CHAPTER 3.1.1: PURSE SEINE	AUTHORS: IEO	LAST UPDATE: Jan. 28, 2008

3.1.1 Description of fishing with purse seine nets

1. General description of purse seine gear and vessels

Pelagic species group together to form dense schools of one or many species (Ariz *et al.* 2001), which has led to the design of fishing gear to catch these schools of fish once they have been found. Hence the appearance of purse seine nets, used to catch these schools that are kept swimming on the surface or close to it. This is the case of the tuna and other small pelagics like the sardine or the anchovy, among others. Originally, these species were caught with traps, hooks, gillnets, sardine nets, etc., but, although these are still used, modern purse seine nets have appeared that allow for larger catches than the aforementioned gear.

Purse seine boats fishing for tuna now make up a very modern fleet that is constantly developing in terms of both size and in their fishing tackle and techniques.

1.a General description of purse seine gear

Gear category: Purse seine
Standard abbreviation: PS
ISSCFG Code: 01.1.0

Length of the gear: Up to 2,000 m
Depth of the gear: Up to 300 m

Purse seine tackle is made up of a trapezoid shaped net made up of a series of horizontal and vertical panels with different sized mesh nets that make up the different parts of the gear. The middle area of the net is called the central body or bag. This is flanked by panels of thicker mesh that form the "cutter" to the stern and the pre-chafer and chafer to the fore that will house the fish once the final bag of the purse seine is formed (**Figure 1**). At either end, the gear has the necessary struts to steer the net to the stern and to close the net to the fore with the help of lines. The material used to make the panels of netting is usually dyed nylon or other kinds of synthetic fibres (Kevlar) and nets are made both with and without knots, although the former are more usual in European boats (Itano 2003). The size of the netting usually varies between 110-150 mm (Doc. Int. IEO-COC 2007).

As "purse seining" is a fishing tackle that is cast vertically and closed at the bottom, it requires buoys or floats to keep it afloat (top rope) that forms a barrier on the surface at the same time, once the net is in the water. These buoys are usually made of cork of plastic and they are usually brightly coloured. The number of buoys will depend on the size of the tackle and the kind of material that the net is made of. To drop the net, there is a steel cable (lower line or weighted line) that runs around the bottom edge of the net, to provide enough weight to keep the gear in a vertical position. To close the net, at the bottom, there is a series of metal rings or ringbolts held by a chain running from strut to strut, through which a steel cable runs, known as the lacing. Once this is tightened, the lacing prevents the fish from escaping from the bottom of the net (**Figure 1**).

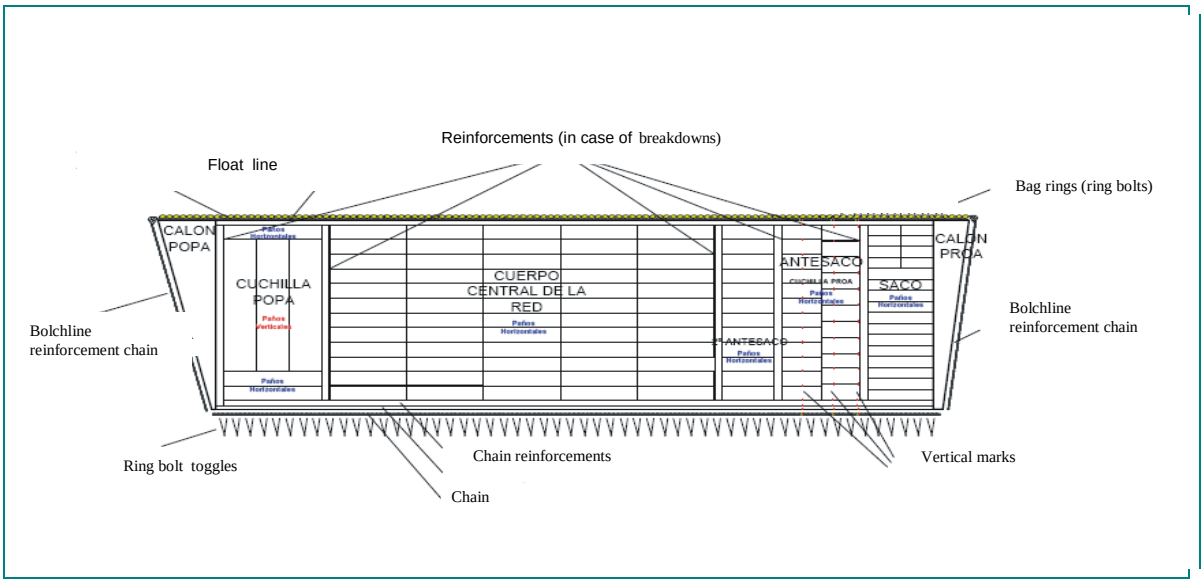


Figure 1. Structure of the purse seine net with lacing used for tropical tuna fishing (calon popa = aft strut; calon proa = fore strut; cuchilla popa = aft cutter; cuerpo central de la red = central body of the net; paños verticales = vertical panels; paños horizontales = horizontal panels; antesaco = bag mouth; saco = bag).

The dimensions of these nets can reach a length of 2,000 m and 300 m in depth. This will vary depending on the characteristics and the power of the boat and the target species. Most of the modern tropical tuna purse seiners fishing in the waters of the Atlantic have nets of around 1,500-1,850 m long and with a depth of 250-280 m (Delgado de Molina *et al*. 2002, Santana *et al*. 2002). In the case of the purse seine nets currently used to catch blue fin tuna in the Mediterranean, they are usually slightly smaller than those used for fishing tropical tuna species (maximum length of 1,800 m and 250 m depth between lines) and the mesh is larger (over 200 mm) (Anon. 2005a).

The net is normally stowed to the stern of the boat and cast off the port side for fishing.

1.b General description of purse seine vessels

Vessel category: Purse seiner
Standard abbreviation: PS
ISSCFV code: 02.1.0

Total length: Between 40-115 m
Hold capacity: Up to 2,000-3,000 m^3

In general, modern vessels have a characteristic silhouette, with a raised crow's nest, the net gear, several decks in the bow half of the vessel, above the water line, a clear bow and a stern fitted with a ramp where both the bug boat (auxiliary boat) and the net are stowed when the trawler is not actually fishing. These vessels usually have fast launches, apart from the bug boat, to help in fishing operations (support in fishing manoeuvres, grouping the school of fish, preventing the school from escaping before the net is closed, etc.)

At the rear of these vessels, there is usually a main deck, two thirds of which is used for stowing the net and for handling the catch. There is a chute running down from this deck to the lower deck for the catch. The lower deck, known as the fish depot, contains the holds where the fish is stored and the conveyor belts or channels that collect the fish dropped down the chute and distributes it to the different tanks.

There is a robust mast in the centre of the vessel, fitted with a crow's nest (observation platform) where part of the visual search systems are located (high resolution binoculars). There is a stanchion fixed to the mast that supports the derrick post of the lead block (steering gear or "yo-yo") that hoists the net aboard (**Figure 2**). The lacing is pulled in by a machine or "*winch*" located on the fishing deck. The net is closed off the port beam to form the chafer by a side roller.

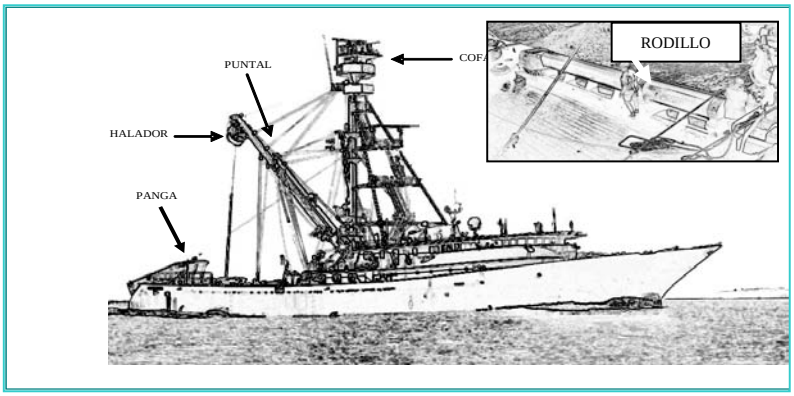


Figure 2. The main parts of the vessels that use purse seine gear (Tuna IEO 2007) (Panga = bug boat; halador = lead block; puntal = stanchion; cofa = crow´s nest; rodillo = roller).

Catches are transferred from the chafer to the deck with the help of a grab net that can hold about 10 t of fish per load (**Figure 3**).

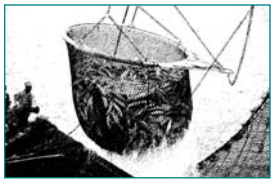


Figure 3. 10 t grab net used in purse seine fishing for tropical tuna (Tuna IEO 2007).

Purse seine boats use most of their facilities for storing the catch, with holds that will vary in number and capacity depending on the length and the beam of the vessel. There are cooling pipes (coils) running along the walls of the holds with cooling liquid running through them (e.g. nitrogen compounds). Purse seine tuna boats fishing for tropical tuna as their target species are vessels that freeze their catch in tanks with brine (salt saturated water) that can reach temperatures of -18ºC to -20ºC. Some recently built purse seiners not only have the conventional tanks, they also have freezing tunnels at -55ºC.

This fleet is equipped with state of the art equipment to locate, catch and conserve the tuna, including a modern communications network that is closely related to the remote sensing systems, which provide satellite information to help locate the schools of fish associated with floating objects fitted with beacons, hence allowing the fishermen to plan their fishing strategy in advance. The bridge is also fitted with radar (even radar for detecting birds as these are often associated with schools of tuna), sonar, sounders and other positioning and detection systems.

The top deck (over the bridge) in many boats is used as a helicopter landing pad, as helicopters were regularly used in the Atlantic and Indian Oceans for locating schools of fish up until the 1990s (Fonteneau *et al*. 1991) (part of the fleet continues to use them in the Pacific Ocean (Itano 2002). More efficient and less costly techniques are used now, thanks to technological developments like the location of floating objects (fish aggregated devices or FADs) by the information sent by the beacons located on them that, in turn, can record information about the presence or absence of fish congregating below the object, together with environmental data (surface temperature, salinity, etc.) (**Figure 4**).

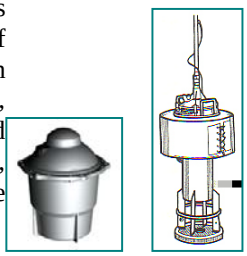


Figure 4. Two kinds of object positioning and location beacons.

The size of the tropical tuna purse seine vessels fishing in the waters of the Atlantic Ocean has increased from a total length of 35 to 40 m to vessels that can now reach a length of 108 m (ICCAT Record of Vessels). In the same way, the size of the gear has also increased from 600 to 800 m in length to 1,900 m and from a depth of 70 m to almost 300 m. With slight variations, the crew of these vessels is usually made up of some 23 people: fishing skipper, captain, bridge officer, chief engineer, 3 greasers, cook and assistant, boatswain, net master and about 12 deck hands.

The target species of the purse seine vessels that fish in the Mediterranean is the bluefin tuna and they are different from the rest of the fleet (Anon. 2005a). These are smaller boats, reaching a maximum of 42 m in length (15-30 m is the usual length) with engines of up to 1800 HP. Instead of the usual stern mast of the purse seiners that fish in Atlantic waters, there is a hydraulic derrick (**Figure 5**). The largest catches of bluefin tuna caught by purse seine fishing in the Mediterranean come from the French fleet. This fleet has developed very quickly since 1985, from wooden boats to custom built metal boats. The hold capacity of these boats is usually between 300-700 t (Sacchi 2001) and the size of the crew has remained the same over the years (12). These boats can remain at sea for a maximum of 10 days.

Figure 5. Purse seine boat fishing in Mediterranean waters.

2. General description of fishing operations with purse seine gear

Tuna fishing using purse seine tackle, mainly for tropical species, started to develop in the 1950s in all the oceans of the world. For the Atlantic Ocean, there are ICCAT statistics that go back to the early 1960s (Fonteneau *et al*. 1991).

Today's purse seine tuna boats can freeze and store up to 200-400 t/day in a series of tanks with a total capacity of up to 3,000 m^3. In some cases, the companies that own the boats bring support or "*supply*" boats into the area to meet the needs of the purse seine boats and to improve their fishing yields, including changes of crew, the placement of objects or supply of gear and, in some cases, acting as tuna aggregating devices by anchoring on submarine mountains (Arrizabalaga *et al*. 2001, Pallarés *et al.* 2002).

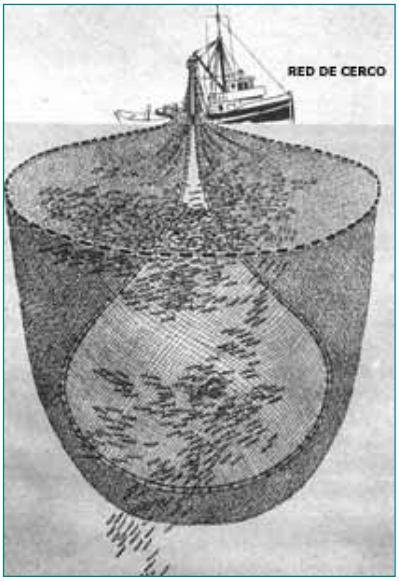
The large purse seine boats can remain at sea for up to two to three months.

Purse seine fishing is usually done by daylight, to be able to locate the schools of tuna. Each operation is called a cast or a drop and it lasts 2-3 hours, depending on the tonnage caught (**Table 1**). The relation between the duration of the cast (**T**) and the size of the catch (**p**) (**T** = a + b**p**) has improved with the improvement in the technology of the tackle (e.g. devices for hoisting the net onboard) (Fonteneau *et al*. 1986).

Table 1. Average duration of the main purse seine manoeuvres in a tuna boat (Doc. Int. 2007, Santana *et al.* 2002).

Manoeuvre	*Usual duration*
Establishing the purse seine	2-4 minutes
Closing the lacing	20-30 minutes
Forming the chafer or bag	1-2 hours
Transfer of the fish	1-2 hours (depending on the amount)

Tuna can be fished from free schools, or from schools associated with floating objects. Signs are used to locate the schools of tuna (whales, dolphins, birds, breeze, etc.). Since 1990, most of the fleet uses objects to attract concentrations of the target species (Bannerman 2001, Morón *et al.* 2001, Pallarés *et al.* 1995). Different kinds of objects can be used (trunks, dead marine mammals, plastic, nets, etc.) The most commonly used artificial objects are made from bamboo poles and panels of netting. These fish aggregated devices (FAD) are monitored by the boat that has "sown" them, using a range of location systems based on beacons that transmit radio signals or by satellite.



Once the school is located, it is visually inspected to assess the size of the school. Sonar can also be used for this, or even an auxiliary launch. The boat then sails around the school of fish at full speed laying the net, which is pulled by an auxiliary launch or "bug boat". The school gradually closes together until they form a chafer (**Figure 6**). It takes from 2 to 4 minutes to lay the net. While this is being done, a fast launch is often placed within the circle formed by the net, next to the floating object, to keep the school in the best position so that it cannot escape before the lacing is closed. In the case of a free school, these launches keep the school of fish together with the noise they make when they sail around it. They may even use dyes to create artificial barriers to prevent the tuna from dispersing and fleeing.

Figure 6. Purse seine net laying manoeuvre (Cifuentes *et al.* 1999).

The net is closed by a lacing (metal line), that is the same length as the cork line, and a series of rings or ring bolts that are hoisted onboard (**Figure 7**). In the 1950s, both the French and the Spanish fleet used the ring system to close the net, but, in the mid-1980s, first the Spanish fleet and later the French fleet replaced this system with the ringbolt system; as this has the advantage of being able to be separated from the lacing by an automatic closing mechanism when the net is hoisted onboard, significantly reducing the friction with the lacing (Itano 2003).

The stern part of the net is hoisted onboard with a *power-block*. On some boats, while the net is being closed, they make noise on the port side (e.g. banging shackles against the deck) to keep the fish away from the window that remains open on the port side before the bow strut is closed (bringing the two lines together).

During the cast, the purse seiner sails the circle that will form the trap (**Figure 8**); while the auxiliary boat, or "bug boat" brings one end of the net (bow strut) to the bow of the boat, moving in the opposite direction from the tuna boat until the circle is closed. The bug boat then keeps the main boat in the right position to prevent the net from collapsing during the fishing operation. This is done by the bug boat pulling the main boat with a line.

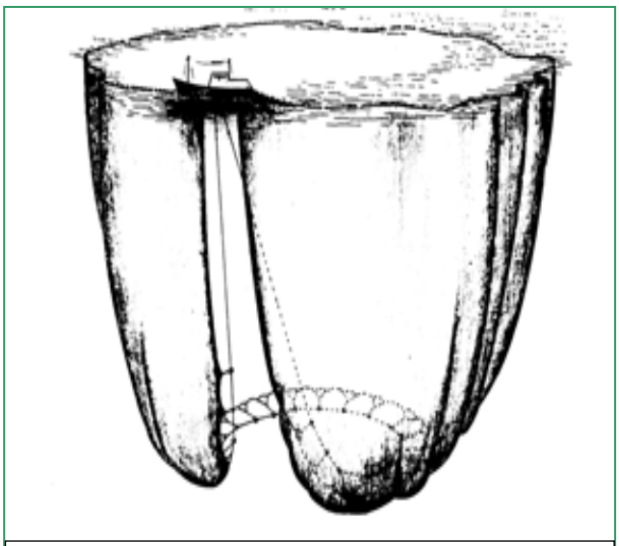


Figure 7. Purse Seine net deployed (FAO 2007).

Once the fish are concentrated in the "chafer" or bag, they are transferred to the deck using a grab net with a capacity of around 10 tonnes. The contents are dumped into a chute hopper leading down to the fishing deck, where the tanks or holds are for freezing the fish.

The purse seine boats that fish in the Mediterranean, when pulling in the net, generally close the circle without using all of it, to prevent the tuna from getting away in a sudden change of direction. The chafer is not fully formed normally in this kind of fishing, with a view to keep the fish alive and in good condition to take them to fattening farms.

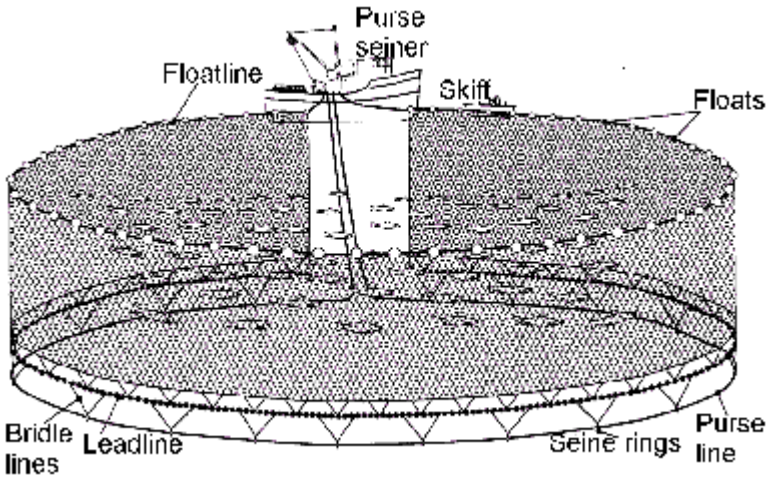


Figure 8. Typical manoeuvre with purse seine gear (Hanrahan *et al.* 1997)

3. Main Atlantic fisheries

3.a Special gear/vessel characteristics

3.a.1 Temperate tuna

As far as temperate tuna are concerned, and particularly for the bluefin tuna in the Mediterranean, fish farming started for this species in the late 1970s in Ceuta (near Gibraltar), copying the style used in Canada in the 1960s. At the end of the 1980s, both adult and juvenile specimens could be sold at slightly lower prices than today (Miyake *et al*. 2003). After 1997 (Anon. 2007), most of the specimens of this species that are caught go directly into fattening cages, where they remain until the fish reaches the desired weight and/or market conditions (price, availability, etc.) are optimum. There are currently a large number of bluefin tuna fattening "farms" throughout the Mediterranean Sea.

There are now fattening cages for bluefin tuna in many ports of the Mediterranean countries, including: Ceuta (since 1979) and Murcia (since 1996) in Spain, Croatia (since 1996), Malta (since 2000) and Italy (since 1999) (Miyake *et al*. 2003), among others.

3.a.2 Tropical tuna species

The main tropical tuna purse seine fleets fishing in the Atlantic Ocean presently sail under European flags (Spanish and French). The size of both the purse seine net and the boats is slightly smaller than those of the fleets of these same countries that fish in the Pacific and Indian Oceans (Doc. Int. IEO-COC 2007). Since many purse seine boats left for the new fishing grounds of the Indian Ocean in the early 1980s (Anon. 1985), there has been a smaller number of vessels that have stayed in the Atlantic Ocean, and these are generally smaller and older than the aforesaid fleets.

One peculiarity of the Ghana fleet is the fact that many of these purse seiners fish in close collaboration with live bait boats (which fish basically with FAD) (ICCAT 2008, Bannerman *et al.* 2005). Once the catch is frozen onboard the purse seine boat, it is then transhipped to the bait boats belonging to the same company at sea, so that the purse seine boat only has to return to port when it needs supplies, and not when the holds are full.

3.b Flag states involved

Table 2 below shows a list of countries have made catches of the different kinds of tuna species targeted by purse seine fishing (1950-2005), with countries that reported at least some annual catch from 2000 to 2005 highlighted in bold type:

Table 2. Flags involved in purse seine fishing (PS) in the period 1950-2005 (Anon 2008).

	Species (FAO Code)											
Country	*BFT*	*YFT*	*ALB*	*BET*	*BLF*	*LTA*	*SKJ*	*BON*	*BOP*	*WAH*	*SSM*	*KGM*
Dutch Antilles		**x**	**x**	**x**		**x**	**x**					
Algeria	**x**					**x**		**x**				
Argentina							x	x				x
Brazil		**x**	**x**	**x**		**x**	**x**	**x**				**x**
Cape Verde		**x**				**x**	**x**			**x**		
Canada	x	x		x		x	x					
Cyprus	**x**											
Colombia		x					x					
Congo		x		x			x					
Croatia	**x**					x		x				
Cuba		x		x		x	x					
Egypt								**x**				
Spain	**x**	**x**	**x**	**x**	x	**x**	**x**	x				
USA	**x**	x	x	x	x	**x**	x	x			**x**	x
Russian Fed.		**x**		**x**		x	**x**					
U.S.S.R.		x	x	x		x	**x**	x				
Yugoslav Fed			x			x		x				
France	**x**	**x**	**x**	**x**	x	**x**	**x**	x				
Ghana		**x**		**x**		**x**	**x**					
Greece	**x**		**x**			**x**	**x**	**x**				
Guatemala		**x**		**x**			**x**					
Cayman Islands		x					x					
Italy	**x**											
Japan		x	x	x			x					
Libya	**x**			x		x		x	x			
Malta	**x**											
Morocco	**x**	x	x	x		**x**	**x**	**x**	**x**			
Norway	x	x		x			x					
Panama	x	**x**	**x**	**x**		x	**x**					
Portugal	**x**	**x**	x	x		**x**	**x**	**x**	**x**			
Repub. of Korea	**x**											
Senegal						**x**	x	x				
Serbia and Montenegro	x					**x**		**x**				
South Africa	x		x	x			x	x				
Tunisia	**x**											
Turkey	**x**		**x**			**x**		**x**				
Venezuela		**x**	**x**	x	**x**	x	**x**					
Yugoslavia	x											

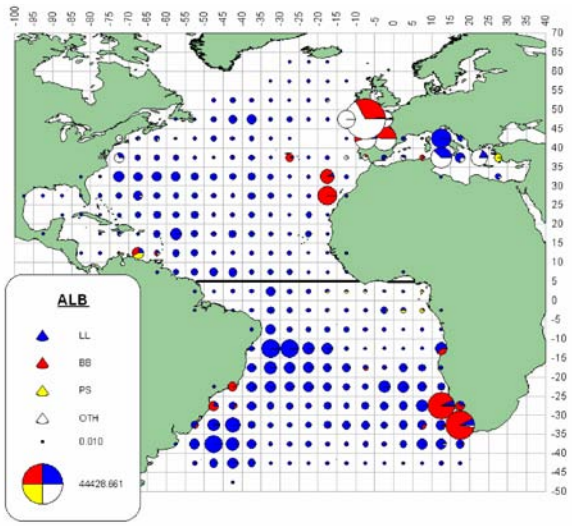
In recent years, in tropical purse seine fisheries, the countries registering the largest catches of the three species (yellowfin, skipjack and bigeye) are: Spain, France and Ghana, in the eastern Atlantic, and Venezuela in the western Atlantic.

Concerning the countries involved in purse seine fishing of temperate species, it should be pointed out that the country that catches the most bluefin tuna is France, followed by Italy and Spain, and Greece reports the largest catch of albacore.

3.c Areas in which purse seine boats operate in the Atlantic Ocean

The zones in which purse seine boats operate in the Atlantic Ocean are determined by the areas of distribution and the abundance of the different target species. The maps below show the origin of the catches of the different species made recently.

3.c.1 Temperate tuna fisheries: (albacore: Thunnus alalunga *and bluefin tuna:* Thunnus thynnus*)*



Albacore are occasionally caught by the purse seine fleet in different areas of the Mediterranean Sea (ICCAT 2007b) (**Figure 9**).

Figure 9. Geographic distribution of albacore catches in the Atlantic Ocean in the period 2000-2004, by type of gear (ICCAT, 2007c).

The main fleet that catches **bluefin tuna,** as a target species, uses purse seine tackle, and fishes in Mediterranean waters. Catches have increased in recent years as many of the specimens caught by this fleet are then transferred to fattening cages (Anon. 2007).

The U.S.purse seine fleet is found in the western Atlantic, operating mainly in the Gulf of Maine waters (40ºN-45ºN), in Cape Cod Bay and between Cape Cod and Cape Hatteras (NMFS 2002) (**Figure 10**).

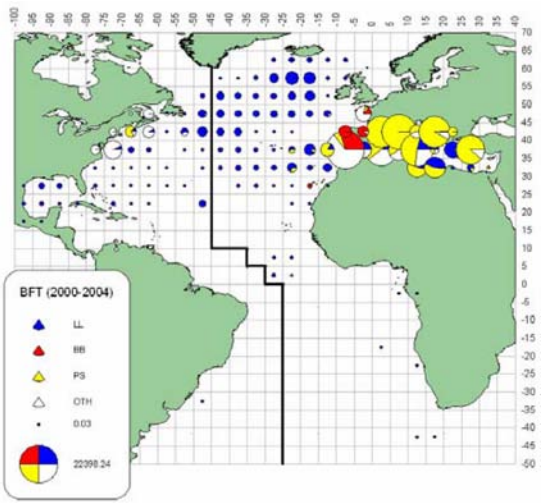


Figure 10. Geographic distribution of bluefin tuna purse seine catches in the Atlantic Ocean 1950-2004 (ICCAT, 2008b).

3.c.2 Tropical tuna fishing (yellowfin: Thunnus albacares*, bigeye:* Thunnus obesus *and skipjack:* Katsuwonus pelamis*)*

The most important purse seine fishing in the Atlantic Ocean targets the tropical tuna species, especially the fisheries of the eastern Atlantic. This fishing is done in tropical waters, between parallels 20ºN-15ºS, and between the west coast of Africa and meridian 30ºE (**Figure 11**). Catches of skipjack tuna in this zone are made

above all by using floating objects (although there are also large catches from free schools), while catches of yellow fin using this technique are very small in comparison with the total catch of the species, and the big eye is caught almost exclusively when it is associated with floating objects (Ariz *et al*. 2000).

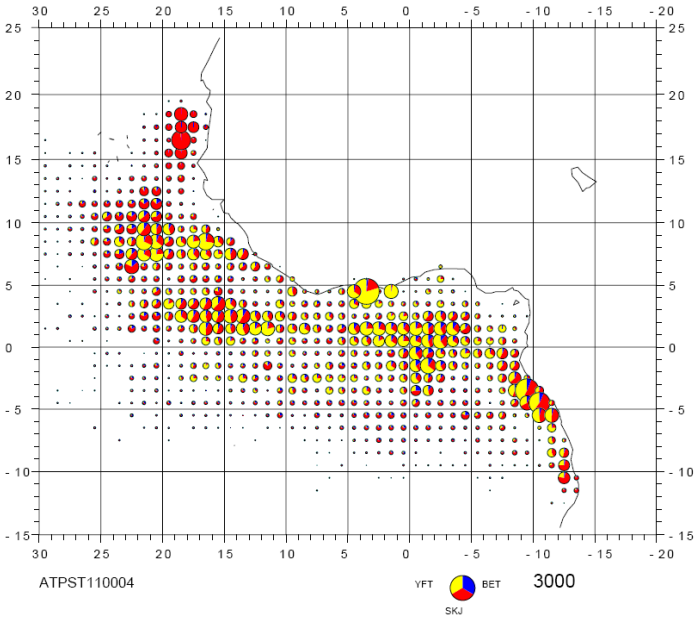


Figure 11. Geographic distribution of tropical tuna catches in the eastern Atlantic Ocean by the European purse seine fleet 2000-2004 by species (Pianet *et al.* 2007).

There is also purse seine fishing targeting tropical tuna species in the western Atlantic Ocean, basically comprising Venezuelan purse seine boats. Catches are made in coastal areas close to the coasts of Venezuela (5ºN-15ºN). The main species caught are the yellow fin and the skipjack tuna.

A new purse seine fishing activity has recently started in Brazil, with boats based in the ports of the southern coast of Brazil, targeting the skipjack tuna (ICCAT, 2007a).

The tropical purse seine fleet makes sporadic catches of albacore over free schools, both in the Eastern and the western Atlantic Ocean. These are made by the European and Venezuelan fleets respectively (Anon. 2004a, ICCAT Task I) (**Figure 11**).

3.d Seasonality

3.d.1 Temperate tuna species

In the case of the U.S. purse seine fishing, catches of bluefin tuna are highly seasonal. Almost 80% of the catch is made in the months of July and August (**Figure 12**).

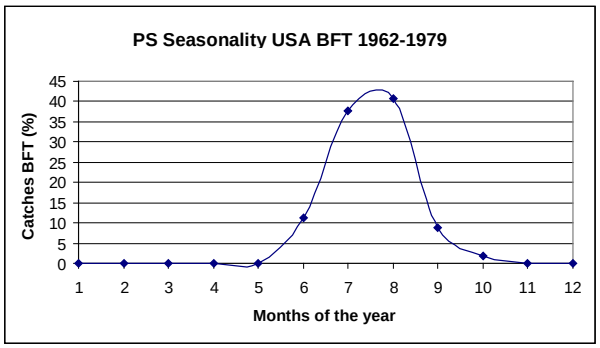


Figure 12. Monthly catches (%) of blue fin tuna by the U.S. purse seine fleet in the western Atlantic Ocean, 1962-1979 (Anon 2008).

The largest catches of bluefin tuna in the Mediterranean Sea are generally made in summer and autumn (**Figure 13**).

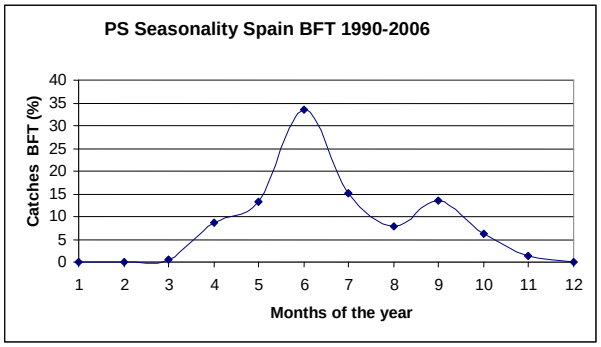


Figure 13. Monthly catches (%) of bluefin tuna by the Spanish purse seine fleet in the Mediterranean Sea, 1990-2006 (Anon 2008).

3.d.2 Tropical tuna species

Eastern Atlantic

From free schools, the purse seine boats catch large **yellowfin tuna** in the equatorial region during the first quarter of the year, coinciding with both the area and the time of spawning. The best catches of yellowfin are usually made in the months of February, March and April, with this period accounting for about 44% of yellowfin catches. **Figure 14** shows the monthly catches of yellowfin by weight category. These catches show the following: the heaviest yellowfin (YFT3: > 30 kg) dominate the catches of this species in all months of the year, with the largest catches obtained in the months of February, March and April (50% of the annual total of this category). The category YFT1 (< 10 kg), the second largest in catches throughout the year, is caught more in the months of September, October, November and December (42% of the annual total of this category) and the intermediate weight yellowfin, category YFT2 (10-30 kg) are the least abundant in all months of the year. The maximum catch of this category are obtained in the months of July, August and September (Ariz *et al*. 2003). Catches of yellowfin associated with floating objects are very occasional and small in relation with the total catch of the species. The largest catches are obtained in the first six months of the year from free schools, especially in the Equator zone (Ariz *et al*. 2000).

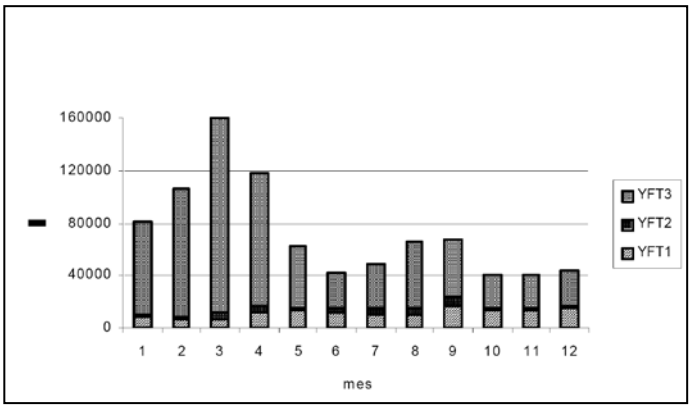


Figure 14. Monthly purse seine catches in the eastern Atlantic Ocean 1991-2001 by yellowfin weight category (Ariz *et al.* 2003).

As we can see in **Figure 15**, the largest catches of yellowfin tuna for the Ghana purse seine fishing fleet, are obtained in the second six months of the year.

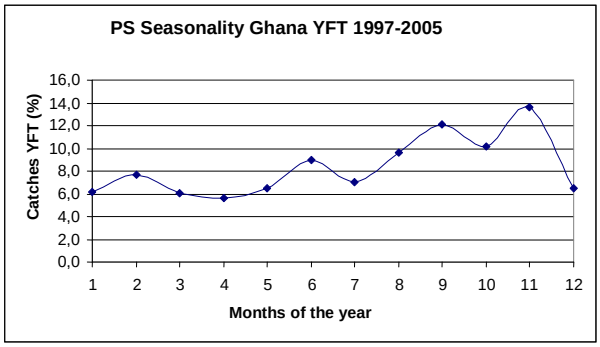


Figure 15. Monthly catches (in %) of yellowfin tuna by the Ghana purse seine fleet in the eastern Atlantic Ocean, 1991-2006 (Anon 2008).

The **bigeye** is caught by the purse seine fleet almost exclusively when associated with floating objects. There is a pronounced seasonality to the catches. Catches are minimal in the third quarter of each year (**Figure 16**). The largest catches come from the Equator zone (Ariz *et al*. 2000).

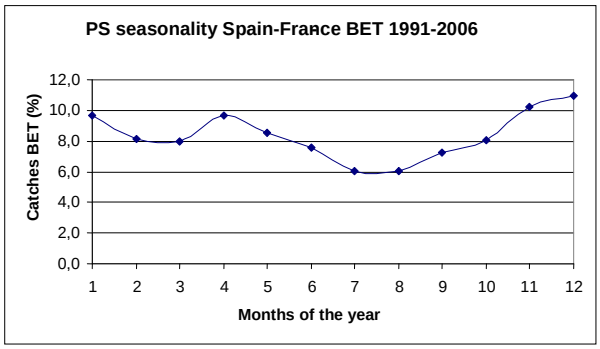


Figure 16. Monthly catches (%) of bigeye tuna by the Spanish and French purse seine fleet in the Eastern Atlantic Ocean, 1991-2006 (Anon 2008).

Catches of **skipjack tuna** are obtained above all, when they are associated with floating objects. There is a pronounced seasonality in catches of free schools, in the second and third quarters of the year, in the areas of Senegal and Cape Lopez respectively. Floating objects are used for fishing especially in the first and fourth quarter of the year, and the skipjack tuna is the dominant species, with lesser amounts of yellowfin and bigeye (**Figure 17**) (Ariz *et al*. 2000).

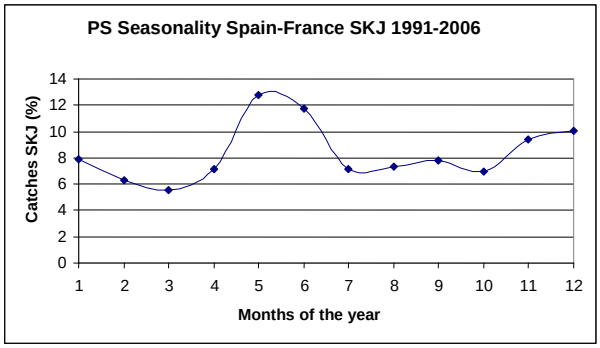


Figure 17. Monthly catches (%) of skipjack tuna by the Spanish and French purse seine fleets in the eastern Atlantic Ocean, 1991-2006 (Anon 2008).

Overall, the Senegal, Equator and Picolo zones (tropical purse seine sampling zones) account for most of the catch of skipjack tuna, although the first of these is exclusively for free school catches (**Figure 18**) (Ariz *et al.* 2000).

Figure 18. ET zones. Spatial strata considered in the work of Ariz *et al.* 2000.

Western Atlantic

There is far less purse seine fishing in the western Atlantic than in the eastern Atlantic, with very small catches of bigeye tuna (less than 500 t/year). Western Atlantic purse seine fisheries are run fundamentally by the Venezuelan fleet.

For both the yellowfin and the skipjack, the maximum catches are recorded in the months of October and November, and the minimum catches in the second quarter of the year (**Figure 19**).

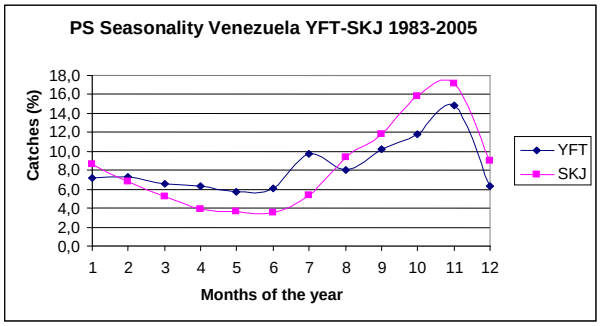


Figure 19. Monthly catches (%) of yellowfin and skipjack tuna by the Venezuelan purse seine fleet in the western Atlantic Ocean, 1983-2005 (Anon 2008).

3.e Target species and size composition

The main species of tuna caught by boats using purse seine gear are as follows:

- Bluefin tuna (*Thunnus thynnus*)
- Yellowfin tuna (*Thunnus albacares*)
- Bigeye tuna (*Thunnus obesus*)
- Skipjack tuna (*Katsuwonus pelamis*)

While bluefin purse seine fishing basically only catches this species, the purse seiners fishing for the tropical species differ in the species composition of the schools, depending on whether they are associated with floating objects or whether it is a free school. When using floating objects, smaller sized specimens are caught from schools made up of a range of different species. In general, tropical tuna purse seine fishing has historically used the yellowfin and skipjack tuna as their target species. The bigeye and other small tuna (frigate tuna and the Atlantic black skipjack) have formed a large part of the by-catch (Anon. 2001a).

3.e.1 Temperate tuna species

In the Mediterranean Sea, the Spanish purse seine fleet catches specimens of **bluefin tuna** with an average size of 85 cm FL (Com. pers. Rodríguez-Marín 2007). The French fleet operating in the Gulf of Lyon and in the Sea of Liguria, catches basically juvenile specimens (Fromentin and Farrugio 2005) with a weight of 10-30 kg (between 78 and 114 cm FL) between spring and autumn, and specimens of 140 and 250 kg (around 200 cm FL) in the Balearic Islands, in the months of June and July. The Turkish fleet catches specimens with an average size of 145 cm (Anon. 2003). In the centre and south of the Tyrrhenian Sea, the purse seine fleet catches specimens with an average length of 173.5 cm (Di Natale *et al.* 2005).

In the western Atlantic, bluefin tuna fishing by the United States fleet is located between Cape Hatteras and Cape Cod, targeting mainly young specimens of bluefin, while the purse seine fishing off Cape Cod Bay targets adult specimens (NMFS 2002).

The **albacore** is not a target species in the Atlantic, and only a low percentage of this species is caught as by-catch (**Figure 20**). The tropical purse seine boats that operate in the oriental zone sporadically make very small catches of this species, with sizes in the range of 85-115 cm FL (Sarralde *et al.* 2003).

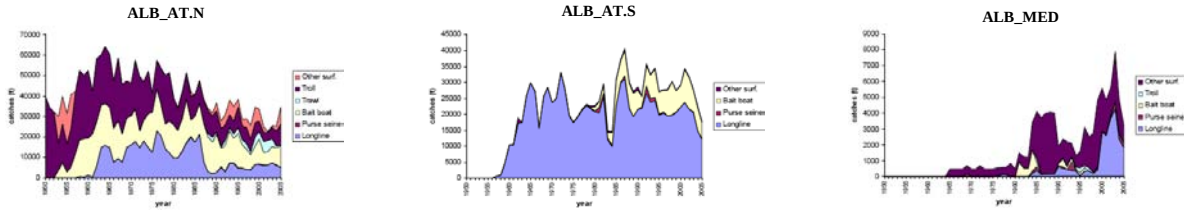


Figure 20. Landings of albacore in the North and South Atlantic and the Mediterranean by gear used, 1950-2005 (ICCAT, 2007c).

3.e.2 Tropical tuna species

From free schools, the main species caught is the yellowfin (with a size of around 150 cm FL), followed by the skipjack (around 46 cm FL); while, in catches with FADs, the skipjack accounts for over 70% and the yellowfin and bigeye (juvenile specimens of around 46 cm FL) represent nearly 15% of each catch (Anon. 2001b, Ménard *et al*. 2000).

Figure 21 shows the average weight of tropical tuna species caught by the European and Ghanaian purse seine fleets from free schools and associated with floating objects. In the case of catches by the Ghanaian boats, the average weight and lengths of the three species are very similar; all of them are small sizes. Concerning catches by other purse seine fleets, there is a pronounced difference in the case of the yellowfin and the big eye caught from free schools (yellowfin: 140-150 cm FL; big eye: 80 cm FL). These sizes are larger than those obtained from FAD fishing (yellowfin and bigeye around 50 cm FL) (Anon. 2004b).

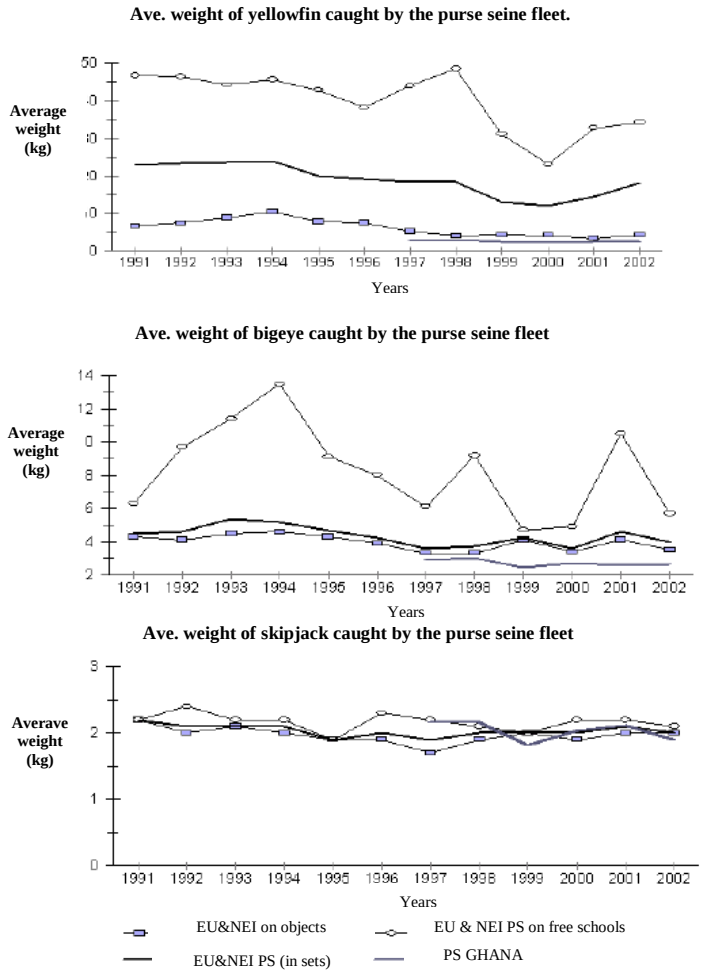


Figure 21. Average weight of tropical tuna caught by purse seine fleets (Anon. 2004b).

Yellowfin tuna

Purse seine fleet catches of yellowfin tuna in the eastern Atlantic are characterised by presenting a bimodal distribution in size classes, with sizes of nearly 50 cm and 150 cm FL, but with very few intermediate sizes (75-95 cm FL) and a high proportion of large fish (over 160 cm FL). The fish caught over free schools present an average weight of about 34 kg (120 cm FL), while those caught with floating objects present an average weight of about 4 kg (58 cm FL), which gives an overall average weight of 18 kg (97 cm FL) (Anon. 2004c, Ariz *et. al.* 2003) (**Figure 22**).

In the western Atlantic, size ranges are smaller than catches from the Atlantic (from 40 to 140 cm FL), with an average weight of 14 kg (89 cm FL) and most show an intermediate, rather than bimodal, distribution of sizes (Anon. 2004c).

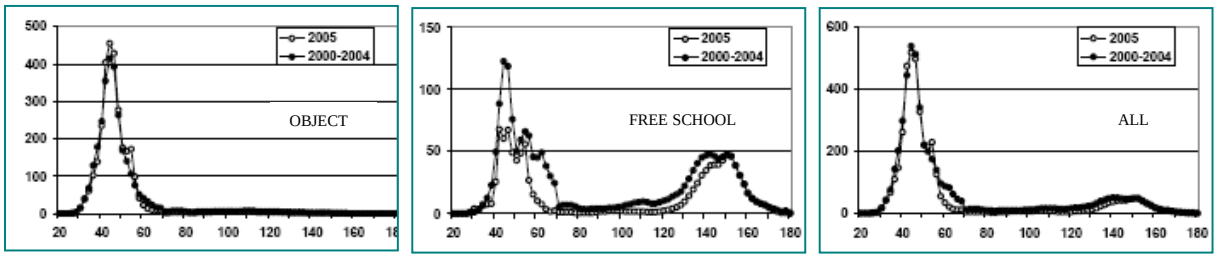


Figure 22. Distribution of sizes of yellowfin (in number), caught by the European purse seine and associated fleets in 2005 and in the period 2000-2004 (Pianet *et al.* 2007).

Bigeye tuna

Purse seine tackle catches specimens of **bigeye tuna** with sizes ranging from 35 to 160 cm FL.

The bigeye catch is principally composed of juvenile specimens (35-65 cm FL) with an average weight of 4 kg (56 cm FL) (**Figure 23**) (Anon. 2005b).

Most of the catch is obtained with floating objects and in mixed schools that include specimens of skipjack and yellowfin tuna too.

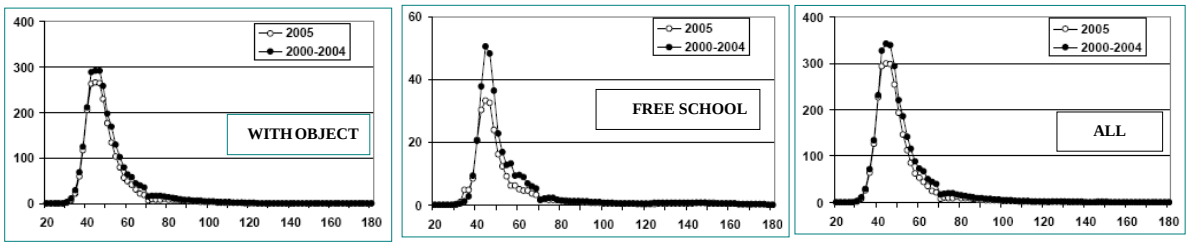
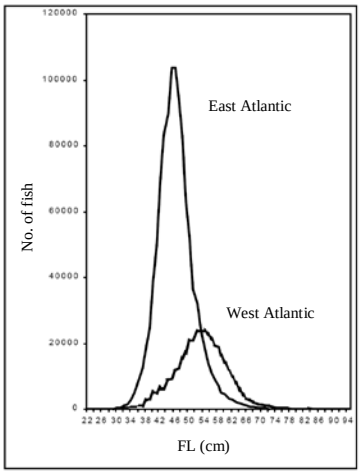


Figure 23. Distribution of sizes of big eye tuna (in number) caught by the European and associated purse seine fleets in 2005 and in the period 2000-2004 (Pianet *et al.* 2007).

Skipjack tuna

Purse seine fishing catches specimens of skipjack tuna of 30-80 cm FL.

The composition by sizes of the catches of **skipjack** in the Atlantic shows that, in the eastern zone, 37% of skipjack catches are below this size (45.5 cm FL on average), while in the western zone, catches are made up fundamentally of large specimens, with 11% below 45 cm FL (52.5 cm FL on average) (**Figure 24** (Anon. 2000).



3.f Tuna storage/processing

The different species of tuna caught by purse seine fishing undergo a range of different storage and processing procedures, depending on the species and the fleet that catches it. In general, the **tropical tuna** are canned, while much of the **temperate species** are eaten fresh (after being fattened in cages for the *sashimi* market), although they are also processed for the canning industry (salted, filleted, roe, etc.).

Figure 24. Skipjack catch, in number of specimens, by size interval in the eastern and western Atlantic, 1980-1998 (Anon. 2000).

The tuna industry

In general, the tuna fishing industry is linked to the canning industry to a certain extent, although there are many companies that are devoted solely to fishing and which have no canning interests whatsoever.

The tuna market is now a global market, with intermediaries that buy the tuna from the fishing companies and offer it to the processing industries.

The major regional markets are Europe, Japan and South East Asia and the United States. The main products that use tuna as the raw material are:

- **fresh** and refrigerated tuna, most of which goes to producing *sashimi* and fillets of tuna;
- **frozen** tuna, most of which is used for making canned tuna, together with *sashimi* and fillets; tuna steaks, semi-processed products (pre-cooked and frozen) obtained near to the production sites in the developing countries and used in the tuna canning industry in the developed countries.

The best known final tuna product is canned or bottled tuna, preserved in vegetable oil, brine or in water.

The European Union is the largest market in the world for canned tuna. Average consumption in the EU is 1.51 kg per inhabitant per year. In Spain, this figure reaches 2.18 kg (FIAC). For canned tuna production, Spain, France and Italy are the three European countries with the largest production. Other producing countries include: Thailand, Ecuador, Colombia, El Salvador, Seychelles, USA, Côte d'Ivoire and Senegal (Catarci, 2003).

The best quality canned tuna (yellowfin and albacore and some skipjack) is processed in solid packs, while most skipjack is processed in chunks. There is also a range of different products that contain tuna, within the category of preserved tuna: tuna salads, tuna in sauce, etc. New products made with tuna are continually being developed. Pouch packs of tuna have recently appeared on the market.

Sashimi is a raw product made from fresh and refrigerated or deep frozen tuna at -55º C that is highly appreciated by the Japanese market and successfully exported to North America and Europe. The best quality *sashimi* comes from the largest specimens of bluefin tuna, caught with long lines and other techniques that minimise the impact caused on the fish. Due to the high demand for tuna sashimi in the last ten years, and the shortage of resources, which are also controlled by means of quotas, the main producers of bluefin tuna like Spain, Italy, France, Croatia, Turkey, Australia and New Zealand, successfully developed the technique of fattening the fish in cages for export to Japan and other consumer countries.

Other products include dried and smoked tuna, consumed mainly in Japan (*fushi*), fillets, paste and, in the Mediterranean, dried tuna roe (*bottarga*).

Finally, the waste materials from processing the tuna are, in turn, processed into animal feed.

3.g Landing ports

In the case of the **bluefin tuna**, in the Mediterranean Sea, it is caught by the purse seine fleet and most of it is then taken to floating cages situated all along both the European and African shores and the off-lying islands (Malta, Cyprus, Crete, etc.). Landings of bluefin by the Spanish purse seine fleet are made principally in several ports of the Mediterranean coast: Catalonia, Balearic Islands, Alicante and Valencia – along the Spanish coasts and France (Port-Vendres and Séte) (Com. pers. Rodríguez-Marín 2007).

Bluefin tuna catches made in the western Atlantic by the U.S. and Canadian purse seine fleets are presently landed in New Bedford, Gloucester and Sandwich (Massachusetts); although, during the 1970s, these catches were landed in several ports in the United States, California and Puerto Rico (NOAA 1999).

The main landing and transhipment ports for **tropical tuna** in the eastern Atlantic are situated along the African coasts: Abidjan (Côte d'Ivoire), Dakar (Senegal) and Tema (Ghana), all of which have tuna processing factories. The European purse seine fleet also lands its catches occasionally in the port of Sao Tomé (Sao Tomé y Príncipe). The Spanish fleet also occasionally uses the Galician ports of La Puebla and Sta. Eugenia de Ribeira.

In the western Atlantic, the largest purse seine fleet sails under the Venezuelan flag, so it lands most of its catch in the Venezuelan port of Cumaná (FAO 2005a).

3.h Historic trends

3.h.1Nominal effort

3.h.1.a Temperate tuna

For **albacore** which, as already mentioned, is not a target species for the purse seine fleet, there is no estimate of the effort devoted to this species.
For purse seine fishing of **bluefin tuna** in the Mediterranean Sea, mainly conducted by French purse seine boats, the nominal effort, in number of boats, shows a rapid increase in the number of vessels, reaching a peak at the beginning of the 1970s, before stabilising at that level until 2000.

For the United States purse seine fleet fishing for bluefin tuna in the western Atlantic,, shows a rapid increase in nominal effort, reaching its peak in 1972, when it starts to fall off, with several fluctuations which, in 1986, lead to a minimum effort being devoted to this species, a situation that continues today (**Figure 25**).

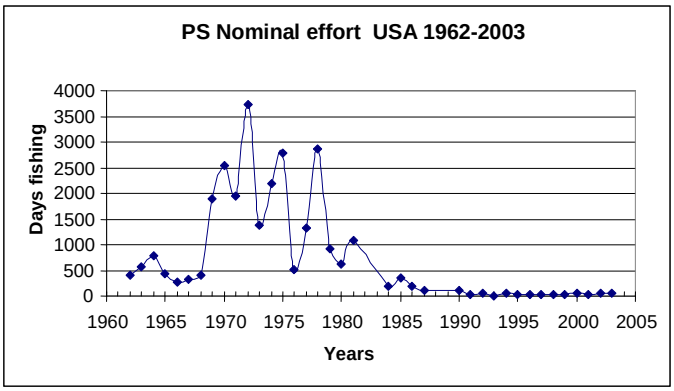
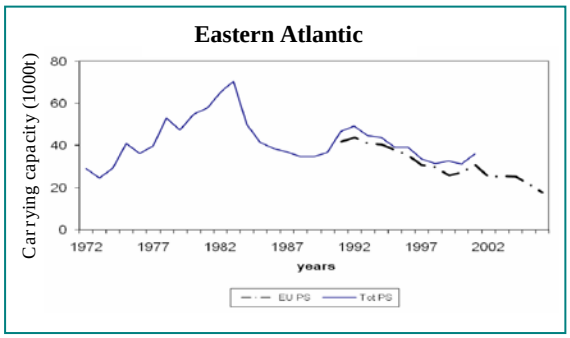


Figure 25. Effort made by the United States purse seine fleet, in days of fishing, in the period 1991-2002 (Anon. 2008).

3.h.1.b. Tropical tuna

In the Atlantic Ocean, purse seine fishing of tropical tuna species started in the 1960s with the transformation of the pole and line boats (Spanish and French) that had moved down to tropical Africa, operating from the ports of Dakar and Abidjan. The purse seine fleet later grew in number and size of boats, while also extending its working area.

The units of nominal effort normally used are days at sea and days of fishing, together with the number of vessels present on the fishing grounds. Another unit of nominal effort is carrying capacity, in tonnes, bearing in mind the time that each vessel is present each year on the fishing grounds and the size of the cargo holds.



This index shows a constant increase in carrying capacity, reaching a maximum in 1983 (70,000 t), before dropping sharply until the early 1990s, when there is a slight increase before starting to fall off again (**Figure 26**).

Figure 26. Carrying capacity (1,000 t) for the entire purse seine fleet that operates in the eastern Atlantic (1972-2006) (ICCAT, 2008d)

The nominal effort in days of fishing since 1991 shows a similar trend to the figures for carrying capacity in recent years (**Figure 27**).

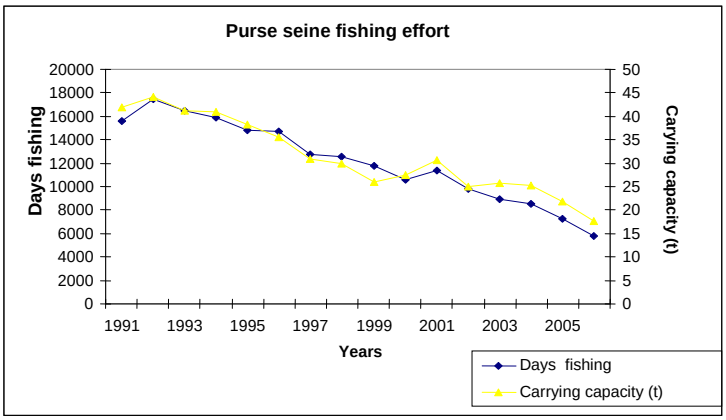


Figure 27. Transport capacity and fishing effort (days of fishing) per year for the European fleet and associates, 1991-2006 (Pianet *et al.* 2007).

In general, the global nominal effort of the tropical purse seine boats is well known, but it is difficult to apply separately to each species that makes up the catch for purse seiners, especially since the mass introduction of FADs.

In the western Atlantic, the nominal effort of the Venezuelan purse seine boats has remained stable over the last 20 years at a slightly lower level than the effort made in the eastern Atlantic (**Figure 28**).

Figure 28. Venezuelan purse seine fleet effort, in days of fishing, in the period 1983-2005 (Anon. 2008).

3.h.2 Technological changes in the gear and in the boats

Up until the mid 1960s, many of the boats fishing for tuna used pole and line and live bait. Many of these were adapted to use the purse seine net and, later, boats were specifically designed and built to use only this tackle.

A major step forward in this sense, was the use of the hydraulic derrick in the 1960s, the progressive increase in the power of the winches, changes in the size and components of the net, the introduction of the bird detection radar in 1987, the introduction of FADs as a fishing method and the use of auxiliary launches (boats that attract fish and co-operate with the purse seine boats with FAD, etc.) (Miyake, 2004).

Purse seine gear has progressively taken on board new technologies aimed at improving manoeuvre times and strategies. The purse seine net has gradually increased in size, as the purse seine boats have done the same. In any event, few modifications have been made to the net itself.

One of the most important changes has been the adoption of the system of ring bolts to close the lacing by all fleets (in the mid 1980s), replacing the classical rings used by vessels prior to this (Delgado de Molina *et al.* 1999) (**Figure 29**). The ring bolt, with its closing mechanism, can be easily separated from the lacing once hauled aboard, saving a lot of time in the manoeuvre. It also prevents the net from opening accidentally.

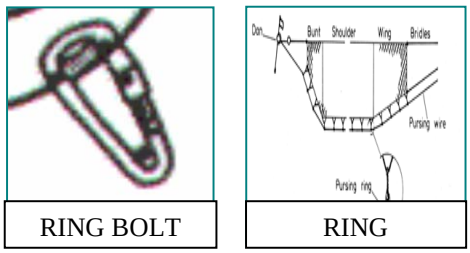


Figure 29. Ring bolt (left) and ring (right) for closing the lacing of the purse seine net.

The size of the grab nets has also changed, growing in its capacity to haul the fish aboard (up to just over 10 t). The power of the auxiliary winches has also increase, as has the main engine of the boat itself. All this has led to a major reduction in the time it takes to conduct the fishing manoeuvre and an increase in the speed of the boats.

There has been a clear development of the boats, especially with regard to the tuna detection and location systems. The height of the observation platform or crow's nest has also increased in recent years, making it easier to search for signs (birds, marine mammals or breezes). Since the times when binoculars were used to

detect signs indicating the presence of schools, several means of detection have been used by the fleet. In the early 1980s, aerial location systems were used relatively frequently (helicopters and light aircraft) (Delgado de Molina *et al.* 1999). Towards the end of the 1980s (1987), bird location radars became widespread. This was because these birds were often associated with schools of tuna. Satellite positioning systems (GPS) have improved substantially, providing boats with much better estimates of their position, navigation, location and the situation of objects, etc. (Itano 2003). With the introduction of floating objects in the 1990s, many different instruments have been fitted on the bridge of boats to locate and follow these (both by radio and by satellite). Moreover, new echo-sounders have come onto the market, together with more powerful and more accurate sonars and a large number of satellite environmental information receivers (chlorophyll, temperature, etc.).

Today's purse seine manoeuvre, described in point 2 of this Manual, is a widespread general technique for the purse seine fleet fishing for tropical tuna in the three oceans. There were some variations that can be mentioned however. These were practised in the Atlantic Ocean, but are no longer used. These include:

- A particular form of purse seine fishing used between 1965 and 1975 by Japanese boats (Marcillé 1969), that consisted in several groups of 3-4 boats. In each group, the two main boats sailed along carrying a net that was 2,000 m long and 240 m high. The two boats would sail apart and surround the school with the help of the other units that made up the group.
- Another manoeuvre consisted of using a large buoy that was thrown into the water carrying the bow strut of the net and acting as a reference point for completing the circle, a buoy was used instead of the current bug boat for setting the net.
- Up to the 1960s, a peculiar form of purse seine fishing for tropical tuna off the African coasts consisted in a partnership between purse seine boats and live bait boats. The latter would hold the tuna in place using live bait.

Although the use of floating objects for tuna fishing was not entirely unknown to the fleet, it was not until the early 1990s (MFRD, Ghana 2005) that the mass use of artificial objects was introduced in the tropical zones of all the oceans (**Figure 30**) to congregate tuna and locate them rapidly with beacons of different types.

The use of FADs DCP (fish aggregation devices or artificial floating objects) has changed the fishing strategy of the purse seine fleet, and thus, to locate the school of fish, purse seine fleets now follow both visual signs and positioning systems (radio or satellite signals). The bird detection radar even allows the boats to receive signals from the radio beacons situated on the floating objects (Itano 2003). Other equipment like the sonar, can also determine the size of the school of fish, the direction they are moving in and the depth. This has led to both qualitative changes (increase in the catch of juveniles, mixed schools associated with objects with the presence of bigeye, etc.) and quantitative changes in fishing (high catch per cast, fall in the number of failed casts, etc.). An example of this is the fact that helicopters are no longer used to locate free schools of fish.

In 1993, a study by Gascuel *et al.* found that, although it is extremely difficult to assess the potential increase in efficiency of purse seine fishing with statistical methods, this same study estimated a 3% annual increase, attributed fundamentally to the mass introduction of bird detection radars and the improvements made to the nets.

In the case of the temperate tuna, technological advances have progressively been introduced to the fleet that catches them. Concerning the dimensions of the net, the French fleet in particular has increased these dimensions from 600 m long, 70 m deep and 180 mm mesh in the 1960s, to 2,000 m long, 230 m deep and 240 mm mesh size in 2000. The purse seine fleet operating in the Mediterranean Sea fishing for blue fin tuna occasionally uses aerial resources (aircraft) to detect schools of fish (Sacchi 2001).

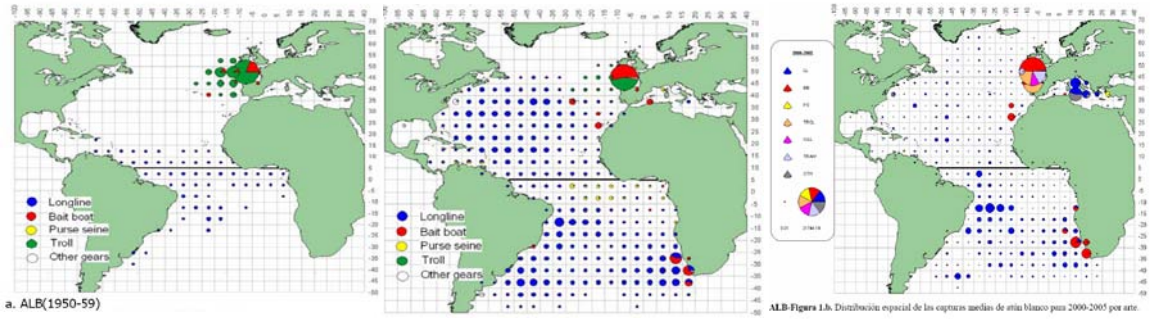
Figure 30. Artificial object or fish aggregation device (FAD), regularly used in tropical purse seine fishing (Tunas IEO 2007).

3.h.3 Fishing zones

Below is a presentation of maps with the geographic distribution of catches of albacore, bluefin tuna, yellowfin tuna, bigeye tuna and skipjack tuna (**Figures 31 to 35**), in different decades, from the first catch data recorded in the ICCAT database, to the current day.

3.h.3.a Temperate tuna

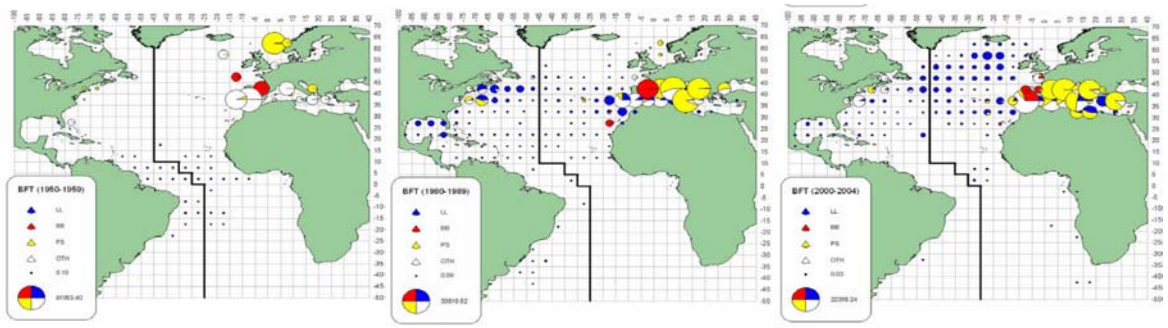
Albacore



a. ALB (1950-59) b. ALB (1980-89) c. ALB (2000-05)

Figure 31. Geographic distribution of albacore catches (ALB) by the main fishing techniques and by decades (1950-2005) (ICCAT, 2008a).

Bluefin tuna

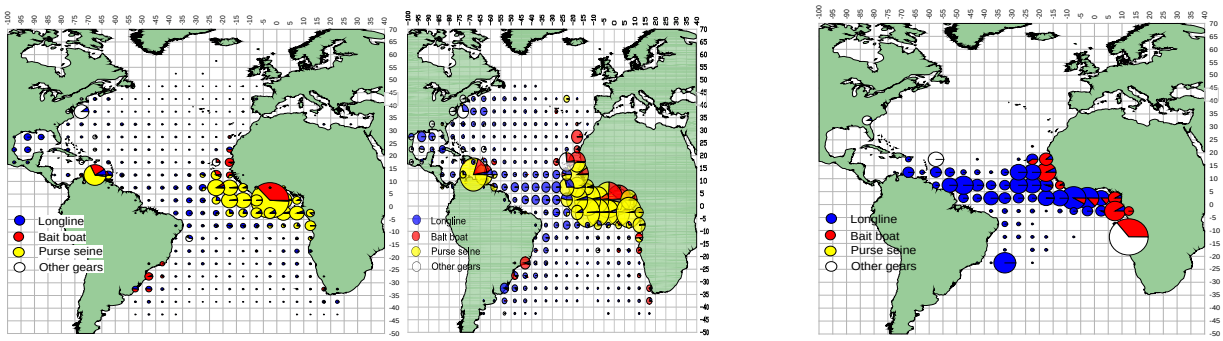


a. BFT (1950-59) b. BFT (1980-89) c. BFT (2000-04)

Figure 32. Geographic distributions of blue fin tuna (BFT) catches by the main fishing techniques and by decades (1950-2005) (ICCAT, 2008b).

3.h.3.b Tropical tuna

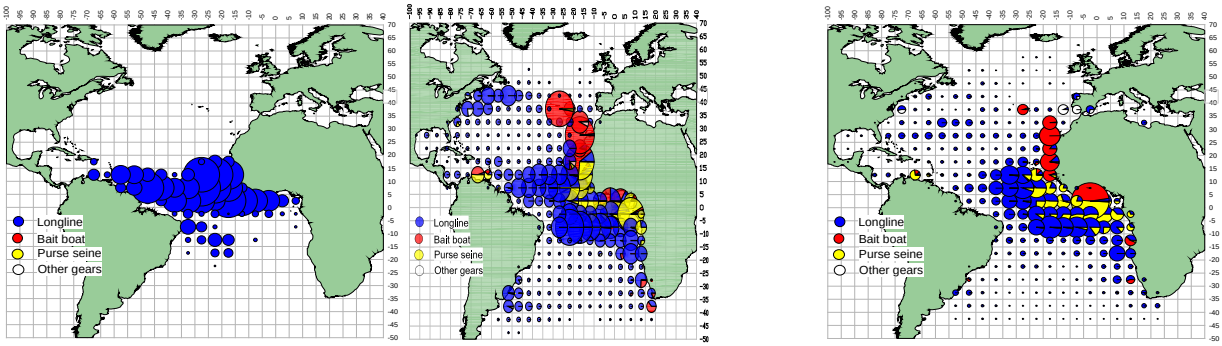
Yellowfin tuna



a. YFT (1950-59) b. YFT (1980-89) c. YFT (2000-04)

Figure 33. Geographic distribution of catches of yellowfin tuna (YFT) by main fishing techniques and by decades (1959-2004).

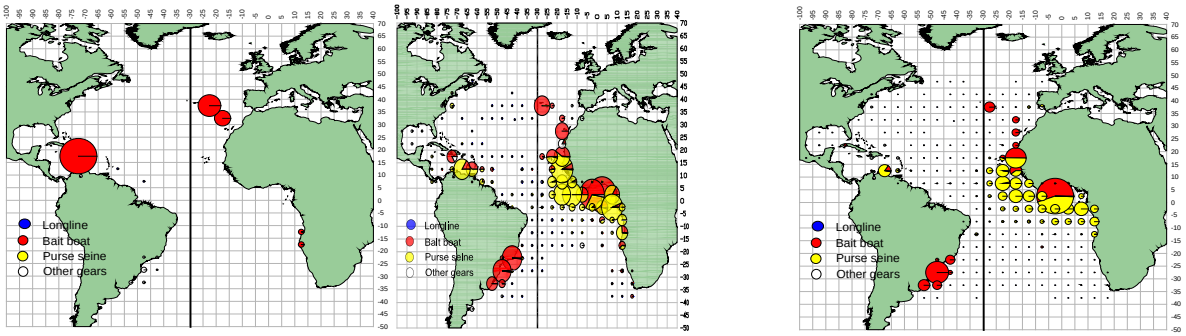
Bigeye tuna



a. BET (1950-59) b. BET (1980-89) c. BET (2000-04)

Figure 34. Geographic distribution of catches of bigeye tuna (BET) by main fishing techniques and by decades (1959-2004).

Skipjack tuna



a. SKJ (1950-59) b. SKJ (1980-89) c. SKJ (2000-04)

Figure 35. Geographic distribution of catches of skipjack tuna (SKJ) by main fishing techniques and by decades (1959-2004).

3.h.4 Catches by species/zone/season/year

The purse seine fleet is by far the fleet that catches the largest amounts of tuna in comparison with the other fishing techniques used in the Atlantic Ocean (ICCAT, 2007b), with a total of 196,335 t of the target species in 2005 and 274,733 t if we count all species (ICCAT Task I).

There was already major purse seine fishing activity in the 1950s, with the bluefin tuna as the target species in the northeast Atlantic (Norway), which disappeared in the 1970s (Fromentin and Powers 2005, Miyake *et al*. 2004), and some landing data for this species in the Mediterranean Sea (Italian and Yugoslav fleet) and in the North West Atlantic (United States fleet). But ICCAT has no data on catches of other tuna species by purse seine fleets until the 1960s.

Catches of **temperate tuna** made by purse seine fleets have remained more or less constant in recent years, around 20,000 t, having reached a peak in 1994 (27,976 t) (ICCAT Task I) (**Figure 36**). A large majority of these catches has been made up of bluefin tuna. The albacore tuna has only been caught very sporadically by purse seine fleets.

The first French and Spanish purse seine boats appeared in the tropical eastern Atlantic in 1963 and they started to exploit and develop a **tropical tuna** fishing industry. Since then, several fleets have joined them on these fishing grounds (Japan, USA and Canada, Côte d'Ivoire, etc.) (Fonteneau, *et al.* 1991). The level of purse seine tropical tuna catches was around 61,000 t by the end of the 1960s.

At the beginning of the 1970s, purse seine fishing spread into the coastal areas from North to South of the African continent, before moving out to exploit more extensive areas of the high seas in the mid-1970s, reaching

30ºW (Delgado de Molina *et al.* 1999). By the end of the 1970s, the figures for tropical tuna catches exceeded 140,000 t (Fonteneau, *et al.* 1991, ICCAT Task I).

In 1984, yellowfin tuna catches fell sharply, due to adverse environmental conditions, so many boats moved into the western Indian Ocean (Anon. 2000b). In the late 1980s, catch figures reached almost 170,000 t (ICCAT Task I).

Some of the most important changes in purse seine fishing occurred in the 1990s, when FADs were introduced. Moreover, the extension of the fishing grounds has changed due to FADs drifting towards the equatorial strip of the western Atlantic (Pallarés *et al*. 1998)..The use of these FADs has had an impact on catch figures, size of the specimens caught (Miyake, 2004) and the composition of species, with large quantities of juvenile tuna specimens (basically yellowfin and bigeye) being observed in landings and an increase of bigeye tuna catches. By the end of the 1990s, catch figures had exceeded 200,000 t (ICCAT Task I).

The composition of the catches made with floating objects is multi-species (yellowfin, bigeye, skipjack, frigate tuna and Atlantic black skipjack) and varied in size and age (predominance of juveniles); while in free school fishing, a single species is usually caught (yellowfin or skipjack) (Ariz, *et al.* 2001). Albacore are occasionally caught in tropical purse seine fishing of free schools.

Since the purse seine gear was first used in the Atlantic Ocean, catches gradually increased to 222,937 t in 1982. Since then, there have been several fluctuations in catches until the record figure was caught in 1993: 278,417 t (ICCAT Task I).

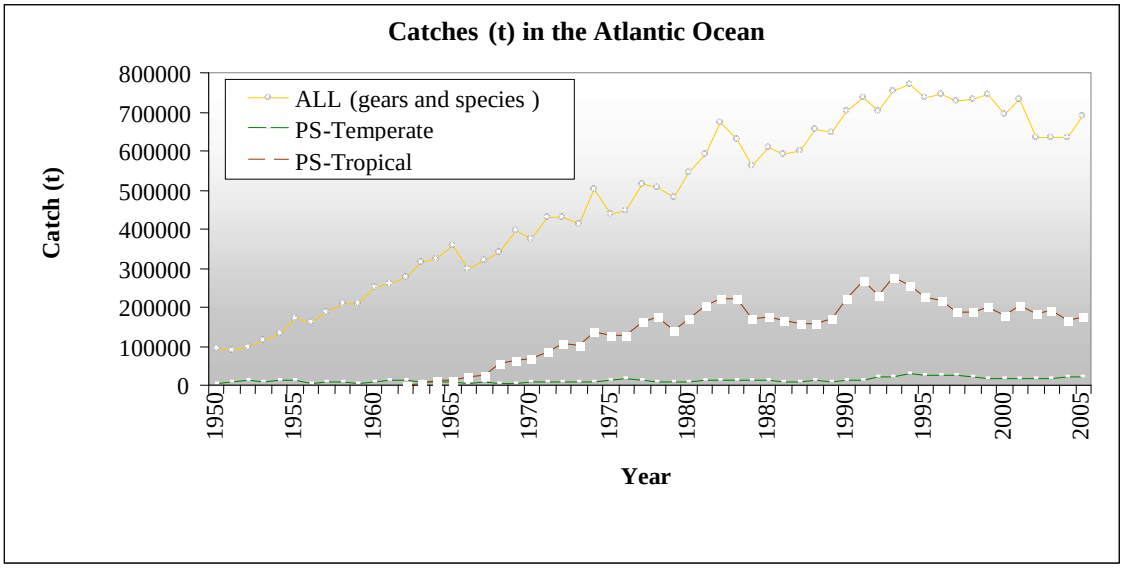


Figure 36. Catches (t) of tuna by the purse seine fleet in the Atlantic Ocean between 1950 and 2005. Figures show catches of temperate tuna (ALB and BFT) and tropical tuna (BET, SKJ and YFT), comparing them with the figures obtained for all fishing techniques (All) and all species ICCAT (ICCAT Task I).

The main grounds where the different purse seine fleets fish are located in the western Atlantic, in Venezuelan waters (tropical tuna) and in the Gulf of Maine (bluefin tuna). In the eastern Atlantic, the main fishing grounds are in tropical waters (off the coast of Africa, mainly from Senegal to the Gulf of Guinea) and in the Mediterranean Sea (bluefin tuna) (**Figure 37**).

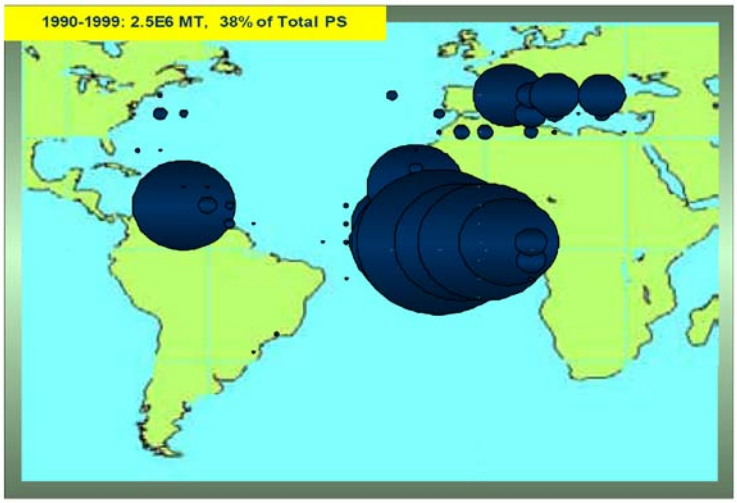


Figure 37. Fishing effort made by the purse seine tuna fleet in the Atlantic Ocean between 1990 and 1999 (ICCAT Record of Vessels).

Up until the 1950s, the purse seine fleet in the Atlantic, in practise, only had one target species, the flue fin tuna. Since the late 1960s, tuna catches have been made up of mainly skipjack and yellowfin tuna. Catches of bigeye have shown a constant increase, on a lower level, since the 1960s, while catches of bluefin tuna and albacore have remained stable over the years (ICCAT Task I) (**Figure 38**).

Currently, the two species most caught by purse seine gear are the yellowfin and the skipjack tuna.

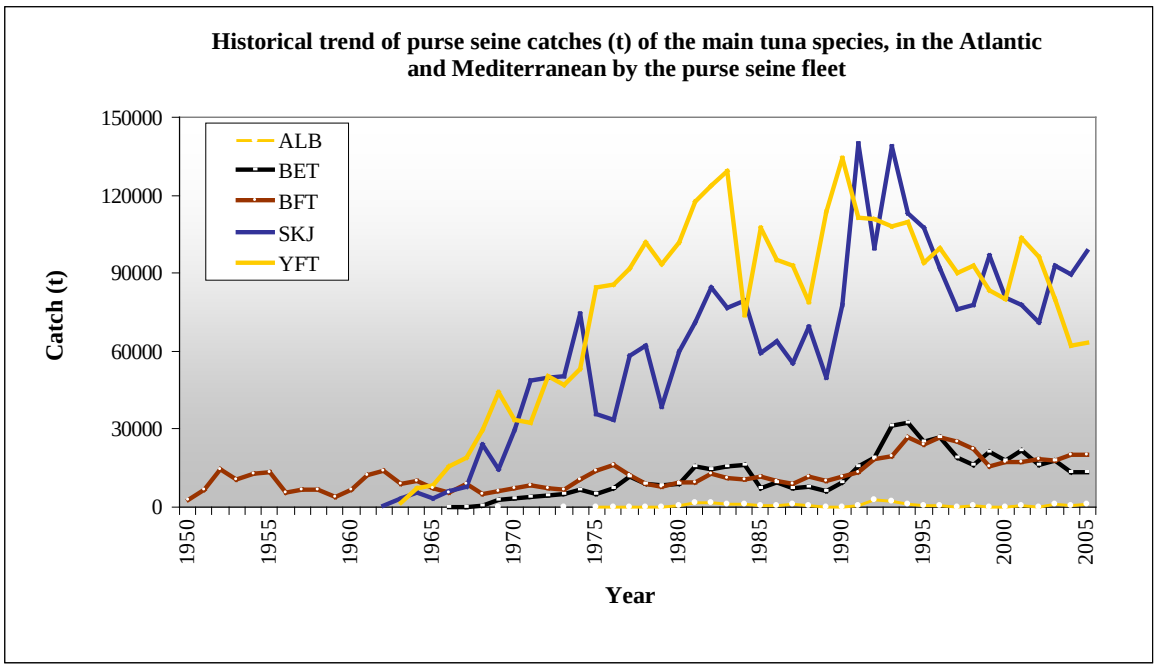


Figure 38. Historical trends in purse seine tuna catches in the Atlantic Ocean by main species (ICCAT Task I).

Albacore (*Thunnus alalunga*)

Albacore is not a target species for purse seine fishing, which is why the catch figures are not very high in comparison with other fleets like the pole and line fleet (1,000 t vs. 15,000 t in 2005) (ICCAT Task I).

In the eastern tropical zone, catches of this species are occasional and they are made when fishing for tropical tuna from free schools.

In the Mediterranean Sea, the French, Spanish, Greek and Turkish purse seine fleets make catches. The highest catches were made in 1993, with a total of 559 t (ICCAT Task I).

Bluefin tuna (*Thunnus thynnus*)

Bluefin tuna fishing with purse seine boats in the eastern Atlantic was basically practised by the Norwegian fleet between the 1930s and the 1950s, fishing in north eastern waters (maximum of around 14,000 t). Catches fluctuated significantly until they fell drastically at the beginning of the 1960s and stopped in the 1970s (Miyake *et al.* 2004) (**Figure 39**).

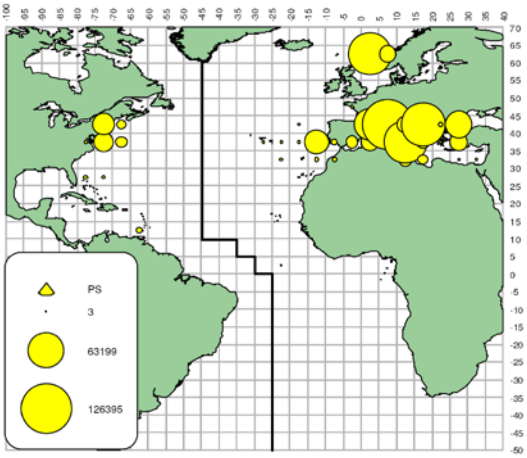


Figure 39. Geographic distribution of bluefin tuna catches between 1950 and 2004 by fishing technique (ICCAT 2008b).

This species was already being fished in the Mediterranean Sea in the 1950s by the Italian purse seine fleet. In 1966, France started fishing in these waters, quickly developing a fishing industry that reached a maximum catch of 3,800 t in 1976. Bluefin fattening cage related activities started in the late 1970s, with new countries joining this industry, which meant an increase in fishing effort and catches of this species. Hence, by the mid-1990s, a new record catch was reached of around 21,000 t (ICCAT Task I) (**Figure 40**) and many countries were engaged in this activity. It is estimated that between 20,000 and 25,000 t of this species are fattened in cages each year since 2003 (Anon. 2007).

In the western Atlantic, the United States purse seine fleet started fishing in the late 1950s, catching a maximum of around 5,000 t in 1963 and another maximum of around 4,000 t in 1970. Since then, the figures for catches have fallen to nearly 300 t in 2005 (ICCAT Task I) (**Figure 40**). This fleet fishes between the Gulf of Mexico and Newfoundland (**Figure 39**).

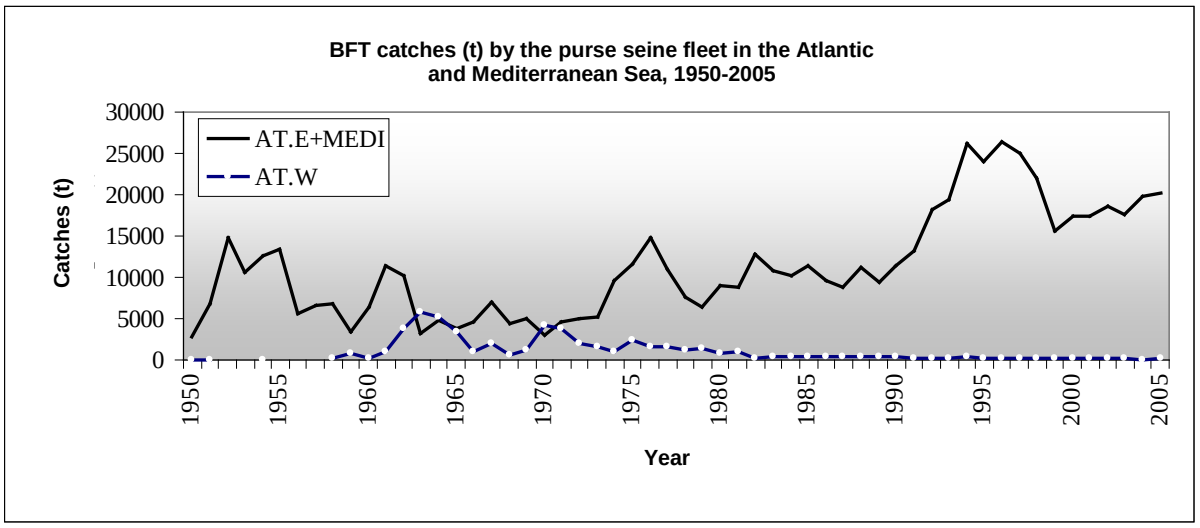


Figure 40. Catches (t) of bluefin tuna by the purse seine fleet in the Atlantic and the Mediterranean Sea 1950-2005. The figures show landings made in the eastern Atlantic and the Mediterranean Sea (AT.E+MEDI) and the western Atlantic (AT.W) (ICCAT Record of Vessels).

Yellowfin tuna (*Thunnus albacares***)**

Purse seine boats caught 58% of the yellowfin tuna catch in the Atlantic Ocean in 2005 (ICCAT Task I), with a total of 62,991 t.

ICCAT has catch data on this species going back to 1963, mainly from the European fleets in the eastern Atlantic, between Senegal and Gabon, and from the Venezuelan fleet in the West, in Venezuelan waters (**Figure 41**).

In the western Atlantic, catches increased from when fishing started in the 1960s until 1983, when over 25,000 t were caught. Catches in the following years showed considerable variations due to the fact that part of the Venezuelan fleet alternated their cruises between the Atlantic and the Pacific Oceans. The average for the period between 2000 and 2005 was around 7,000 t (ICCAT Task I) (**Figure 42**).

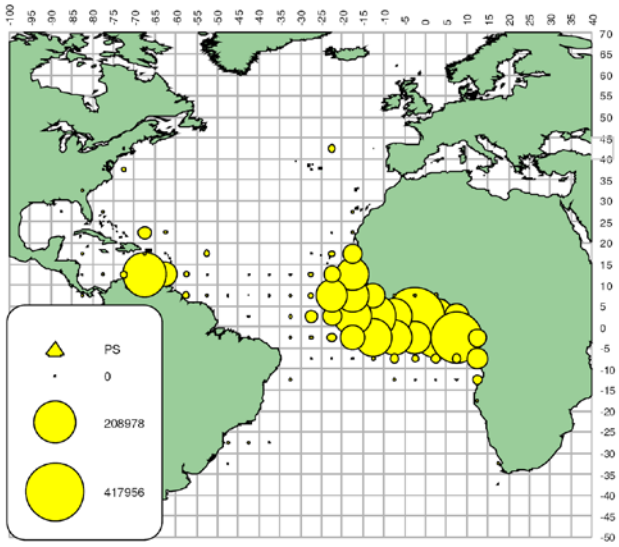


Figure 41. Geographic distribution of catches of yellowfin tuna *(Thunnus albacares)*, by the purse seine fleet between 1950 and 2004 (ICCAT, 2006a)

In general, catches of yellowfin tuna in the eastern Atlantic increased in spectacular fashion in the early years of this activity, increasing from an average of around 18,000 t in the 1960s to some 100,000 t in the 1980s. Catches remained stable at this level until 1983, when they started to fall to around half that figure in 1984, due to the fact that much of the French, Spanish and associated purse seine fleet left for the Indian Ocean. The departure of part of the fleet was due to a fall in the catchability of this species, for oceanographic reasons (collapse of the thermocline) and the excellent prospects of the new fishing grounds in the Indian Ocean. Catches later increased, with a record in 1990 of over 127,000 t, followed by a falling trend in the following years, reaching a figure of 89,000 t in 2001. In recent years, the highest catches have been made by the French and Spanish fleets (around 33,000 t in 2005), basically fishing from free schools, apart from the catches made by boats flying the Ghanaian flag (about 8,000 t in 2005), many of them working with live bait boats (Anon. 2008) (**Figure 42**).

In the western Atlantic, catches increased from when fishing started in the 1960s until 1983, when over 25,000 t were caught. Catches in the following years showed considerable variations due to the fact that part of the Venezuelan fleet alternated their cruises between the Atlantic and Pacific Oceans. The average for the period between 2000 and 2005 was around 7,000 t (ICCAT Task I) (**Figure 42**).

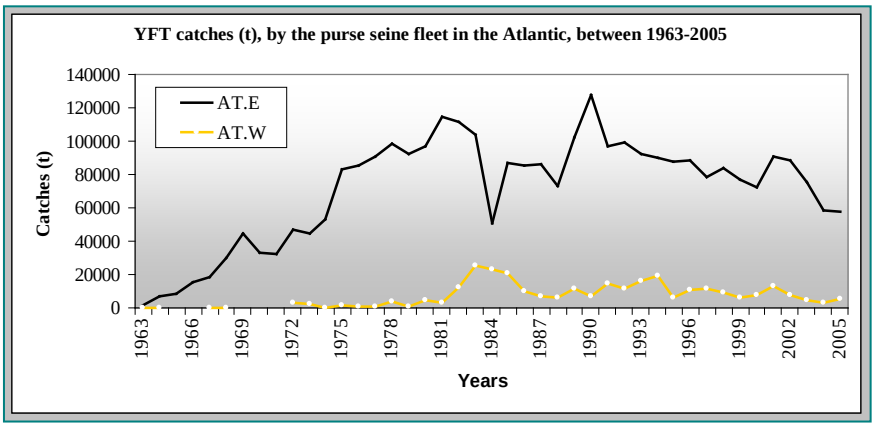


Figure 42. Catches (t) of yellowfin tuna by the purse seine fleet in the Atlantic 1963-2005. Figures show landings made in the eastern Atlantic (AT.E) and the western Atlantic (AT.W) (ICCAT Task I).

Bigeye tuna (*Thunnus obesus*)

Bigeye tuna is not a target species for purse seine fishing, although it is caught in schools associated with floating natural and artificial objects, normally associated with skipjack tuna and juvenile yellowfin. Data on this species started to be collected in the 1960s (about 800 t on average), with stable catch figures, although there was a regular increase from1970 (about 6,000 t in the 1970s), below the figures obtained for other species of tropical tuna (Fonteneau *et al.* 1991) (**Figure 43**).

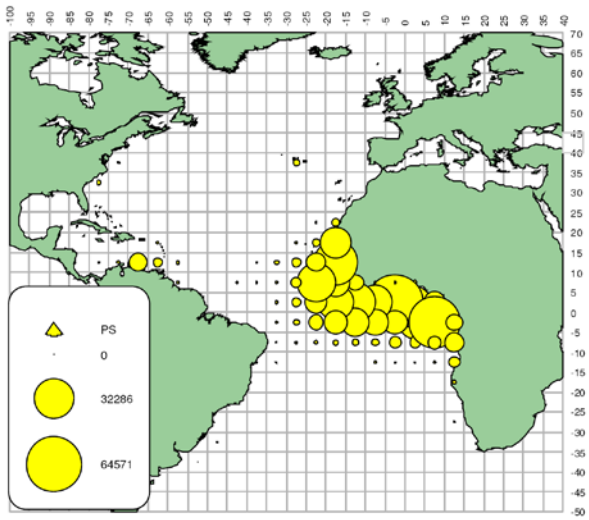


Figure 43. Geographic distribution of catches of bigeye tuna (*Thunnus obesus*) by the purse seine fleet 1950-2004 (ICCAT, 2006a).

Catches reached 10,000-15,000 t in the 1980s (**Figure 44**). During the 1980s, figures started to be recorded for catches in the western Atlantic (nearly 400 t by the Venezuelan fleet).

In recent years, catches of bigeye tuna have been closely related to the use of FADs and the areas in which these are used, such as the Ghanaian fleet fishing with FADs in the Gulf of Guinea.

An all time high of 32,000 t was reached in 1994. Since then, the figures have continued to fall, with slight fluctuations (reaching the figure of 13,000 t in 2005) (ICCAT Task I) (**Figure 44**).

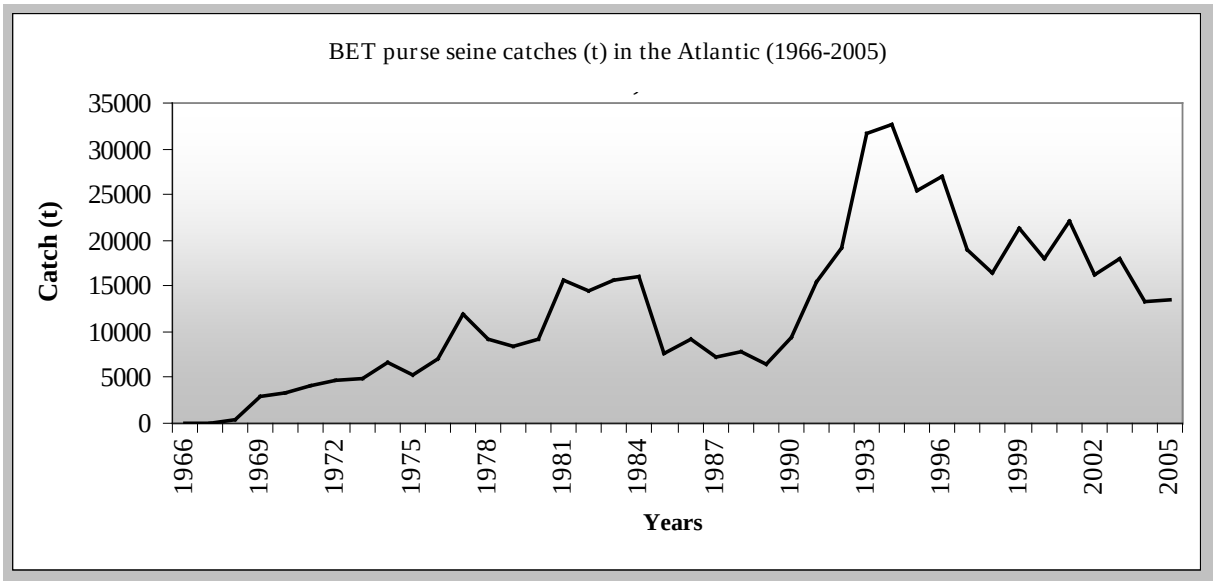


Figure 44. Catches (t) of big eye tuna by the purse seine fleet in the Atlantic 1966-2005 (ICCAT Task I).

Skipjack tuna (*Katsuwonus pelamis*)

Purse seine fishing of skipjack tuna in the eastern Atlantic started in the 1960s in the Gulf of Guinea by the Spanish and French fleets (**Figure 45**). These developed rapidly, replacing the pole and line boats (Miyake *et al.* 204). In the early 1970s, purse seine catches reached figures of 30,000-75,000 t (around 40% of the total catch of skipjack tuna). In the early 1990s, with the use of FADs, catches of this species increased considerably, to record figures of over 100,000 to in the 1990s (maximum above 130,000 t in 1991). Since then, the figures have fallen, with slight fluctuations (ICCAT Task I) (**Figure 46**).

The catch of skipjack tuna by the purse seine fleet now accounts for 65% of the catch for this species (ICCAT Task I).

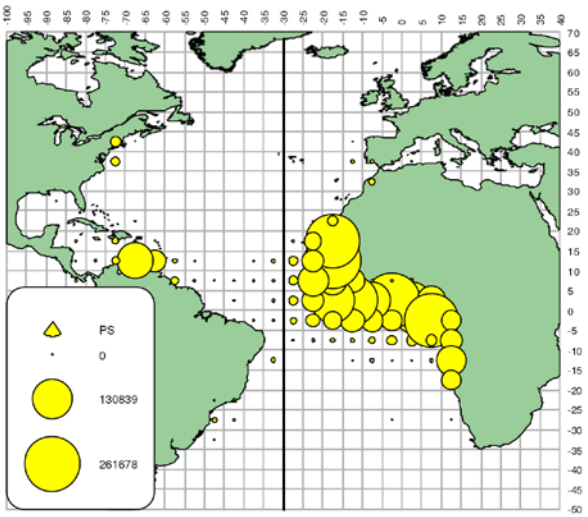


Figure 45. Geographic distribution of catches of skipjack tuna (*Katsuwonus pelamis*) by the purse seine fleet 1950-2004 (ICCAT, 2006a).

In general, higher catch figures are recorded in the eastern Atlantic than in the western Atlantic (90,000 t vs. 8,000 t in 2005) (**Figure 46**). In the western Atlantic, the Venezuelan fleet has caught an average of 2,600 t (mean for 2000-2005) (ICCAT Task I) using boats en route to or from the Pacific Ocean (Miyake *et al.* 2004).

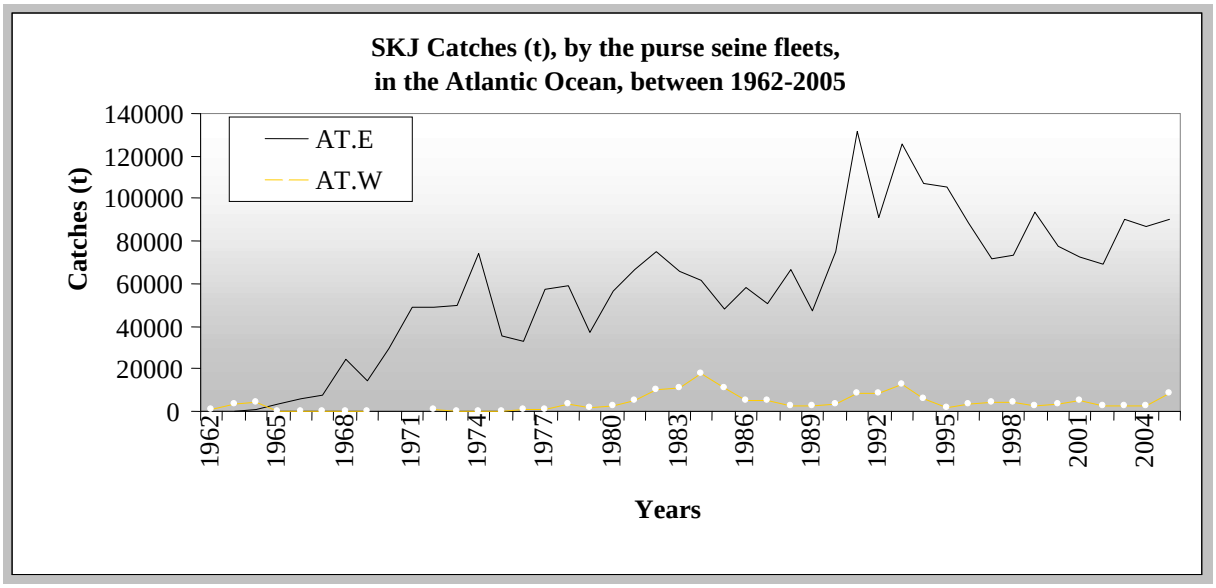


Figure 46. Catches (t) of skipjack tuna by the purse seine fleet in the Atlantic 1962-2005 (ICCAT Task I).

3.i Special sampling considerations

The multi-species nature of tropical tuna fishing makes it difficult to make a basic estimation of catches by species and sizes, so the sampling system now used by most purse seine fleets targeting these species in the Atlantic is a multi-species sampling, in order to obtain the composition by species and sizes of the catches by kinds of school and for a defined spatial-temporal space.

The basic information necessary for identifying the sampling to be done, is provided by the captains on board, using their fishing reports and the plan of the tanks that they fill in each time that they store the catch.

The aim of the sampling is to discover the composition by species and sizes of a cast, which belongs to pre-defined space/time strata. The main strata considered are:

- Kind of school (Free School-BL/Object School-BO)
- Fishing zone
- Quarter

It is important to remember that the flag that the boat is flying (in the case of the European and associated fleet) is not considered a significant factor of the sampling, and the choice will be made by the available strata for the purse seine fleet landing in port as a whole, irrespective of the flag (that is, Spanish, French and associated flag fleet) and not by the flag of origin.

3.j Potential impacts on the ecosystem, including by-catch

In general, tuna fishing implies the elimination of several thousands of tonnes of specimens that are near the top of the food chain from the ecosystem, year after year. In 2003 the technique of purse seine fishing landed 60% of the total world industrial tuna fishing catches (FAO 2005b). The large tuna catches and their elimination from the ecosystem could lead to their ecological niche being occupied by other species that are at the same level of the food chain, but which are not target species for purse seine fishing boats, such as sharks, swordfish, marine mammals, etc.

Tropical tuna purse seine fishing of free schools catches very few accessory species. It is fishing on floating objects that generates a large amount and diversity of associated species per cast.

As regard to the **bluefin tuna** fattening in marine farm cages, this could cause similar impacts on the ecosystem as those that occur in places where different models of fish farming are developed. Great care is needed in choosing the site for the fattening cages to minimise the impact of the detritus, unconsumed feed, etc. (Miyake *et al*. 2003).

Some authors have recently highlighted the accidental catch of certain species due to abandoned floating objects and due to changes in migratory routes, behaviour and transfer of biomass from one area to another of the creatures that associate with artificial floating objects and which follow their drift.

To summarize purse seine fishing of tuna, in general, generates the following **direct** impacts on the marine environment:

- Large catches of target species, which could lead to over-fishing or over-exploitation of resources.
- Fishing of juvenile specimens associated with floating objects, as this is not a selective technique insofar as the size of the specimens caught.
- Catch of species associated with free schools of tuna, especially with floating objects regularly used for catching **tropical tuna**. Sporadic catches of marine mammals have been reported when fishing in free schools. These accessory species include, apart from other small tuna species, other species of fish and marine turtles and, very rarely, in the case of the Atlantic Ocean, the odd cetacean (Delgado de Molina *et al*. 2005).

The following points are considered the main **indirect** effects on the marine environment:

- Effect on inter-species relations of communities, due to the elimination of large numbers of these species, -which are close to the top of the food chain- from the ecosystem.
- Discarded catch encourages the proliferation of carrion and detritus feeding species.
- There is also evidence suggesting that floating objects affect the dynamic and structure of schools of tuna, affecting their feeding ecology and possibly act as a barrier to natural movements and migrations (Marsac *et al*. 2000). These effects appear to be more intense in young populations and in populations of small size specimens as vulnerability and catch rates of juvenile stocks increase, which will affect the very structure of the population and its reproductive potential.

Below is a qualitative list of the main taxa of accessory species associated with purse seine fishing in the Atlantic Ocean and the Mediterranean Sea (Anon. 2008).

Mantas and rays		
Scientific name	**Common name**	**Code**
Dasyatis violacea	*Blue stingray*	PLS
Manta birostris	Giant Manta	RMB
Mobula lucasana		
Mobula mobular	Manta ray	RMM
Rhinoptera spp		
Torpedo nobiliana	Torpedo	TTO
Coastal sharks		
Carcharodon carcharias	Great white shark	WSH
Rhincodon typus	Whale shark	RHN
Sphyrna lewini	Scalloped hammerhead	SPL
Sphyrna mokarran	Great hammerhead	SPK
Sphyrna spp	hammerhead	SPN
Sphyrna zygaena	Smooth hammerhead	SPZ
Pelagic sharks		
Carcharhinus Falciformis	Silky shark	FAL
Carcharhinus longimanus	Oceanic white tip	OCS
Isistius brasiliensis	Cookiecutter shark	ISB
Isurus oxyrinchus	Short fin Mako	SMA
Prionace glauca	Blue shark	BSH
Bony fish (ICCAT species)		
Acanthocybium Solandri	Wahoo	WAH
Auxis rochei	Frigate tuna / Bullet tuna	FRT
Auxis thazard	Frigate / Bullet tuna	FRT
Euthynnus alletteratus	Black skipjack tuna	LTA
Istiophorus albicans	Atlantic sailfish	SAI
Katsuwonus pelamis	Skipjack tuna	SKJ
Makaira nigricans	Blue marlin	BUM
Scomberomorus tritor	Spanish mackerel	SSM
Tetrapterus pfluegeri	Spearfish	SPF
Tetrapturus albidus	White marlin	WHM
Bony fish (ICCAT species)		
Thunnus alalunga	Albacore	ALB
Thunnus albacares	Yellowfin tuna	YFT
Thunnus atlanticus	Black fin tuna	BLT
Thunnus obesus	Bigeye tuna	BET
Thunnus thynnus	Bluefin tuna	BFT
Xiphias gladius	Swordfish	SWO
Bony fish (excluding scombridae and bill fish)		
Abalistes stellatus	Starry triggerfish	
Alutera punctata		
Balistes carolinensis	Grey triggerfish	TRG
Balistes punctatus	Blue spotted triggerfish	
Belonidae	Needle fish	BES
Canthidermis maculatus	Oceanic triggerfish	CNT
Caranx crysos	Blue runner	RUB
Coryphaena equiselis	Pompano dolphin fish	CFW
Coryphaena hippurus	Common dolphin fish	DOL
Diodon hystrix	Porcupine fish	DIY

Elagatis bipinnulata	Rainbow runner	RRU
Euleptorhamphus velox	Flying halfbeak	
Exocoetidae	Flying fish	
Kyphosus sectator	Bermuda sea chub	
Lampris guttatus	Opah	LAG
Lobotes surinamensis	Atlantic triple tail	LOB
Masturus lanceolatus	Sharptail mola	MRW
Mola mola	Sun fish	MOX
Naucrates ductor	Pilot fish	NAU
Marine turtles		
Caretta caretta	Loggerhead turtle	TTL
Chelonia mydas	Green turtle	TUG
Dermochelys coriacea	Leatherback turtle	DKK
Eretmochelys imbricata	Hawksbill turtle	TTH
Lepidochelys kempii	Kemp's Ridley turtle	LKY
Marine mammals		
Balaenoptera acutorostrata	Minke whale	MIW
Balaenoptera borealis	Sei whale	SIW
Balaenoptera edeni	Bryde's whale	BRW
Phtheirichthys lineatus	Slender suckerfish	HTL
Remora remora	Common remora	REOI
Ruvettus pretiosus	Oil fish	OIL
Scomber scombrus	Atlantic mackerel	MAC
Seriola rivoliana	Almaco jack	YTL
Sphyraena barracuda	Great Barracuda	GBA
Uraspis secunda	Cottonmouth jack	USE
Marine mammals		
Balaenoptera physalus	Fin whale	FIW
Delphinus delphis	Common dolphin	DCO
Globicephala macrorhynchus	*Short fin pilot whale*	SHW
Orcinus orca macrocephalus	Killer whale	KIW
Pseudorca crassidens	False killer whale	FAW
Stenella attenuata	Spotted dolphin	DPN
Stenella clymene	Clymene dolphin	DCL
Stenella coeruleoalba	Striped dolphin	DST
Stenella longirostris	Spinner dolphin	DSI
Steno bredanensis	Rough toothed dolphin	RTD
Tursiops truncatus	Bottle nosed dolphin	DBO

3.k Environmental impacts on fishing operations

The environmental conditions of the oceans (temperature, nutrition, oxygen, currents, etc.) have a direct influence on the local abundance of tuna stocks and, therefore, on their catchability. These conditions, together with the food and spawning zones can, therefore affect the migratory patterns of these species (Anon. 2000a). The main environmental variables to take into consideration are as follows (Fonteneau 1998):

- Surface temperature, as most adult tuna are found at or above the level of the thermocline (Stretta 1988). Hence, the 21ºC isotherm is a frequency limiting factor for tropical tuna, whereas the temperate tuna are caught in areas with temperatures above 20ºC or between 10 and 20ºC.
- Thermocline structure and depth gradient, which affects the distribution of the tuna biomass. In the Atlantic Ocean, surface thermoclines (< 70 m) are the most favourable for catching these species with purse seine gear.
- Regime of winds, which have an impact on recruitment and the seasonal variability of resources.
- Oceanic currents, which are a consequence of the winds and a factor that is probably related to migratory movements (for example, Gulf Stream, *up-welling* off the African and American coasts).
- Geographic and bathymetric distribution of oxygen, which affects the distribution of species.
- Bathymetrics, as tuna are more often caught in certain areas of the ocean (continental shelves, submarine canyons, islands, sea mounts, etc.).
- Nutrients, as juvenile specimens in particular, are abundant in nutrient rich areas.

Temperate tuna

Few studies have been carried out on the environmental effects on Atlantic tuna, yet it is believed that the environment could play an important role for temperate water tuna: bluefin and albacore. Hence, for example, the reproductive strategy of the Atlantic bluefin tuna, its spawning occurs in a narrow time area window, making its recruitment vulnerable to local environmental changes, which translate into local variations in abundance (Anon. 2000a).

Tropical tuna

An example of the influence of the oceanic environment on purse seine fishing has been mentioned several times in this chapter: the drastic fall in yellowfin tuna catches in 1983, which led to many French and Spanish purse seine boats that fished in the tropical eastern Atlantic to move into the Indian Ocean. It was later shown that the absence of yellowfin had been due to a fall in the thermocline in this area.

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