cm in the overall catches from Turkish waters and the other parts of the Mediterranean Sea is an important indicator of this situation.

In the Mediterranean Sea, ICCAT recommended to prevent the capture of the bluefin tunas smaller than 6.4 kg (ICCAT, 2002). However, the capture of the bluefin tunas smaller than 90 cm (15 kg and 3years old of age) is strictly forbidden in Turkey. It is obvious that the fishery regulations regarding the bluefin tuna fishery in Turkish seas are more advantageous than the ICCAT's recommendation, for the conservation of the species. Cooperation of the countries along the Mediterranean coasts is necessary to provide a sustainable bluefin tuna fishery.

The first bluefin tuna farms in Turkey were established in 2002. Today, a total of 5 bluefin tuna farms are present. Two of them are located in the Mediterranean Sea (near Antalya), and the remainig three farms are in the Aegean Sea (two of them near Çanakkale and one near İzmir) (ORAY and KARAKULAK, 2003). The bluefin tunas, captured by purse-seiners in summer months, when the price of the fish is quite low, are fed for 3 to 6 months and then sold, when the market conditions are suitable to provide significant profit.

Due to the competition between the countries, the importance of the bluefin tuna farms is increasing day by day. The increasing number of these farms may have negative effects on the natural populations of the bluefin tuna. Capture of the young individuals in summer months may result in a significant decrease in the recruitment of the natural stocks. On the other hand, possible environmental impacts of these farms are still unknown. A bluefin tuna farm, established near Sivrice, an important touristic place in Çanakkale (Northern Aegean Sea), has been rejected by the local people and the fishermen. The number of farms should be restricted with respect to the quotas set in the bluefin tuna fishery. At the same time such these farms should be located in suitable places and their environmental impacts should be monitored.

In 1999, ICCAT set quotas on the bluefin tuna fishery in the Mediterranean Sea. Those quotas have been determined based on the capture amounts of the countries between 1994 and 1995. Quotas of the countries for 2002 are shown in Table 3.

Table 3. Quotas determined by ICCAT for the Mediterranean in 2002 (ICCAT, 2002).

	Quota (MT)
European Community	19,615
Algeria	1,700
China (People's Republic)	76
Croatia	971
Japan	2,911
Korea	49
Tunisia	2,087
Libya	1,330
Morocco	3,030
Others	1184

Turkey is not a member of ICCAT, therefore, it is placed, together with other six non member Mediterranean countries. As seen from the table, the fishery quota of these seven non member countries is 1,184 tons. In order to have more reasonable quota, first of all, Turkey should be a member of this organization. Turkey is a peninsular country surrounded by three seas, total length of its coastal line is 8333 km. Its fishing fleets are well-developed and the history of the bluefin tuna fishery in Turkey dates back to ancient ages. Considering its fishing potential, historical background and the recently established bluefin tuna farms, ICCAT should determine a reasonable quota for the Turkish bluefin tuna fishery.

Breeding grounds, spawning seasons, migration routes, development eggs and larvae, and the genetics of the bluefin tuna in the Mediterranean Sea, as well as the environmental impacts of bluefin tuna farms on ecosystem, and social and economical aspects of the mentioned sea farms have been investigated by ICCAT and COPOMED. However, most of these researches, in spite of providing valuable data on the above subjects, have been carried out in the western and central parts of the Mediterranean Sea. On the other hand, researches on the bluefin tuna populations in the eastern Mediterranean, Aegean and Marmara Seas are very limited. Therefore, more extensive investigations are necessary in order to provide contemporary data on the status of the bluefin tunas living in the latter seas, and the cooperation among the Mediterranean countries, based on joint projects, shall provide better information strategies for the conservation of this species.

REFERENCES

AKŞIRAY, F. 1987: Fishes of the Turkish Seas, with identification key of the species. Publications of the Istanbul University, No: 3490, pp. 471-477. (In Turkish)

AKYÜZ, E. F. 1956. The bluefin tuna fishery in Turkey. Balık ve Balıkçılık, pp. 12-16, Istanbul. (In Turkish)

AKYÜZ, E. F., ARTÜZ, İ. 1957. Some Observations on the Biology of Tuna (*Thunnus thynnus*) Caught in Turkish Waters. Conseil général des pêches pour la Méditerranée, Document Techniques, No. 14, pp. 93-99, Rome.

CANYİĞİT. A. 1962. Japanese style bluefin tuna fishery and preparation of the fishing outfit. Balık ve Balıkçılık, Vol. X, No 5-6, pp. 9-12, Istanbul. (In Turkish)

CUVIER M. B., VALENCIENNES, M., 1969: Histoire Naturelle des Poissons. p. 57-113, Amsterdam.

DIE, 1970-2000. Fishery Statistics. State Institution of the Statistics Prime Ministry Republic of Turkey, p.30, Ankara. (In Turkish)

DEVEDJIAN, K., 1926. Pêche et Pêcheries en Turquie. Imprimerie de l'Administration de la Dette Publique Ottomane, İstanbul , 480 pp.

DUMONT. H., MAMAEV, V.O., ZAITSEV, Y.P. 1999. Black Sea Red Data Book. P. 413, United Nations Office for Project Services.

ICCAT. 1999. Collective volume of scientific papers. Vol. XLIX (2), p.151, Madrid.

ICCAT. 2002. Resolutionsand and Recommendations. http:/www.iccat.es/Documents /Recs. October 2002, Madrid.

IYIGÜNGÖR, D. 1957. Méthods et Moyens de Pêche au Thon Actuellement en Usage en Turquie. Gen. Fish. Coun. Medit., No. 33, pp. 251-255.

KARAKULAK, F.S. 1992. Personnal communication with fishermen.

KARAKULAK. F.S. 1994. Length-weight relationship of bluefin tuna (*Thunnus thynnus* L. 1758) caught in Turkey (Master thesis). 46 pp. İstanbul University, İstanbul. (In Turkish)

KARAKULAK, F.S. 1999. The Fishing Technology and the Biology of the Bluefin Tunas (*Thunnus thynnus* L. 1758) in Turkish Waters. (Doctoral thesis). pp.169, İstanbul University. İstanbul. (In Turkish)

KARAKULAK, F. S. 2000. The trap nets in and around the Strait of İstanbul. In: ÖZTÜRK,B., KADIOĞLU,M., ÖZTÜRK,H. (eds). "Marmara Sea 2000" Symposium. 11-12 November 2000, İstanbul Turkish Marine Research Foundation (TUDAV), Publication Number No: 5, İstanbul, p. 426-435. (In Turkish)

KARAKULAK, F. S., ORAY, I.K. 2001. Age et croissance du thon rouge (*Thunnus thynnus* L.1758) pêche de la mer Egée et de la mer Méditerranée en Turquie. Rapp. Comm. Int. Mer Médit., 36, p.284, Monaco.

KARAKULAK, F. S. 2002. Catch and effort of the bluefin tuna purse seine fishing in Turkish waters. I. International Symposium on Domestication of bluefin tuna *Thunnus thynnus thynnus* (DOTT), 3-8 February 2002, Cartagena, Spain.

MINISTRY OF AGRICULTURE AND RURAL AFFAIRS, Turkey. 1985-2002. Instructions for the regulation of commercial marine and inland fishery in 1985-2002 period. Ankara, 84 pp. (In Turkish).

ORAY, I.K., KARAKULAK, F.S. 1997. Some remarks on the bluefin tuna (*Thunnus thynnus* L.1758) fishery in Turkish waters in 1993, 1994, 1995. ICCAT, Coll. Vol. Sci. Pap., Vol. XLVI (2): pp. 357-362, Madrid.

ORAY, I.K., KARAKULAK, F.S., GÖNÜL, M. 2000. Some remarks on the bluefin tuna fishery in turkey. Il Mondo delle Tonnare Tratradizione Eproduzione, 15-16 May 1999, I.CI.MAR Istituto delle civiltà del mare, Periodico di studi, ricerca e informazione, pp. 11-13, Sardegna.

ORAY, I.K., KARAKULAK, F.S. 2003. General review of bluefin tuna farming in Turkey. ORAY, I.K. and KARAKULAK,F.S. (eds). "Workshop on Farming, Management and Conservation of Bluefin Tuna", 5-7 April 2003, Istanbul. Turkish Marine Research Foundation (TUDAV) Publication Number No: 12 (in this volume).

ÖZTÜRK, B., KARAKULAK, F.S., ÇIRA, E. 2002. The place of the living resources in the Aegean Sea conflict In: GÜNDÜZ, A. and ÖZTÜRK, H. (eds)."Ege Kıta Sahanlığı ve İlişkili Sorunlar" Sempozyumu, 14-15 December 2002, İstanbul. Turkish Marine Research Foundation (TUDAV), Publication Number No: 12, İstanbul, p. 118-138. (In Turkish)

PICCINETTI-MANFRIN, G., MARANO, G., De METRIO, G., PICCINETTI, C. 1995. An attempt to find eggs and larvae of bluefin tuna (*Thunnus thynnus*) in the Black Sea. ICCAT Report 1994, SCRS/94/96, pp. 316-317, Madrid.

SARA, R. 1964. Données, Observations et Commentaires sur La Présence, Le Comportement, Les Caractéristiques et Les Migrations des Thons en Méditerranée. Proc. Gen Fish. Coun. Medit., 7: pp.371-388.

SARIKAYA, S. 1980. Fishery and the fishing technology. Publications of the Departmant of Fisheries, Ministry of Agriculture, pp. 65-103, Ankara. (In Turkish)

SLASTENENKO, E. 1955-1956. The fishes of the Black Sea basin. Publications of the Meat and Fish Department of State, pp. 518-521, Istanbul. (In Turkish)

TEKİN, O. 2000. Golden Horn and the Tunas of Istanbul. İstanbul Dergisi, Sayı 32, p. 92-94, Golden Horn Istanbul. (In Turkish)

VODYANITSKY, V. A. 1936. Observations on pelagic eggs of epy Black Sea fishes. Travaux de la Station Biologique de Sebastopol, Tome V, p. 3-40 (in Russian).

ZAITSEV, Yu. P., MAMAEV, V. 1997. Marine Biological Diversity in the Black Sea. A Study of Change and Decline. GEF Black Sea Environmental Programme, 208 p., United Nations Publications, New York.

A BRIEF HISTORY OF TURKISH TUNA EXPORT

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The history of bluefin tuna exports from Turkey started in the early 1980's. Fish caught by simple equipments as hooks or single fish captured by the purse-seiner vessels while catching other pelagic fish during the winter season in the Marmara Sea were exported to Europe and Japan by air.

The main problem in those days was handling the fish in top quality to the consuming markets. The infrastructure of fishing and transportation was not so good to ship a big and perishable cargo like the bluefin tuna. Unexpected changes in the conditions during the shipment were directly affecting the meat quality and value of the fish. All these difficulties forced the exporting companies to be well organised and to control the possible variables during the shipping process. Due to high quality control on the product, they created a better image in the Japanese market for Turkish bluefin tuna, thus the market price increased.

In the middle 1980's Japanese processing vessels were coming and buying the bluefin tunas directly from the Turkish fishermen at the Marmara ports and freezing on board.

Also, in those days, especially big fish were shipped to Japan in season by cargo planes in substantial quantities. As the meat quality was highly appreciated in the Japanese market, the prices were raised to very high level.

Application of the new technologies and development on fishing equipments increased the catch of bluefin tuna. This consequence and growing profit of the independent groups were the first evidences of the tuna business considered as a special sector.

The supply of small fish of bluefin tuna and other species "albacore, striped tuna, bullet tuna" to the European markets on a more commercial base started during this period.

Well-organised handling and marketing of these fishes in big quantities to the consuming markets in Europe broke down the power of many traditional Mediterranean tuna producing countries.

In the 1990's, the phenomenon most disturbing was the booming of the catch in the whole Mediterranean, which led to the decline of the price.

Furthermore, increasing fuel prices, other costs and civil wars in the middle of Europe restricted the transportation and increased the levels of general costs. These conditions reflected negatively on the Turkish tuna fish exports. Turkish exporters tried to overcome these handicaps by concentrating their effort to raise the quality.

The adaptation period of the changes to the EU regulations during the same period was also a difficult round for the unprotected Turkish fishing sector. In those days, the EU authorities unfortunately did not pay necessary attention and interest to the civil groups representing the fishing sector in Turkey, but continued their negotiations only with the government organisations. Consequently, the attitudes of EU and Turkish officials to the sector were not in a guiding manner but in a commanding style. Application of the new regulations in the fishing sector is mainly succeeded with the strong support and positive and dynamic approaches of the sector members.

Recently, major fishing and exporting companies concentrate on bluefin tuna farming. Fish caught in the summer periods are farmed and prepared for the high market demand period. As the meat quality, and consequently the market value, is increasing, this activity is carried out by the whole sector. Obviously these developments are through a horizon restricting the over catching of tuna fish. Fishermen are going to make more profit by catching less fish.

Because of the natural and strategical marine geography, it is clear that Turkey is going to have an increasing importance on bluefin tuna fishing and marketing. We hope that official authorities and foreign civil organisations, who did not give necessary care to the Turkish fishing sector, civil organisations and research institutions up to now, would notice this dynamism and share our vision on the re-planning the future of Mediterranean bluefin tuna sources and their common uses.

EVALUATION OF THE MONTHLY MEAN VALUES OF THE METEOROLOGICAL STATIONS ON THE MEDITERRANEAN COASTS OF TURKEY IN 1980 - 2000

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ABSTRACT

In this study, the monthly means of the climatic parameters of the meteorological stations, Antalya ($36^0 53'$N–$30^0 42'$E), Anamur (36^0 $06'$N–32^0 $50'$E), Alanya ($36^0 33'$N–$32^0 01'$E), İskenderun ($36^0 37'$N–$36^0 07'$E), Mersin ($39^0 48'$N–$30^0 09'$E), Finike ($36^0 18'$N–30^0 $09'$E), and the maximum values of water temperature, air temperature, cloudiness, mean rainfall air pressure, wind direction and speed of wind were evaluated. Herewith it was intended to help to work out programs for fishing biology, fish catching technology, aquaculture, feeding of the fish, choosing the sites for aquaculture, adaptation, growth performance, for monitoring diseases, time of catch and catch period.

By means of this study; the differences and similarities of the climatic parameters on the Mediterranean coasts of Turkey were put forth for consideration.

INTRODUCTION

In this study, the meteorological parameters in Finike, Antalya, Alanya, Anamur, Mersin and İskenderun on the Mediterranean coast of Turkey and of the surrounding regions; the monthly averages of the mean and extreme values of air temperature, sea water, temperature, cloudiness, rainfall, air pressure reduced to sea level, wind direction and speed of wind in years between 1980 and 2000 were evaluated.

All data were studied objectively. By using graphs; similarities, distinctions and continuities were determined. The aim of this study is to give guideline for air and sea transport, for the development of tourism and especially for the regional fisheries, for fishing, determining the periods of fishing and selecting suitable sites for aquaculture considering the effects of the regional winds (Figure 1).

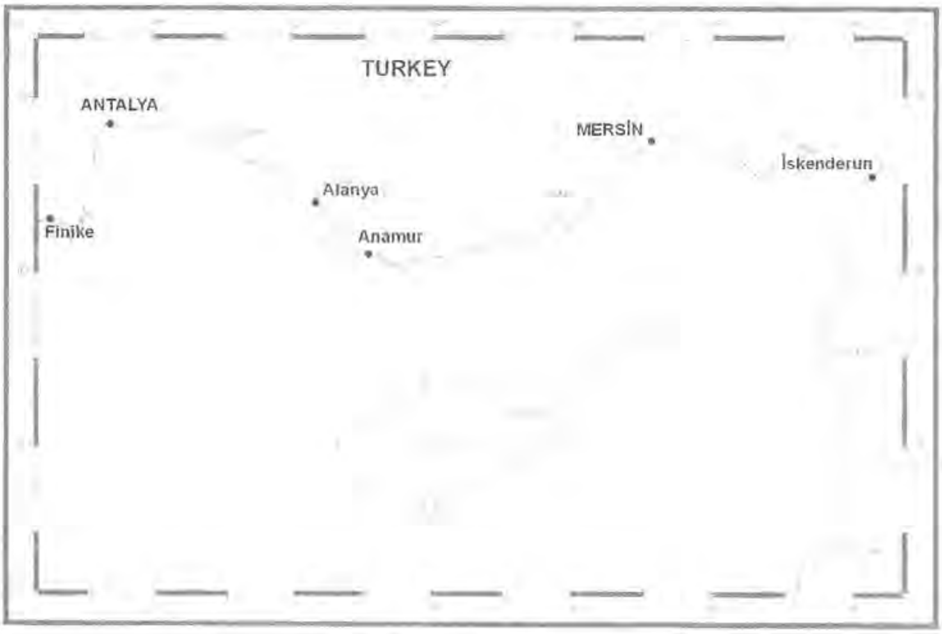


Figure 1. Stations in the Mediterranean.

MATERIALS AND METHODS

In this research, the monthly averages of time limited numeric values and extreme values of meteorogical parameters (1980 - 2000) in Finike, Antalya, Alanya, Anamur and Mersin stations of Turkish State Meteorological Service were used.

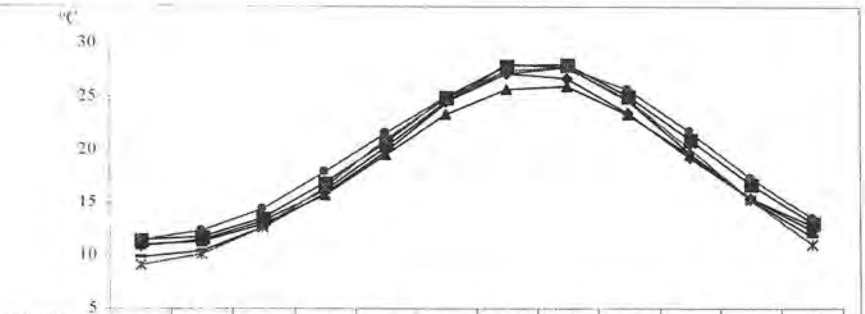
Graphs were drawn. Distinctions, similarities and continuities were determined.

RESULTS

In this study, the evaluations about the meteorological parameters were investigated an hand of the monthly averages and the extreme values of the data of the last 20 years.

1. Air Temperature

The mean values of the whole region in winter are minimum. In Finike 10,9 °C, Antalya 9,8 °C, Alanya 11,0 °C, Anamur 11,5 °C, Mersin 9,1 °C, İskenderun 11,4 °C in January. After January these values linearly incerase to their maximum values till July. In Finike 27,2 °C, Antalya 28,1 °C, Alanya 25,8 °C, Anamur 28,0 °C, Mersin 27,5 °C, İskenderun 27 °C (Figure 2).

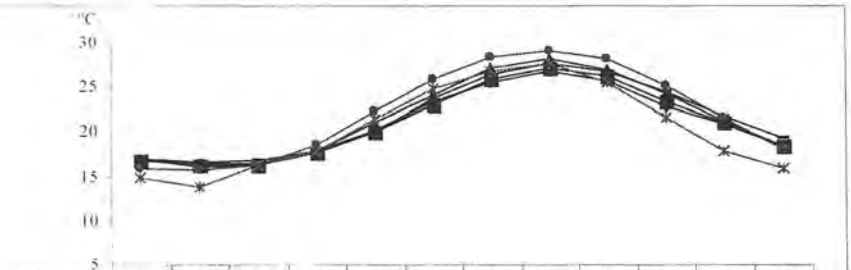


Months	1	2	3	4	5	6	7	8	9	10	11	12
Finike	10,9	11,4	13,2	16,2	20,3	24,6	27,2	26,8	23,5	19,3	15,4	12,3
Antalya	9,8	10,5	12,7	15,9	19,8	24,4	28,1	27,8	24,7	19,7	15,3	11,7
Alanya	11,0	11,3	12,9	15,8	19,5	23,4	25,8	26,0	23,4	19,5	15,4	12,8
Anamur	11,5	11,7	13,6	16,9	20,8	25,0	28,0	28,1	25,1	21,1	16,7	13,1
Mersin	9,1	10,1	12,6	16,5	21,0	24,8	27,5	27,8	24,8	20,1	15,3	11,1
İskenderun	11,4	12,3	14,4	17,9	21,6	25,0	27,2	27,8	25,8	21,8	17,3	13,5

Figure 2. The mean air temperature values for all stations.

2. Sea Water Temperature

In winter the mean minimum sea water temperatures are in Finike 16,6 °C, Antalya 16,8 °C, Alanya 16,1 °C, Anamur 16,4 °C, Mersin 13,9 °C, İskenderun 15,8 °C in February. After February these values linearly incerase to their maximum values till August as in; Finike 26,8 °C, Antalya 27,7 °C, Alanya 28,2 °C, Anamur 27,1 °C, Mersin 27,7 °C, İskenderun 29,2 °C (Figure 3).

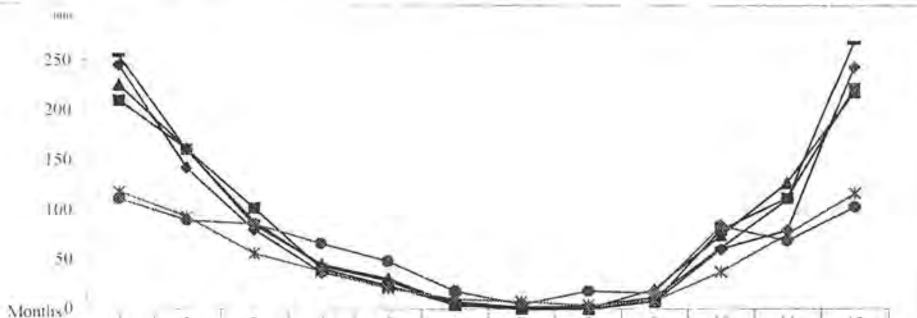


Months	1	2	3	4	5	6	7	8	9	10	11	12
Finike	17,1	16,6	16,6	17,9	20,3	23,4	25,6	26,8	25,8	22,9	21,0	18,4
Antalya	17,0	16,7	16,8	18,0	20,0	23,8	26,4	27,7	26,8	24,5	21,8	19,4
Alanya	17,0	16,1	16,3	17,9	21,1	24,2	27,1	28,2	26,9	24,4	21,3	18,4
Anamur	16,8	16,4	16,4	17,8	20,0	23,1	25,9	27,1	26,2	23,5	21,2	18,4
Mersin	14,9	13,9	16,3	18,0	21,5	24,9	26,8	27,7	25,6	21,7	17,9	16,0
İskenderum	16,0	15,8	16,4	18,7	22,4	26,0	28,4	29,2	28,3	25,2	21,7	18,2

Figure 3. The mean sea water temperature values for all stations.

3. Rainfall

Mean values of rainfall in winter season reach their highest values in January as follows; 246.1 mm for Finike, 255,8 mm for Antalya, 226,0 mm for Alanya, 210,5 mm for Anamur, 118.8 mm for Mersin, 111,8 mm for Iskenderun. Rainfall amount rapidly decreases after January. In summer mean rainfall values are as follows; 4,8 mm for Iskenderun in july, 0,5 mm for Finike, 2,4 mm for Antalya, 0,6 mm for Alanya, 0,1 mm for Anamur and 4,0 mm for Mersin in August (Figure 4).

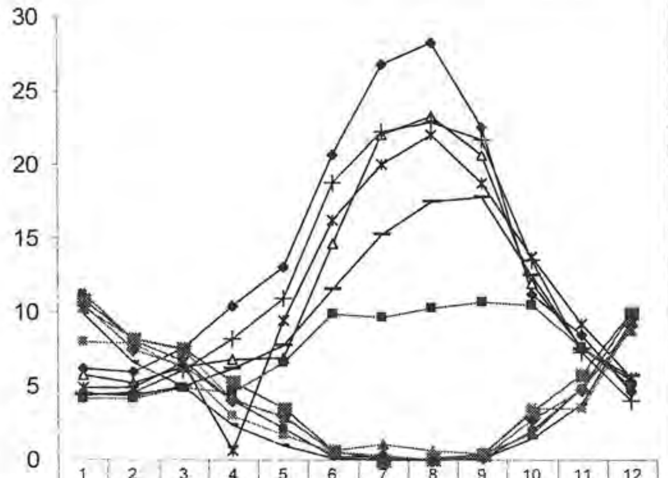


	1	2	3	4	5	6	7	8	9	10	11	12
Finike	246,1	143,4	80,7	37,3	22,7	7,3	1,9	0,5	7,8	60,7	80,3	244,7
Antalya	255,8	161,3	89,4	43,7	29,2	3,2	2,5	2,4	12,1	62,2	111,5	269,8
Alanya	226,0	161,9	85,8	45,4	31,0	5,3	1,5	0,6	20,3	75,0	128,2	219,4
Anamur	210,5	162,0	102,9	41,2	24,0	4,6	0,1	0,1	7,8	80,5	113,0	223,3
Mersin	118,8	94,2	56,5	38,5	21,2	10,0	7,8	4,0	8,7	38,1	76,2	117,9
Iskenderum	111,8	90,3	86,7	66,5	48,6	18,4	4,8	18,5	16,7	85,1	69,4	103,9

Figure 4. The mean rainfall for all stations.

4. Cloudiness

The minimum number of clear days in winter are in Anamur 4 days, Finike 4,7 days in December. Alanya 4,9 days, İskenderun 4,2 days in January, Antalya 5,2 days, Mersin 4,4 days in February. Starting from March, the numbers of clear days rapidly increase. The maximum number of clear days in the summer are in Finike 28,4 days, Antalya 23,4 days, Alanya 22,1 days, Anamur 23,0 days in August, Mersin 17.9 days, Iskenderun 10,7 days in September (Figure 5).



	1	2	3	4	5	6	7	8	9	10	11	12
Finike Clear	6,2	6,0	7,6	10,4	13,1	20,7	26,9	28,4	22,7	11,3	8,5	4,7
Finike Cloudly	8,0	7,9	6,2	3,0	1,7	0,5	0,1	0,0	0,3	3,5	3,5	9,2
Antalya Clear	5,7	5,2	6,3	6,8	6,9	14,7	22,1	23,4	20,7	12,0	7,7	5,4
Antalya Cloudly	10,8	8,2	7,6	5,3	3,5	0,6	0,0	0,1	0,4	3,3	5,9	10,0
Alanya Clear	4,9	4,9	6,6	0,6	9,5	16,3	20,1	22,1	18,8	13,8	9,3	5,6
Alanya Cloudly	11,3	8,1	6,7	4,0	2,1	0,2	0,2	0,0	0,1	2,0	4,9	9,9
Anamur Clear	4,4	4,6	6,1	8,2	11,0	18,8	22,3	23,0	21,8	13,6	7,3	4,0
Anamur Cloudly	9,9	6,6	5,0	2,3	1,0	0,1	0,0	0,0	0,1	1,5	3,8	9,5
Mersin Clear	4,5	4,4	5,0	6,2	7,8	11,6	15,3	17,6	17,9	12,6	7,6	5,7
Mersin Cloudly	10,5	7,4	6,4	4,0	3,0	0,5	0,3	0,0	0,2	2,8	4,8	9,2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

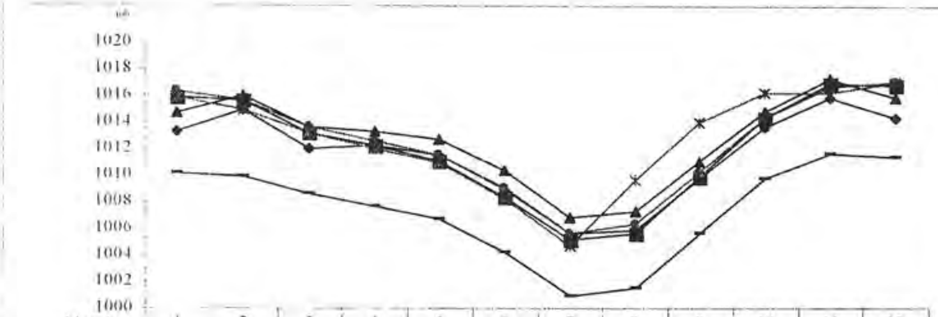
Figure 5. Cloudiness for all stations.

The number of cloudy days in winter in Finike are 8,0 days, Antalya 10,8 days, Alanya 11,3 days, Anamur 9,9 days, Mersin 10,5 days and İskenderun 10,3 days in January. The number of cloudy days in the summer in Finike, Alanya, Anamur and Mersin are 0,0 days in August. Only in Antalya 0,1 days and in İskenderun 0,6 days are cloudy.

5. Air Pressure

The air pressure reduced to sea level generally gains maximum values in winter. The values in Finike are 1014,3 hpa, Antalya 1011,4 hpa, Anamur 1016,9 hpa, Mersin 1017,1 hpa in December, İskenderun 1017,1 hpa and Alanya 1017,3 hpa in November.

The air pressure reduced to sea level generally gains minimum values in summer. Values are in Finike 1005,6 hpa, Antalya 1000,9 hpa, Alanya 1006,8 hpa, Anamur 1005,2 hpa, Mersin 1004,7 hpa, İskenderun 1005,6 hpa in July (Figure 6).

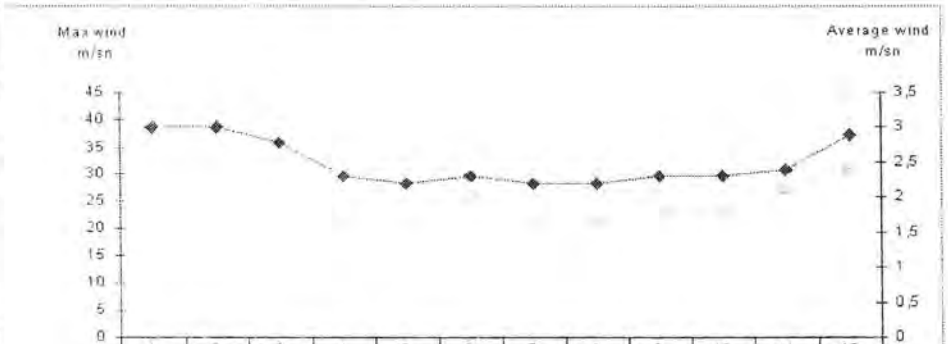


Months	1	2	3	4	5	6	7	8	9	10	11	12
Finike	1013.3	1015.0	1012.0	1012,2	1011.5	1009,0	1005.6	1005.9	1009.8	1013.7	1015.9	1014.3
Antalya	1010.1	1009.9	1008.6	1007,6	1006.7	1004.2	1000.9	1001.5	1005.7	1009.8	1011.6	1011.4
Alanya	1014.7	1016.0	1013.7	1013,3	1012.7	1010.3	1006.8	1007.3	1011.1	1014.8	1017,3	1015.9
Anamur	1015.9	1015.7	1013.2	1012.2	1011.1	1008.4	1005.2	1005,7	1009.9	1014.3	1016,9	1016.8
Mersin	1015.9	1015.0	1013.2	1012.0	1010,9	1008.2	1004,7	1009.6	1014,0	1016,2	1016.2	1017.1
İskenderun	1016.4	1015.6	1013.6	1012.6	1011.5	1009.1	1005.6	1006.3	1010.2	1014.4	1016.7	1017.1

Figure 6. The mean atmospheric pressure for all stations.

6. Wind Speed and Direction

In Finike; the average wind speed is between 4,0 - 3,0 m/s and the maximum wind speed is between 30,2 - 18,2 m/s. The direction of the winds are generally SSW in January, February and March, WNW in April and May, WSW in June, July and August, NNW in September, WNW in October, November and December (Figure 7).



	1 SW	2 W	3 SW	4 ESE	5 WSW	6 W	7 N	8 N	9 N	10 NW	11 E	12 NNW
Maximum	41,4	29,2	32,6	21,2	19,8	25,5	20,2	20,8	22,9	22,9	27,4	30,5
Average	3	3	2,8	2,3	2,2	2,3	2,2	2,2	2,3	2,3	2,4	2,9

Months

Figure 7. The mean and maximum wind values in Finike.

In Antalya, the average wind speed is between 3,6 - 2,7 m/s and maximum wind speed is between 38.7 - 18.7 m/s. The direction of the winds are generally SSE in December, NNW in January, February and March, S in April, N in May, WNW in June, N in July, NW in August, N in September, SW in October, NNW in November (Figure 8).

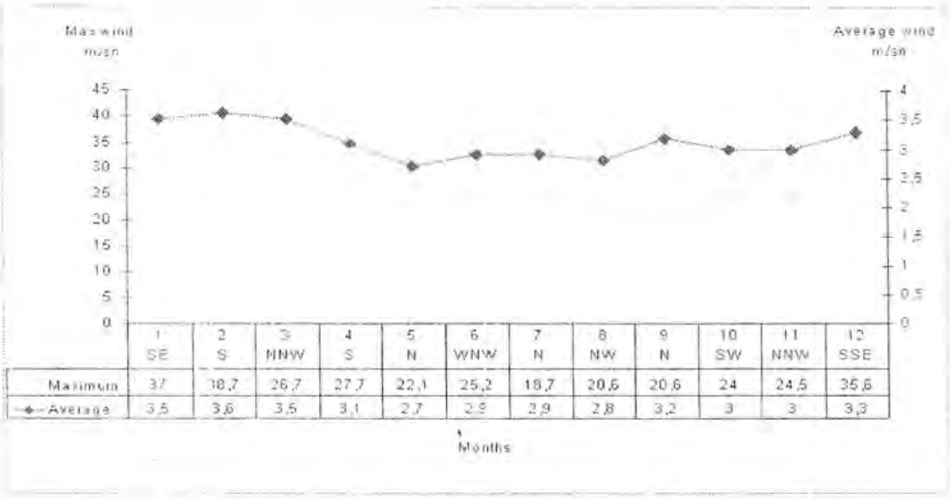


Figure 8. The mean and maximum wind values in Antalya.

In Anamur, the average wind speed is between 3.0 - 2,2 m/s and the maximum wind speed is between 41.4 - 19,8 m/s. The direction of the winds are generally SW in January, SW in February and March, ESE in April, WSW in May, W in June, N in July, August and September, NW in October, E in November, NNW in December (Figure 9).

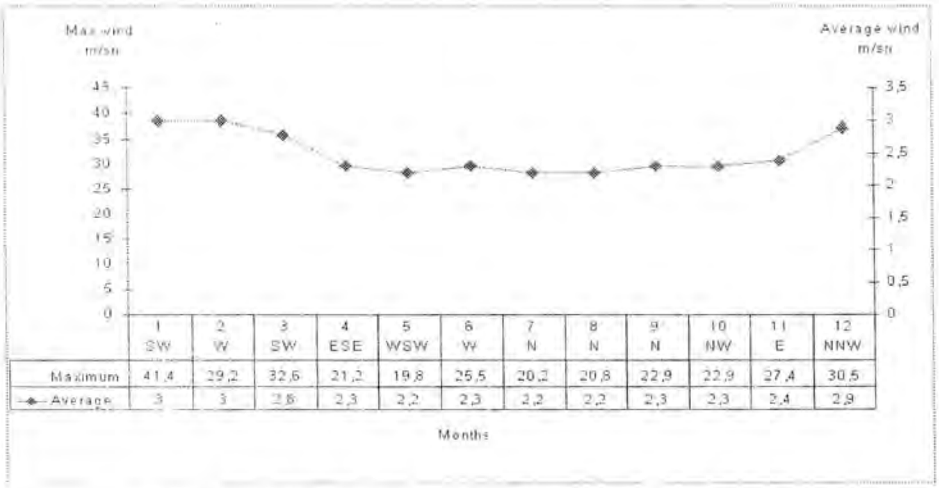
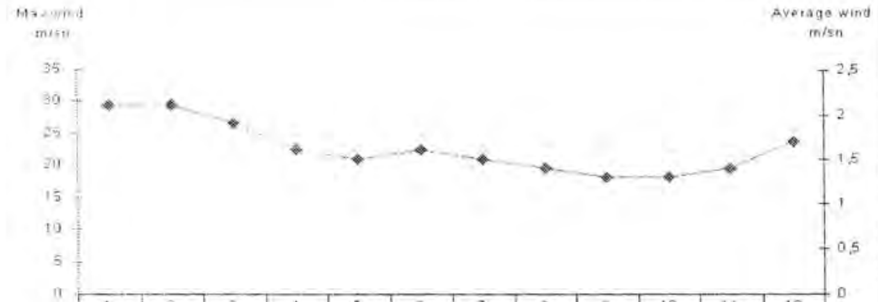


Figure 9. The mean and maximum wind values in Anamur.

In Alanya, the average wind speed is between 2,1 - 1,3 m/s and the maximum wind speed is between 30,8 - 15,8 m/s. The directions of the winds are generally S in January, WSW in February, W in March, WSW in April and May, W in June, NNE in July, N in August and September, NNW in October, W in November, and WSW in December (Figure10).

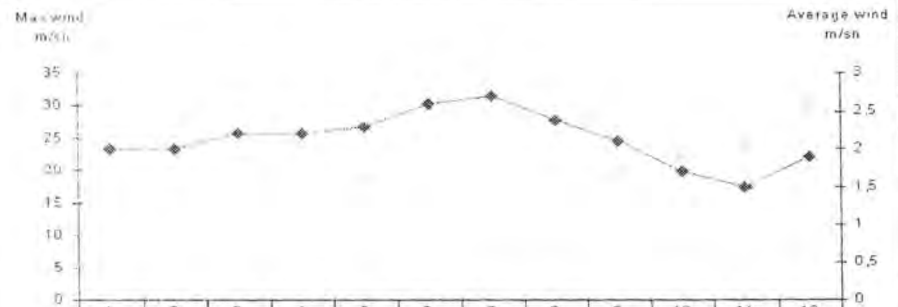


	1 S	2 WSW	3 W	4 WSW	5 WSW	6 W	7 NNE	8 N	9 N	10 NNW	11 W	12 WSW
Maximum	30,8	30	29,4	18,9	23,2	15,8	25,2	23,4	23,8	23,1	28,8	25,7
Average	2,1	2,1	1,9	1,6	1,5	1,6	1,5	1,4	1,3	1,3	1,4	1,7

Months

Figure 10. The mean and maximum wind values in Alanya.

In Mersin, the average wind speed is between 2,7 - 1,5 m/s and the maximum wind speed is between 30.0 - 15,4 m/s. The directions of the winds are generally S in December and January, W in February, WSW in March and April, SW in May, W in June and July, NNE in August, N in September, SE in October, and SSE in November (Figure 11).

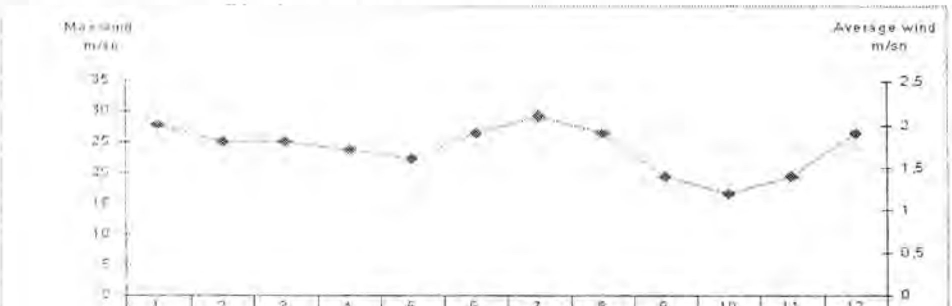


	1 S	2 W	3 WSW	4 WSW	5 SW	6 W	7 W	8 NNE	9 N	10 SE	11 SSE	12 S
Maximum	29,7	23	22,2	21,7	18,4	24,5	15,4	18,9	19,3	22,4	24,7	30
Average	2	2	2,2	2,2	2,3	2,6	2,7	2,4	2,1	1,7	1,5	1,9

Months

Figure 11. The mean and maximum wind values in Mersin.

In İskenderun, the average wind speed is between 2,0 - 1,2 m/s and the maximum wind speed is between 30,5 - 18,1 m/s. The directions of the winds are generally W in January, SE in February, S in March, SSE in April, SE in May, N in June, WNW in July, NW in August, NNW in September, NW in October and November, ESE in December (Figure 12).



	1 W	2 SE	3 S	4 SSE	5 SE	6 N	7 WNW	8 NW	9 NNW	10 NW	11 NW	12 ESE
Maximum	26,1	30,5	27,2	31,2	22,2	18,1	12,8	26,4	26,8	24,1	24	24,6
Average	2	1,8	1,8	1,7	1,6	1,9	2,1	1,9	1,4	1,2	1,4	1,9

Months

Figure 12. The mean and maximum wind values for İskenderun.

DISCUSSION

In this study, the means of the meteorological parameters based on a wide range of years which affect the Mediterranean coasts of Turkey were investigated. These parameters have a great importance for the selection of sites for aquaculture, for fish production and feeding and growth, observation of diseases, planning the fishing periods and seasons.

1. Air Temperature

In all regions minimum values are seen in the winter. Starting from February, in all regions sea water temperatures increase and reaches maximum values in July and in August. Starting from September, in all regions air temperatures decrease. In general overview there is no differences between the mean temperatures between the stations (except Iskenderun). The mean temperatures in Iskenderun are always higher than the stations

2. Sea Water Temperature

In all regions minimum values are seen in the winter. Starting from February, in all regions sea water temperatures increase till summer. In August we see maximum values in all stations. Starting from September, in all regions the sea the water temperatures decrease till winter. From September to March the sea water temperatures in Mersin are lower than other regions.

3. Rainfall

In general. Finike, Antalya, Alanya, Anamur have the highest rainfall during winter.

Mersin and Iskenderun have relatively lower rainfalls. Starting from March all the stations have similar rainfall values. As the summer approaches the rainfall decreases. In July and August rainfall reaches the minimum values.

4. Air Presure

Except Antalya, the air pressure reduced to sea level shows similarities in all stations during whole year. Air pressure in Antalya is relatively lower than other regions. All stations reach the maximum values during winter. Starting from March air pressure continuously decreases. In July it reaches minimum value. Starting from August till winter the air pressure continuously increases.

5. Wind speed and direction

Directions of the dominant winds show similarities in all regions while some distinctions are observed in some months.

In Finike; in January, February and March wind directions are W-S, in April and May the wind directions are W-WNW, in June, July and August the wind directions are WSW and during September, October, November and in December the wind directions are N-W.

In Antalya; in October, December. January February and in April the wind directions are S-E and S, during March, May, June, July, August, September and November the wind directions are N-NW.

In Alanya; in December, January, February, April, May and June the dominant wind directions are S-W. in July the dominant wind directions are NNE, in August and September the wind directions are N, in October the wind directions are NNW and in November the wind directions are W.

In Anamur; in April the dominant wind directions are ESE while from January till June the wind directions are S-W, in July, August and September the wind directions are N, in October the wind directions are NW, in November the wind directions are E and during December the wind directions are NNW.

In Mersin in December and January the dominant wind directions are S, in February the dominant wind directions are W, March, April and May the dominant wind directions are WSW-SW, in June and July the dominant wind directions are W, in August the wind directions are NNE, in September the wind directions are N, in October the wind directions are SE and during November the wind directions are SSE.

In İskenderun in January the dominant wind directions are W. in February, March, April and May the dominant wind directions are S-SE, in June the dominant wind directions are N, from July to end of November the dominant wind directions are WNW-NW and during December the dominant wind directions are ESE.

REFERENCES

TURKISH STATE METEOROLOGICAL SERVICE, 1980-2000. Meteorological data. Devlet Meteoroloji İşleri Genel Müdürlüğü, Ankara.