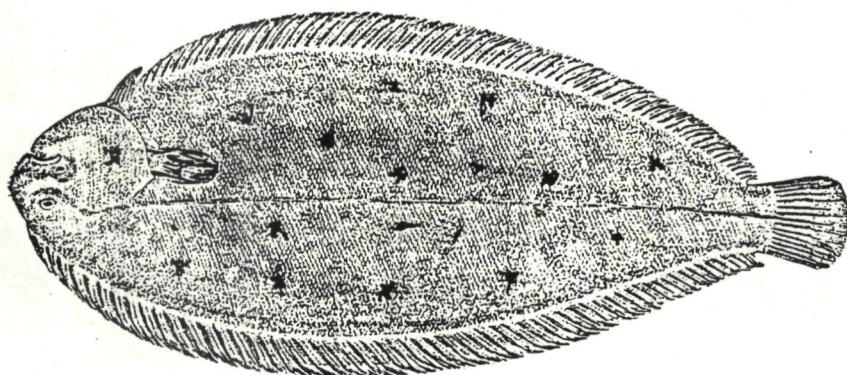


EUROPEAN COMMISSION

STUDY OF THE SOLEIDAE IN COMMUNITY WATERS



Interim report contract nr 83/1/MO6P1

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Note: This report does not necessarily reflect the views of the Commission, and in no way commits the Commission as to its future position in this field.

GENERAL

The sole is the most common species of the family of the Soleidae in European waters. The different sole stocks are generally restricted to wide coastal areas.

The great possibilities of adaptation are responsible for a large distribution in the East Atlantic, from the Scandinavian coasts up to the Senegal coast (Figure 1). From the Eastern part of the Baltic till the Islas Canarias sole stocks occur. The main component of the Northeast Atlantic sole stock is situated in the North Sea south of 57 ° N.

In the Mediterranean the sole occur in nearly all coastal areas. Their frequency is however much more variable compared to the Northeast Atlantic stocks, mostly in the Adriatic and the Golf du Lion. The eastern border of occurrence is the South of the Black Sea, the Bosphorus and the Marmara Sea.

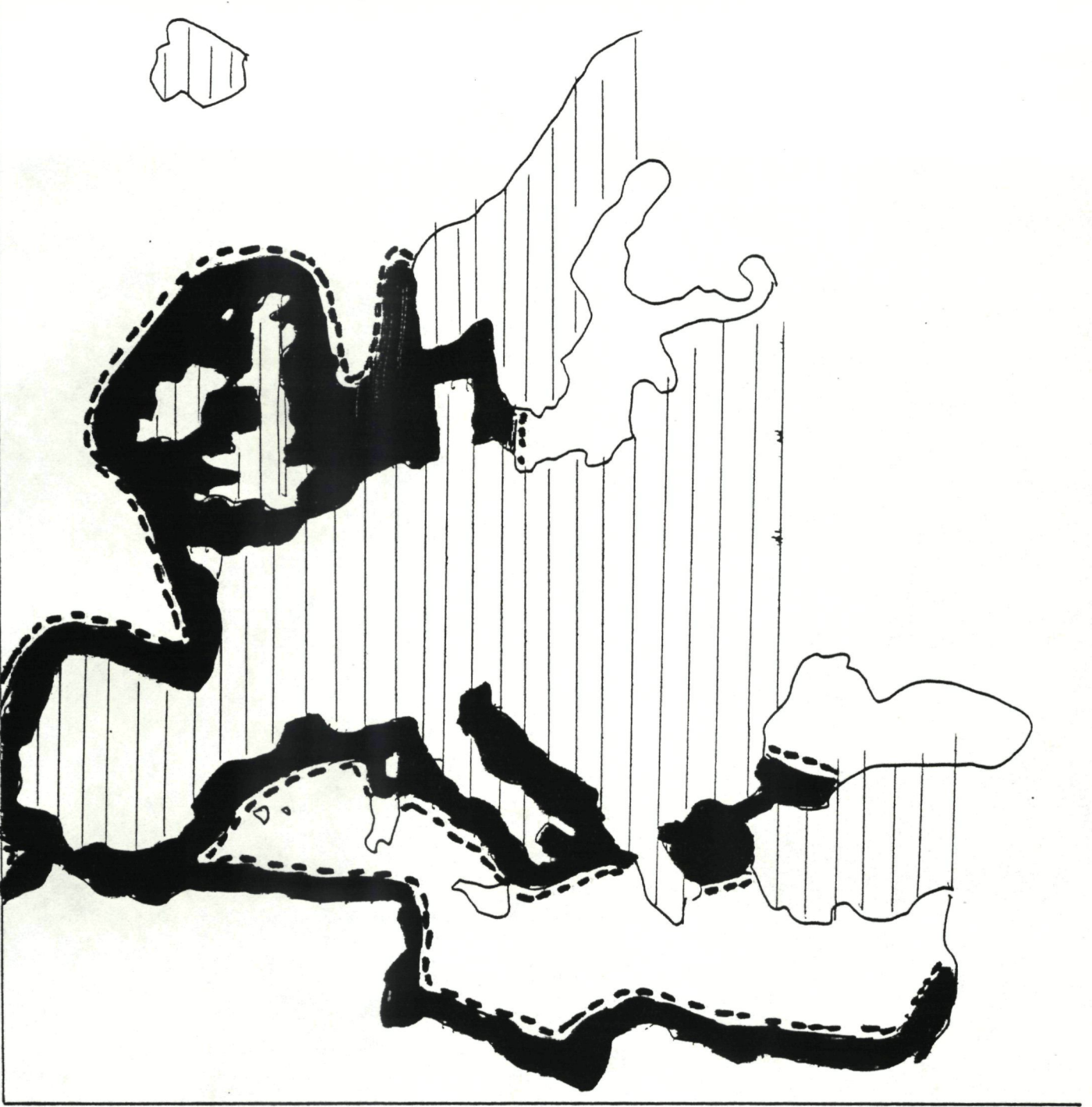


Figure 1 : Occurrence of Solea solea L. in European waters.

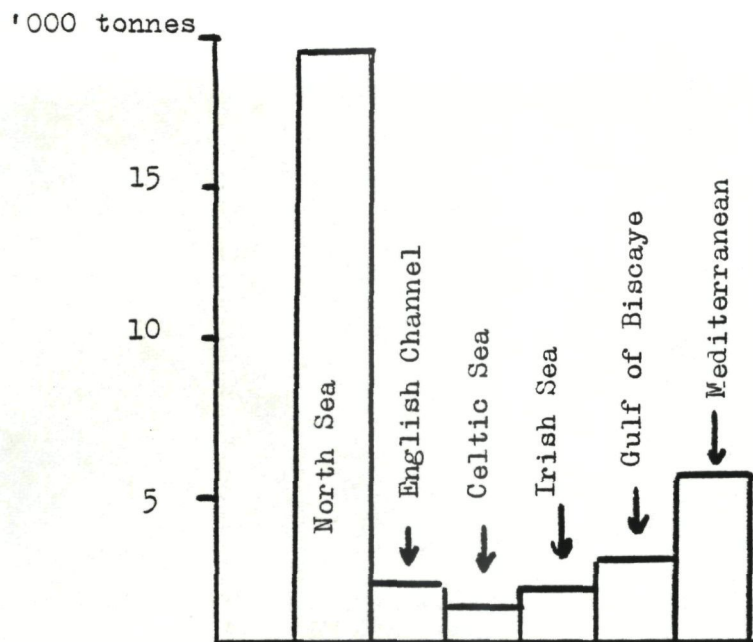
LANDINGS

Figure 2 shows the average catches over the period 1970-1980 of the several exploited sole stocks in the Community.

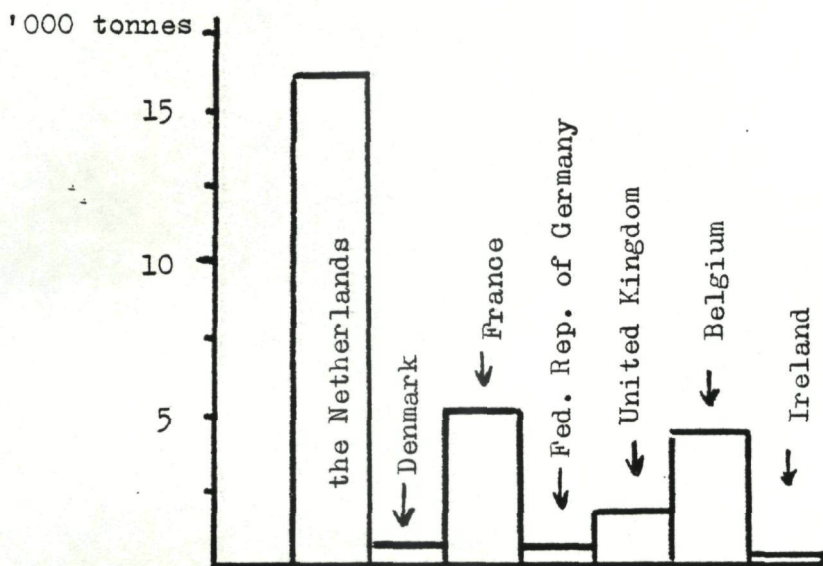
When comparing by areas the North Sea has the highest production which is close to 20,000 tonnes (Figure 2A). The other areas as the English Channel, the Celtic Sea and the Irish Sea are producing catches from 1,800 tonnes to 1,200 tonnes. The total of the latter is 7,300 tonnes. The Mediterranean landings amount to 5,400 tonnes being 17 % of the total sole landings.

In the Northeast Atlantic fisheries the Netherlands are the most important sole fishing nation with a yearly mean landing figure of 16,100 tonnes. France is the second leading sole fishery as the mean landing figure is about 4,100 tonnes (Figure 2B). Belgium has a yearly catch of 4,000 tonnes. Other sole fishing countries are United Kingdom with 1,600 tonnes, Denmark with 700 tonnes, the Federal Republic of Germany with 400 tonnes and Ireland with 200 tonnes.

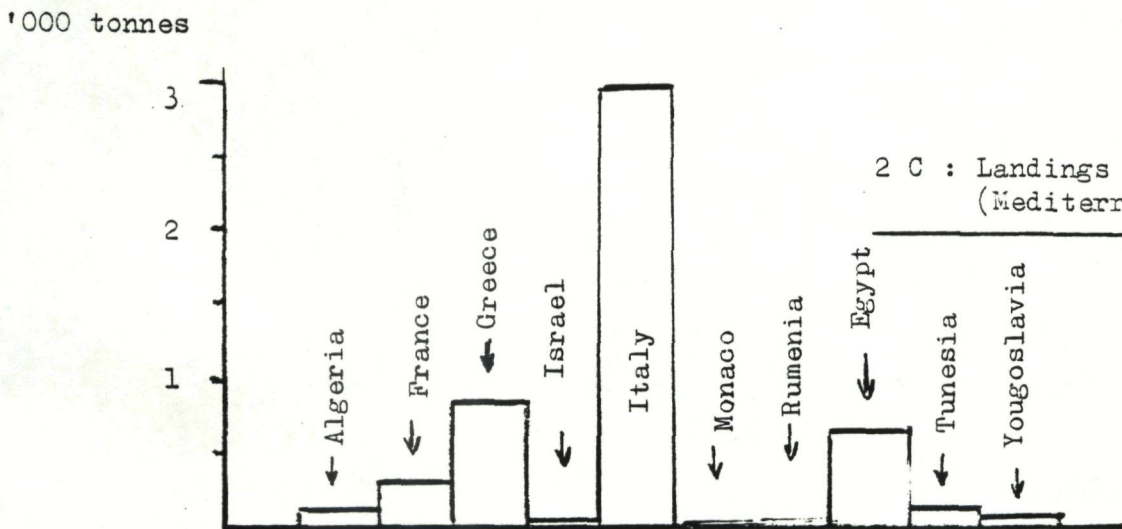
In the Mediterranean Italy is the leading sole fishing nation. Their annual mean catch is close to 3,000 tonnes. This catch is about 56 % of the total Mediterranean catches. On the basis of this the Adriatic Sea seems to be the most productive area for the sole in the Mediterranean. Other important sole fishing nations are Greece (885 tonnes), Egypt (662 tonnes) and France (337 tonnes). It must be stressed that all those values could be seriously underestimated. (Figure 2C).



2 A : Landings by area



2 B : Landings by country
(NE Atlantic)



2 C : Landings by country
(Mediterranean)

Figure 2 : Distribution of the landings per fishing ground and per country.

North Sea sole

Several countries are exploiting the North Sea sole stocks, viz. Belgium, Denmark, the Federal Republic of Germany, the Netherlands, United Kingdom and France. The majority of the catches is caught by the beamtrawl fishery. Due to the high exploitation rate and the high variations in recruitment the catches during the period 1950- 1980 fluctuated substantially. Mean catch 1970-1980 : 19,666 tonnes.

English Channel sole

Separate coastal sole populations occur along the French and English coasts. These populations are exploited on a moderate way by the French, English and belgian fleet. The fishery is carried out by beamtrawl, ottertrawl and trammelnets. Some part of the fleet of France and United Kingdom is artisanal. Mean catch 1970-1980 : 1,847 tonnes.

Celtic Sea sole

Belgian beamtrawlers and French and Welsh ottertrawlers are exploiting the stock which is predominantly in the Bristol Channel. The Belgian fleet is taking the bulk of these catches up to about 80 % of the total international landings. Mean catch 1970-1980 : 1,222 tonnes

Irish Sea sole

In the Liverpool Bay as well as near the Irish coast a sole fishery is carried out by several countries, viz. Belgium, France, Ireland, the Netherlands and United Kingdom (England and Wales, Northern Ireland, Scotland and Isle of Man). This fishery is essential a spawning fishery (April-May). Mean catch 1970-1980 : 1,504 tonnes.

Bay of Douarnenez sole

An artisanal French fishery is exploiting the sole stocks around Bretagne. Catch statistics are not available.

Bay of Biscay sole

Although most of the grounds are not suitable for sole fishery some concentrations of fishing areas exist in the Southern part of the Bay of Biscay. The main exploiting countries are France (95 %) and Spain. Some occasional fishery occurred in the past by the Belgian and the French fleet.

Mean catch 1970-1980 : 2,708 tonnes.

Portuguese coastal sole

Spain and Portugal are exploiting coastal stocks. Catch statistics are not available.

1. Review of growth data per sex in the North Sea, English Channel, Celtic Sea and Irish Sea.
-

JUVENILES

Growth is not a constant proces for sole in the NE-Atlantic areas. The winter period is characterized by a growth stagnation whereas during the summer period rapid growth is a result of an active feeding period. This is clearly demonstrated on figure 3. After spawning the fertilized eggs produce larvae which after metamorphosis become baby soles. First observations of trawling indicate a length of about 5 cm in the southern North Sea after two or three months of live. This growth is continued till October. At that moment sole are close to 10 cm of length. The whole winter period is a period of growth stagnation. It is until the next spring that intensive feeding and growth starts again resulting in a mean length close to 17 cm at an age of about 16 months. The next winter period a new growth stagnation starts.

The behaviour in the Irish Sea is identical to the one observed in the North Sea (Corlett 1967). However the length increment is much lower. At the end of the first year of total length of about 6,5 cm is obtained. During the second year total length is about 14 cm.

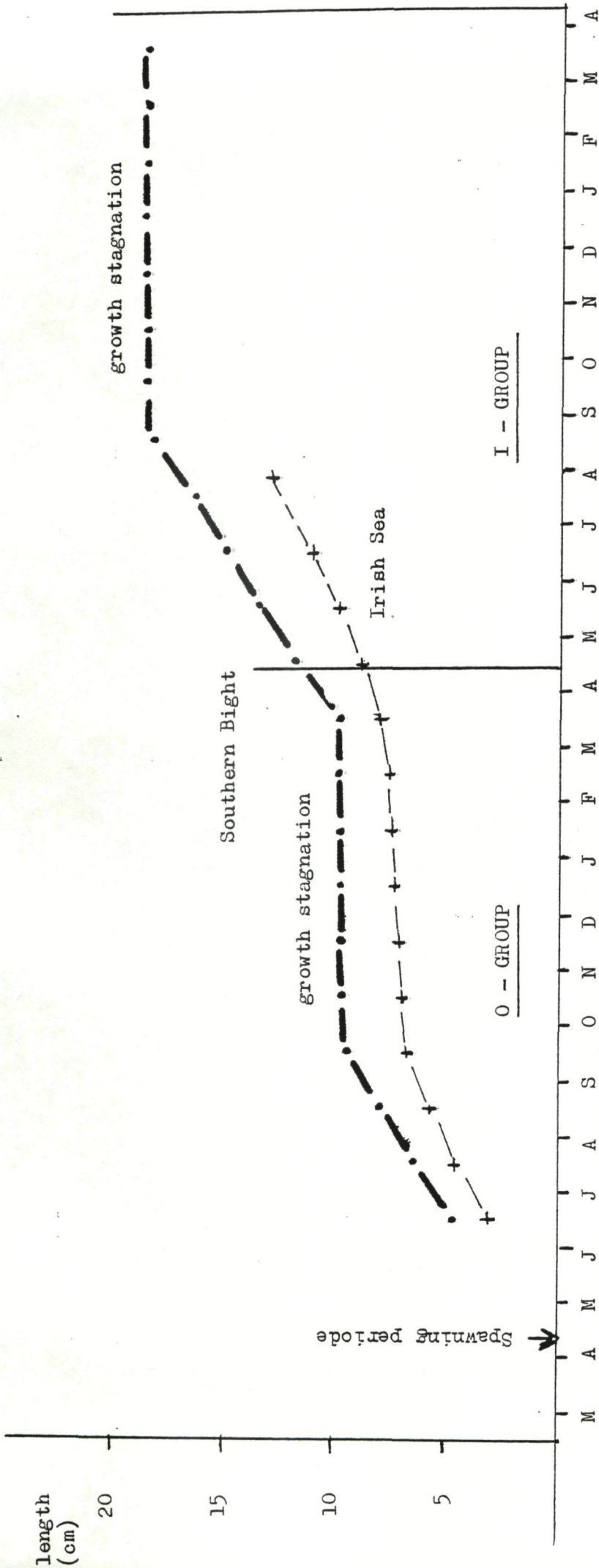


Figure 3 : growth curves for juvenile sole in the Southern North Sea and the Irish Sea.

ADULTS

Growth in length of the adult sole populations.

Figures 4 - 17 show the length increament for male and female soles in the following fishing grounds : Southern North Sea, Central North Sea, English Channel, Celtic Sea, Irish Sea, Bay of Douarnenez and Bay of Biscay.

The mean length per age group and per stock is compiled in table 1. Except of the data from the Bay of Douarnenez and the Bay of Biscay, all data are derived from catch sampling during the fourth quarter of the years 1978-1983.

The following growth parameters were calculated :

L_{∞} : theoretical maximum length

K : Growth constant

t_0 : Time of birth

The results are given in table 2.

The main conclusions of this study can be summarized as follows:

1. In all stocks male sole is reaching a maximum length inferior than the one calculated for females.
This difference is between 6 to 8 cm.
2. Little distinction in growth rate is observed in the male sole stocks of the North Sea (both areas), Celtic Sea, English Channel and Irish Sea. The maximum length in all these areas is close to 34 cm.
3. Female soles reach maximum lengths of about 43 to 44 cm in the North Sea and the English Channel.

In the other "Northern" areas there seems to be a slower growth pattern. This is most pronounced in the Irish Sea where the maximum length is 40.6 cm. The observed slower growth already shown in the juvenile stock (figure 3) is thus continued in the adult period.

4. There is an indication that male soles in the Southern areas as Bay of Douarnenez and Bay of Biscay reach higher length than in the Northern areas. The data from the stock around Bretagne however (Deniel, 1981) could be biased as they are derived from a small and single sample. The same reservation could be expressed for the female stock in that area.

Table 1 : Length at age for several NE-Atlantic sole stocks.

(x):Deniel (1981) ; (xx): Guillou (1973).

N.D. No data

MALES

Age	North Sea South	North Sea Central	English Channel	Celtic Sea	Irish Sea	Bay Douarnenez	Bay of Biscay
1	24.1	N.D.	N.D.	N.D.	N.D.	21.6	N.D.
2	26.3	26.7	26.8	26.2	24.5	25.8	24.0
3	29.0	27.7	28.4	28.5	25.7	30.3	26.4
4	30.2	29.3	29.6	30.0	27.2	34.0	28.4
5	30.9	30.9	32.4	31.7	28.5	35.6	29.1
6	31.3	32.1	33.1	32.6	29.2	38.2	30.2
7	32.1	32.8		32.9	30.3	38.1	31.5
8	32.6	32.8		35.0	30.6	40.0	33.1
9	33.0	33.1		32.4	31.7	39.8	33.8
10	34.8	32.6		35.5	31.1		36.8
11		34.0			31.6		35.8
12						(x)	35.0
							(xx)

FEMALES

Age	North Sea South	North Sea Central	English Channel	Celtic Sea	Irish Sea	Bay Douarnenez	Bay of Biscay
1	24.7	N.D.	N.D.	N.D.	N.D.	21.4	N.D.
2	28.1	28.3	27.0	27.1	24.7	25.2	24.4
3	31.9	31.6	31.4	31.5	28.3	31.7	28.3
4	34.8	34.6	34.3	34.7	31.1	35.5	31.3
5	36.5	36.6	35.5	36.7	33.9	39.5	33.4
6	37.9	38.4	37.9	38.0	34.5	40.8	34.8
7	38.6	39.7	39.4	39.0	35.7	42.9	36.8
8	39.0	40.3	39.7	39.3	37.2	44.1	37.2
9	40.8	41.8	39.6	40.2	37.5	44.8	36.0
10	40.2	42.2	40.8	40.8	36.6	44.3	38.1
11	41.2	43.0	43.0	41.7	38.7		40.0
12	42.7	42.8	41.5		38.7		38.3
13	42.5		43.0		39.4		41.5
14			43.0		41.4	(x)	(xx)

Table 2 : Growth parameters in the different stocks

MALES

	L_{∞}	K	t_0
North Sea South	34.7	0.255	-3.67
North Sea Central	34.7	0.200	-3.54
English Channel	34.2	0.246	-3.40
Celtic Sea	35.7	0.271	-2.90
Irish Sea	34.0	0.171	-5.36
Douarnenez	39.1	0.397	
Bay of Biscay	36.5	0.220	-2.85

FEMALES

	L_{∞}	K	t_0
North Sea South	43.2	0.243	-2.47
North Sea Central	44.5	0.240	-2.18
English Channel	43.7	0.241	-2.28
Celtic Sea	41.2	0.371	-0.89
Irish Sea	40.6	0.241	-1.96
Douarnenez	48.2	0.328	
Bay of Biscay	39.6	0.299	-1.26

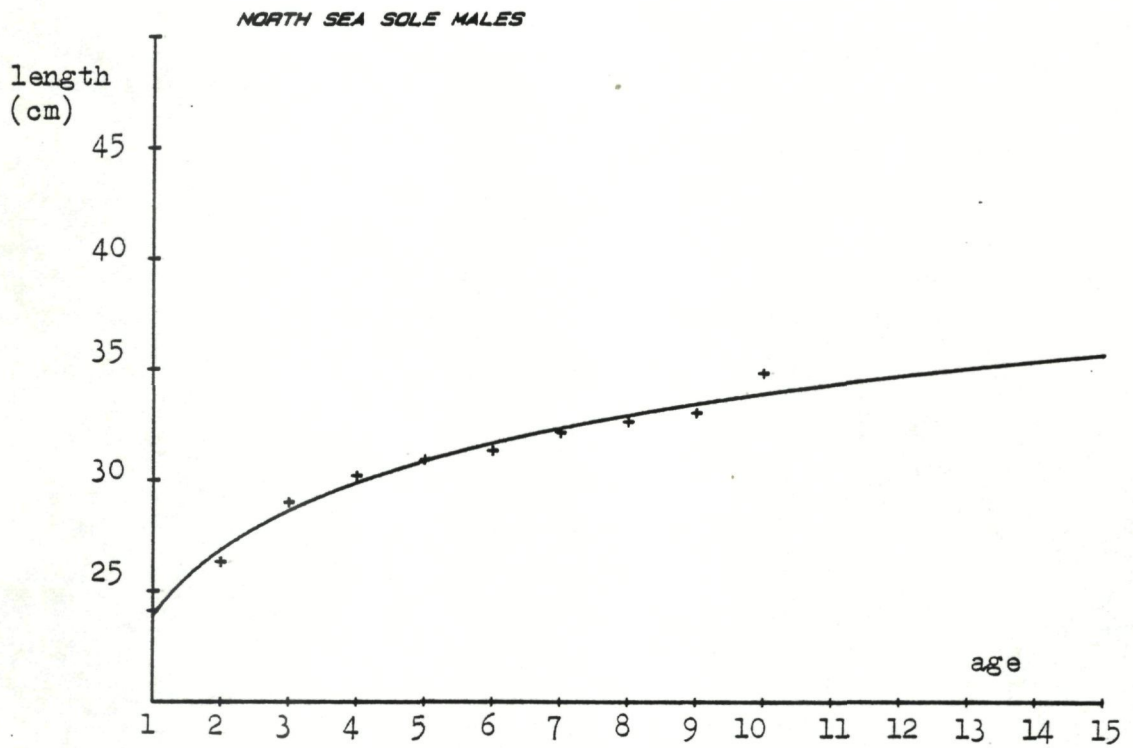


Figure 4 : length increase at age for North Sea sole males.
(southern Bight area)

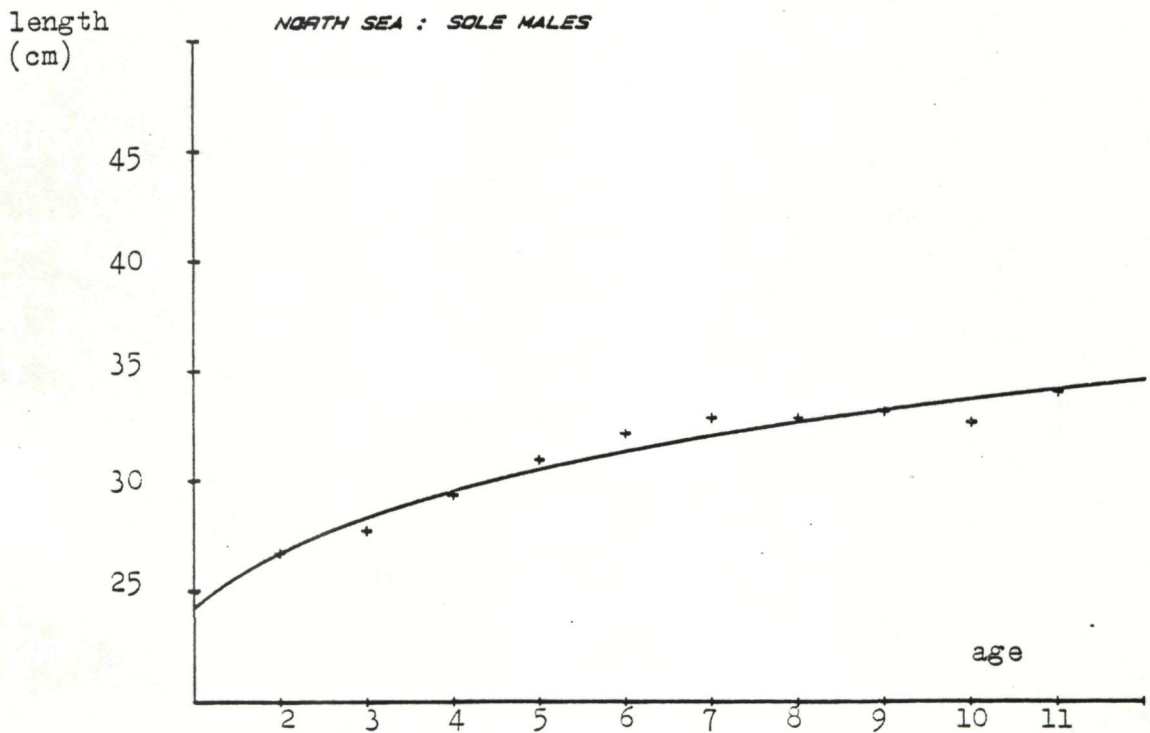


Figure 5 : length increase at age for central North Sea male soles.

EASTERN ENGLISH CHANNEL MALES

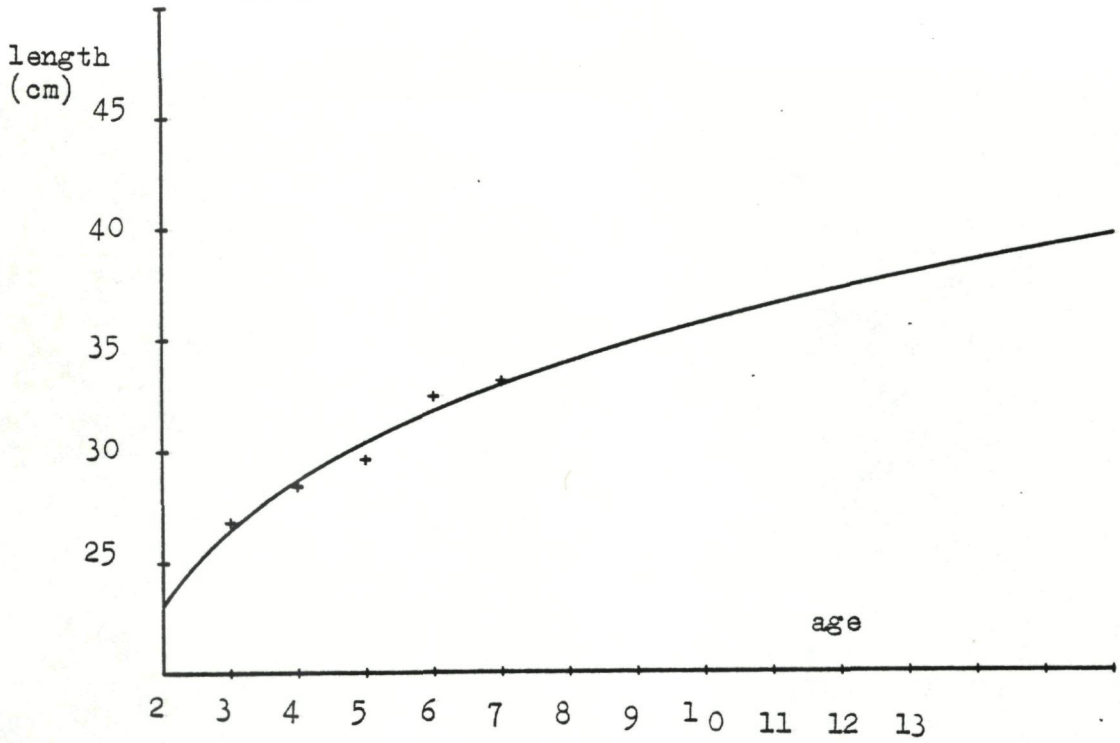


Figure 6 : length increase at age for eastern English Channel male soles.

CELTIC SEA SOLE MALES

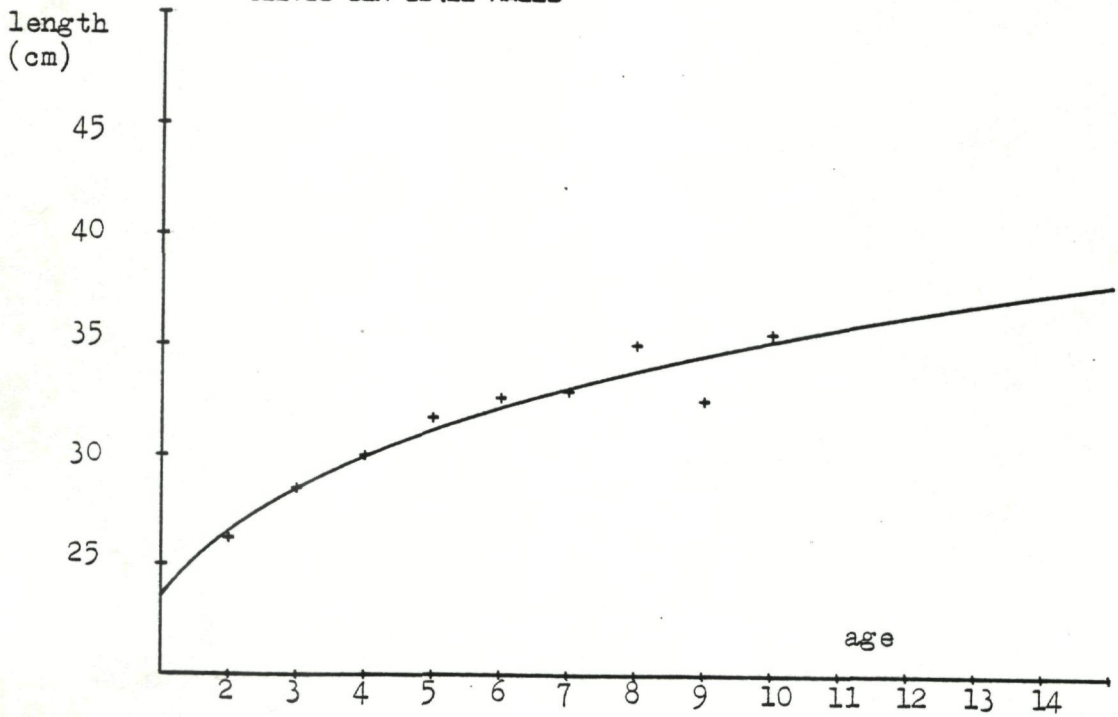


Figure 7 : length increase at age for Celtic Sea male soles.

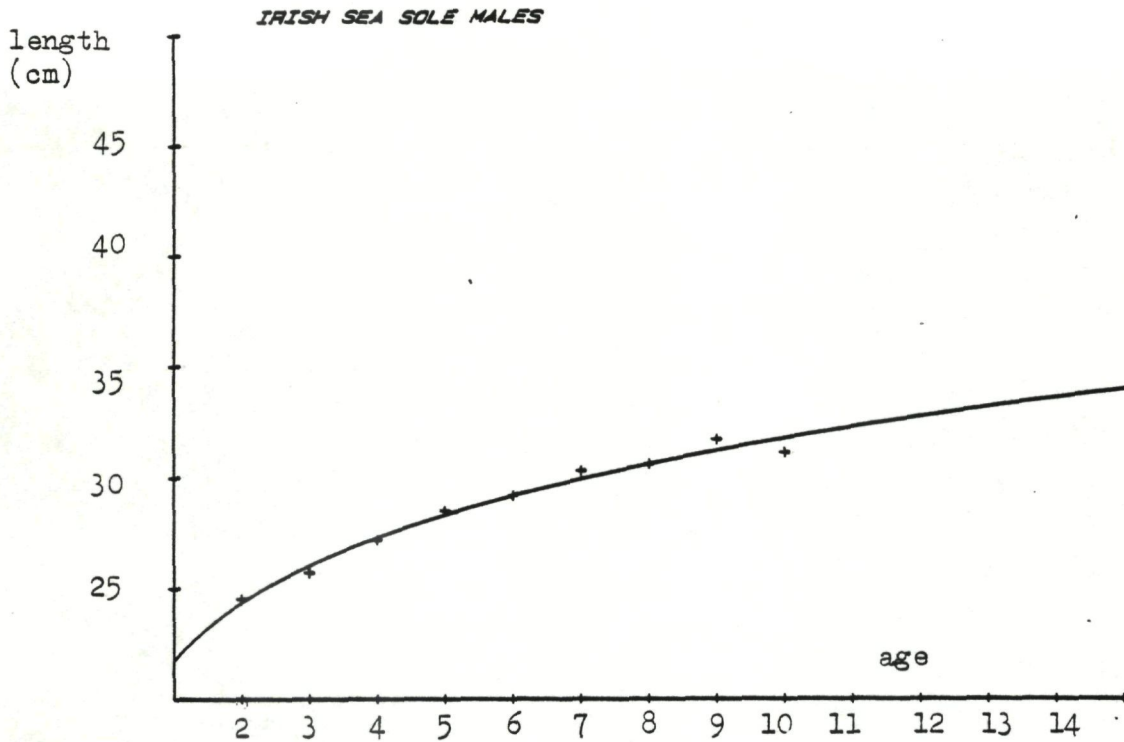


Figure 8 : length increase at age for Irish Sea male soles.

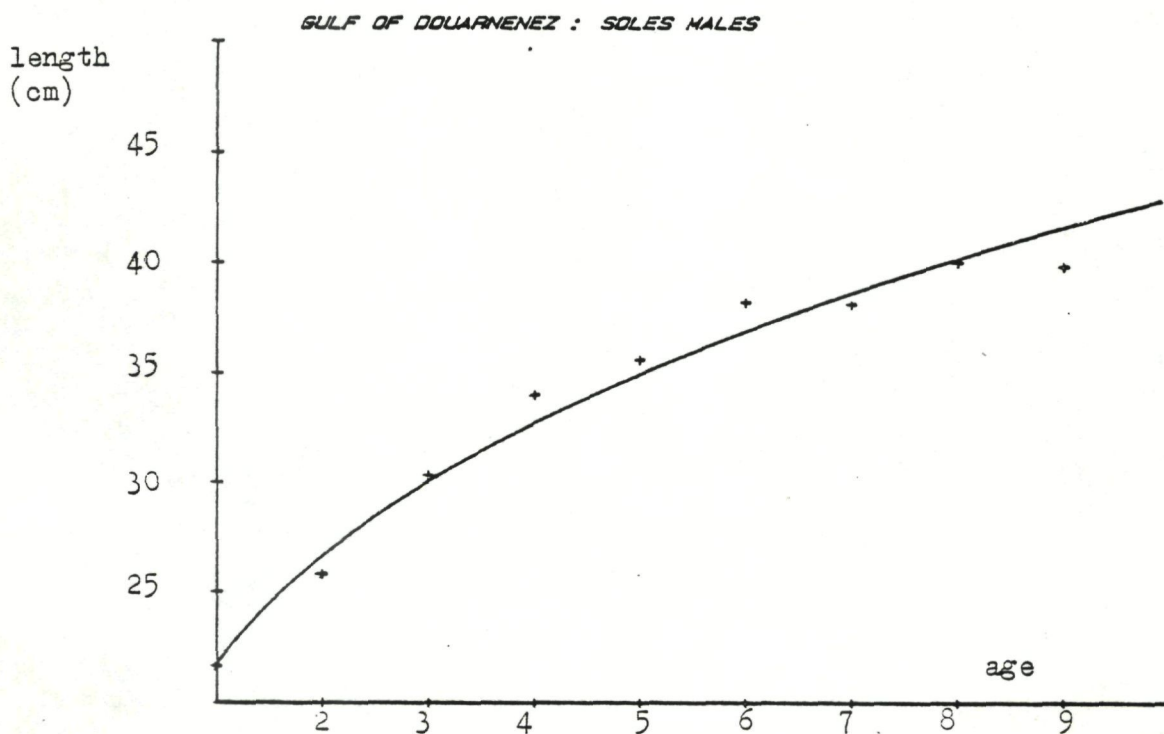


Figure 9 : length increase at age for Gulf of Douarnenez male soles.

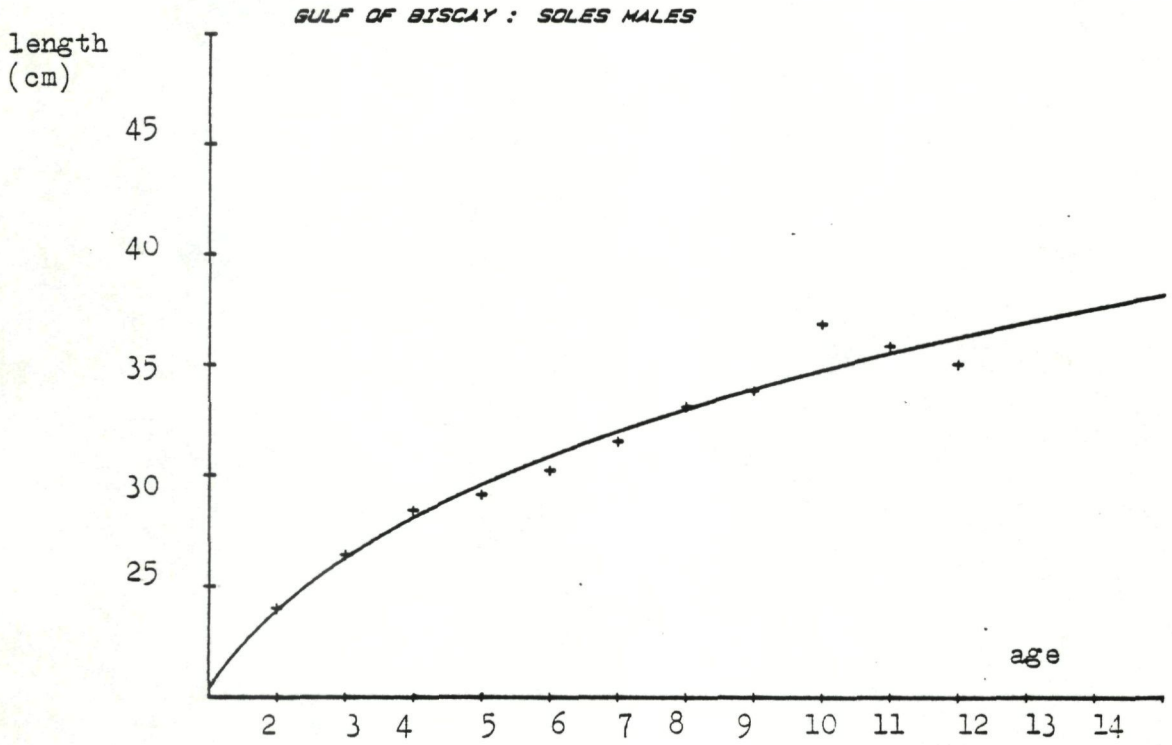


Figure 10 : length increase at age for Bay of Biscay male soles.

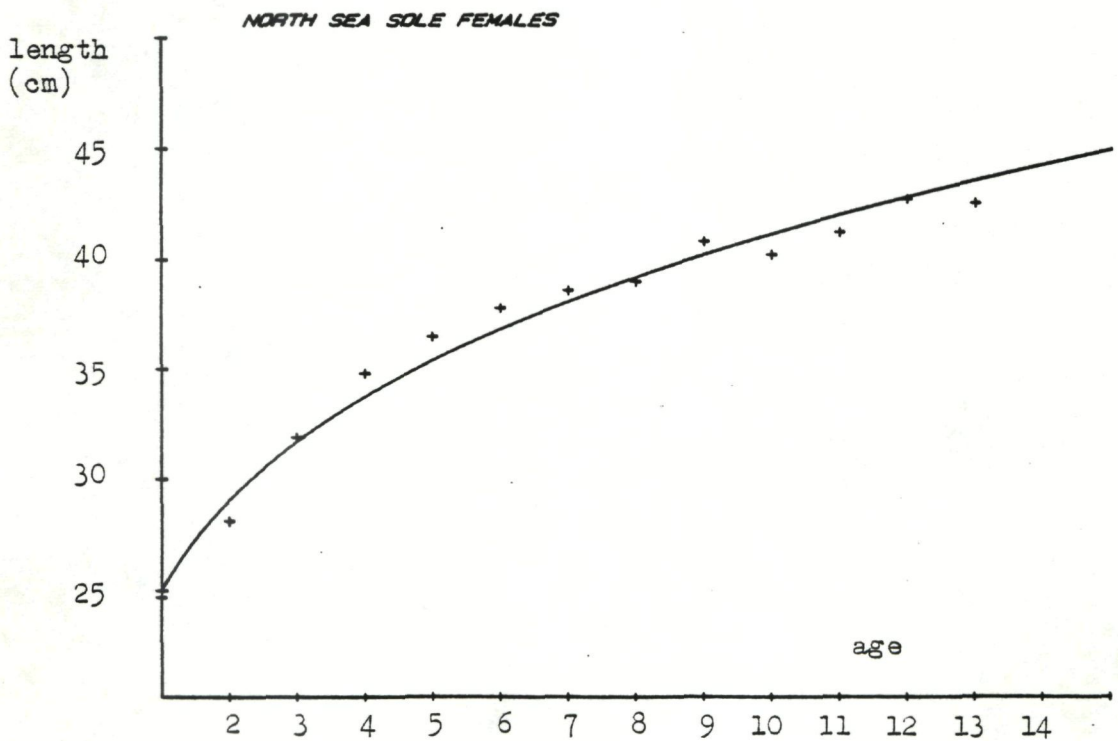


Figure 11 : length increase at age for North Sea female soles.

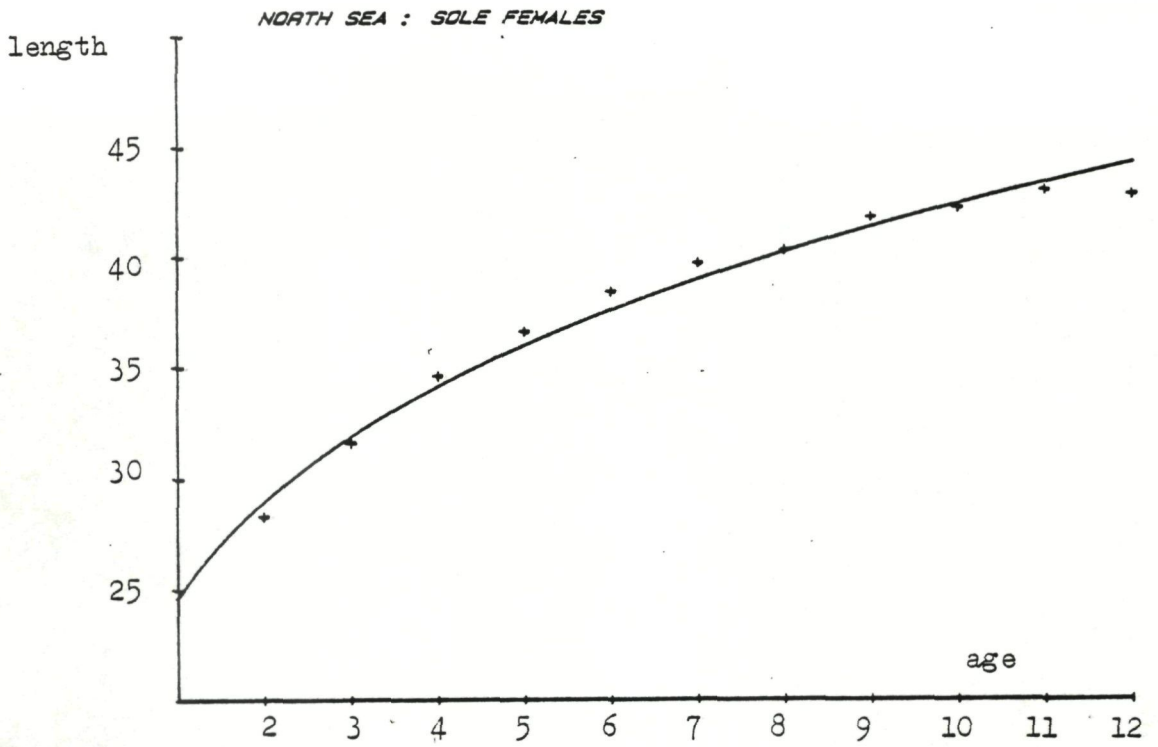


Figure 12 : length increase at age for central North Sea female soles.

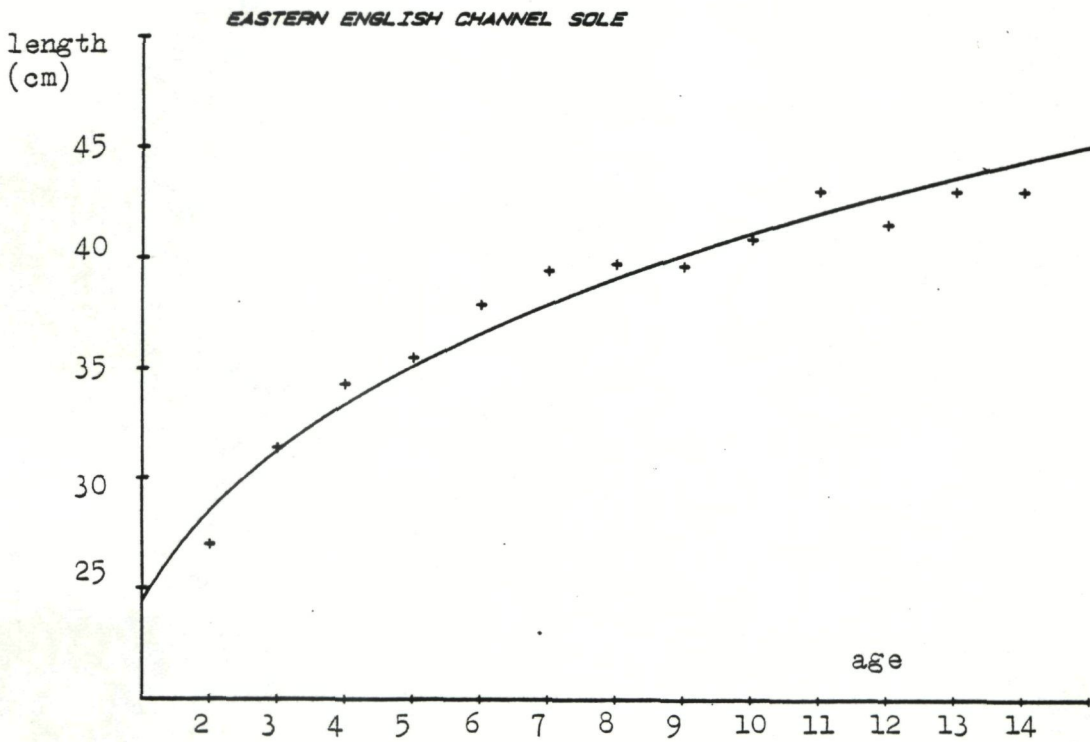


Figure 13 : length increase at age for eastern English Channel female soles.

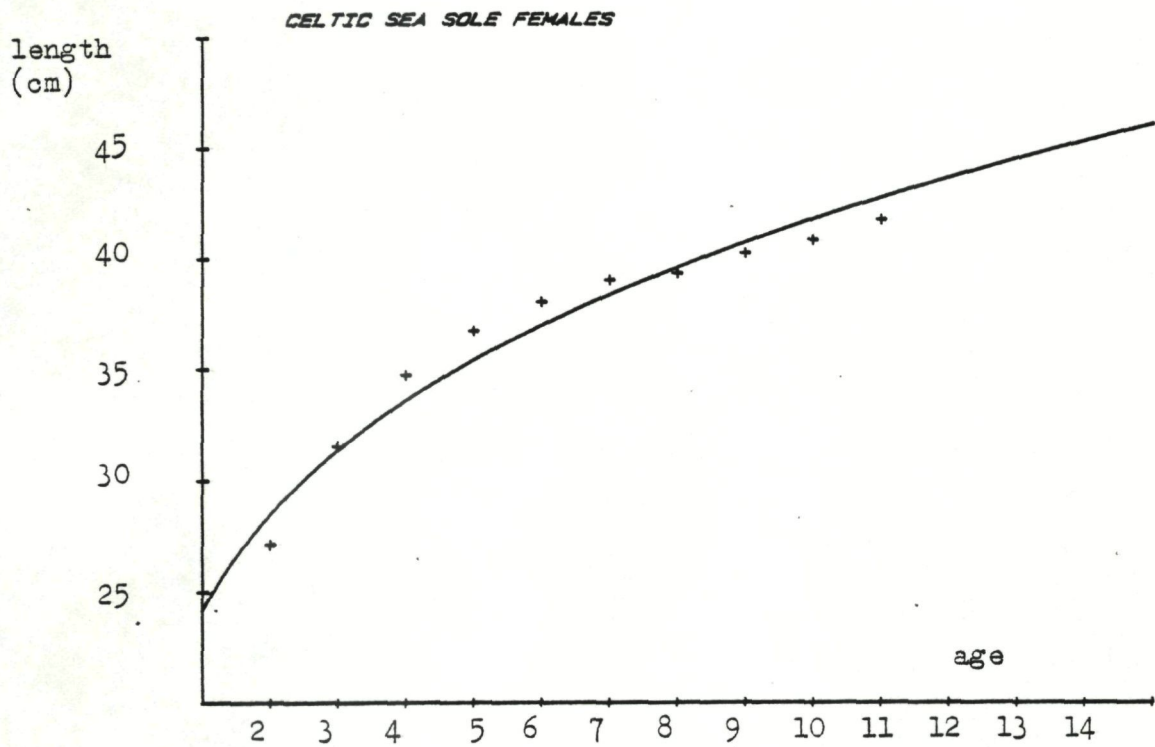


Figure 14: length increase at age for Celtic Sea female soles.

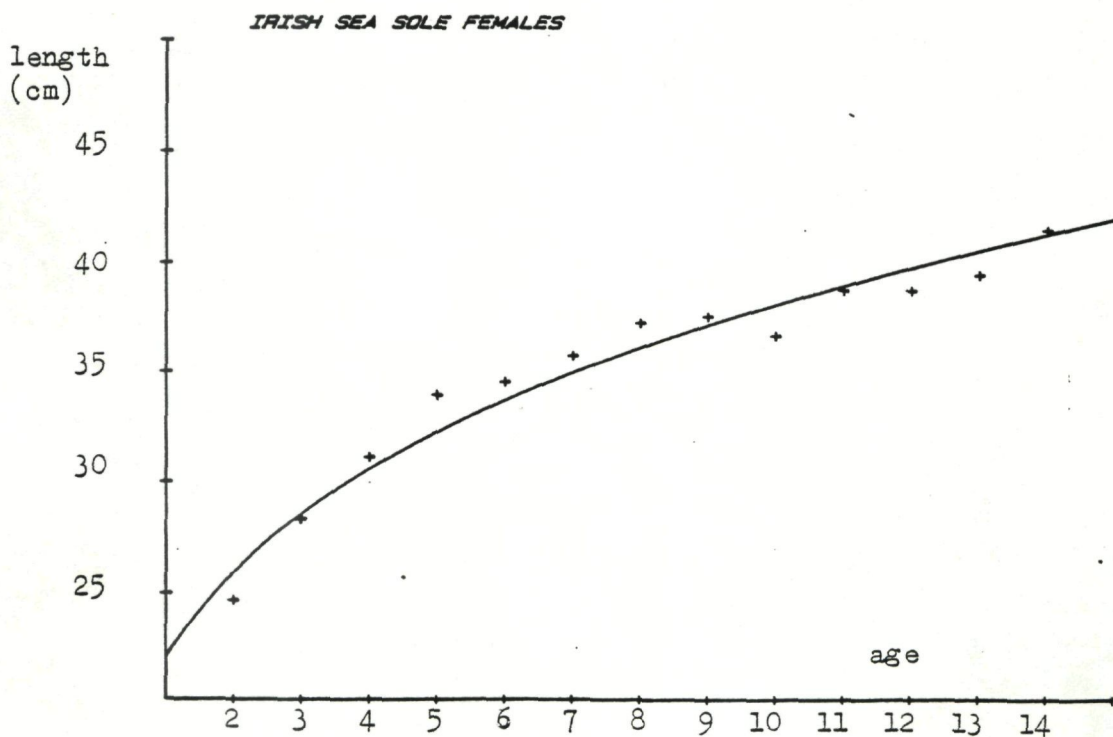


Figure 15: length increase at age for Irish Sea female soles

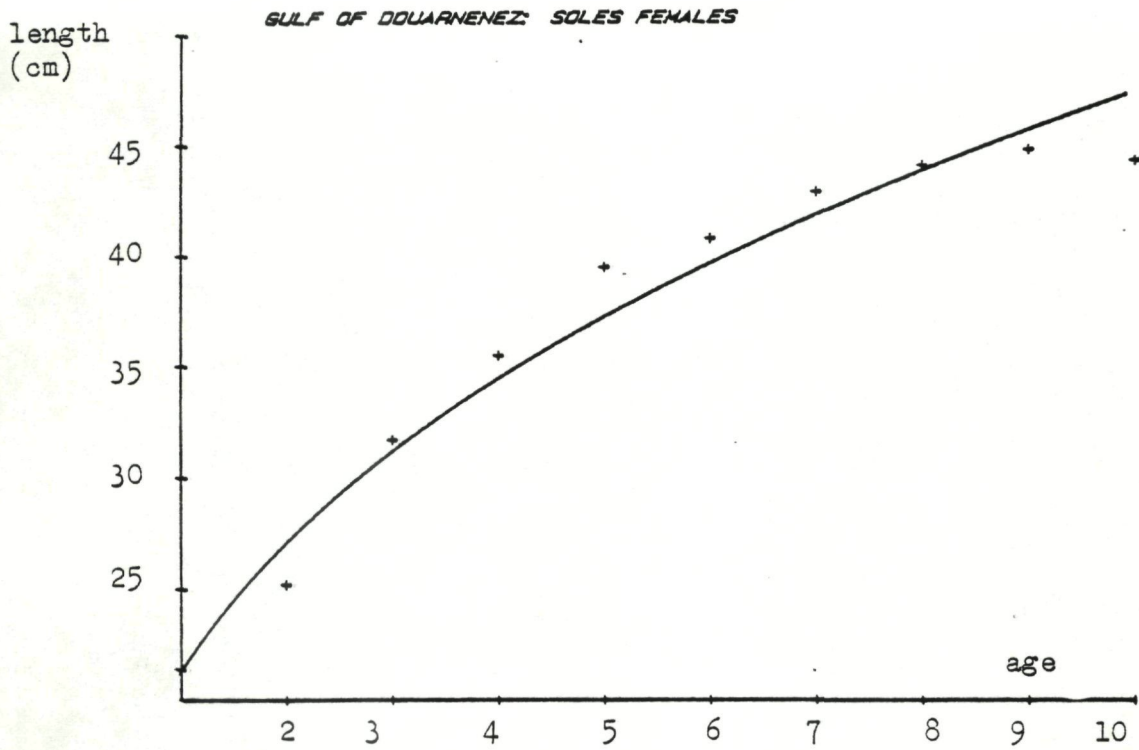


Figure 16 : Length increase at age of Fulf of Douarnenez female soles.

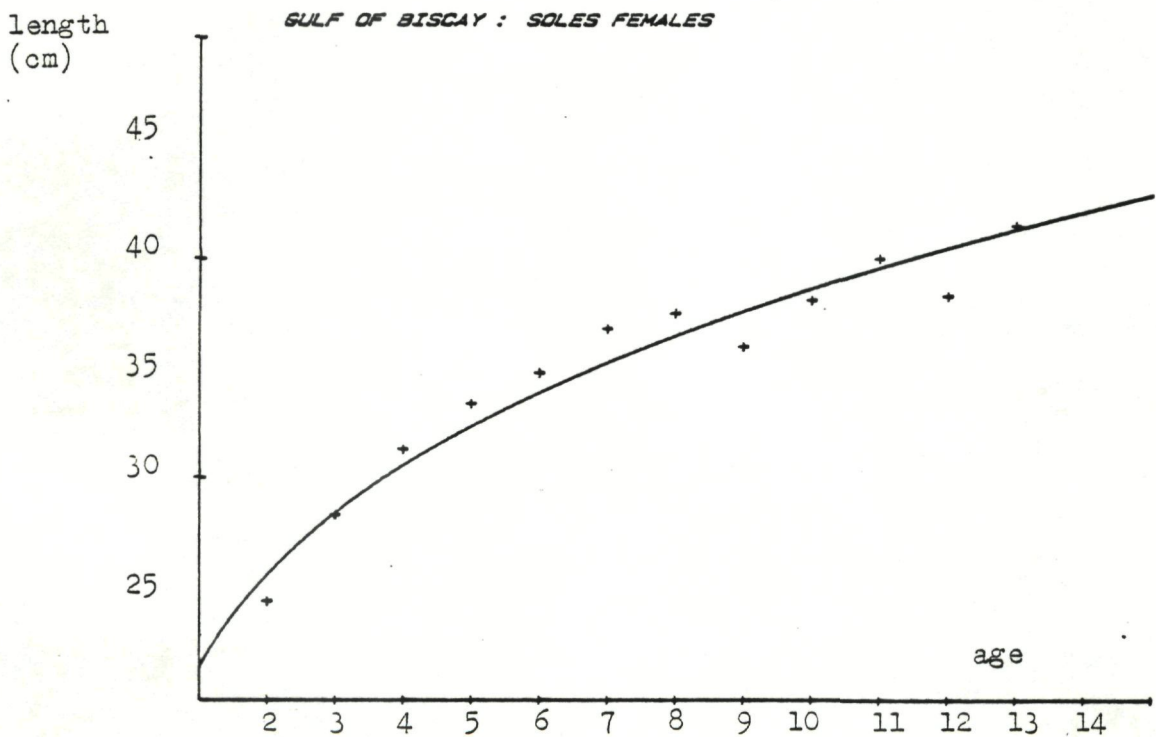


Figure 17 : Length increase at age for Bay of Biscay female soles.

Growth in weight of the adult sole populations.

The weight at age data for some sole populations is given in figures 18 - 25 and in table 3.

On the basis of this preliminary exercise it is clear that North Sea sole and Celtic Sea sole do not differ very much in the weight increase at age. However the Irish Sea data indicate a very slow weight increase for both sexes. This was not so clear in the length data.

Also the results from the studies in the Bay of Biscay demonstrate lower weight at age than the one observed in the North Sea. Differences in the food supply could be the main reason for this discrepancies.

Table 3 : Weight at age for several NW-Atlantic sole stocks.

(xx): Guillou (1973)

N.D. : No data

MALES

Age	North Sea South	North Sea Central	English Channel	Celtic Sea	Irish Sea	Bay Douarnenez	Bay of Biscay
1	121.8			97.0	N.D.		N.D.
2	161.5			147.1	124.5		102.0
3	220.2			189.4	151.0		139.0
4	245.1			229.0	174.4		174.0
5	272.7			252.9	200.5		188.0
6	279.6			294.1	215.9		211.0
7	293.5			334.1	254.8		240.0
8	303.9			316.1	246.3		283.0
9	327.6			337.9	270.4		302.0
10	322.0			382.5	262.2		394.0
11	309.3			394.0	292.9		361.0
12	340.2			430.2	256.6		336.0
13	401.6			406.7	303.0		
14	380.0			404.0	293.3		(xx)

FEMALES

Age	North Sea South	North Sea Central	English Channel	Celtic Sea	Irish Sea	Bay Douarnenez	Bay of Biscay
1	124.5			N.D.	N.D.		N.D.
2	209.4			163.6	129.9		108.0
3	325.8			255.7	202.8		173.0
4	415.0			364.2	277.1		237.0
5	443.8			414.4	343.8		291.0
6	508.2			427.3	361.6		328.0
7	543.0			517.9	449.0		392.0
8	609.0			529.9	472.2		406.0
9	638.6			606.6	501.2		367.0
10	583.3			678.4	514.7		438.0
11	655.9			629.8	561.9		511.0
12	692.7			684.2	623.1		443.0
13	679.0			720.3	569.3		573.0
14				693.3	599.2		(xx)
				720.0			

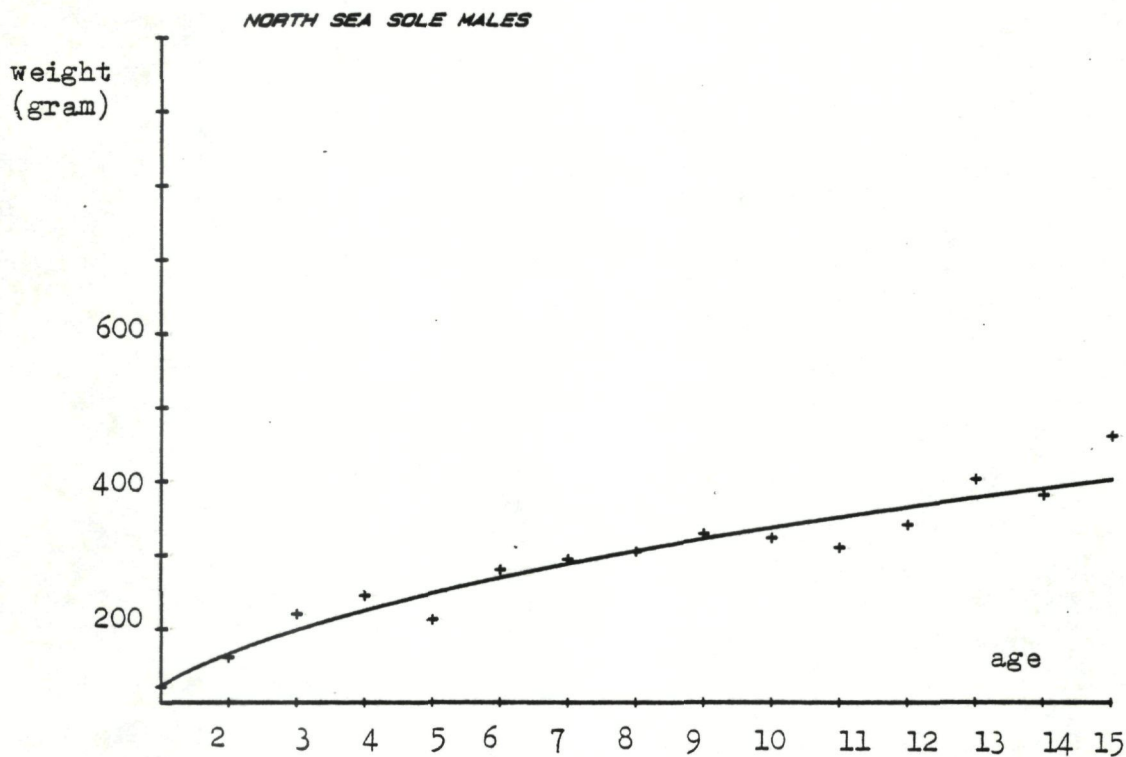


figure 18 : weight increase at age for North Sea male soles.

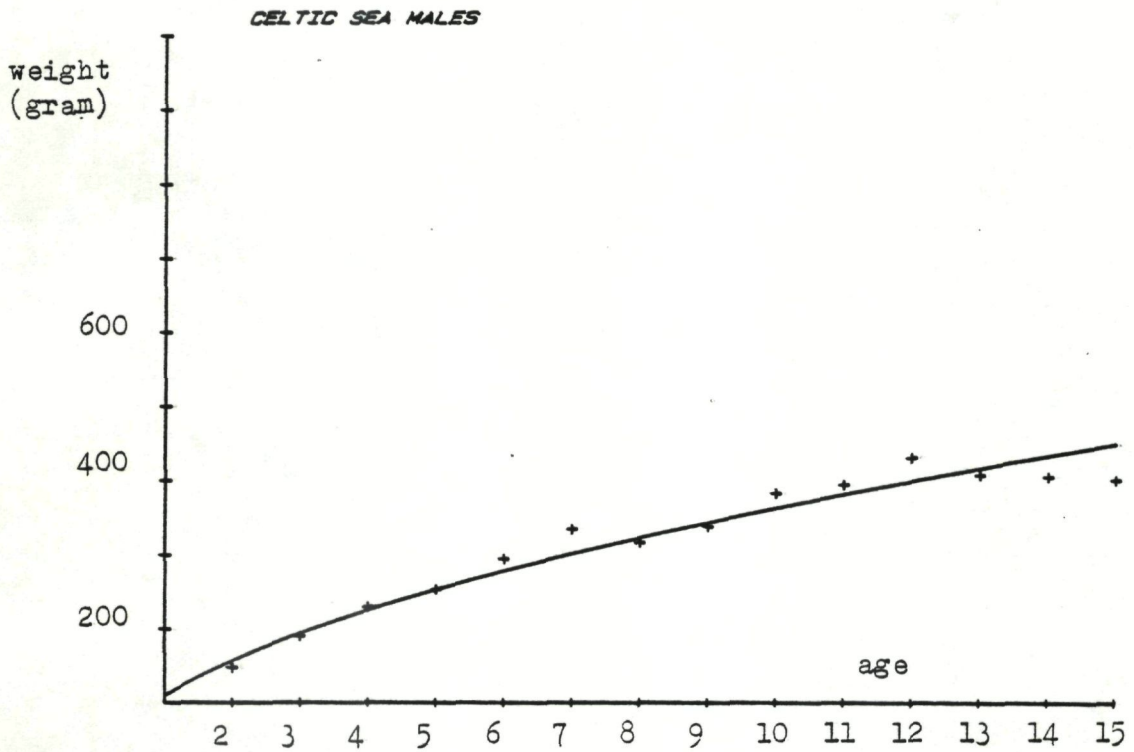


Figure 20 : weight increase at age for Celtic Sea male soles.

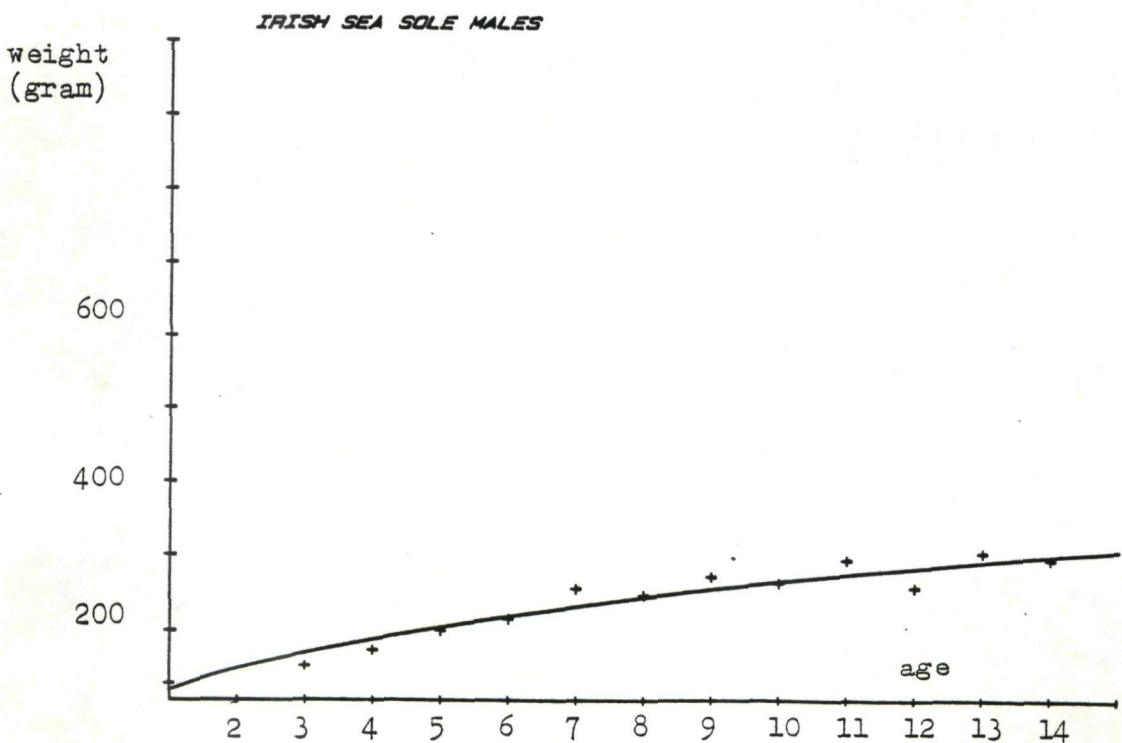


Figure 21 : weight increase at age for Irish Sea male soles.

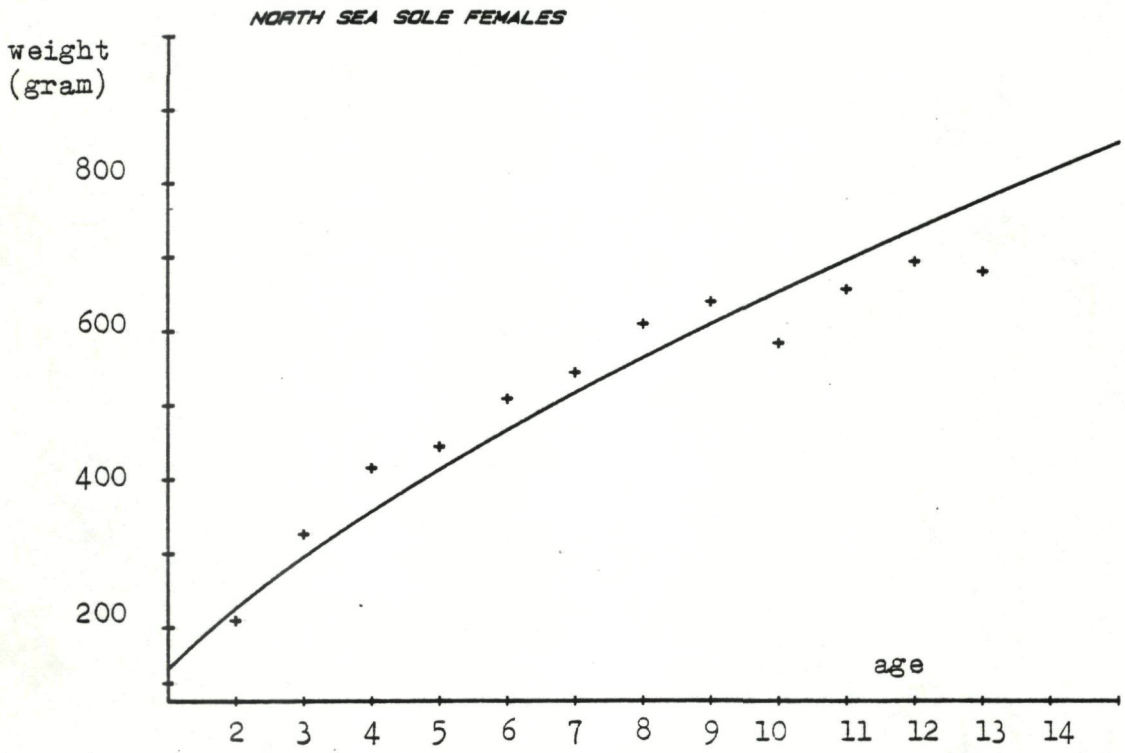


Figure 22 : weight increase at age for North Sea female soles.

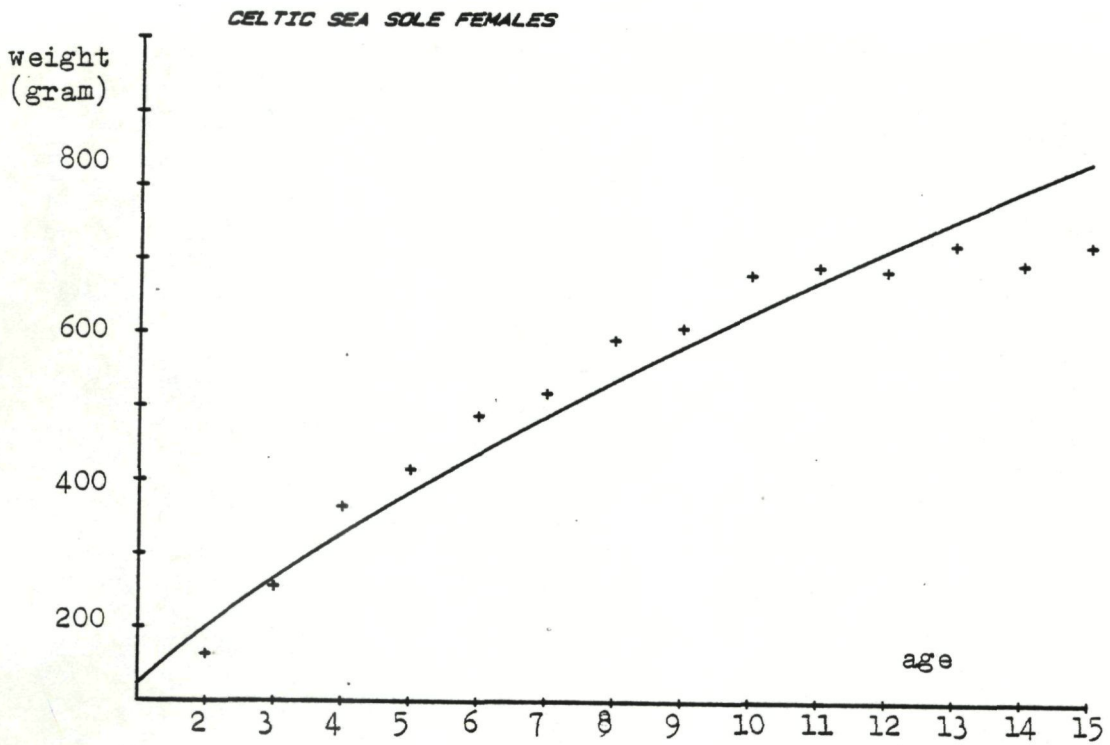


Figure 24 : weight increase at age for Celtic Sea female soles.

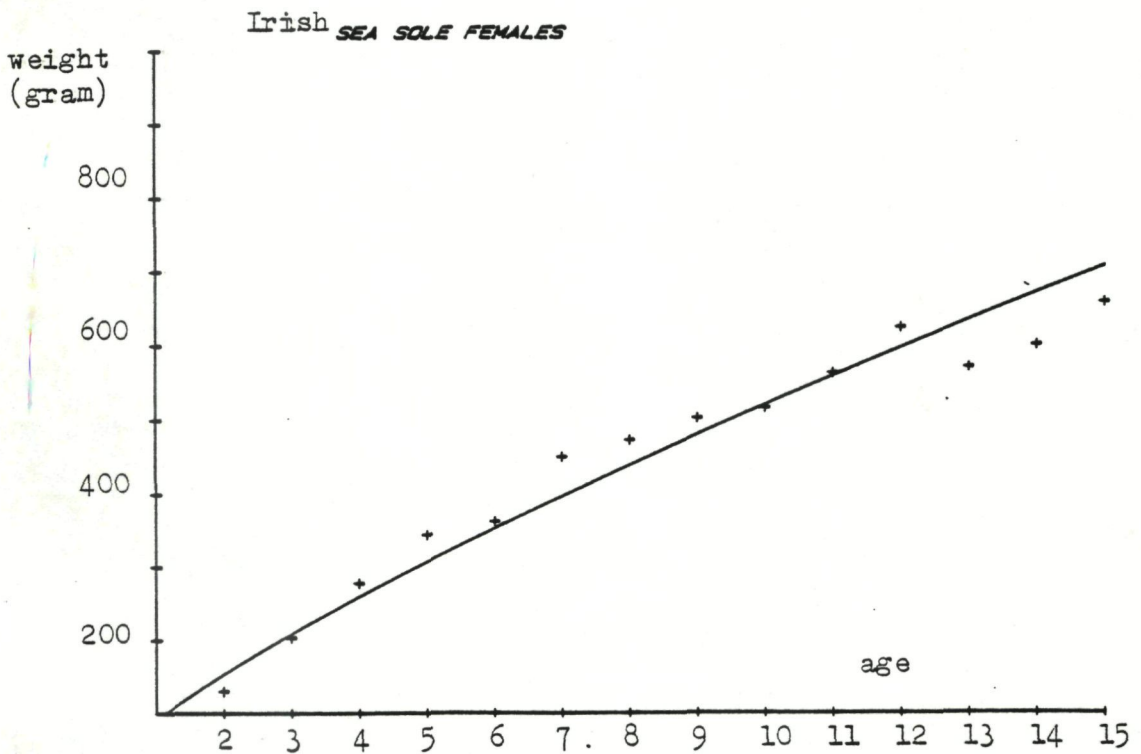


Figure 25 : weight increase at age for Irish Sea female soles.

2. Review of growth data per sex in the Adriatic Sea and in other Mediterranean areas.

The following information is available for the Mediterranean.

First of all length increase seems to be a continuous process during at least the first year of life. Born in winter, between November and March, a total length of between 18 - 20 cm is already reached after a period of 12 months. When comparing with the North Sea situation, this value could also be obtained in that area in the absence of a growth stagnation period. The result of a 12 month feeding period is indeed also close to 20 cm length in the North Sea. The cold winter temperatures in the North Sea must be responsible for the growth stagnation during that period of the year.

In the Adriatic Sea the following growth parameters were calculated :

$$L_{\infty} : 40.1 \text{ cm} \quad K : 0.679$$

This value is for sexes combined and is not very different with the NE-Atlantic stock

Females also show a more rapid growth than the males.

The relation length/ weight is as follows:

$$M + F \quad W = 0.693 \cdot 10^{-2} L^{3.084}$$

$$F \quad W = 0.571 \cdot 10^{-2} L^{3.143}$$

$$M \quad W = 0.864 \cdot 10^{-2} L^{3.013}$$

Other observations in the Mediterranean are summarized below :

Gulf of Lions -(Mendez de Elguezebal)

	L	K
Males	53.8	0.160
Females	47.2	0.274

$$\text{males : } L_t = 53.83 (1 - e^{-0.16(t + 2.472)})$$

$$\text{females } L_t = 47.23 (1 - e^{-0.27(t + 1.545)})$$

$$\text{males : } W = 0.182 \cdot 10^{-2} L^{3,464}$$

$$\text{females : } W = 0.136 \cdot 10^{-2} L^{3,541}$$

The individual length at age is as follows:

age	males	females
1	25.07	23.70
2	30.05	24.35
3	34.32	33.64
4	37.94	36.84
5	41.04	39.87

These observations show a different growth pattern compared with all other observations as well in the Northeast Atlantic as in the Adriatic Sea.

3. Review of biological parameters and age composition in the North Sea, English Channel, Celtic Sea and Irish Sea

Catches per age group were compiled for the period 1970-1980 (Anon. 1981). Information was collected from the areas North Sea, English Channel, Celtic Sea and Irish Sea.

The distribution pattern of the age groups in the catch is rather different from one area to another (Figure 26). This is logic as the exploitation pattern in each fishing zone is depending of the existing fleets.

The North Sea and English Channel catches show a rather similar picture. The bulk of the catch is composed by the age groups II-, III- and IV . These three age groups contribute for more than 70 % of the total annual landings in these areas.

The Celtic Sea sole catch composition is showing a gradual decrease from the age groups III onwards. The catch seems to be rather distributed over several age groups.

In the Iris Sea the total composition is mainly determined by the age groups IV- to VI. Due to the slow growth pattern ages II and III are not yet fully recruited to the stock.

In all stocks it is obvious that an important part of the catch (about 10% on average) is composed by the age group older than 10 years. This means that due to the behaviour of the soles and also the degree of catchability a buffer stock remain at sea for a long period. Soles older than 30 years old are not seldom in the catches.

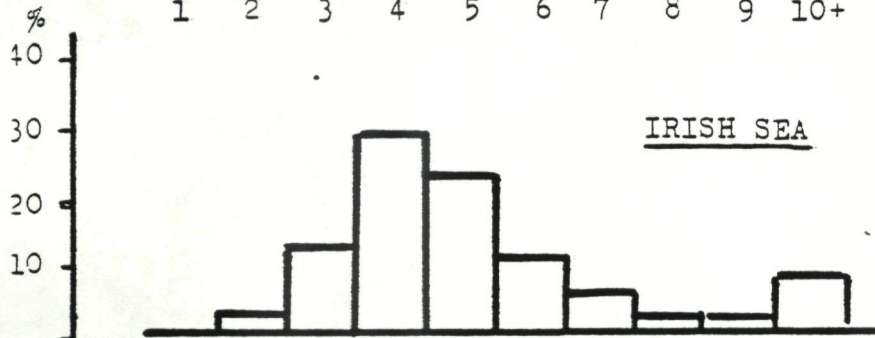
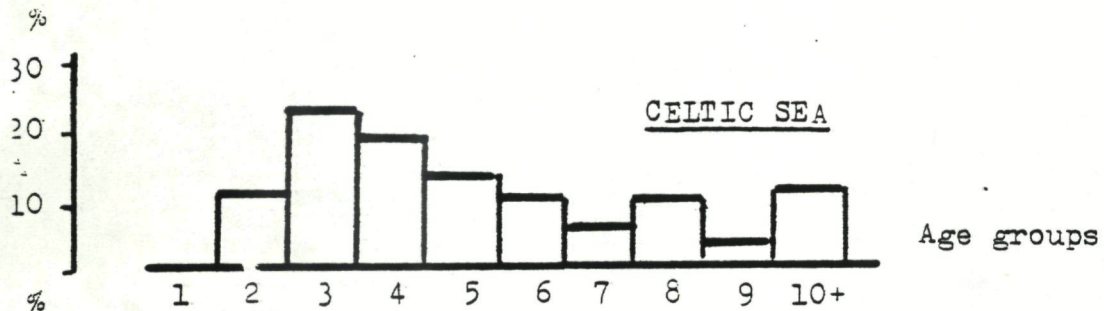
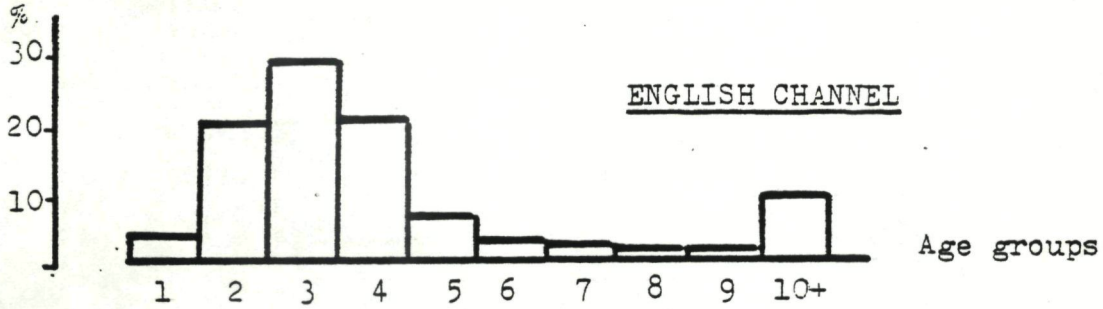
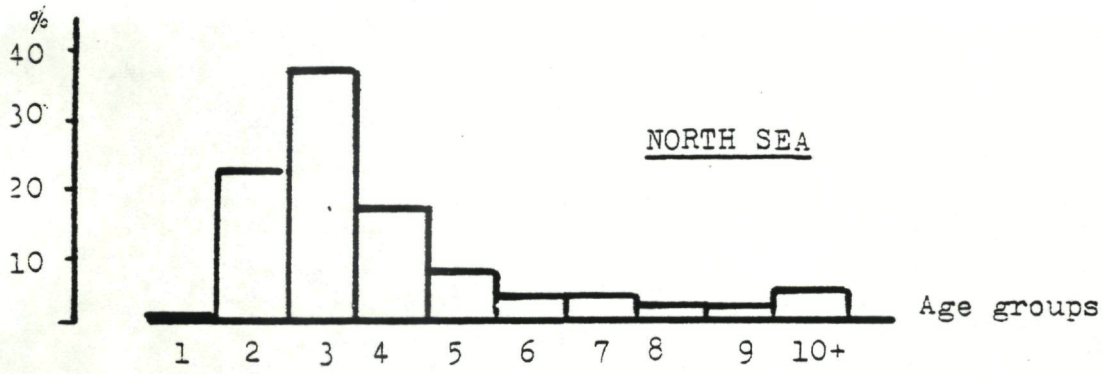


Figure 26 : Age distribution of the total international catch by area.

4. Review of biological parameters and age composition in the Adriatic Sea

As catch statistics and regular catch sampling programmes are liable to be improved only scarce information on this subject is available.

In the Adriatic Sea (Figure 27) a clear distinction can be shown in the distribution of the juvenile and the adult stock. The juvenile stock with lengths of 12- 15 cm occur along the coastal line at a few miles distance of the coast. From the age I onwards the majority of the stock is in the regions with a depth between 25 and 100 meters.

In the absence of an age composition of the catches in that area, the length distribution of the experimental catches (figure 28) is revealing the fact that the catches are mainly composed by the age groups 0 and I. The fishery therefore is mainly a recruitment fishery. The high season of catches is concentrated in October and November when the new year-class (as 0-group) is reaching a length of about 15 cm.

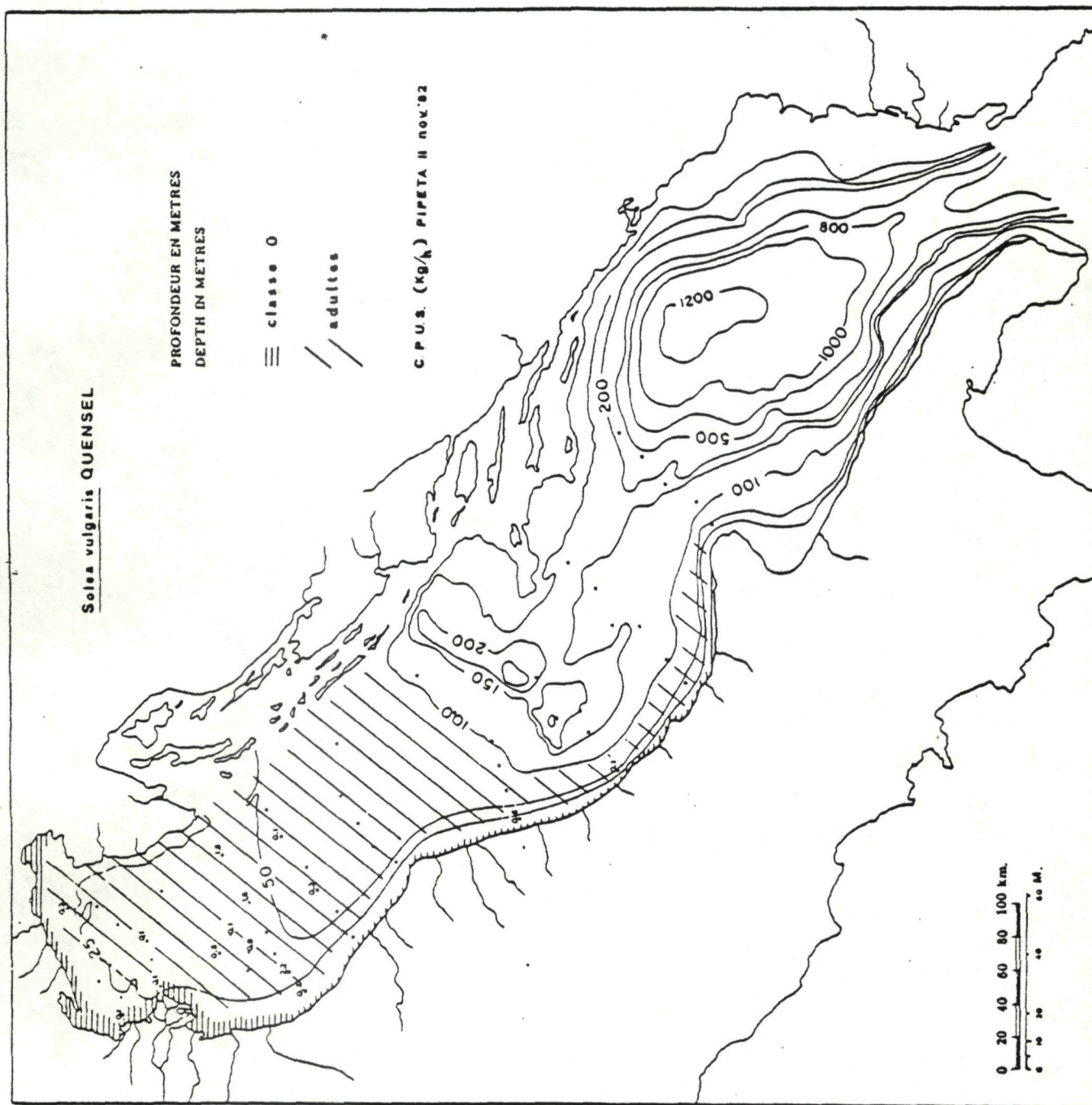


FIG. 1

Figure 27 : distribution pattern of soles in the Adriatic Sea

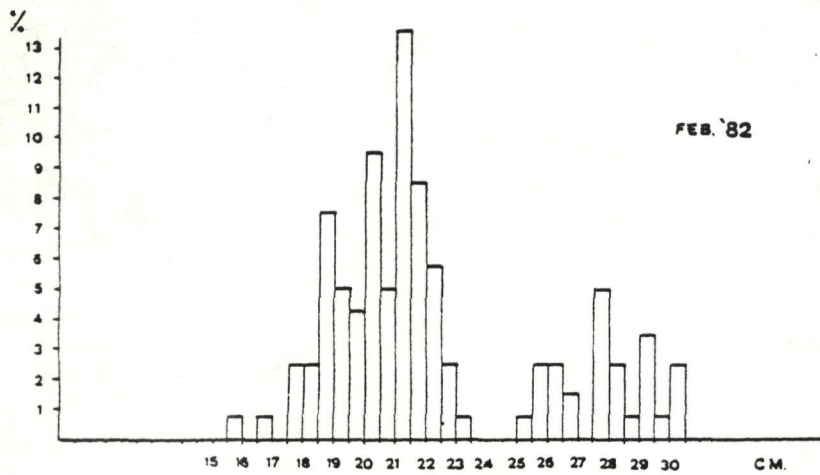
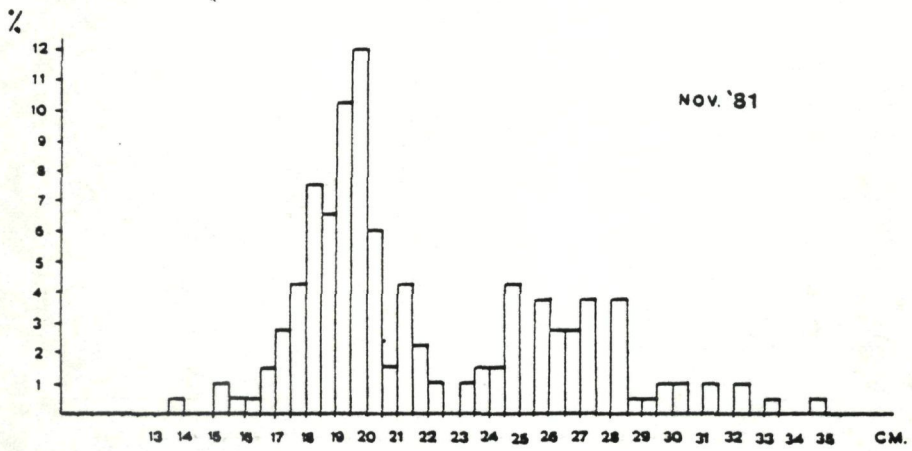


Figure 28 : Length frequency distribution of soles in the Adriatic Sea.

