

## BLUEFIN TUNA (*THUNNUS THYNNUS* L.) CATCH COMPOSITION IN THE TYRRHENIAN SEA AND IN THE STRAITS OF SICILY IN 2002 AND 2003

A. Di Natale, A. Mangano, A. Asaro, B. Bascone, A. Celona, M. Valastro<sup>1</sup>

### SUMMARY

*The more efficient system putted in place with the enforcement of the EC Reg. 1543/00, called "EC Data Collection Programme" is slowly overcoming the difficulties in obtaining reliable size data from the bluefin tuna fishery that, after the adoption of the quota system and the development of tuna caging, presented several problems. The data presented in this report include either size data or, for 2002, biological data, providing an updated overview of the current fishery activity in the Tyrrhenian Sea and in the Straits of Sicily. For the first time, it has been possible to obtain data also from the fattening plants, trying to restore the previous data bank existing for the purse-seine fishery. It is important to underline that relevant percentages of giant bluefin tuna (over 3 m or >300 kg have been measured for the first time after many years, in the two areas and in the two years taken into account. A specimen of 640 kg represents the maximum catch size. Differences in catch composition among the various gear used are quite remarkable. These data appears particularly important, because they have been collected during a period where the climate conditions have been very particular, with a strong increasing of the surface temperatures.*

### RÉSUMÉ

*Le système plus efficace qui a été mis en place avec l'exécution de la Réglementation communautaire 1543/00, dénommé « Programme de collecte des données de la CE » surmonte lentement les difficultés en obtenant des données de taille fiables de la pêcherie de thon rouge qui, après l'adoption du système de quota et l'essor de la mise en cage des thons, présentait plusieurs problèmes. Les données fournies dans le présent rapport incluent soit des données de taille, soit pour 2002 des données biologiques, fournissant un aperçu actualisé des activités de pêche actuellement menées dans la mer Tyrrhénienne et dans le Détroit de Sicile. Pour la première fois, il a également été possible d'obtenir des données des installations d'engraissement, en essayant de restaurer la base de données antérieure qui existait pour la pêcherie de senneurs. Il est important de souligner que les pourcentages pertinents du thon rouge géant (de plus de 3 m ou > 300 kg) ont été mesurés pour la première fois après de nombreuses années dans les deux zones et au cours des deux années prises en compte. Un spécimen de 640 kg représente la taille de capture maximale. Il existe des différences assez remarquables dans la composition de la capture parmi les divers engins utilisés. Ces données semblent particulièrement importantes car elles ont été recueillies à une époque où les conditions climatiques étaient très particulières et où les températures de surface avaient subi une forte augmentation.*

### RESUMEN

*El sistema más eficiente establecido con la puesta en vigor del Reglamento de la CE. 1543/00, denominado "Programa de Recopilación de Datos de la CE", está superando lentamente las dificultades para la obtención datos de talla fidedignos para la pesquería de atún rojo que, tras la adopción del sistema de cuotas y el desarrollo de la cría de atún en jaulas, planteaba varios problemas. Los datos presentados en este informe incluyen datos de talla o, para 2002, datos biológicos, proporcionando una visión actualizada de la actividad pesquera existente en el mar Tirreno y el Estrecho de Sicilia. Se han obtenido por primera vez datos de las instalaciones de cría, y se ha intentado corregir los datos anteriores de la pesquería de cerco. Es importante resaltar que, por primera vez tras muchos años, también se han medido los porcentajes pertinentes de atunes rojos gigantes (más de 3 m o 300 kg), en las dos zonas y los dos años*

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*considerados. La máxima talla capturada corresponde a un espécimen de 640 kg. Se ha constatado una notable diferencia en la composición de la captura de los diferentes artes utilizados. Estos datos parecen especialmente importantes porque han sido recopilados en un periodo en el que las condiciones climáticas han sido muy especiales, con un fuerte incremento de las temperaturas de superficie.*

#### KEYWORDS

*Age determination, Growth curves, Sexual maturity; Size frequency analysis; Long-line fishing; Hand-line fishing; Purse-seine fishing; Catch composition; Data collection; Large pelagic species; Bluefin tuna; Mediterranean Sea*

## 1. Introduction

The bluefin tuna fishery is an historical and traditional fishing activity in Italy, but particularly in southern Italy (Cau *et al.* 1999), since ancient times. Besides of the few remaining tuna traps in the eastern Sicily (the first industrial fishery in the Mediterranean), the most important production source is the purse-seine activity, while other fisheries are targeting this species in the area, the long-line fishery, the harpoon fishery and the hand-line fishery. Gillnets provide a very low amount of bluefin tuna as a by-catch.

The most important fishing grounds are located in the southern Tyrrhenian Sea (off the coasts of Campania, Calabria and northern Sicily, near the Aeolian Archipelago and the isle of Ustica) and in the Straits of Sicily, including some parts of the southern Mediterranean Sea and the area around Malta. The latter area increased its importance since 1998, while the spawning concentration of bluefin tuna in the southern Tyrrhenian Sea had decreased in a significant manner.

The importance of the bluefin tuna fishery for the local economy is quite important, as well as for the social side, and some small coastal villages (like Cetara in Campania) are depending upon this fishing activity for a major part of the year.

As a matter of fact, the bluefin tuna fishing is carried out from late April to July in the Straits of Sicily waters, while it covers a shorter number of months in the southern Tyrrhenian. The hand-line fishing has two major fishing seasons, in March-April and in August-October, with variations from year to year. Since several years, a part of the purse-seiners resident in the area usually moves to the Adriatic Sea at the end of winter, for a short fishing season there.

Catches are landed everywhere, in every harbour and sometimes also along beaches. In some case, particularly in the long-line fishing, catches could be transhipped at sea from various vessels into one single vessel and then landed all together, causing confusion in landing reports. At the same time, the huge development of tuna caging activity all over the Mediterranean had a certain impact on the previous usual behaviour of the purse-seine fleet, which now tranship most of the tuna from the purse-seine to floating cages directly at sea. Then, the floating cages are slowly moved from the fishing ground to the final destination by tug vessels. This activity had created several difficulties in getting at least size data from the fishery (Miyake *et al.* 2002).

Data from these fisheries are collected since several years and included in several previous reports (Di Natale 1990, 1999; 2004), Di Natale *et al.* 1987; 1988; 1995; 1998; 2000; 2002).

## 2. Methods

The EC Data Collection programme (EC Reg. 1543) is now setting up a new mandatory sampling scheme for many species exploited by the EU fleets, including the large pelagic species. Data on size are collected every year, while biological data (sex, sexual maturity, age composition) are collected every three years. Data that are mandatory according to ICCAT rules must be collected with the same methodology requested by ICCAT. This part of the programme is conventionally called CAMPBIOL in Italy. In 2002, due to bureaucratic problems linked with the start-up of the new programme and to the late arrival of the contract, data have been collected only in the second half of the year, applying a high, intense and costly effort with the purpose to cover the necessary sample scheme.

The data from the bluefin tuna fisheries have been collected in several landing places, partially the same used in previous studies, with the purpose to continue the historical series obtained till now. The harbours where landing controls were carried out are Ponza (central Tyrrhenian Sea), Lipari, Milazzo and Messina (southern Tyrrhenian Sea), Favignana, Trapani, Mazara del Vallo and Marsala (Straits of Sicily). Data related to the purse-seine catches transferred into floating cages in Malta have been collected as well, thanks to the help of the staff of the Malta Direction General for Fisheries and Aquaculture and to the Director General, Dr. Anthony Gruppetta. Usually, landing controls cover two weeks per month. Due to the well-known problems for collecting all the necessary information at landings, several data have been collected directly at sea or at the fattening plants, using scientific observers.

Sometimes, due to the practice of the handling procedures or to local difficulties, only one single size parameter was collected (length or weight).

Age was determined by cross-reading sections of the first spine of the dorsal fin, according to the methodology established at the Italian national co-ordination level, by the Italian Society of Marine Biology.<sup>2</sup>

Data have been regularly transmitted to the national co-ordination of CAMPBIOL that, after checking the data coherence, produced the mid-time and the yearly report for the Italian Direction General for Fishery and Aquaculture. The Ministry, after checking the quality of the data, transmitted the report to the EC Direction General for Fisheries, for the final evaluation.

The data included in this paper have been officially submitted in details to ICCAT Secretariat by the Italian Direction General for Fishery according to Task II format.

### 3. Discussion

Even if the data collection begun very late in 2002, it was possible to obtain 3814 length data, 29.9% from the Straits of Sicily and 70.1% from the central and southern Tyrrhenian Sea. In the same year, the total number of weight samples was of 1749; among these, 55.6% is from the Straits of Sicily and 44.4% from the Central and Southern Tyrrhenian Sea.

In the central and southern Tyrrhenian Sea the collection included a total of 2672 length data, showing a mean FL of 170.8 cm; among these, 197 specimens were from the hand-line fishery (157.7 cm mean LF), 289 specimens from the purse-seine fishery (173.5 cm mean LF), 2085 specimens were fished by purse-seiners but collected at the tuna cages (175.5 cm mean LF) and 100 specimens were from long-line fishery (94.6 cm mean FL). **Figures 1 to 5** show the length frequencies of these catches, by 5 cm classes.

In the same Tyrrhenian area the collection included a total of 777 weight data, showing a mean weight of 124.42 kg; among these, 199 specimens were from the hand-line fishery (69.14 kg mean RW), 119 specimens from the purse-seine fishery (97.34 kg mean RW), 359 specimens were fished by purse-seiners but collected at the tuna cages (184.9 kg mean RW) and 199 specimens were from long-line fishery (16.9 kg mean RW). **Figures 6 to 7** show the weight frequencies of these catches by 5 kg classes.

Due to the fact that it was possible to have samples by sex only from two fisheries (hand-line and purse-seine) it was decided to separate the two data sets, because of the possible selectivity of the gear. The first data set concerns the hand line fishery in the Strait of Messina (South Tyrrhenian Sea), the most important area for S-N and viceversa migrations. **Figures 11, 12 and 13** show the length-weight correlation for male, female and non-determined sex bluefin tuna. The curves obtained for the males and females show a good correlation, with a slight difference between them, while the third one is only a segment. **Figure 14 and 15** show the length-age correlation in male and female bluefin tuna, which appears very similar. Age was determined up to 10 years+. **Figures 16 and 17** show the sexual maturity at length of male and females bluefin tuna in the same area but due to the sampling period, most of the specimens were in a post-spawning situation.

The second data set regards the purse-seine fishery in the Southern Tyrrhenian Sea in 2002. **Figures 18, 19 and 20** show the length-weight correlation for male, female and non-determined sex bluefin tuna. The curves

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<sup>2</sup> The Authors would like to thank Dr. Antonio Potoschi (Department of Marine Ecology and Animal Biology, University of Messina), for his important help in getting age analysis from the samples.

obtained for the males and females show a good correlation, with a slight difference between them, and the third one is more similar to that of males. **Figure 21 and 22** show the length-age correlation in male and female bluefin tuna, which appears similar in trend, but with a difference induced by the large number of giant males in the sample. Age was determined up to 18 years+, with a lot of difficulties in reading the spine slices after 15 years age. **Figures 23 and 24** show the sexual maturity at length of male and females bluefin tuna in the same area but, even here, due to the sampling period, most of the specimens were in a post-spawning situation.

**Figure 25** shows the length-weight correlation in bluefin tuna from the long-line fishery in the Tyrrhenian Sea, for a data set without a sex determination. The curve includes smaller fishes than the others and has a slight different trend.

In the Straits of Sicily the collection in 2002 included a total of 1142 length data, showing a mean FL of 168.3 cm; among these, 853 specimens were from the longline fishery (166.6 cm mean LF) and 289 specimens from fattening cages (173.5 mean LF). No other fisheries (e.g. tuna trap) have been sampled in the area, due to the late beginning of the data collection. **Figures 26 to 28** show the length frequencies of these catches, by 5 cm classes. In the same Straits of Sicily area the collection included a total of 972 weight data, showing a mean weight of 83.51 kg; among these, 853 specimens were from the longline fishery (81.58 kg mean RW), and 119 specimens from fattening cages (97.34 mean RW). **Figures 29 to 31** show the weight frequencies of these catches by 5 kg classes.

Even for the data from the Straits of Sicily in 2002, it was decided to separate the two data sets, because of the possible selectivity of the gear. The first data set concerns the longline fishery, carried out in a very large area. **Figures 32, 33 and 34** show the length-weight correlation for male, female and non-determined sex bluefin tuna. The curves obtained for the males and females show a good correlation, with a slight difference between them due to the higher number of large males in the sample, but also the third one is similar, besides of the lower number of samples, confirming the good validity of the curves to describe these bluefin tunas. **Figure 35 and 36** show the length-age correlation in male and female bluefin tuna, which appears very similar, possibly partially affected by the number of large males. Age was determined up to 16 years. **Figures 37 and 38** show the sexual maturity at length of male and females bluefin tuna in the same area; it is important to remark that it was possible to find some spawning specimens, besides of the late season of sampling, due to the high temperature at sea for a long period. Anyway, even in the Straits of Sicily, most of the tuna were in a post-spawning condition, because of the late sampling.

The second data set regards the tuna kept in fattening cages and originally caught by purse-seine fishery in the Straits of Sicily in 2002. **Figures 39, 40 and 41** show the length-weight correlation for male, female and non-determined sex bluefin tuna. The curves obtained for the males and females show a good correlation, with a very slight difference between them; the third one is partially affected by the lower number of large specimens in the sample. **Figure 42 and 43** show the length-age correlation in male and female bluefin tuna, which appears similar in trend, but with a slight difference induced by the lower number of males in the sample. In any case, the trend is overlapping that of **Figures 35 and 36**, confirming its validity. Age was determined up to 16 years+. **Figures 44 and 45** show the sexual maturity at length of male and females bluefin tuna in the same area but, even here, due to the sampling period, all the specimens were in a post-spawning situation.

From the above reported data, it appears quite clear that the Tyrrhenian fishery uses a broader portion of the stock, not in quantity but in variety, possibly because is able to operate with a larger number of fishing gear. The gear selectivity makes the difference and, as a consequence, size frequency data shows different pattern in the Tyrrhenian Sea and in the Straits of Sicily.

As concerns the partial variability of the length-weight correlation in 2002 from one gear to another or between the two areas, this is possibly due to the time scale in which the sampling has been carried out. A more stable sampling, covering all the year round, might possibly overcome the variability. Quite interesting are the overlapping results obtained in the age-length correlation, providing useful new data from these two important fishing grounds. The data analysis on sexual maturity was generally affected by the late beginning of the sampling in both areas, due to the late arrival of the contract for bureaucratic reasons.

The data collection in 2003 covered all the year round, besides of many bureaucratic problems. In this last year it was possible to obtain 2597 length data, 61.3% from the Straits of Sicily and 38.7% from the central and southern Tyrrhenian Sea, reversing the proportion of 2002 for several factors. In the same year, the total number of weight samples was of 3225; among these 68.9% are from the Straits of Sicily and 31.1% from the Central and Southern Tyrrhenian Sea.

The factors causing this different proportion in the sample were the difficulties created by the fattening plants to have access to the tuna, the lack of any longline fishery in several Tyrrhenian areas and possibly the different proportion in catches. On the opposite, it was possible to have some samples from the tuna traps and to increase the data collection from cages in the Straits of Sicily, thanks to the good co-operation with the Direction General for Fisheries in Malta, where some Italian catches were caged.

In the central and southern Tyrrhenian Sea the collection included a total of 1004 length data, showing a mean FL of 175.3 cm, with an increase of 2.6% on the previous year; among these, 67 specimens were from the hand-line fishery (170.5 cm mean LF), 929 specimens from the purse-seine fishery (176.5 cm mean LF), 56 specimens were fished by purse-seiners but collected at the tuna cages (238.38 cm mean LF) and 52 specimens were by-catch from gillnet fishery (91.1 cm mean FL). Figures 46 to 50 show the length frequencies of these catches, by 5 cm classes.

In the same Tyrrhenian area the collection included a total of other 1004 weight data (non necessarily all from the same fishes used for the length sampling), showing a mean weight of 104.32 kg, with a decrease of 16.2% on the previous year; among these, 77 specimens were from the hand-line fishery (79.58 kg mean RW), 826 specimens from the purse-seine fishery (101.12 kg mean RW), 56 specimens were fished by purse-seiners but collected at the tuna cages (244.05 kg mean RW) and 45 specimens were by-catch from gillnet fishery (131.54 kg mean RW). **Figures 51 to 55** show the weight frequencies of these catches by 5 kg classes.

**Figures 56, 57, 58 and 59** show the length-weight correlation for the various samples obtained from the various fisheries. Most of the curves are clearly affected by the composition of the sample, but particularly the curve obtained from the fattening cages clearly shows the abnormality of this sample compared to all the others. In this second year of the data collection programme the biological sample was not mandatory.

In the Straits of Sicily the collection in 2003 included a total of 1593 length data, showing a mean FL of 161.7 cm, showing a decrease of 3.9% on the previous year; among these, 988 specimens were from the longline fishery (158.6 cm mean LF), 123 specimens were from tuna traps (157.5 cm mean FL) and 482 specimens from fattening cages (169.5 mean LF), **Figures 60 to 63** show the length frequencies of these catches, by 5 cm classes.

In the same Straits of Sicily area the collection included a total of 2221 weight data, showing a mean weight of 66.98 kg, showing a decrease of 19.8% on the previous year; among these, 988 specimens were from the longline fishery (77.94 kg mean RW), 751 specimens were from tuna traps (35.73 kg mean weight) and 492 specimens from fattening cages (94.95 mean RW). **Figures 64 to 67** show the weight frequencies of these catches by 5 kg classes.

The length-weight correlation curves have been plotted separately for the three fisheries concerned (**Figures 68 to 72**) and, in this area, it was also possible to use data by sex for the tuna trap samples, even if this was not mandatory by the EC Data Collection programme. The curve obtained from the longline samples (**Figure 69**) fits very well the data distribution and is certainly interesting. At the same time, it is interesting to remark that the two curves obtained from the trap fishery, both for males and females, are almost overlapping (**Figure 70 and 71**). The curve obtained from the samples collected at the fattening cages is certainly less significant (**Figure 73**).

#### 4. Conclusion

Taking into account the conclusion reported in a previous paper (Di Natale *et al.* 2002), it appears quite clear that the EC Data Collection programme (EC Reg. 1543/2000) had resulted in a serious increasing of data availability for all the species concerned, including the bluefin tuna. Of course, the start-up phase was affected by various factors, but most of them are not unusual in a huge programme like this.

Looking at the first two years of the new CE Data Collection Programme in the Tyrrhenian Sea and in the Straits of Sicily (limited to bluefin tuna, in this case), it is evident that the information provided is quite useful, either for feeding the already existing ICCAT data bank or for better focus the sampling or the analysis in the future. The length-weight curves and the age-at-length correlation provided by this paper are certainly new recent information from these areas.

Some problems, already known from the past, still exist and requires a particular attention to be properly faced and solved, sometimes by adjusting the strategies, some others by a more strict regulation. The factors still affecting the sampling in these areas are the following:

- Important reduction of the purse-seine landings;
- Tuna farming transshipments and fattening activities;
- High migratory behaviour of the long-line fleet;
- Landings in foreign harbours.
- Driftnet ban.

At the same time, the atypical climate situation recorded the last two years (high temperatures for long period, abnormal stratification of the water column, long period of calm weather in 2003, etc.) clearly influenced the behaviour, the distribution and the biology of the bluefin tuna in 2002 and 2003.

Again, according to the several observations made at sea and to the fishermen's reports, the presence of the bluefin tuna in the Central Mediterranean Sea continues to appear quite relevant in the last seven years while, according to the eastern Atlantic (including the Mediterranean) population model outputs, this fact was not expected, even if the model was not geographically oriented.

The long spawning season in 2002 and even longer in 2003 should result in some important changes in the next recruitment of bluefin tuna.

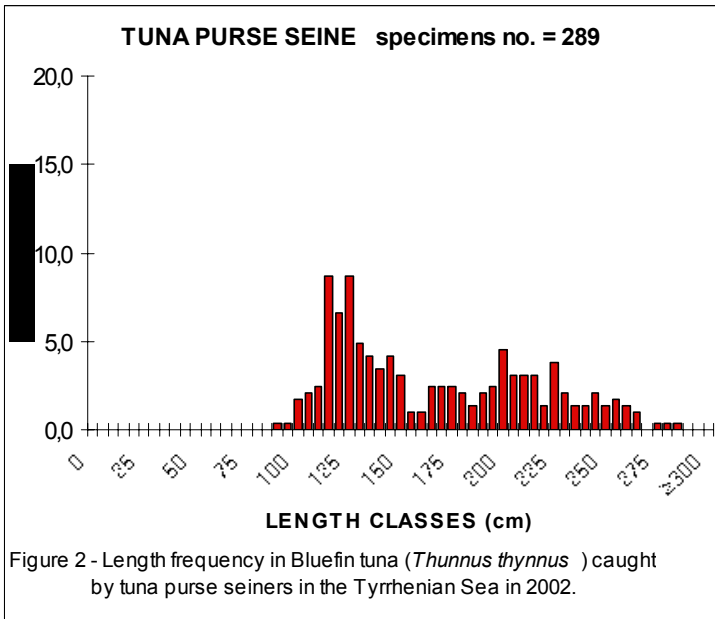
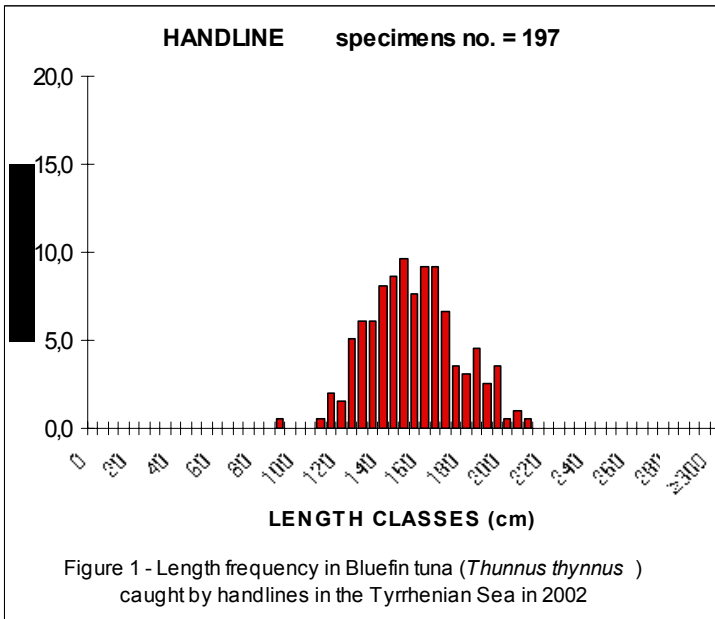
The remarkable catch of several giant specimens, particularly in 2002, is a relevant information that increases our knowledge of the current composition of the stock.

Besides of these statements, examining the last six years data we can confirm that the bluefin tuna length composition of the stock in the area is almost stable, with a high variability from sample to sample and a more limited variation from year to year, due to the various types of gear used and the origin of the samples.

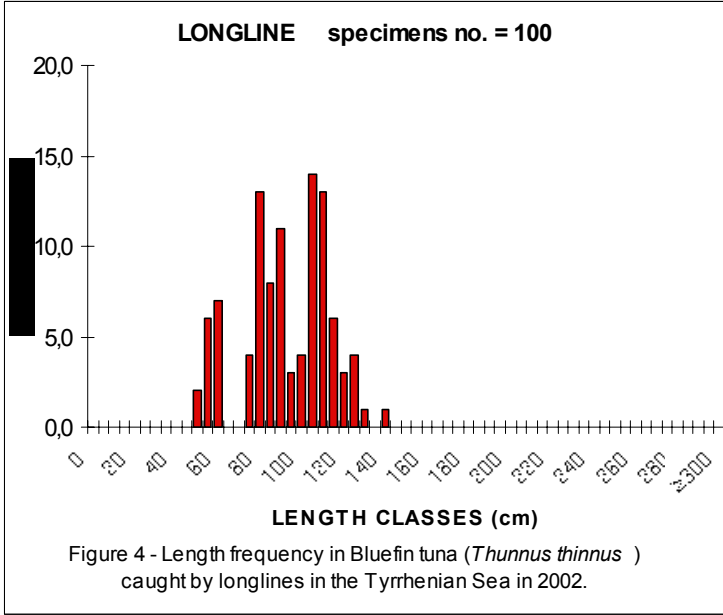
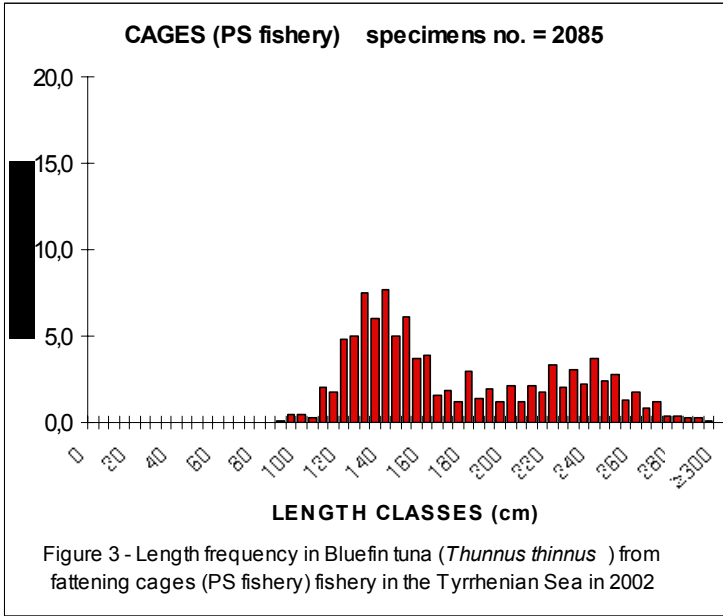
## 5. Bibliography

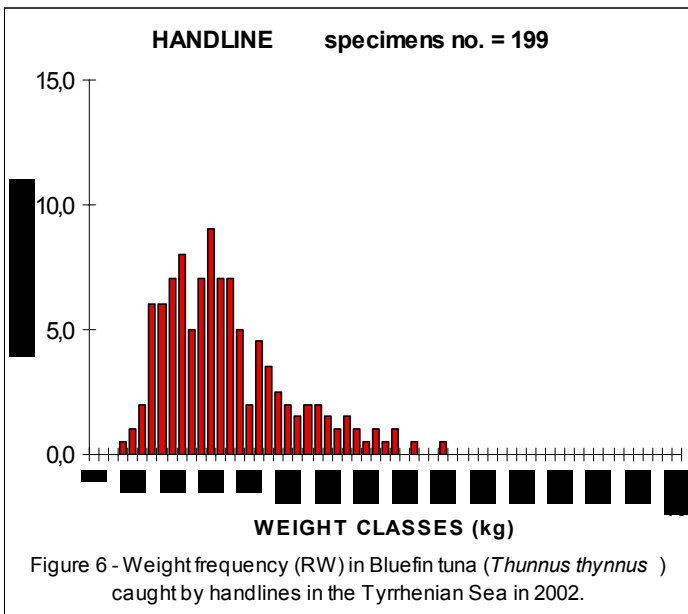
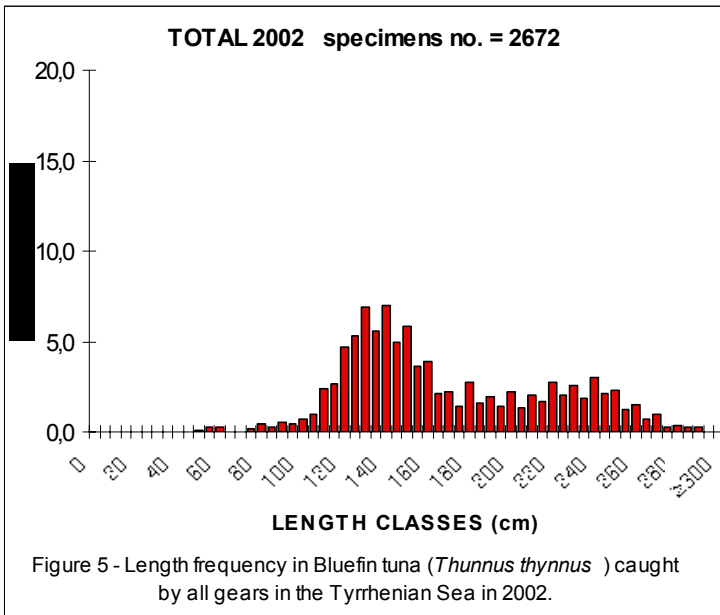
- CAU A., G. Cavallaro, G. De Metrio, A. Di Natale, G. Marano, L. Orsi Relini, C. Piccinetti. 1999. Revision of recent bluefin tuna catches in Italy. SCRS/98/89, Genova, September 1998, ICCAT Coll. Vol. Sci. Pap., XLIX: 434-436.
- DI NATALE, A.. 1990. Bluefin tuna (*Thunnus thynnus* L.) and Albacore (*Thunnus alalunga* Bon.) fishery in the Southern Tyrrhenian sea: 1985-1989 surveys. FAO/GFCM - ICCAT Expert Consultation on large pelagic species, Bari, Coll.Vol. Scient.Pap., XXXIII: 128-134.
- DI NATALE A.. 1999. La ricerca sulla pesca: I Grandi Pelagici. In. Le Ricerche sulla Pesca e sull'Acquacoltura nell'Ambito della Legge 41/82. Parte 4: Relazioni. M.P.A., Roma, 1999; *Biol. Mar. Medit.*, 7(4): 46-58.
- DI NATALE A, (ed.). 2004. Una rete coordinata per l'acquisizione di indici di reclutamento del tonno e del pescespada nei mari italiani. Relazione riguardante l'area del Tirreno centro-meridionale e dello Stretto di Sicilia. 6-A-19. Report to: Direzione Generale della Pesca e dell'Acquacoltura, Ministero delle Politiche Agricole e Forestali, 96 p + all.
- DI NATALE A., E. D'Orazio, G. Leonardi, A. Mangano, N. Mento, S. Prestipino Giarritta, C. Scuderi, M. Sarà. 1987. Rilevazioni delle quantità pescate e dello sforzo di pesca esercitato nei confronti di alcune specie di Scombroidei.. Report to: Ministero della Marina Mercantile, Roma: 1-212.
- DI NATALE A., E. D'Orazio, G. Leonardi, A. Mangano, N. Mento, S. Prestipino Giarritta, C. Scuderi, M. Sarà. 1988. Rilevazioni delle quantità pescate e dello sforzo di pesca esercitato nei confronti di alcune specie di Scombroidei. Relazione preliminare. Atti Sem. UU.OO. Prog. Ric. Piano Pesca Acquac., CNR, Roma, (1): 301-317.
- DI NATALE A., A. Mangano, E. Navarra, M., Valastro. 1995. Osservazioni sulla pesca dei grandi Scombroidei nei bacini tirrenici e dello Stretto di Sicilia (prosecuzione). Report to: Ministry of Agricultural, Food and Forestry Resources, Direction General for Fishery and Aquaculture, Rome, 322-329.

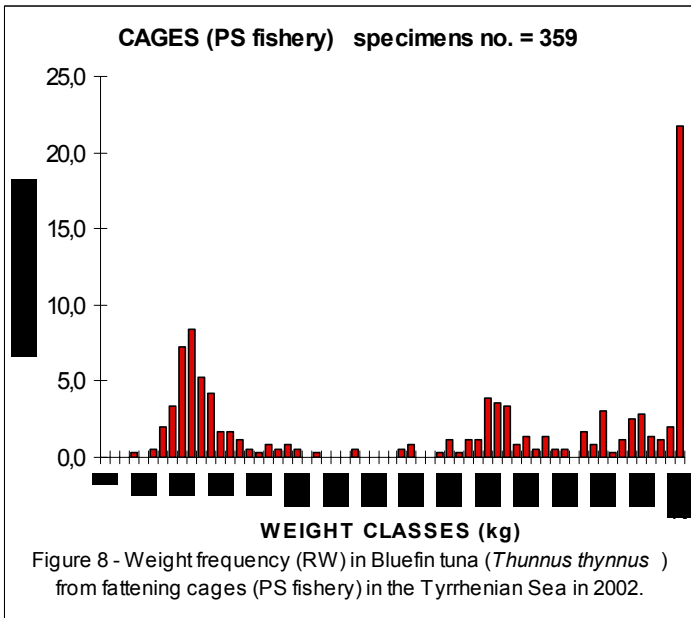
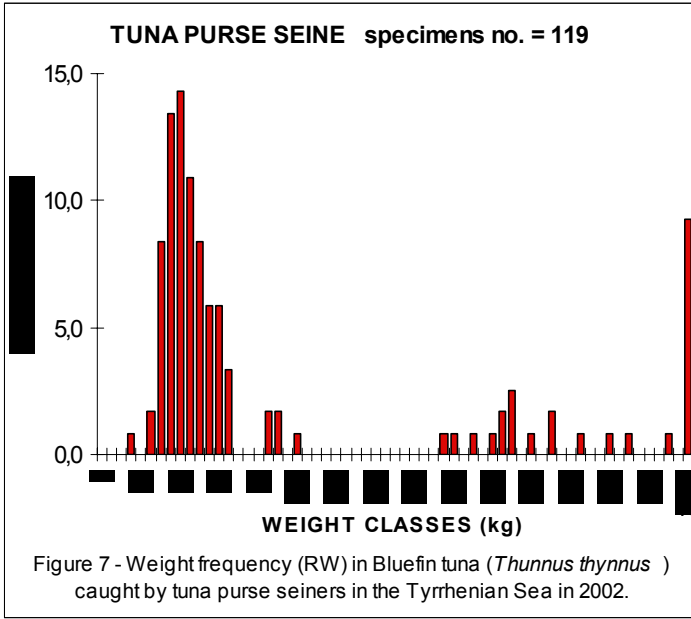
- DI NATALE A., A. Mangano, E. Navarra, M., Valastro. 1998. Osservazioni sulla pesca dei grandi Scombroidei nei bacini tirrenici e dello Stretto di Sicilia. In; Le Ricerche sulla Pesca e sull'Acquacoltura nell'Ambito della Legge 41/82. Parte 1. M.P.A., Roma: 189-198.
- DI NATALE A., A. Mangano, A. Asaro, M. Bascone, A. Celona, E. Navarra, M. Valastro, B. Zava. 2000. Osservazioni sulla pesca dei grandi Scombroidei nei bacini tirrenici e dello Stretto di Sicilia. Report to: Direzione Generale Pesca ed Acquacoltura, Ministero delle Politiche Agricole e Forestali, Roma: 1-250 + all.
- DI NATALE A., A. Mangano, A. Asaro, M. Bascone, A. Celona, E. Navarra, M. Valastro, B. Zava. 2002. Size frequency composition of the Bluefin Tuna catches in the Tyrrhenian Sea and in the Straits of Sicily in the period 1998-2001. ICCAT/GFCM Expert Consultation, Malta, in press, SCRS/02/46, ICCAT Coll. Vol. Sci. Pap.: 28 p.
- MIYAKE P.M., J.M De La Serna, A. Di Natale, A. Farrugia., I. Katavic, N. Miyabe, V. Ticina. 2002. General review of bluefin tuna farming in the Mediterranean area. ICCAT/GFCM Expert Consultation, Malta, in press: 6p.

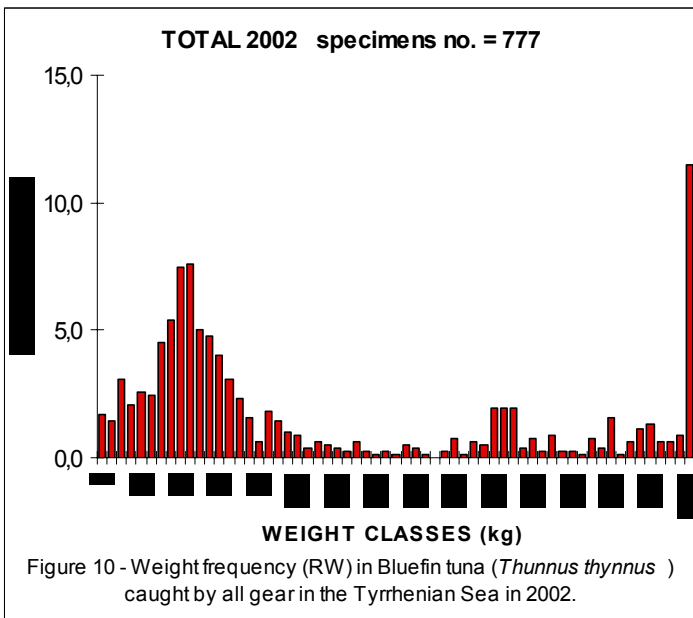
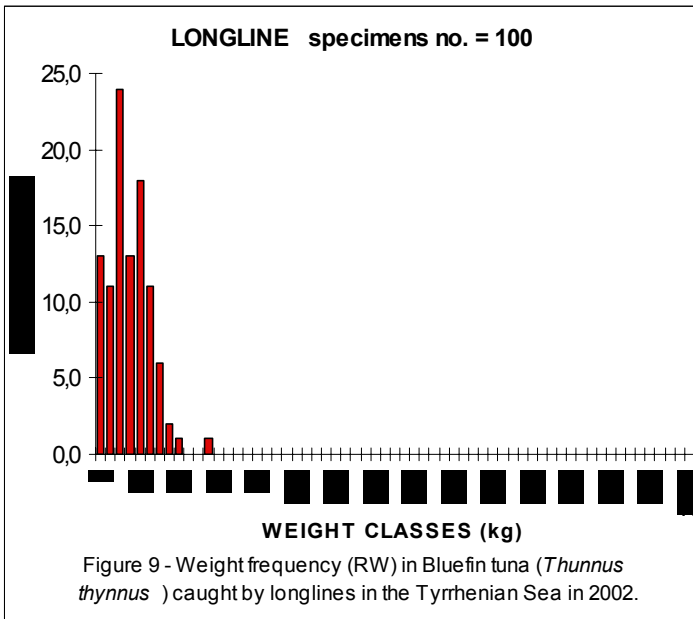


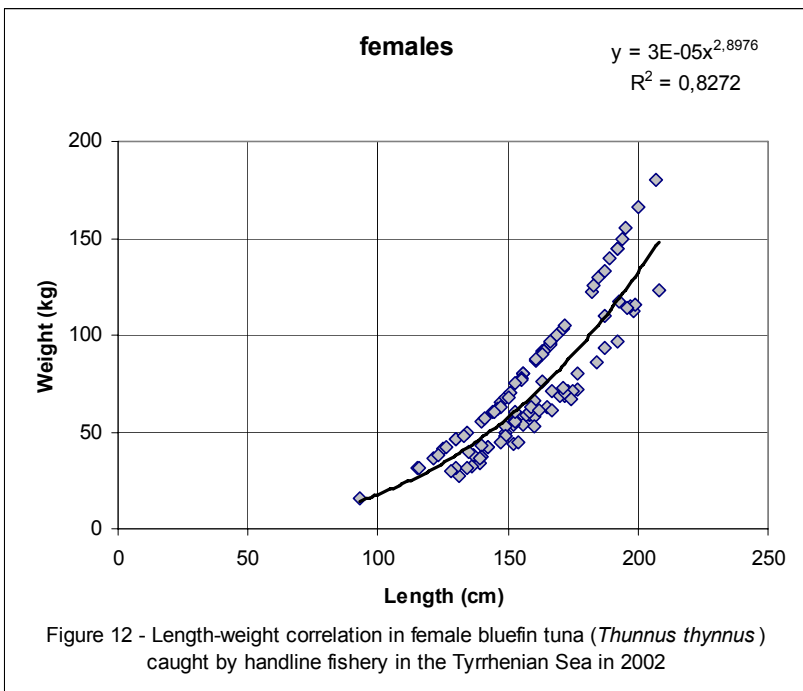
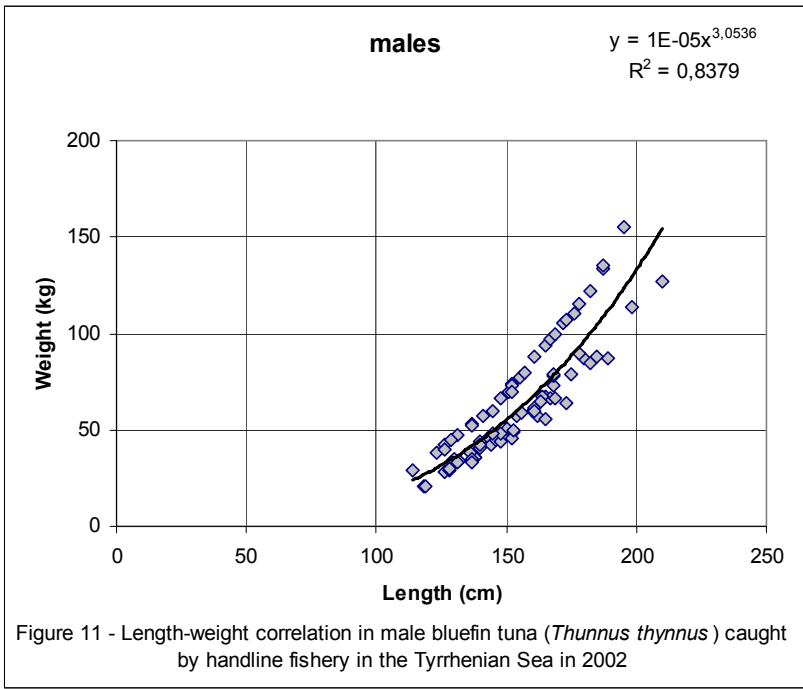


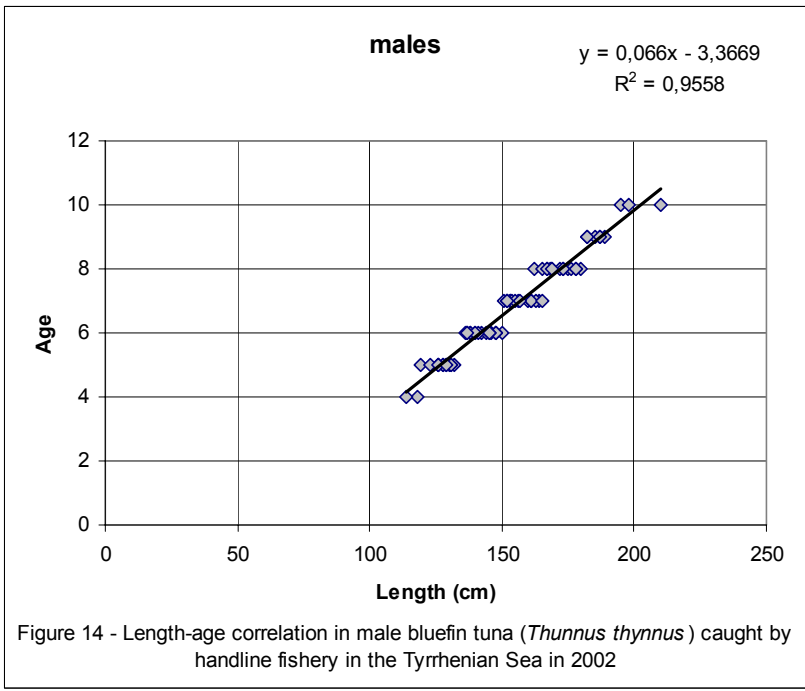
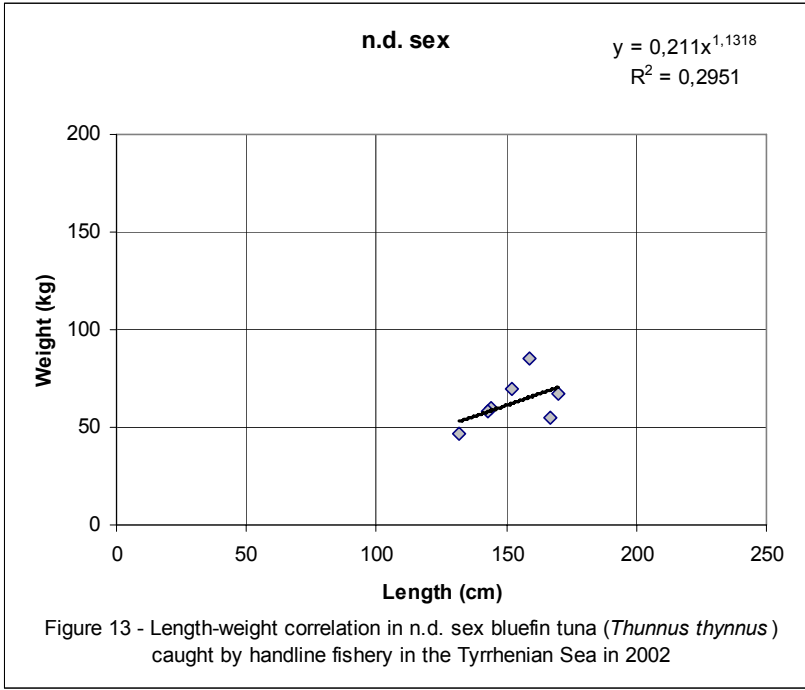


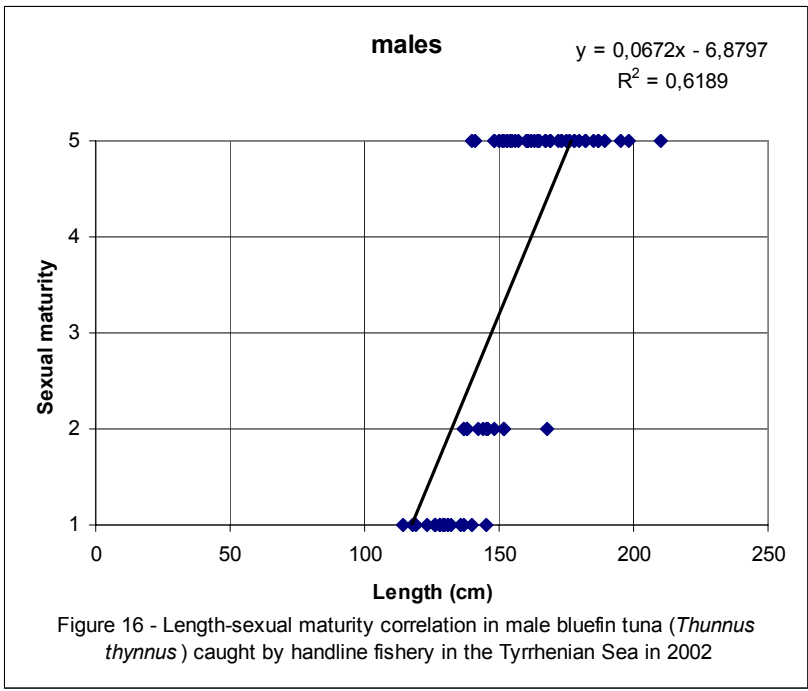
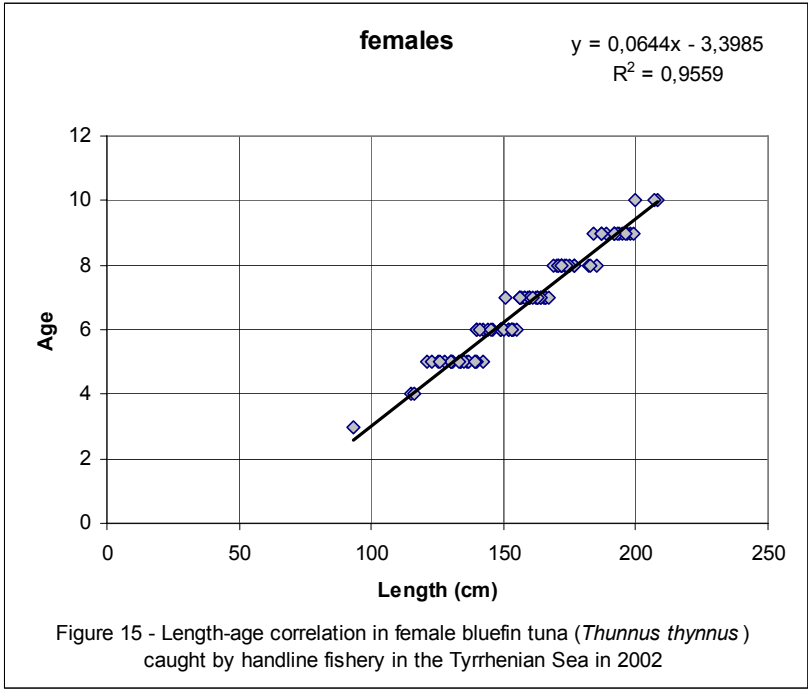


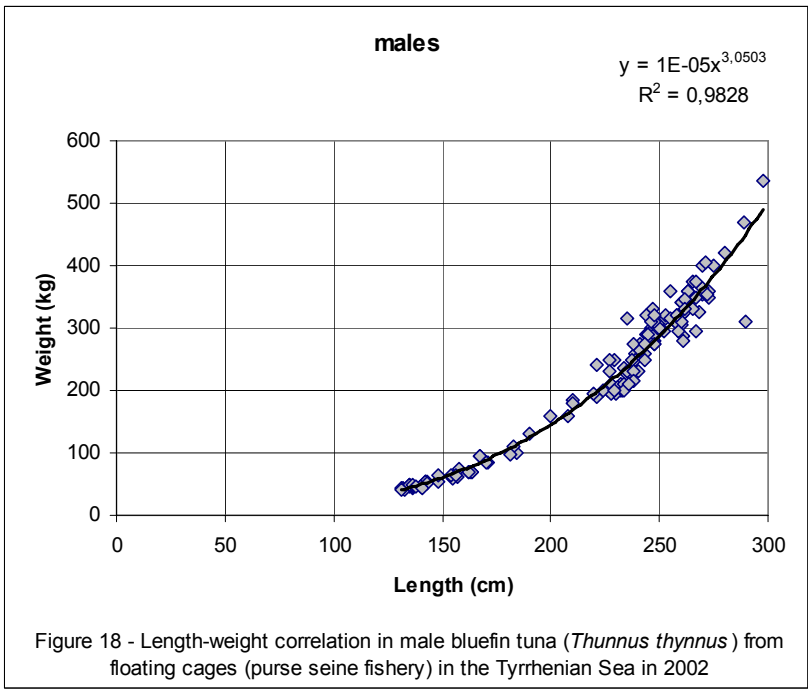
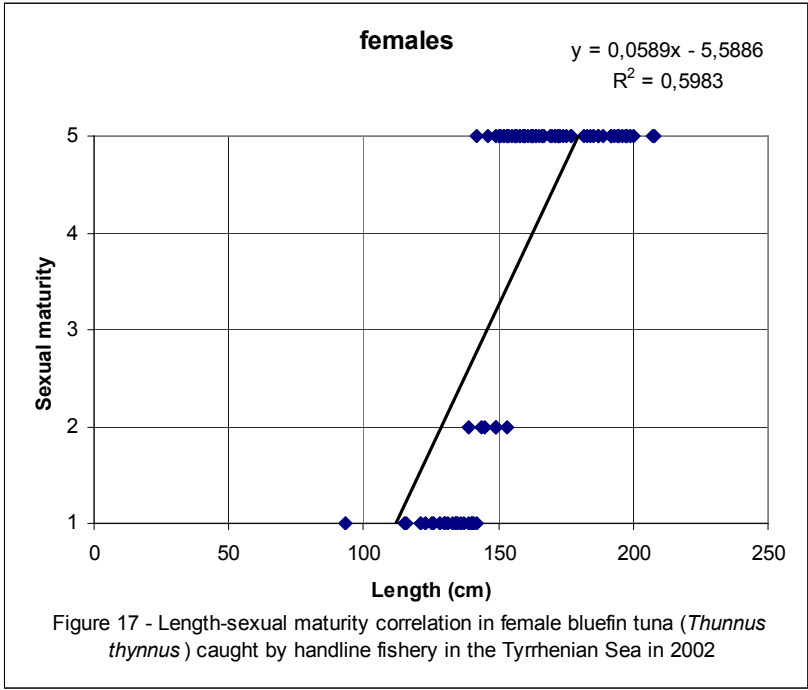




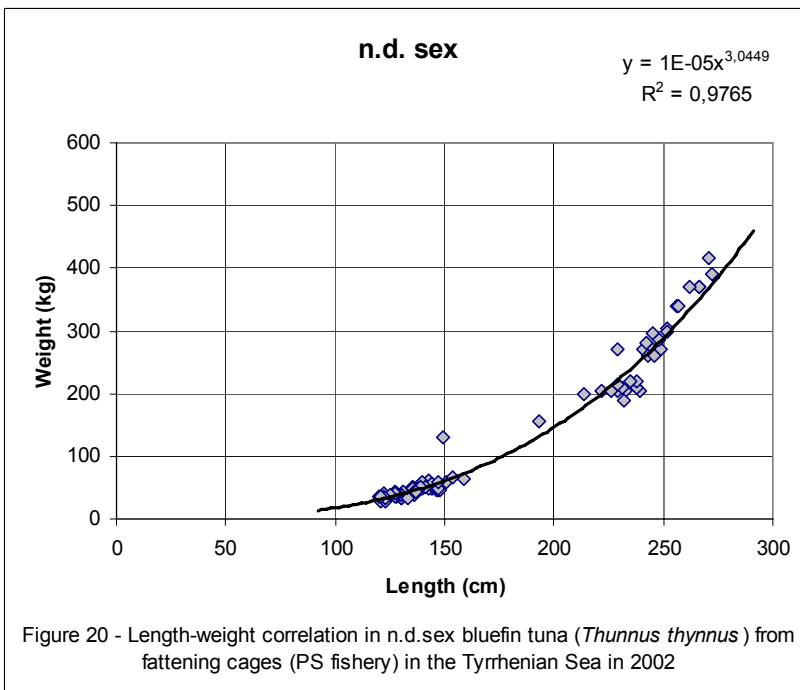
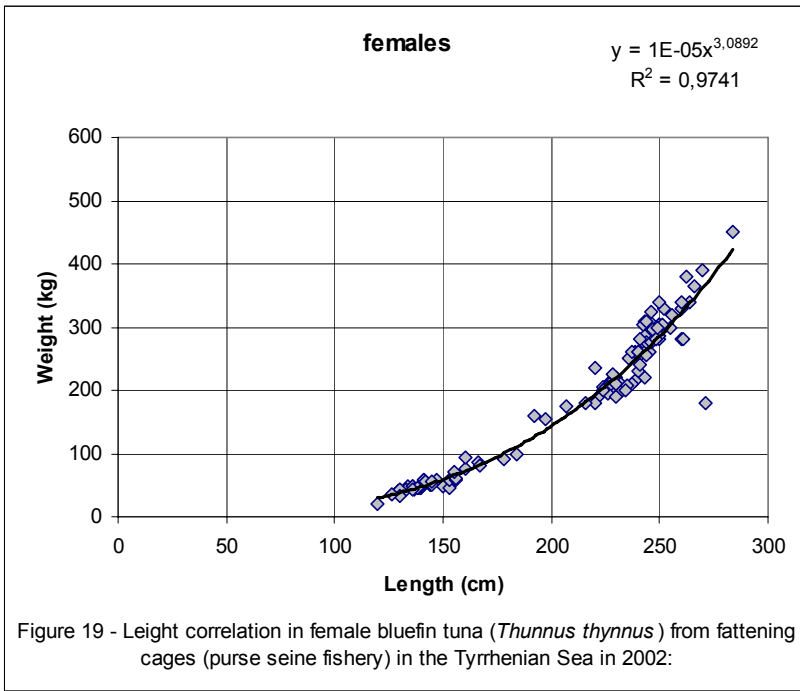


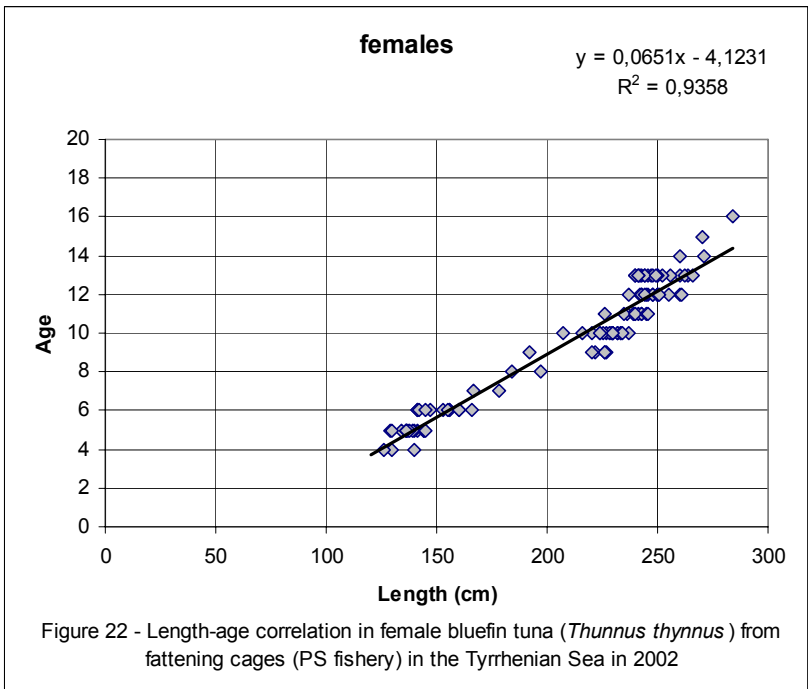
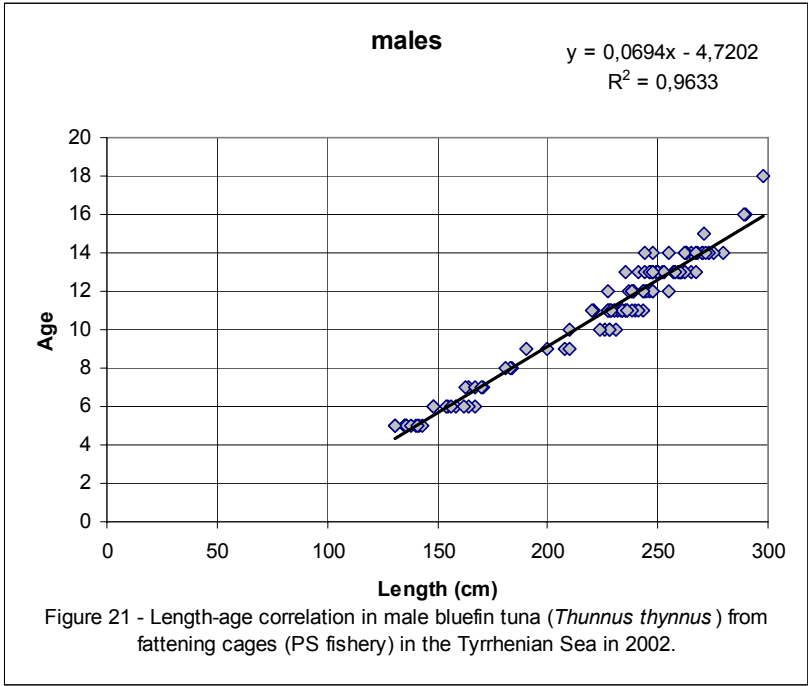


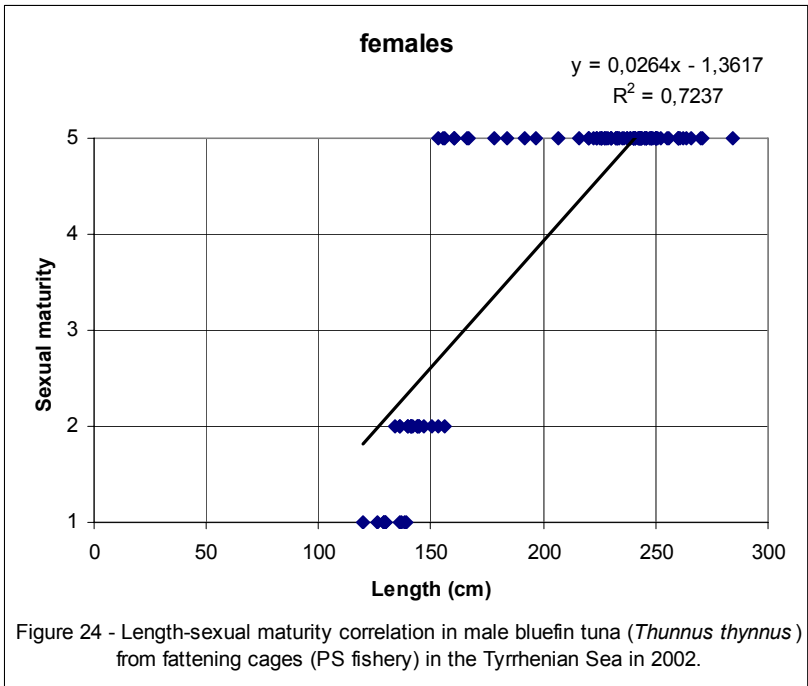
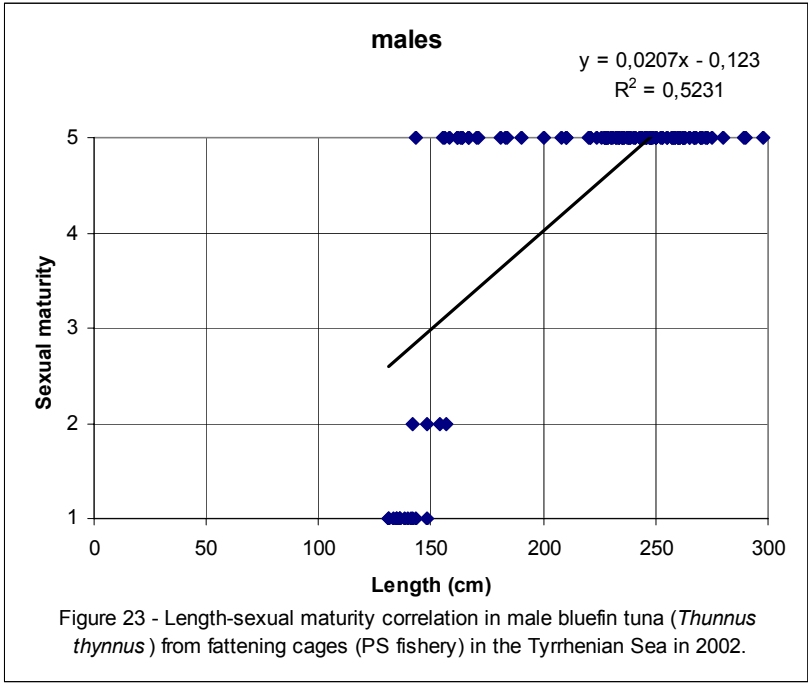


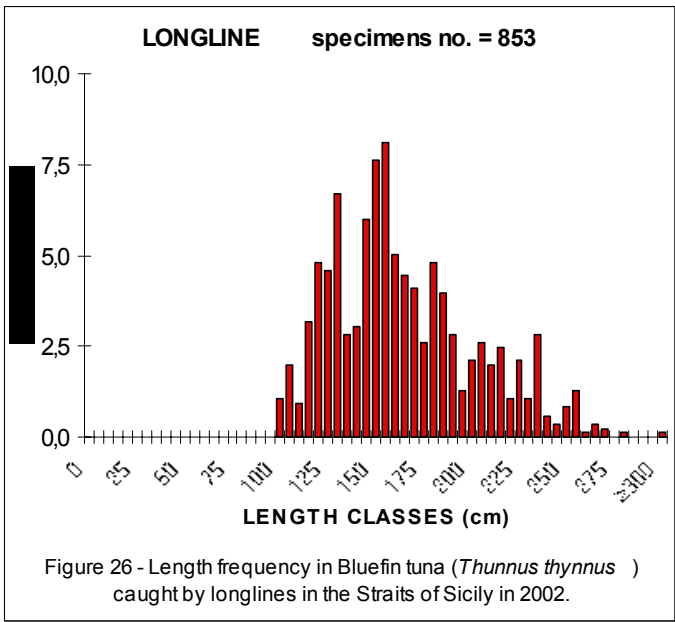
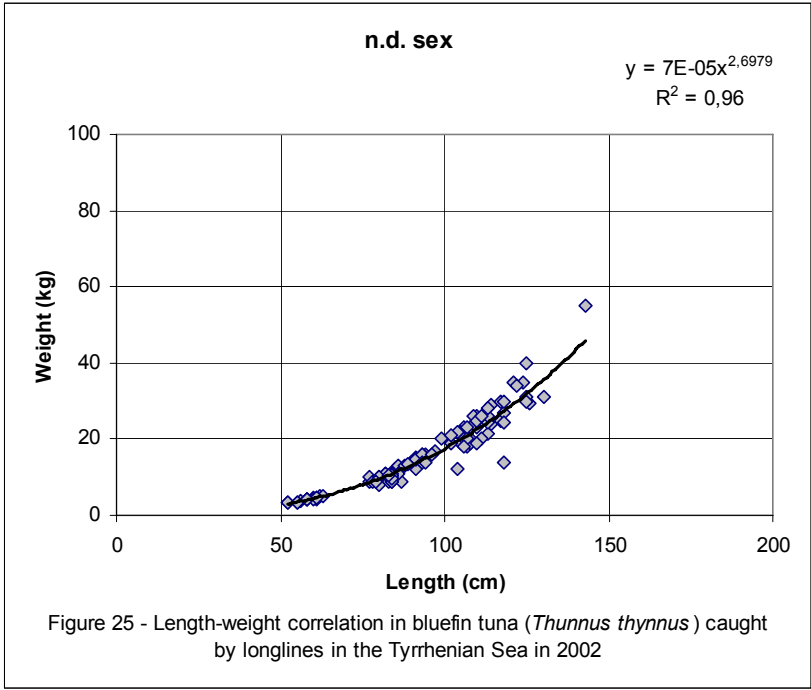


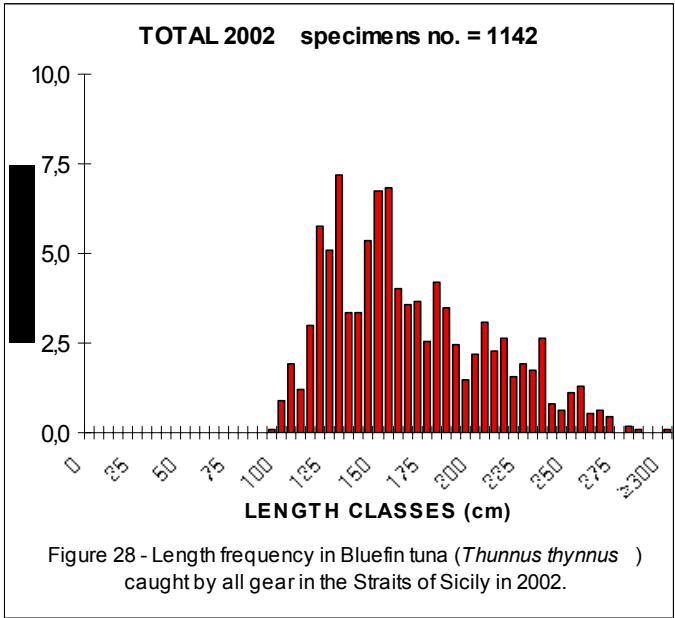
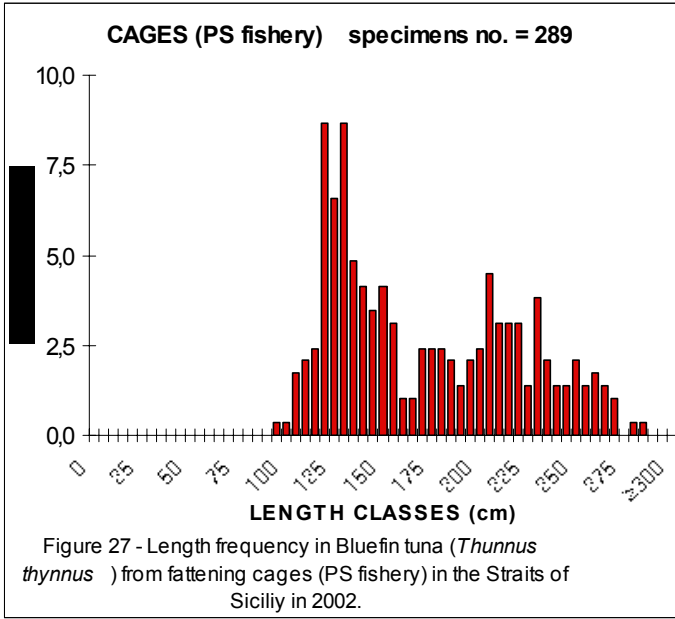


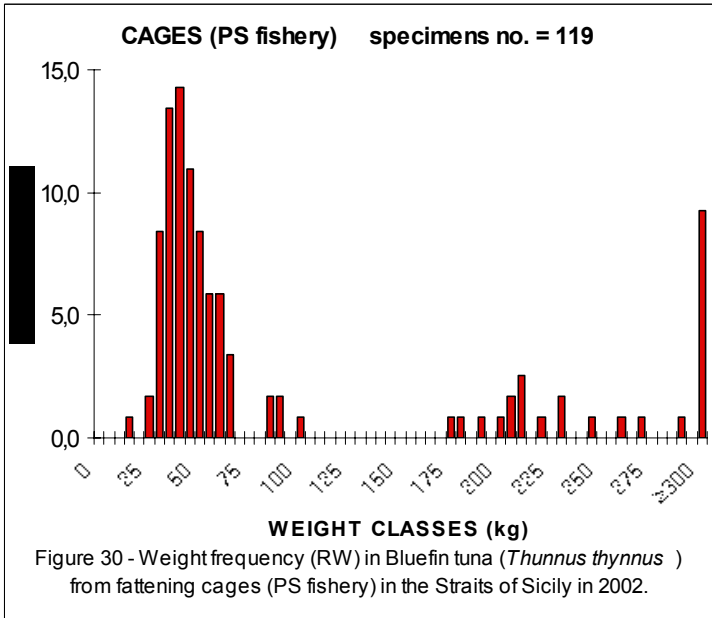
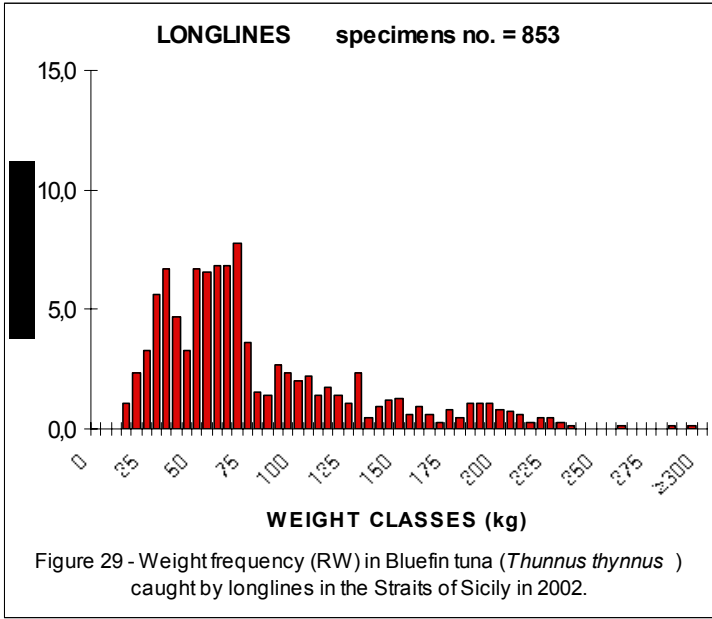


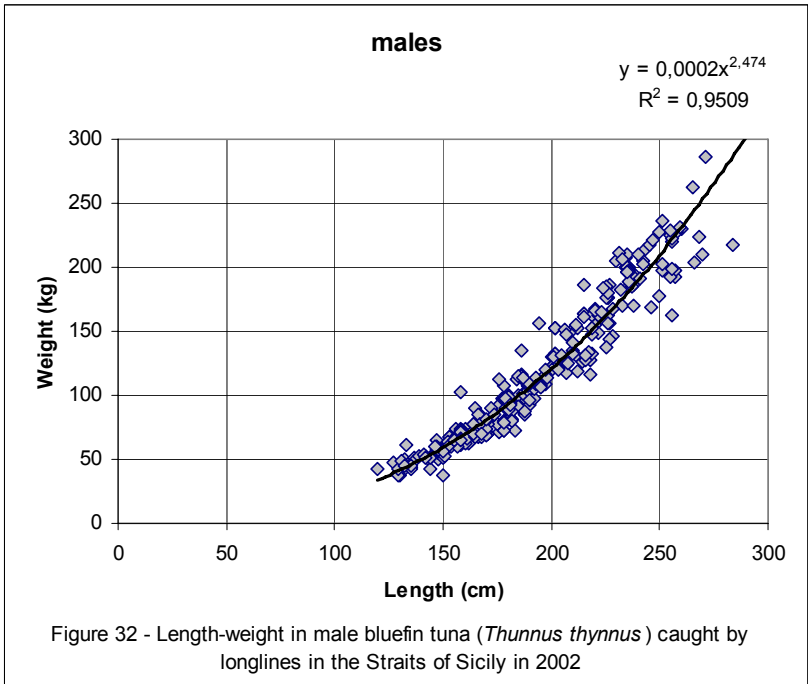
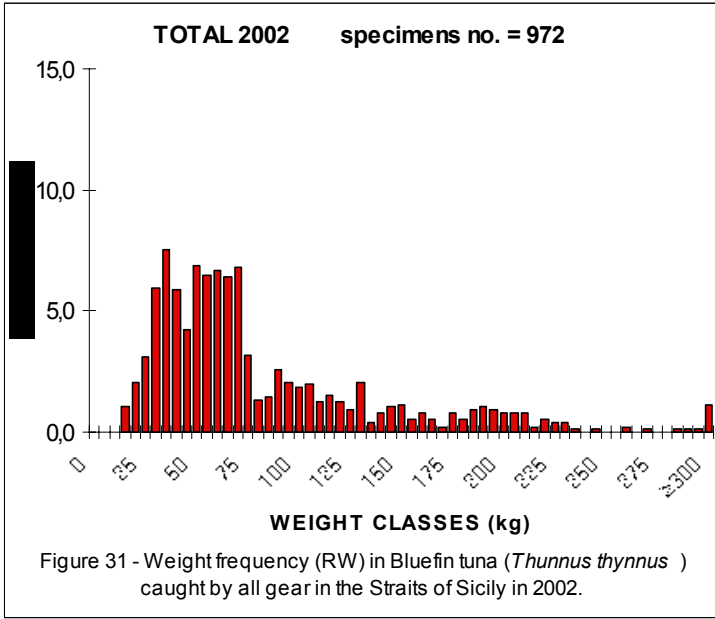


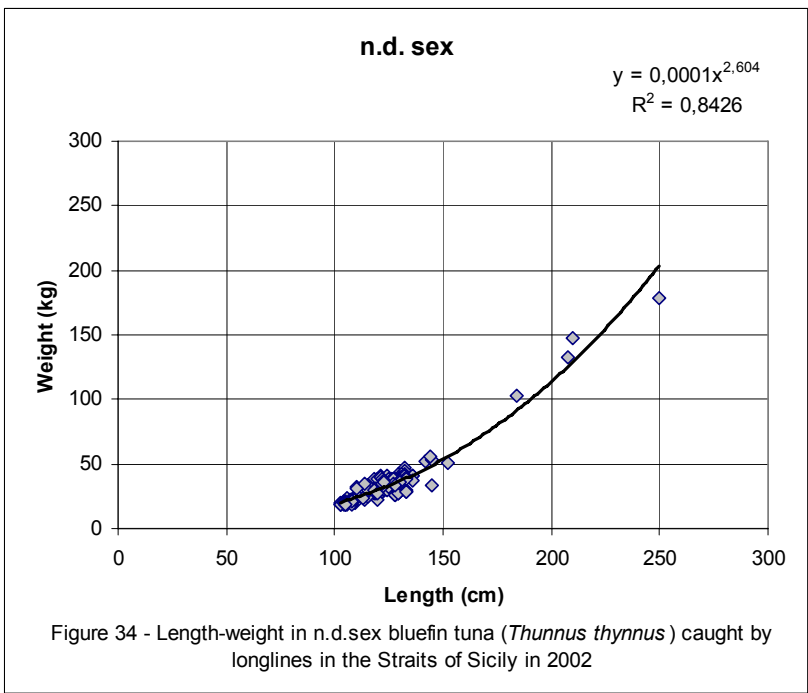
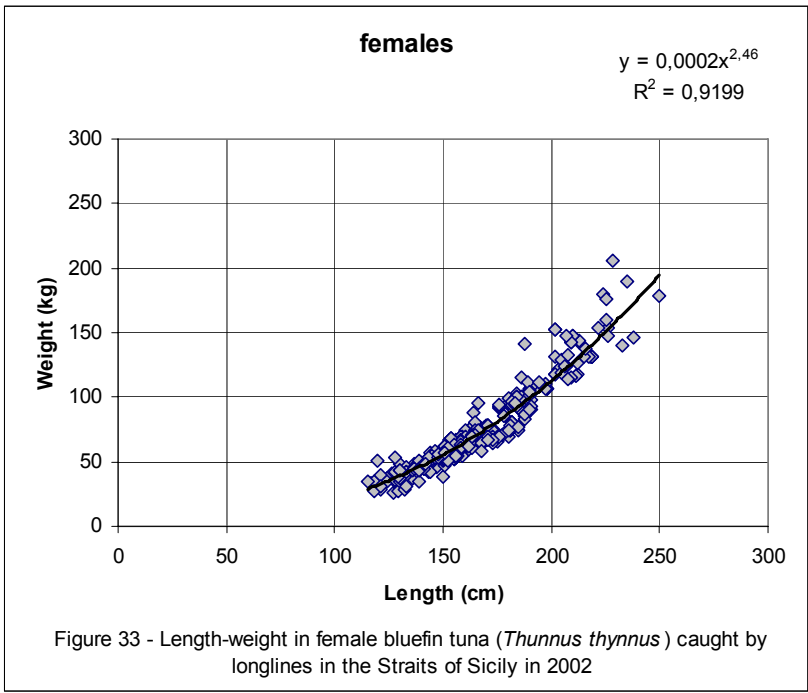




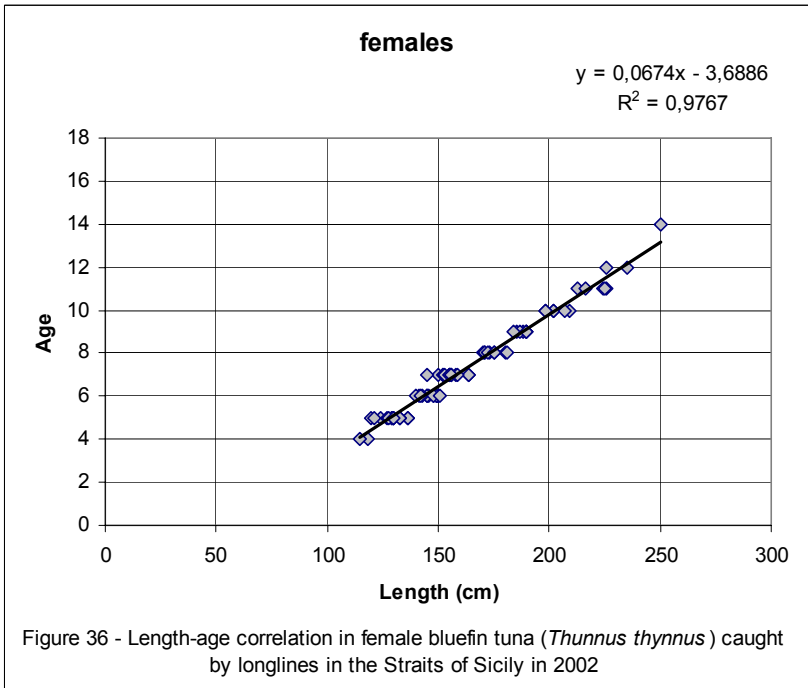
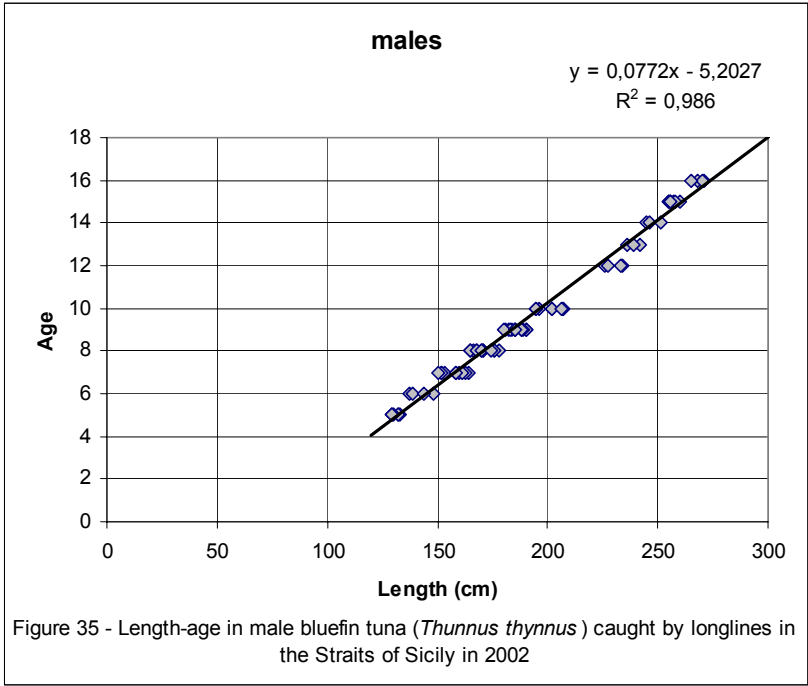


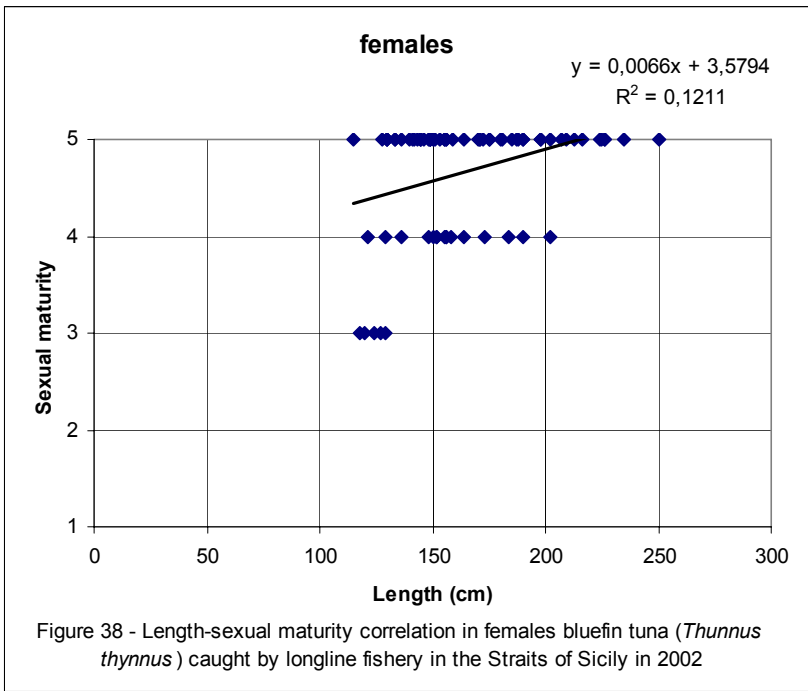
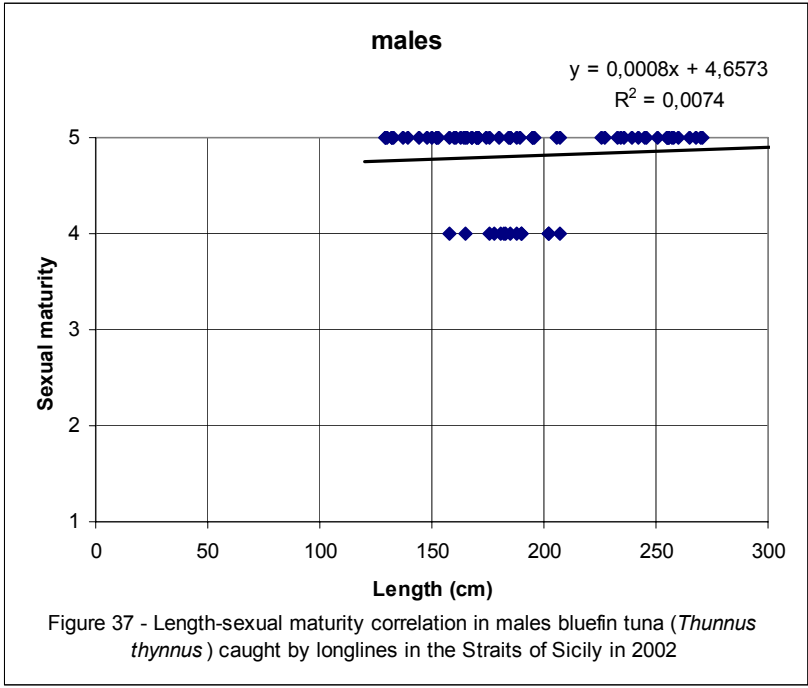


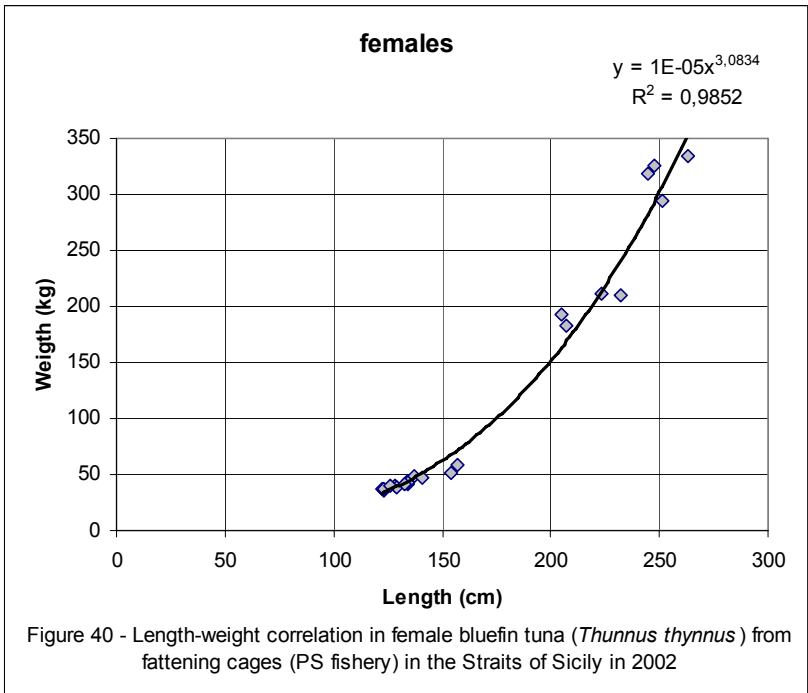
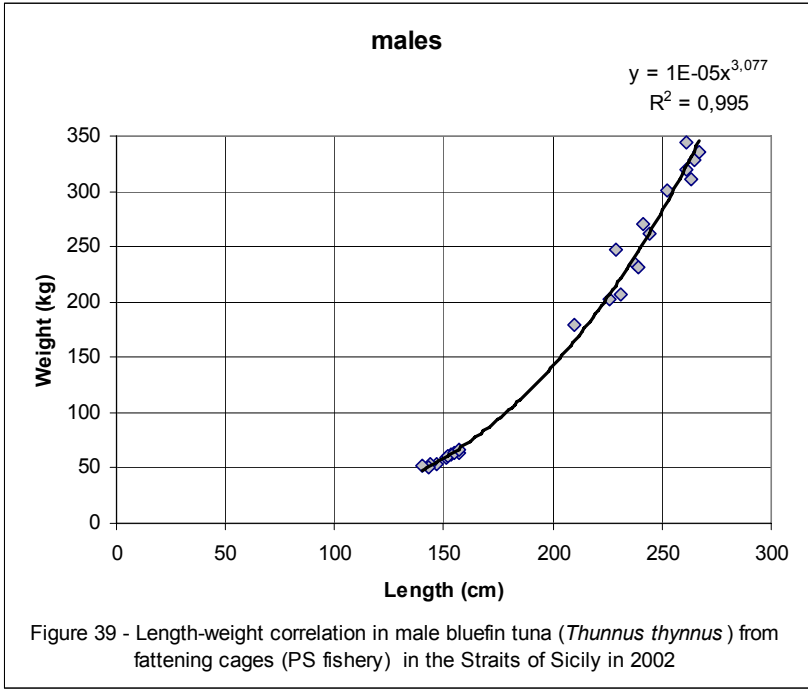


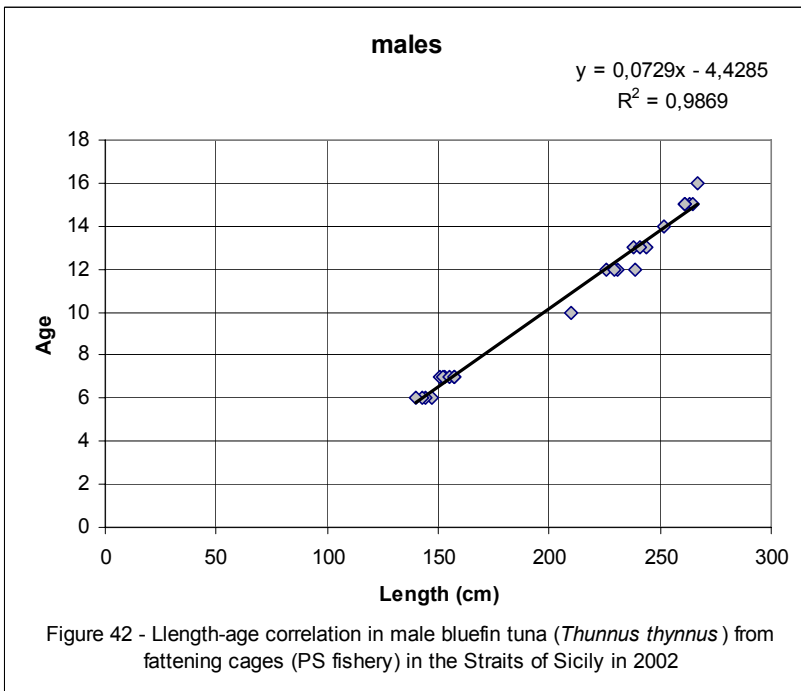
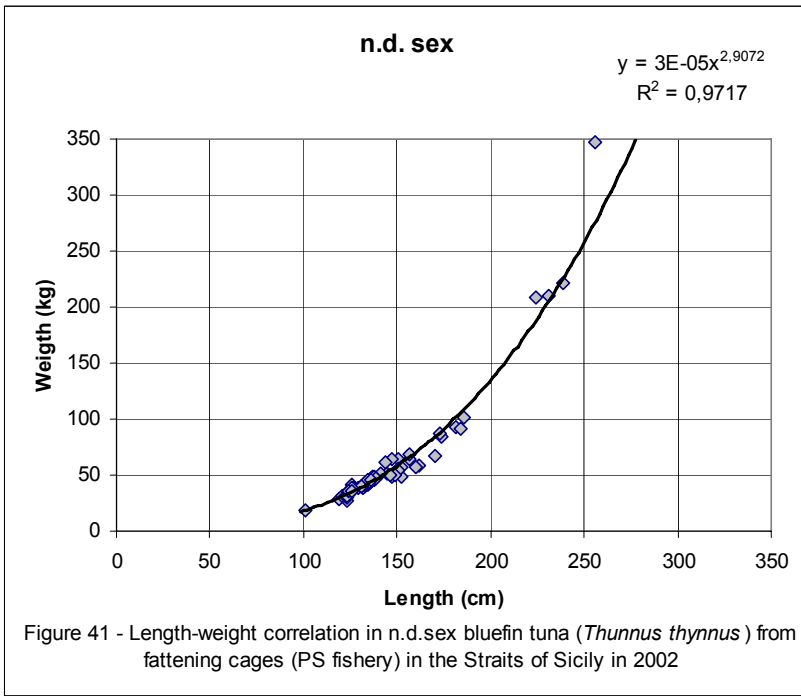


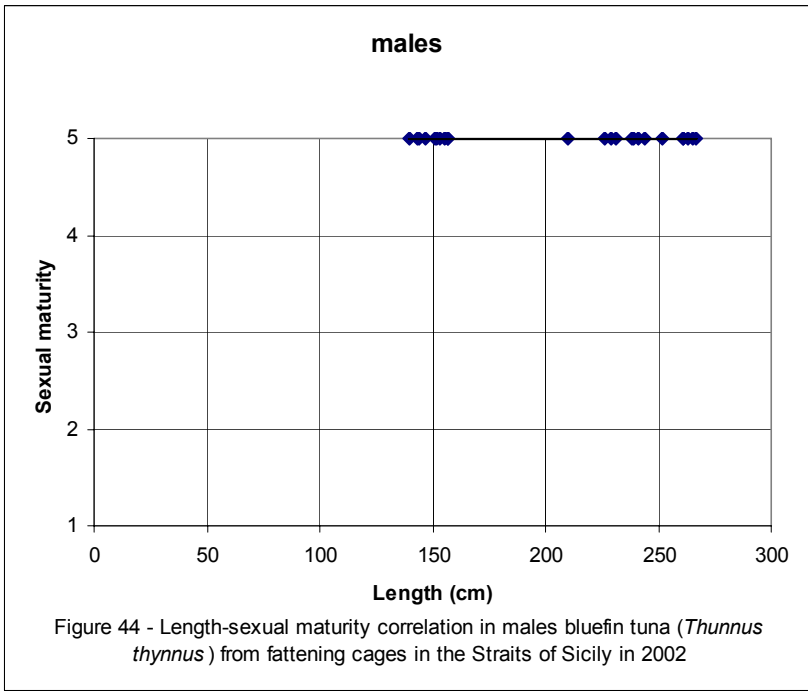
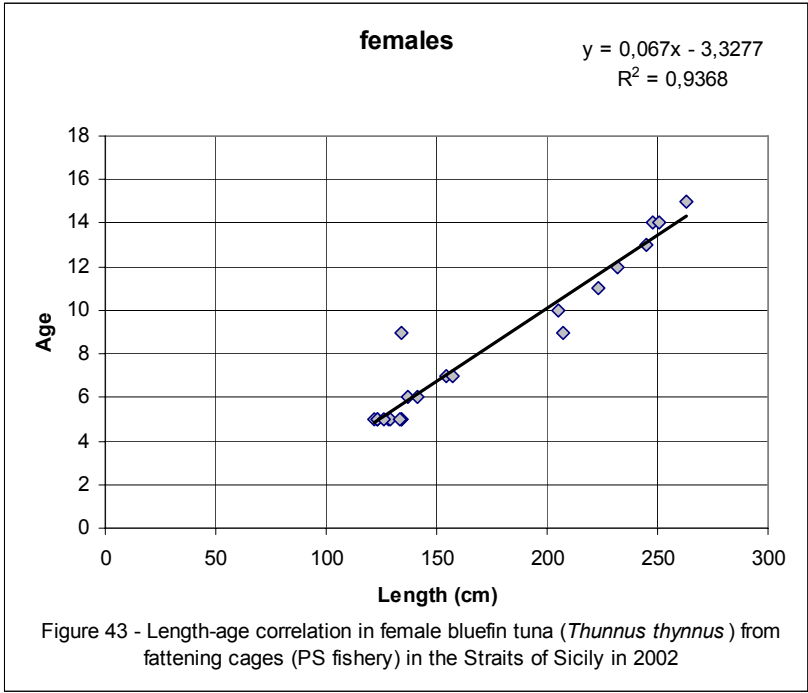


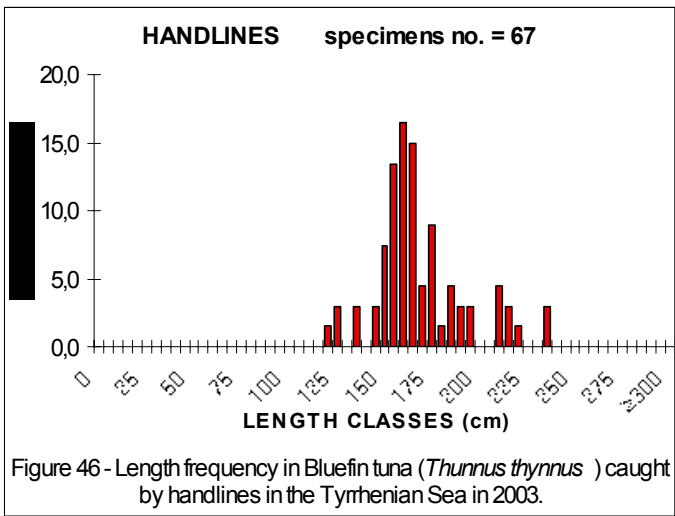
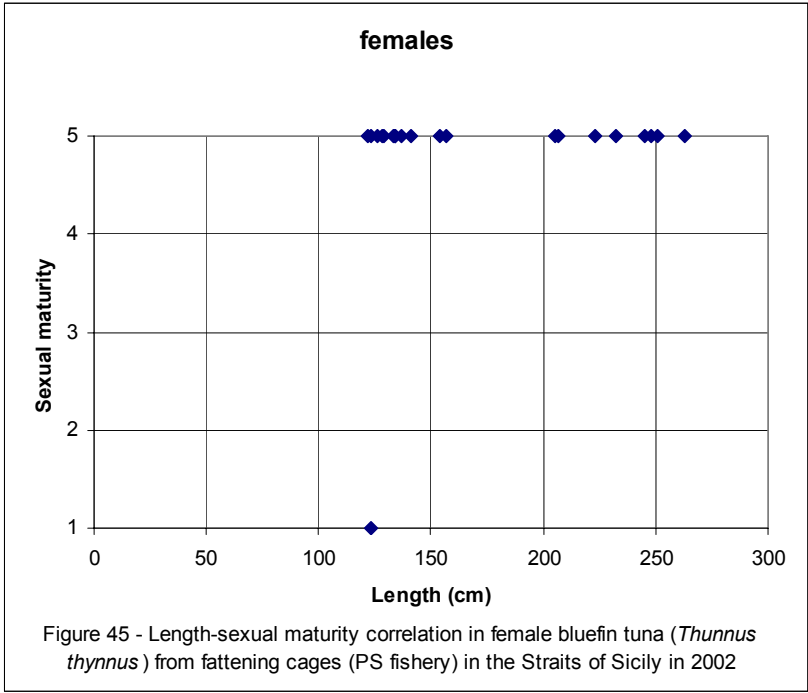


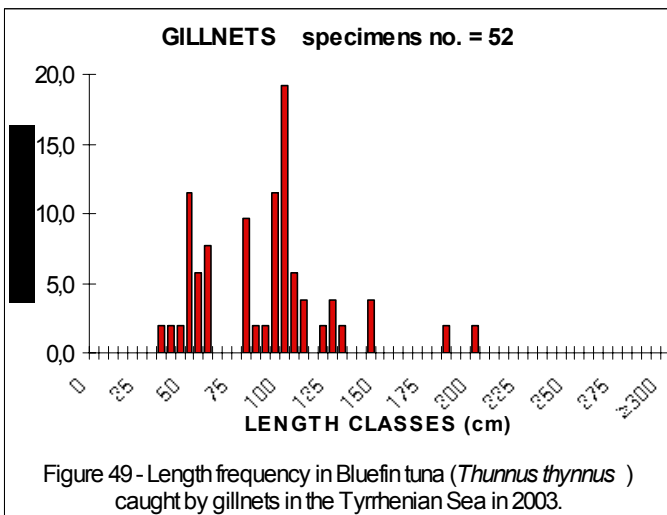
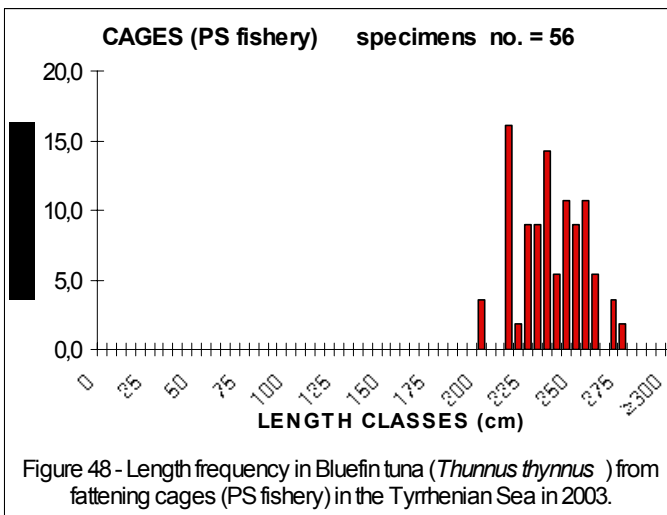
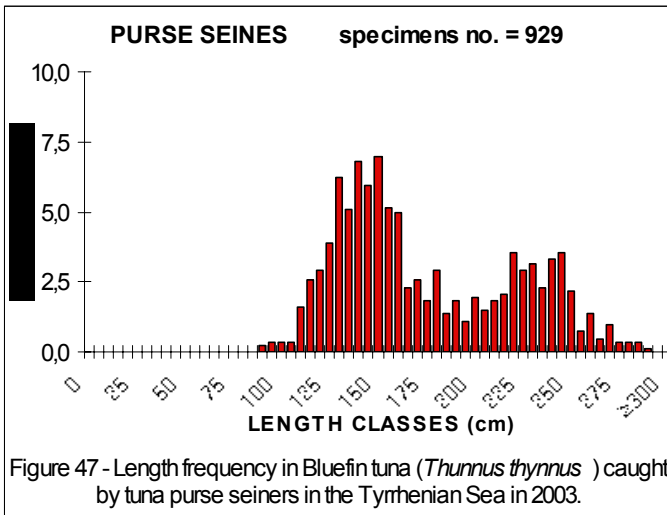


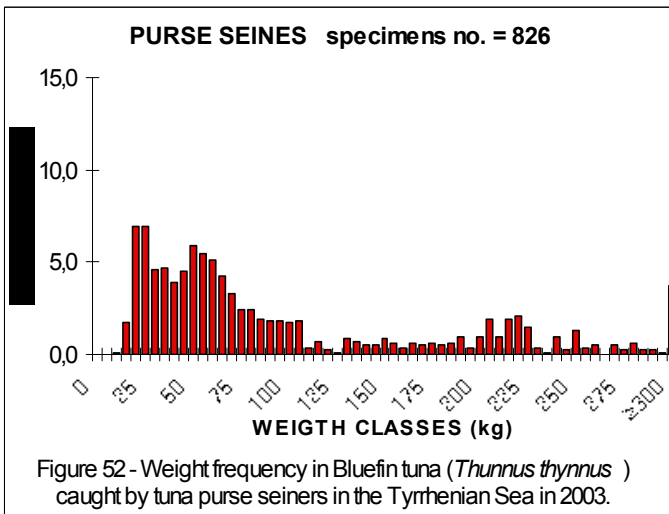
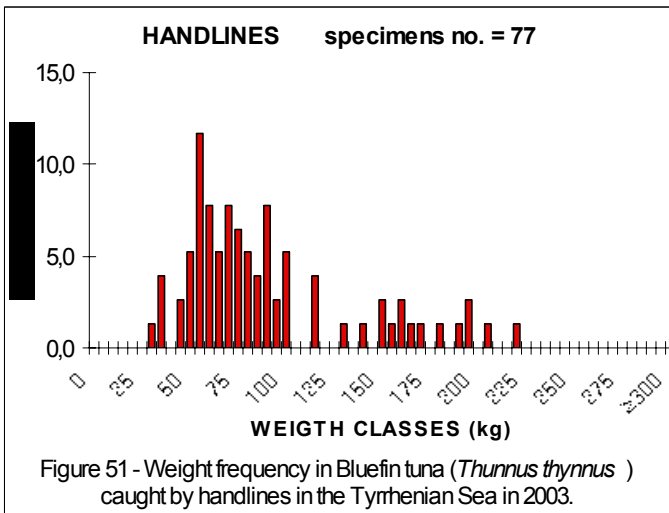
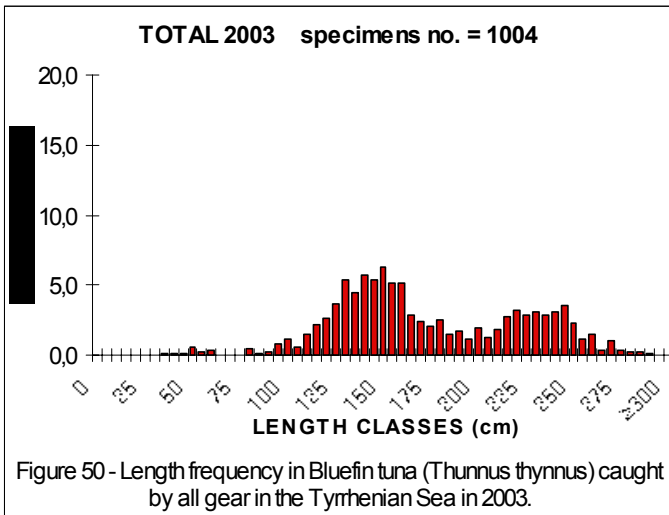




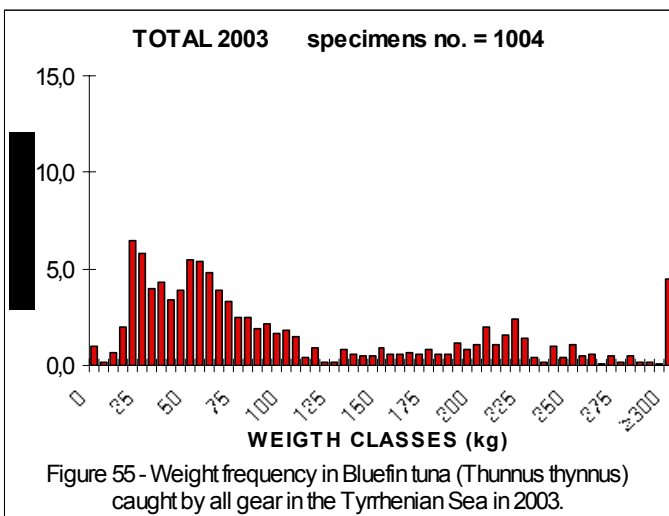
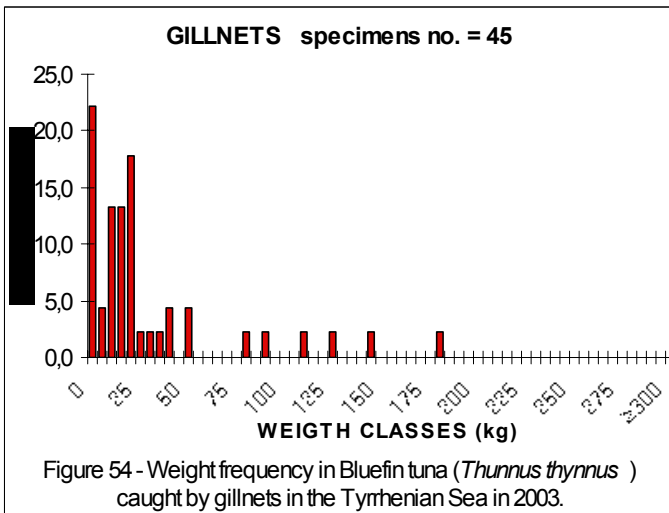
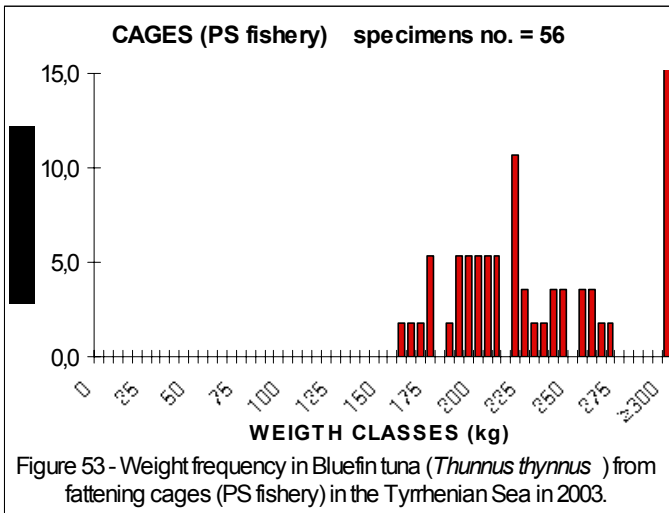


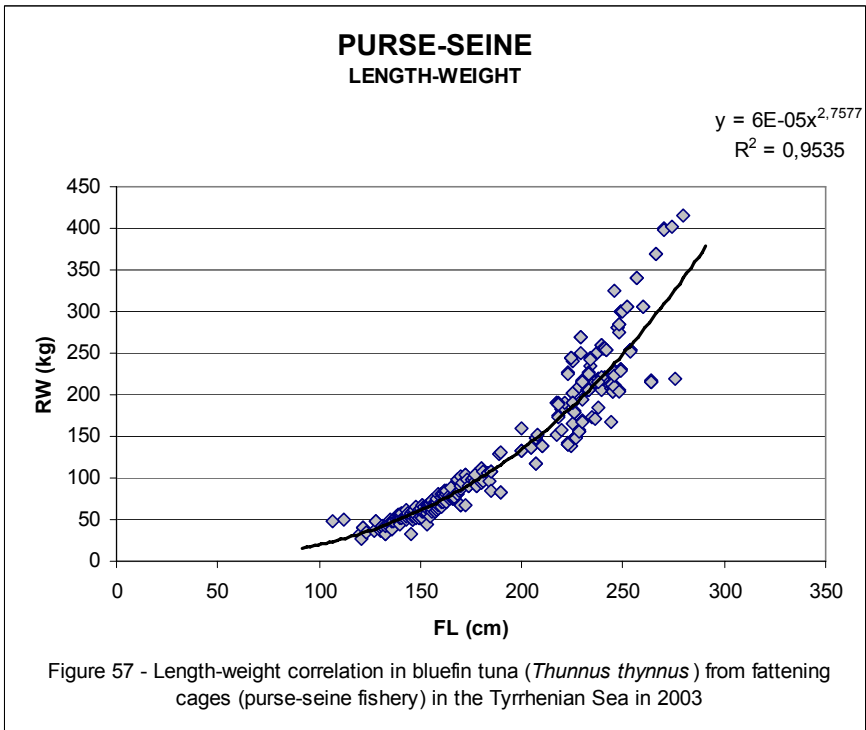
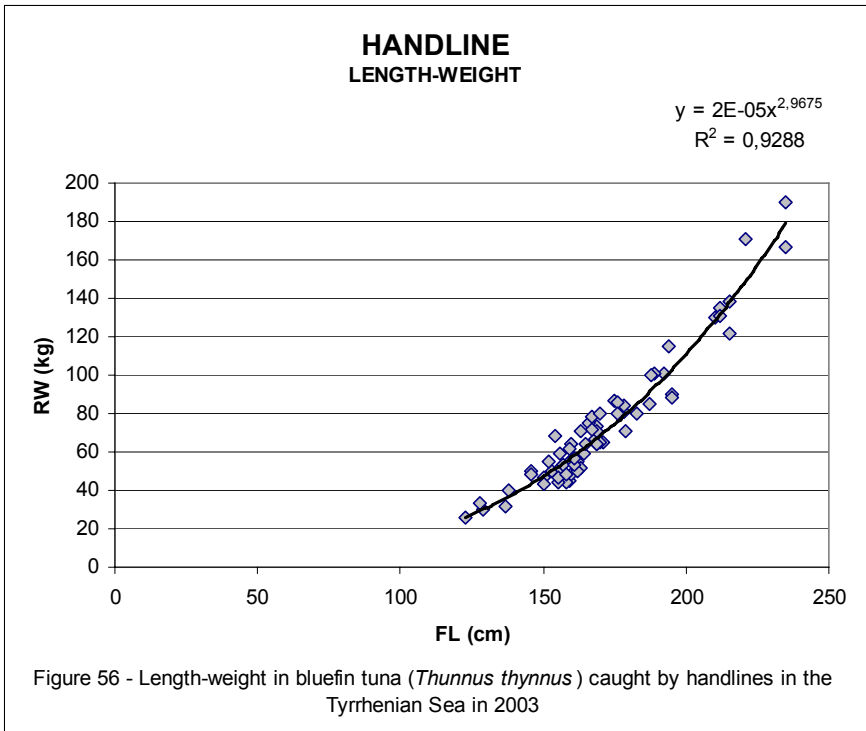












**FATTENING CAGES  
LENGTH-WEIGHT**

$$y = 0,0035x^{2,0332}$$
$$R^2 = 0,4557$$

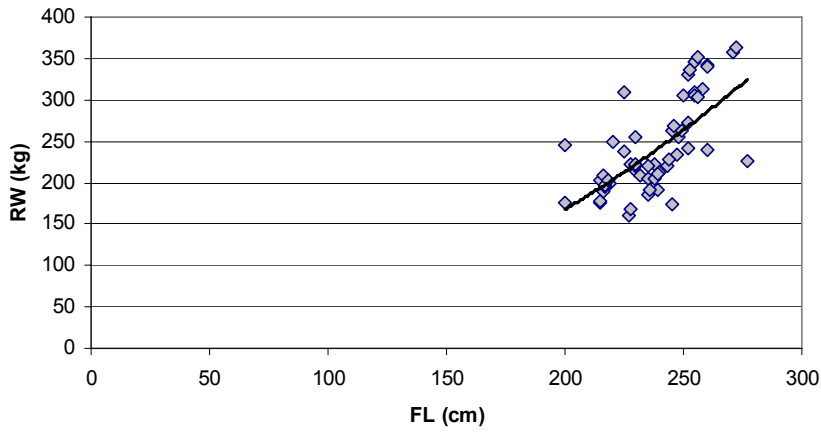


Figure 58 - Length-weight correlation in bluefin tuna (*Thunnus thynnus*) from fattening cages (purse-seine fishery) in the Tyrrhenian Sea in 2003

**GILLNET  
LENGTH-WEIGHT**

$$y = 0,0001x^{2,5898}$$
$$R^2 = 0,9835$$

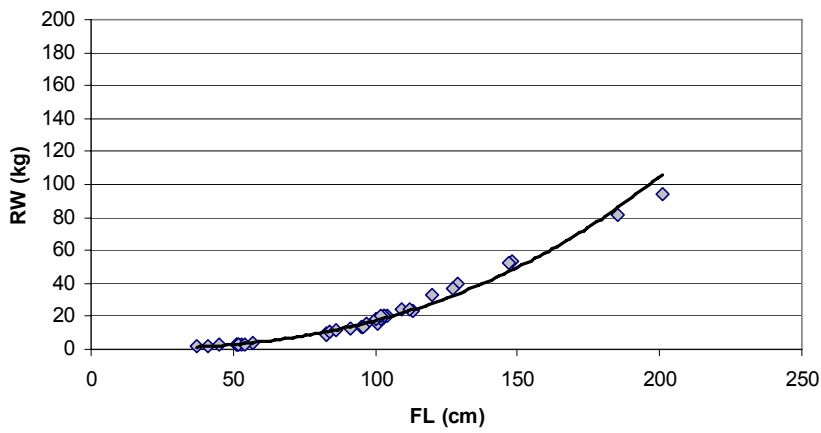
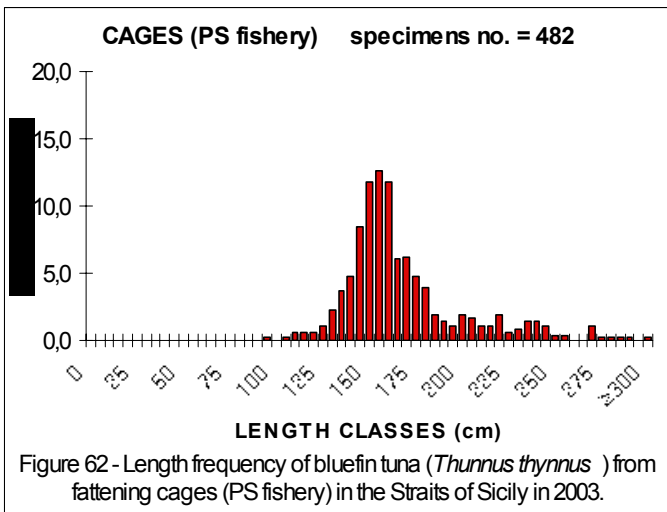
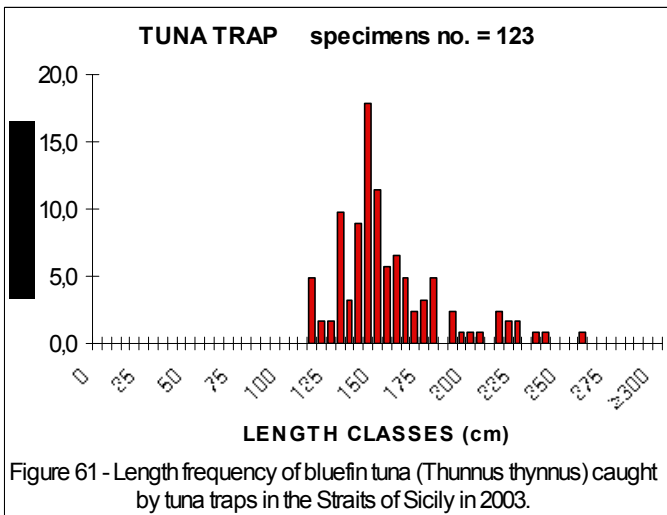
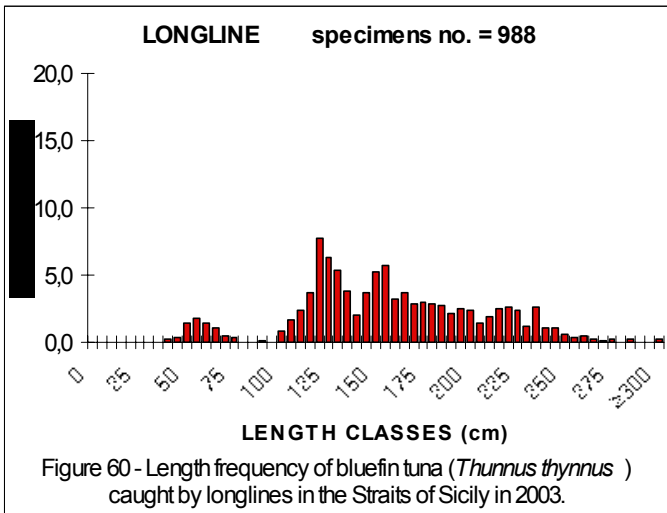
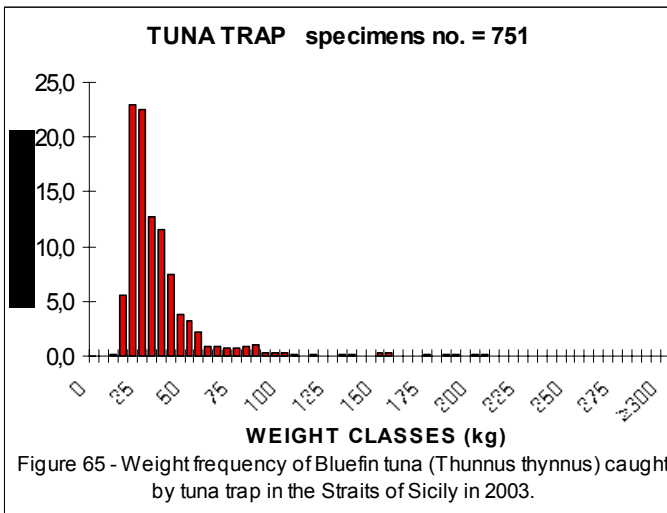
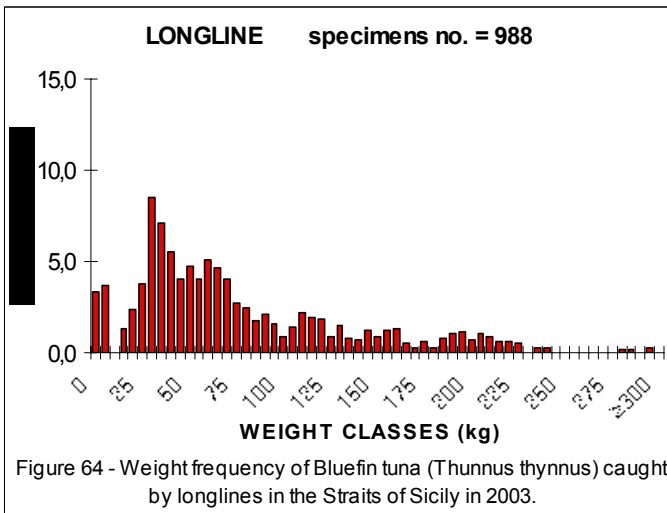
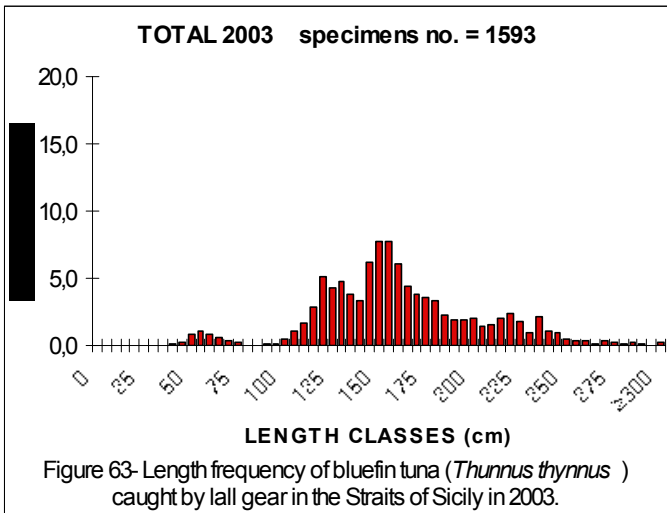
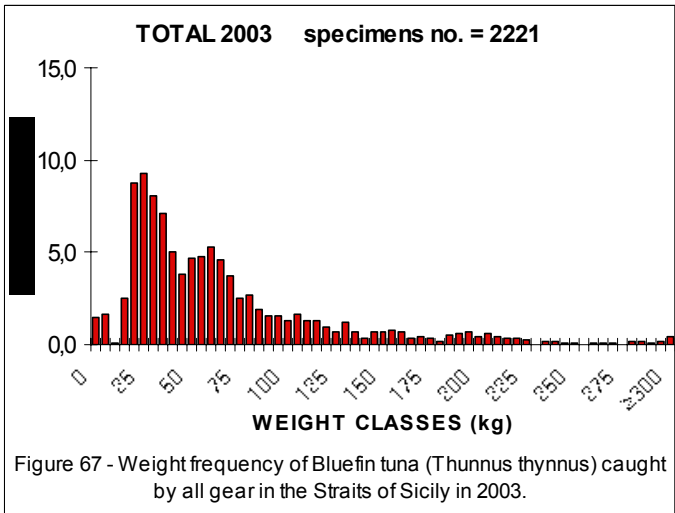
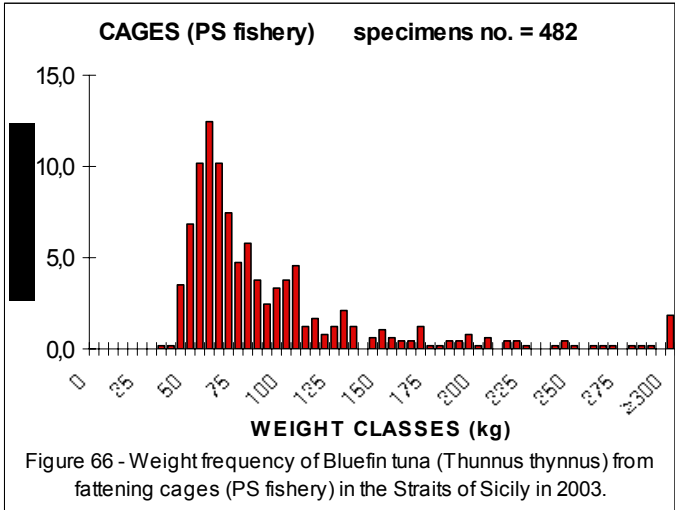
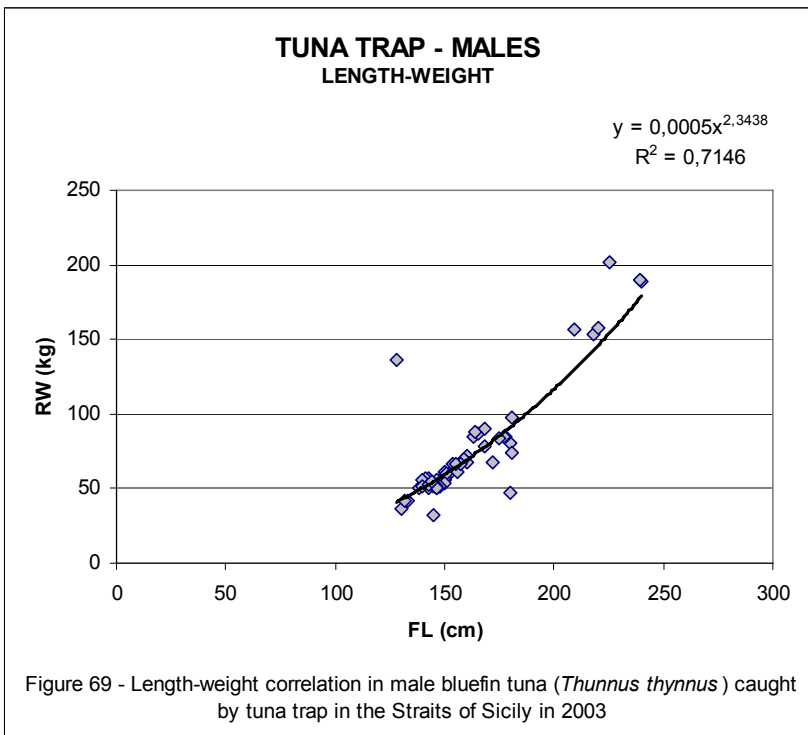
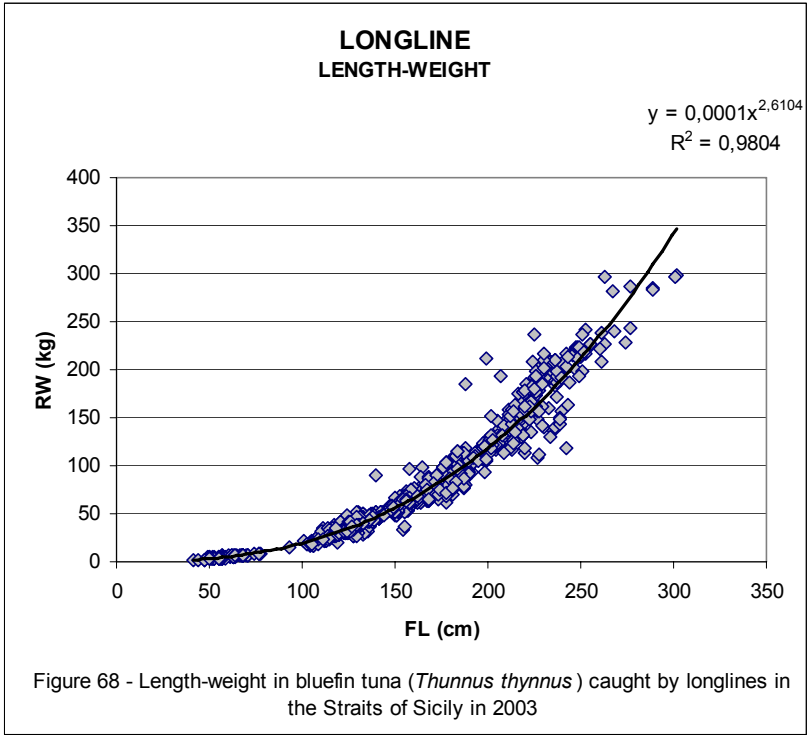


Figure 59 - Length-weight correlation in bluefin tuna (*Thunnus thynnus*) caught by gillnets in the Tyrrhenian Sea in 2003









**TUNA TRAP - FEMALES  
LENGTH-WEIGHT**

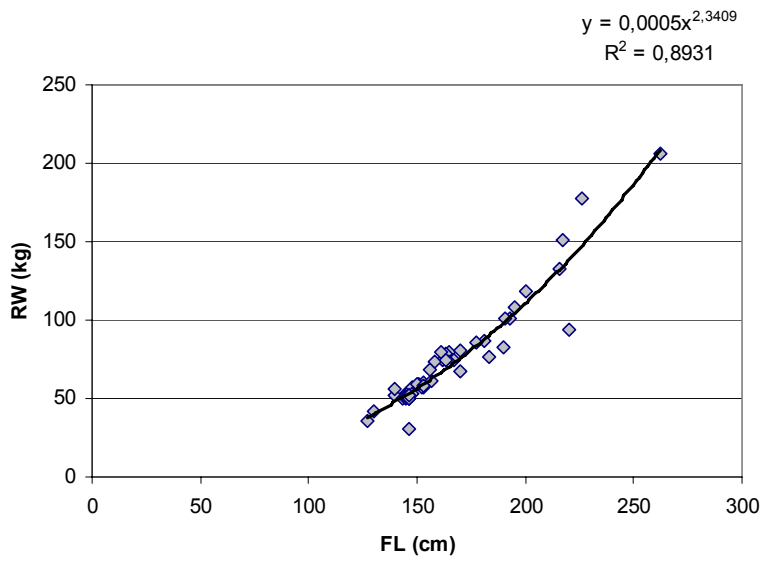


Figure 70 - Length-weight correlation in female bluefin tuna (*Thunnus thynnus*) caught by tuna trap in the Straits of Sicily in 2003

**TUNA TRAP - N.D. SEX  
LENGTH-WEIGHT**

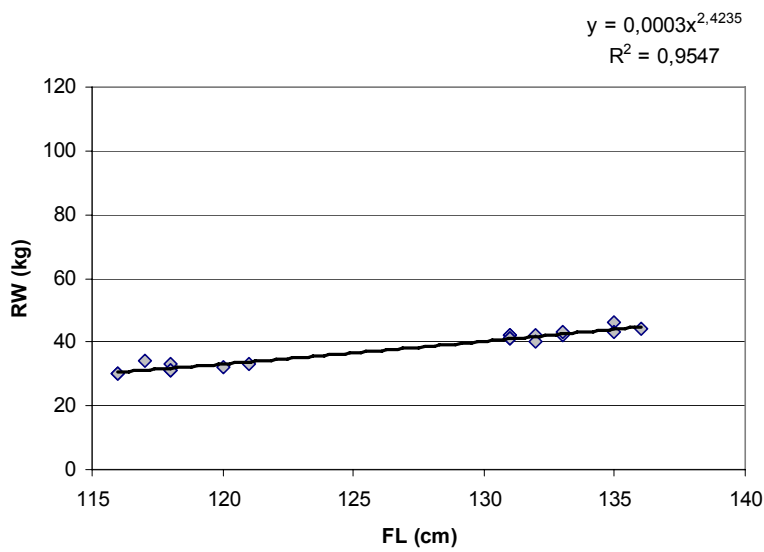


Figure 71 - Length-weight correlation in n.d.sex bluefin tuna (*Thunnus thynnus*) caught by tuna trap in the Straits of Sicily in 2003



**PURSE-SEINE (FATTENING CAGES)**  
**LENGTH-WEIGHT**

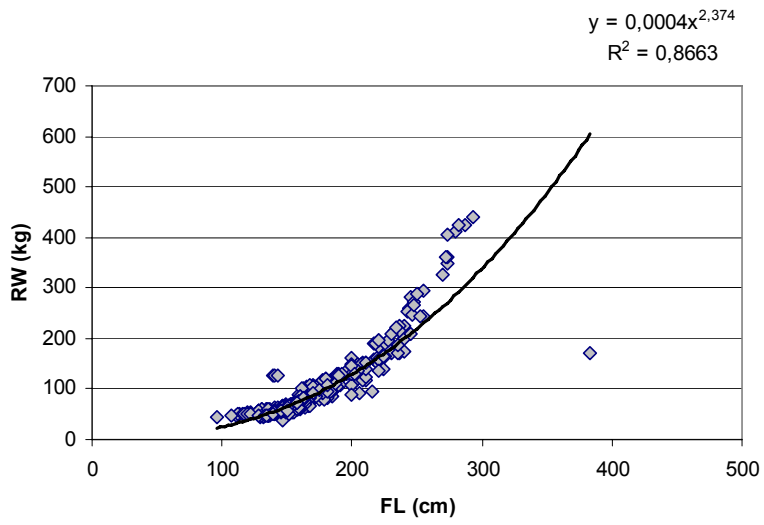


Figure 72 - Length-weight correlation in bluefin tuna (*Thunnus thynnus*) from fattening cages (PS fishery) in the Straits of Sicily in 2003