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Bluefin tuna *(Thunnus thynnus* L.) farming on the Croatian coast of the Adriatic Sea – Present stage and future plans

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SUMMARY – In Croatia, during the last five years, bluefin tuna (BFT) farming reached around 2500 tonnes per year of harvested fish. The industry consists of 6 commercial companies using 9 lease sites. It was based on fishing BFT by purse seine and growing them in the 50 m diameter cages for a few months up to a couple of years. The BFT are fed small pelagic fish by hand, six days per week, twice per day. Farm mortality is about 3% to 5% per year, while stress-related mortality during the adaptation period is around 2%. Daily feed consumption was in average around 5% of biomass, within the temperature range from 18°C to 24°C. Some poorly planned and managed BFT operations had negatively impacted natural environment. The improvement of the environmental performances in BFT farming is of the highest importance for this industry in Croatia.

Key words: Bluefin tuna, purse seine, grow-out in cages, environmental impact.

RESUME – *"Elevage du thon rouge (*Thunnus thynnus *L.) sur la côte croatienne de la mer Adriatique - Situation actuelle et plans pour l'avenir". En Croatie, pendant ces dernières cinq années, l'élevage du thon rouge a atteint 2500 tonnes de poisson récolté par an. L'industrie est formée par 6 compagnies commerciales qui utilisent 9 sites en bail. Elle est basée sur la pêche du thon rouge par des senneurs et sur leur engraissement dans des cages de 50 m de diamètre pendant quelques mois jusqu'à deux années. Les thons rouges reçoivent de petits poissons pélagiques distribués à la main, six jours par semaine, deux fois par jour. La mortalité dans ces fermes est de 3 à 5% par an, tandis que la mortalité due au stress pendant la période d'adaptation est d'environ 2%. La consommation journalière d'aliment a été en moyenne d'environ 5% de la biomasse, tandis que les températures allaient de 18º à 24ºC. En raison de certaines opérations mal planifiées et mal gérées concernant le thon rouge, il y a eu des impacts négatifs sur l'environnement. L'amélioration des performances environnementales pour cet élevage de thon rouge est de la plus grande importance pour cette industrie en Croatie.*

Mots-clés : *Thon rouge, senneur, engraissement en cages, impact environnemental.*

Introduction

Commercial activities in fattening of captive bluefin tuna (BFT), *Thunnus thynnus,* have been recently undertaken in Croatia. It has been based on fishing BFT in their natural habit of the Middle Adriatic and/or Eastern Mediterranean and fattening them in floating cages, located semi-offshore, within a rearing period that could be from a few months up to couple of years.

The first development program was established in 1996 and 39 tonnes of gutted and gilled fish were exported to Japan. The transfer of farming technology originated from southern BFT (*Thunnus maccoyii*) in Australia and investments by Croats living in Australia made enable a rapid increase of farmed BFT. The export increased from 390 tonnes in 1997 to 1090 tonnes in 2000 according to Croatian Statistical Documents. Recently (January, 2002), six medium to large farms are operating at nine leased sites, with installed capacity of about 3000 tonnes.

An overview of the data and experience collected over the previous five years farming caged tuna is provided as well as the danger of over fishing and the perspectives of BFT farming are discussed.

Fishing methods and techniques

Purse seine is a principal fishing gear used for fishing bluefin tuna in the Adriatic. The number of

active purse seine fishing vessels increased from 19 in 1999 to 30 in 2000, showing an increased interest for tuna farming among Croatian fishermen. However, the international quota system allocated to Croatia (876 tonnes only) is not meeting growers' needs, and some BFT farmers are obtaining greater sized fish caught in the Mediterranean by buying portion of EU quota.

The BFT are caught predominantly from June to October when they are present in the deep waters of central Adriatic. The BFT schools are found, seined and transferred via connections from nets to towing cages. About 80 to 100 tonnes of 5 to 25 kg BFT are towed at about 1.2 knots to the farm areas. However, adult fish that are caught in the Mediterranean usually during June and first half of July are towed several weeks what involves some feeding of the fish. By means of special hook some specimens are weighted, and then, using underwater video cameras they are counted as they are transferred into 50 m diameter and 20 m deep cages. In this way the total biomass in the cages is estimated as to adjust feeding strategy. Most of BFT farms are placed in a relatively shallow semi-offshore marine environment of the eastern central Adriatic Sea (Fig. 1).

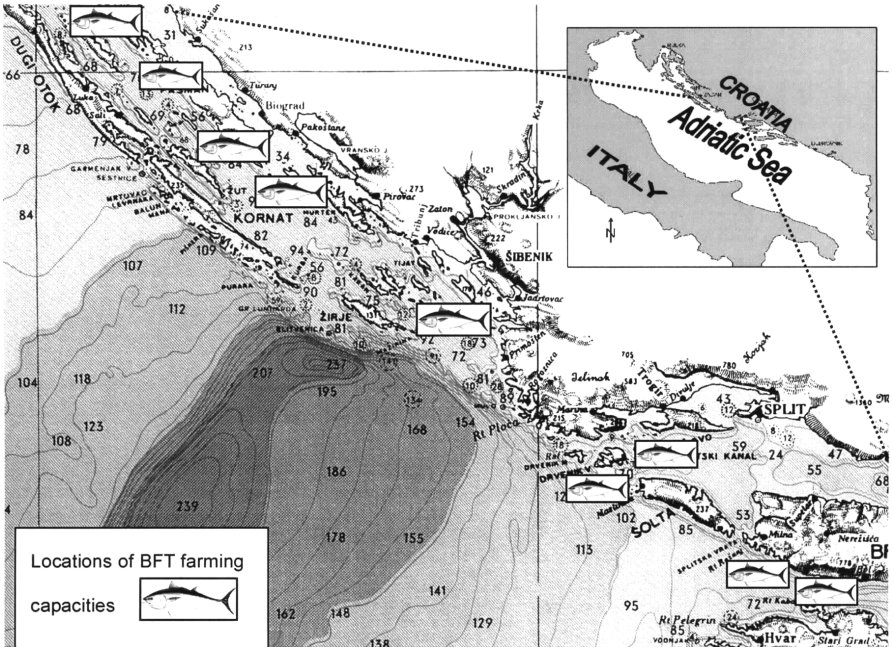

Fig. 1. Locations of bluefin tuna grow-out cages on the central part of eastern Adriatic Sea.

The size composition of fish stocked into the cages correspond to the catch size composition (Fig. 2). Analysed catch data for the period of 1999 to 2001, showed a progressive increase of the proportion in the number of small BFT specimens.

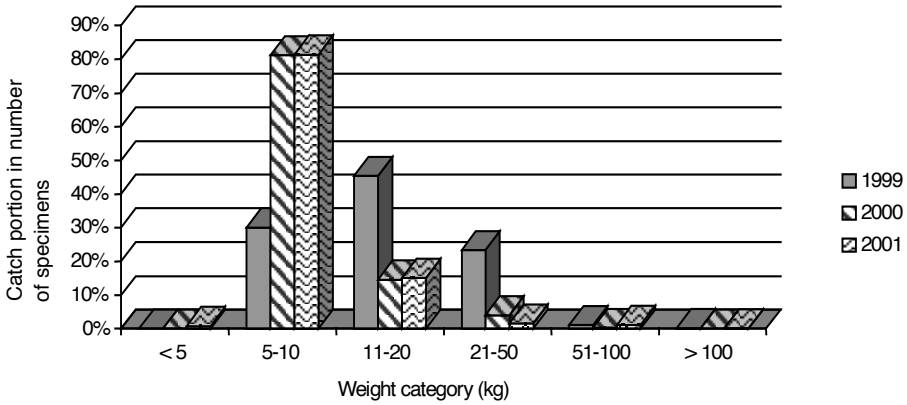

Fig. 2. The catch size composition of the bluefin tuna in the Adriatic by year (1999-2001).

Feeding of BFT in the cages

While being fattened the fish are fed with defrosted small pelagic fish such as herrings (*Clupea harengus*), pilchard (*Sardina pilchardus*) and round sardinella (*Sardinella aurita*) and also shortfin squid six days per week, twice a day, generally done by hand. In 2001 about 15,000 tonnes of baitfish were used, sourced from North Sea (i.e. herrings) and locally.

Typically, during the fattening season, bluefin tunas are overfed. The food conversion ratios are about 15 to 20:1. The highest feed consumption occurred at 23-25°C, which may be up to 10% of body biomass. It may reduce twofold at 20°C, and at 18°C daily feed consumption is not exceeding 2% to 3% of body weight (Fig. 3). It is obvious that tuna can tolerate a wide range of temperatures. The anatomical, physiological and biochemical features makes this fish to maintain its body balance even during the wintertime when the fish were taking food at 11°C. During the adaptation period, due to the stress and injures mortality is about 2% while the farm mortalities are about 3-5%.

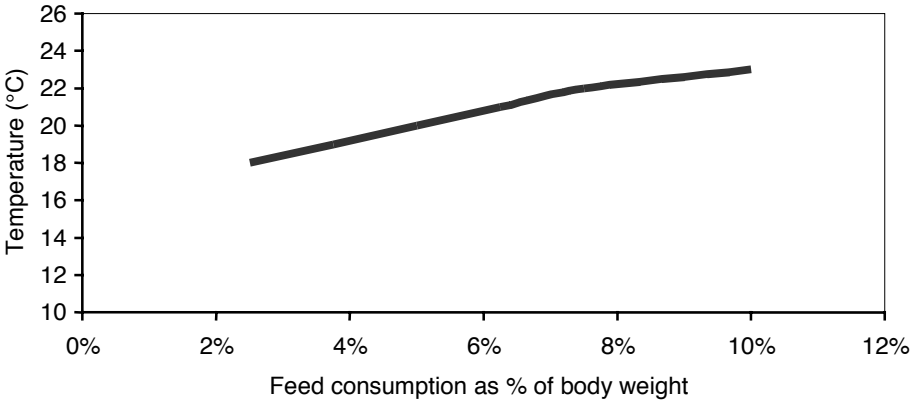

Fig. 3. Relation between sea water temperature and feed consumption of BFT in the cages.

Daily husbandry practices include diving inspections for regular checking of mortalities, moorings and integrity of nets. Cleaning of nets and floating infrastructure is usually undertaken on shore when all BFT are harvested.

Fattening of adult bluefin tunas take four to six months to get required quality and appreciable price. However, the majority of the fish caught in Adriatic are 5 to 25 kg. Therefore, these tunas for value-adding purpose, usually remain in the cages for couple of years. It should be noticed that this new practice could cause difficulties in terms of the catch statistics and concurrence of catch data with trade data.

Harvesting

Harvesting strategies vary predominantly with size of the harvested fish. Typically BFT are crowded into a small area using a net where divers capture them by hand. The divers kill tunas with a spike to the brain, and then swim with them to the harvesting point with the pontoon where tunas are pulled out from the water. At the slaughtering table they are cored, a wire passed through their neural canal and left bled. The post harvests activities depend on whether they are send to Japan market by plain or sea cargo. That may include fresh, chilled or frozen product to be marketed. In any case, methods of killing more than anything else influence the quality of tuna meat. The fish that straggle during the slaughter have a less pink or reddish meat that makes the market price inferior.

Environmental issues

Rearing sites

Experiences have shown that environmental planning for BFT farming was inadequate and a more

comprehensive approach to sitting these farms has to be used. Minimisation of conflicts and environmental impact requests careful planning of such farms by avoiding conflicts with other users.

Up to the present there were no any damages caused by the environment-related phenomenon in Croatia. The experience gained from tuna farming up to now particularly emphasises the importance of choosing a suitable location for tuna farming, which should comply with the following requirements: (i) a suitable rearing site must not be affected by muddy waters from rivers or any other inflow of waters from the land that may clogged the gills and cause mass mortality (Lee, 1998); and (ii) ensuring the open sea dominant influence on the dynamics of water masses having high transparency and high dissolved oxygen to sustain their physiological maintenance and continuous swimming costs.

Environmental impact of the BFT farming

While being very sensitive to environmental impact, tuna farming, such as most of the other economic activities, may have an undesirable impact on the marine environment. Environmental studies were carried out on several locations where the cages have been installed. The most common problems are caused by overfeeding and smell pollution during the summer season. Uncollected fat skim on the sea surface may be widespread much outside of concessioned zones and have disastrous effects on the beaches. This is a very important aspect of BFT management causing a negative reactions in the major tourist destinations. The next problem is associated with tuna killing and dressing the fish, and a method of removing waste (head, intestine, blood) to a safe deposit on farms when some waste may be deposited. Several hundreds of tonnes of waste have not been used yet, even though it can be a profitable business operation.

So far, there has been no functional, environmental monitoring of key water quality parameters and sediment chemistry at the tuna farms. However, some poorly planned and managed bluefin tuna operations have resulted in negative impacts on ecosystems and communities. Because of great public oppose of placing tuna farms into the coastal and island areas there is an urgent need to improve environmental performances of tuna farming. A comprehensive area plan for coastal zone must be worked out as soon as possible in order to allocate areas for the various aquaculture activities with particular reference to BFT farming.

Economic and social issues

When dealing with economic issues of tuna farming at this stage one must consider two approaches. One is fattening of adult stock through four to six months that gives quick revenue of capital investment and before tax profit from 15 to 40%. This profit depends on the initial cost of fish stocked in the cages (e.g. Mediterranean vs. Adriatic BFT) and the integration of the BFT project into compatible and supporting fisheries activities. However, the production costs of small tunas of different sizes through several years is still to be evaluated. Based on some data that comes from some Croatian growers that fattened young BFT through two or more years, it is clear that such production is feasible and justifiable, but economically inferior to the farming of adult fish.

It is obvious that such a grow-out operations may negatively affect on accuracy of ICCAT bluefin tuna statistical document (BTSD), and make disagreements between the final production, export records and catch reported.

Bluefin tuna farming and farming related activities generated a large number of jobs and a very significant income. Employment on the heavily depopulated Croatian islands is very important social issue, and tuna business in Croatia has enabled about 300 on farm jobs and much more through rather high multiplication factor. It is even more important as it is practised around Croatian islands where new industries and jobs are needed badly.

BFT farming vs. traditional fisheries

Bluefin tuna farming in Croatia has an important impact on the traditional fisheries in whole. As

98% of BFT have been caught by purse seine, and the rest by long lines and hooks. Farming activities attract a number of fishermen to become active partners, either as suppliers or tuna farmers. So, the number of purse seine vessels that actively fishing bluefin tunas has increased from 19 in 1999 to 30 in 2000. This facts show a growing importance of tuna farming for fishermen that own large fishing vessels equipped with purse seines for fishing on large pelagic species. The remaining big fishing vessels are employed in fishing small pelagic fish to feed tuna in cages. This fact makes a lot of troubles to fish processing factories in obtaining necessary row material at the acceptable price level.

Further positive effect to Croatian demersal fisheries is a fact that 30 trawlers found interest to be fully integrated into tuna farming operations, either in transporting or delivering feed to the fish on farm. This will reduce fishing pressure on already over-exploited demersal fish resources.

Research programme on bluefin tuna in Croatia

Due to the increased interest in the growing of BFT, and because of necessity to continue fattening operation of majority of captured fish up to a couple of years, the growing performances of various size of BFT reared in the cages are studied. Some provisional information on growth of BFT held in cages has been reported (Katavic *et al*., 2002) in addition to the age composition of BFT catches in Adriatic (Ticina *et al.,* 2002). Morphological characteristics and feeding of wild bluefin tuna were studied earlier (Ticina, 1994). Study on growth patterns of BFT when reared in the floating cages, including conversion factors for tuna products originating from the cages, will be carried out within framework of the ICCAT Bluefin Year Program (BYP).

Perspectives

With all limitations we have learned that the BFT project is growing in Croatia, and it is commercially successful. It is clear that the major problem in expanding BFT farming is and will be a further decline in quota of eastern BFT stock. Recent analyses as presented at the 2001 SCRS Meeting in Madrid (Spain) indicate that current catch estimated at 31,935 tonnes or more is not sustainable. A reduction to 75% of the 1994 level was not sufficient to prevent a continuing decline in spawning biomass. A catch of 25,000 tonnes, or less, may be acceptable. However, it should be noted that even these quantities might be too optimistic since they assume that future recruitment continues at average level observed so far. There is a great concern about the high percentage of small individuals in catches (fish <10 kg), that will seriously reduce the long term potential yield, especially if such a stock is not used for further, at least two to three years growing period in cages. Namely, catching of small tuna make sense only if the aim is to increase tuna production in a quantity.

Various measures that has been taken by ICCAT such as minimum size tolerance in number of fish and by not allowing any tolerance with respect to age 0+ fish, weighted less than 3.2 kg. In addition to this protective measure, the prohibition of purse seine fishing in the Mediterranean from 16 July to 15 August while in the Adriatic during May, were designed to protect juveniles. However, reservations on the effect of these new measures have to be expressed. Recent abrupt increase of catches of large fish in the Mediterranean during the spawning season is likely to influence spawning stock biomass and future reduction in recruitment is expected. Massive expansion of tuna farming makes pressure on juveniles that needs to be properly evaluated and regulated under the ICCAT management strategies. It is not clear enough whether such a practice is interfering with existing conservation measures or BFT farming reduces the pressure on wild stocks. The fact is that in recent years the tuna industry stepped from the conditioning of the wild caught fish before being marketed towards growing them up to a couple of years. The practice of tuna growing affords further opportunities of the utilisation of an existing natural resource. It represent also intermediate phase from wild fisheries to fully controlled farming as has happened with other species now well established in mariculture. In any case, it is obvious that such a grow-out operations will affect the accuracy of ICCAT bluefin tuna statistical document (BTSD), and make disagreements between the export records and catch reported.

The fact is that progress in successful rearing of BFT does not contribute significantly to basic problems that are the reproduction control and captive breeding of the different life stages of the BFT.

Having in mind all what was said, the closing the life cycle of the BFT in captivity is the only guaranty that sustainable BFT production will be established. This will eventually lead to decreased pressure on the natural stocks as has happened with other cultivated marine species.

Conclusive remarks

Bluefin tuna farming in Croatia has yielded an economic benefit to the fisheries industry with some 50,000,000 € income realised in 6 commercial companies using 9 lease sites. Improvement in environmental performances of BFT farming is needed to reduce the environmental pressure to the companies involved and to avoid further conflicts with other coastal users. It is a general opinion that zoning for tuna culture and development of an offshore technology is needed to facilitate environmental compatibility of BFT farming industry. Rapid and innovative low cost environmental impact assessment programme, as well as, an acceptable environmental monitoring based on key environmental performance indicators will be highly beneficial to the future BFT farming programme. There will be need to establish a full feeding control over tuna farming that includes the optimisation of the feeding frequency, amount of the feed and feeding techniques to be adjustable to BFT behaviour. By minimizing waste release, dispersal and accumulation of organic matter there will be benefit to both, BFT farming economy and environmental quality. Harvesting and post harvesting methodology and techniques should be also improved as to minimise pollution in the cage area and to meet requirements of export market.

A multidisciplinary approach focused on growth, nutrition, environmental issues and full control of reproduction may lead to the sustainability of BFT farming industry and decrease of pressure on the natural stocks.

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