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**THE DEVELOPMENT OF A NEW GILLNET FISHERY FOR ANGLERFISH  
(*LOPHIUS PISCATORIUS*) IN NORWEGIAN WATERS;  
BIOLOGICAL PARAMETERS, SELECTIVITY IN SIZE AND SEX RATIOS FOR GILLNETS  
WITH 300 AND 360 MM MESH SIZES.**

by

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**ABSTRACT**

In autumn 1992 a direct gillnet fishery for anglerfish (*Lophius piscatorius*) started on the continental shelf off the northwestern coast of Norway. The anglerfish had previously only been taken as bycatch in trawls and gillnets. The annual catches increased from 880 tons in 1991 to 4,447 tons in 1993, and then decreased to 2,621 tons in 1994.

Studies on the fishery started in november 1992. Monthly sampling was conducted from commercial catches in 1993 and 1994, for length and weight analysis. Age was determined by otolith- and first dorsal fin ray readings. Estimates of catch per unit effort were based on information from 5 commercial vessels. In 1994, the sex ratios and gonad development were analysed.

In 1993 the average size of the anglerfish was 12.1 kg (n=706) decreasing to 11.2 kg (n=615) in 1994, all catches from gillnets of 360 mm stretched mesh size. In 1994 the average size of the fish from 300 mm mesh size was 7.8 kg (n=433). The difference in average length and weight between the two mesh sizes, corresponds to approximately 1 year of growth. Adult females are larger than males. 360 mm gillnets caught more females than the 300 mm gillnets, respectively 81 % and 62 %.

In 1992, CPUE was 1-2 kg with maximum 3-4 kg per day per net. The catch rates started decreasing during summer 1993 and was estimated to 0.3 kg per net per day in autumn 1994.

## INTRODUCTION

In autumn 1992 a direct gillnet fishery for anglerfish (*Lophius piscatorius*) started on the continental shelf off the northwestern coast of Norway. Previously the anglerfish had only been taken as bycatch in trawls and gillnets. The annual catches increased from 880 tons in 1991 to 4,447 tons in 1993 and then decreased to 2,621 tons in 1994 (**figur 1**). At the same time the fishery has expanded geographically. In 1993, 66% of the total catch was taken outside Møre & Romsdal (**figur 2**), while in 1994 only 38% was taken in this area.

Most of the gillnet fishery for anglerfish inside 12 n.mile is carried out by boats smaller than 17 meters. Until 1994 the fishery was also carried out by a few bigger boats 20-30 m in size. The smaller boats (<17 m) have 100-500 gillnets per boat and the crew varies from 1-4 persons. The bigger boats have 700-1500 gillnets per boat. The gillnets used, are specially made for this fishery. When the gillnet fishery started in 1992, 360 mm stretched mesh size was mostly used, but some boats had 300 mm and some a mix of 300 and 360 mm. As the catch rates and the size of the anglerfish decreased, more of the boats started to use the smaller mesh size. This was stopped from the the 1.st of January 1995 because a new regulation forbid smaller mesh size than 360 mm in the direct fishery for anglerfish in Norwegian waters.

The fishermen early experienced that daily handling of the gillnets gave less catch per unit of effort than a longer soak time. The gillnets were therefore occasionally handled only once a week which resulted in a poorer quality of the fish. To avoid this, a new regulation in June 1994, restricted the soaktime to two days.

Investigations on the Norwegian angler fishery started in November 1992 as a cooperation between The Institute of Marine Research, Bergen and Møre Research Foundation, Ålesund. The results will be used in the stock assesments / regulations for anglerfish in Norwegian waters.

## MATERIALS AND METHODS

### Biological parameters

In Møre & Romsdal monthly sampling from catches with 360mm gillnets were conducted in 1992 (November), in 1993 (January-November) and in 1994 (January-August). In addition, samples from 300 mm gillnets were obtained in 1994 (June-October) (**table 1**). The catches were obtained from the grounds off Møre og Romsdal for both mesh sizes (n=1823) (**figur 2**). Catch data information was given from the skippers of the boats. Recording of the biological parameters were mainly carried out when the fish was landed. Only two of the samples were recorded at sea, one sample from 180 mm in February 1993 and one from 150 mm in July 1994.

South of Møre and Romsdal, 102 anglerfishes were sampled in 1993 and 1994, most of them caught by trawl. In the following, these fishes have only been used for age determination.

In 1993 total length (TL) and gutted weight were recorded. Otoliths were taken for age determination. In 1994 most of the sampling were carried out on round fish and additional parameters were recorded: Round weight, sex, gonad weight and gonad development. The first dorsal fin ray (illicium) was collected together with the otoliths for further study. Gonadosomatic index (GSI) were estimated for the females (n=537) and for the males (n=191). Gonad development was determined using a modification of the maturity stages described for *L. americanus* (Armstrong *et al.*, 1992).

**Table 1.** Number of anglerfish length records from the anglerfish investigation in Møre & Romsdal Norway, in 1992, 1993 and 1994. The records are separated for different sampling months and gillnet mesh sizes.

Year	Mesh size (mm)	Jan	Feb	Ma	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Sum
1992	360											69		69
1993	360	109	132		68		110	119	104			64		706
1994	360	66	217	73		95	79	34	51					615
1994	300						65	283			85			433
<b>Total length records in Møre &amp; Romsdal</b>														<b>1823</b>

### Age determination

A variety of different ossified structures, including otoliths, first dorsal fin ray (illicium) and vertebrae, were examined for annual growth patterns. 1090 otoliths and 572 illiciums were examined. The number of vertebrae in the material was low (n=73) due to difficult sampling. Otoliths were cut in two through the nucleus, burnt over alcohol flame, coated with olive oil, and read in reflected light. Crossections of illiciums (0.2-0.4 mm thick), moulded in epoxy, were read in transmitted light. Vertebrae were read whole in reflected light. The age readings from the different structures were compared using Wilcoxon's matched pairs signed rank test (WMPSRT) (Siegel, 1956).

### Catch per unit of effort

Estimates of catch per unit of effort (CPUE) were based on informations from logbooks from 5 commercial vessels in Møre & Romsdal. The logbooks gave informations about fishing depth, number of gillnets, mesh size, soaking time in days, total weight and the number of landed anglerfishes. Three of the logbooks gave information about bycatches of other species. Two of the logbooks gave informations from October 1992-October 1994 and three of them gave information from October 1992-summer 1993. CPUE was estimated as kg (round weight) per gillnet per day.

## RESULTS

### Weight-total length in 1993 and 1994

The weight and total length in 1993 were compared with the same parameters in 1994 in catches from gillnets with 360 mm mesh. In 1993 the mean weight was 12.1 kg and the mean length 95.4 cm (n=706). In 1994 the mean weight decreased to 11.2 kg and the mean length to 91.8 cm (n=615). The difference was mostly due to a bigger amount of fishes larger than 100 cm in the catches from 1993 (**figur 3**).

### Catch per unit of effort

In October 1992 information from the logbooks showed that CPUE varied from 1.2 kg to 3.3 kg per net per day. In summer 1993 the catch rates decreased and in autumn it was very poor. At this time many boats, and three of the boats writing logbooks, stopped the direct gillnet fishery for anglerfish.

In winter 1994 just a few boats were fishing anglerfish because the traditionally cod fishing gave a better economical result at this time. In summer and autumn 1994, CPUE was estimated to 0.3 kg per net per day for the remaining two boats writing logbooks (figure 4).

### Mesh size selectivity

In 1994 more of the fishing boats started to use gillnets with 300 mm mesh size. Records of the catches this year, showed that the mean size of the anglerfish caught by 300 mm gillnets, was 7,8 kg and 82.7 cm (n=433) and for catches by 360 mm gillnets, 11,2 kg and 91.8 cm (n=615) (table 2, figure 5). The reduction of 11 cm in mean total length by using 300 mm mesh size, corresponds approximately to 1 year according to the age determination.

Records of females and males in 1994, showed that females dominated the catches from 360 mm gillnets, varying between 77-88% of the total number. The females were bigger than the males and the mean length was 94,1 cm, varying between 63-132 cm. For the males, mean length was 81,3 cm, varying between 50-98 cm. For gillnets with 300 mm mesh size, the mean length of females was reduced to 84,4 cm and for males to 76,3 cm. Reducing the mesh size also resulted in a doubling of males in the catches, from 19% by 360 mm to 38% by 300 mm.

Table 2. Records of anglerfish sampled in 1994 from catches with gillnets of 360 mm and 300 mm mesh size.

Mesh size	Fishes No.	Total length cm	STDEV	Weight kg	STDEV	%
Total length records						
- 360 mm	615	91.8	13.6	11.2	5.8	
- 300 mm	433	82.7	13.3	7.8	4.5	
Females						
- 360 mm	485	94.1	13.7	12.2	6.0	81
- 300 mm	171	84.4	14.4	8.9	4.9	62
Males						
- 360 mm	108	81.3	7.4	7.1	1.8	19
- 300 mm	103	76.3	8.8	5.9	1.8	38

### Age, growth and gonad development

From otolith readings the anglerfish was aged determined from 2 to 14 years old. From illicium readings the corresponding ages were from 2 to 13 years. Vertebraes were mainly from younger individuals, ranging from 1 to 12 years old. Otoliths tended to give one year older age than illiciums and vertebraes (WMPSRT). The illicium was found to be the structure most suitable for age determination, both due to being the easiest structure to sample and read

and also since multiple readings gave consistent results. In all three structures a markable change in the appearance of the age zones were observed in the third to the fifth age zone, dominated by the fourth age zone for both sexes. This change of appearance was called the "age at maturity", indicating that it may be caused by changes in the growth pattern due to maturation. In otoliths and illicium the zone appears as a strong broad dark band, and in the vertebrae as a broad dark band on a protruded part of the inner surface. The age - length relationships from otolith and illicium readings are given in **figure 6**.

There are obvious clear differences in the growth of females and males as the females become bigger than the males. All fishes in the materials bigger than 98 cm were females. There is also a small difference between the sexes in the length - round weight relationship for fishes longer than 70 cm (**figure 7**).

The estimation of GSI for the females, indicated developing ovaries from January to June. The highest values of GSI were in June when some of the ovaries was 20-30% of the round weight. Only females bigger than 90 cm had GSI values indicating developing ovaries (**figure 8**). Resting and spent ovaries dominated for the females the whole year. For the males, the developing stage dominated throughout the year with some ripe tests in the material from March to October.

## DISCUSSION

The CPUE and most of the biological data of anglerfish in this report come from Møre & Romsdal off the northwestern coast of Norway where most of the fishery has been conducted. The data may, however, due to the limited geographical area not be representative for anglerfish in all parts of Norway.

The decreasing CPUE together with the decreasing mean size of the catches, indicate that the new direct gillnet fishery for anglerfish had exploited an accumulated stock in these first 2-3 years of the fishery. The decrease in mean size from 1993 to 1994 is clearly shown by a decrease in number of fish larger than 95 cm in the catches.

A fishery using 300 mm mesh size will exploit males and females in a more equal ratio than 360 mm gillnets. However, a change to lower mesh size will, without additional regulations, not decrease the effort, but rather increase it, at least towards younger fish. A mesh size of 300 mm will catch more anglerfish down to 50 cm, i.e., more immature fish. Preliminary analyses have also shown that maximum yield per recruit will be 22% less using 300 mm instead of 360 mm gillnets (Staalesen 1995). A possible sudden increase in catch rates when going from 360 mm to 300 mm would therefore be of short duration. Although there are growth differences between the sexes, we believe that it is most correct to maximize towards the faster growing and biggest females, and try to keep the catch at a sustainable level by quotas if necessary. When harvesting the anglerfish resources in Norwegian waters by gillnets we therefore think it is correct to have 360 mm as the lowest legal mesh size. We are aware of that the mostly used mesh size for gillnets fishing anglerfish in the North Sea is 262 mm (10.5''), and at the Faroes 300 mm (some 280 mm).

Age readings of the first dorsal fin ray (illicium) were preferred instead of the otoliths and the vertebrae, mainly due to easier sampling, more consistent age reading method, and more distinct age zones than the other structures. This method has been used earlier in ICES Division VII and VIII (Depouy *et al.* 1986). Crozier (1989) found that the number of age zones varied dependent on where the cross-section was taken on the illicium. This variation was reduced by standardizing the sectioning method. "Age at maturity" has not been described earlier for anglerfish from ossified structures. From studies on the maturity stages of the gonads in relation to age, Fulton (1902) indicates that anglerfish reach maturity when they are 4 to 6 years old. This corresponds to the possible "age at maturity"-marks found in otoliths, illiciums and vertebrae. This should, however, be better verified in future studies.

The round weight-total length relationships are based on catches taken through the whole year. This relationship will probably vary through the year because of the gonad development. Investigations of catches from the Portuguese coast, indicates that the weight-length relationships may also vary between different areas (Vasconcelos *et al.* 1986).

The long period of the year in which developing ovaries were found in the material may indicate that spawning goes on for a long period of time. It may, however, also be that the ovaries need a long time for developing. As most of the recorded ovaries were in a spent or resting spent stage, this may indicate that some individuals of the anglerfish in Norwegian waters only spawn each second year. For *L. americanus* spawning took place primarily in May and June. Males appeared to develop earlier in the season and remained ripe longer (Armstrong 1992). These findings correspond to the Norwegian investigation.

Further research of anglerfish in Norwegian waters should look at the recruitment processes. Although spawning has been observed, we do not know whether the anglerfish in Norwegian waters are self-recruiting or dependent on a flow of larvae and juveniles from other areas. Tagging experiments, both in Norwegian and more southwestern areas, may reveal possible spawning migrations. At present, we'll follow the further development of stock and fishery by collecting at least one age-length sample each quarter of the year and continue to analyse logbooks from 2-3 gillnet vessels.

## AKNOWLEDGEMENT

The fishermen helping with logbook information deserve our thanks for excellent cooperation.

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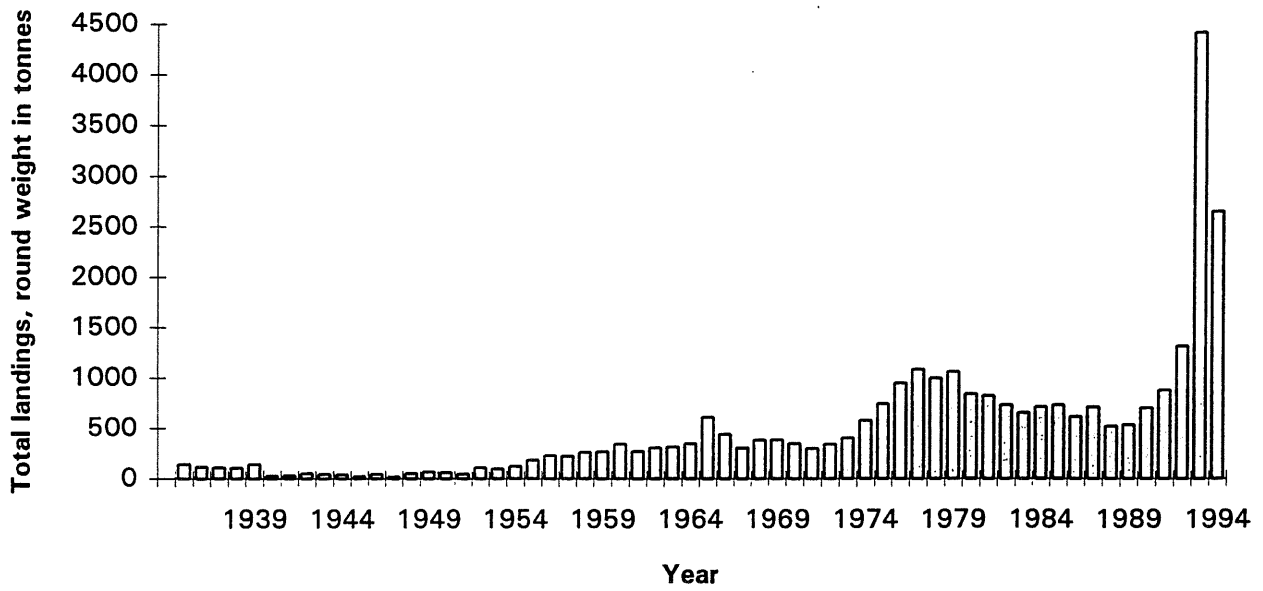


Figure 1. Norwegian catches of anglerfish from 1935-1994.

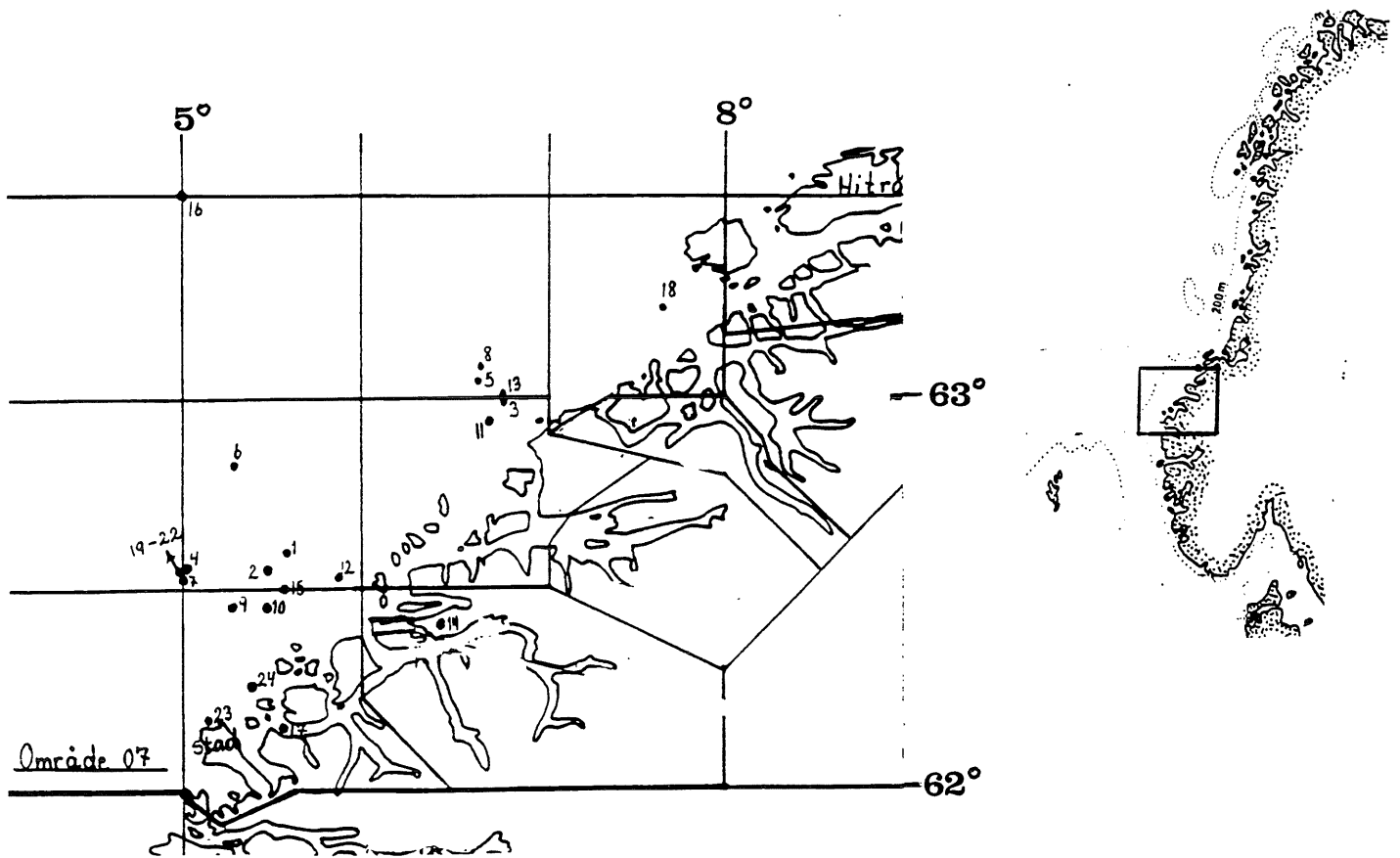
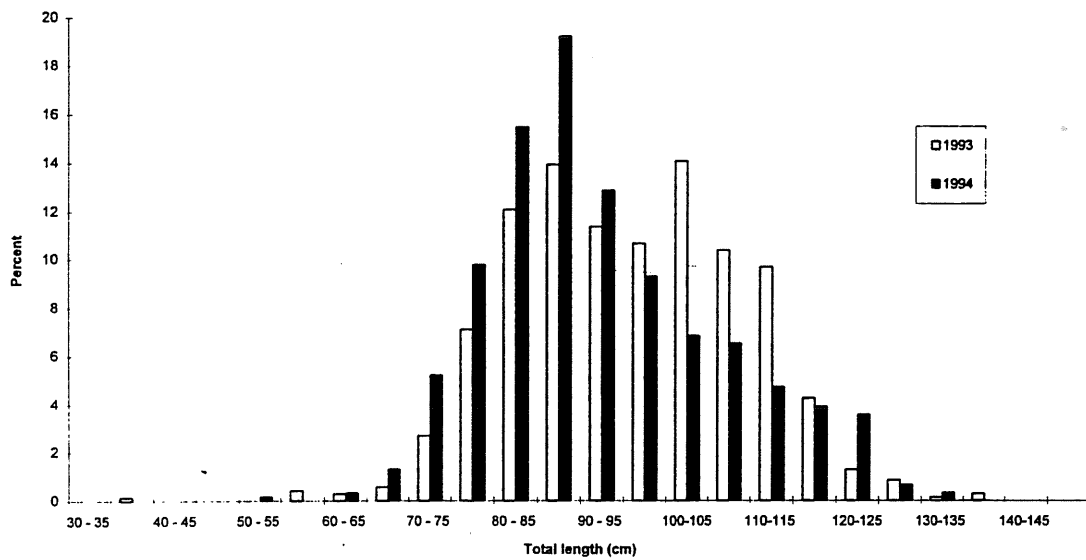
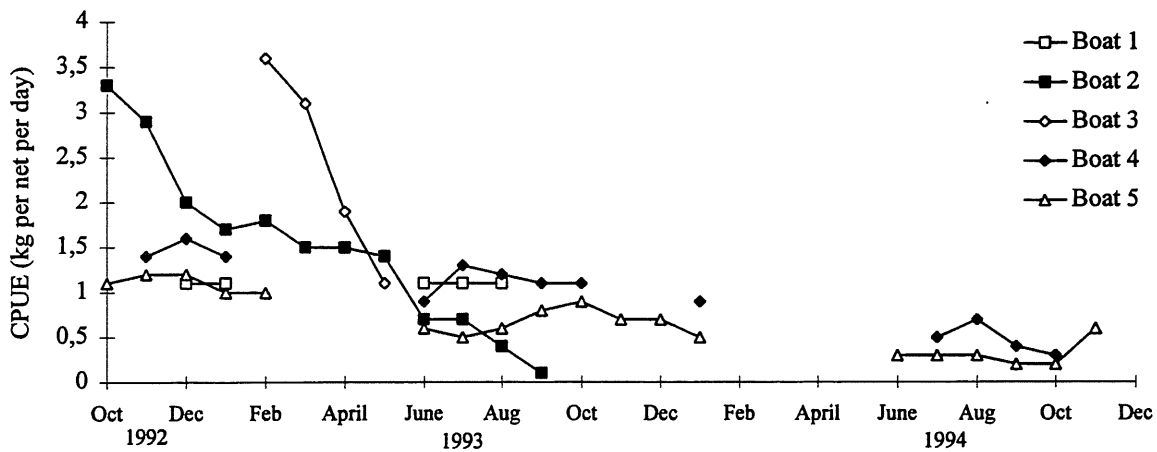


Figure 2. Map showing the main grounds for the gillnet fishery for anglerfish outside Møre & Romsdal.

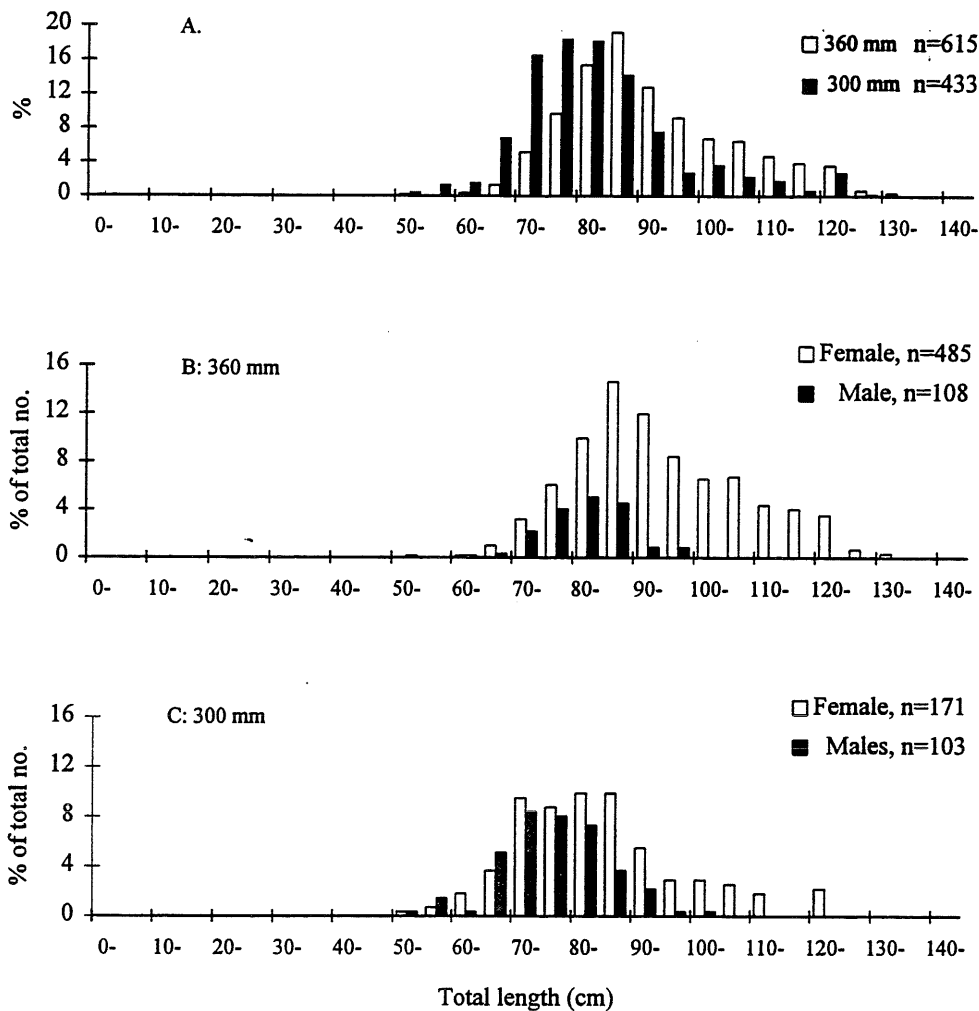




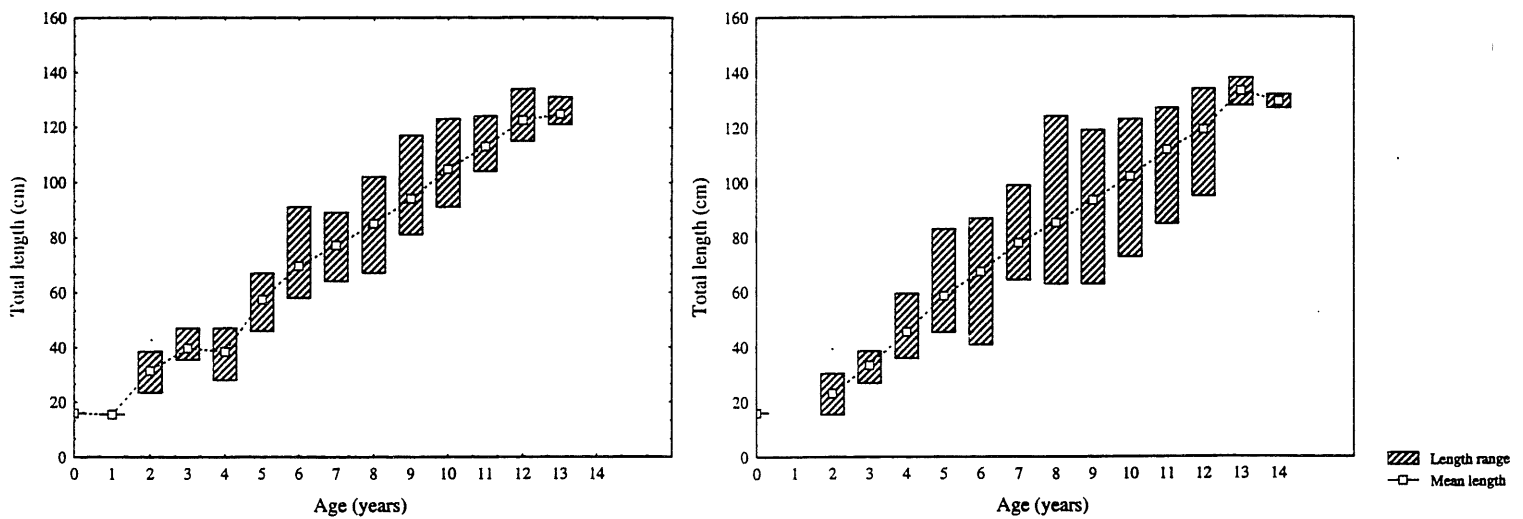
**Figure 3.** Size distribution (%) for anglerfish in 1993 (n=706) and 1994 (n=615). Samples taken from gillnet catches, 360 mm mesh size, in Møre & Romsdal.



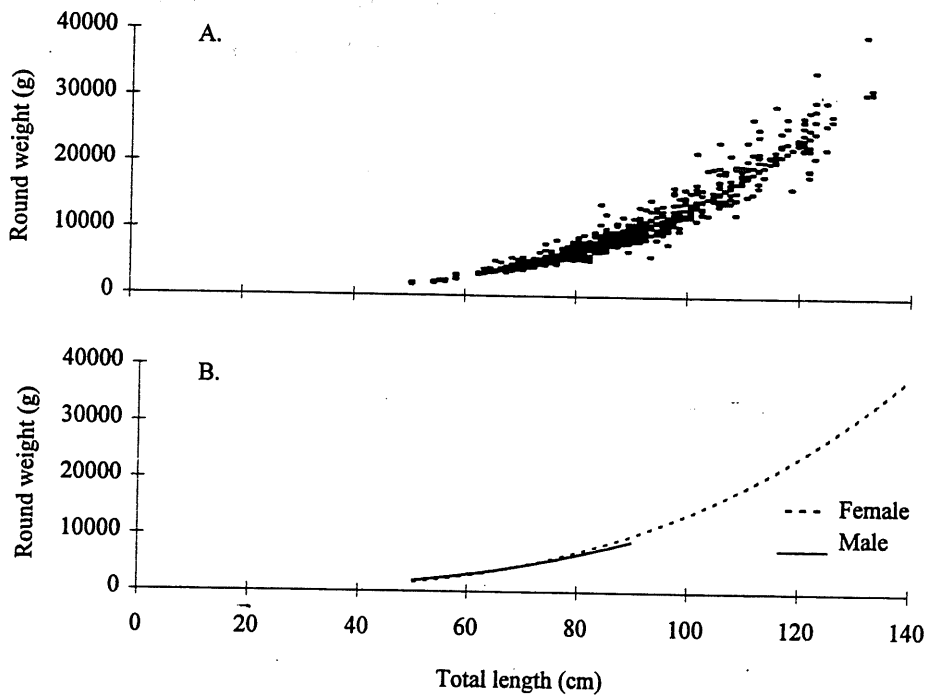
**Figure 4.** Catch per unit effort for five boats in the gillnet fishery for anglerfish in Møre & Romsdal in the period October 1992 - October 1994. Boats 1 > 25m; Boats 2 ca. 20m; Boat 3 ca. 10m; Boat 4 and 5 ca. 16m. Boat 1-4 were fishing with gillnet 360 mm mesh size, boat 5 with 300 mm mesh size.



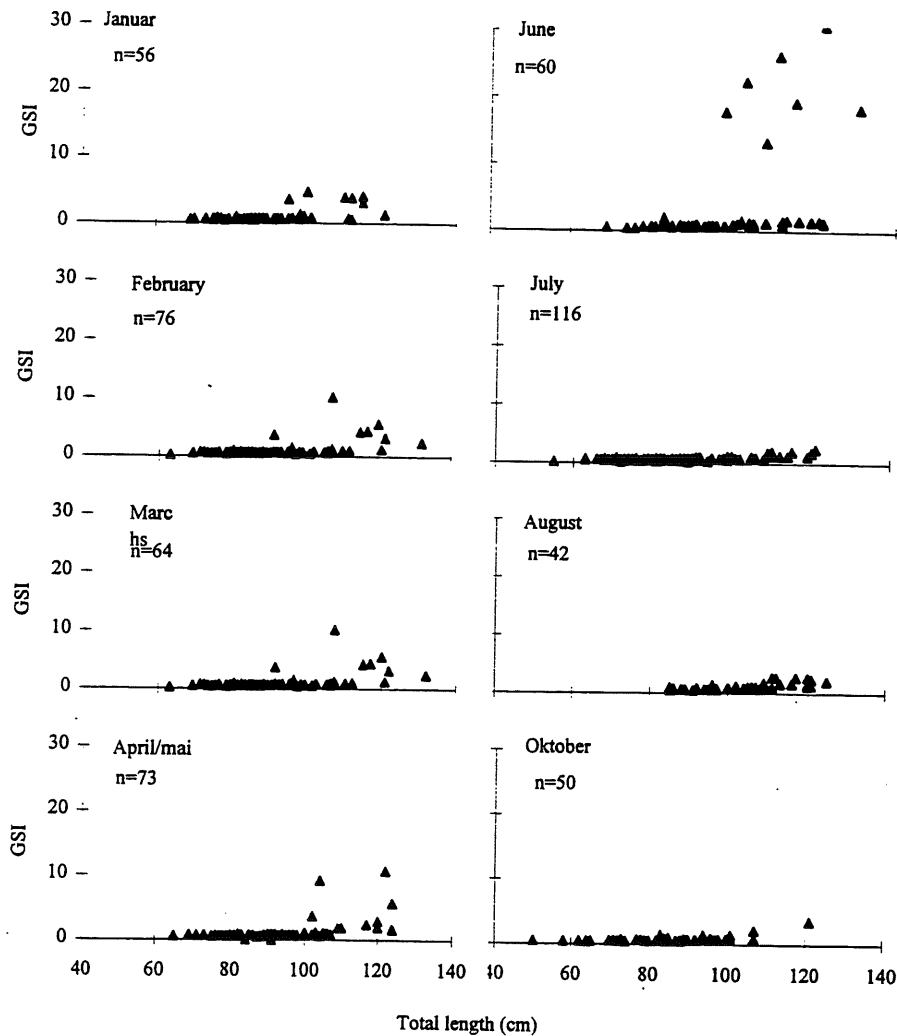
**Figure 5.** Total length (TL) and sex distribution for catches of anglerfish in Møre & Romsdal 1994. A: TL distribution for 360 and 300 mm mesh size. B: TL and sex distribution for 360 mm mesh size. C: TL and sex distribution for 300 mm mesh size.



**Figure 6.** Total length and age relationship. Mean length and length range are given for (A) first dorsal fin ray (illicium) and (B) otoliths.



**Figure 7.** Total length/round weight relationship for anglerfish. Samples from catches in Møre & Romsdal in 1994. A: Both sexes ( $W=0,011*L^{3,04}$ ;  $r^2=0,939$ ) B: Females ( $W=0,011*L^{3,04}$ ;  $r^2=0,939$ ) and males ( $W=0,058*L^{2,66}$ ;  $r^2=0,876$ ).



**Figure 8.** Gonadosomatic index (GSI) for monthly catches of female anglerfish from Møre & Romsdal from January to October 1994.