10 Anglerfish in ICES Subareas I and II

10.1 General

Our present knowledge about anglerfish (*Lophius* spp.) in ICES Subareas I and II is based on two master theses (Staalesen 1995 and Dyb 2003), a report from a Nordic project (Thangstad *et al.* 2006), working documents to the ICES ASC, WGNSDS and WGCSE, and more recent catch data collected by the Norwegian Reference Fleet since 2006 (Anon. 2013). ICES suggests that this stock is considered as a Category 4 stock, since the only data available to assess stock status is landings statistics and commercial catch data from the Norwegian Reference Fleet (ICES CM 2012/ACOM:68).

Species composition

Two European anglerfish species of the genus *Lophius* are distributed in the Northeast Atlantic: white (or white-bellied) anglerfish (*L. piscatorius* L.) and black (or black-bellied) anglerfish (*L. budegassa* Spinola). *Lophius budegassa* are rarely caught in Nordic waters. In Norwegian waters, 1 out of about 2 600 anglerfish landed from the Møre coast north of 62°N (IIa) and 1 out of about 1000 from the North Sea were *L. budegassa* (Dyb 2003; K. Nedreaas, pers. comm.).

Stock description and management units

The WGNSDS (Northern Shelf Demersal Stocks) considered the stock structure on a wider European scale in 2004, and found no conclusive evidence to indicate an extension of the stock area northwards to include Division IIa. Anglerfish in IIa has therefore been treated and described separately by the Celtic Sea Ecoregion working group (WGCSE) who is now assessing the anglerfish in the neighbouring areas. Currently, anglerfish on the Northern Shelf are split into Subarea VI (including Vb(EC), XII and XIV) and the North Sea (& IIa (EC)) for management purposes. However, genetic studies have found no evidence of separate stocks over these two regions (including Rockall) and particle-tracking studies have indicated interchange of larvae between the two areas and further towards ICES Divisions IIa, Vb and Va (Hislop *et al.*, 2001). So, at previous WGs, assessments have been made for the whole Northern Shelf area combined, but exclusive ICES Divisions IIa, Vb and Va. In fact, both microsatellite DNA analysis (O'Sullivan *et al.*, 2006) and particle tracking studies carried out as part of EC 98/096 also suggested that anglerfish from further south (Subarea VII) could also be part of the same stock. Hislop *et al.* (2001) simulated the dispersal of *Lophius* eggs and larvae using a particle tracking model. Their results also show the likelihood for *Lophius* at both Iceland (Solmundsson *et al.* 2007), Faroe Islands (Ofstad 2013) and Norwegian waters north of 62°N (i.e. Subareas I and II) to be recruited from the area west of Scotland including Rockall. This is also supported by research survey data as a migration east-/northeastwards with size is seen in the IBTS- and other survey data (e.g., Dyb 2003).

Recent results from the use of otolith shape analysis in stock identification of anglerfish (*L. piscatorius*) in the Northeast Atlantic (Cañás *et al.* 2012) and previous references on *L. piscatorius* stock identification find no biological evidence to support the current separation of *Lophius* stocks in the northeast Atlantic, but find substructures within the area.

Anglerfish were tagged during two IBTS surveys in the North Sea and five one-day trips using a small (15 m) Danish seiner off the Norwegian coast at around 62°40'N

(Møre) (Thangstad *et al.* 2006). A total of 526 individuals were tagged with conventional Floy dart type tags, 118 in the North Sea and 408 at Møre. This is further described in Thangstad *et al.* (2006). Figure 10.12 shows some preliminary results until 2006. There are more recapture data than shown in the figure, and these should be tabulated and presented. In general we've seen migration in all directions, i.e., recaptures from the southern North Sea, at the Shetland/Faroes and northwards to Lofoten. Most of the recaptures were done at Møre where most of the fish were tagged.

Fishery

In autumn 1992 a direct gillnet fishery for anglerfish (*L. piscatorius*) started on the continental shelf in ICES Division IIa off the northwestern coast of Norway. The anglerfish had previously only been taken as bycatch in trawls and gillnets. Until 2010-2011 there was a geographical expansion of the fishery which was largely due to a northward expansion of the Norwegian gillnet fishery (Figure 10.2). It is not known to what extent this northwards expansion of the fishing area is caused by an expansion of favourable environmental conditions for the anglerfish or the fishers discovering new anglerfish grounds. At Iceland, Solmundsson *et al.* (2007) concluded that changes in the distribution of anglerfish and increased stock size have co-occurred with rising water temperatures that have expanded suitable grounds for the species. Another observed feature of the fisheries is that regional peaks in the catches of anglerfish often culminate after a couple of years' fishing (Figure 10.2).

Norway is by far the largest exploiter of the anglerfish in Subareas I and II accounting for more than 96% of the official landings (Table 10.1). The coastal gillnetting accounts for about 90% of the landings (Table 10.2). The landings of anglerfish in Subarea I and II have been about 1/4-1/3 of the total landings from the other Northern Shelf areas (IIIa, IV and VI).

No TAC is given for Subarea I and II, Norwegian waters. Catches of anglerfish in Division IIa, EC waters, are taken as a part of the EC anglerfish quota for ICES areas III, IV and VI, or as part of the Norwegian 'Others' quota in EC waters. The Norwegian fishery is regulated through:

A discard ban on anglerfish regardless of size

A prohibition against targeting anglerfish with other fishing gear than 360 mm (streched mesh) gillnets

A minimum catch size of 60 cm in all gillnet fisheries, and a maximum permission of 5% anglerfish (in numbers) below 60 cm when fishing with gillnets

72 hours maximum soak time in the gillnet fishery

A maximum of 500 gillnets (each net being maximum 27.5 m long) per vessel

A closure of the gillnet fishery from 1 March to 20 May. This closure period was expanded to 20 December-20 May in the areas north of N 65° in 2008 and further expanded southwards to N 64° since 2009.

A maximum of 15 % bycatch of anglerfish in the trawl- and Danish seine fisheries, and maximum 10 % bycatch of anglerfish in the shrimp trawl fishery. When fishing for argentines and Norway pout/sandeel a maximum of 0.5% bycatch is allowed within a maximum limit of 500 kg anglerfish per trip

A maximum of 5 % bycatch of anglerfish in gillnets targeting other species.

10.2 Data

Landings

The Norwegian statistical areas and locations used by the fishers for reporting their catches are shown in Figure 10.1. A very small fraction of the catches (2 tonnes in 2016) are taken in statistical area 03 which falls within ICES Subarea I, and in Division IIb (less than 1 ton in 2016). The official landings for each country are shown in Table 10.1, and Norwegian landings by gear and fisheries in Table 10.2. Landings as reported to ICES for Subareas I and II decreased rapidly from 2011 to 2015, to the lowest since 1997, but showed a small increase in 2016 caused by an increase in the southern part of the area. Taken into account the expansion of the fishing area towards the margins of this species' distribution, and that we don't expect to discover more new fishing grounds, the current rapid decline in catches per year without any new regulations enforced gives reasons for concern. No information suggests that the official landing figures from Norway give a biased estimate of the actual landings.

Discards

The absence of a TAC in Norwegian waters probably reduces the incentive to underreport landings. Anecdotal evidence from the industry, observer trips and data from the self-sampling-fleet (the Norwegian reference fleet; Anon. 2013) suggest that a small percentage of the catch (not marketable) is discarded. This happens when the soaking time is too long, mostly due to bad weather. Work is ongoing to estimate discards based on data from the Reference fleet.

Biological

Length distributions are available from the directed gillnet fishery during the period 1992—2013 and 2016, but data are lacking for 1997—2001 (Figure 10.3a,b). The length data indicates a drop in mean length of 15—20 cm occurring during the period without length samples (Figure 10.4). Since then the mean length has increased steadily during the last decade to the present average of 95 cm (about 10 years old and 12 kg), and is now at the level seen during the 1990s (Figure 10.4). One third of the anglerfish measured during the 1990s were above 100 cm, this proportion was between 1—6% for the early 2000s and 12—17 % in 2006-2010. This indicates recruitment into Subarea II during 1997—2001 which has not happened since to a similar degree. For 2006—2011 and 2016, some length data from anglerfish caught as bycatch in other fisheries are presented in Figure 10.5a,b. This shows some promising recruitment of small anglerfish (40-50 cm) not yet big enough for the large-mesh gillnets used in the directed anglerfish fishery. These recruits correspond with the promising yearclasses seen further south in the North Sea.

Sex ratios in Subarea II show that females outnumber males above approximately 75 cm, and above 100 cm all fish were females (Thangstad *et al.* 2006). This is very similar to sex ratios reported from distant Portuguese and Spanish waters (Duarte *et al.* 1997) and hence supports a sex growth difference independent of latitude.

Spawning has been documented to occur in ICES Division IIa in spring, but the present abundance of anglerfish in Subarea I and II seems to be dependent on influx or migration of juveniles from ICES Subareas IV and VI. k estimated the estimation of GSI (gonad-somatic index) for females in Division IIa, indicating developing ovaries from January to June. The highest values of GSI were found in June when some of the ovaries were 20-30% of the round weight. Only females bigger than 90 cm had elevated GSI

values indicating developing ovaries. Dyb (2003) found that the length at which 50% of the females were mature (L50) was between 60-65 cm, and that all females above 80 cm were mature.

Some age readings exist of anglerfish in Division IIa, and comparative analyses of different structures, preparations and methods used for age readings were done by Staalesen (1995) and Dyb (2003). The Norwegian Institute of Marine Research adopted the ICES age reading criteria using the first dorsal fin ray (illicium) as its routine method, but few fish have been aged since the above mentioned projects. The material collected and read was, however, considered sufficient for yield-per-recruit estimations (Figure 10.11). As a very simplified 'rule of thumb' one may divide the fish length by 10 to get an approximate age, i.e., a fish of 100 cm is approximately 10 years old and 13 kg while a fish of 70 cm is about 7 years old and 7 kg.

Figure 10.6 shows that a fishery using 300 mm mesh size will exploit males and females in a more equal ratio than 360 mm gillnets (Dyb 2003). 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. A mesh size of 360 mm is also more in line with the minimum legal catch size of 60 cm, the length at first maturity of females and the utilization of the species' (especially the females') growth potential.

Surveys

Anglerfish appears in demersal trawl surveys along the Norwegian shelf, but in very low numbers. There has been a change in the surveys, going from single species- to multispecies surveys, during recent years. The procedures for data collection on anglerfish have varied and, at present, no time-series from surveys in Division IIa yields reliable information on the abundance of anglerfish.

Commercial CPUE

Reliable effort data are not available from the Norwegian gillnetters due to non-mandatory effort recording. In late 2005, ten gillnetters were included in a self-sampling scheme established along the Norwegian coast within Division IIa. Detailed information about effort and catch is provided through this scheme. In Figure 10.7 standardized CPUE is presented for the two most active anglerfish gillnetters in this fleet. The standardized CPUE has been estimated in the following way: a CPUE series has been estimated for each vessel's seasonal fisheries (altogether three sub-series), and then an average of the three relative CPUEs was estimated each year resulting in a standardized CPUE time series. The figure shows that the average standardized catch rates have decreased by about 35% in recent years. The fishing effort (i.e., number gillnet soaking days per year) was generally halved since 2011 (Figure 10.8). However, this decreasing trend seems now to have stopped. The current catch rates, i.e., about 0.3 kg per gillnet soaking day, are, however, and for time being, at about the same level as the catch rates seen after the "Klondyke" fishing period during 1992-1994 in the southern area of IIa (Figure 10.9).

Yield-per-recruit estimations

Based on preliminary analyses and yield-per-recruit estimations done back in 2006 (Thangstad *et al.* 2006), the current fishing mortality in Norwegian waters seems to be too high to secure a high, sustainable and stable long-term yield, while the fishing pattern achieved by mostly using large meshed gillnets seems to be rather good concerning the net growth potential of the species. This is illustrated in Figure 10.10. Input data to the Y/R estimations are given in Table 10.3. The fishing mortality was estimated from catch curves (assuming M=0.15) and also by combining equations from the fishery population dynamics (Thangstad *et al.* 2006). These Y/R estimations must be considered very preliminary and approximate, and indicative rather than accurate, a.o. since the catch-at-age data available for anglerfish were too limited to follow a cohort through the fishery, i.e., the age distribution of catches is from one particular year (2002) to represent a single cohort's development.

Historical stock development

Anglerfish in Subareas I and II have never been assessed quantitatively and besides the presented catch and CPUE series it is not possible to describe the historical stock development. Some very preliminary attempts to fit the Gadget model to the anglerfish data were done by Dyb (2003), but this need to be revisited and much more work is necessary before it can be properly evaluated. Former ICES-RG has recommended using the available catch data to perform a Depletion-Corrected Average Catch (DCAC) analysis and compare the results with possible trends in the other time-series (ICES CM 2012/ACOM:68). Work on this should be prepared for the coming anglerfish benchmark assessment (2018).

10.3 Management considerations

Since indicators of stock size such as CPUE and mean length in the catch are available that may provide reliable indications of trends in stock metrics such as mortality, recruitment, and biomass, the Review Group suggested that this stock may be most appropriately considered as a Category 4 stock, and that the anglerfish stock component in Subarea I and II should be annually monitored due to the reduced catches and possible decreasing trend in CPUE. (ICES C. M. 2012/ACOM:68).

The WG notes the apparent changes in size composition in anglerfish caught in the gillnet fishery during the last two decades. To our knowledge the selectivity in the gillnets has been sufficient stable that this could be interpreted as an altering of the size spectrum in the stock as new year classes enter the area in pulses. The present time-series on effort and catch by length should be further analysed to facilitate future analytical assessments of this stock. The sex ratio in the catches should be monitored and considered in future analyses. The possibility of establishing a standardized survey should be considered for Division IIa. It is observed that the anglerfish spawn in Division IIa, and the magnitude of this spawning, at present considered being marginal, should be better revealed. The role of the anglerfish population in Subarea I and II (mainly Division IIa) in the whole Northeast Atlantic stock complex should be better known. There are more recapture data than summarized and presented in this report, and these should be tabulated and presented before next WG.

The present abundance of anglerfish in Subarea I and II seems to be totally dependent on influx or migration of juveniles from ICES Subareas IV and VI. It is therefore expected that an effective discard ban on anglerfish in these areas will have a positive impact on the abundance north of 62°N. The AFWG strongly supports that ICES

Subareas I, II, III, IV and V should be investigated together to get a more complete understanding of migrations and distributions. A rapidly decreasing catch in recent years until 2016, decreasing trends in CPUE, and a northwards movement of the fishery that has culminated give reasons for concern. Increasing mean length of the caught anglerfish during the last decade is a likely sign of reduced recruitment to Subarea I and II, but signs of smaller anglerfish recruiting to the bycatch in less selective gears may be a first indication of future improved recruitment to the directed fishery. Hence, monitoring of the fishery will be important in near future to protect the young specimens from recruitment- and growth overfishing. Furthermore, the fishing mortality has previously been estimated to a level well above F_{max}. The WG hence recommends that the anglerfish stock component in Subarea I and II is annually monitored and a 20% reduction in fishing effort per year (also as an uncertainty cap) should be imposed until the decrease in CPUE is stopped.

Table 10.1. Nominal catch (t) of Anglerfish in ICES Subareas I and II, 1996–2016, as officially reported to ICES

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016*
Denmark	+	+	+	2	+	-	1	-	-	-	-	+	-	-	-	-	-	-	-
Faroes	+	+	-	1	1	2	5	11	4	7	4	2	1	+	+	1	+	+	1
France	-	-	-	-	-	-	-	-	1	-	-	-	-	1	3	2	-	4	2
Germany	53	4	17	65	59	55	70	55	+	+	0	+	82	70	0	-	+	+	+
Iceland	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-
Norway	1489	1733	2952	3554	2000	2405	2907	2650	4257	4470	4007	4298	5391	5031	3758	2988	1655	933	1355
Portugal	-	-	-	-	-	-	-	-	-	-	2	6	1	+	-	-	-	-	-
UK	7	6	30	2	11	15	18	19	86	114	138	152	40	3	3	111	2	105	76
Others															1	1	-	-	+
Total	1549	1743	2999	3624	2071	2477	3001	2735	4348	4591	4151	4458	5515	5112	3765	3103	1657	1043	1435

***Preliminary**

Table 10.2. Anglerfish in ICES Subareas I and II. Norwegian landings (tonnes) by fishery in 2005–2016. The coastal area is here defined as the area inside 12 nautical miles from the baseline.

Fleet	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Coastal gillnetting	2 302	3 723	4 039	3 574	3 934	4 806	4 557	3 521	2 758	1 506	829	1231
Offshore gillnetting	115	261	204	240	171	391	319	115	158	95	52	62
Offshore dem trawling	77	75	65	34	36	48	19	11	8	7	3	5
Coastal Danish seine	54	54	63	75	68	40	26	16	19	11	12	17
Other gears	102	144	98	84	89	106	83	96	45	36	37	40
Total	2 650	4 257	4 470	4 007	4 298	5 391	5 031	3 759	2 988	1 655	934	1355

Table 10.3. Input data to the yield-per-recruit calculations based on (A) the exploitation pattern of the Norwegian gillnet (360 mm) fishery only, and (B) on the present exploitation pattern for the total fishery for anglerfish in the NEZ (incl. gillnet, trawl, Danish seine). In both cases the exploitation pattern has been scaled so that the average for the age group 7-10 becomes equal to 1.0 (F7-10 = 1.0). As a simplification, a knife-edged maturity at age 8 has been used. See Thangstad *et al.* (2006).

Age	Natural mortality	Maturation	Individual weight in stock and catch (kg)	Exploitation pattern (**A**)	Exploitation pattern (**B**)
1	0.15	0	0.53	0.0004	0.109
2	0.15	0	0.88	0.0040	0.180
3	0.15	0	1.70	0.035	0.239
4	0.15	0	3.16	0.106	0.250
5	0.15	0	3.97	0.171	0.350
6	0.15	0	5.75	0.266	0.408
7	0.15	0	7.44	0.564	0.677
8	0.15	1	9.37	0.829	0.832
9	0.15	1	11.08	1.188	1.182
10	0.15	1	13.12	1.420	1.310
11	0.15	1	17.24	1.539	1.462
12	0.15	1	21.12	1.121	1.439

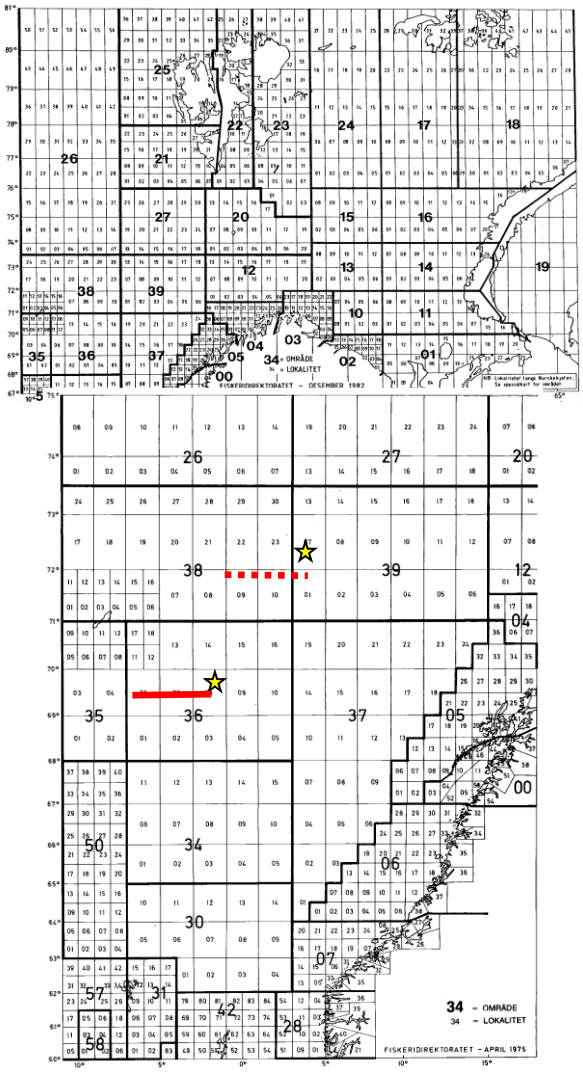

Figure 10.1. Norwegian statistical areas and locations used by the fishers for reporting their catches. The 62°N and 67°N (stippled) latitudes are marked. The fishing areas of the two gillnetters in the coastal reference fleet used for calculating CPUE are marked with yellow stars.

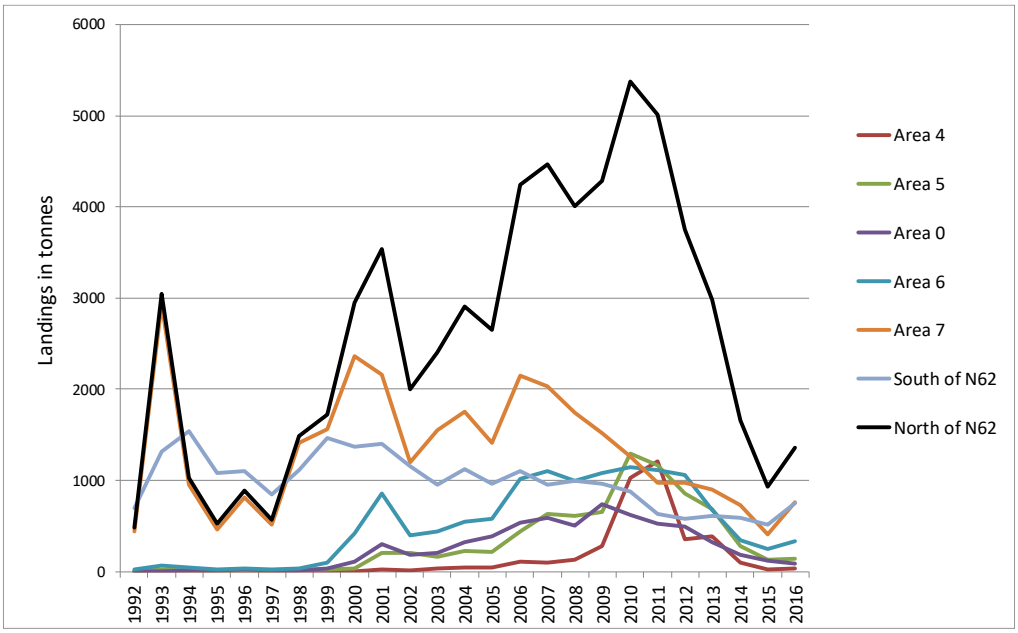

Figure 10.2 . Norwegian offical landings (in tonnes) of anglerfish (*Lophius piscatorius*) per statistical area (see Fig. 10.1) within ICES areas I and II during 1992-2016. Norwegian landings from the area south of 62°N (ICES IV and III) are shown for comparison.

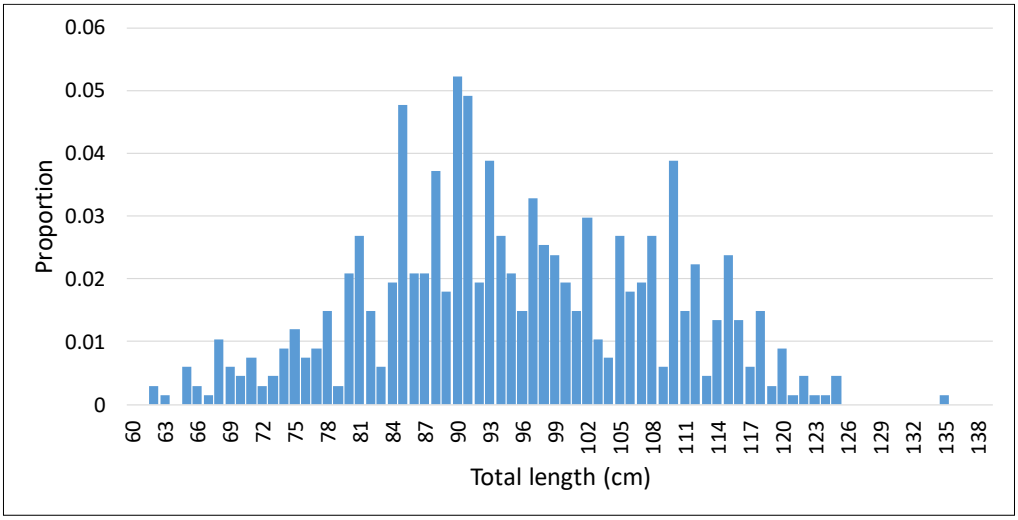

Figure 10.3a. Anglerfish (*Lophius piscatorius*) in IIa. Total lenghts in directed gillnetting, 2016. Based on 61 samples from 4 vessels (N=671).

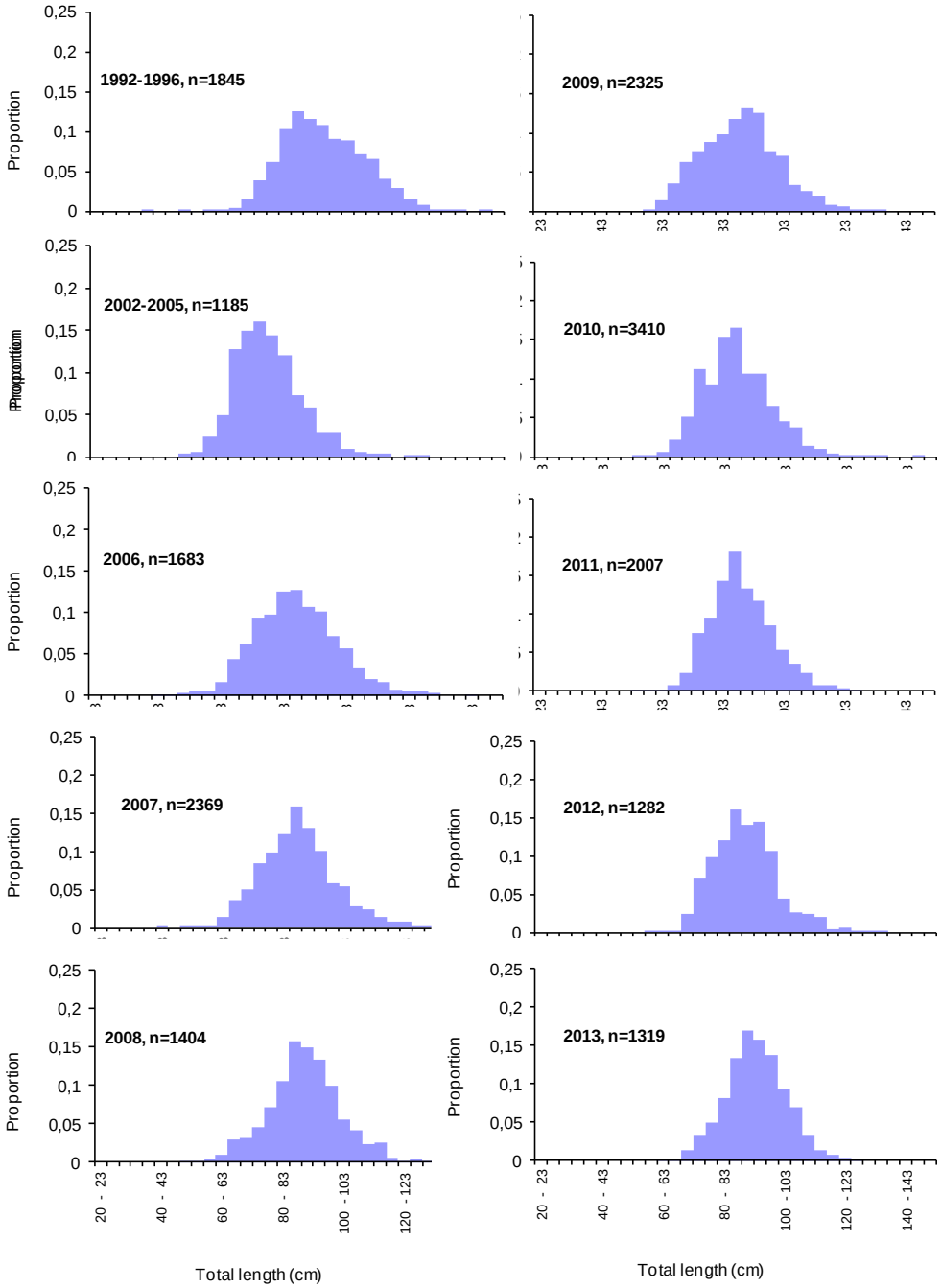

Figure 10.3b. Anglerfish (*Lophius piscatorius*) in IIa. Length distributions for anglerfish caught in the directed coastal gillnetting in Division IIa during 1992-2013. Note that data are lacking for 1997-2001.

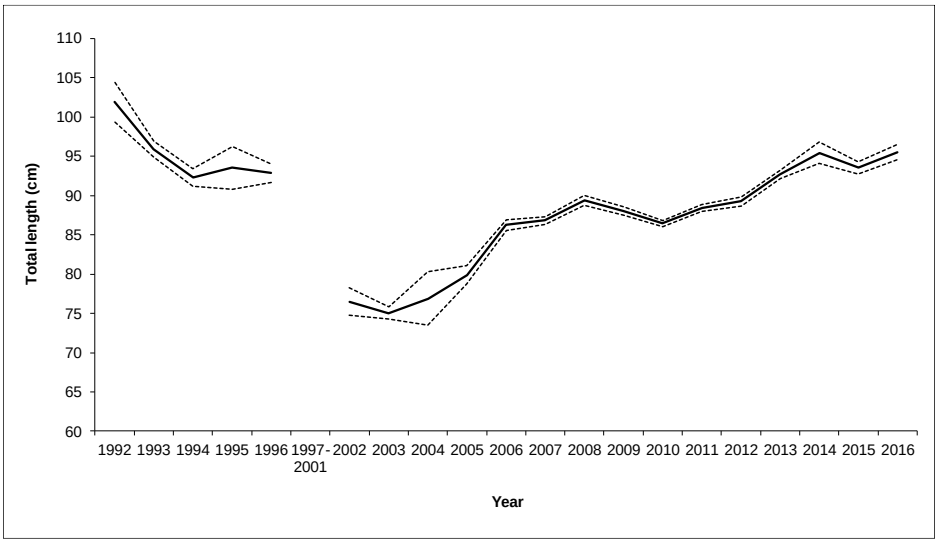

Figure 10.4. Anglerfish (*Lophius piscatorius* in Subarea I and II. Mean lengths for anglerfish caught in the directed coastal gillnetting in Division IIa during 1992-2016, dotted lines represents ±2SE of the mean. Note that data are lacking for 1997-2001.

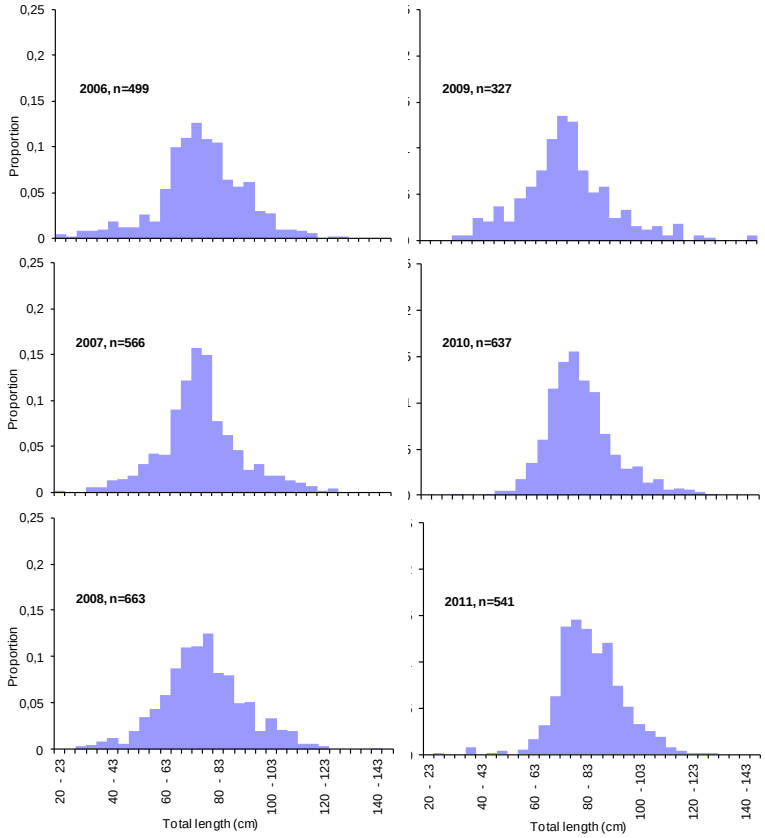

Figure 10.5a. Anglerfish (*Lophius piscatorius* in Subarea I and II. Length distribution for anglerfish caught as bycatch by other gears (offshore gillnetting and longlining) in Division IIa in 2005-2011.

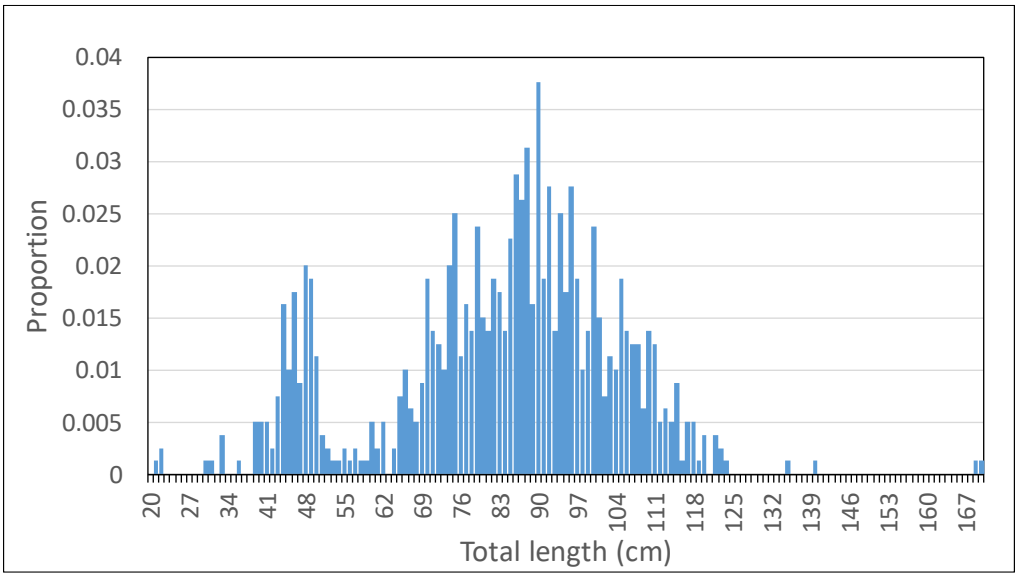

Figure 10.5b. Anglerfish (*Lophius piscatorius)* in IIa. Total lengths, other gillnets and longline 2016. From 141 samples (N=799). Note the small (40-50 cm) anglerfish recruiting to these gears.

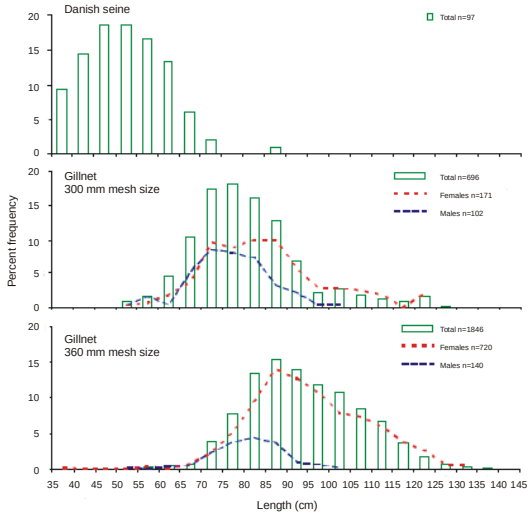

Figure 10.6. Length distributions of commercially landed catches of anglerfish from the Møre coast (ICES IIa; Norw stat.area 07), 1992-1997, illustrating the fishing gears' different selectivity and the sex differences.

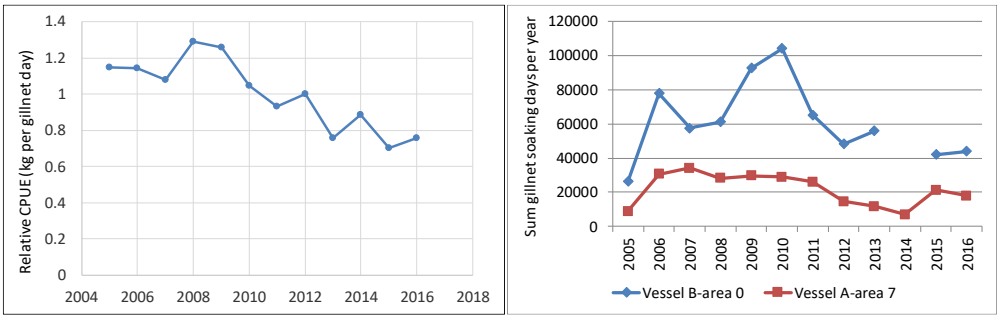

Figure 10.7. Relative (to the 2005-2010 average) CPUE (kg per gillnet day) of anglerfish for two vessels (A and B) in the Norwegian reference fleet in ICES Subarea IIa, and the corresponding fishing effort (right panel). Note that vessel B (northern area) stopped fishing in 2014 due to low catch rates.

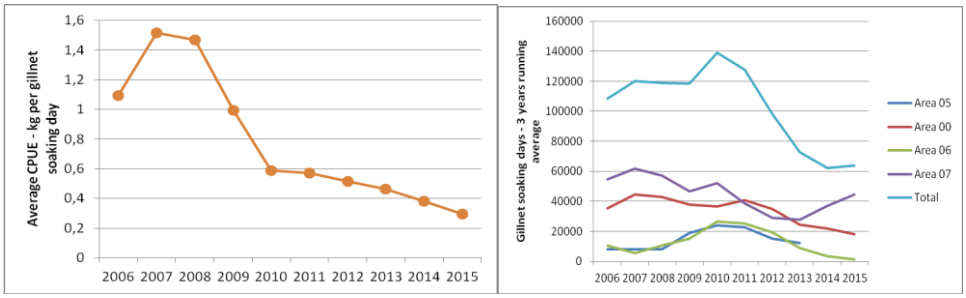

Figure 10.8. CPUE and fishing effort - 3 year running average of gillnet soaking days per year and area and CPUE for the entire Norwegian Coastal Reference fleet fishing anglerfish in ICES Subarea IIa.

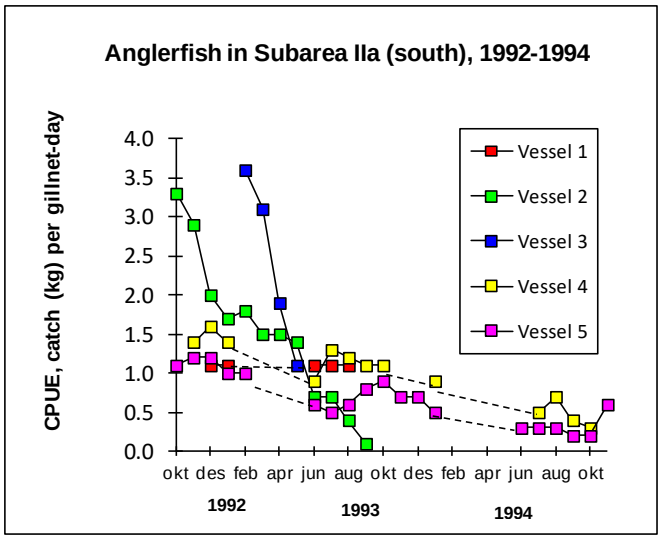

Figure 10.9. Catch per unit effort for five boats in the gillnet fishery for anglerfish in Møre & Romsdal (the same area as vessel A in figure 8 is fishing in) in the period October 1992 - October 1994. Boats 1 > 25m; Boats 2 ca. 20m; Boat 3 ca. 10m; Boat 4 and 5 ca. 16m. Boats 1-4 were fishing with gillnet 360 mm nesh size, boat 5 with 300 mm mesh size.

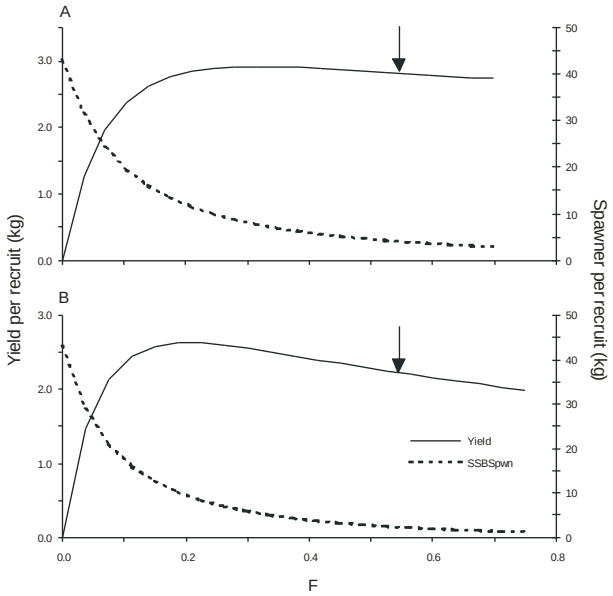

Figure 10.10. Yield- and spawning stock per one year old recruit when (A) based on the exploitation pattern representative of the Norwegian gillnet (360 mm) fishery, and (B) based on the present exploitation pattern for the total fishery for anglerfish in the NEZ (incl. gillnet, trawl, Danish seine). M=0.15, and the age range for the reference F includes ages 7-10. Input data are given in Table 10.3.Thangstad *et al.* (2006) for information about the input data.

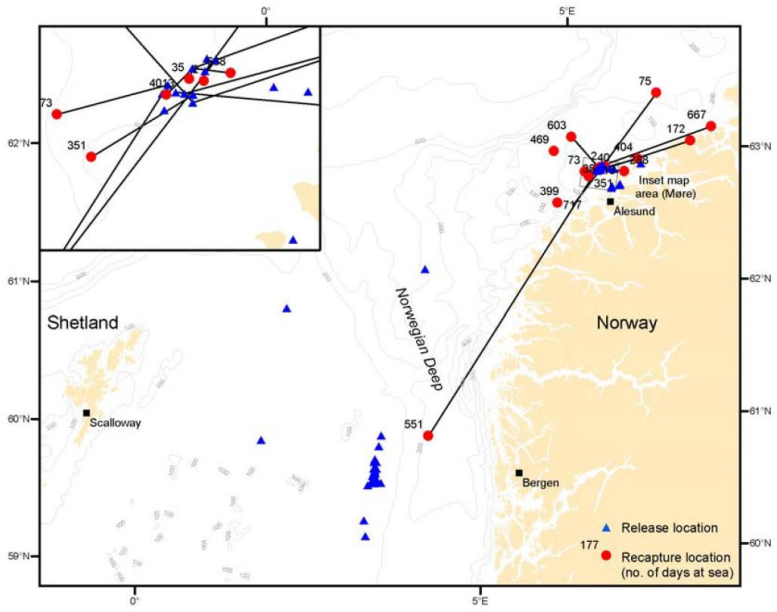

Figure 10.11. Anglerfish tagging locations 2003-2005 on the coast of western Norway in ICES IIa and during the North Sea IBTS surveys, and recapture locations (until 2006) with number of days at sea.