ELEVEN YEARS - 1995-2005 – OF EXPERIENCE ON GROWTH OF BLUEFIN TUNA (*THUNNUS THYNNUS*) IN FARMS

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SUMMARY

Atlantic Bluefin Tuna (BFT) farming has taken place in SE Spain since 1995. A data base based on 44 tuna cages and 20.622 tunas from 1995 to 2005 has been analyzed to estimate FL-RW relationship and growth in farming conditions. FL-RW relation has been calculated per month and cage. There are many factors which can affect BFT growth under ranching conditions. The present work describes some of these factors with the aim to properly assess growth during farming.

KEYWORDS

Bluefin tuna, Farmed Tuna Growth.

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Introduction

The first fattening experience with Atlantic bluefin tuna (BFT) was conducted in 1995 in the Mediterranean Sea with tunas captured by purse seiners in the vicinity of the Balearic Islands. Since then, this practice has spread throughout our *Mare Nostrum*.

As opposed to other types of marine aquaculture, and apart from the BFT farms established in Croatia, the main objective of BFT fattening is not to increase the ranched animals' biomass to achieve an optimal commercial size. A large share of tunas fattened in floating cages goes to the "*sushi*" market in Japan and other places in the world where this type of cuisine is booming. The main purpose of the BFT fattening business is, therefore, to provide this market with the desired quality of meat to prepare the aforementioned dish.

Nonetheless, supplying food for a given period of time will, evidently, produce an increase in biomass of the farmed stock. A study on the monitoring of farmed BFT growth started in 1995 to find out the conditions or systems that would optimize such growth and would make the BFT farming business more efficient in terms of BFT feeding under captive conditions.

Given the current control measures on the resource, BFT growth analysis in floating cages is essential to determine the initial caught biomass and, therefore, to estimate the amount of biomass removed from the wild stock.

Currently, there is no standardized direct system to determine BFT growth under captive conditions. Image analysis for southern bluefin tuna (*Thunnus maccoyii*) (83-141 cm) was conducted with a stereo-video camera system (Harvey *et al.* 2005) which seemed quite efficient at estimating growth of small specimens. Moreover, Aguado and Garcío-García (2005a) developed a measuring video-laser device which allowed the measurement of larger specimens, although with less precision than the system developed by Harvey *et al.* (2005).

Even though video images used when transferring tunas from purse seiners' nets to transport cages cannot accurately estimate the transferred fish weight, they can be useful for getting a first estimate of this weight and of the population structure of the transferred stock.

In the case of small tunas, tag and recapture methodology to conduct growth studies of tuna kept in captivity presents some difficulties (Ticina *et al.*, 2004), and it becomes almost impossible in the case of large tunas due to their fragility when handled. It is also worth mentioning that after a - longer or shorter - period of time following the handling a decrease in the condition of the tagged tuna has been observed.

Thus, in practice, a simple way of estimating growth, in terms of biomass, is to compare the weight of wild and reared tunas of the same size class.

The aim of the present work is to estimate BFT growth in fattening farms from SE Spain from 1995 to 2005. The Fork Length – Round Weight (FL-RW) relationship of 19,798 BFT specimens from a total of 42 fattening cages during the abovementioned period is presented in this work.

Likewise, FL-RW relationships in harvested fish are shown from July to April of the following year in order to estimate the monthly increase in reared biomass.

Data obtained from experiences of fattening young specimens that were caught in the Balearic Islands and Gulf of Lions have also been analyzed.

Finally, the weight gain rates obtained for the different size classes is also compared to the results from other authors.

In order to estimate the initial length and weight at catch of farmed specimens and thus total removals from the wild stock, different equations are proposed based on the final harvested weight.

There are a number of factors that can affect BFT growth under captive conditions. Some of these factors are listed at the end of the paper in order to provide valuable tools for properly assessing tuna growth.

Materials and Methods

Data were obtained between 1995 and 2005 from the farms that used to be located in Gorguel bay and in San Pedro del Pinatar (Murcia, Spain) and were run by Tuna Farms of Mediterraneo (TFM), Tuna Farms Grosa (TFG) and Ecolofish.

Location	**Company**	**ICAR No.**	**Latitude**	**Longitude**
Gorguel bay	TFM	ICAR No. 08	34º34´25´´ N	000º52´32´´W
San Pedro del Pinatar	TFG	ICAR No. 07	37º48´30´´N	000º40´42´´W
	ECOLOFISH	ICAR No. 14	37º49´06´´N	000º40´07´´ W

Fish were kept in polyethylene cages of 32, 40, 50 and 90 m diameter and 35 m average depth. Water temperature at 5 m depth ranged from 28 ºC in August to 14 ºC in February.

During the fattening period in the farm, BFTs were fed Atlantic mackerel *Scomber scombrus*, chub mackerel *Scomber japonicus*, Madeiran sardinella *Sardinella maderensis*, horse mackerel *Trachurus spp.* and *Illex spp.* squid until full. When maximum feeding activity occurred, daily feeding rate (TI) was estimated at 6 % (Norita, 2003) and 8 % of body weight for adults and juveniles, respectively. At minimum feeding activity TI was estimated around 1.5 % for the whole population.

Table 1 and **Figure 1** show the data from the equations describing size-weight relationship which were obtained in cages with tunas originating from the Balearic Islands, Tyrrhenian Sea and Central Mediterranean (Libya-Tunisia-Malta area) fisheries. The average transportation time from the capture location to the fattening farm was 30 days for the Tyrrhenian Sea and 60 days for the Central Mediterranean. Tunas were not fed during the transport.

In order to observe the weight increase or the relative growth rate (RGR %) of the reared stock, the analysis was conducted both individually (per fully-harvested cage) and monthly (limited to the cages from the Balearic Islands' catches; this way, data from specimens arriving in poor condition, due to the long transportation time and the lack of feeding during this time, were avoided).

FL of each specimen was measured immediately after its harvesting. RW was done either on board the freezer or the processing vessels. When gutting was conducted on board a vessel, total weight was estimated using Cunningham's equation (Cunningham *et al.*, 2002), which converts eviscerated weight into total weight.

To analyze the 42 fully-harvested cages individually, the size-weight relationship was calculated by means of the following equation:

$$RW=a*FL^{b}$$

Where RW is total weight in kg and FL is the straight fork length measured in cm. Length - weight relationship was studied through a potential regression using Statgraphics 5.1. A statistically significant relationship was assumed when $P < 0.01$.

Similarly, to observe the weight increase of a given size throughout the production process, FL-RW monthly equations for the Balearic Islands' catches were calculated. To do the comparative study with wild populations, the FL-RW equation described by Aguado and García-García (2005 b) was used as initial condition, since it was obtained from purse seine catches in the Balearic Islands in July.

To calculate RGR %, the following equation was used:

$$RGR\% = \frac{RWf - RWi}{RWi} * 100$$

Where RW*f* is final weight and *RWi* is initial weight for the same size (Aguado and García-García, 2005 b).

The condition coefficient (K; Rodríguez-Roda, 1964) was also calculated throughout the production cycle:

$$K=RW/FL^3*10^5$$

Two fattening experiences were conducted for juvenile tunas. One cage contained catches from the Balearic Islands (BRD98) and fattening lasted for 167 days; the other cage was filled with tunas from the Gulf of Lions (PC4000) which were kept in captivity for 473 days. In both cases, the average initial weight was below 20 kg.

Results and Discussion

The size class distribution figure for the Balearic samples (**Figure 2**) shows that there are two distinctive size class groups. One for juvenile tunas, where the prevailing size is 130/140 cm, and another for large reproductive tunas, where the dominant size is 220 cm.

In the present work, the FL-RW equations obtained from fattening cages with large specimens are comparable to those published by other authors (**Table 2**). Overall it can be observed that at the end of the fattening process and under different rearing conditions, the final condition of BFT when kept in fattening cages is very similar. Interestingly, in the present study even when the tunas were transported for a long time (such as the ones coming from Italy or Libya) the final weight was not very different from those cases where the transportation time was short.

Table 3 shows monthly data obtained from specimens caught in the Balearic Islands; **Figure 3** depicts the overall RW-FL curve. The analysis of cumulative monthly RGR vales (**Table 4**) shows that large tunas significantly increase their weight during the first fattening months, stabilizing afterwards. After 8 months of fattening, the most abundant size class (i.e. 220 cm) can increase its weight by 32 %. Data from this and other studies suggest that small tunas (100 – 160 cm) grow less than large tunas (Aguado and García-García, 2005; Tzoumas *et al.*, 2010). This result, among other reasons, is usually a direct consequence of the population structure within the different tuna cages. In those cages where large tunas are dominant (in terms of biomass), small tunas are almost totally suppressed from feeding and stay near the bottom of the net for nearly the entire process. Only when (after a while) larger specimens significantly reduce their feeding activity smaller specimens begin to feed. Similarly, in cages where the ratio of young specimens is much higher than large specimens, the latter hardly feed, losing significant weight at times.

In the winter months, when the farming process is ending, a slight decrease in weight takes place which is reflected in the tuna condition coefficient (**Figure 4**). This is a direct result of the feeding rate which is very high in the months prior to their capture and then it significantly decreases with temperature, reaching a feeding level that we could call of maintenance or basal. This is similar to what happens to reared southern BFT (*Thunnus maccoyii*): its increase in weight is minimal below 15 ^{o}C (Glencross *et al.*, 2002). The condition coefficient in the present work ranged from 1.81 in July to 2.12 in February. The July condition coefficient varied from 1.6 to 2, which are the values obtained by Rodríguez-Roda (1964) for the tunas entering and exiting the Gibraltar strait, respectively.

In those cages with just young tunas, growth is more important as the direct competition for food has been removed. Data from the experiences with juveniles originating from the Balearic Islands' catches are shown in **Table 5**. In this case the weight increase is more significant, reaching a RGR of 88.8 % in November (121 days) and then decreasing slightly afterwards. It seems that this decrease occurs equally in natural populations, where, from the end of fall and depending on the tuna size, the increase in weight stops (Mather *et al.*, 1995). Data from the experience with tunas originating from the Gulf of Lions, which involved a farming period of 473 days, is shown in **Table 6**. In this case, RGR reached a value of 221.7 %.

The growth analysis in cages with juveniles is relatively simple, as populations are usually very homogeneous and with very little dispersion. With large reproductive specimens, however, the analysis becomes more difficult as dispersion for both size and weight is high from the beginning.

Table 7 shows the equations allowing computing, for large specimens, length from final weight, for different farming periods (in months) as determined by the month of harvesting. From this initial length, the fished biomass can be estimated using FL-RW equations suitable to wild tunas during the fishing season.

In BFT rearing, growth (in terms of biomass increase) is difficult to model as there are different factors that could make this increase vary considerably, at any given time, from one facility to another and even from one cage to another within one facility.

Following are listed some of the reasons that after a decade of experience seem crucial to determine bluefin tuna growth in captivity:

- **Water temperature:** This is a crucial factor as it seems to be directly responsible for the decrease in feeding rate. Note that in our case, BFT decreased their TI few days prior to the steepest temperature decline (from 3 to 5 °C), which usually occurred in mid-October in SE Spain. As a curiosity, even though their initial condition was very different, tunas originating from both the Balearic Islands and Central Mediterranean decreased their feeding almost at the same time.

- **Size distribution:** It is a key factor for tuna growth in fattening cages. Due to the clear gregarious behavior of this species when in captivity, non-dominant sizes frequently have feeding problems which in turn result in lower growth rates.

- **Food type:** It is another factor that significantly affects tuna growth under captive conditions. Early in the process, when the water temperature is high BFT is not very selective in terms of food, equally predating on the different types of food provided. After a while, when BFT is in its optimal condition, it becomes very selective and it can even reject certain types of food that were being consumed early in the process. A good choice of food provided may result in a better fattening performance.

- **Final product destination:** This is another important factor that determines BFT growth. Depending on where the output will be sent (i.e. Japanese or Western market) and the type of final product (i.e. fresh or frozen market) a differential feeding strategy can be performed that will make certain BFT groups grow more in terms of biomass.

- **Facility operating capacity:** The facility operating capacity is another factor that determines to some extent BFT weight increase. Operational issues such as the strategy in food supply (one o several intakes per day, feeding time, etc.) or the harvesting frequency can markedly influence the differences in weight increase between facilities or cages.

It should be noted that this study has not considered any potential length increase during the fattening period, due to the difficulty in assessment. It is therefore possible that the real weight increase might be slightly higher than the estimated as the comparison should start from a lower initial length.

Using this type of indirect methodology to estimate the weight increase has the added problem that wild FL-RW data comes from the literature. Looking at data from various authors it can be concluded that the difference in weight of wild specimens of the same size in one area can account for more than 20 %, depending on their physiological or feeding condition. So using a single FL-RW equation to assess the various facilities could increase the estimation error. This is the reason why, in order to get a more precise estimation of BFT growth in fattening cages and of the population's initial condition in each area, it would be important to conduct a sampling strategy at the farms targeting the specimens that die during transport or during the first weeks in maintenance cages.

It can be concluded from this study that for the most commonly observed BFT size class (200 – 240 cm), corresponding to large animals, growth in farms in the Mediterranean can range from 20 to 35 % in a typical farming season . When catches are homogenous growth can reach values close to 80 % in the case of juveniles (120 - 150 cm). But in the case of cages with mixed size classes, the growth of small specimens appears to be much smaller, and alternative methods for its assessment should be found.

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Table 1. FL-RW equations obtained from each cage, once fully harvested.

Cage	Equation	R^2	N	Min (cm)	Max (cm)	Start	End	Days	Origin
95BR	RW=0,00000395*FL2,879	0.970	73	118	278	01/07/95	01/01/96	184	Balearic
SmPC97	RW=0,00001*FL3,142	0.950	89	145	247	15/06/97	24/11/97	162	Balearic
BPC97	RW=0,0000128*FL3,090	0.954	150	130	276	15/06/97	30/11/97	168	Balearic
PC5098	RW=0,00000775*FL3,173	0.955	461	123	282	16/06/98	09/02/99	238	Balearic
PC32A98	RW=0,0000126*FL3,09	0.932	83	185	275	20/07/98	26/10/98	98	Balearic
PC32B98	RW=0,0000106*FL3,113	0.958	255	119	272	23/07/98	19/01/99	180	Balearic
PC4098	RW=0,0000147*FL3,056	0.953	162	116	265	30/06/98	29/12/98	182	Balearic
C499	RW=0,0000102*FL3,144	0.975	521	120	273	25/07/99	01/02/00	191	Balearic
PC4099	RW=0,0000130*FL3,089	0.972	353	112	263	15/06/99	01/12/99	169	Balearic
PC5099	RW=0,0000131*FL3,086	0.969	880	117	272	16/07/99	07/02/00	206	Balearic
C199	RW=0,00000809*FL3,177	0.952	161	119	260	01/07/99	10/01/00	193	Balearic
C299	RW=0,00000420*FL3,277	0.920	143	163	275	10/06/99	30/10/99	142	Balearic
C399	RW=0,00000806*FL3,185	0.975	645	118	285	25/06/99	20/03/00	269	Balearic
C49000	RW=0,00000602*FL3,23	0.979	1761	107	283	27/06/00	09/04/01	286	Balearic
C29000	RW=0,0000135*FL3,084	0.964	1002	113	280	12/06/00	14/12/00	185	Balearic
C39000	RW=0,00001570*FL3,047	0.956	533	105	280	29/06/00	30/11/00	144	Balearic
SP49001	RW=0,00000754*FL3,202	0.953	543	120	285	08/09/01	25/03/02	198	Italy
SP19001	RW=0,0000245*FL2,984	0.968	198	112	270	07/06/01	04/02/02	242	Balearic
PC5001	RW=0,0000165*FL3,05	0.949	103	150	242	14/07/01	05/12/01	144	Balearic
SP29001	RW=0,0000107*FL3,135	0.953	916	109	282	20/08/01	08/04/02	231	Libya
SP39001	RW=0,0000104*FL3,134	0.951	860	126	260	23/08/01	18/04/02	238	Libya
C19001	RW=0,00000636*FL3,212	0.980	445	95	283	29/05/01	04/12/01	189	Balearic
C29001	RW=0,00000910*FL3,159	0.958	559	114	272	10/07/01	21/01/02	195	Balearic
C39001	RW=0,00000722*FL3,18	0.966	1283	106	289	25/07/01	09/01/02	168	Balearic
G29002	RW=0,0000031*FL3,336	0.955	597	154	282	12/08/02	25/03/03	225	Italy
G39002	RW=0,00000383*FL3,305	0.945	1259	115	285	12/08/02	13/02/03	185	Italy
G49002	RW=0,00000120*FL3,091	0.979	105	111	247	12/08/02	24/03/03	224	Italy
SP19002	RW=0,00000279*FL2,969	0.969	83	108	268	10/08/02	02/11/02	84	Italy
SP39002	RW=0,00000171*FL3,455	0.942	896	120	290	07/08/02	20/03/03	225	Italy
SP29003	RW=0,00000205*FL3,412	0.956	197	125	270	12/06/03	24/03/04	286	Balearic
SP39003	RW=0,00000702*FL3,175	0.963	821	110	278	01/08/03	08/03/04	220	Italy
SP49003	RW=0,00000440*FL3,254	0.958	128	113	265	15/07/03	09/03/04	238	Italy
G19003	RW=0,00000251*FL3,362	0.938	1218	130	285	19/07/03	23/04/04	279	Libya
G29003	RW=0,0000111*FL3,090	0.936	571	112	292	03/08/03	21/12/03	140	Libya
G39003	RW=0,00000226*FL3,387	0.950	879	145	275	06/08/03	13/04/04	251	Libya
G19004	RW=0,00000760*FL3,187	0.910	321	130	282	17/08/04	20/01/05	156	Italy
G39004	RW=0,00000673*FL3,219	0.961	68	120	270	10/06/04	23/12/04	196	Balearic
SP19004	RW=0,00001164*FL3,119	0.980	142	125	280	09/07/04	22/11/04	136	Balearic
SP39004	RW=0,0000145*FL3,068	0.976	35	110	268	10/08/04	28/10/04	79	Italy
SP49004	RW=0,00000612*FL3,248	0.945	45	173	263	18/08/04	02/12/04	106	Italy
J19005	RW=0,00000686*FL3,202	0.941	168	135	180	18/07/05	07/12/05	142	Balearic
J29005	RW=0,00000634*FL3,127	0.951	86	165	265	23/06/05	28/02/06	250	Balearic

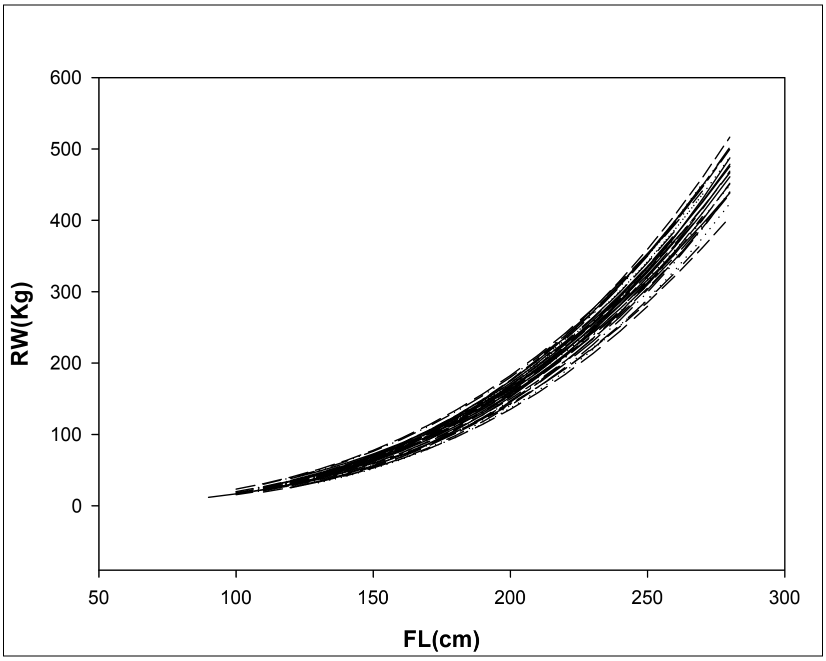

Figure 1. FL-RW equations obtained from each cage, once fully harvested.

Table 2. Comparison of data from the present study with fattened BFT data from other authors found in the literature.

	RW (kg.)				**Present study**		
FL (cm.)	**Aguado & García-García**	**Tzoumas *et al.***	**Gordoa**	**Neves dos santos *et al.***	**Balearic.**	**Italy.**	**Libya.**
100	17.5	19.2	19.6	15.8	19.4	19.1	20.7
110	23.8	25.9	26.2	21.7	26.1	24.02	27.3
120	31.4	34.2	34.0	28.8	34.4	30.55	35.2
130	40.5	44.1	43.3	37.5	44.3	39.66	44.4
140	51.3	55.9	54.1	47.8	55.9	50.25	55.1
150	63.9	69.6	66.6	59.9	69.5	62.08	67.3
160	78.5	85.5	80.8	74.1	85.2	76.36	81.1
170	95.2	103.7	97.0	90.4	103.2	94.72	96.7
180	114.2	124.3	115.2	109.0	123.5	113.84	114.2
190	135.7	147.7	135.6	130.2	146.5	135.47	133.6
200	159.7	173.9	158.2	154.1	172.2	159.8	155.1
210	186.6	203.1	183.2	180.8	200.8	186.98	178.6
220	216.4	235.5	210.8	210.6	232.6	217.21	204.5
230	249.4	271.3	240.9	243.7	267.6	250.66	232.6
240	285.6	310.6	273.9	280.2	306.0	287.51	263.2
250	325.3	353.7	309.7	320.4	348.0	329.59	296.3
260	368.6	400.8	348.5	364.4	393.8	370	332.1
270	415.7	451.9	390.4	412.4	443.6	415.34	370.5
280	466.8	507.3	435.5	464.7	497.5	478.39	411.7

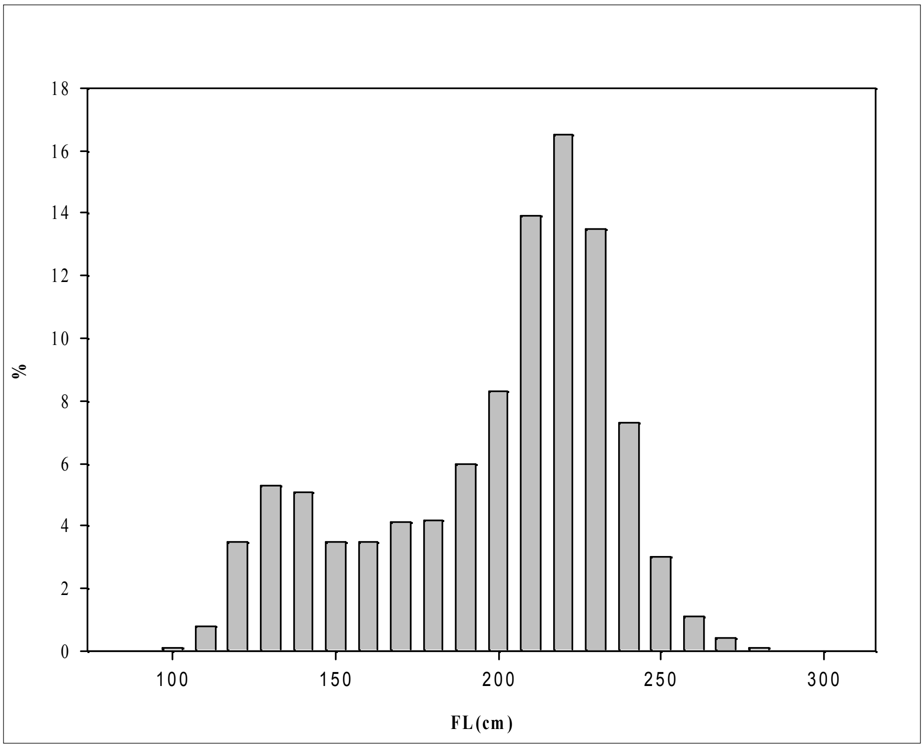

Figure 2. Distribution by size class of specimens from the Balearic Islands' catch, n =12,647

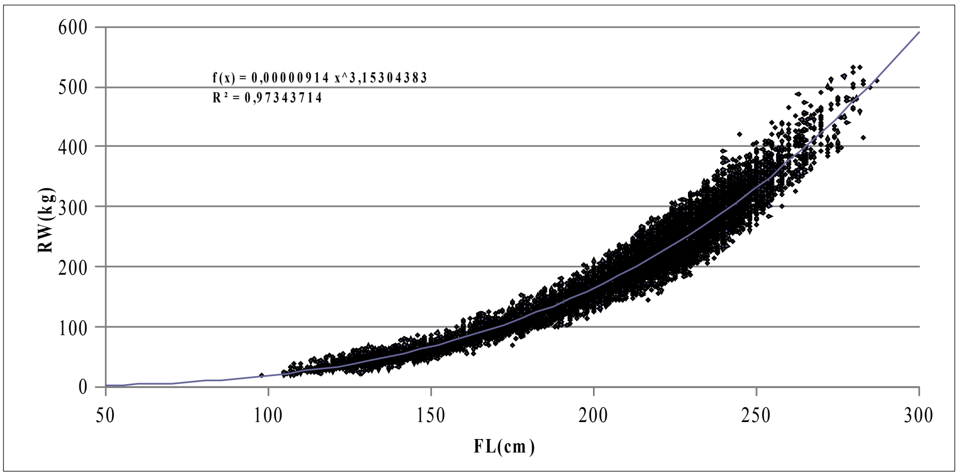

Figure 3. RW-FL curve for specimens from the Balearic Islands' catch, n=12,647

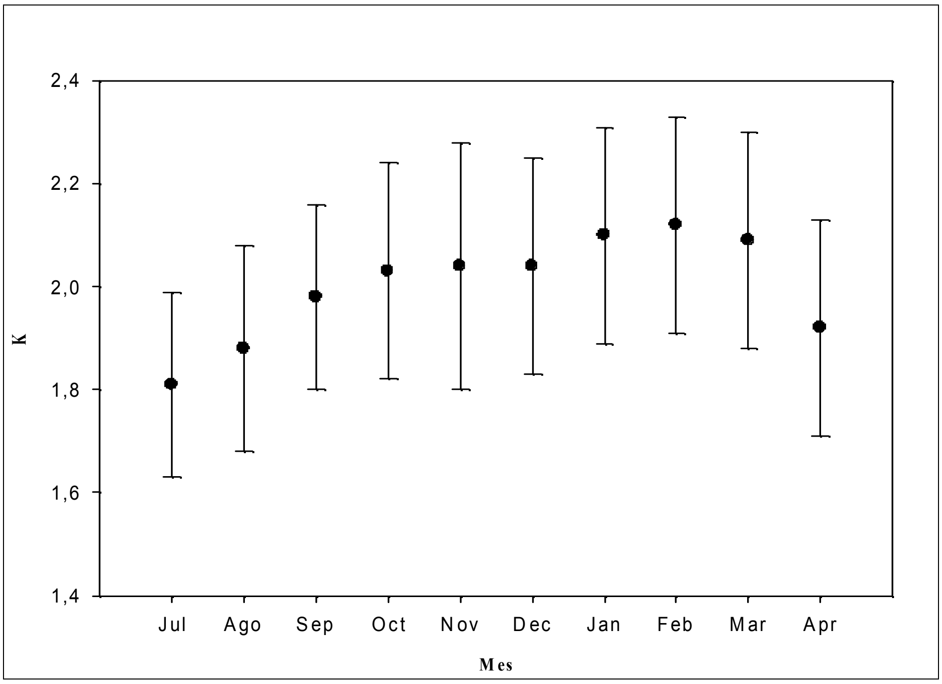

Figure 4. Progress of condition factor K throughout the fattening process.

Table 3. Results from the Balearic Islands' cages for the monthly growth analysis. This includes the data obtained to find the monthly FL-RW relationship which is defined as follows: RW=a*FL^b

		a	**b**	**R^2**	**n**	**Min**(cm.)	**Max**(cm.)	**K**	**Std Dev**	**Cage No.**
July		1.890E-06	3.419	0.943	89	164	275	1.81	0.18	3
August		5.51E-006	3.241	0.958	75	119	262	1.88	0.20	4
September		5.640E-06	3.233	0.947	321	125	274	1.98	0.18	10
October		1.090E-05	3.116	0.977	967	98	287	2.03	0.21	11
November		9.960E-06	3.136	0.971	1,780	106	283	2.04	0.24	13
December		1,120E-05	3.112	0.971	2,951	107	282	2.04	0.21	14
January		1.109E-05	3.120	0.976	2,950	110	285	2.10	0.21	9
February		5.150E-06	3.264	0.972	1,718	113	305	2.12	0.21	7
March		6.700E-06	3.211	0.974	1,454	107	283	2.09	0.21	3
April		6.030E-06	3.225	0.980	338	118	273	1.92	0.21	1

Table 4. Estimated monthly cumulative Relative Growth Rate (RGR%) per size class throughout the fattening process.

FL	Aug	%	Sept	%	Oct	%	Nov	%	Dec	%	Jan	%	Feb	%	Mar	%	Apr	%
100	16				19	-7.0%	19	-7.2%	19	-6.6%	19	-4.1%			18	-12.3%		
120	28	-15.1%	30	-9.9%	33	0.0%	33	0.0%	33	0.3%	34	3.2%	31	-4.5%	32	-4.1%	30	-9.4%
140	46	-8.1%	49	-2.5%	53	6.3%	54	6.7%	53	6.5%	55	9.7%	52	3.8%	52	3.4%	49	-2.2%
160	71	-1.5%	75	4.4%	81	12.0%	81	12.7%	81	12.2%	84	15.7%	81	11.6%	80	10.4%	75	4.5%
180	104	4.8%	110	10.9%	117	17.4%	118	18.4%	117	17.5%	121	21.3%	118	19.0%	116	16.9%	110	10.9%
200	147	10.7%	155	17.1%	162	22.4%	164	23.7%	162	22.5%	168	26.5%	167	26.0%	163	23.1%	155	16.8%
220	200	16.3%	211	22.9%	218	27.1%	221	28.7%	218	27.1%	226	31.4%	228	32.7%	221	29.0%	210	22.5%
240	265	21.7%	280	28.5%	286	31.5%	290	33.4%	286	31.5%	296	36.1%	303	39.1%	293	34.6%	278	28.0%
260	343	26.8%	362	33.9%	367	35.8%	373	37.9%	367	35.7%	380	40.5%	393	45.3%	379	40.0%	360	33.2%
280					463	39.8%	470	42.2%	462	39.7%	479	44.7%	500	51.2%	480	45.1%		

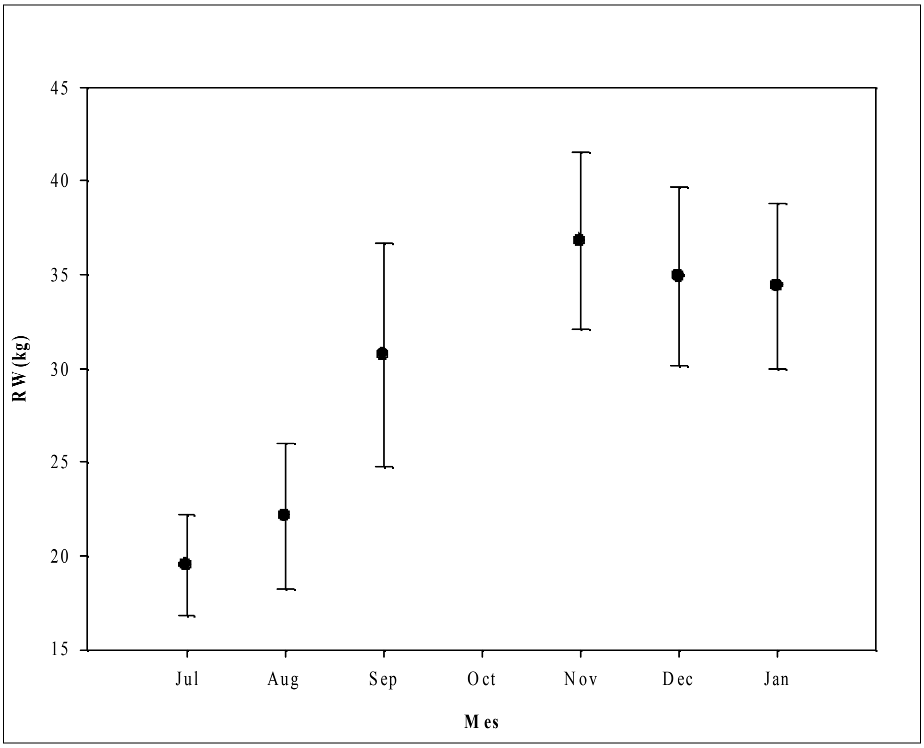

Figure 5. Juvenile weight increase in cages exclusively with small fish from the Balearic Islands.

Table 5. Weight increase data for juveniles caught in the Balearic Islands.

Month	**Avg(Kg.)**	**Std Dev**	**n**	**Days**	**RGR%**
July	19.5	2.7	27	0	
August	22.1	3.9	11	31	13.5%
September	30.7	6.0	7	60	57.6%
October	--	--	--	91	--
November	36.8	4.7	52	121	88.8%
December	34.9	4.8	516	152	79.1%
January	34.4	4.4	108	167	76.5%

Table 6. Weight increase data for juveniles caught in the Gulf of Lions.

Date	**Avg(Kg.)**	**Std Dev**	**nº**	**Days**	**RGR%**
01/11/2000	18.7	2.9	9	25	
01/02/2001	32.8	3.7	12	117	75.4%
23/01/2002	60.2	6.5	82	473	221.7%

Table 7. Equations relating length to the final weight for different harvesting months after farming.

August	$FL=e^{(LNRW+12.48431)/3.241}$
September	$FL=e^{(LNRW+12.08563)/3.233}$
October	$FL=e^{(LNRW+11.42675)/3.116}$
November	$FL=e^{(LNRW+11.51693)/3.136}$
December	$FL=e^{(LNRW+11.33060)/3.112}$
January	$FL=e^{(LNRW+11.40947)/3.120}$
February	$FL=e^{(LNRW+12.17651)/3.264}$
March	$FL=e^{(LNRW+11.91340)/3.211}$
April	$FL=e^{(LNRW+12.01876)/3.225}$