THE DOLPHINFISH FISHERY IN MAJORCA ISLAND.
Report 2004

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April 2005

IMEDEA

Govern de les Illes Balears

Illes Balears, Spain

Introduction

In the island of Majorca around 45% of the small scale fleet is engaged in three main seasonal fisheries directed at *Aphia minuta* from December to March, *Palinurus elephas* from March to August, and to *Coryphaena hippurus* from August to December. The gears used are boat seine; trammel nets and a surrounding net without a purse line, respectively. The fishery for dolphin-fish deploys Fish Aggregation Devices (FADs) (Iglesias *et al.* 1994). Other small-scale fisheries developed at the Island are directed to cuttlefish (*Sepia officinalis*), common seabream (*Pagrus pagrus*), common dentex (*Dentex dentex*), great amberjack (*Seriola dumerili*) and squid (*Loligo vulgaris*), using a combination of different gears (Iglesias *et al.* 1994).

The dolphinfish fishery in Majorca Island corresponds to a single operational unit (document submitted by Spain at Rome 2001 meeting). In short, it corresponds to a pelagic resource in oceanic waters, targeting dolphinfish from the second quarter of August to December. The fishery corresponds to GSA (**5**). The fishery uses fishing aggregation devices (FADs) and a surrounding net (Massutí & Morales-Nin 1991). This fishery is restricted to the Island of Majorca due to cultural reasons, because the fish is present in the rest of the Archipelago.

The Fisheries Directorate from the Balearic Islands (D.G.Pesca, Govern Balear) manages the dolphinfish fishery implementing several measures: 1) determining the date of opening of the fishery, 2) establishing Saturday and Sunday morning as no fishing days, 4) restricting the use of gears during the fishing season, and 5) limiting the number of licenses and allocating a system for the distribution of FAD zones around Majorca based on the establishment of specific geographical zones for each port's Fishermen Guild (Cofradia). Each registered fisherman, with a license for dolphinfish, applies for a zone and a lottery takes place in each port. This is an objective method to allocate the zones for the fishermen every year. The fishery catches 3 main species: dolphinfish, pilot fish and lemon fish (*Coryphaena hippurus, Naucrates ductor, Seriola dumerili*) with occasional catches of small *Balistes carolinensis* that are returned to the sea.

The Majorcan fishery has been studied in two European funded previous projects (D.G.XIV UE Biological studies 94/31 and 95/73) and in a FAO-COPEMED project. A preliminary population dynamics analysis was submitted to the SAC meeting on 2004. This report reflects the work carried out to study the 2004 dolphinfish fishery in Majorca

Island in the framework of FAO-COPEMED to characterize the operational units and to contribute to its first socioeconomic analysis. To develop the activities, the Fisheries Directorate from the Balearic Islands (D.G.Pesca, Govern Balear) has provided support giving access to information as well as funding a fellowship that supported Mrs. M. Valls work.

Material and methods

For the pilot study and based on previous data on the fish spatiotemporal distribution, we divided the Island in two strata:

1-North-West: comprising the ports of Andratx, Fornells, Soller, Pollença.

2-South-East: comprising the ports of Cala Rajada, Cala Bona, Portocolom, Santanyi, and Palma.

One sampling port was selected on each stratum. However, due to the bad weather conditions and the cessation of the fishing in the N-W since middle October, the sampling effort was dedicated to Portocolom in the S-E. Thus, the sampling ports were: N-W: Soller; S-E: Cala Rajada and Portocolom.

One sampler was dedicated to each stratum, being responsible to carry out the interviews and collecting the information for the fishing activities and socio-economic data, following the questionnaires designed by FAO. Also, the samplers collected the length-frequency data and went on board to implement other relevant information.

Daily information of all landings at the Fishing Warf in Palma de Mallorca (the only Warf in the Island) was collected through the Voucher Scheme. The Fishing Warf has recently implemented the automatic selling system. This allowed also determining if some of the registered boats did not fish. The biological samples were obtained on the Fishing Warf.

Dolphinfish fishery 2004

Boats and gear

The 2004 fishery registered 42 boats although only 40 actually fished (Table 1). The S-E stratum had 25 boats fishing, while the N-W stratum had 15. All the boats are small corresponding to the fleet segment C (<12 m). The number of boats by harbour is similar, except in Cala Bona, Portocristo and Fornells where there are two and three, respectively.

Table 1. Registered boats for the 2004 fishing season by port. In **dark** the boats that did not fish. The sampling ports are marked.

Port	**Boats**	**Nº of boats**
	South-east stratum	
CALA RAJADA	*Bartolo Juan*, *Moreste II*, *Hispaniola* 2000, *Vima*, Nova Princesa, *Picaseu*	6
CALA BONA	*Son Servera*, *Cala Bona II*	2
PORTOCRISTO	*Calima, Sirena*	2
PORTOCOLOM	*Solaret*, *Rosita*, *Enginyer*, *Cap de Reig*, *Creus*	5
SANTANYÍ	*Badia*, *Porret*, *Poseidon Segundo*, *Tenassa Uno*, *Micima*	5
PALMA	*Marcos*, *Hermanos Vera*, *Santa Isabel, Hermanos Gonzalez*, *Teresa Segundo*	5
	North-west stratum	
ANDRATX	*José Isabel*, *Hnos. Cabrera, Moron II*, *Reme Toni III, Sito I*	5
FORNELLS	*Esperanza*, **Tato**, *sa Llagosta*	3
SÓLLER	*Kiko*, *sa Pedruscada*, *Sparus*, **Vila Deia**, *Joilu II*	5
POLLENÇA	*Katy*, *Orion III*, *Tinu II*, *l'Avançada*	4

The characteristics of the fleet by stratum are different, probably due to two new boats that are based on Calarajada. However, these differences (Table 2) in size (smaller boats in the N-W) are compensated by the higher engine power. However, the small differences may be also due to the characteristics of the sampling port in the N-W stratum. Note that although the size of the boat is more or less similar, the engine power varies greatly inside each stratum.

The fishing gears that these boats employ along the year besides dolphinfish net, are lobster trammel net, bottom long line, fish trammel net and more infrequently *Aphia minuta* net.

Table 2. Summary of the boat and gear characteristics by stratum. In brackets standard deviation. Number of sampled boats: N-W=2; S-E: 7.

	N-W	S-E
GRT	3.11 (1.86)	6.57 (3.07)
Boat length (m)	8.40 (1.59)	9.08 (1.27)
Engine HP	91 (66.46)	82.28 (42.05)
Nº FADs	32.5 (3.5)	40.85 (5.9)
Distance between FADs	250 (70)	350 (95)
Gear length (m)	110 (2.83)	158.57 (3.08)
Gear height (m)	15 (7)	16.21 (2.19)

The FADs (“capcers”) consisted of a float with some palm grounds or bush branches tied on top and below for location and to increase their surface, respectively. The composition and form of the FAD varied, from the traditional of cork to a group of tires. The material is selected for its capability to float at some centimeters below the surface. They are moored using a lime stone (“pedral”) for anchorage. The FADs and gear used in Majorcan fishery have been described by Morales-Nin et al. (1999). Every year the individual mooring places, inside each mooring area (Fig.1), are sorted in each harbour and attributed to the boats registered for the fishery. These 45 groups of FADs have different arrangements for each port: in Andratx there are 4 alignments, 6 on Soller, 8 on Pollença, 12 in Calarajada, 5 in Palma, 5 in Santanyi, 2 in Portocristo and 5 in Portocolom. The FADs are placed in lines (“andanas”) being in average 30-40 surface FADs for each boat mooring location, except in Port de Soller where 30-35 FADs/boat are deployed (Table 2). The fishermen may lay the FADs as they wise in their allocated zone, generally with spacing of 200-300 m and in a variable number by boat. In the ports of Pollença and Cala Rajada each boat has 2 zones.

The net (“llampuguera”) is a surrounding net without purse line and with a small lateral bag where the fish are collected during hauling operations. The number of FADs and the net size depend of the boat characteristics. By stratum there are differences in both variables (Table 2) related to the bigger size of the boats in the S-E stratum.

Fishing activity

The fishery started laying down the FADs at the beginning of August; the official start of the fishing operations was August 25th, although the boats may start fishing latter.

The way of fishing is to visit the boat fishing area (FAD alignment), but the first FAD visited depends on sea conditions and the previous day catches. Before casting the net, the fishermen determine if there is fish, either by visual census or by a hand trolling line. The number of visited FADs depends of the catches and if they are not sufficient, they may search for floating objects and fish on them. This practice is most frequent in Port de Soller, where they spend a substantial part of their time searching for fish outside the FADs fishing zone. Moreover, the fishermen may not visit the FAD zone at all in their fishing trip. Also in this port, they have a single day outing returning to port in the afternoon.

Usually, weather permitting; the boats do two outings a day, one in the early morning ours ("d' auba") and another at sundown ("de prima"). The landings are commercialized at the Fish Warf in Palma (the only Fish Warf of the Island) where they are transported in refrigerated lorries.

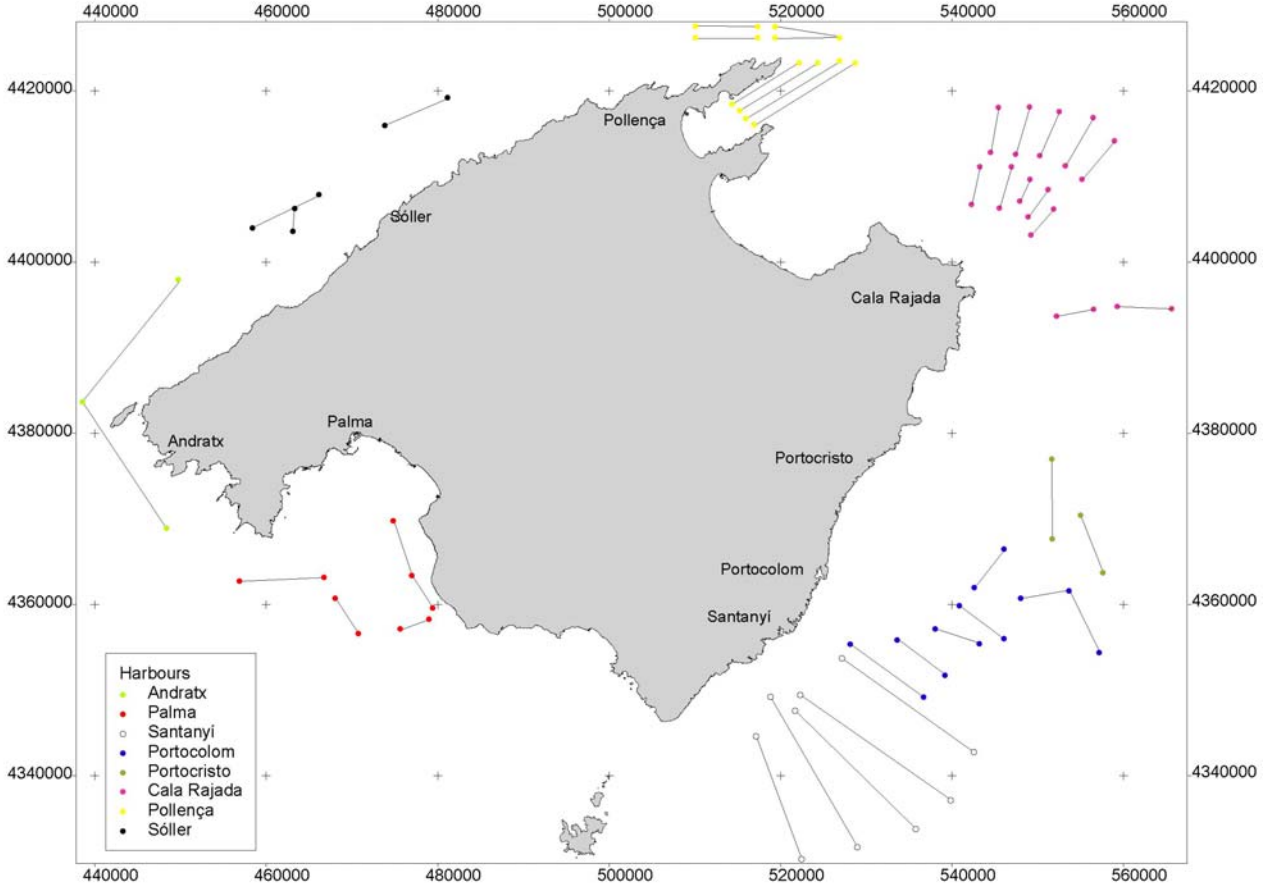
The activity is regulated by forcing the registered boats to fish exclusively for dolphinfish while they have the FADs operative. Secondly, the Saturday all day and Sunday mornings are non-activity periods. The Central Fish Warf at Palma is closed on Sundays and Mondays. Thus, the fish captured on Sunday afternoon and Monday is sold on Tuesdays.

The 2004 fishing season started in August, with good catches on September but bad weather limited the operations in October and most of November. The fishing season was practically paralyzed by the mid of November due to bad weather conditions causing the early stop of the fishing operations in some ports. For instance, in the S-E stratum port Calarajada, 4 of the 6 boats cut their FADs on November 17th. The remaining boats except one stopped fishing one the 18th after a day without catches, and the last boat the 19th after landing only pilot fish. Thus, the fishing operations finished completely by November 20th. As an example of the bad 2004-fishing season, from 37 visits to the port, 11 days had the fleet inactive due to bad weather (30%).

In the N-W stratum port Soller, from the five registered boats only four fished. The first day of fishing operations was August 25th by a single boat, followed by the remaining three on August 26th. Due to the bad weather two boats stopped fishing operations on October 8th, the other two stooped the first week of November. Hence, Portocolom (S-E) was selected to complete the sampling, starting operations on October 17th. The weather conditions were also bad, with three positive sampling days and 15 negative. The fishermen started cutting the FADs and by November 25th the fishery stopped completely.

The sales registers showed the first sale on August 26th and the last one on November 30th.

Fig.1. Location of the FAD'mooring lines by port.



Effort and Catch

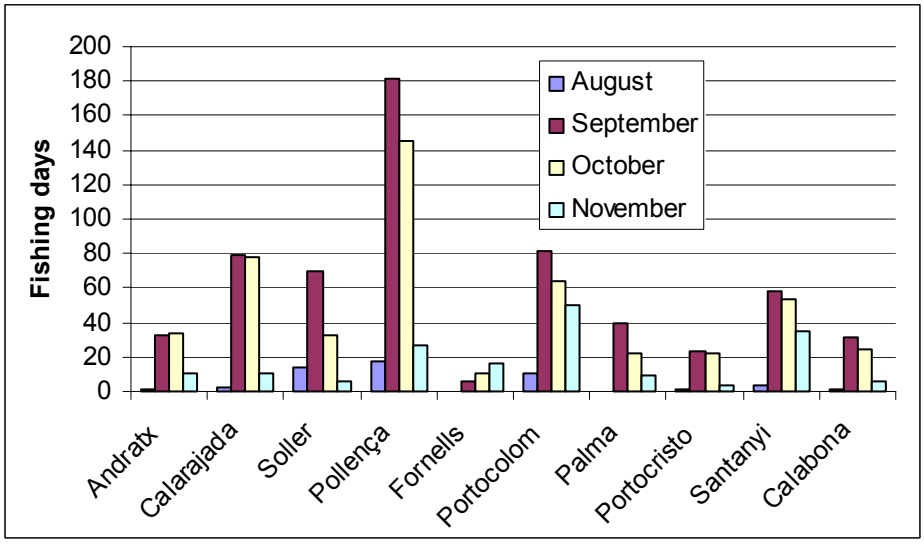
To obtain and estimate of the fleet activity we used two approaches: 1) the sales daily registers for the target species (dolphinfish, lemon fish and pilotfish) on the Fishing Warf and 2) the interviews designed by FAO-COPEMED.

Daily sales

The number of daily registered sales by port, comprising all the sales of the port boats fishing for dolphinfish, was considered as a measure of the effort from the port. Although this estimate does not include the days when there was a trip but no catches, we used it to have a general vision of the effort distribution.

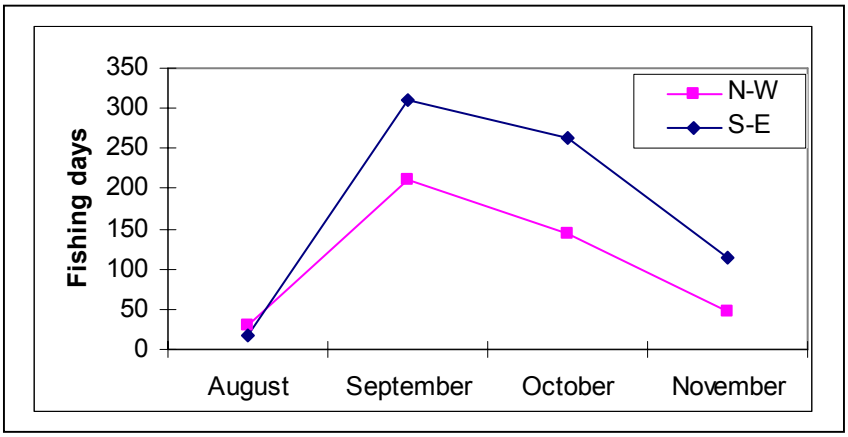
The activity calculated as the total number of days with sales for the sampling ports (Fig.2) shows a clear peak in September (39.5% for Portocolom, 56.9% for Soller). However, the activity in Portocolom (S-E stratum) is more stable than in Soller where the activity in August is more important (4.9% in Portocolom, 11.4% in Soller), but with the exception of September, the other months are less active. In November only 4.9% of the activity is carried out in Soller, while in Portocolom still 24.4% of the activity corresponds to this month. In Cala Rajada the activity is almost the same in September and October. The port with more fishing days has been Pollença, due to its protected position inside a Bay (Fig.1).

Fig.2. Fishing activity by port and by month measured as port daily sales.



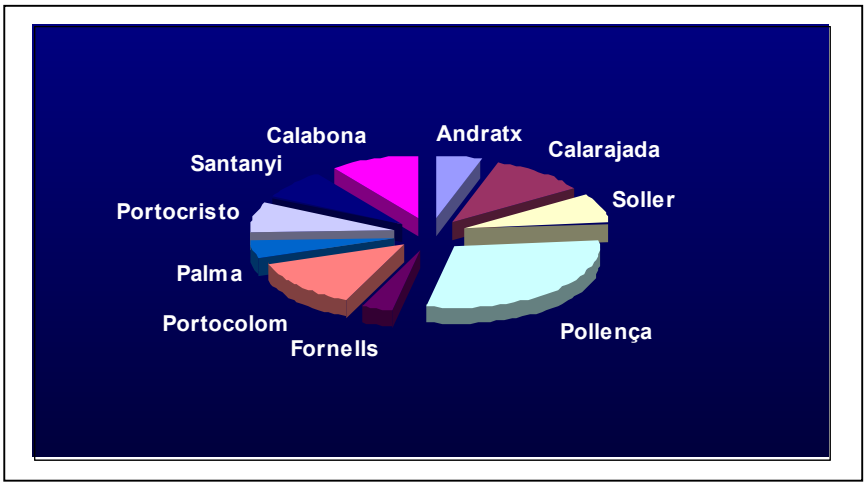
When we consider the fishing activity by stratum from the 1141 registered sales, the N-W represents 37.94% of the activity and the S-E 62.2%. In the NW Stratum the strong currents, added to the scarce protection from the Tramontana winds, causes that the bad weather is stronger in this area. This is related with a marked decrease of activity when the fall storms started (Fig.3).

Fig.3. Fishing activity by stratum.



If we consider the number of boats by port, it is evident that the positive days with sales are very uneven between ports (Fig.4) being the most successful Pollença and Portocolom.

Fig.4. Days with registered sales relative to number of boats and for each port.



Interviews

The data recopilated by the interviews corresponded to 6 boats from Calarajada, 1 from Portocolom and 2 from Soller. A total of 37 visits to Calarajada have been carried out by the sampler. The catch and effort data have been collected using the provided forms. A total of 180 interviews have been obtained. From these 75 corresponded to daily trips without catches (N=21) or days without fishing activities for the boat (N=54). On Soller there were a total of 16 visits and 4 in Portocolom, where 124 and 32 interviews have been obtained, respectively. From these 47 and 20 corresponded to daily trips without catches or days without fishing activities for the boat.

These data have been submitted to FAO-COPEMED and are in the process of analysis. However, using Calarajada as an example of the effort in the fishing operations, some preliminary data can be obtained.

The number of FADs visited in each trip is very variable and shows some temporal trends. For instance in September the mean of FADs visited was 33.06 (s.d.=9.23), 28.24 (s.d.=12.37) in October and decreasing to 26.49 (s.d.=11.78) in November. A similar tendency is found in the mean number of net castings by trip, being 13.27 (s.d.=8.28) in September, 6.02 (s.d.=3.38) in October and 3.21 (s.d.=1.72) in November. Considering these values, it seems that the number of FADs visited in a trip is more or less similar but the presence of fish (the castings are carried out after testing the presence of fish with a hand line) was much more frequent in September. This is confirmed by the mean dolphinfish landings by trip, which were 232.62 kg (s.d.=198.82) in September, 109.9 kg (s.d.=114.67) in October and 142.24 kg (s.d.=133.97) in November. The high variability in the catches, probably related to the school behavior of the species, is shown by the wide range of the trip catches that can oscillate between 10 and 778 kg/trip and the number of net castings that range from 1 to 27/trip.

If we consider the proportion of fished FADs/ visited FADs as a measure of fish abundance, the values range between 16 to 100%. The relative abundance also decreases along the fishing season from 40% (s.d.=23%) in September, 24% (s.d.=16%) in October to 12% (s.d.=5%) in November.

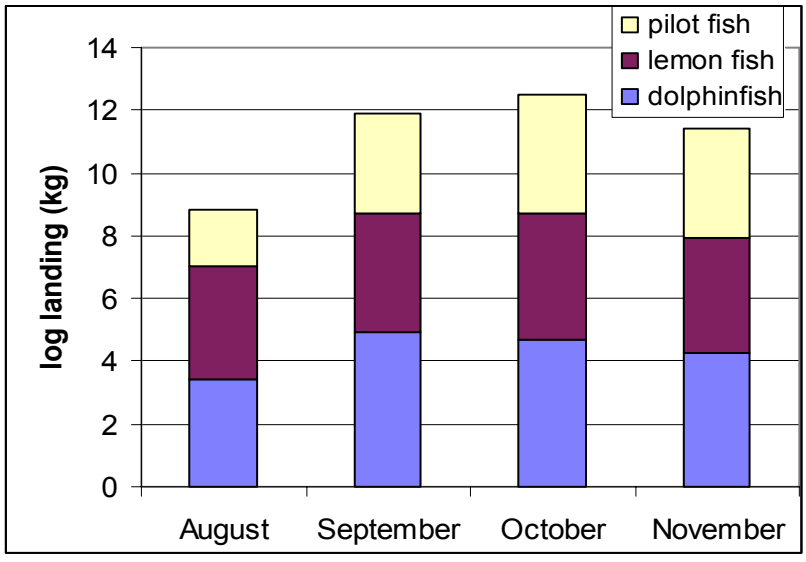
The effort measured as hours/trip decreases along the fishing season from 6.14 to 5.28 and 4.57 h from September to November. The catches by hour fishing range from 37.32, 20.10 to 28.73 kg/h for the same 3 months.

Landings

Daily information of all landings at the Fishing Warf in Palma de Mallorca (the only Warf in the Island) was collected through the Voucher Scheme. The Fishing Warf has recently implemented the automatic selling system. The fish are sold in boxes in a decreasing price auction. The mean weight of the dolphinfish fish box is 15.53 kg ranging from 8.7 to 20.10 kg/box. The mean weigh of the pilot fish box is 4.6 kg ranging from 1.5 to 9.5 kg/box and 5.1 kg for lemon fish, ranging from 1.8 to 7.1 kg.

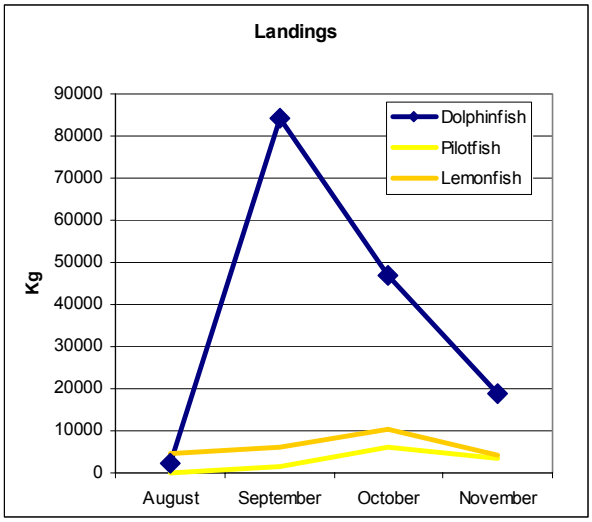
The landings for the 2004 fishing season have been 152,522.99 Kg of dolphinfish, 25,625 Kg of lemon fish and 10,881 Kg of pilot fish, corresponding to 442,831 €, 161,663 € and 19,873 €, respectively. The total landings commercialized throughout the Fishing Warf were 198,021 Kg corresponding to 624,367 €, from these 77% of the landings corresponded to dolphinfish 12.9 % to lemon fish and 10.1 % to pilot fish. In value 70.92 % corresponded to dolphinfish, 25.89 % to lemon fish and 3,18% to pilot fish. Probably part of the catch is sold directly, but we could not estimate the magnitude of the unreported catches. The relative contribution of each species by month is shown in Fig.5. The dolphinfish dominates the landings in all months, but with a relative increase of the other species at the end of the fishing season.

Fig.5. Relative contribution of the species to the fishery.



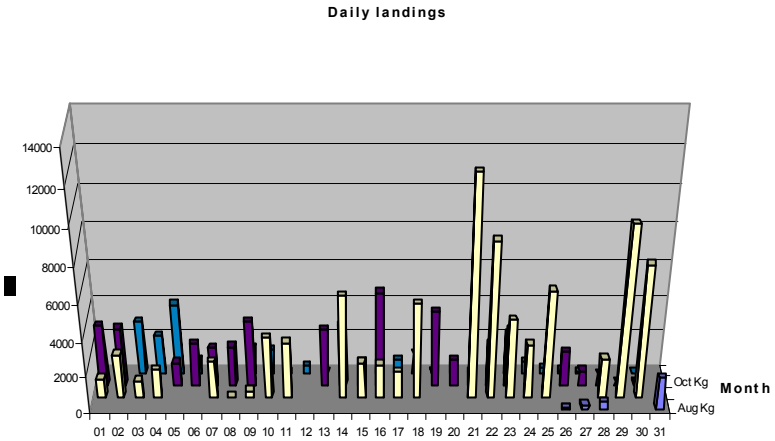
The main dolphinfish landing was produced in September, whilst for the other species the peak corresponds to October (Fig. 6). However, it is interesting to keep in mind that when the dolphinfish is very abundant the fishermen might discard the other species, due to the small size of the boats.

Fig. 6. Monthly landings of the target species of the dolphinfish fishery.



The daily landings of dolphinfish are highly variable (Fig.7) without a clear pattern. The Sales Warf is closed on Sunday and Monday, causing the lack of landings on these dates (Fig.7) and generally a big sale on Tuesday.

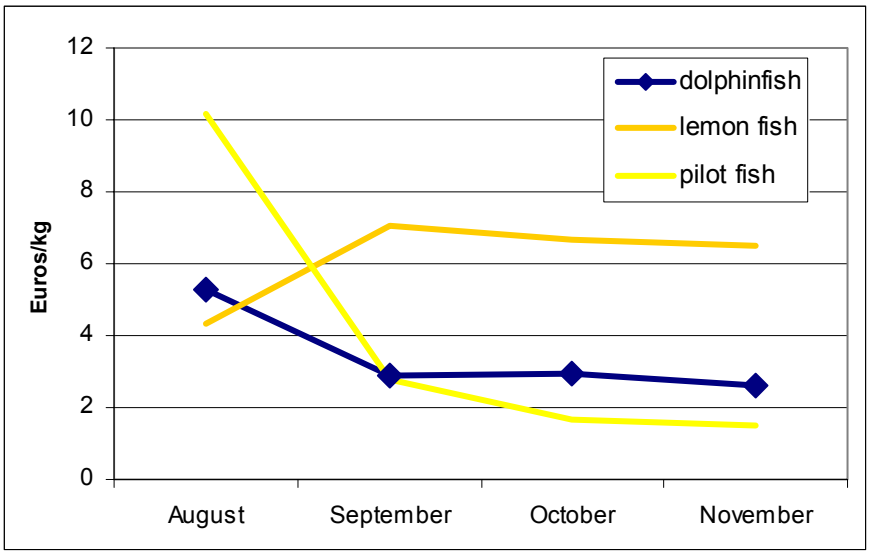
Fig.7. Daily landings by month of dolphinfish.



Prices

The evolution of the price by kg along the fishing season (Fig.9) depends of the abundance. Thus at the beginning of the fishing season the pilot fish was very expensive (10.10 €/kg) decreasing afterwards (1,48 €/kg), the dolphinfish had a similar decrease corresponding to the September high catches (5.30 to 2.63 €/kg), but with more stable prices the rest of the season. The lemon fish had the contrary effect at the beginning of the season, remaining the most expensive species until the end of the fishery (from 4.3 to 7.03 €/kg). We have to consider that these prices are gross sale prices, being the retail prices on the fishing markets and shops much higher.

Fig.9. Evolution of the prices at the Fishing Warf for the target species.



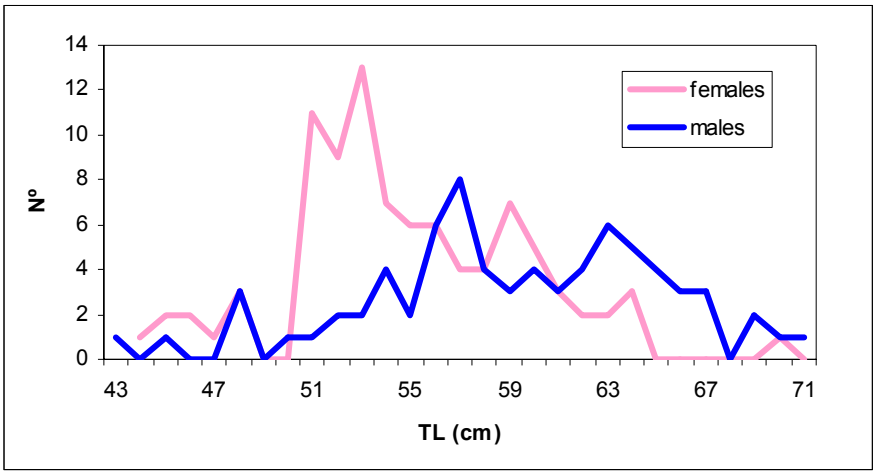
Collection of biological samples

The biological sampling procedure was based upon the collection of 2 boxes of dolphin fish at intervals, depending on the available landings, from Cala Rajada and Soller ports. But at the beginning of the season, we were instructed by the D.G.Pesca that we must buy the samples on the Fishing Warf. Thus, we had to change the planed scheme from buying on board the sampling boats to buy at the Warf. The sampling started on October and has been concentrated on November. Administrative problems with the Fishing Warf and a combination of bad weather and no landings from the selected port originated the delay in the biological sampling.

A total of 168 fishes have been sampled corresponding to 9 sampling days. The cephalic, fork and total length were collected as well as weight, sex and sexual development. The sagitta and lapillus otoliths were collected for all specimens, cleaned of all tissues and stored in vials with distilled water. The water has been changed to keep the otoliths in the best conditions.

The biological samples covered the length range from 43 to 70 cm TL. All the fish were immature being the females predominant (55.36%) over the males. The males were predominantly bigger than the females (Fig.9).

Fig.9. Length distribution by sexes.



Length frequency distribution

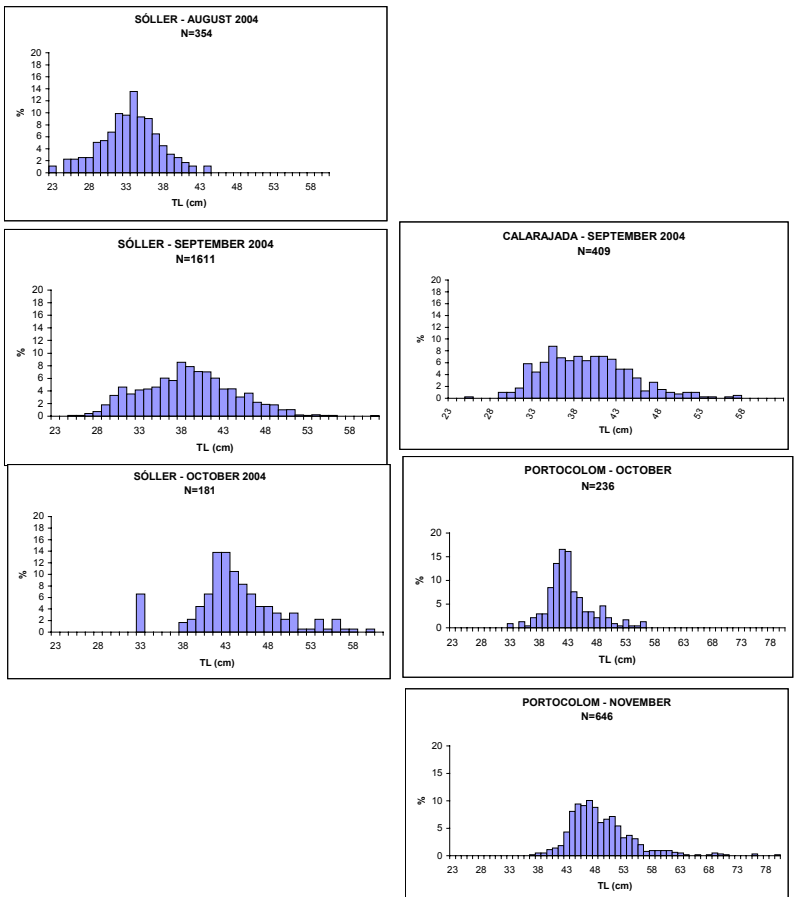
A total of 24 length frequency samples (Table 3) of the catch were obtained covering from 23 to 80 cm TL. A total of 3437 fish were measured. Due to the unfortunate weather conditions it was impossible to obtain regular samplings that allowed determining the length composition of the catches at smaller time intervals than the month. Also the sampling started in August in the N-W strata and ended in October, whilst in the S-E strata started in September and ended in November.

Table 3. Description of the length frequency sampling.

Port	Sampling date	Nºof sampling days	Nºfish measured	Length range (cm)
Calarajada	September	6	409	24-51
Soller	August	5	354	23-44
Soller	September	7	1611	25-61
Soller	October	2	181	33-60
Portocolm	October	1	236	33-56
Portocolom	November	3	646	37-80
Total		24	3437	24-80

The length composition by month and strata show a similar distribution and the rapid fish growth (Fig.10).

Fig.10. Length composition by stratum and month.



The length composition of the catches for the sampling day, obtained from the sampling on board the fleet, was extrapolated to the total daily catch taking into account the weigh of the sampled fish and the registers of total catch of the day from the Fish wharf of Palma by stratum (Tables 4 and 5).

Table 4. Length composition of the catch by month in numbers for the North-West stratum. Sampling port Soller.

TL cm	August port	August stratum	September port	September stratum	October port	October stratum
23	0,23	159,02	0,00	0,00	0,00	0,00
24	0,00	0,00	0,00	0,00	0,00	0,00
25	0,41	278,53	0,02	431,28	0,00	0,00
26	0,35	235,60	0,02	491,77	0,00	0,00
27	0,55	373,64	0,07	1509,47	0,00	0,00
28	0,23	153,09	0,13	2769,14	0,00	0,00
29	0,93	627,43	0,34	6978,70	0,00	0,00
30	0,60	403,57	0,74	15266,00	0,00	0,00
31	1,03	701,02	1,13	23334,31	0,00	0,00
32	1,41	959,13	1,11	22829,47	0,00	0,00
33	1,88	1271,23	1,38	28432,31	0,00	0,00
34	2,36	1598,03	0,80	16447,46	0,00	0,00
35	1,47	995,44	1,06	21866,92	0,00	0,00
36	0,99	671,95	1,21	24969,07	0,00	0,00
37	0,31	210,86	0,70	14477,57	0,00	0,00
38	0,30	203,45	0,95	19575,70	0,13	1363,82
39	0,31	211,70	0,88	18201,10	0,17	1818,43
40	0,57	384,57	0,49	10142,73	0,26	2737,74
41	0,06	43,50	0,62	12713,24	0,38	3956,76
42	0,04	29,00	0,46	9414,53	0,63	6569,91
43	0,00	0,00	0,29	5870,09	0,57	5970,50
44	0,04	29,00	0,38	7733,39	0,48	5041,08
45	0,00	0,00	0,20	4174,84	0,37	3822,06
46	0,00	0,00	0,23	4644,98	0,26	2757,95
47	0,00	0,00	0,15	3017,88	0,15	1538,93
48	0,00	0,00	0,08	1732,36	0,18	1838,63
49	0,00	0,00	0,11	2302,74	0,20	2128,23
50	0,00	0,00	0,04	768,24	0,09	919,32
51	0,00	0,00	0,04	920,74	0,17	1828,53
52	0,00	0,00	0,01	290,00	0,01	154,90
53	0,00	0,00	0,00	82,21	0,01	154,90
54	0,00	0,00	0,01	164,41	0,09	919,32
55	0,00	0,00	0,00	82,21	0,01	154,90
56	0,00	0,00	0,00	82,21	0,06	619,61
57	0,00	0,00	0,00	0,00	0,01	154,90
58	0,00	0,00	0,00	0,00	0,04	454,61
59	0,00	0,00	0,00	0,00	0,00	0,00
60	0,00	0,00	0,00	0,00	0,01	154,90
61	0,00	0,00	0,00	41,10	0,00	0,00

Table 5. Length composition of the catch by month in numbers for the South-East stratum. Sampling ports CalaRajada and Portocolom.

TL cm	September port	September stratum	October port	October stratum	November port	November stratum
23	0,00	0,00	0,00	0,00	0,00	0,00
24	0,00	0,00	0,00	0,00	0,00	0,00
25	0,02	1268,79	0,00	0,00	0,00	0,00
26	0,00	0,00	0,00	0,00	0,00	0,00
27	0,00	0,00	0,00	0,00	0,00	0,00
28	0,00	0,00	0,00	0,00	0,00	0,00
29	0,13	8563,05	0,00	0,00	0,00	0,00
30	0,13	8075,27	0,00	0,00	0,00	0,00
31	0,22	14131,72	0,00	0,00	0,00	0,00
32	0,79	50112,64	0,00	0,00	0,00	0,00
33	0,53	33826,38	0,01	368,68	0,00	0,00
34	0,80	51009,48	0,00	0,00	0,00	0,00
35	1,06	67447,90	0,02	553,02	0,00	0,00
36	0,79	50278,97	0,01	184,34	0,00	0,00
37	0,57	36007,00	0,03	921,71	0,00	53,46
38	1,11	70780,30	0,04	1290,39	0,01	261,44
39	1,21	77295,15	0,04	1290,39	0,01	183,15
40	1,27	80894,35	0,10	3686,83	0,03	498,05
41	1,38	87885,79	0,16	5898,93	0,04	683,27
42	0,84	53229,77	0,20	7189,32	0,05	833,64
43	0,96	61400,30	0,19	7004,98	0,11	2037,72
44	0,64	40738,40	0,09	3318,15	0,20	3603,97
45	0,37	23366,86	0,08	2765,12	0,26	4802,48
46	0,24	14986,89	0,04	1474,73	0,24	4369,66
47	0,72	45999,39	0,04	1474,73	0,28	5170,20
48	0,14	9125,04	0,03	921,71	0,24	4487,57
49	0,14	9166,67	0,06	2027,76	0,16	3027,30
50	0,10	6660,07	0,03	921,71	0,21	3945,75
51	0,20	12480,29	0,01	368,68	0,18	3391,53
52	0,12	7928,85	0,01	184,34	0,14	2523,04
53	0,03	1646,86	0,02	737,37	0,08	1438,63
54	0,10	6679,96	0,01	184,34	0,10	1823,86
55	0,00	0,00	0,01	184,34	0,07	1339,65
56	0,10	6679,96	0,02	553,02	0,05	909,86
57	0,05	3293,73	0,00	0,00	0,03	502,19
58	0,00	0,00	0,00	0,00	0,02	444,59
59	0,00	0,00	0,00	0,00	0,02	457,32
60	0,00	0,00	0,00	0,00	0,03	555,65
61	0,00	0,00	0,00	0,00	0,02	421,83
62	0,00	0,00	0,00	0,00	0,01	213,86

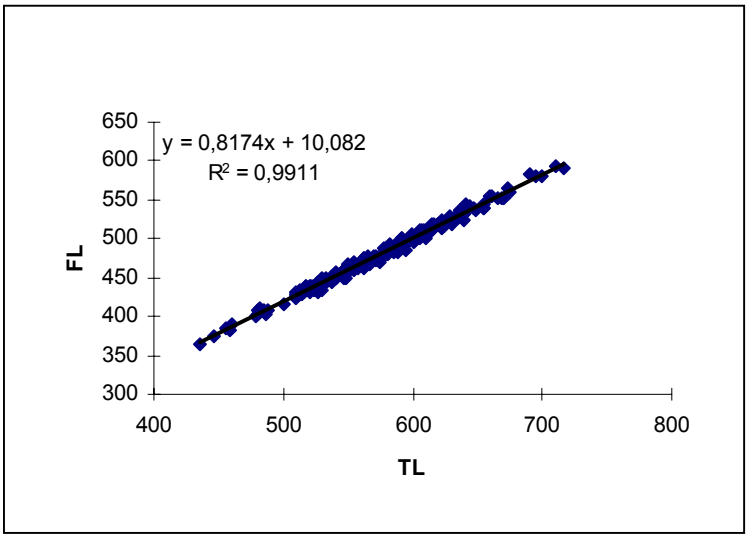
Morphometrics

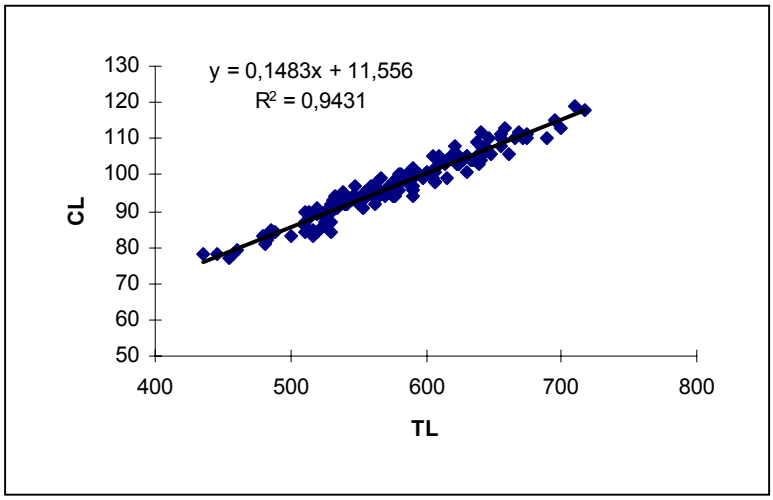
The length-weight for the total of the population was calculated for the total length range 43.61 cm to 71.7 cm, corresponding to weigh 535 g to 2060 g:

$$TL\ (cm) = 0.0201\ W^{2.6962}\ (g)\ (r^2 = 0.9618,\ N = 166)$$

The total length relationships with fork length as well as with the cephalic length (from nose to the tip of the operculum) were also determined (Fig.10).

Fig.10. Morphometric relationships for the dolphinfish from Majorca. FL: fork length, TL: total length, CL: cephalic length.





Age and growth

The total number of otoliths available for age determination were: 163 for Majorca, 79 for Tunisia and 156 for Malta. Although the sampling was more numerous (166, 156 and 171, respectively) there were vials without otoliths, otoliths were lost during preparation or there were errors in the register number of the vial (i.e. duplicated numbers).

In this report we include only the results for Majorcan dolphinfish.

Otolith description

In a previous study on the otolith age determination on dolphinfish, it was determined that lapillus gave similar results to sagittae being more easily prepared for observation (Morales-Nin et al, 1999). The lapilli are small and flatter growing mainly in the fish frontal plane (Fig.11a). The dorsal side is flat, while the ventral side has more ornamentation (Assis, 2000). Thus, the otoliths were glued to the microscope slide with the ventral side up and grinded and polished until the core was close to the surface. The otolith was removed and turned, being processed as before to obtain a thin section. The frontal section was washed, air dried and mounted with immersion oil and a cover slide placed on top. The otolith reading was done at 400X or 1000X on an image system screen coupled to a Leica microscope.

The lapillus had differential growth depending on the axis; repeated readings showed that the rostrum-core radius had clearer but less increments than the maximum radius (core-post-rostrum) (Fig.11a). This difference consisted in an apparent stop in the former grow (determined by following the increments along the perimeter). While the formation continued in the post-rostrum. Thus, the lapilli were read twice using both radius and the last increments were determined on the otolith post-rostrum to the core radius (Fig. 11a reading radius). When the two otolith readings differ more than 5%, the otolith was discarded.

In 11.9% of the otoliths from Majorca an accessory primordium was present (Fig.11c) close to the otolith primordium. The increments initially are very thin (Fig.11d) and representing around 2 weeks of growth, followed by progressively thicker increments. These wide increments (mean width 6.92 µm, s.d. 1.85) may have numerous sub-increments that confound the age determination being necessary to contrast the

increment with its continuity along the otolith perimeter (Fig.11b,12a). The marginal increments were more thin (mean width 1.8 µm, s.d. 0.99) and representing between 1 or 2 months of life (Fig.12b).

Fig.11. Dolphinfish lapillus. a) Whole otolith and reading radius (arrow) (X100). b) Increments along the reading radius (X400). c) Central area with two cores (arrows) (X400). d) Core and first increments (X400).

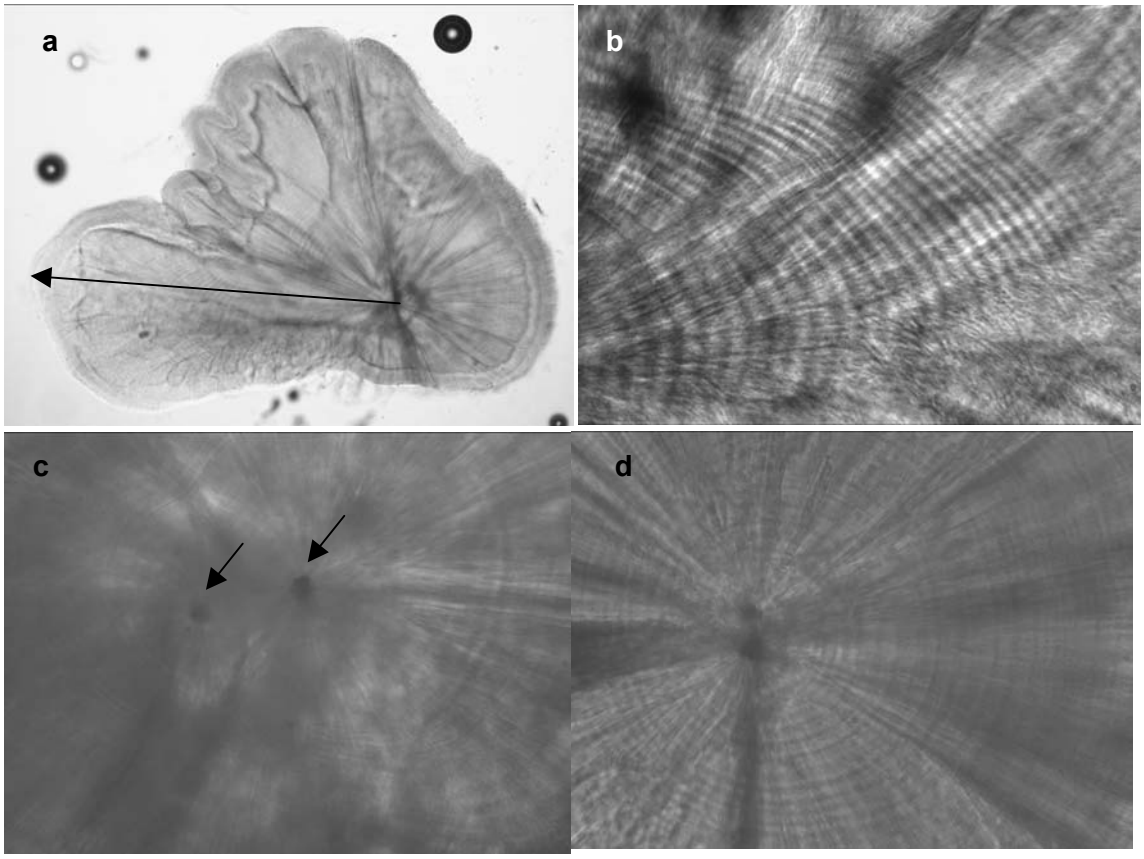
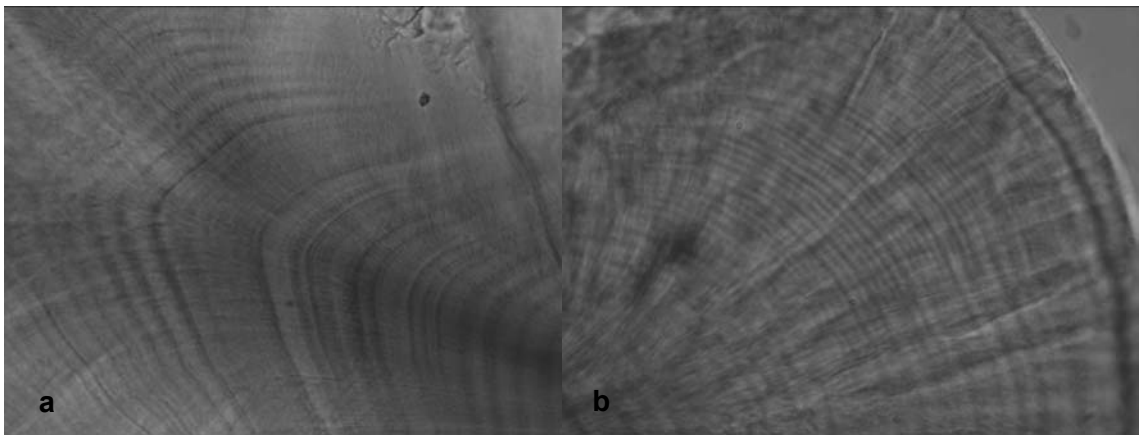


Fig.12. Dolphinfish lapillus. a) Wide growth increments in the intermediate zone and b) thin increments in the edge. (X400).



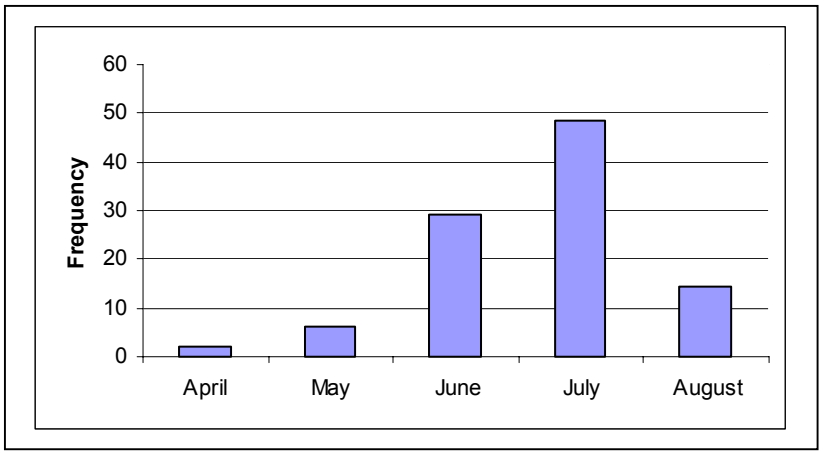
Age determination Majorca

From the 168 fish sampled, 148 otoliths could be read (88%). The remaining otoliths were either damaged during the preparation or were unreadable. The ages ranged from 81 to 199 increments corresponding to a total length of 56.9 cm and 64.3 cm, respectively.

As no validation method could be applied to validate the age determination, hence the daily nature of the increments could not be assessed, we back-calculated the hatch date distribution by subtracting from the catch date the age in days. This method has been previously used with sagitta otoliths as an indirect validation method.

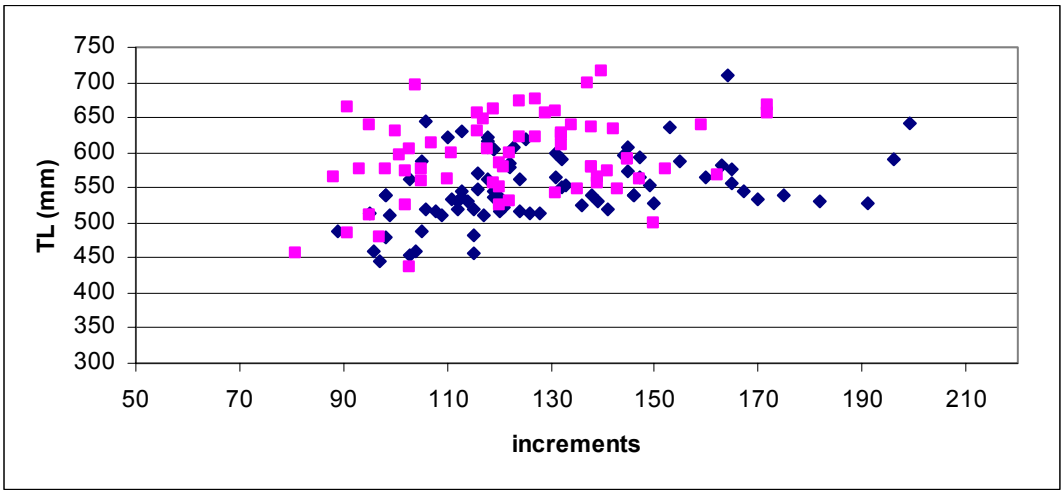
The hatch date distribution showed an early start of the spawning activity at the end of April and finishing by middle August. The main part of the hatching occurred on June-July with the 77% of the total (Fig.13). These dates are supported by previous studies of dolphinfish maturity and reproduction, which showed that the dolphinfish in Majorcan waters are mature from May to September (Massutí & Morales-Nin, 1995, 1997). This hatchdate distribution is also coincident with the periods calculated from sagitta and lapillus otoliths age determinations for Sicily and Majorca (Morales-Nin et al. 1999).

Fig.13. Hatch date distribution for Majorca dolphinfish back calculated from the age and the date of capture.



Thus, we consider that the increments in the lapillus otoliths could be an indicator of age, although we do not know the exact age when the increments start being lay down. This might imply an underestimation of the real age of few days. The length-age relationship is shown in Fig 14. It appears clear sexual dimorphism at this early stage of immature fish. The females seem to have higher lengths at a given age than males. These results show that the fishery acts upon fish from 3 to 6 months of age.

Fig.14 .Age-length relationship by sexes determined from lapillus interpretation. Pink squares females, blue males.



Socioeconomic data

In the N-W stratum the boats are manned by 4 fishermen (s.d.=1.4), while in the S-E the crew is 2.43 (0.53). There are some fishermen with salary, but most get a share of the sales of the week. The cost of fuel (100 % of the boats) and ice (89 % of the boats) are deduced from the catch value before splitting. The percentage share for the crew is 25 %, taking into account the part the owner receives for being a part of the crew.

The running costs of the fishery are the fuel, the mooring of the boat on the harbor, the fish boxes, the ice, the fish transport to the Warf and the oil. Every 7 months the boats are pulled out of the water for painting (cost approximately 700 €). Other costs depend on the events, like reparations. The FADs are built each year and have a small value (around 5 €/each), the ropes (around 25 €/each) may be recovered and reused but the mooring (around 20 €/each) is generally lost. During the fishing season a feasible number of FADs (around 30 %) are lost due to bad weather or by interaction with other surface fishing gears. Some boats might replace them with the consequently additional cost. The net is repaired and used for several years.

The value of the boat with gears and equipment is very difficult to estimate, the optimistic perception of the owners (44.100 €, s.d.= 7.778 in the N-E, 140.800 €, s.d.=96.758 in the S-E stratum) is based on the costs incurred not in the real market value.

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