

Bluefin tuna fishing and ranching: a difficult management problem

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1. Introduction

In Australia the farming of bluefin tuna in cages is reported to be pioneered by a Yugoslavian immigrant called Dinko Lukin. The decreasing catches of bluefin tuna by the Australian fleet, from 21,500 mt in 1982 to a maximum allowed quantity of 5,250 mt in 1990 (Ottolenghi et al., 2004) were the reason other ways of producing this expensive fish were explored. That fishery is capable of reducing the stocks of this species can also be explained by its behaviour: bluefin tuna move in schools and appear in the same season in certain places sometimes not even too far from the coast. While hunting they circle and chase their prey (sardines, anchovies, herring) to the surface, and this quickly attracts flocks of fish-eating birds. An observer in a high place (tower, mast of a ship) can easily spot the birds or school of fish from a great distance.

The bluefin tuna that are kept in cages belong to 2 species: the northern bluefin tuna that lives in the northern Atlantic Ocean (*Thunnus thynnus*) and the species living in the Pacific and Indian Ocean (*Thunnus maccoyii*). But the northern species does not keep to the north: there is also a population of this tuna in the Atlantic Ocean near South Africa. Both species migrate over great distances. From all

Abstract

The fish processing industry and consumers in Japan are willing to pay high (and sometimes outrageous) prices for fresh bluefin tuna with fat content and flesh colour just right to be served raw as sashimi or sushi. This willingness was and still is the economic incentive for a high fishing pressure and for the development of tuna fattening in floating cages. After seeing the economic success of tuna fattening in Australia companies in the Mediterranean region also started with the fattening of bluefin tuna (*Thunnus thynnus*). So bluefin tuna fishing and ranching in the Mediterranean has grown out of proportion. Such an expansion is very difficult to justify when taking into account the total dependence of tuna ranching on the bluefin tuna fishery, a fishery that has been facing serious difficulties for more than a decade now and for which both scientists and NGOs have been consistently warning that catch levels are too high.

Key words: fish market; bluefin tuna ranching; sustainability

Résumé

Au Japon, l'industrie de transformation et les consommateurs sont disposés à payer des prix très élevés, parfois exorbitants, pour le thon rouge frais; il a une teneur en graisse et une couleur de chair bien adaptées pour être servi cru comme sashimi ou sushi.

La disponibilité à payer était, et est encore, le prime économique qui entretient une haute pression de la pêche ainsi qu'un développement de l'élevage du thon en cages flottantes.

Après les expériences couronnées de succès économique de l'élevage du thon en Australie, les entreprises de la région méditerranéenne se sont mises à engraisser le thon rouge. C'est ainsi que la pêche et l'élevage du thon rouge en Méditerranée se sont développés démesurément.

Un tel développement est difficile à justifier, étant donné la dépendance totale du thon élevé vis-à-vis de celui que l'on pêche; or cette activité de pêche se heurte, depuis plus de dix ans, à de graves difficultés à propos desquelles tant les scientifiques que les ONGs avertissent constamment que le niveau des captures est trop élevé.

Mots clé: marché du poisson, élevage du thon rouge, durabilité

tuna species the bluefin tuna has least fear of cold water: it prefers temperate and cold seas (up to Nova Scotia near America and the Lofoten Islands of Norway). Spawning takes place in warmer waters. The spawning grounds of the Atlantic species are in the Gulf of Mexico and in the Mediterranean Sea (near Mallorca and some other places). The Southern species spawns in the seas south of Java. In the Gulf of Mexico the bluefin tuna spawn first at an age of eight years, but it seems that the population that prefers to spawn in the Mediterranean Sea can already spawn for the first time at the age of five. The tuna enter the Mediterranean Sea in May and return to the cooler waters of the Atlantic Ocean in July. A big female can lay over 30 million eggs. The northern species can live up to 15 years old, but the southern species can reach an age of twenty years. In the Atlantic Ocean a bluefin tuna over 4.5 m in length and weighing 684 kg has been caught. The southern species can grow up to 2.45 m and reaches a weight of 260 kg.

By catching over 800 tunas near the east coast of America and releasing after inserting small transponders and devices that register body temperature, water temperature and depth, many facts about this remarkable fish have been revealed (Block et al., 2001). The bluefin tuna is a very fast fish (anglers claim it can reach a speed of 80 km/hr!) that each covers huge distances. This strong marathon swimmer has a high metabolism. Although it moves in waters varying

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from 3 to 30 °C the fish manages to maintain a constant body temperature of around 25 °C. Some biologists consider this species to be the most advanced fish in evolutionary development. In the skin is a very fine blood vessel system that is closely linked to the blood circulatory system in the muscles and that acts like a cooling device. Tuna can migrate across the ocean in a short time: a tuna marked near the American east coasts was recaptured 40 days later on the other side of the Atlantic Ocean. Others were recaptured in the Mediterranean. From the measuring devices planted in the fish it could be deduced that tuna move most in the upper 300 m layer of water, but they can dive to 1000 m depth.

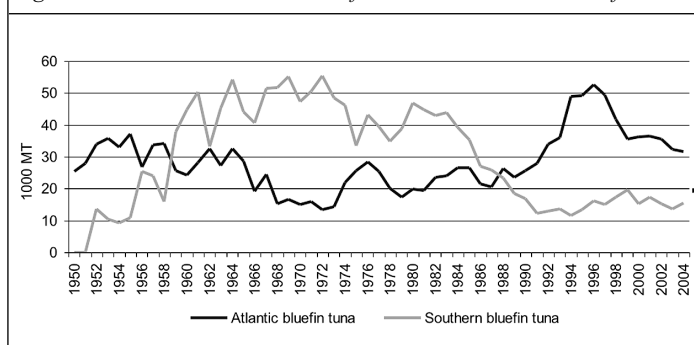
Predictable migratory behaviour, their presence being noticed from great distances when the schools of preys are chased near the surface, and sometimes fabulous prices paid in Tokyo for a great, fresh fish of very good sashimi quality (over \$ 45 000 was paid for one big fish of exceptional quality); is it a miracle that worldwide the stocks are in bad shape? The southern species has been put on List 1 by CITES (Convention on International Trade in Endangered Species), which means that only a limited amount can be traded internationally under certain conditions. From many years the capture of tuna is monitored by ICCAT (International Convention for the Conservation of Atlantic Tunas) of which nearly all tuna-fishing nations are a member. ICCAT also tries to regulate the capture but has not been very successful and could not prevent that the blue fin tuna stocks today are only a fraction of what they used to be before. Of the western bluefin tuna that spawns in the Gulf of Mexico the breeding stock has decreased to approximately 5% of the number of 30 years ago, before the onset of large scale fishing with long lines (Chambers, 2001). For a long time a ship owner not willing to abide to the rules and regulations of ICCAT could avoid prosecution and sanctions by registering his ship in a nation that was not a member of ICCAT and so it did not have to abide by the rules of this Convention.

2. Bluefin tuna catches

The fisheries for Atlantic bluefin tuna (*Thunnus thynnus*) are currently distributed from the Gulf of Mexico to Newfoundland in the West Atlantic, from roughly the Canary Islands to south of Iceland in the East Atlantic, and throughout the Mediterranean Sea. It is worth noting that the catches of bluefin in the East Atlantic (including Mediterranean) are greater than in the West. But Southern bluefin tuna (*Thunnus maccoyii*) is distributed only in the southern hemisphere and has been caught since the early 1950s, at first in tropical waters.

The Atlantic catch stayed at a fairly high level of 30 000 tonnes in the 1950s and into the early 1960s. The major gears were traps in the Mediterranean and near Gibraltar and purse seines in the north-eastern Atlantic. However, the trap catch peaked in 1958, and then declined sharply into the early 1960s. Purse-seine catches during this period were most-

Figure 1 shows the annual catches of Atlantic and Southern bluefin tuna.



ly made by the Norwegian fleet in the north-eastern Atlantic: the catches showed large yearly fluctuations, declined very sharply in the early 1960s, and ceased in the 1970s.

Annual catches of bluefin by the Bay of Biscay baitboat fishery were at a relatively high level of about 4 to 5 thousand tonnes until the mid 1950s, then they dropped sharply to 1 to 2 thousand tonnes throughout the 1960s. The total Mediterranean bluefin catch was stable at 5 to 7 thousand tonnes until the mid-1970s, as the reductions of trap catches were compensated by increased gillnet and longline catches.

Therefore, the overall catch of the Atlantic bluefin tuna (including the Mediterranean catches) dropped to a lower level of 15 to 20 thousand tonnes from the early 1960s until 1973. Starting in 1974, the Mediterranean catch showed a very rapid increase until it reached the first peak in 1976. Although the east Atlantic catch stayed at a low level of less than 10 000 tonnes, the overall catch from the eastern stock (Atlantic and the Mediterranean) resumed its upward trend in the late 1970s, and after some decline in the early 1980s, increased very rapidly in the 1990s to a peak in 1996. These increases in the Atlantic bluefin tuna catch were possibly the result of an increase in fishing effort, generated by the increasing demand for bluefin for the sashimi market. Until the 1970s, most of the bluefin caught in the Mediterranean and north-eastern Atlantic by the coastal states was sold in the local European market for consumption as fresh fish and/or for canning, with some minor exceptions of trap catches of large fish just about to spawn, which were exported to the Japanese sashimi market. The longline catches by oriental longliners were also for the Japanese sashimi market. Starting in the mid-1980s, Japan started importing fish caught by purse seiners, and as a result purse-seine effort has continued to increase. Also, more oriental longliners concentrated in the Atlantic near Gibraltar and in the Mediterranean, and their catches increased as well. In the 1990s, many IUU (illegal, unreported and unregulated) longliners joined the Mediterranean fishery, and their catches became very significant. Learning from these longliners, the coastal states (e.g. Spain and Italy) also developed bluefin longlining in the Mediterranean in the 1990s. In the meantime gillnet catches decreased, as a consequence of the ban on gillnets by the UN Resolution.

Bluefin tuna farming activities in the Mediterranean have had a strong effect on the increasing effort. Farming started

in the 1980s in Ceuta, where spent lean large bluefin caught by traps were fattened and sent to the Japanese market (Miyake et al., 2004). However, in the mid-1990s a new type of farming was developed in the Mediterranean, in which medium or small bluefin caught by purse seines were fattened and shipped to Japan. This product developed a new market in Japan and, in consequence, farming spread out in the Mediterranean and stimulated more interest in the purse-seine fishery.

The Atlantic bluefin catch has been under the ICCAT management scheme since 1995, and this is reflected by the reduction of the total reported catches since 1996.

The main Atlantic bluefin tuna catching nations are concentrated in EU, with France, Spain and Italy as the main producers (figure 2). Other important Atlantic bluefin tuna catching nations are Japan, Morocco and Tunisia.

Bluefin Tuna) since its establishment in 1994, and was kept at around 15 000 tonnes in the 1990s. The total catch started increasing again in the late 1990s due to the increase of catches by non-member fleets of CCSBT, i.e. the Republic of Korea, Taiwan Province of China and Indonesia.

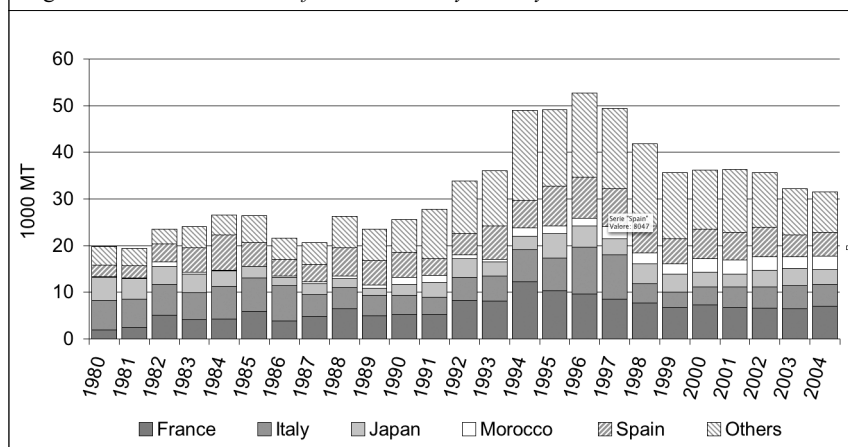
3. Bluefin tuna culture

The first attempts to raise tuna in cages took place in Japan in 1970. Because of stress and the lack of experience with regard to holding tuna the results during the first 3 years were disappointing. But with perseverance problems were gradually overcome and at present 8 companies are fattening a total of around 300 tons of tuna in 18 locations in Japan (Ottolenghi et al., 2004). Starting material for this culture are bluefin tuna weighing 150 to 500 gr that are caught by trawlers in Japanese coastal waters. The fish are raised 3 to 4 years in floating cages to a weight of 30 to 70 kg. The production volume is determined by the fluctuating amount of small fish available each year. Mortality among the small fish is still high due to stress and skin damage during capture. Also wounds resulting from swimming with great speed against the nets contribute to the considerable mortality rates among the young tuna.

Already in 1979 Japanese researchers managed to reproduce bluefin tuna in captivity, but raising the fry and fingerlings was very difficult. Only in 2002 researchers of the Kinki University managed to close the cycle for the first time, when a female bluefin tuna that was bred and raised in captivity spawned for the first time.

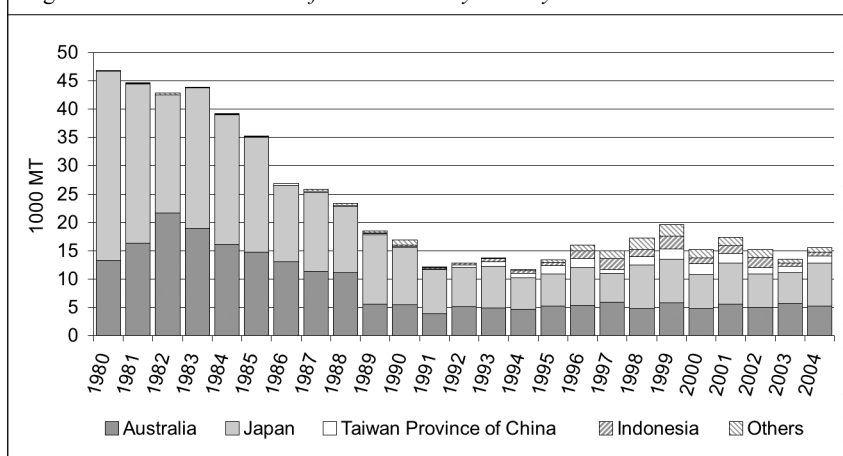
In Australia the fattening of bluefin tuna in cages started in 1990. The activity is concentrated along the south coast with Port Lincoln as the centre. As

Figure 2. World Atlantic bluefin tuna catch by country.



With regard to Southern bluefin tuna, the major fishing countries are Australia and Japan (figure 3). The Australian fishery has used several gears, including baitboats, purse seines, and trolling gear. The Japanese fishery uses only longlines. The catch of Southern bluefin tuna was around 12 000 to 15 000 tonnes in the 1950s (figure 1), and was used mostly for canning. When Japanese longliners adopted super-cold freezers and started fishing for the sashimi market, southern bluefin tuna acquired a high value in their market, as a substitute for (northern) bluefin tuna. Consequently the catch increased suddenly to a peak of 55 000 tonnes in the 1960s, after which it gradually decreased to about 40 000 tonnes in the 1980s, due mostly to a decline in the catch rate. In the early 1980s a quota system was introduced under a trilateral agreement among Australia, Japan and New Zealand. The annual quota has been reduced since then, as reflected by a sharp decline of the catch, and by the early 1990s had been reduced to less than 13 000 tonnes. The quota has been decided by the CCSBT (Commission for the Conservation of Southern

Figure 3. World Southern bluefin tuna catch by country.



a result of good cooperation between the tuna growers (Tuna Boat Owners Association), the Japanese Overseas Fishery Cooperation and the government of southern Australia the industry could grow to become the biggest sub-sector of Australian aquaculture, with production exceeding 9000

tons in 2001. Seed material for fattening are 15 to 25 kg bluefin tuna caught in open sea. Helicopters search the schools and after spotting the skipper of the tuna vessel is informed of the exact location of the school. When the vessel has caught up with the fish a purse seine is set around the school and after closing the net a floating cage is connected to the seine. Scuba divers drive the fish carefully from the seine into the cage. Once enough tuna has been caught this way the cage is towed slowly with a speed of 1 to 2 km/hr to the coast, a trip that can last several weeks. During this transport sharks attempt to enter the cage and the divers enter the cage almost daily to chase the sharks out and repair the net. When the transport arrives in a protected coastal area the cage is anchored and the tuna are fattened for 3 to 10 months on fish and squid. At the time of harvest the fish have gained 10 to 20 kg in weight. Attempts to fatten the fish with feed pellets have not been successful yet due to the relatively old age and short time the fish are kept in the cages. It would be an improvement when tuna could be raised on pellets because of the reduced risk of infection and reduction of pollution.

In the Japanese market the quality of the tuna determines the price. Freshness, right flesh colour and high fat content determine whether tuna is suitable for sushi or sashimi, and the price per kg buyers will offer. The colour and quality of the flesh is influenced by the way the fish are harvested. All efforts are focussed to avoiding stress during the harvest and to assure a quick death, thorough bleeding and cold environment. Only without stress the flesh will maintain the red-pink colour that costumers prefer. With too much stress the flesh colour becomes darker and the price per kg drops. In many tuna farms scuba divers again play a major role during harvest. First the tuna are with a net concentrated in one part of the cage. The divers grab the fish one by one and place them on a raft. In other farms the fish are concentrated above a lift net and raised on board a vessel, a few at a time. Once out of the water the fish are quickly killed by hitting a stake in the brain. Very large fish are shot in the head with a shotgun. To avoid any further muscle contractions (that would lead to acid conditions and dark flesh colour) the central nerve system is cut and the fish is bled by cutting the gill arches. Then the intestines are removed and the fish is thoroughly washed. When the fish is destined for the fresh market each individual is transported individually by plane on ice in a "tuna coffin". When the fish is destined for the frozen market the fish are deep frozen (-60 °C) and transported by plane or boat to Japan.

4. The tuna ranching boom in the Mediterranean

Already in 1979 some tuna that had been caught in large traps were kept in cages by Spaniards. These tuna had fin-

ished spawning and were on their way out of the Mediterranean and back to the Atlantic Ocean. After the Australians had developed the technique to catch whole schools of tuna and transport them alive in cages, tuna fattening also became a serious industry in the Mediterranean Sea. However tuna ranching began its expansion in the late 1990s. Since then, this industry has been expanding throughout the region, with little regulation and guided largely by the decisions of a few investors. Such an expansion is very difficult to justify when taking into account the total dependence of tuna ranching on the bluefin tuna fishery, a fishery that has been facing serious difficulties for more than a decade now and for which both scientists and NGOs have been consistently warning that catch levels are too high.

The farming process starts with fish weighing 20 to 200 kg and is mainly aimed at raising the fat content of the meat to fetch the higher price. In the region Spain is the biggest producer of fattened bluefin tuna (11,852 tons/year), followed by Malta (9,650 tons), Turkey (9,460 tons), Italy (5,800 tons) and Croatia (5,350 tons) (table 1).

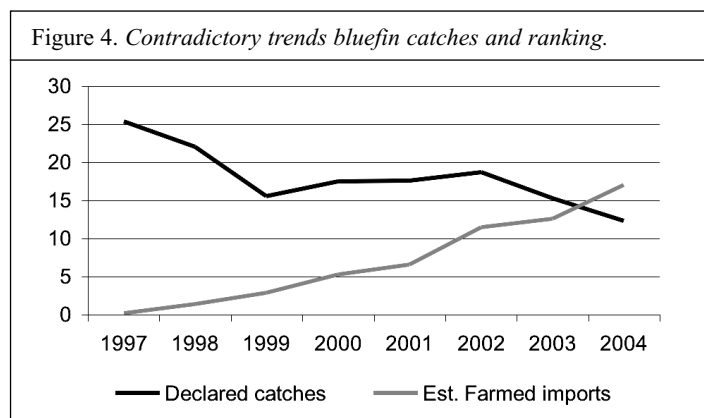
Table 1. Reported farming capacity in the Mediterranean Sea (2006).

Country	No. of farms	Farming capacity (tonnes)
Croatia	5	5350
Cyprus	3	3000
Greece	1	1000
Italy	9	5800
Libya	1	1000
Malta	7	9650
Morocco	1	1000
Portugal	1	500
Spain	14	11852
Tunisia	4	2400
Turkey	12	9460
TOTAL	58	51012

Source: Our processing of ICCAT data

On a smaller scale tuna fattening is also taking place in Cyprus, Tunisia, Greece, Morocco, Libya and Portugal. The total reported farming capacity of 51,012 tonnes is an indisputable incentive for illegal catches in the region, when compared to a legal quota of 32,000 t. In fact, as it has been noted by the FAO "since 1996 the percentages of bluefin tuna used for farming have increased continuously, so currently most of the bluefin tuna catch in the Mediterranean is used for farming" (Lleonart and Majkowski, 2005). In order to restrain illegal and non-reported catches, all ICCAT Contracting Parties importing bluefin tuna must request that tuna entering their markets is accompanied by a certificate called Bluefin Tuna Statistical Document (BTSD), validated by the authority of the exporting country. The document, in force since 1993, requires mandatory reporting of the area of capture, flag of the fishing vessels, quantity and type of products, shipping ports, etc. But

the difficulty in bluefin tuna catches management is highlighted by Miyake P. (2005). His studies are based on different sources, including imports recorded by the Japanese custom services and imports of farmed tuna recorded through the Bluefin Tuna Statistical Documents (BTSD). His calculations are made using some standardized conversion factors and are an attempt to calculate the quantity of fish really caught for farming. It is interesting to compare what purse seining fishing countries declare to have caught with the estimated tuna that entered to the farms and has been exported to Japan. In figure 4 it is clear that



trends do not match at all. While exports of farmed tuna to Japan - and therefore inputs for tuna farming - grow, declared purse seine catches decrease. There is only one way to explain that: unreported - and overall illegal - catches are increasing. As scientists have stated, under-reporting has been a matter of concern since 1998. Unreported catches come mainly from the Mediterranean and not from the East Atlantic, since the Mediterranean is where most purse seine catches are from, and this gear seems to be the main responsible for misreporting. Reported farming capacity in the Mediterranean Sea, summarised in table 1, does not however reflect the real farming capacity. Libya, for example, reported one farming facility to ICCAT in 2006 although their involvement in tuna ranching has been known for a number of years already. Furthermore, experts have noted that Algeria, Syria, Israel and Lebanon could become important either in the capture or in the farming of bluefin tuna in the Mediterranean (FAO, 2005). Except for Algeria they are not ICCAT Contracting Parties. Although Lebanon has not provided official data, sources state that one farm was planned for 2004.

The real amount of tuna ranching in the Mediterranean is an almost impossible question to answer, as is the real amount of tuna caught to provide live tuna for the ranches. Both industry and Governments are failing to fulfil their obligations to provide accurate statistical data to ICCAT, which is resulting in widespread under-reporting of catches in the region. This lack of effective controls in the region together with illegal practices such as re-export of Mediterranean bluefin tuna through third countries are resulting in catch levels above those reported, and very clearly much

higher than the amount of tuna that can be legally caught.

ICCAT is well aware of these problems: "The reported catch for 2004 is 26,961 t, but it is incomplete and substantial revisions are expected. A substantial amount of additional unreported catch that was not in accordance with the Commission's recommended allocation scheme has previously been recorded through the Bluefin Tuna Statistical Document program. Unfortunately, the Committee is no longer confident that this system provides an adequate basis for estimating total unreported catch levels since the markets for "sashimi" have expanded beyond that of Japan and since not all countries are reporting to the program" (ICCAT Report 2004-2005 – Vol. II). It is impossible to provide accurate figures for almost every aspect of the Mediterranean bluefin tuna fishery.

Tuna ranching is a highly profitable industry, a fact that explains the huge amount of money invested in the Mediterranean region for its development. These investments have usually taken place in the form of joint ventures between local entrepreneurs and foreign investors, mainly from Japan. However, not only is tuna farming a very profitable activity but it is well known that it has received large public subsidies. Unfortunately, for most countries in the region it is very difficult to get information about this financial support. This information gap includes the level of subsidies granted by the European Union, as well as those granted by its Member States individually. Let's have a closer look at the tuna fattening that takes place in Sicily.

5. The case of tuna farming in Sicily

The fattening of Bluefin tuna started in Italy in 2001 by a farm of 4 cages located in Sicily. In 2005, there were 2 farms worth 10 floating cages in which captured Bluefin, mostly in May, were fattened up to commercial size.

The case of tuna farming in Sicily is based on data gathered by direct survey of two companies which are active in the tuna fattening business. For this they have large floating cages with a diameter of 50 m, 25 m depth and a volume of 49 000 m³. At the start of the season (June/July) each cage is stocked with 140 tons of tuna. The fish are fed once per day with herring, sardines, mackerel and squid. The feed is stored and transported in frozen form. Before the actual feeding the fish is defrosted and put into the cage through a tube. Scuba divers observe the tuna during feeding and they indicate to the people on the boat when feeding should be stopped or continued. Depending on the water temperature the fish are fed 5 to 8% of the estimated body weight/day. Per kg of growth 20 to 25 kg of fish is fed. During the fattening of tuna disease or parasite problems are seldom encountered. Five months after stocking, in November-December, an average of 168 tons of tuna is harvested from a cage. All fish are for the Japanese market.

The capture or purchase of tuna to stock the cages makes up 61% of the variable costs for Sicilian tuna farms. The large quantity of herring, squids and other feeds comprise

20% of the costs, transport 11% and labour costs are only 5% of the total variable costs. Total production costs are around € 14.41/kg, and the sale price is between € 16 and € 20/kg. With such a cost structure a sale price of € 16.70/kg would mean a profit of EURO 350 000 per cage per season, making this activity the most lucrative form of aquaculture in Sicily at this moment.

6. Conclusion: tuna fishery management complicated by aquaculture

Today most of the tuna capture taking place in the Mediterranean Sea is for on-growing and fattening. This causes quite some headaches for ICCAT managers and scientists. Dead bluefin tuna that is internationally traded is obliged to have a certificate stating its origin, but life tuna can be traded without a certificate. This makes tracing of the country of origin of the tuna coming from farms very difficult; determining whether country X has filled or exceeded its bluefin tuna quota becomes nearly impossible. To avoid stress the tuna are not individually counted or weighed after capture and the amount stocked in cages is not known exactly but estimated. Cages can be stocked by mixing several batches obtained from different vessels. Cage owners and skippers are not always complete and accurate in their reports to governments. In Croatia cages are stocked with tuna that are often younger and smaller, and these need to be kept in the cage more than a year to reach harvest weight. In the second season larger fish may be added to the cage, making it impossible to estimate accurately the quantity of tuna that was caught in a certain year. Facing these difficulties with obtaining accurate data from the bluefin tuna producing countries ICCAT focussed its data gathering efforts in 2001 on the few places in Japan where bluefin tuna enters the market. The fish traded in Japan are relatively well monitored and their origin is registered. By assuming that fattened tuna gains on average 25% in weight during the time they are kept in farms the

amount of life tuna caught by Mediterranean purse seiners is easily computed by multiplying the quantities of fattened tuna coming from the Mediterranean region with the factor 0.8. It's a rather rough method, but what else is there to do when the industry at its source is not very transparent?

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